MINERALOGY, LITHOLOGY, PARAGENESIS & DATING OF THE ELDOR CARBONATITE

Work in Progress

by
Rod Tyson
B.Sc., P.Geo.

<u>Front cover photo</u>: Parisite $Ce_2CaF_2(CO_3)_3$ with fluorite and hydrocarbon on dolomite from diamond drill hole #EC08-016 at 87.12 metres

Commerce Resources Corporation's

Eldor Carbonatite Project

near LacLemoyne, Quebec

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1. Executive Summary and Conclusions

List of minerals.

I have compiled a list of **sixty-four** minerals that have been mentioned in various reports or noticed by the author this year in Appendix A of this report. A few of these minerals, such as glaucophane and fergusonite are unlikely to be found at Eldor. There are a dozen or more unidentified minerals that remain to be identified. (The Eldor carbonatite has the potential to produce some of the world's best specimens for the rare earth species parisite.)

Photos of minerals and lithologic phases observed.

Section seven of this report outlines all the various minerals and lithologic phases observed by the author in his study of the 2008 diamond drill core. There are five basic lithologic groups: **calcite carbonatite, dolomite carbonatite, glimmerite, andesite and hydrothermal mineral assemblages**. The carbonatite phases have sub-groups with varying mineralogies and cumulate layering. Rare earth fluorocarbonate mineralization has been found in both calcite and dolomite carbonatite and can be found in most of the 2008 diamond drill holes.

The 2008 diamond drilling did not establish the extent of the carbonatite body (*i.e.* did not find an edge).

Proposed paragenetic model.

The Eldor carbonatite is a complicated body, combining intrusion with fenitization, faulting (being near a major thrust fault), folding and metamorphism over a span of 1.858±25 Ma. There were multiple carbonatite intrusions followed by multiple tectonic and metamorphic events. Overprinting is common and difficult to sort out. Further research into the paragenetic sequence will aid in directing exploration. See Section 5 of this report.

In the course of sorting out the lithologies and suggesting a paragenetic model the author discovered two lithlogies that had been attributed to carbonatites which proved to be remobilized dolomite and calcite. The terminology for describing the various carbonatite phases at Eldor currently employs the terms "carbonatite 1", "carbonatite 2", "carbonatite 3" and "carbonatite 4". Carbonatites 1 & 2 are calcite carbonatites of differing colour and texture; carbonatites 3 & 4 are dolomite carbonatites of differing colour and texture. Under this classification "Carbonatite 1" included the remobilized calcite and "carbonatite 4" included the remobilized dolomite.

This study indicates that there is only one calcite carbonatite intrusion and while there are at least two different dolomite carbonatite intrusions, further characterization is required before it will be possible to distinguish between them by eye. Until such characterization is done, I suggest the classification should be either calcite or dolomite carbonatite with associated descriptive mineralogy.

The fluorite-REE mineralization has not been tied to a particular dolomite carbonatite intrusive phase (see "hydrothermal mineral assemblages" in Section 7 of this report and "paragenesis" in Section 5). Only further SEM/EMPA characterization can solve this question.

Interpretation of mineralogical data with a focus on economic minerals.

The **niobium** and **tantalum** that brought the original exploration to Eldor is unlikely to be economic. The historic values of 5.4% & 11.4% Nb reported by Knox, A.W.(1986) ***have not been duplicated since***. The highest assay for Nb reported in 2008 was 1.267% (DDH EC08-015 182.27 to183.52m). The values for both niobium and tantalum found to date are inconsistent and, overall, low (see Section 4 of this report and assay values appended to lithologies in Section 7).

Phosphate and **zirconium** values are consistent throughout the carbonatite and should be considered for possible by-products. **Fluorine** content has not been assayed but as it is a persistent companion for the rare earth fluorocarbonates, it will have to be separated from the rare earths in the preparation of a rare earth concentrate and could be considered for a possible by-product.

Diamond drilling of the **fluorite-rare-earth-fluorocarbonate** zone known as the Ashram is being extended to the north-northwest. This zone is open at depth and in every direction, having the potential to be large.

Thorium and **uranium** are contaminants in a rare earth concentrate and further study of the mineralogy of the Ashram zone is required to know if the thorium- and uranium-bearing minerals can be separated from the rare earth fluorocarbonates. Also, the minerals carrying the thorium and uranium will contain some of the rare earth minerals being reported in the total REE+Y; it is essential to find out how much of those values will be lost by removing the radioactive contaminants. Whether or not these minerals have a potential value, having been successfully separated from the rare earth fluorocarbonates, remains to be determined.

Fibrous amphiboles

I discovered several sections of glimmerite with fibrous, blue amphiboles like the samples on p. 49 &116. These fibrous amphiboles can have **major health and safety implications** for mining.

The hydrocarbon found in the rusty porous dolomite of the Eldor Carbonatite (see EC08-005 106.33m) will almost certainly be accompanied by hydrocarbon gases such as methane and hydrogen. In the mines of the Kola Penninsula, Russia, such hydrocarbons have resulted in mining accidents involving poisonous, explosive gas. In addition, these gases have been linked to rock bursts. This discovery at Eldor has implications for mine development.

For a more detailed discussion on economic minerals refer to Section 3 of this report.

Summary

I have reviewed all available geological, mineralogical, petrological, and paragenetic data on Eldor. In this report I have: created a master list of mineral species for the Eldor Carbonatite (see Appendix A); discussed the possible economic interest of several of these minerals; determined the rare earth minerals of interest at Eldor--in descending order of importance--to be parisite, bastnaesite, synchisite and possibly monazite (pointing out several occurrences of these minerals from the 2008 diamond drilling); determined the age of the Eldor carbonatite; presented a visual guide to the known carbonatite phases and attendant mineraologies found at Eldor; proposed a paragenetic model (that can be changed as our understanding grows); sorted out confusing terminology in use for the carbonatite phases; and discovered possible issues with fibrous amphiboles and hydrocarbon gas at Eldor.

I intend this report to be useful in the field and the board room. It is a work in progress to be added to as the Eldor project proceeds.

2. RECOMMENDATIONS

1. I recommend detailed mapping of the Eldor Carbonatite, accompanied by further mineralogical research. Understanding the mineralogy will refine the pargenetic model, which in turn will help with the modelling of the carbonatite body for exploration. Knowing the mineralogy in detail will give the field geologists greater control over sampling and field identification of various lithologies.

2. I recommend a winter drilling program, with a larger drill, to extend the known Ashram zone. I believe there is a connection to the REE mineralization found in diamond drill hole EC08-005 (roughly one kilometre to the northeast of EC10-027) that extends underneath Center Lake. (See GamX report eU diagram.)

3. I recommend a detailed study of the Ashram rare earth zone mineralogy to determine: if a rare earth concentrate can be made; if the thorium and uranium contaminants can be removed; and the content of the rare earths in the contaminant minerals.

4. I recommend further research into the presence of hydrocarbons at Eldor, to determine whether or not they are a concern for drilling.

5. I recommend follow-up SEM/EMPA work be conducted on the thin sections prepared for this report and subsequent characterization of the various areas of the Eldor Carbonatite.

3. INTRODUCTION

I, Rod Tyson Bsc. P.Geo., have spent thirty-six years visiting occurrences with exotic mineralogy in Canada. I have worked in alkaline carbonatite terranes in Ontario, British Columbia and Quebec.

Commerce Resources hired me to: visit the Eldor project on the Lac LeMoyne carbonatite south of Kuujuuaq, Quebec; create a comprehensive list of minerals found there (Appendix A); compile photos and descriptions of the various mineral and lithologic phases observed (Section 7, pp. 21-146); offer a paragenetic model (Section 5, pp. 17 & 18); and provide an interpretation of all available mineralogical data with a focus on economic minerals (Section 4, pp. 9-15).

My work on the Eldor project included three weeks onsite in July of 2010 reviewing and sampling core from 27 diamond drill holes. I sent 59 samples to Vancouver Petrographics for thin sections and those thin sections were, in turn, sent to Dr. Craig Leitch for a petrographic report (see Appendix B). In October, I spent one week at the University of Alberta's Earth and Atmospheric Sciences department conducting SEM work and laser ablation dating (Section 6, p. 19).

This report combines my geological and mineralogical observations with the petrological report from Dr. Craig Leitch and other geological, petrological and mineralogical reports listed in the references or appendices. The resulting **conclusions** are presented in Section 1, pp. 4 & 5. My **recommendations** for further work can be found in Section 2, p. 6.

In the course of this research I found a rare occurrence of **hydrocarbon** in the Eldor Carbonatite which has significant consequences for exploration and development there (see Sections 1, 2 & 5 of this report).

Rod Tyson B.Sc. P.Geo.

Ordre des Géologues du Québec
Permis no. 1294

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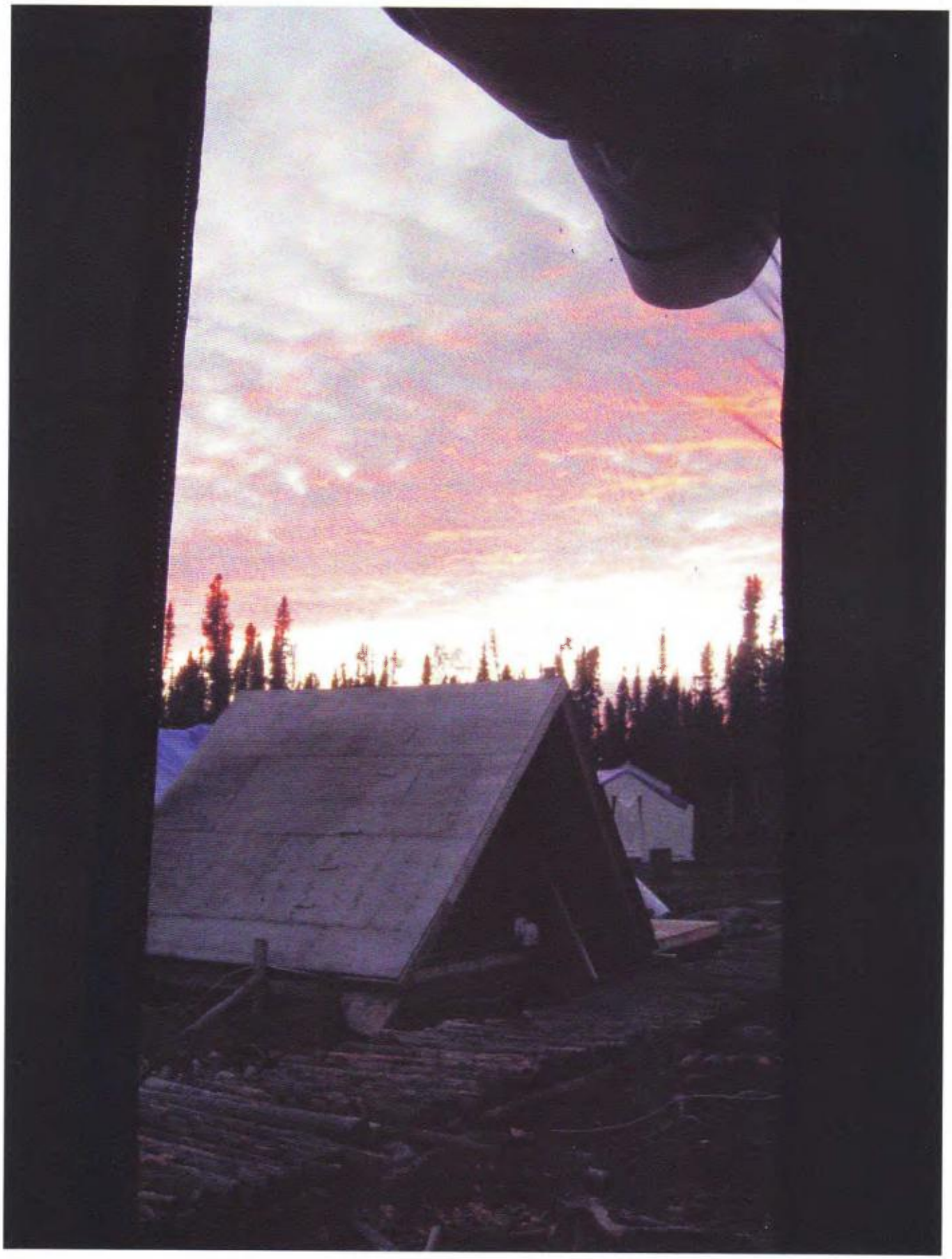


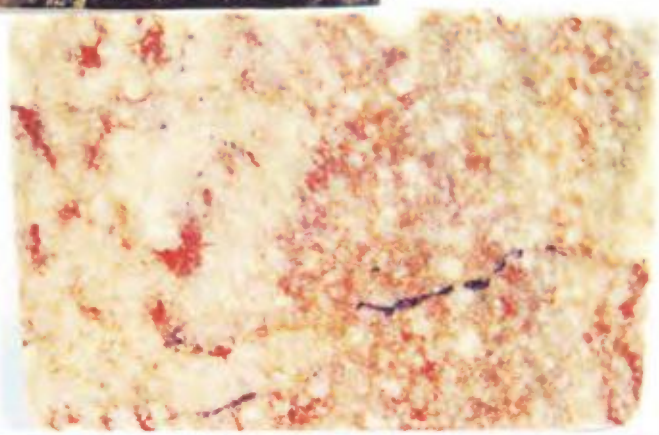
Rare earth sunset over camp Eldor

4. MINERALS OF ECONOMIC INTEREST

A. REE bearing fluorocarbonates

Parisite-(Ce) $Ce_2CaF_2(CO_3)_3$ along with **Bastnaesite-(Ce)** $(Ce,La)(CO_3)F$ followed by **Synchysite-(Ce)** $Ca(Ce,La)(CO_3)_2F$ are, in decreasing order of abundance, the three primary REE bearing minerals of interest in the Eldor Carbonatite. The only persons to note the presence of rare earth flurocarbonates (bastnaesite) before 2009 were Birkett & Clark, 1991. The Ashram zone is by far the most notable occurrence found to date but there are many other occurrences in the first twenty-six drill holes including one interval at the bottom of EC08-005 that is similar to the Ashram zone material in Figure 2 (below). The interval in EC08-005 gave a spot high of 3% REE's with a portable XRF machine.

Fig.1 EC10-027 115.62m Fluorite (purple) with parisite (reddish-brown) in dolomite carbonatite.



Fig, 2 EC10-027 221.74m Parisite (orange-red) with fluorite in dolomite carbonatite.

Fig. 3 EC10-027 230.77m Parisite (orange-red) in dolomite carbonatite(?) with fluorite (purple). Note metamorphic foliation.

Rare earth fluorocarbonate minerals have been found in both calcite and dolomite carbonatites as well as dolomite +/- fluorite re-mobilized rock types. Other occurrences can be seen in section 4 of this report at EC08-001 173.60m, EC08-002 5.10m, EC08-003 144.96m, EC08-019 118.33m, EC08-014 169.81m, EC08-015 160.45m, EC08-016 87.12m & EC08-016 111.93m.

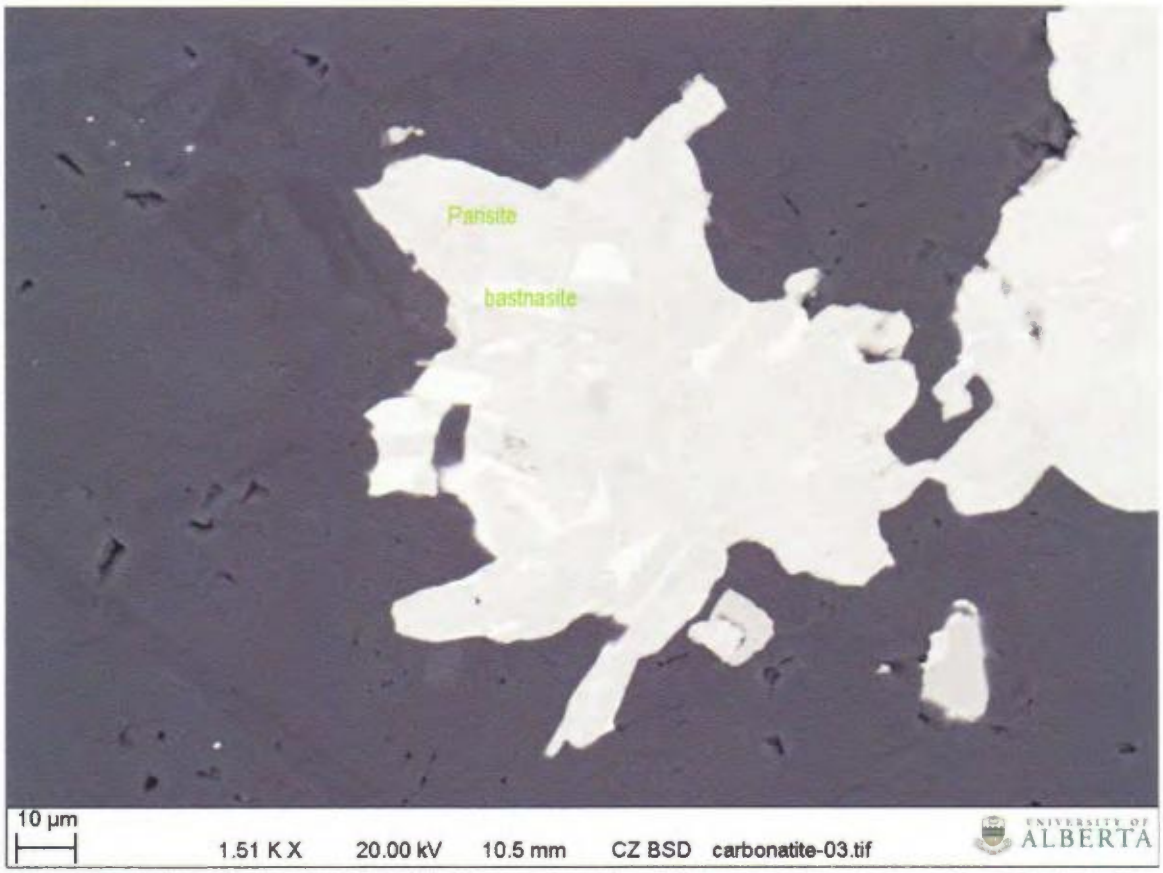
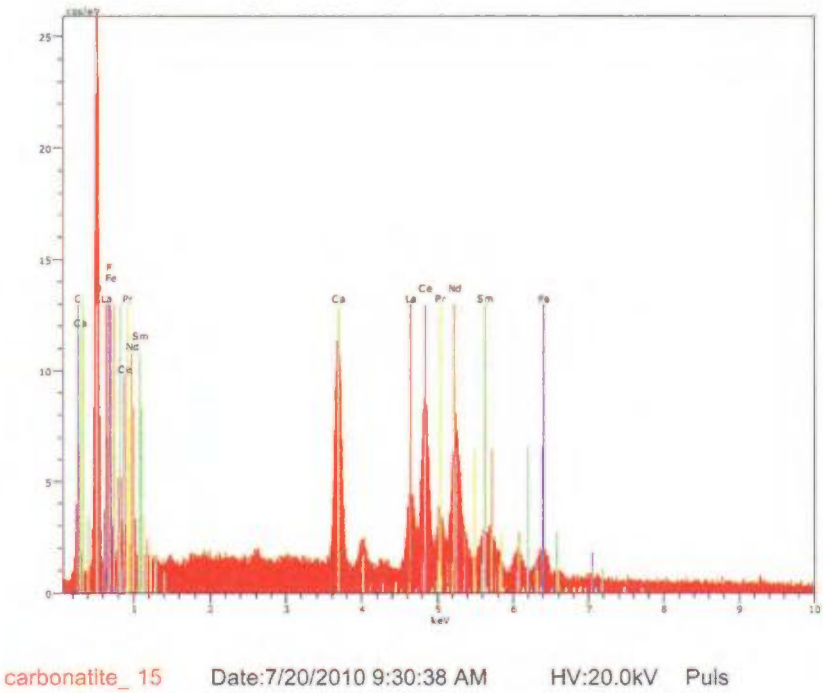


Fig. 4 Parisite (light gray in BSE image above), with syntactic intergrowth of bastnasite (white), all in dolomite matrix. (From Locock, 2010)



Parisite: major Ca, La, Ce

Bastnasite yields a very similar spectrum, but without Ca, just the REE.

Fig. 5 SEM spectrum for Parisite, from Locock 2010.

B. REE bearing phosphates

Monazite-Ce (Ce,La,Nd,Th)PO_4 and **Xenotime (Yb,Y,Er)PO_4** have been identified at Eldor. There may be a considerable amount of monazite in some areas; it may be the main thorium-bearing mineral in the Ashram zone.

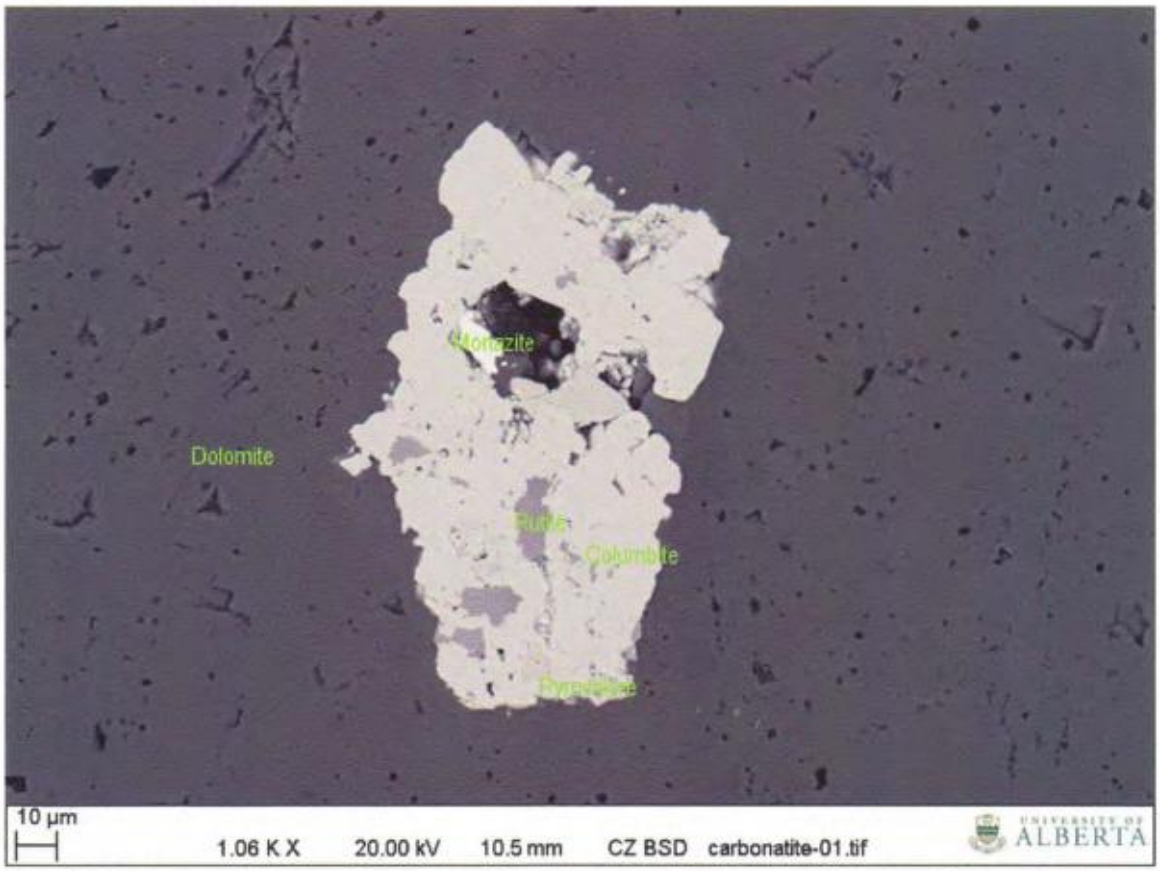


Fig. 6 BSE image of **ferrocolumbite** with inclusions of **rutile**, **pyrochlore** and **monazite** from EC10-027 320.59m.

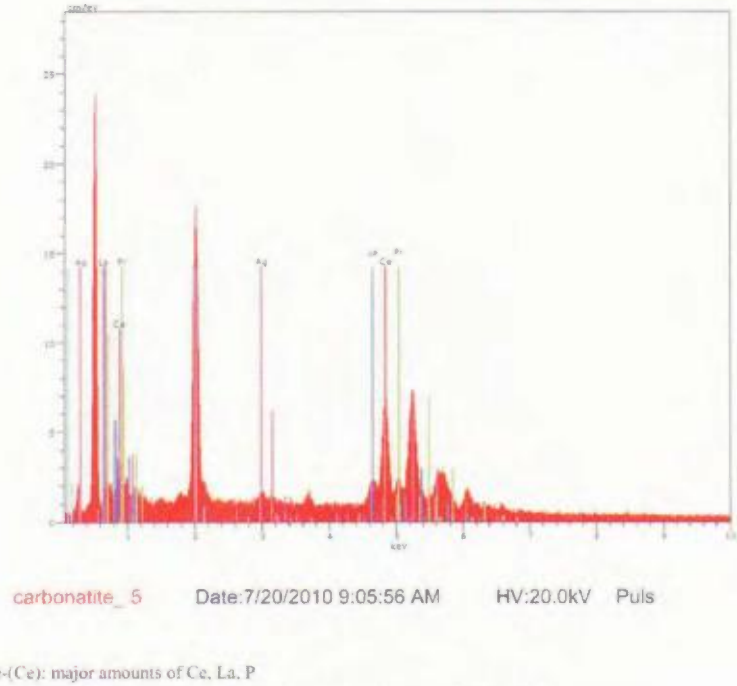
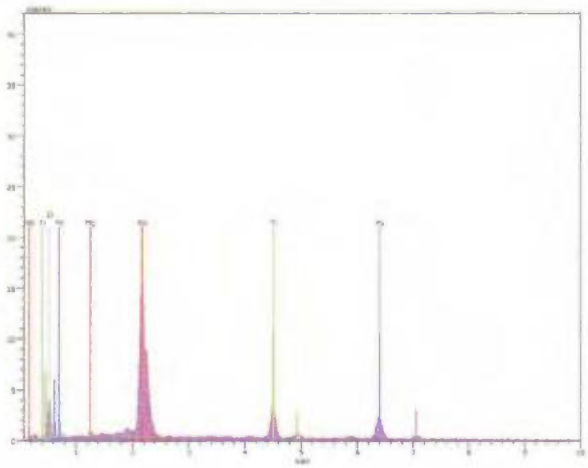


Fig. 7 SEM spectrum for monazite from Locock 2010.

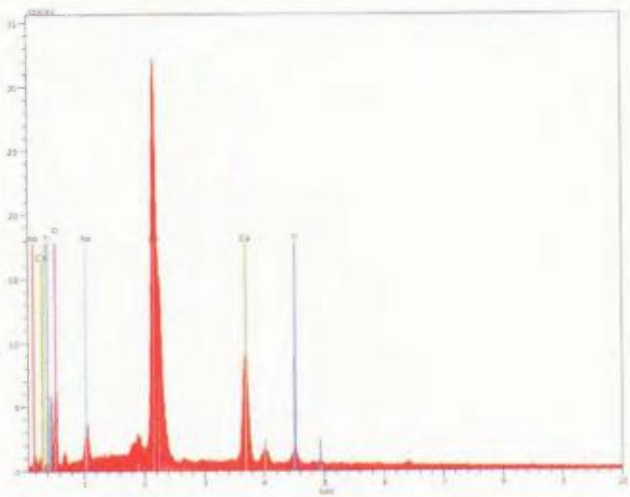
C. Primary Niobium and Tantalum minerals

Pyrochlore $(Ca,Na)_2Nb_2O_6(OH,F)$, Ferrocolumbite $FeNb_2O_6$ and **Fersmite $(Ca,Ce,Na)(Nb,Ta,Ti)_2(O,OH,F)_6$** have all been identified at Eldor. Pyrochlore and ferrocolumbite are the main niobium- and tantalum-bearing minerals present. All of these minerals can carry some rare earth elements and often have inclusions of other rare earth-bearing minerals such as monazite and thorite (see Fig.6 on page 11 of this section). The overall assayed values for both niobium and tantalum to date in the Eldor carbonatite are **low** and/or **inconsistent** (see assay values in section 4). Because these minerals occur with rare earth fluorocarbonates in the Ashram rare earth element zone (and will be the main radioactive contaminent in a rare earth concentrate), they need to be considered as a possible by-product and further quantitative work needs to be done to this end.



Energy dispersive X-ray spectrum of Ferrocolumbite (major amounts of Fe, Ti and Nb). Markers of X-ray emission lines also shown at uniform heights for *K* and *L* lines. Note for example that Mg is very low abundance in spectrum, but marker is same height as that of Nb.

Fig. 8 SEM spectrum for ferrocolumbite from EC10-027 (Ashram zone). From Locock, 2010.



Pyrochlore: major amounts of Ca, Nb; less Ti, Na

Fig. 9 SEM spectrum for pyrochlore from EC10-027 (Ashram zone). From Locock, 2010.

D. Uneconomic REE, Nb, Ta-bearing minerals

Aeschynite-Ce $(Ce,Ca,Fe,Th)(Ti,Nb)_2(O,OH)_6$

Allanite-Ce $\{Ca,Ce\}\{Al_2,Fe^{2+}\}(Si_2O_7)(SiO_4)O(OH)$ and **Thorite $(Th,U)SiO_4$** have all been identified at Eldor. Further quantitative work is required to know how much of the total rare earths found in the Ashram zone are bound up in these difficult- or impossible-to-refine minerals. These minerals are all radioactive sources that will need to be dealt with in creating a rare earth concentrate.

E. Other REE bearing minerals

Fluocerite-Ce $(Ce,La)F_3$ is a rare mineral that has been identified at Eldor. It is unlikely to occur in sufficient quantity to be considered in any way.

F. Zirconium-bearing minerals

Baddeleyite ZrO_2 and **Zircon $ZrSiO_4$** are both found at Eldor. The whole rock analyses from 2008 show that zirconium has fairly consistent values throughout the known carbonatite body (averaging around 250 ppm, pers. comm. Darren Smith) and might be a viable by-product.

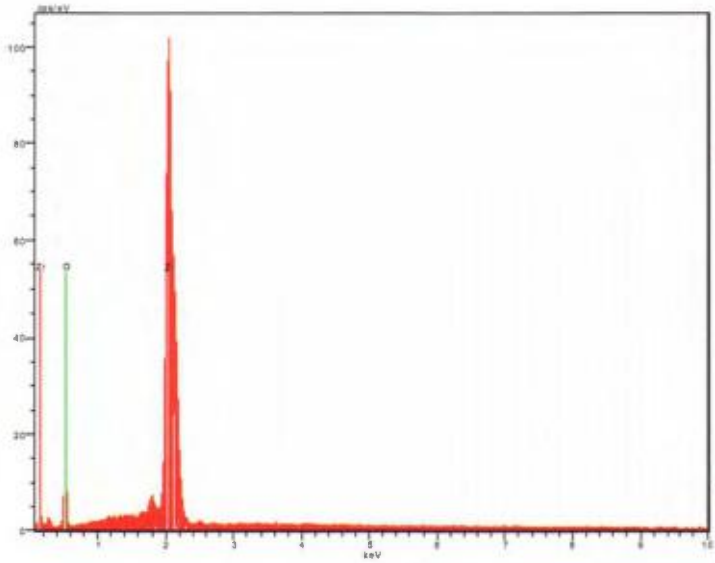


Fig.10 EDS spectra for baddeleyite in EC08-113.9m

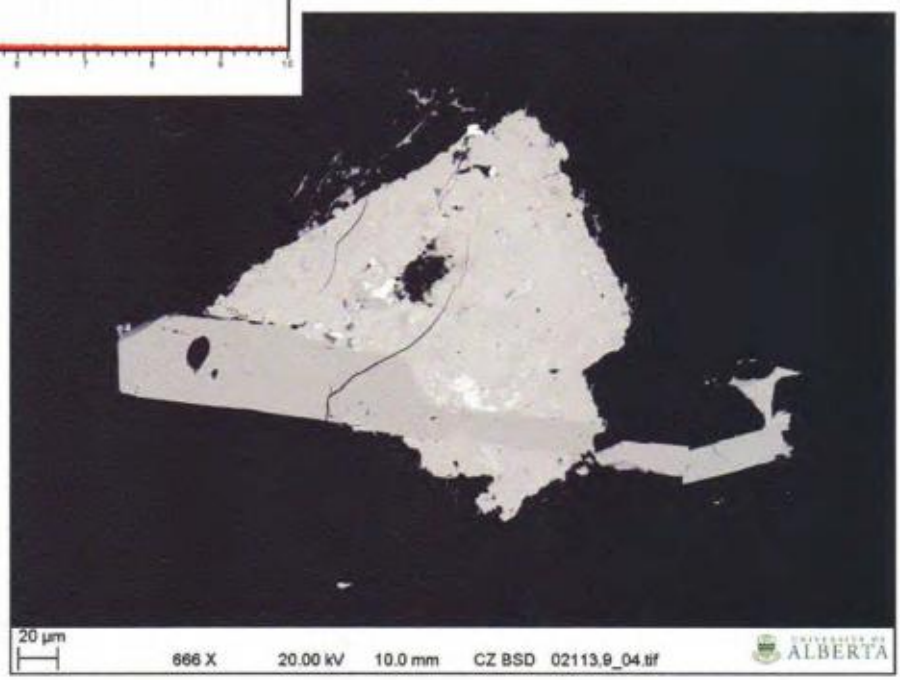
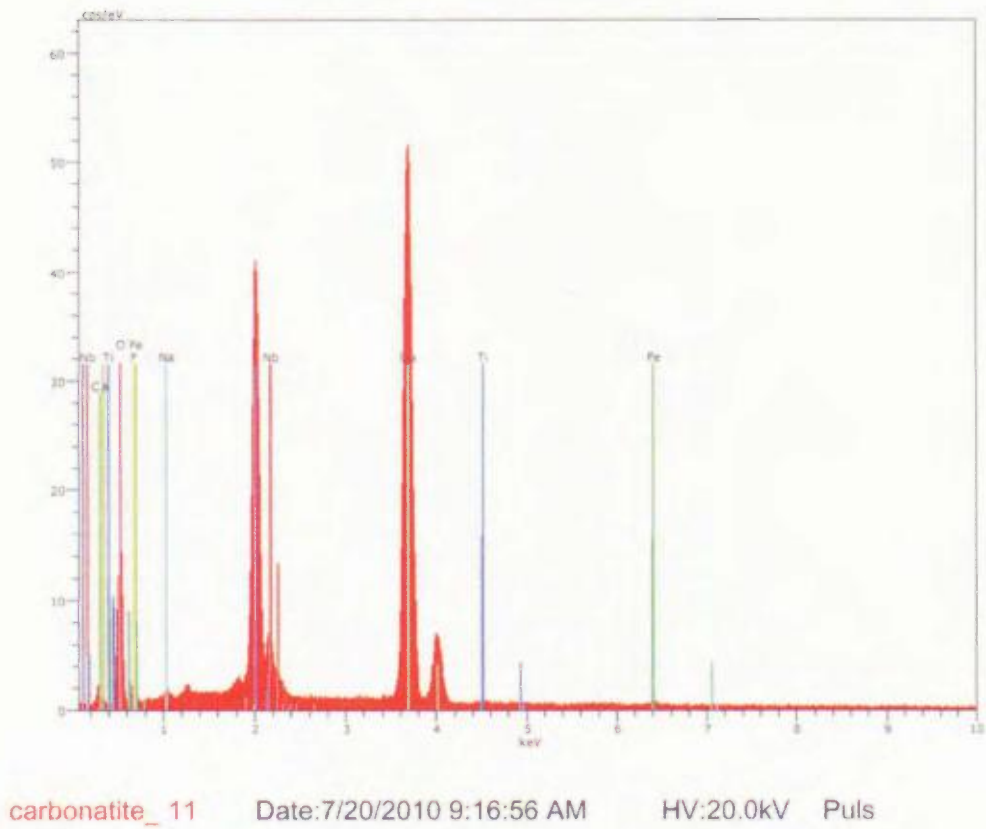


Fig 11 BSE image of prismatic baddeleyite crystal with pyrochlore.

G. Phosphate P_2O_5

Most of the phosphate at Eldor occurs as the mineral **Apatite $Ca_5(PO_4)_3F$**. The apatite content of the Eldor Carbonatite is quite consistent and probably averages 4.5% with several zones of mineable width over 10%. It could be considered as a viable by-product for phosphate fertilizer supply to Europe.



Apatite – major Ca, P

Fig. 12 EDS spectra for apatite from the Ashram zone EC10-027. From Locock, 2010.

H. Fluorine

The bulk of the fluorine found at Eldor occurs as the mineral **Fluorite CaF_2** and is intimately associated with the rare earth fluorocarbonates in the Ashram zone. The fluorite is relatively free of silicate minerals and would be separated from the rare earth element mineralization as a part of the recovery process. Fluorine should be considered as a possible by-product for mining at Eldor.

I. Sulphides

Molybdenite MoS_2, Galena PbS, Sphalerite ZnS, and **Chalcopyrite $CuFeS_2$** have all been found at Eldor. While these sulphides are present, they currently have not been found in sufficient quantity to be considered economically interesting.

J. Uranium & Thorium

Overall, the values for uranium are low and irregular in the known Eldor Carbonatite. Uranium content in the pyrochlore might be considered an asset if a viable concentrate could be made.

Thorium values at Eldor generally exceed the uranium values by a factor of four to five times, occasionally ten or more times. Thorium is more consistent throughout the known carbonatite body than uranium. Thorium is a detrimental element because there is an increased cost for processing radioactive material, its containment and disposal. More work is needed to quantify the thorium-bearing phases.

BOTRYOIDAL HYDROCARBON ON DOLOMITE

PLATE I. Hydrocarbons in carbonatite are rare. This micro-photo shows a sample I found in diamond drill hole EC08-005 at 110.2 metres in a small dolomite vug. The presence of solid hydrocarbons strongly suggests the presence of gaseous hydrocarbons as have been found in the Khibiny carbonatite complex in the Kola Penninsula, of NW Russia. (Nivin, V. A. *et al.*, 2005.) The gaseous hydrocarbons at Khibiny have been both poisonous and explosive. Recent research has also tied the gaseous hydrocarbons with areas of rock burst (*ibid.*, p.94)

6. COMMENTS ON POSSIBLE PARAGENESIS

The Eldor Carbonatite is 1.858±25 Ma (DuFrane & Tyson, section 6 of this report). The carbonatite has been folded, faulted and metamorphosed at different times, so there has been multiple overprinting of events. Every metre of every diamond drill core examined from 2008 was brecciated. As a result, I consider **the entire carbonatite body to be a complex set of breccias with lithologic subtexts.**

Based on my observations from the 2008 core I have made the following provisional paragenetic sequence:

1) Calcite Carbonatite Intrusion

I have found dolomite carbonatite intruding calcite carbonatite--but not the other way around. See drill core sample EC08-004 at 71.64 m in section 4 of this report. This interpretation contradicts Wright *et al.*, 1998 who have the carbonatite sequence starting with an ankerite carbonatite.

2) Dolomite Carbonatite Intrusion

Based on the evidence in sample EC08-004 a dolomite carbonatite is the second intrusional event. **Again, this interpretation contradicts Wright *et al.*, 1998.**

3) Dolomite Carbonatite Intrusion

There have been multiple dolomite carbonatite intrusions at Eldor. The evidence for this is found in EC08-004 63.46m, which shows two different dolomite carbonatites in contact, and EC08-014 28.69m, a breccia with dolomite carbonatite clasts in a dolomite carbonatite matrix.

4) Dolomite-Fluorite-REE Carbonatite Intrusion

I found it impossible to conclude whether or not the fluorite-rich, REE-bearing dolomite carbonatite was a separate intrusive event or simply a late stage pulse of immiscible elements from one of the two dolomite carbonatite intrusions.

5) Brecciation

As stated above, the entire Eldor carbonatite is brecciated. There are breccias that are undoubtedly magmatic in origin (such as EC08-014 28.69m) and others that could be tectonic (EC08-001 151.12m), where it is difficult to distinguish breccia clasts from the surrounding matrix.

There are two reasons for the provisional nature of this paragenetic sequence.

First, there has been no EMPA work done on the carbonate mineralization at Eldor. Consequently, I do not know if we are dealing with more than two dolomite carbonatites or what their unique signatures might be. Dr. Roger Mitchell (2010) and Dr. Craig Leitch (Appendix B) both suggest we are dealing with a magnesium-rich carbonate that is midway between siderite and magnesite in composition. The magnesian carbonate is likely a primary carbonatite signature. Electron microprobe work on the carbonates would provide the characterization needed to sort out the various intrusions. It would be desirable to refine the exploration model by attributing the fluorite-REE mineralization to a particular intrusive phase.

Second, my observations were limited to the diamond drill core. Mapping and subsequent petrological study of the Eldor Carbonatite will provide refinements to the paragenetic model I have presented here.

Comment on Extrusive vs. Intusive Carbonatites

Birkett *et al.*, 1991, p.18 claim that there is "a massive, intrusive facies, and a scoriaceous, block extrusive facies" of carbonatite represented at Eldor. **I have found no evidence to support the premise of an extrusive carbonatite phase at Eldor.** There are no lapilli, no cross-bedded tuffs, and no vesicular or spongy textures indicative of extrusive volcanism. There are, however, several intrusive phases.

Comment on Fenitization by Carbonatite Intrusion at Eldor

At first I thought the glimmerites present at Eldor were the result of fenitization of a fine-grained country rock by the calcite carbonatite intrusion (see glimmerites EC08-001 at 10.25m, EC08-001 at 141.34m, EC08-002 at 38.25m and EC08-007 at 39.46m in section 7 of this report). EC08-001 at 10.25m shows a glimmerite with coarse amphiboles brecciated by a calcite carbonatite. The coarse amphiboles are broken at the edges of the glimmerite clasts showing that **the glimmerite existed before the calcite carbonatite intrusion.** Unless the glimmerite was created by an earlier calcite carbonatite intrusion then its origin is unclear.

Further EMPA work would be required to shed light on the topic of fenitization at Eldor.

Comment on Glimmerites at Eldor

There remains a question of the origin of the glimmerites found at Eldor. Are they a product of the carbonatite intrusions or are they inclusions of hypabyssal glimmerite?

Unusual Magmatic Textures

I have observed some interesting textures (see Section 7, EC08-002 122.22m) in the calcite carbonatite. These textures are reminiscent of spinifex textures observed by the author with Dr. Dale Pyke (see Pyke *et al* . 1973) in the Matheson, Ontario region. A. H. Treiman, 1989, p.89 refers to these textures as "comb-layering of calcite crystals with interstitial silicate and oxide minerals" and these "may represent dendritic crystals grown *in situ* on the walls of a magma chamber".

Hydrocarbon Content in the Eldor Carbonatite

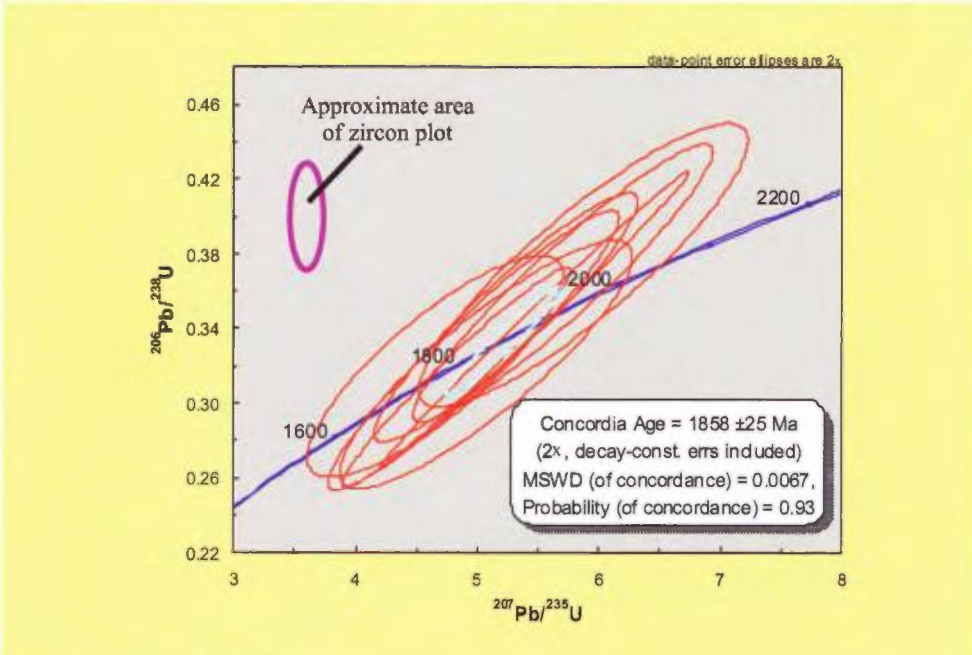
In July I 2010 found botryoidal hydrocarbon in vugs in a porous, remobilized dolomite carbonatite (see EC08-005 106.33m and "Euhedral Minerals" in section 7 of this report). Apart from being an unusual mineralogical find, this has implications for mining of the Eldor carbonatite. **With the solid hydrocarbon there is the possibility of explosive, poisonous, gas.** This type of abiogenic gas occurrence, found in the Kola Penninsula of Russia, has also been linked to rock bursts. These rare occurrences have been documented in detail by Niven *et al.*, 1991, 1993, 2001.

Paragenetic Conclusions

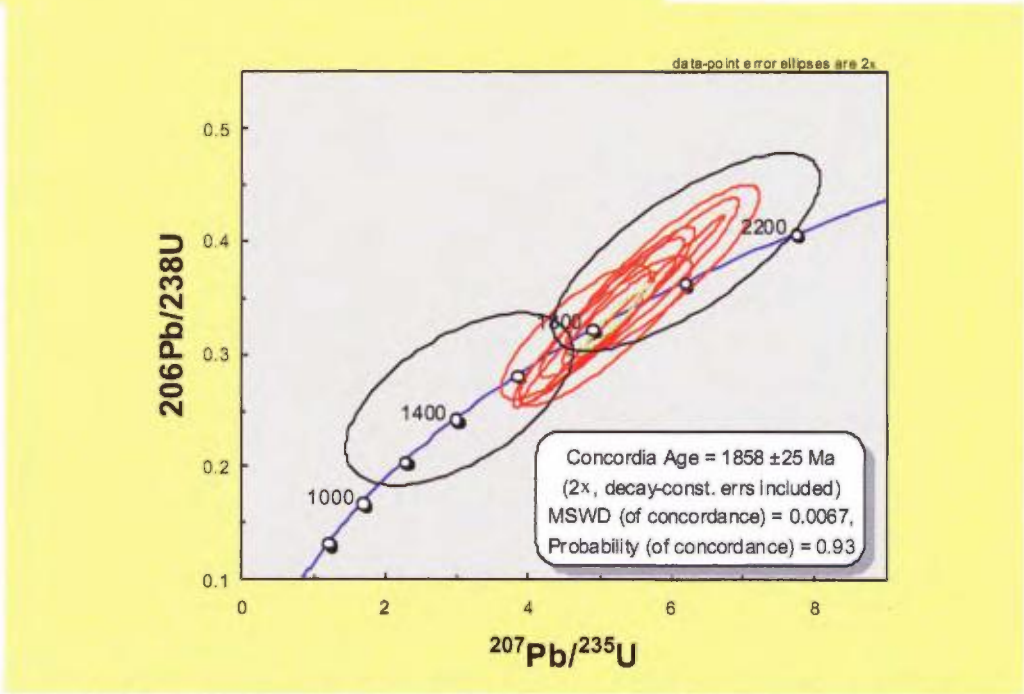
Because of its long history, the geology of the Eldor Carbonatite is complex. To understand these complexities will require more research into the mineralogy of the various carbonatite and country rock phases. Unraveling these complexities will provide direction for the ongoing exploration of the Eldor carbonatite.

6. DATING THE ELDOR CARBONATITE

In October, 2010 I, Rod Tyson, conducted trials on three different minerals from the Eldor Carbonatite to try to establish a date of intrusion for the Eldor Carbonatite. The work was performed at the University of Alberta Earth and Atmospheric Sciences under the direction of Dr. S. Andrew Dufrane. The three minerals tried were monazite, zircon and baddeleyite. The monazite proved too low in uranium to give a reliable date. The zircon plotted so high above Concordia that it warrants further investigation according to Dr. S. Andrew Dufrane and Dr. Larry Heaman at the University of Alberta (pers comm). The baddeleyite gave a good date of 1,858±25 Ma (see plots below).



These two concordia plots from the analyzed baddeleyite are courtesy of Dr. S. Andrew Dufrane at the University of Alberta. The ellipse showing approximate area of unusual zircon plot was added by Rod Tyson



A date of 1,858±25 Ma fits well with what Maurice *et al.* propose based on other dates in the area, stating that "the second depositional episode includes a platform sequence composed of sandstones, iron formation, turbidite and basalts lying unconformably on both the Archean craton and the first depositional cycle. Its age is constrained by gabbroic sills (*ca.* 1.88 Ga), the Lac Lemoyne carbonatite (<1.87 Ga), and the Lac Castignon lamprophyre (*ca.* 1.88 Ga #4, Fig. 3)." Maurice *et al.*, (2009), p.164

GALENA WITH UNKNOWN ORANGE, POSSIBLE REE MINERAL & DOLOMITE

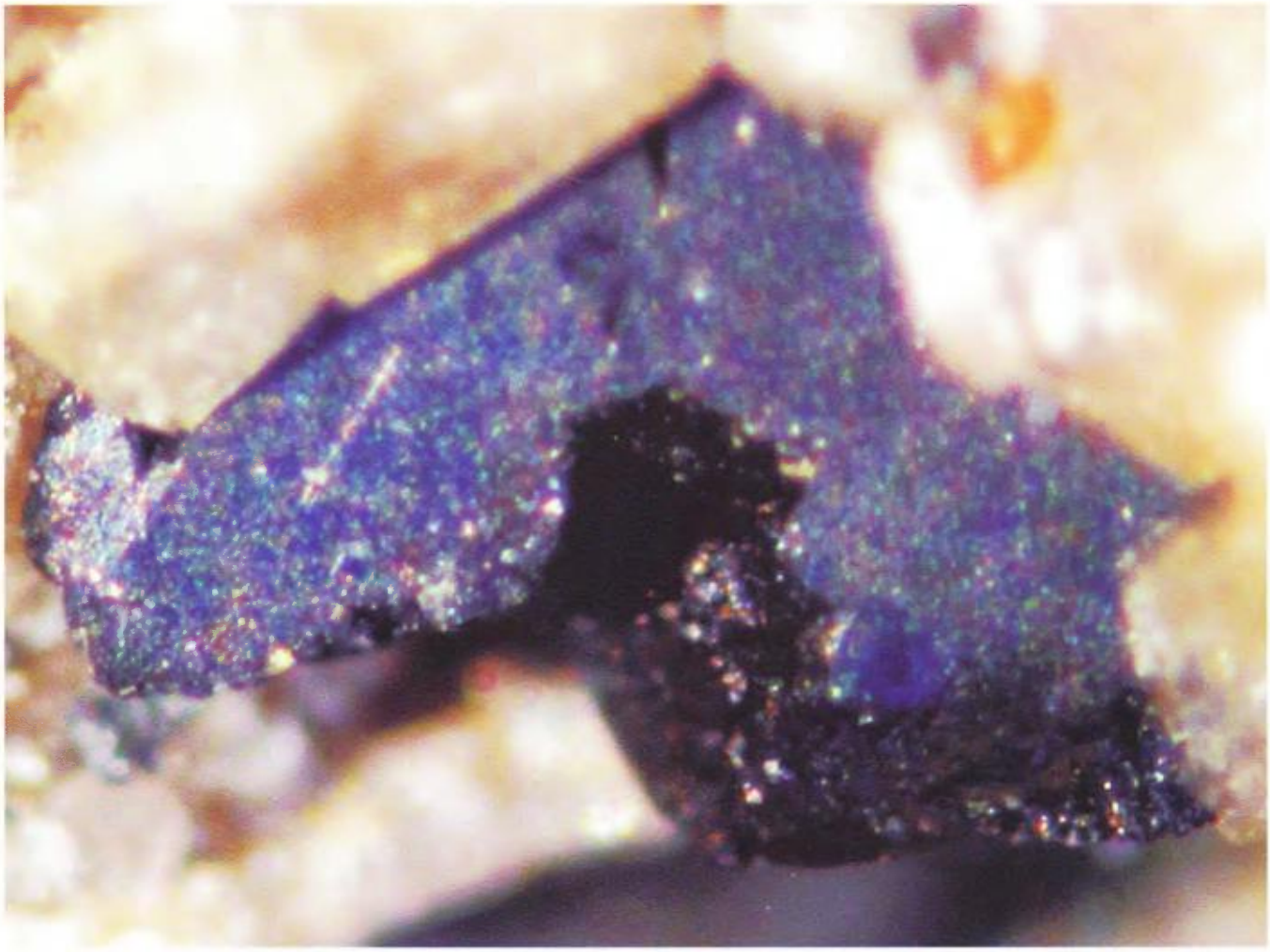


PLATE II. Galena is uncommon at Eldor. It is most often seen as microscopic inclusions in pyrochlore. The presence of this micro galena crystal in a dolomite vug (sample EC08-015 at 29.37m) attests to the re-mobilization of this interval. This galena is probably remobilized radiogenic lead.

7. DETAILED LITHOLOGIES

In July of 2010 I spent three weeks sampling core from the twenty-six diamond drill holes completed in the 2008 field season, plus one diamond drill hole from the 2010 field season. My purpose was to determine the different lithologies and mineralogy present at Eldor. Fifty-nine samples were chosen representing the different lithologies and mineralogy and sent to Vancouver Petrographics for thin sections and a petrologic report by Dr. Craig Leitch. Fifty-eight of these samples were from the 2008 diamond drill core and one sample was from the 2010 Ashram zone drilling.

This section outlines the three basic groups of rocks found at Eldor: Carbonatites, Country rock types & Hydrothermal mineral assemblages and presents them visually.

Within the carbonatite group are included breccias with carbonatite clasts and matrix; cumulates in both calcite and dolomite carbonatites; and one example of a calcite silico-carbonatite. The country rock observed in the 2008 drill core fall into two categories: glimmerite—whose origin remains uncertain; and metamorphosed andesite. The hydrothermal mineral assemblages intrude the carbonatite facies but not the glimmerite or andesite country rock types.

Unfortunately, time and budget did not permit for more detailed mineralogy of the 59 thin sections made.

I have incorporated Dr. Leitch's photographs in this section. His full report can be found in Appendix B.

The lithologies found to date in the drill core from the Eldor project are:

CARBONATITES

Calcite carbonatite	**pp. 24-51**
Dolomite carbonatite	**pp. 54-80**
Breccias with dolomite carbonatite clasts but none with calcite carbonatite clasts	**pp. 82-95**
Cumulates with calcite and dolomite carbonatite hosts	**pp. 98-106**
Calcite silico-carbonatite	**pp. 108-109**

COUNTRY ROCK TYPES

Glimmerite with brecciation by either calcite or dolomite carbonatite	**pp.110-118**
Andesite altered by metamorphism	**pp.120-121**
Ultramafic rock (1) of currently uncertain origin	**pp. 122-123**

HYDROTHERMAL MINERAL ASSEMBLAGES

Fluorite in veins, breccias (both as filling and clasts), layered with dolomite and often associated with rare earth fluorocarbonate mineralization.	**pp. 124-131**
Dolomite as breccia clasts and rock, often associated with fluorite or rare earth fluorocarbonates, likely remobilized.	**pp. 132-140**
Sulphides. In one instance there is a vein of molybdenite.	**pp. 142-143**
Euhedral minerals are found in vuggy portions of the dolomite carbonatite	**pp. 144-146**

Possible sources of error in this section.

1) **Incorrect sample meterage on my samples.** In the course of taking samples I had difficulties with the core mark-up. There were no meter marks, no sample marks, missing & illegible blocks, and obviously missing core. The core storage was poor – homemade rebar and wood stands that had sagged or tilted, jamming both core and core boxes.
2) **Miss-match between my sample and the whole rock assay.** There are several cases where the whole rock assays do not fit with the samples that I took. There are two possible reasons for this discrepancy: a) I have the incorrect interval on my sample; or b) my sample was not representative of the interval sampled—there being no sample marks it was impossible to tell if there had been any lithologic control exercised in the sampling.

In several cases I went to the original core photos to see if I could resolve the miss-match problem. I was unable to, however, because the sample intervals were not marked on the core in the photographs (the core had been photographed after it was cut or split for sampling). In addition, the core photos were of poor resolution and core blocks were not always legible. In several photos there were shadows on the core, making it difficult to see lithologic changes. Also, I noticed that the sample intervals in the assay logs varied from 0.5 to 4 meters in size.

Please note that the above remarks apply to the 2008 diamond drill core only. Darren Smith and his crew from Dahrouge Geological Consulting have addressed these issues for the 2010 season.

FLUORITE WITH POSSIBLE REE INCLUSIONS

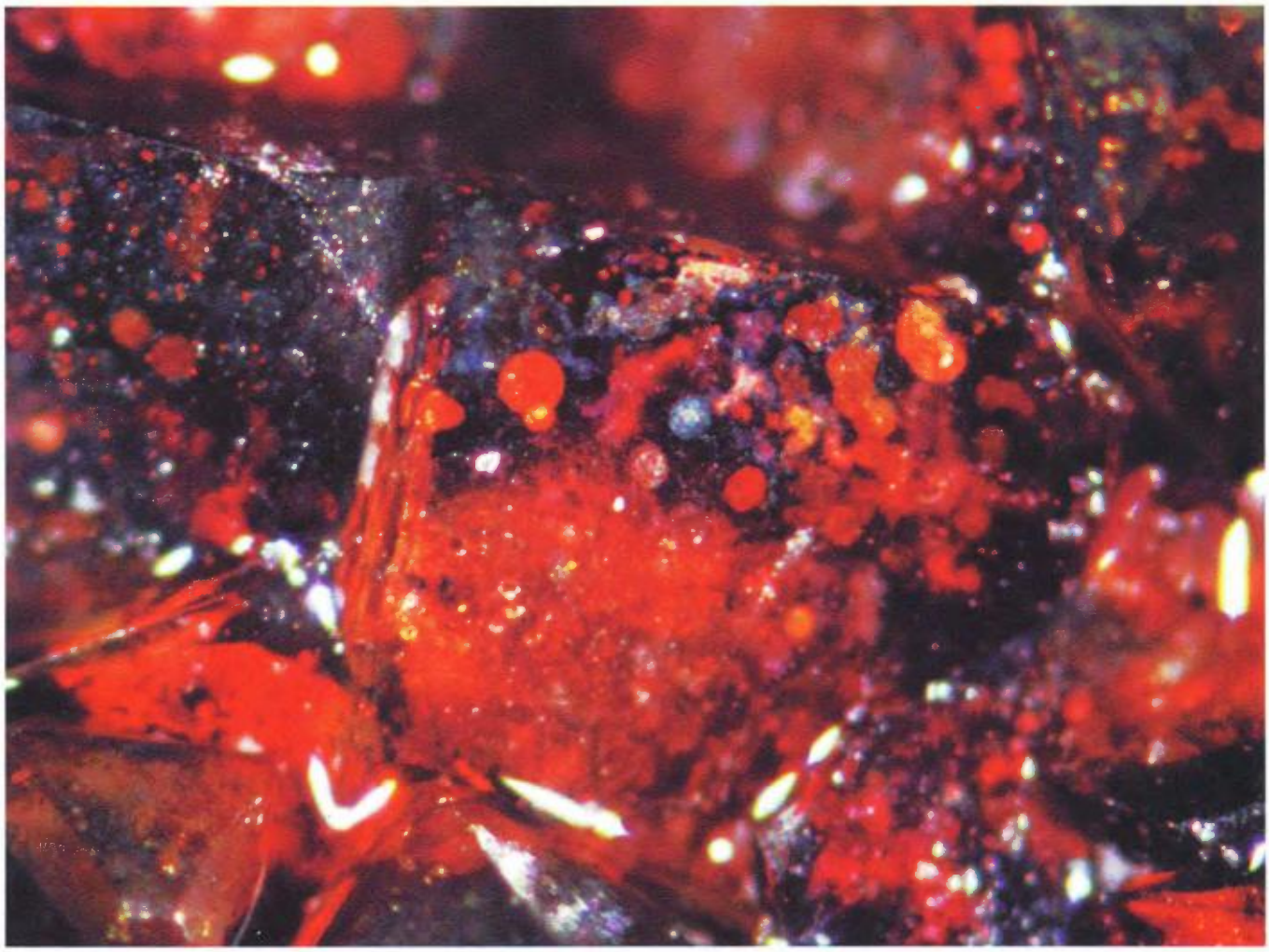


PLATE III. ***Fluorite is intimately associated with the rare earth mineralization at Eldor.*** This 5mm octahedrally modified fluorite cube has numerous bright orange inclusions that could be rare earth minerals. Further work is required for an accurate determination.

Calcite Carbonatite with REE minerals

EC08-002 at 5.1m

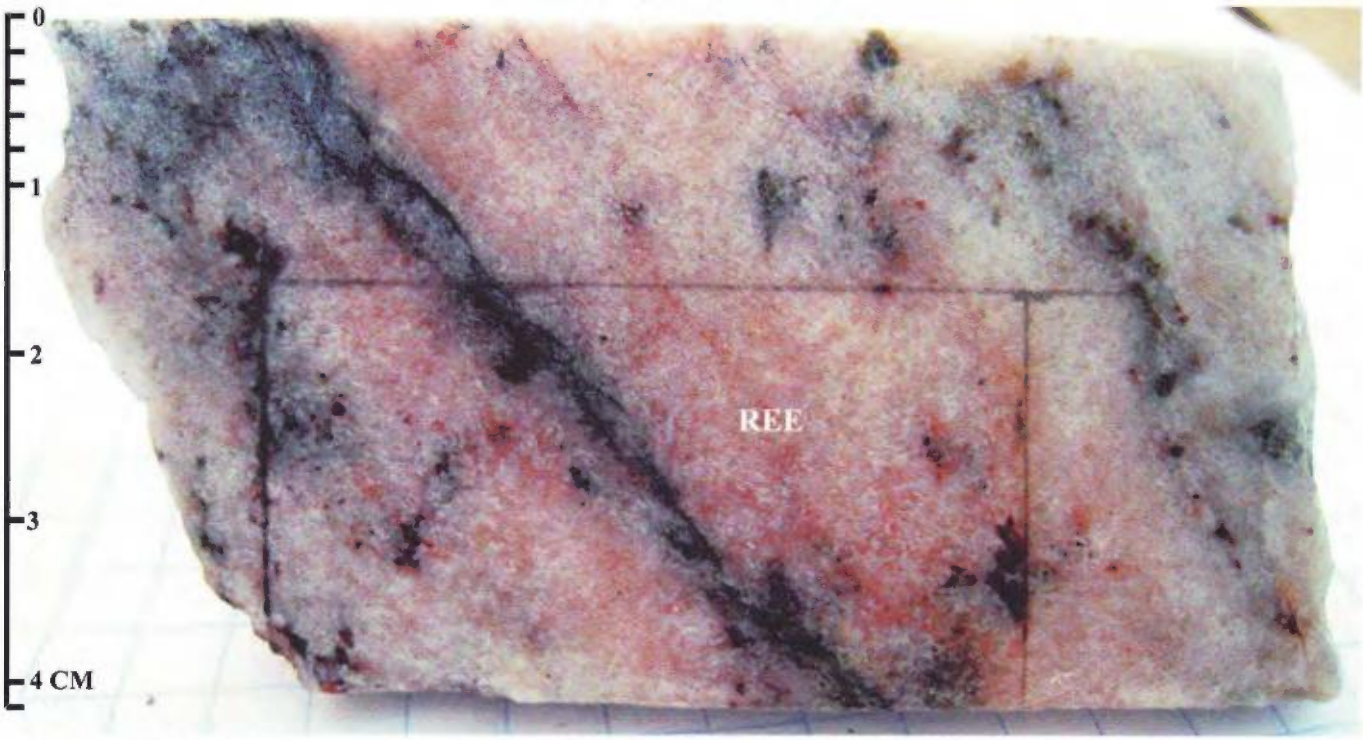


Fig.1 Calcite carbonatite with red REE mineralization (REE). This calcite carbonatite with disseminated REE mineralization (likely parisite, <2 weight%) shows weak metamorphic foliation. P_2O_5=2.3%, Nb=1465.2 ppm, Ta=120.5 pm, REE+Y=0.17%

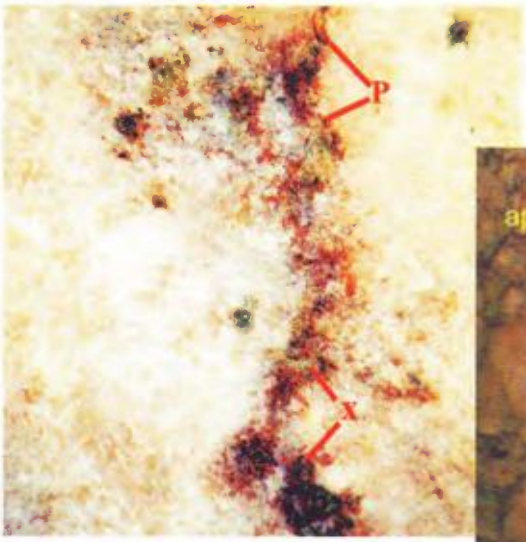


Fig. 2 Close-up of REE minerals. Note that there are more rare earth mineral phases (X) present than just the red parisite (P). SEM/EMPA work is required to identify these other phases.

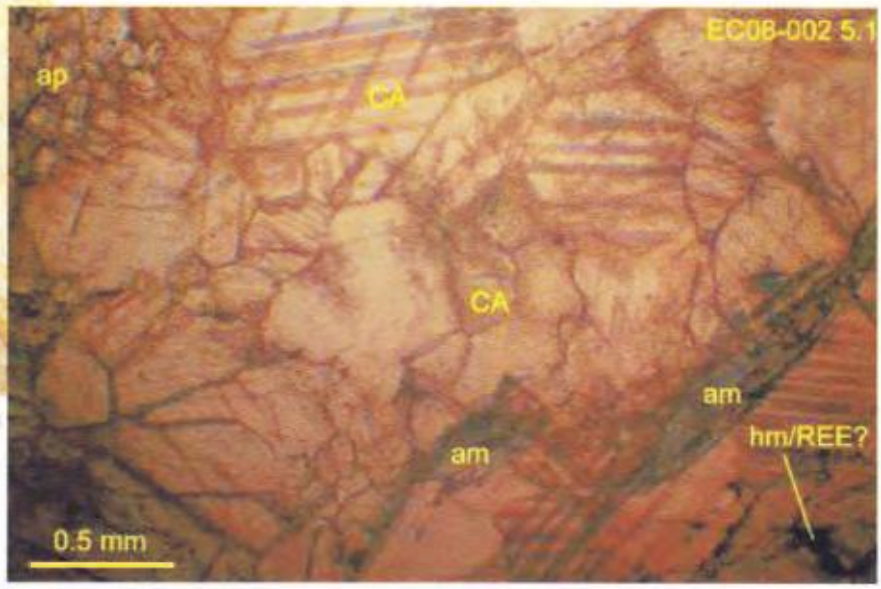


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-002 5.1m, am=amphibole, ap=apatite, CA=calcite, hm/REE?=hematized REE? Transmitted plane light, uncrossed polars.

continued ...

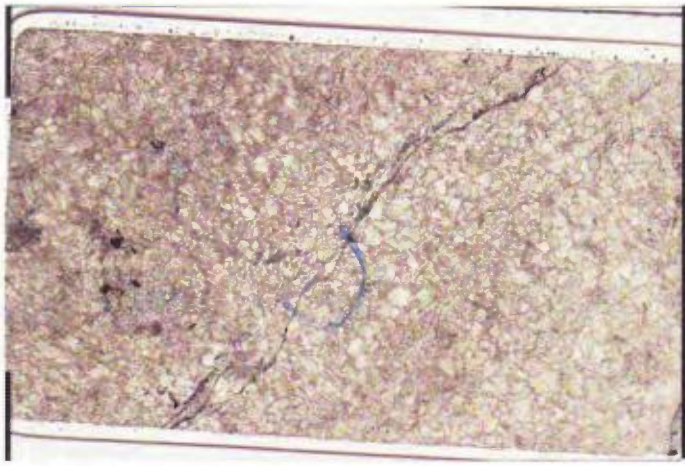


Fig.4 Thin section EC-08 002 5.1m plane polars

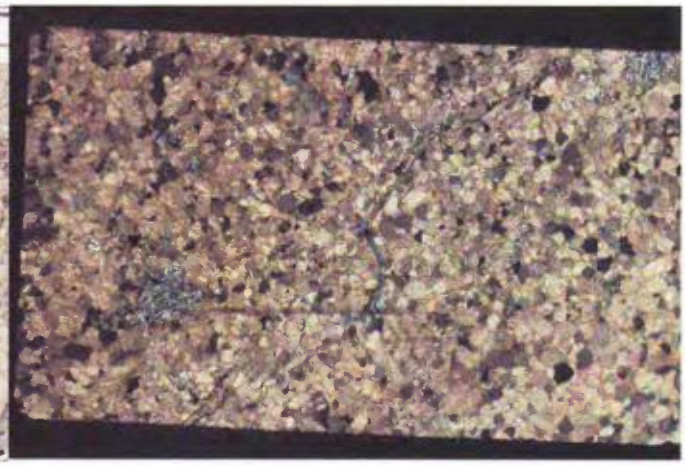


Fig.5 Thin section EC-08 002 5.1m cross polars

This sample demonstrates that the REE fluorocarbonate mineralization can be found in more than one carbonatite phase (the Ashram zone REE mineralization is in a dolomite carbonatite).

Calcite Carbonatite with chlorite

EC08-002 at 113.9m

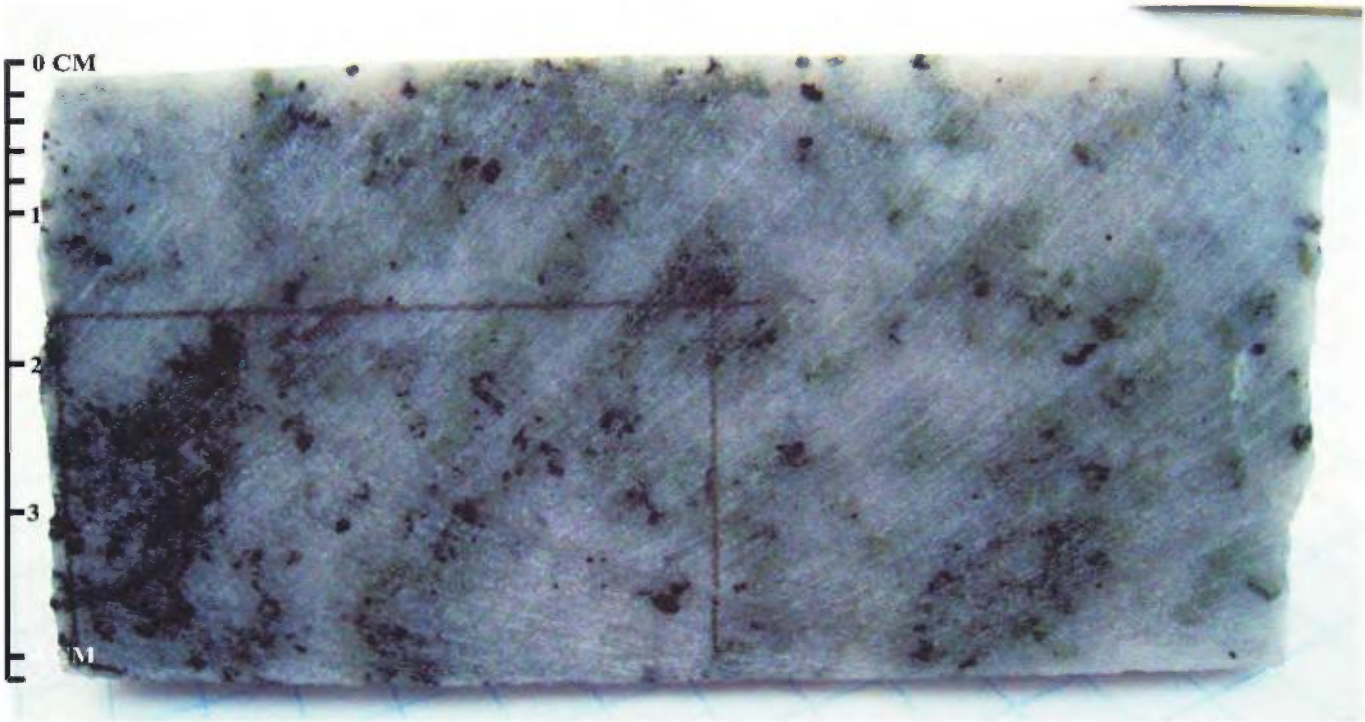


Fig.1 Calcite carbonatite with chlorite (green patches). P_2O_5=2.98%, Nb=180.5 ppm, Ta=19.8 ppm, REE+Y=0.17%

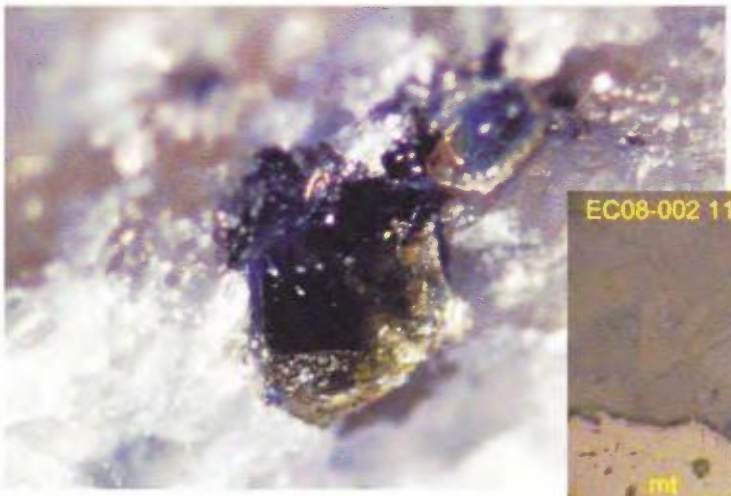


Fig. 2 Micro-photo of Chlorite

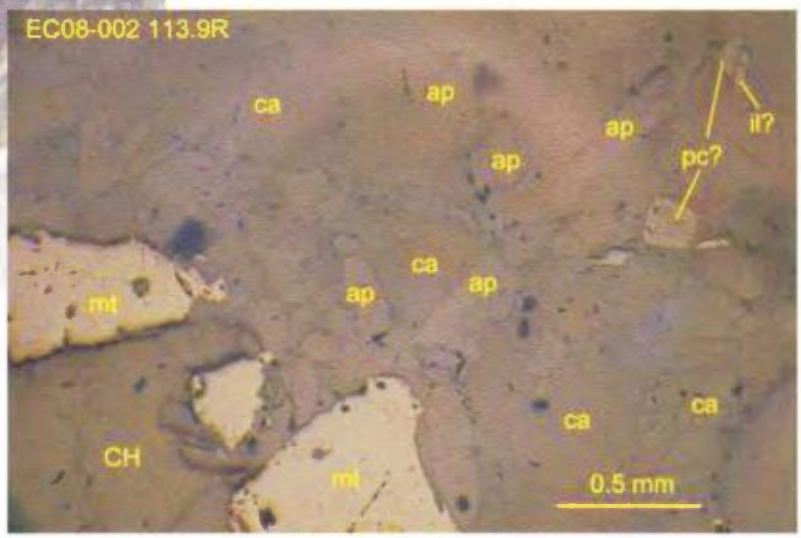


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-002 113.9m, ca=calcite, mt=magnetite, CH=chlorite, ap=apatite, pc?=pyrochlore?, il?=ilmenite? Reflected light, uncrossed polars.

continued ...

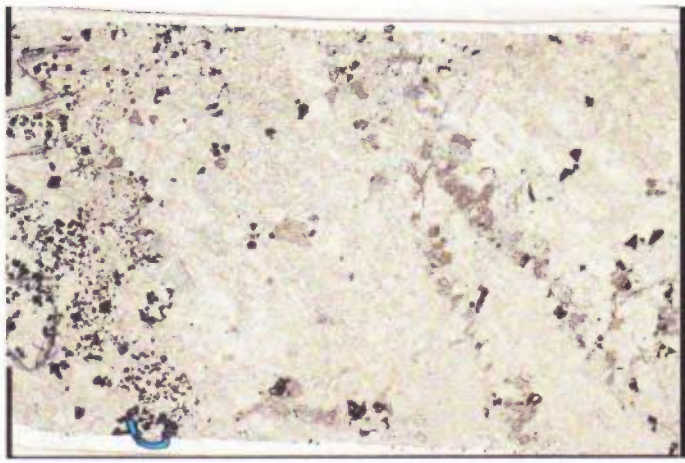


Fig.4 Thin section EC-08 002 113.9m plane polars

Fig.5 Thin section EC-08 002 113.9m cross polars

The tabular ilmenite (il?) noted by Craig Leitch in the thin sectionin Fig. 3 is baddeleyite. SEE SEM-EDS and BSE images below. This thin section provided the baddeleyite used to date the Eldor carbonatite - see Section 5 of this report .

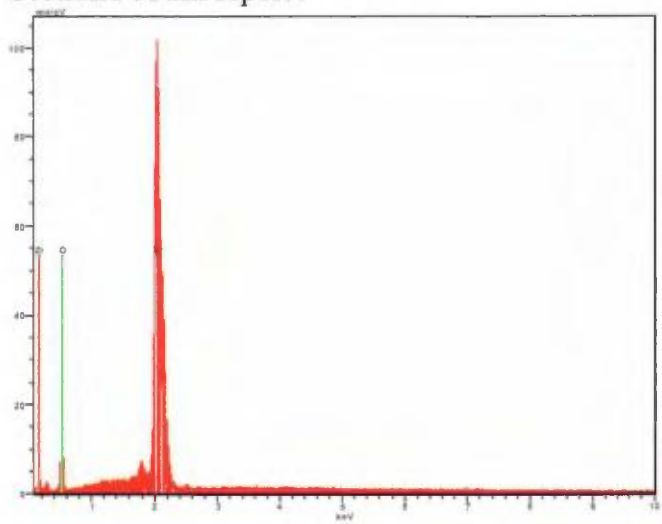


Fig.6 EDS spectra for baddeleyite in EC08-113.9m described as ilmenite by Dr. Craig Leitch.

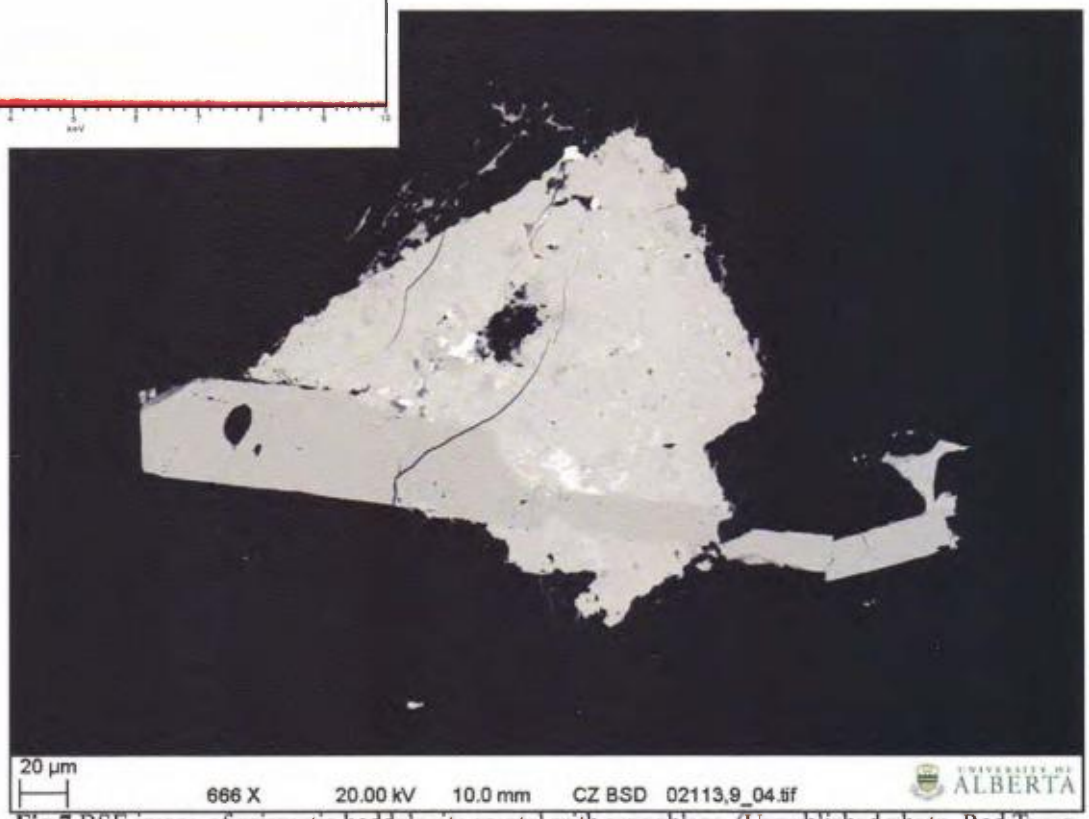


Fig 7 BSE image of prismatic baddeleyite crystal with pyrochlore. (Unpublished photo, Rod Tyson and DeAnn Rollings, 2010).

Calcite Carbonatite with comb-textures

EC08-002 at 122.22m

Fig.1 Calcite carbonatite with unusual textures for a carbonatite; they have been observed at Oka and possibly elsewhere and are superficially like spinifex textures in komatiites. P_2O_5=5.4%, Nb=551.4 ppm, Ta=55.3 ppm, REE+Y=0.22%

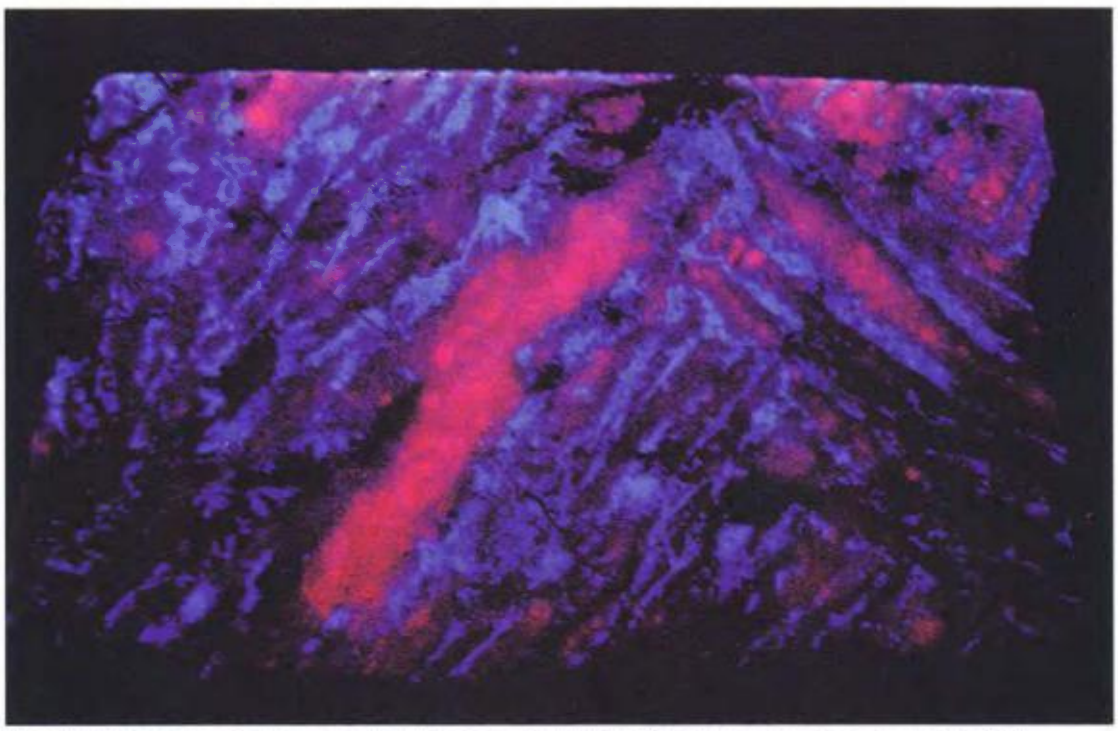


Fig.2 Spinifex-like textures under midrange UV light. Blue-white is apatite and red is calcite.

continued ...

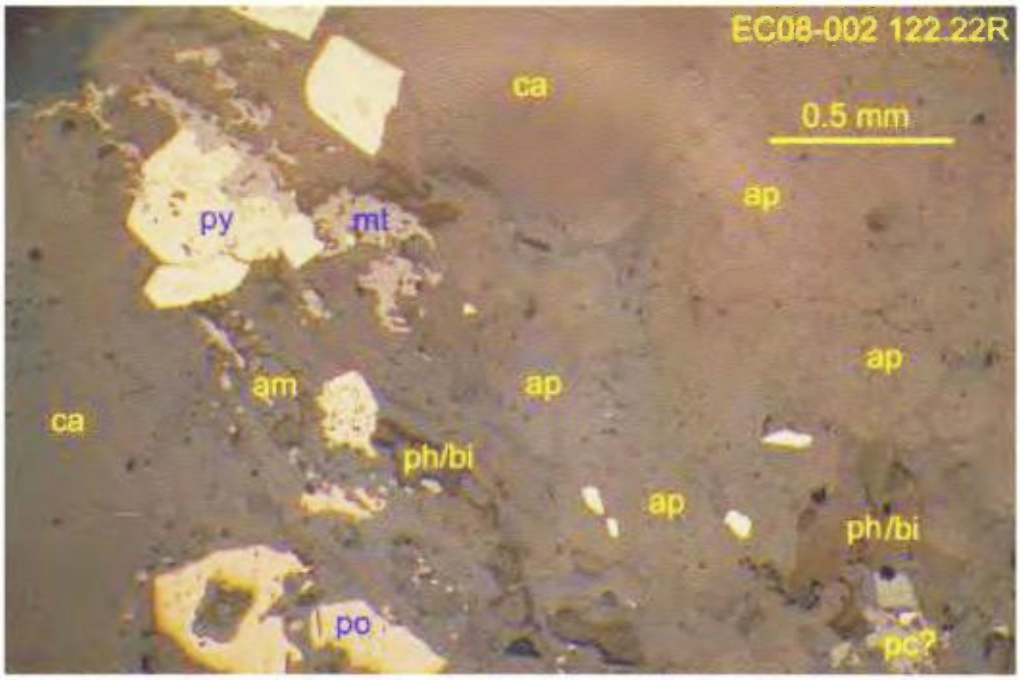


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-002 122.22m, ca=calcite, ph/bi=phlogopite/biotite, ap=apatite, am=amphibole, pc?=pyrochlore, po=pyrrhotite, mt=magnetite, py=pyrite. Reflected light, uncrossed polars.

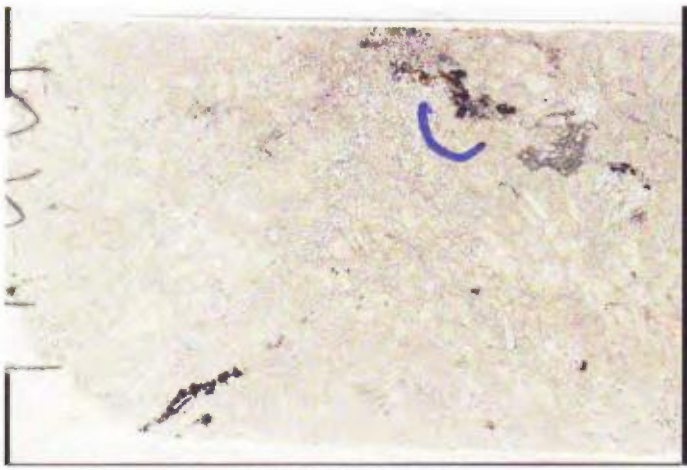


Fig.4 Thin section EC-08 002 122.22m plane polars

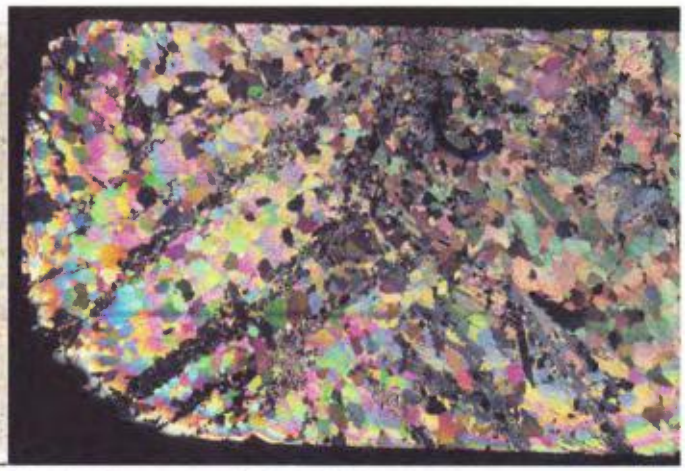


Fig.5 Thin section EC-08 002 122.22m cross polars

These textures are reminiscent of spinifex textures observed by the author with Dr. Dale Pyke (see Pyke *et al.* 1973) in the Matheson, Ontario region. A. H. Treiman. (1989, p. 89) refers to these textures as "comb-layering of calcite crystals with interstitial silicate and oxide minerals", which "may represent dendritic crystals grown *in situ* on the walls of a magma chamber".

Calcite Carbonatite with orange crystals

EC08-005 at 98.08m

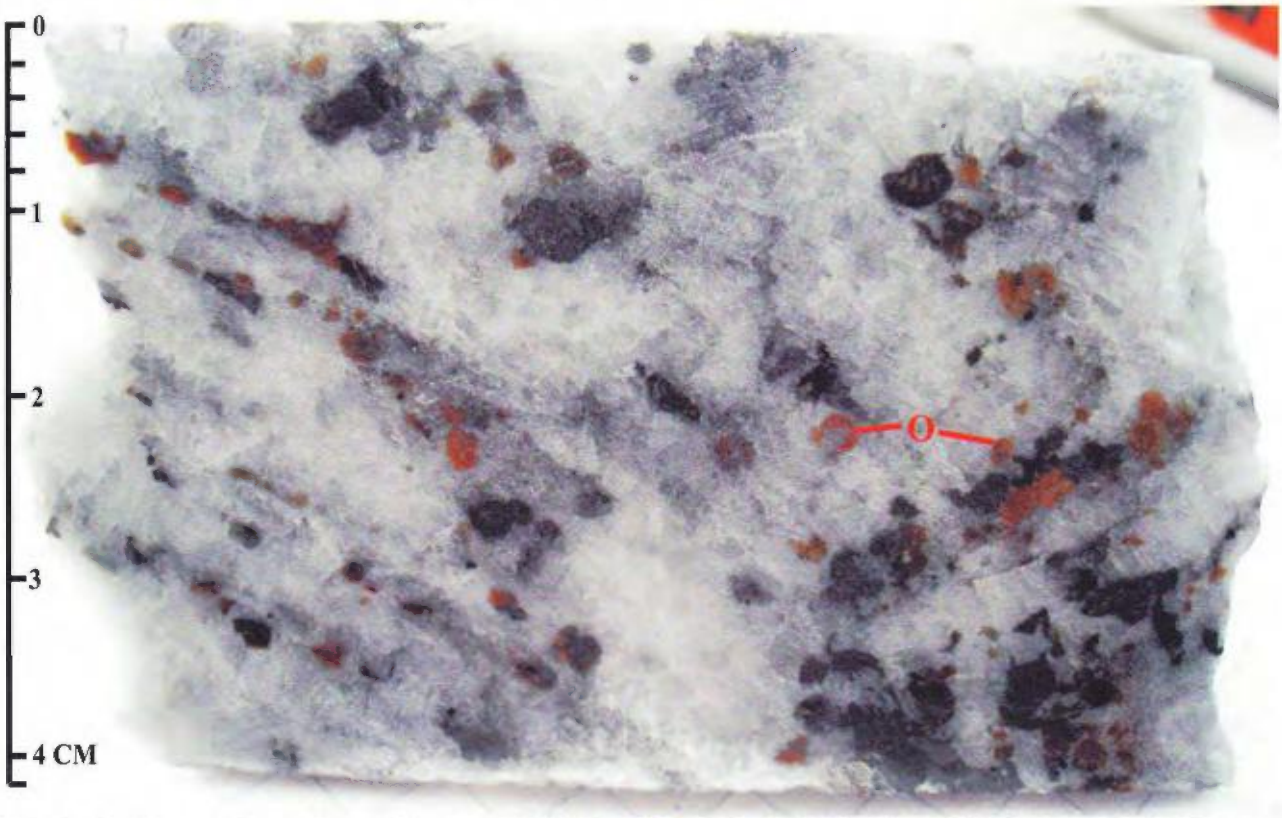


Fig.1 Calcite carbonatite with altered ?olivine(O). P_2O_5=3.09%, Nb=1162.3 ppm, Ta=26.5 ppm, REE+Y=0.22%

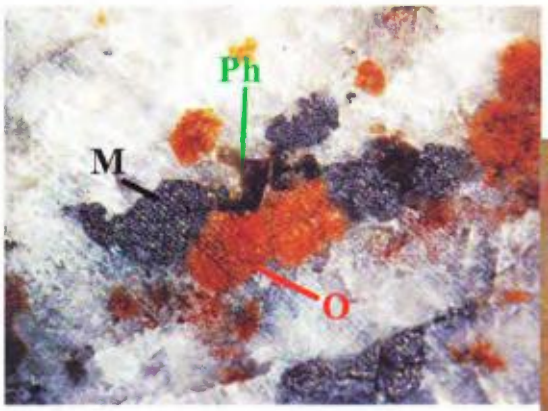


Fig. 2 Close-up of altered ?olivine(orange,O), magnetite (black,M) and phlogopite (brown/green,Ph).

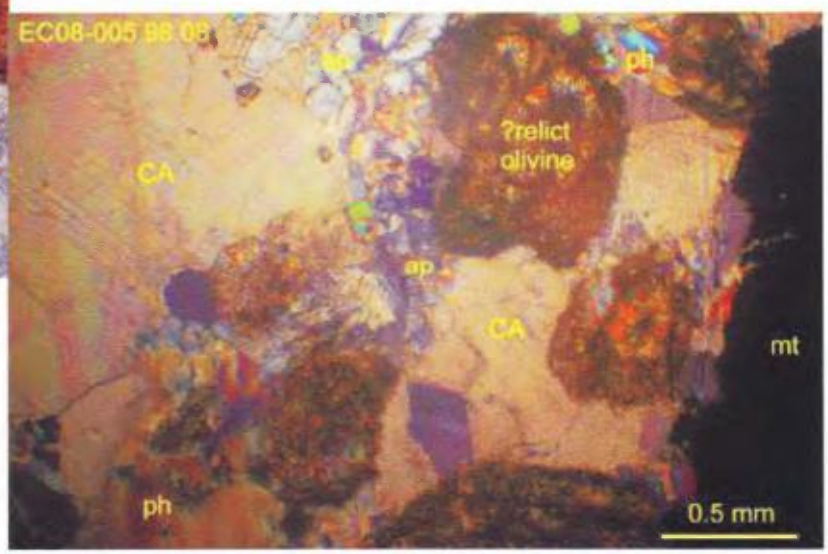


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-005 98.08m, ph=phlogopite, CA=calcite, ap=apatite, mt=magnetite, ?relict olivine. Transmitted light, crossed polars

continued ...

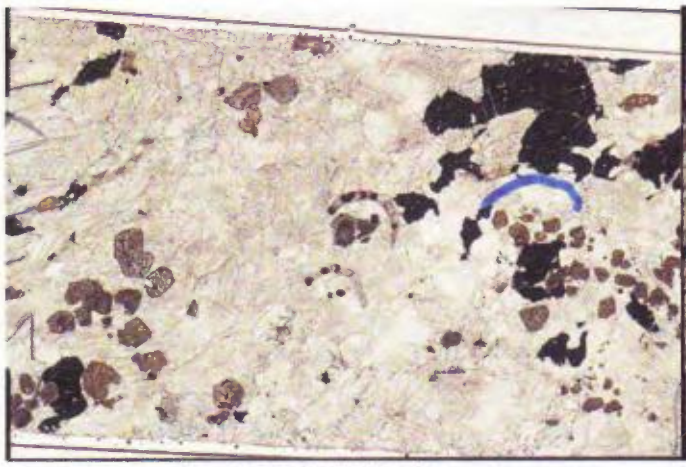


Fig.4 Thin section EC-08 005 98.08m plane polars

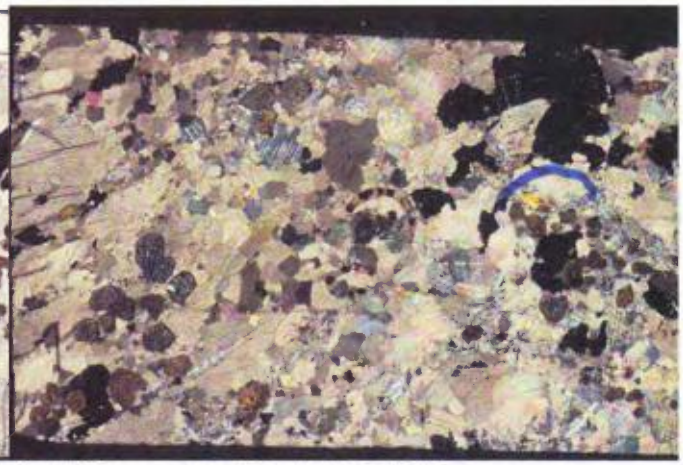


Fig.5 Thin section EC-08 005 98.08m cross polars

This sample requires further SEM/EMPA work to better define the mineral assemblage.

Calcite Carbonatite

EC08-018 at 145.98m

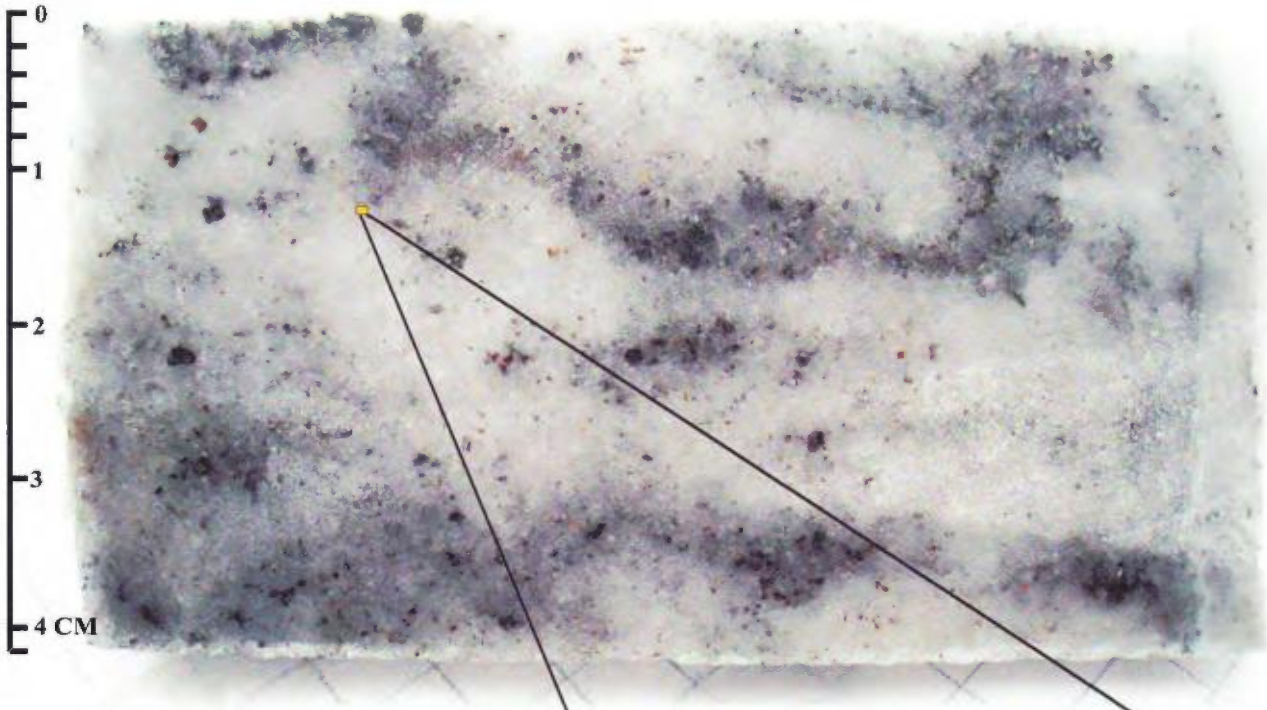


Fig.1 Calcite carbonatite with ?monazite. P_2O_5=3.03%, Nb=1988.6 ppm, Ta=4.2 ppm, REE+Y=0.18%.

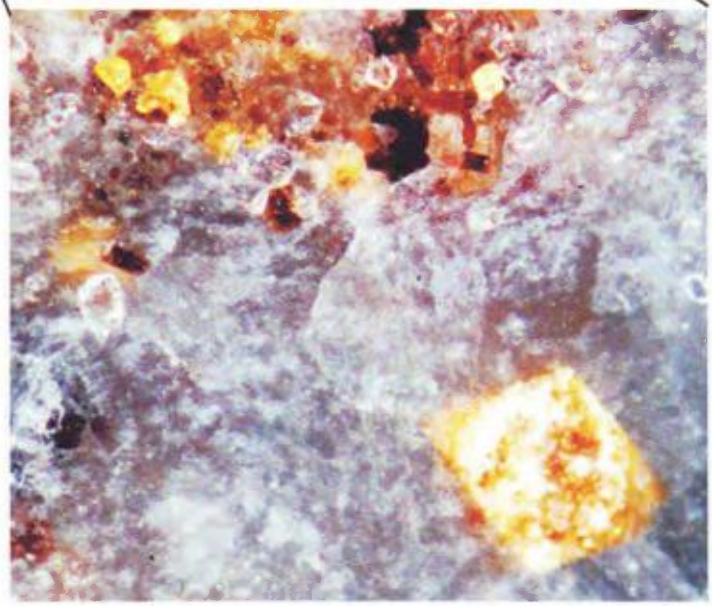


Fig. 2 Micro-photo of REE mineral possibly monazite

continued ...

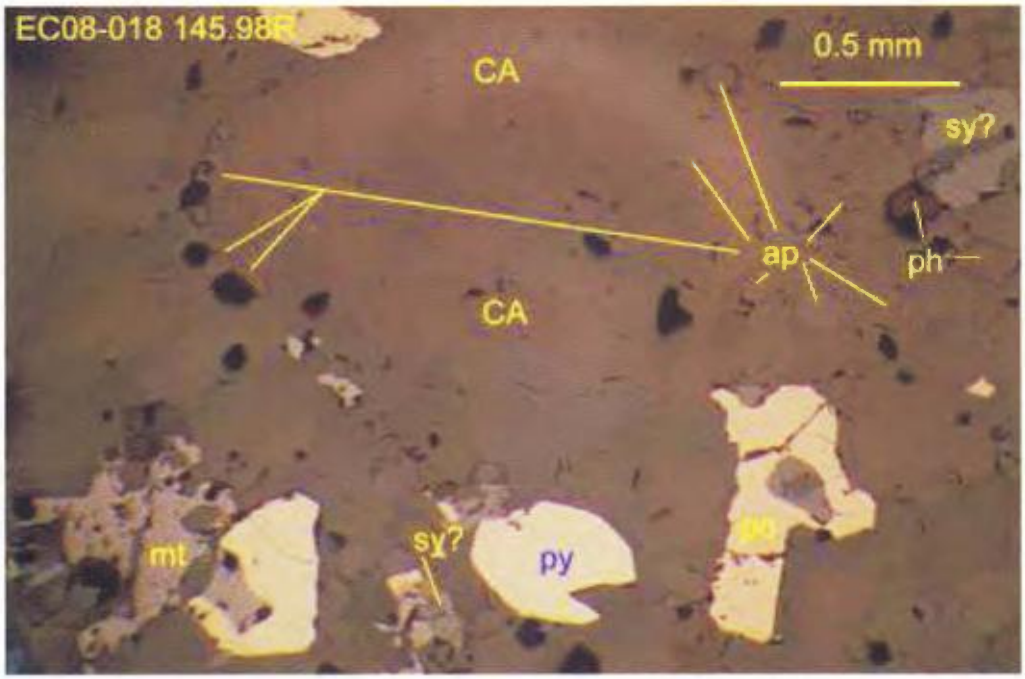


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-018 145.98m, CA=calcite, sy?=synchesite?, py=pyrite, mt=magnetite, po=pyrrhotite, ph=phlogopite, ap=apatite. Reflected light, uncrossed polars.

Fig.4 Thin section EC-08 018 145.98m plane polars

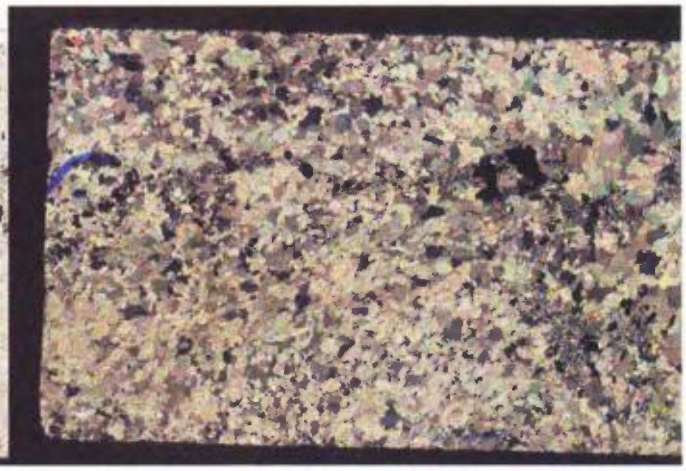


Fig.5 Thin section EC-08 018 145.98m cross polars

SEM work is needed to define REE-bearing minerals.

Calcite Carbonatite with skeletal textures

EC08-021 at 181.50m

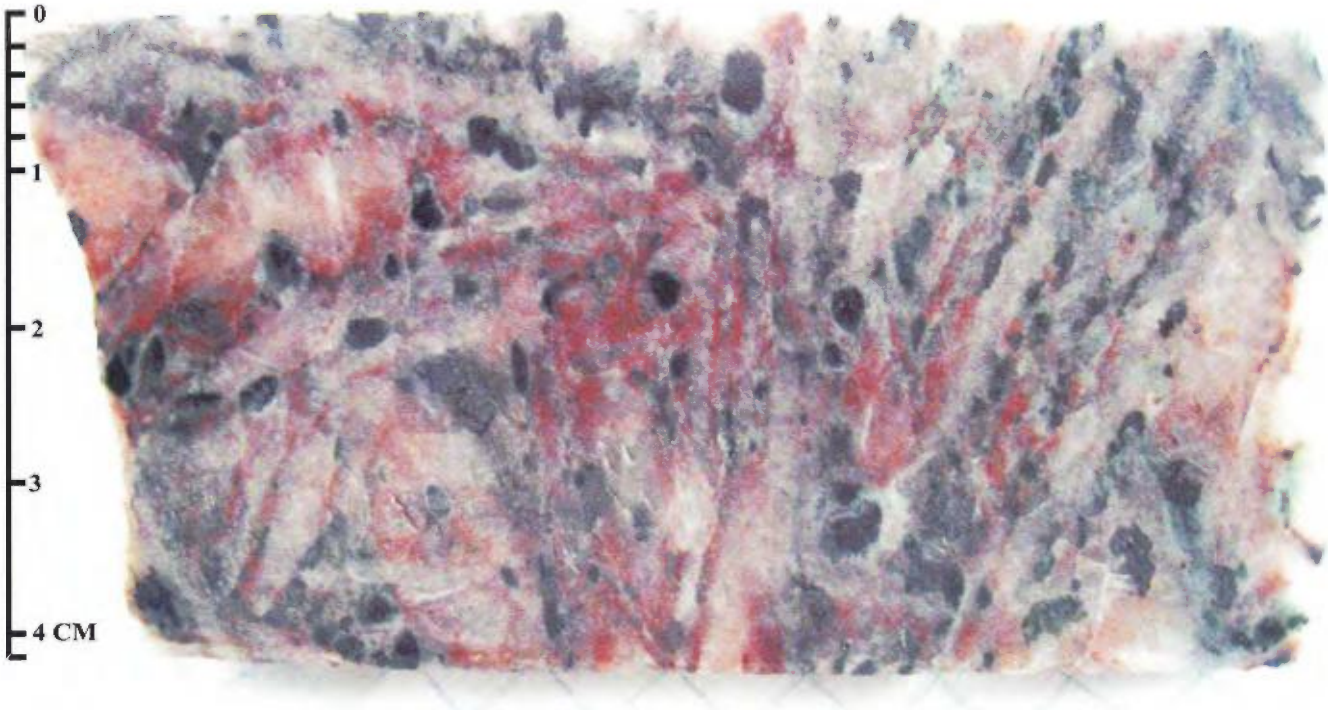


Fig.1 Reddish calcite carbonatite with spinifex-like textures. P_2O_5=5.01%, Nb=1422.8 ppm, Ta=97.9 ppm, REE+Y=0.27%

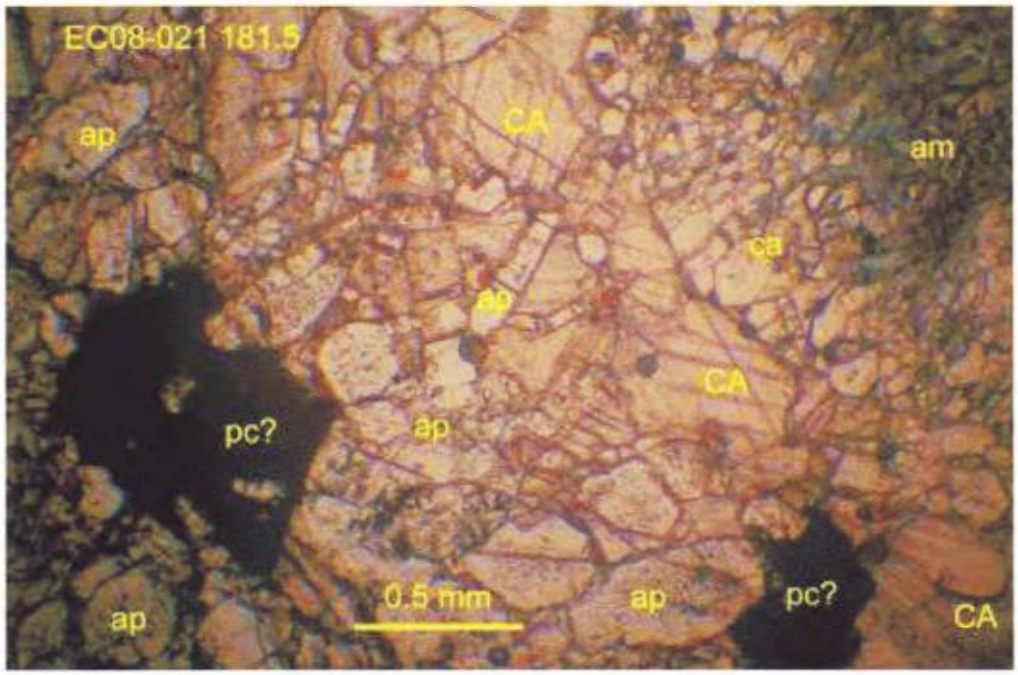


Fig. 2 Photo by Craig Leitch, CA=coarse-grained calcite, cb=fine-grained calcite, pc?=pyrochlore?, ap=apatite, am=amphibole

continued ...

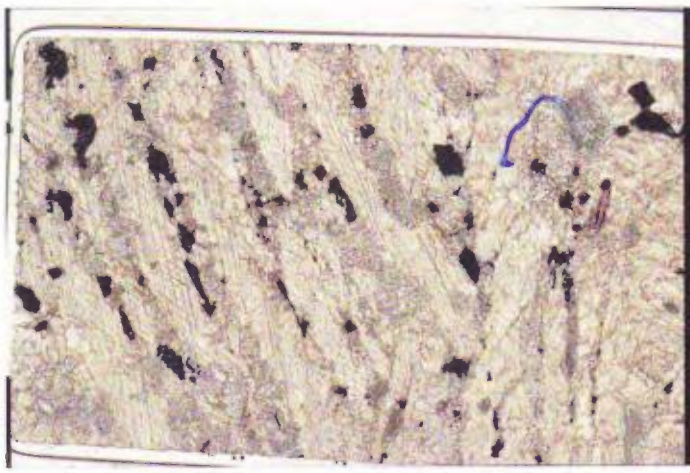


Fig.3 Thin section EC-08 021 181.50m plane polars

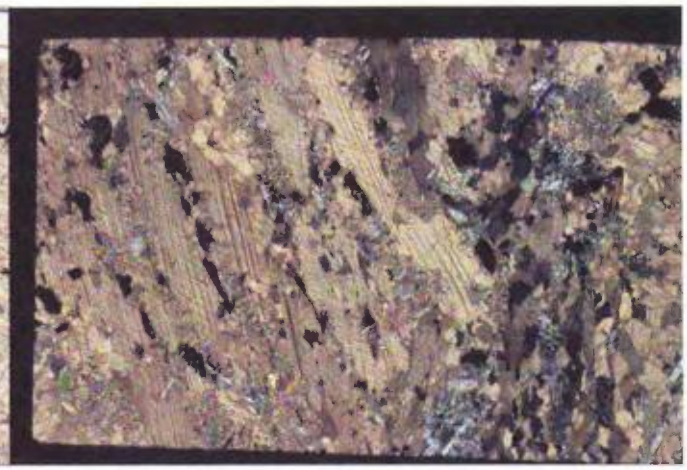


Fig.4 Thin section EC-08 021 181.50m cross polars

These textures are reminiscent of spinifex textures observed by the author with Dr. Dale Pyke (see Pyke *et al.* 1973) in the Matheson, Ontario region. A. H. Treiman. (1989, p. 89) refers to these textures as "comb-layering of calcite crystals with interstitial silicate and oxide minerals", which "may represent dendritic crystals grown *in situ* on the walls of a magma chamber". These are the same textures as observed in EC08-002 at 122.22m but with different interstitial mineralogy. If Mr. Treiman is right then these two disparate occurrences may have originally had some planar affinity.

Calcite Carbonatite

EC08-021 at 265.70m

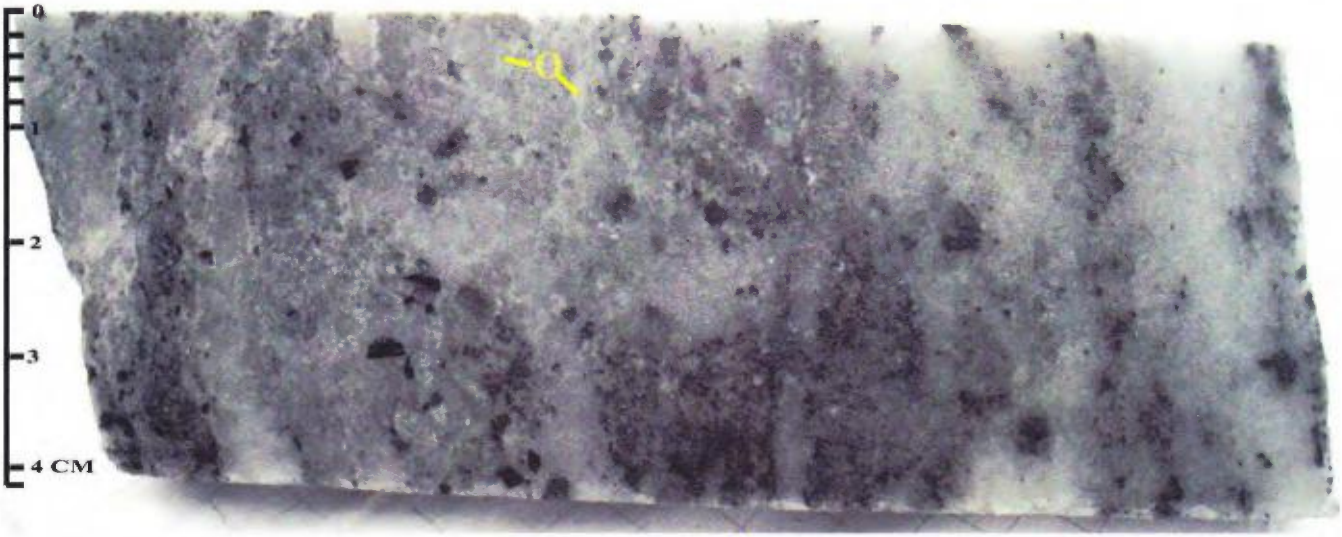


Fig.1 Calcite carbonatite with serpentized ?olivine(O). P_2O_5=5.85%, Nb=2976.6 ppm, Ta=4.7 ppm, REE+Y=0.19%

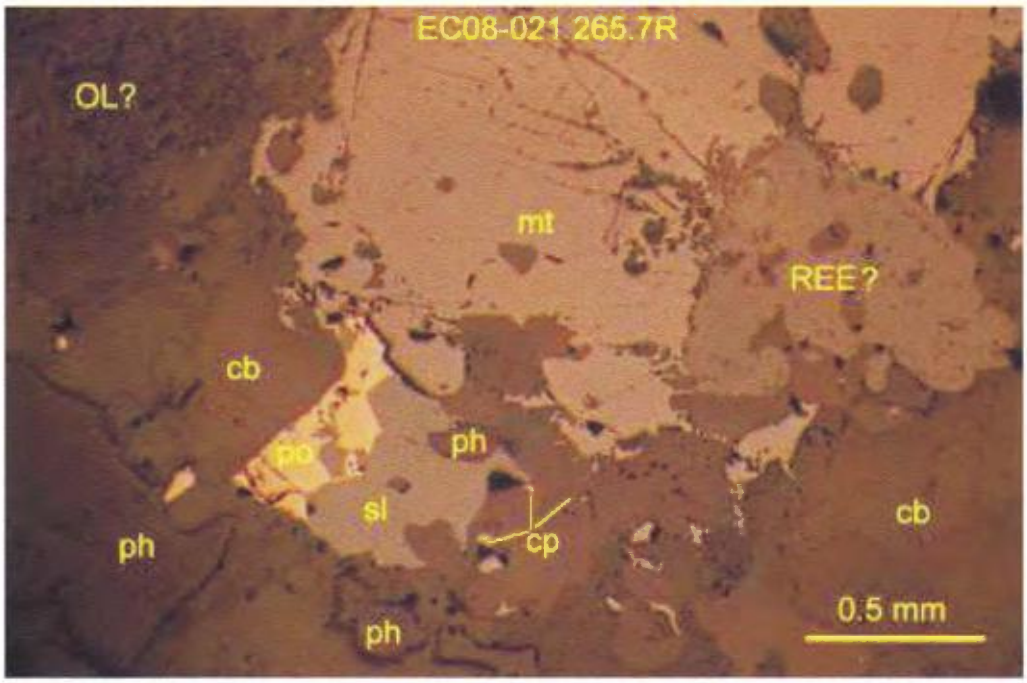


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-021 265.70. OL?=olivine?, cb=carbonate, cp=chalcopyrite, ph=phlogopite, po=pyrrhotite, mt=magnetite, REE?=unidentified rare earth mineral?, sl=sphalerite. Reflected light, uncrossed polars.

continued ...

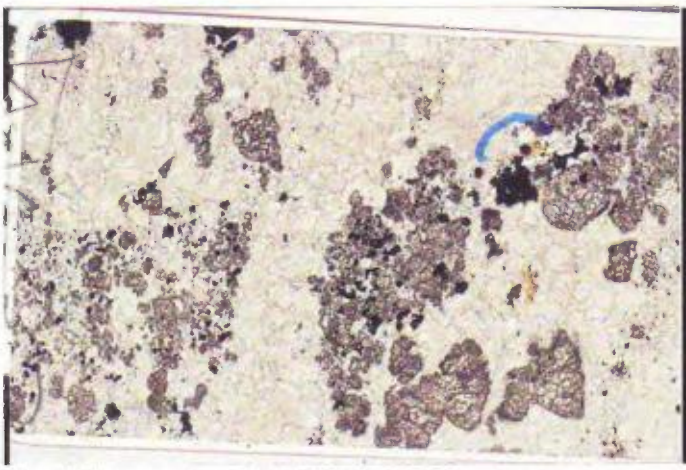


Fig.3 Thin section EC-08 021 265.70m plane polars

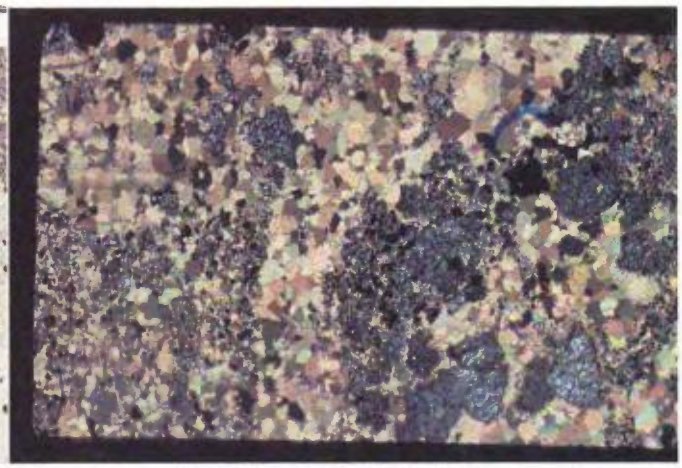


Fig4 Thin section EC-08 021 265.70m cross polars

This sample has a crude foliation.

Calcite Carbonatite with cross-cutting dolomite vein

EC08-001 at 34.50m

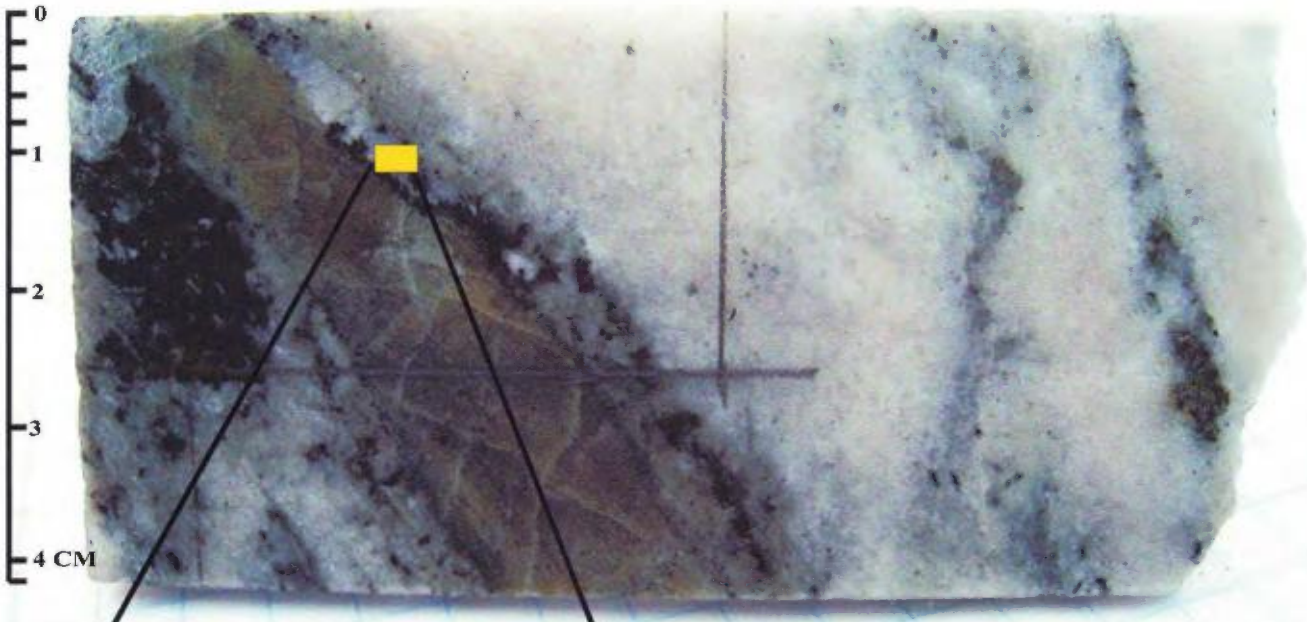


Fig.1 Calcite carbonatite cross-cut by dolomite vein. P_2O_5=5.45%, Nb=1819.8 ppm, Ta=85.5 ppm, REE+Y=0.20%

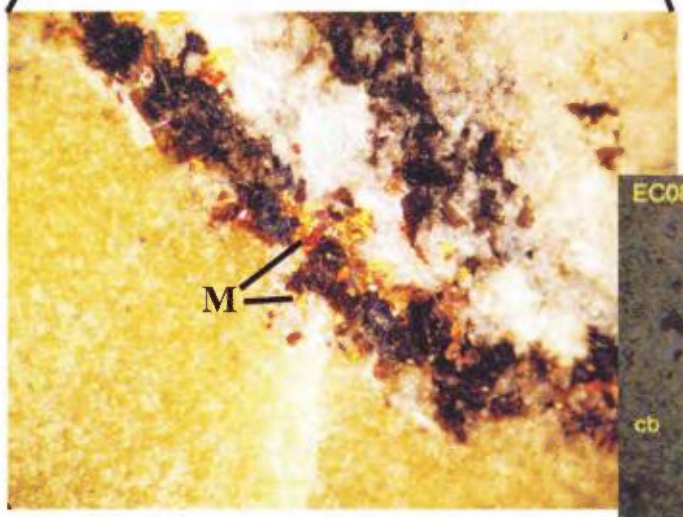


Fig. 2 Micro-photo of ?monazite (M) along contact between dolomite vein and calcite carbonatite. SEM confirmation needed.

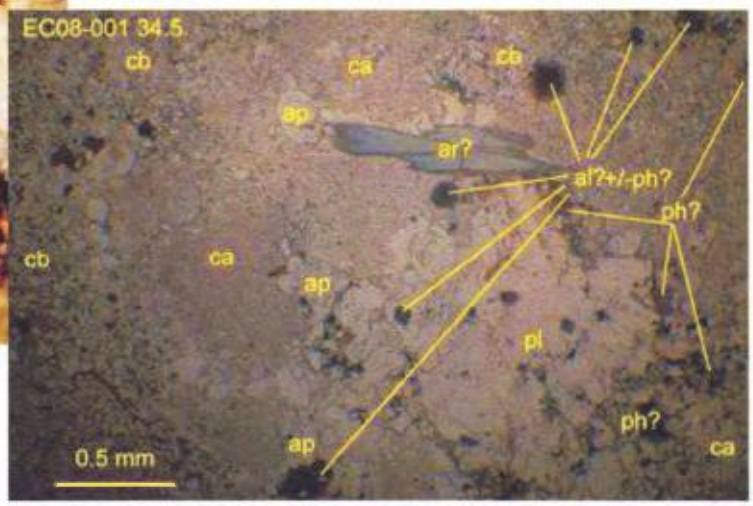


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-001 34.5m, transmitted plane light, ca=calcite, cb=dolomite, ar?=arfvedsonite, ap=apatite, pl=plagioclase, al?=allanite.

continued ...

Fig.4 Thin section EC-08 001 34.5m plane polars

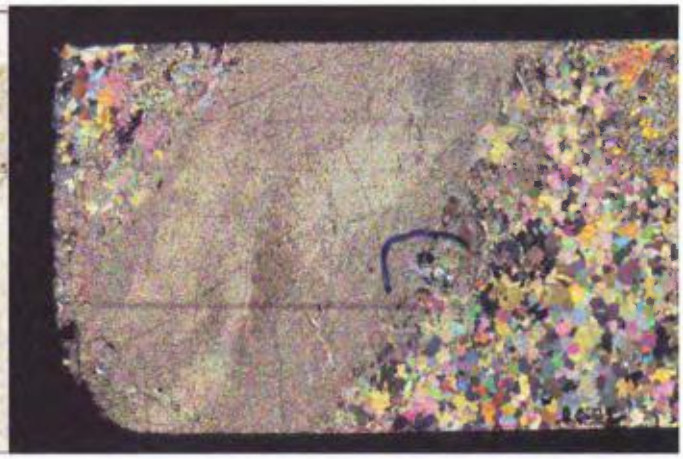


Fig.5 Thin section EC-08 001 34.5m cross polars

This cross-cutting Fe-dolomite vein is composed of re-mobilized dolomite--it is not a carbonatite. Dr. Craig Lietch describes this vein as having a "sucrosic" texture.

Calcite Carbonatite with magnetite, pyrite and pyrrhotite

EC08-001 at 43.50m

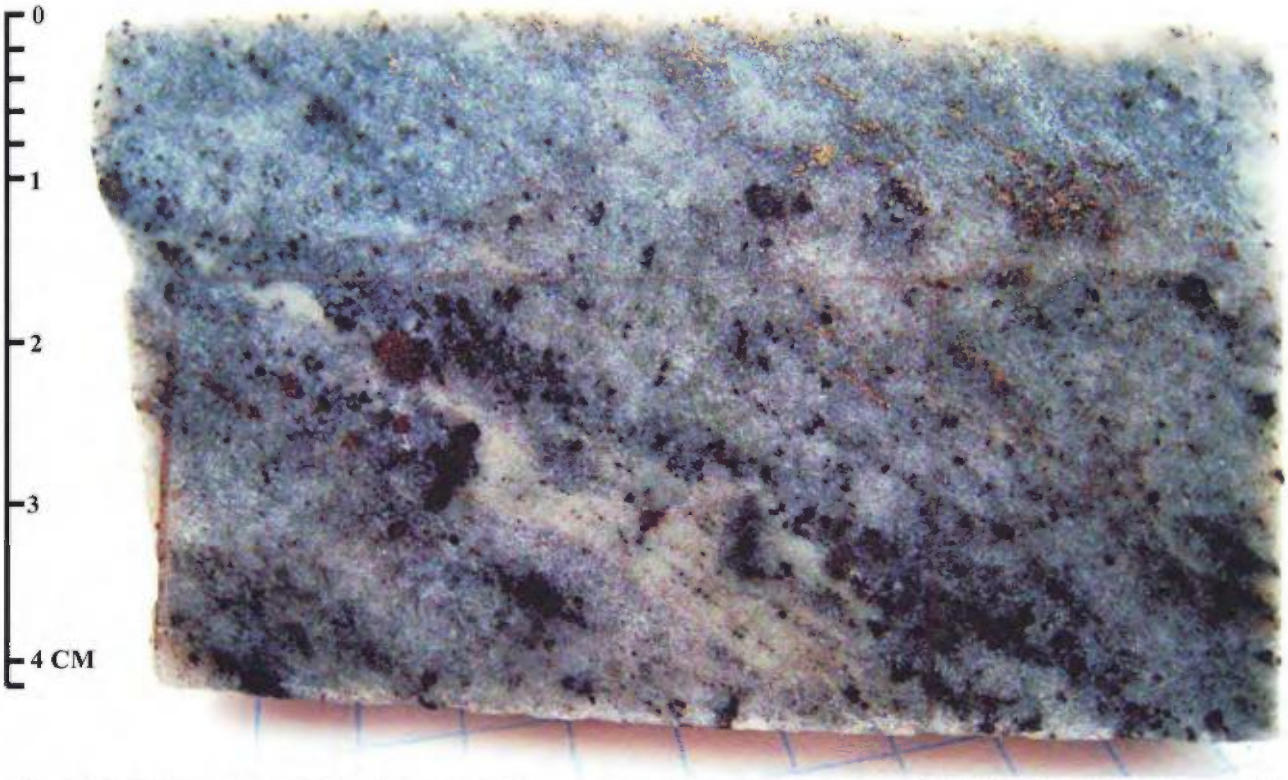


Fig.1 Calcite carbonatite with magnetite, pyrite and pyrrhotite. P_2O_5=10.51%, Nb=4034.3ppm, Ta=66.1 ppm, REE+Y=0.25%

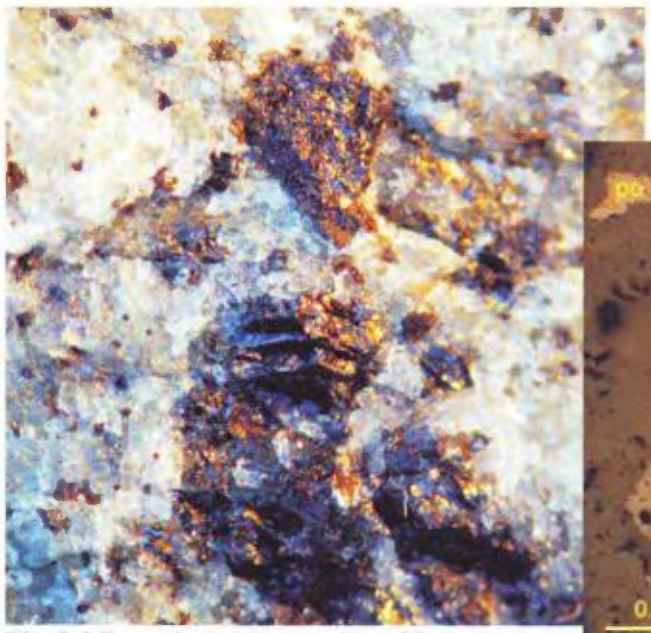


Fig. 2 Micro-photo of magnetite with pyrrhotite.

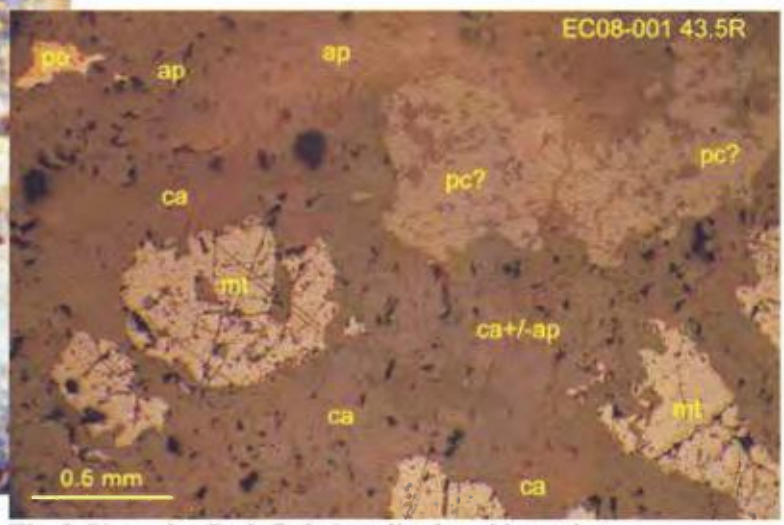


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-001 34.7m, pc?=pyrochlore, ph=phlogopite, ap=apatite, po=pyrrhotite, cb=Mg-Fe carbonate, ca=calcite, transmitted plane light, uncrossed polars.

continued ...

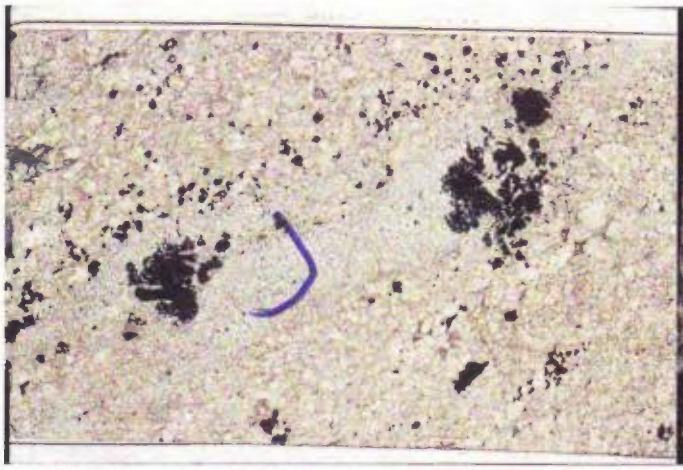


Fig.4 Thin section EC-08 001 43.5m plane polars

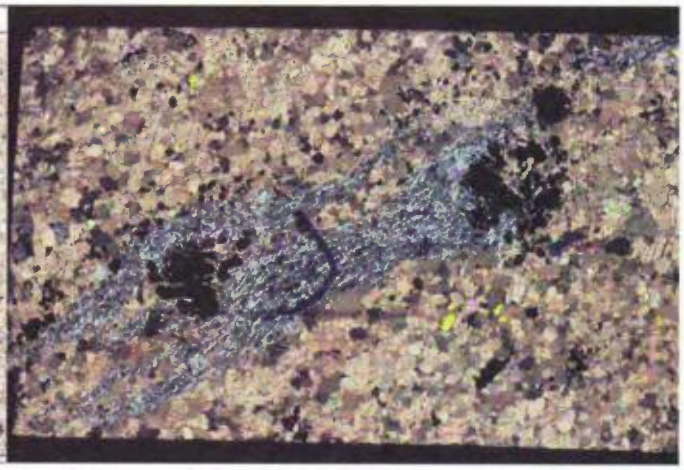


Fig.5 Thin section EC-08 001 43.5m cross polars

This sample is poorly foliated and shows brecciation of the mineral assemblage (broken, rounded magnetite, fractured apatite and ?pyrochlore). Notice the phosphate content is 10.51%.

Calcite Carbonatite with visible pyrite and pyrrhotite

EC08-001 at 34.70m

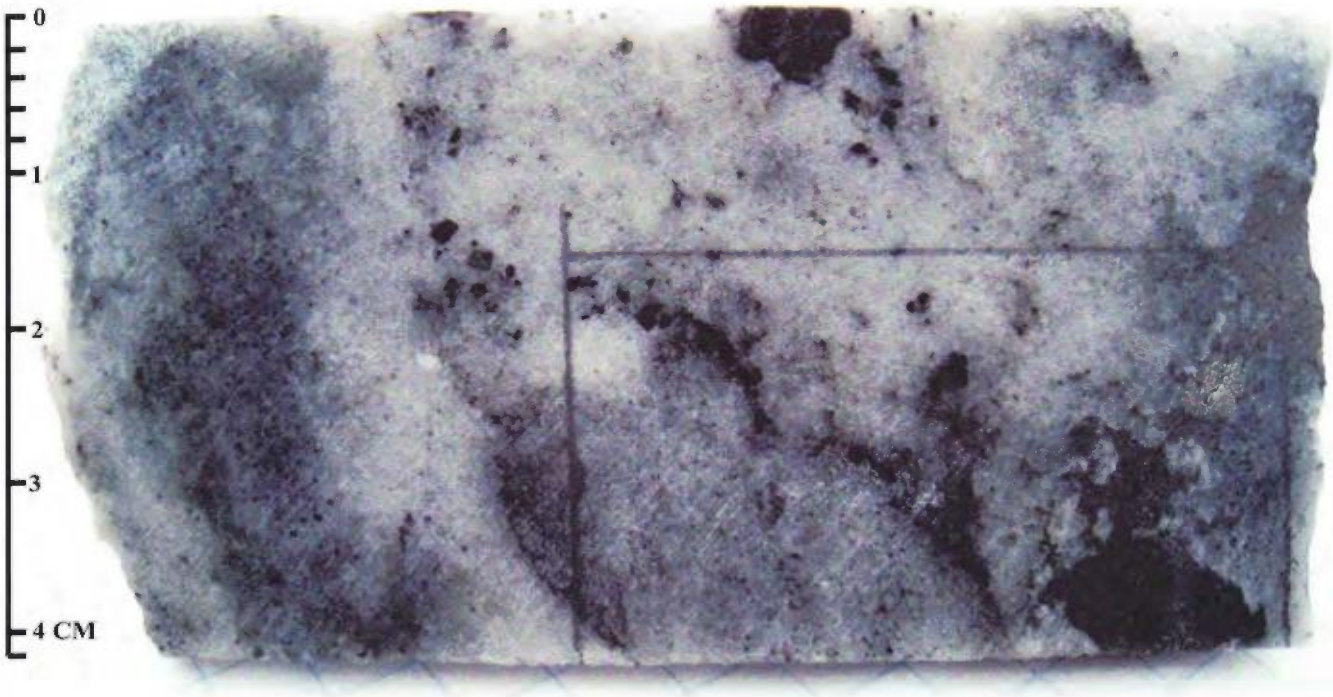


Fig.1 Calcite carbonatite with euhedral pyrite and anhedral pyrrhotite. P_2O_5=5.45%, Nb=1819.8 ppm, Ta=85.5 ppm, REE+Y=0.20%

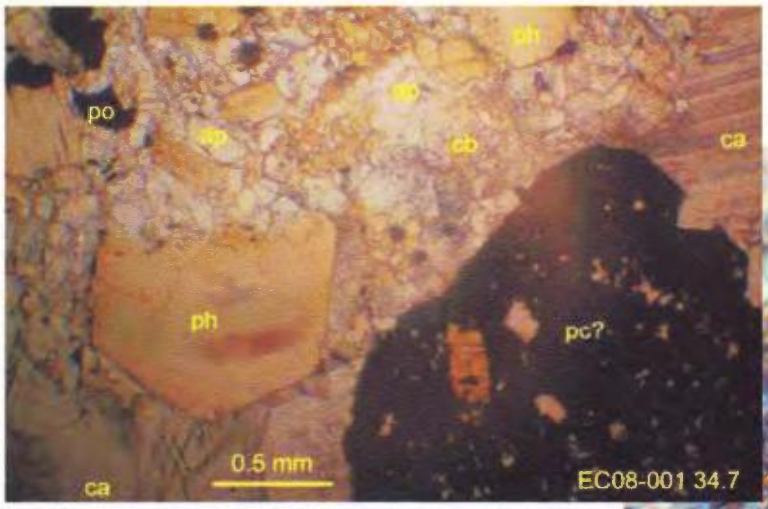


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-001 34.7m, pc?=pyrochlore, ph=phlogopite, ap=apatite, po=pyrrhotite, cb=Mg-Fe carbonate, ca=calcite, transmitted plane light, uncrossed polars.

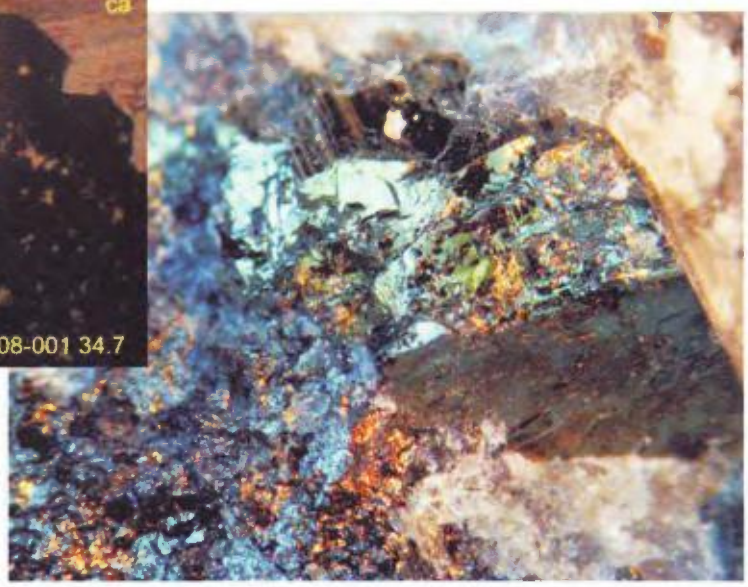


Fig. 3 Micro-photo of Pyrite with pyrrhotite.

continued ...

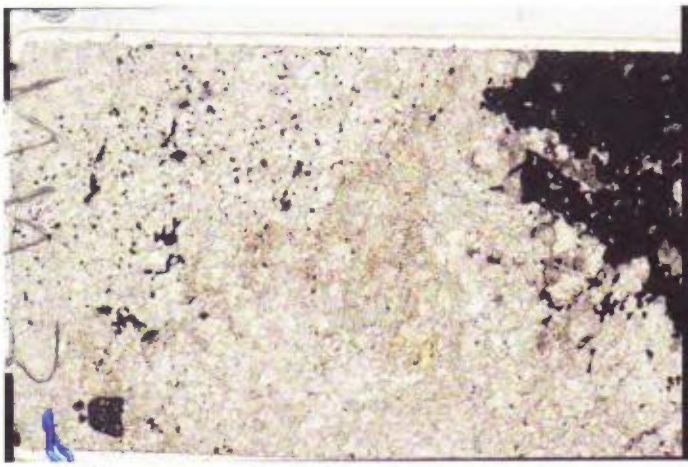


Fig.4 Thin section EC-08 001 34.7m plane polars

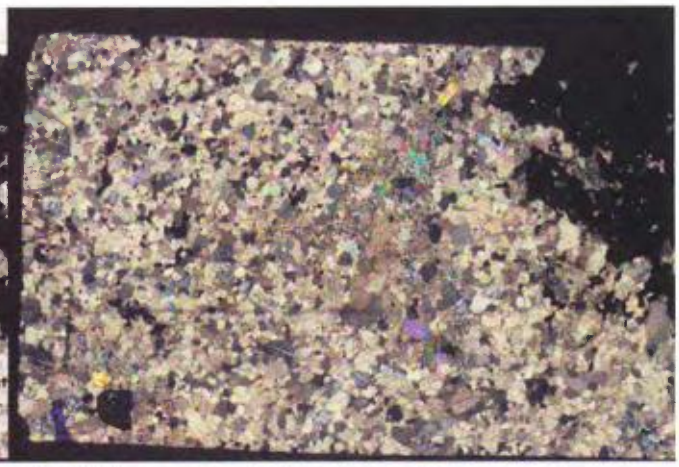


Fig.5 Thin section EC-08 001 34.7m cross polars

Dr. Craig Lietch describes irregular, anastomozing zones less than 2mm thick of what may be a fine-grained dolomite carrying apatite, and possible pyrochlore in this sample. This suggests that this sample has been brecciated by a dolomite carbonatite on a scale not discernable to the naked eye or that calcite and dolomite co-existed in the same intrusion.

Calcite Carbonatite with magnetite cumulate

EC08-003 at15.82m

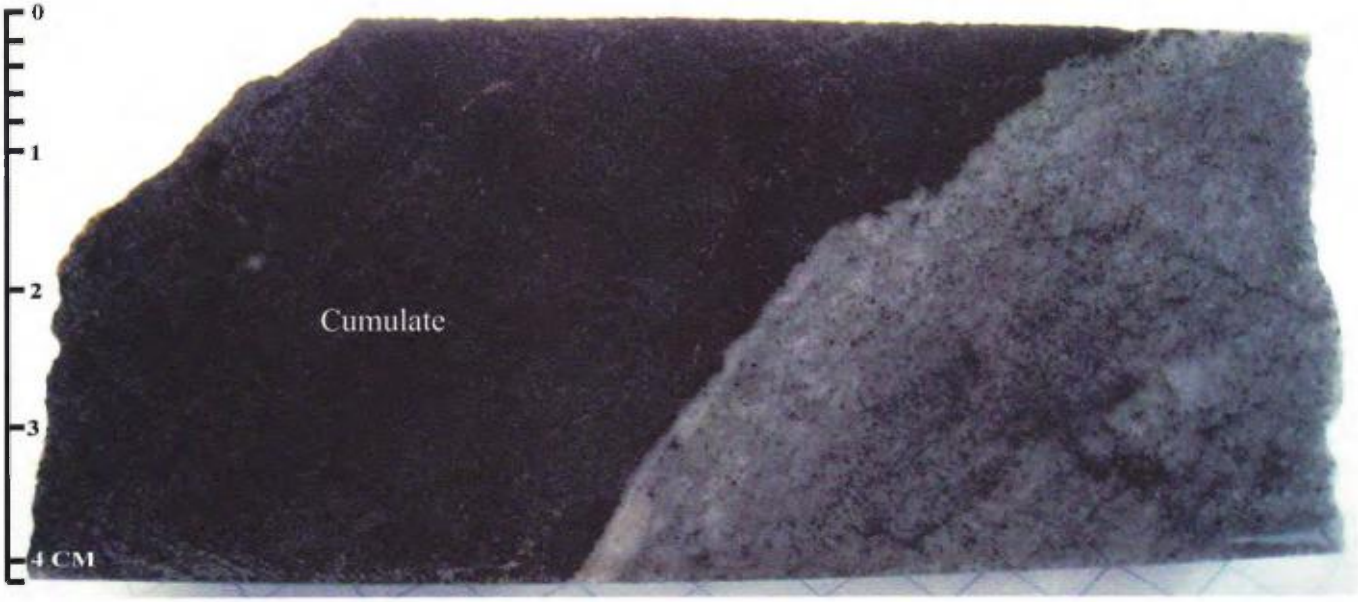


Fig.1 Calcite carbonatite with re-mobilized? magnetite cumulate. P_2O_5=4.79%, Nb=4115.2 ppm, Ta=79 ppm, REE+Y=0.26%

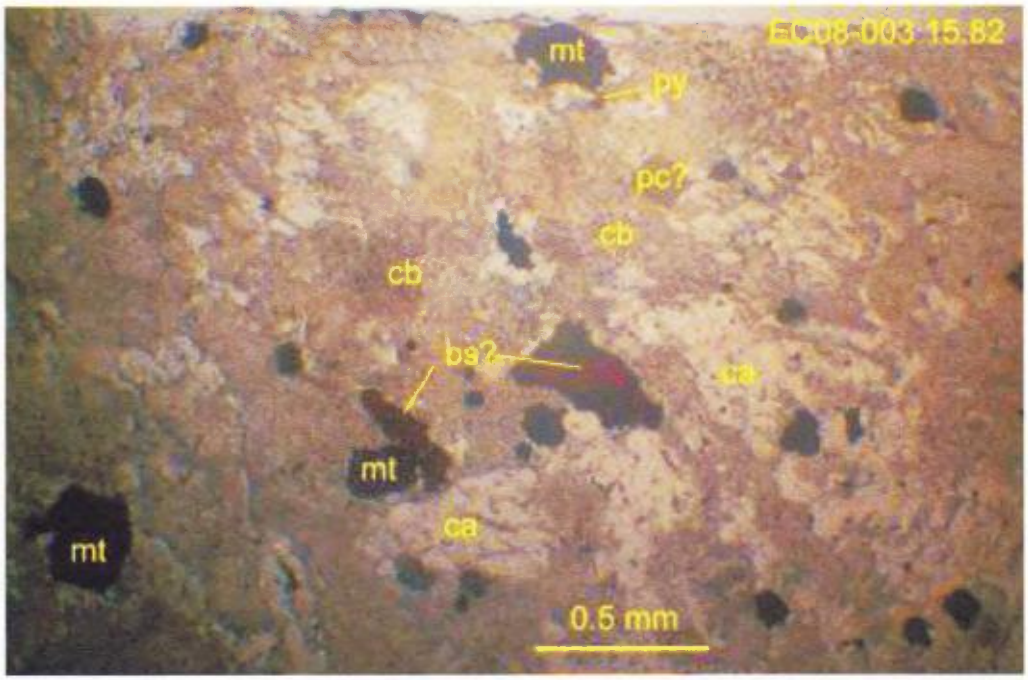


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-003 15.82m, mt=magnetite, cb=carbonate, ca=calcite, bs?=bastnaesite?, py=pyrite, pc?=pyrochlore? Transmitted plane light

continued ...

Fig.3 Thin section EC-08 003 15.82m plane polars

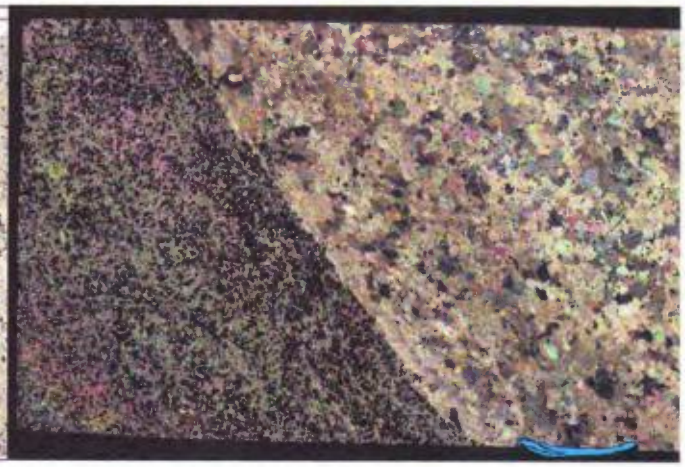


Fig.4 Thin section EC-08 003 15.82m cross polars

The texture of the magnetite in this possible cumulate band suggests dendritic growth. Brownish colour in the carbonate layer is due to minute inclusions of unknown minerals. Both layers contain REE-bearing minerals that need identification. There is a possibility of a second carbonate phase in this sample. Because its reaction to HCL suggests calcite and the Alizarin staining by Dr. Craig Lietch was indeterminate for calcite--it suggests the presence of some Fe-dolomite or another carbonate phase. SEM/EMPA work is required to characterize the carbonate phases present in this sample.

Calcite Carbonatite with magnetite

EC08-002 at 201.44m

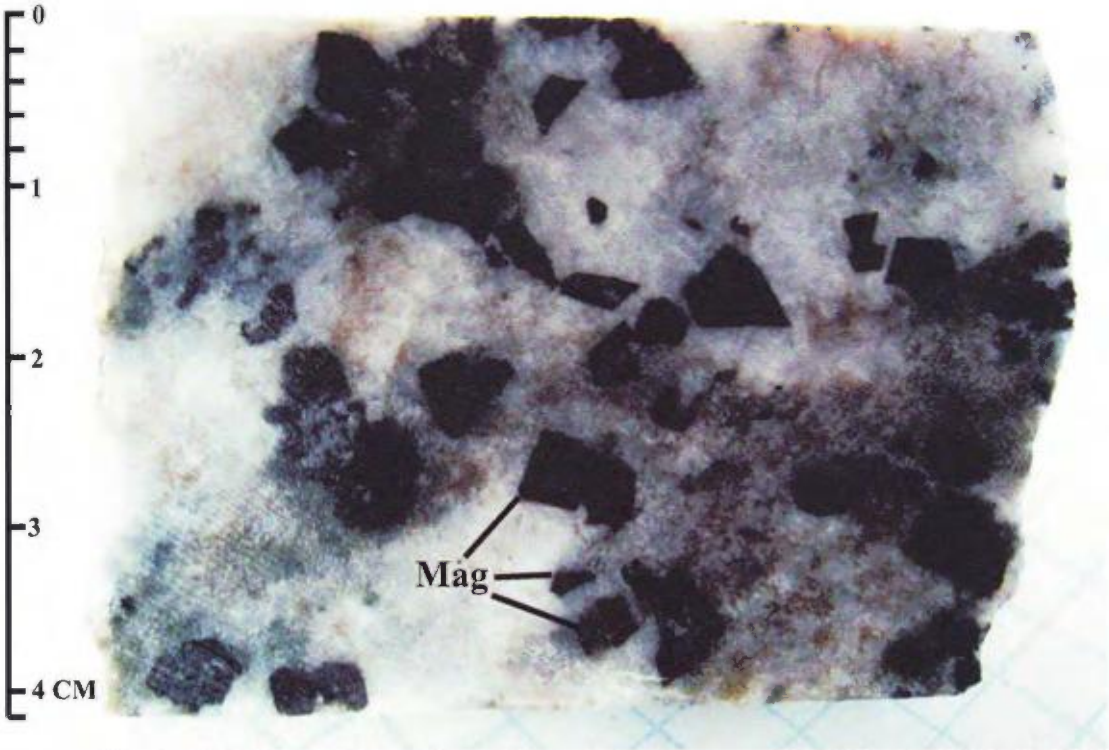


Fig.1 Calcite carbonatite with euhedral magnetite (Mag). P_2O_5=5.01%, Nb=271.7 ppm, Ta=48.3 ppm, REE+Y=0.16%

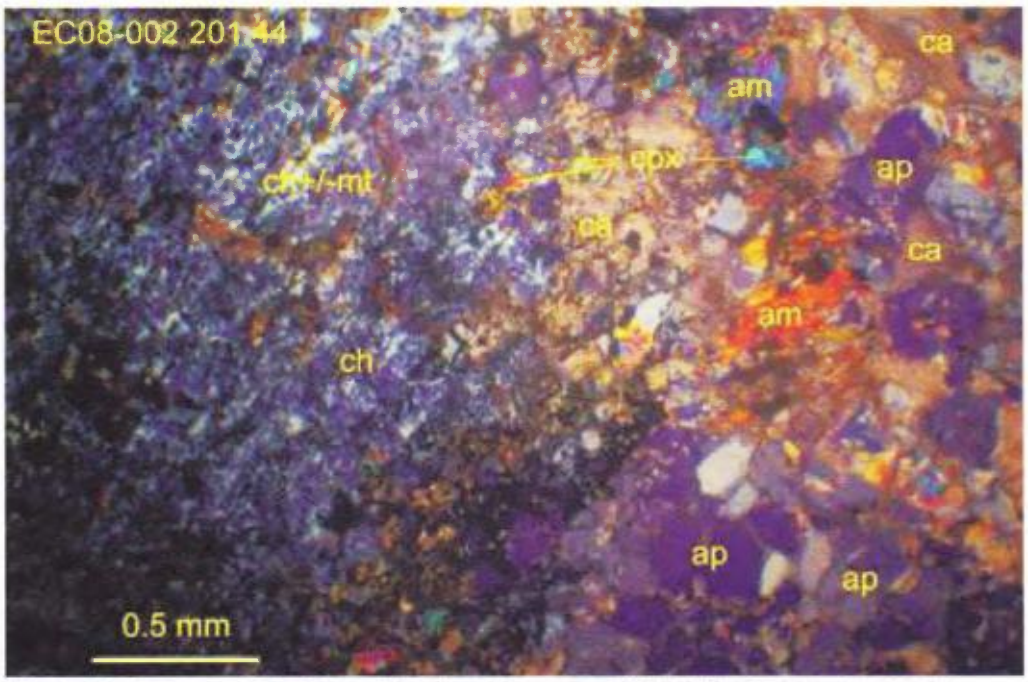


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-002 201.44m, ap=apatite, ch=chlorite, am=amphibole, ca=calcite, cpx=clinopyroxene, ch+/-mt=chlorite+/-magnetite. Transmitted light, crossed polars.

continued ...

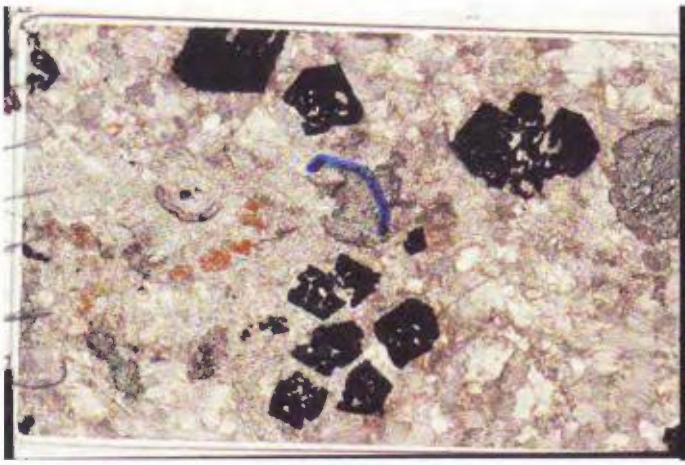


Fig.3 Thin section EC-08 002 201.44m plane polars

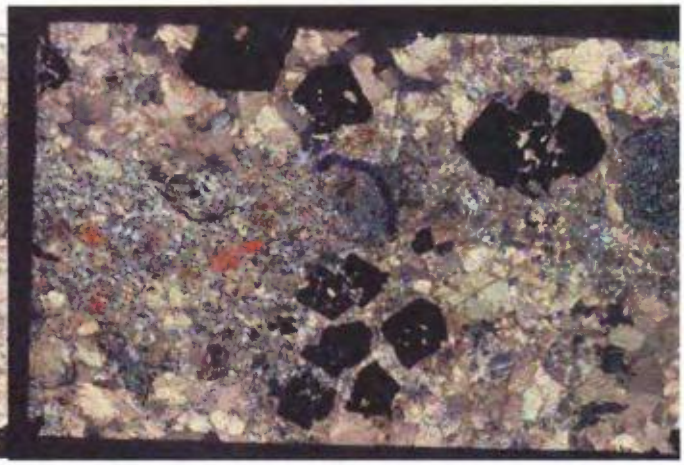


Fig.4 Thin section EC-08 002 201.44m cross polars

Because the magnetite and apatite are euhedral and not brecciated, this could be a primary carbonatite texture with metamorphic alteration of an unknown clinopyroxene.

Calcite Carbonatite grey with white

EC08-003 at 6.24m

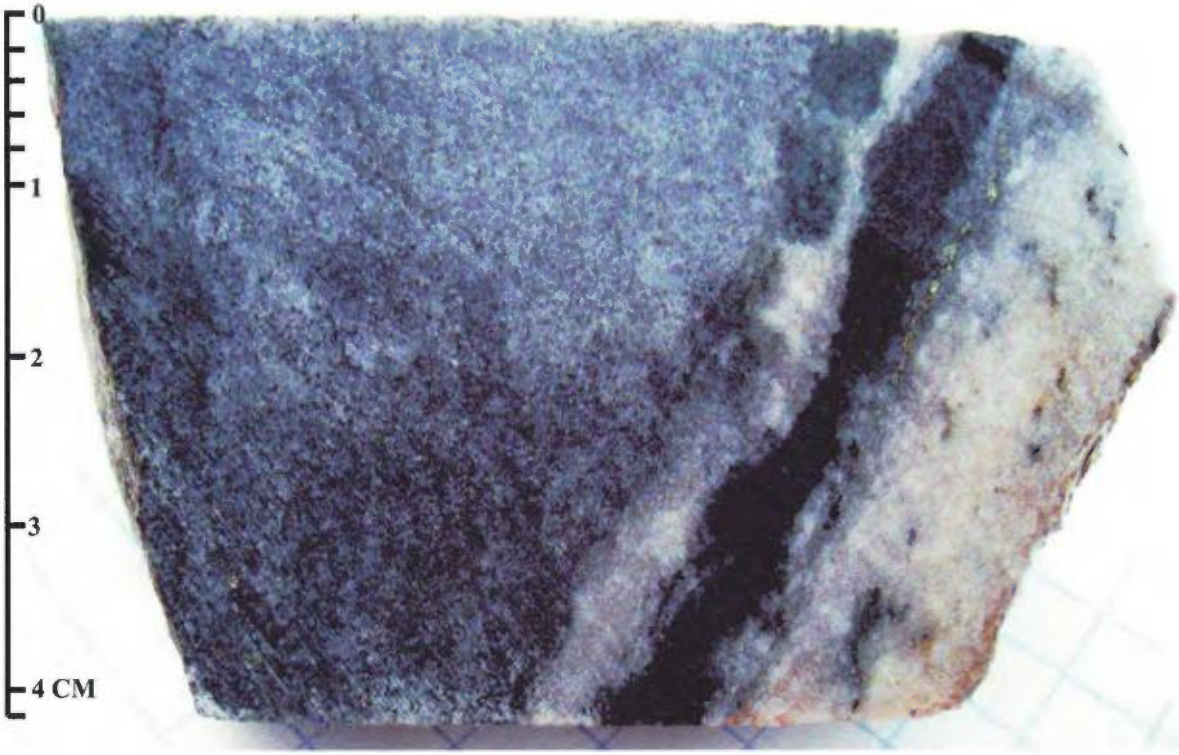


Fig.1 Calcite carbonatite contact between grey and white. P_2O_5=3.08%, Nb=918.9 ppm, Ta=26.5 ppm, REE+Y=0.15%

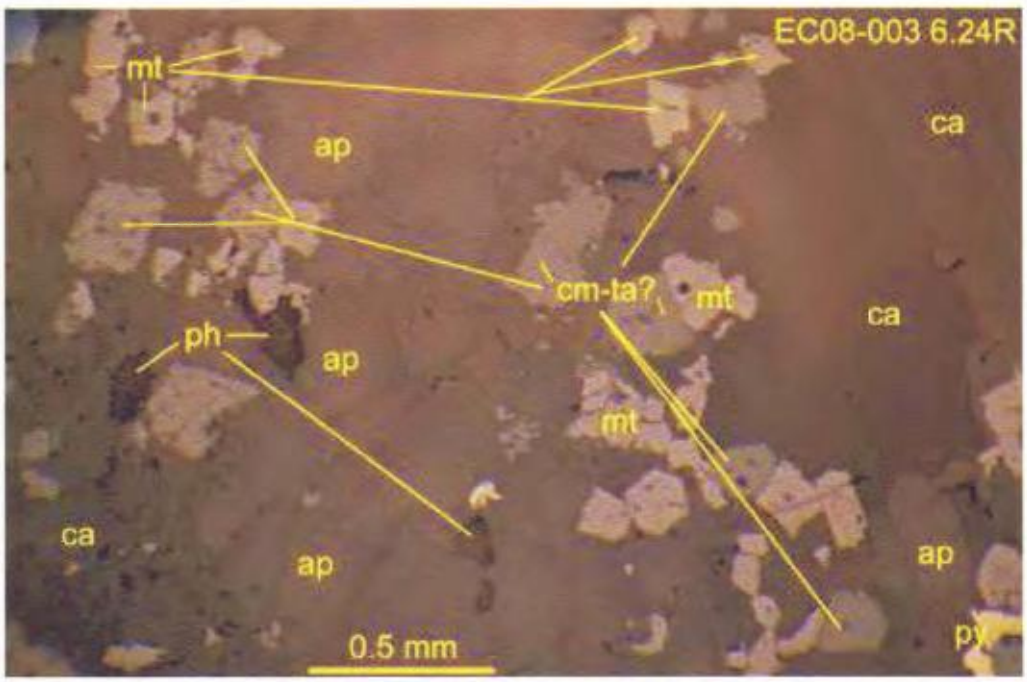


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-003 6.24m, ph=phlogopite, ap=apatite, mt=magnetite, ca=calcite, cm-ta=columbite-tantalite, py=pyrite. Reflected light, uncrossed polars.

continued ...

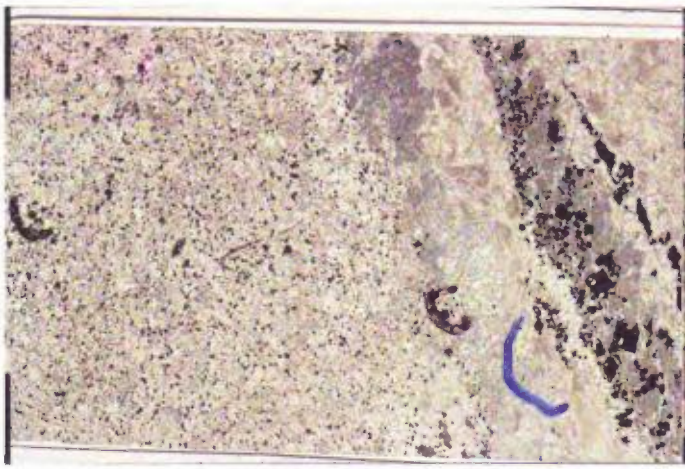


Fig.3 Thin section EC-08 003 6.24m plane polars

Fig.4 Thin section EC-08 003 6.24m cross polars

Many of these dark grey intervals were left unsampled in 2008. These carbonatite units are dark grey because of their microscopic sulphide and oxide content. This fine-grained grey calcio-carbonatite is probably a segregation withing the calcite carbonatite intrusion, perhaps a variation of a cumulate.

Calcite Carbonatite with magnesio-arfvedsonite

EC08-026 at 187.85m

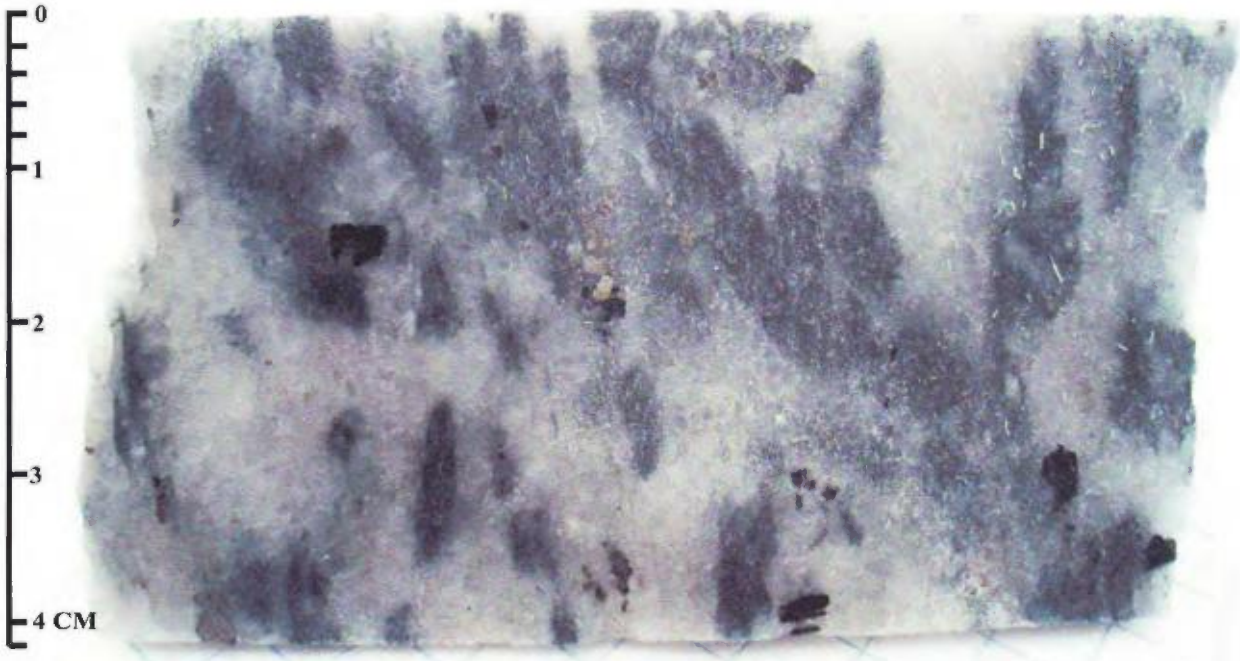


Fig.1 Calcite carbonatite with amphibole patches. P_2O_5=4.26%, Nb=1694.8 ppm, Ta=10 ppm, REE+Y=0.19%

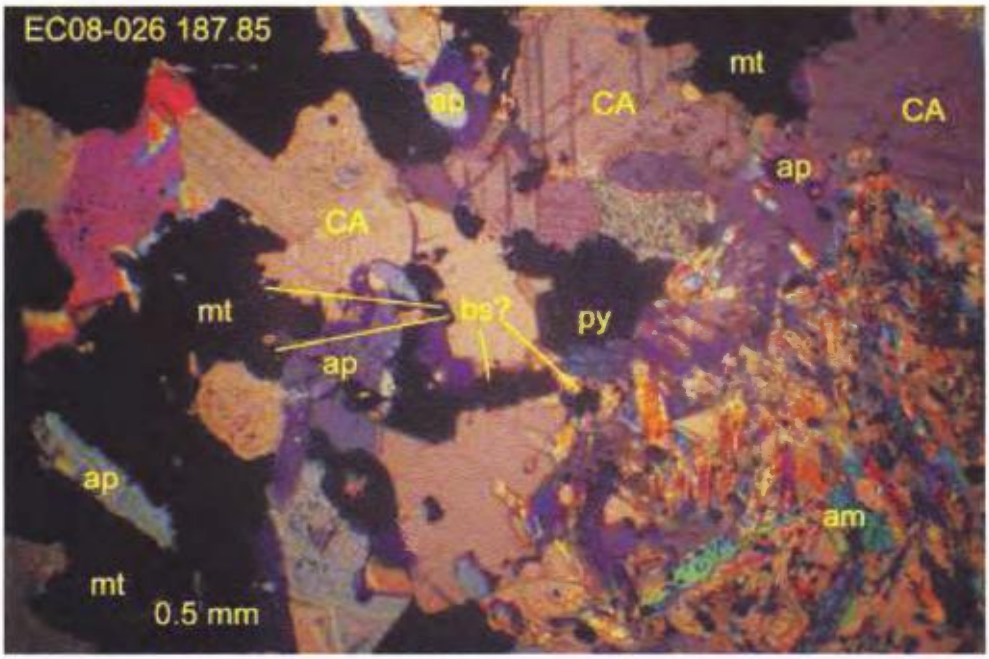


Fig. 2 Photo by Craig Leitch. CA=calcite, mt=magnetite, ap=apatite, am=amphibole, py=pyrite, bs?=bastnaesite? Transmitted light, crossed polars.

Owing to time constraints at the University of Alberta the thin section for this sample was not scanned.

Dr. Leitch suggests that the lensoid patches of amphibole might have originally been another mineral such as olivine that has metamorphosed to the phase present here. EMPA work is needed to determine the identity of the amphibole phase.

Calcite Carbonatite with fibrous amphibole

EC08-026 at 188.65m

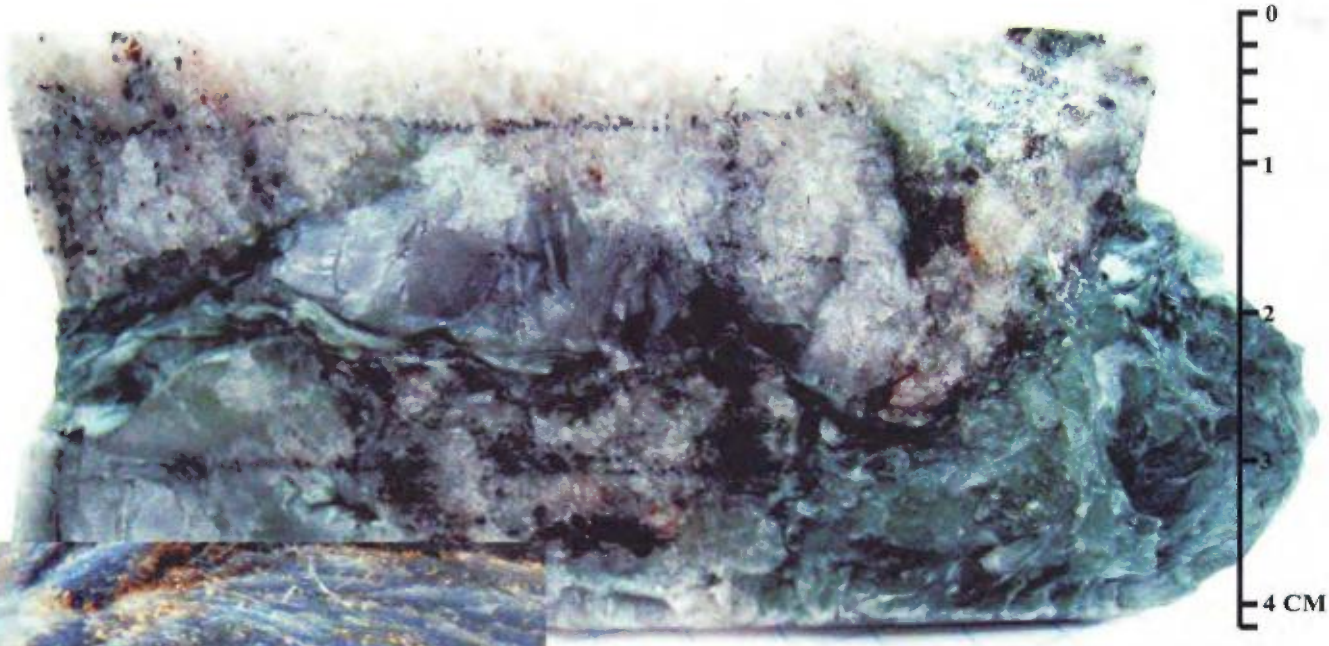


Fig.1 Calcite carbonatite with fibrous blue amphibole . P_2O_5=1.57%, Nb=1831.6 ppm, Ta=21.6 ppm, REE+Y=0.24%

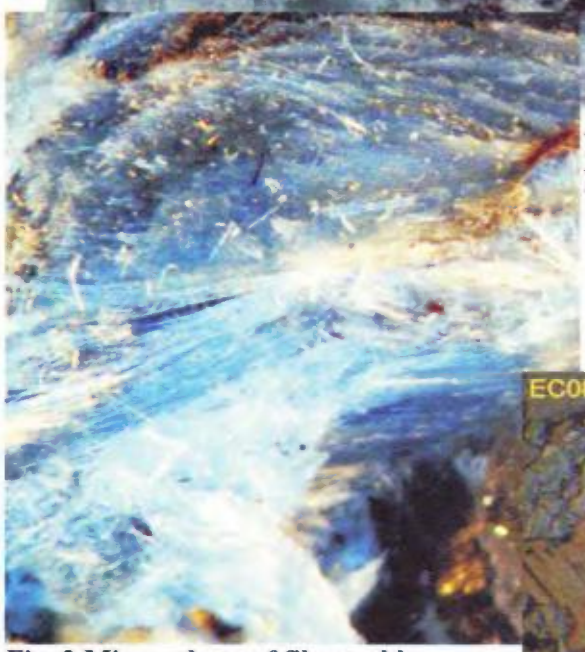


Fig. 2 Micro-photo of fibrous blue amphibole.

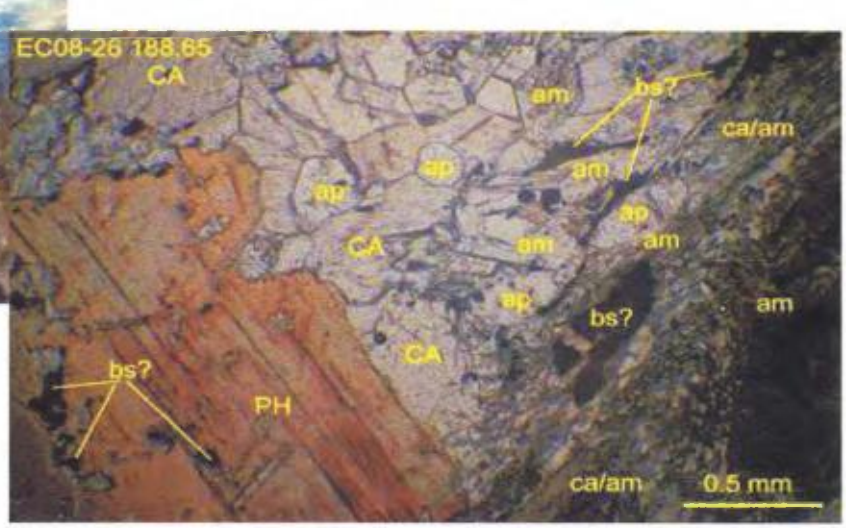


Fig. 3 Photo by Craig Leitch. CA=calcite, PH=phlogopite, ap=apatite, am=amphibole, bs?=bastnaesite? Transmitted light, uncrossed polars.

Owing to time constraints at the University of Alberta the thin section for this sample was not scanned.

This sample and the one taken at 187.85 metres are have a similar composition. EMPA work would be required to identify the amphibole phase present. **Note:** fibrous amphiboles can have major healthe and safety implications for mining.

PARISITE WITH CHALCOPYRITE AND QUARTZ

PLATE IV. The Eldor carbonatite hosts spectacular, well crystallized examples of the mineral parisite. The potential for this carbonatite to produce some of the world's best examples for this species is considerable. Mt. Malosa in Malawi, Zagi Mountain in Pakistan, and the Muzo Mine in Columbia have all produced remarkable specimens of parisite (up to three centimeters). The crystal above is 5 mm long.

SPHALERITE WITH IRRIDESCENT COATING OF ?PYRITE

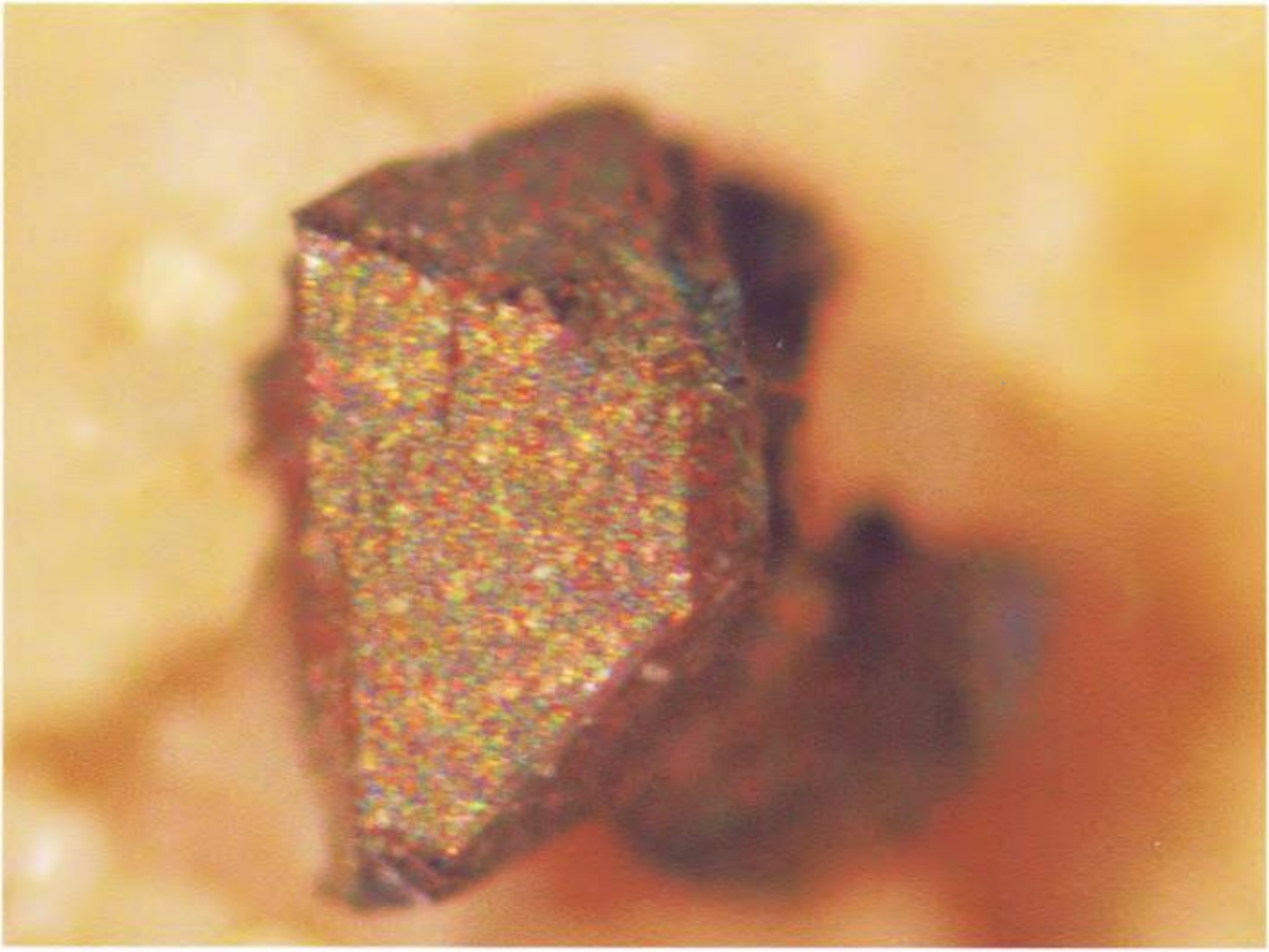


PLATE V. Sphalerite is not common at Eldor. Sphalerite is easily confused with pyrochlore or ferrocolumbite unless large enough to subject to a scratch test. This micro-photo shows how, occasionally, euhedral crystals like the one above can be found in the porous, re-mobilized, dolomite carbonatite.

Dolomite Carbonatite
brecciated contact between two units

EC08-004 at 63.46m

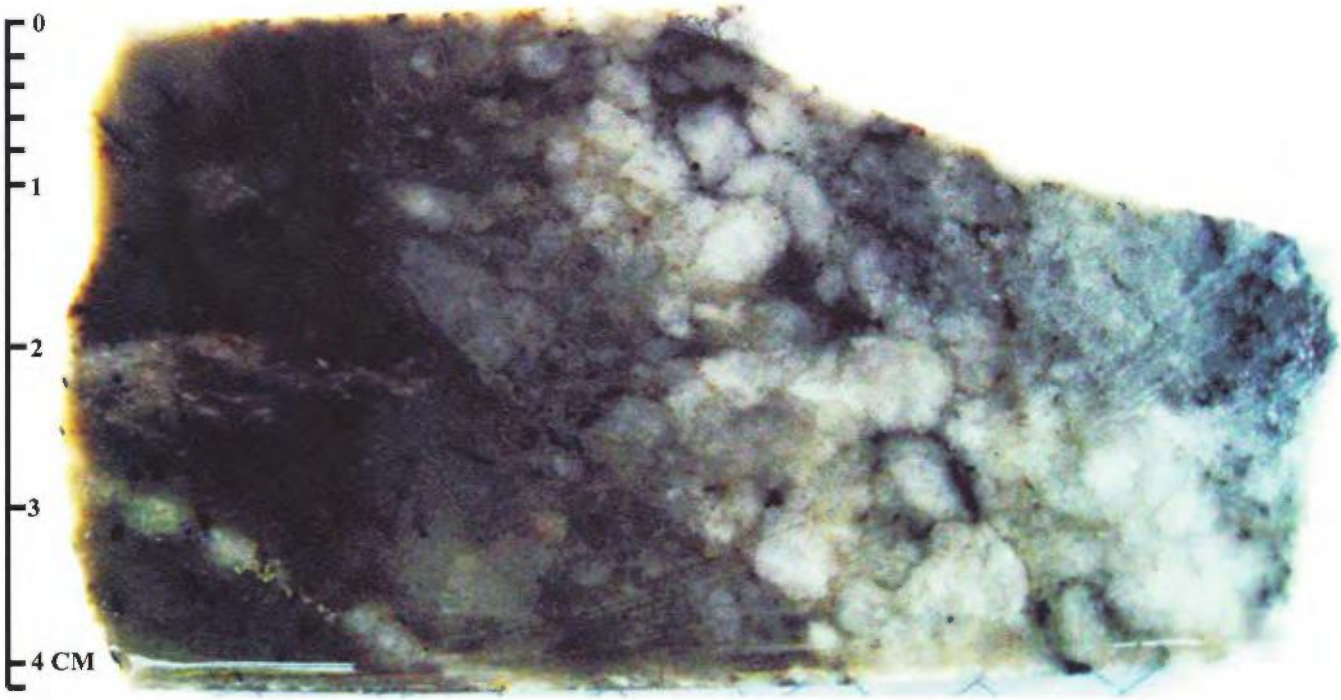


Fig.1 Fine-grained dolomite carbonatite in brecciated contact with medium-grained dolomite carbonatite. P_2O_5=5.52%, Nb=2127.4 ppm, Ta=61.2 ppm, REE+Y=0.21%

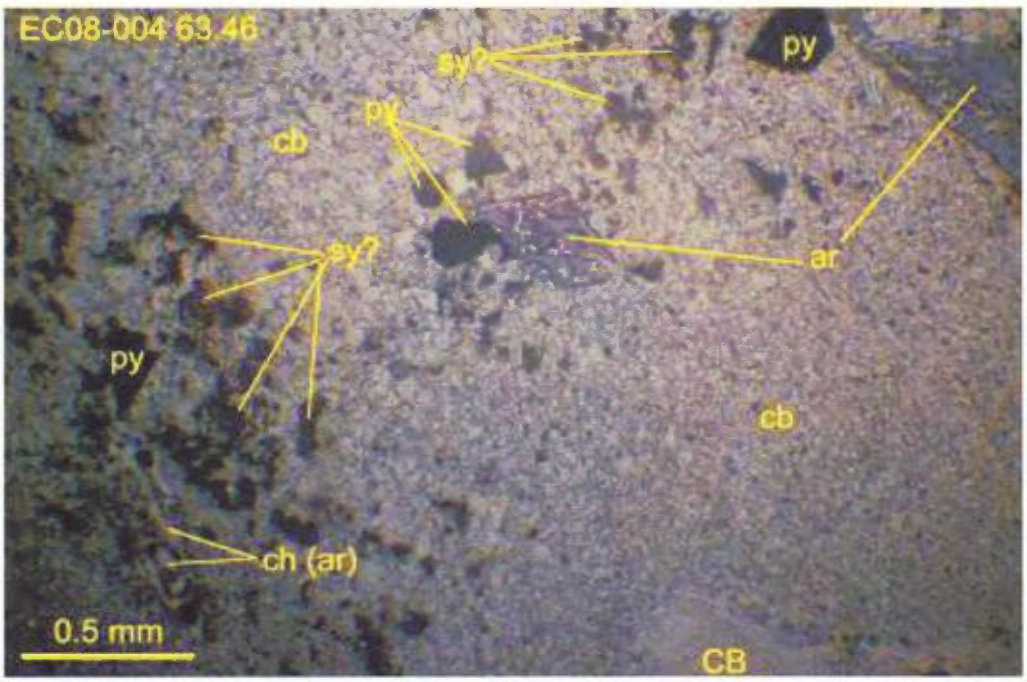


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-004 63.46m, py=pyrite, cb=fine-grained carbonate, CB= coarsegrained carbonate, sy?=synchesite?, ar=arfvedsonite. Transmitted plane light.

continued ...

Fig. 3 Micro-photo of unknown amphibole in Ec08-004 63.46m.

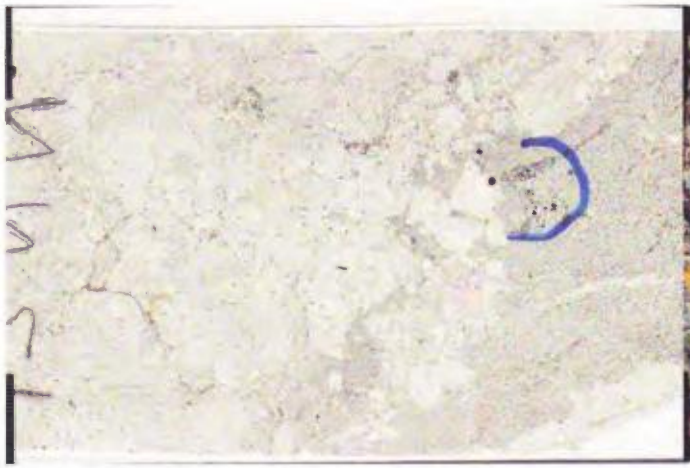


Fig.4 Thin section EC-08 004 63.46m plane polars

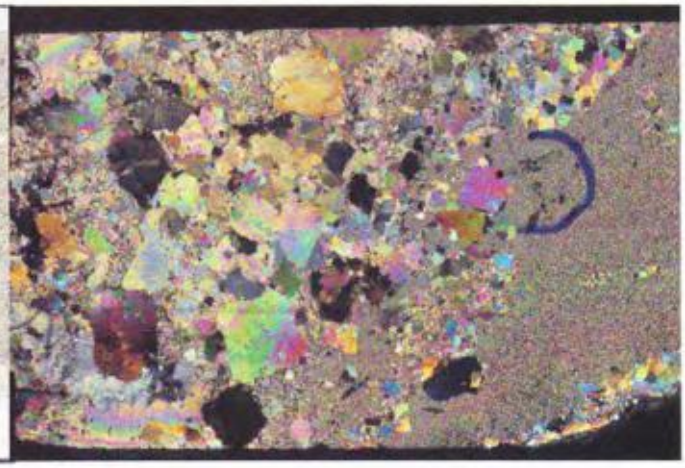


Fig.5 Thin section EC-08 004 63.46m cross polars

In this core sample fine-grained dolomitic carbonatite is invading coarser-grained dolomitic carbonatite. The large clasts of dolomite may represent dolomite recrystallized under metamorphic/tectonic conditions with remobilized, fine-grained carbonatite infill. Or alternatively, this may be the contact between two separate dolomite carbonatite intrusions with re-crystallization and brecciation along the contact. I tend to believe the latter interpretation.

Dolomite Carbonatite Contact with calcite carbonatite

EC08-004 at 71.64m

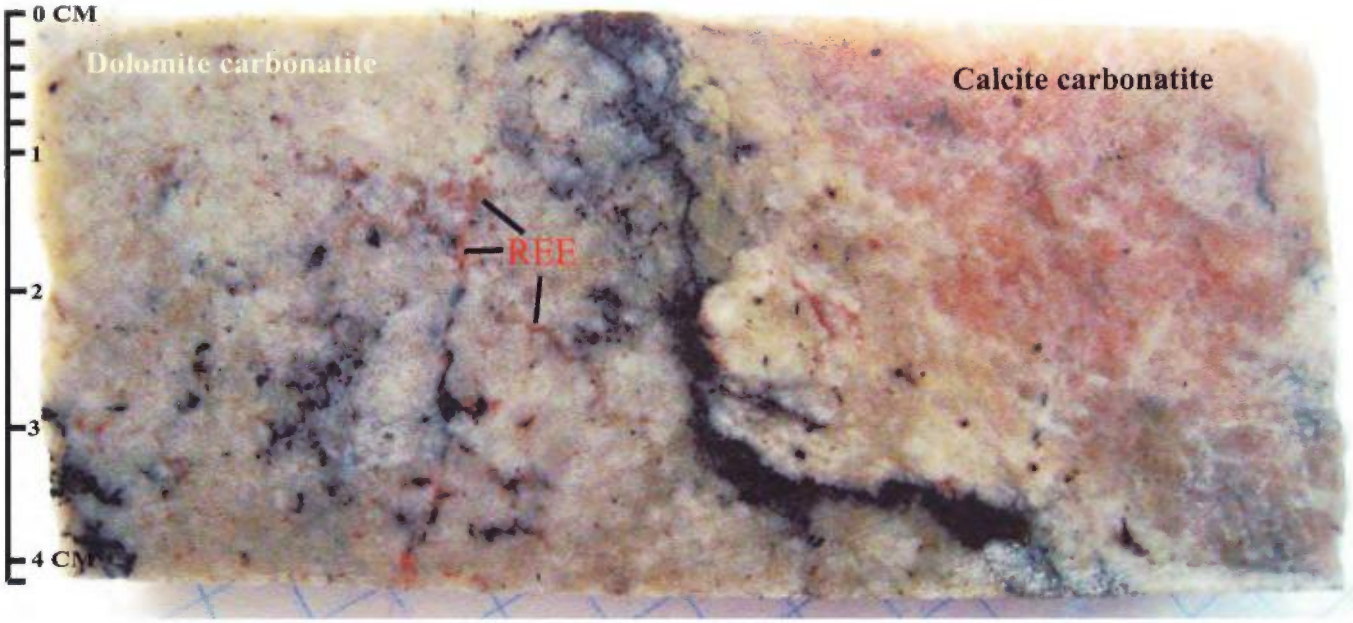


Fig.1 Yellow/grey/green/brown dolomite carbonatite with rare earth fluorocarbonates (REE) in contact with calcite carbonatite. P_2O_5=1.75%, Nb=875.3 ppm, Ta=91.4 ppm, REE+Y=0.32%

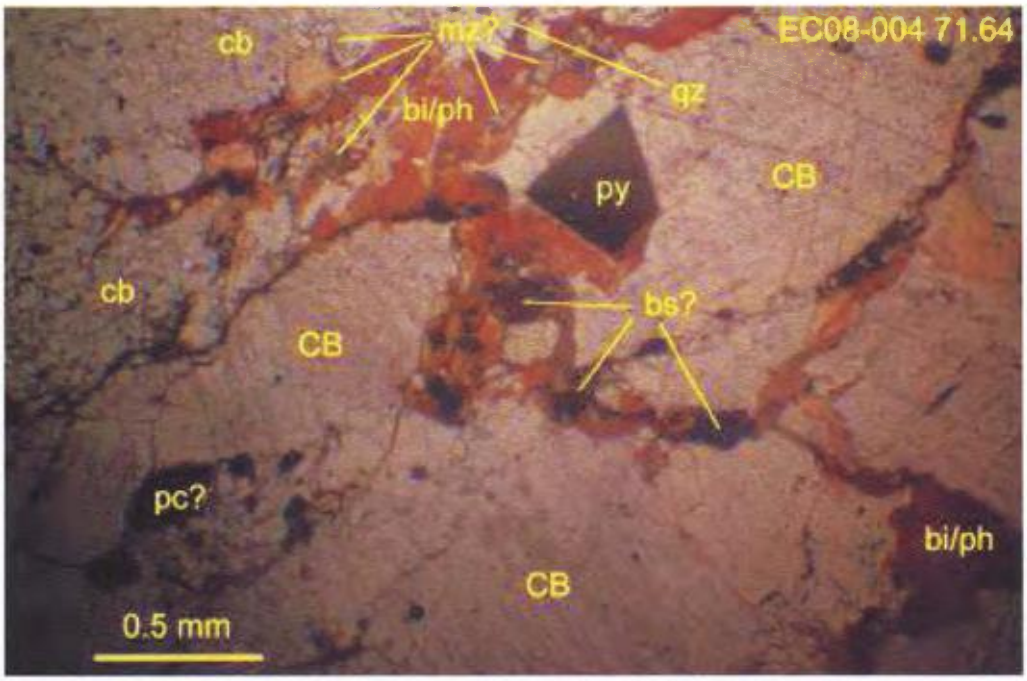


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-004 71.64m, CB=coarse-grained carbonate, cb=fine-grained carbonate, bi/ph= biotite/phlogopite, pc?=pyrochlore?,qz=quartz, mz?=monazite, py=pyrite. Transmitted plane light.

continued ...

Fig.3 Thin section EC-08 004 71.64m plane polars

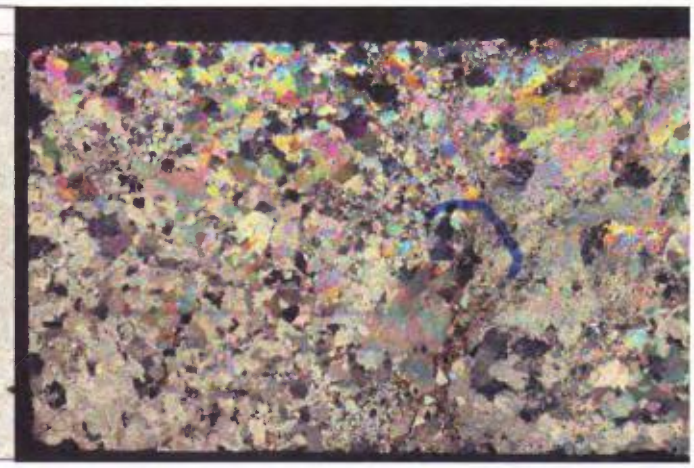


Fig.4 Thin section EC-08 004 71.64m cross polars

The yellow/grey/green/brown dolomitic carbonatite has a fine-grained zone along the contact that appears to be invading the coarser-grained calcite carbonatite, suggesting that the dolomite carbonatite intrusion came after the calcite carbonatite intrusion. The calcite carbonatite was missed when the thin section was prepared. As a result, Dr. Craig Lietch's write-up of this section describes only the two grain sizes of dolomite carbonatite and not the calcite carbonatite in contact with the dolomite carbonatite.

Dolomite Carbonatite

EC08-022 at 18.60m

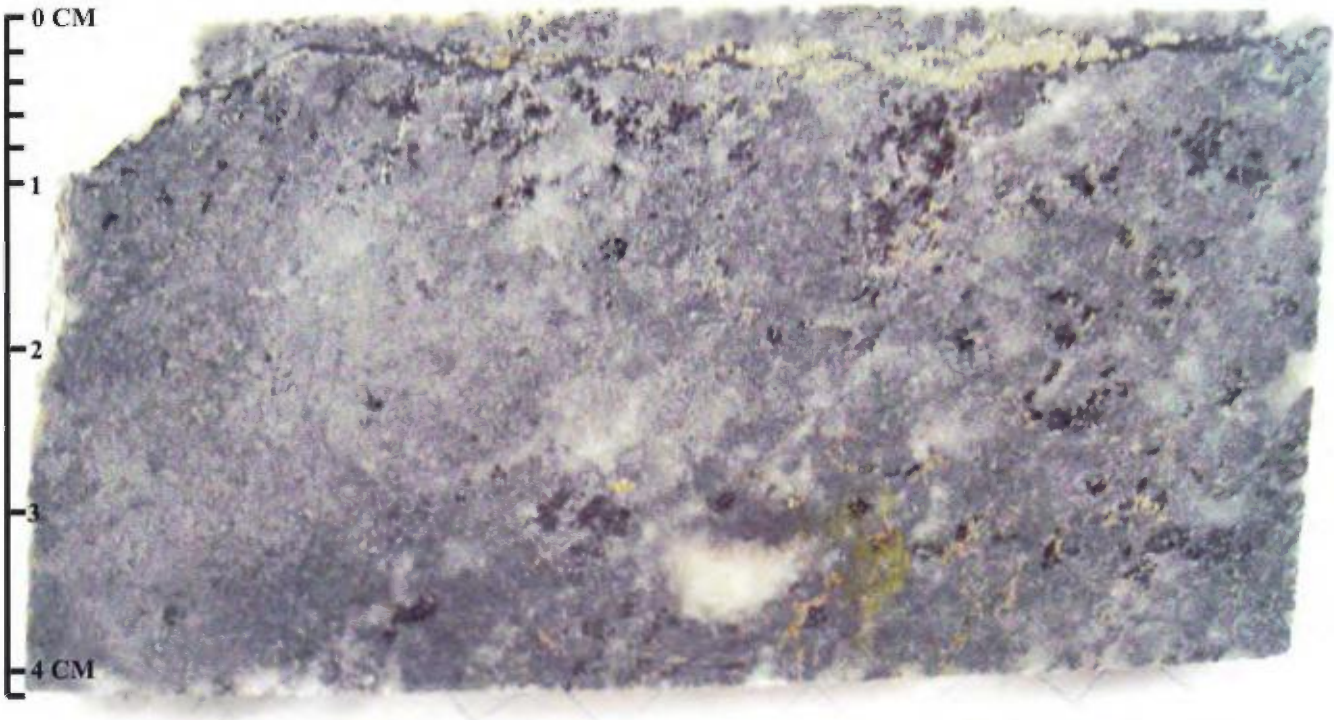


Fig.1 Grey dolomite carbonatite. P_2O_5=11.48%, Nb=1166.4 ppm, Ta=78.5 ppm, REE+Y=0.21%

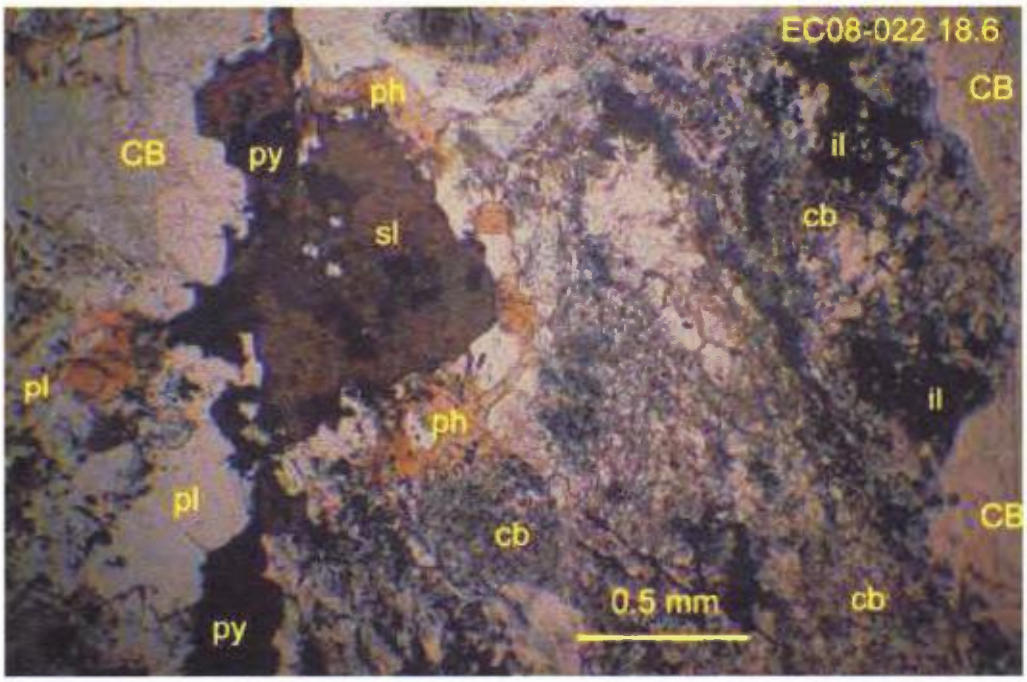


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-022 18.60. pl=plagioclase, cb=fine-grained carbonate, CB=coarse-grined carbonate, il=ilmenite, sl=sphalerite, ph=phlogopite, py=pyrite. Transmitted plane light.

continued ...

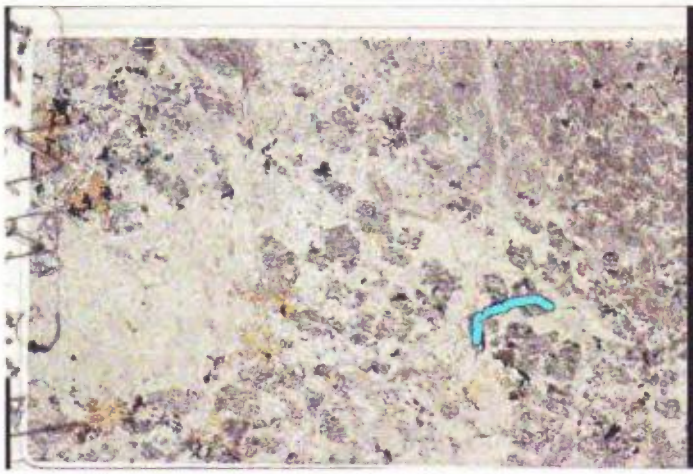


Fig.3 Thin section EC-08 022 18.60m plane polars

Fig4 Thin section EC-08 022 18.60m cross polars

Dr. Leitch states that the dark fine-grained, possibly ankeritic carbonate in this sample could have come from alteration of olivine. Further SEM/EMPA work would be required to confirm this hypothesis.

Dolomite Carbonatite with calcite vein

EC08-001 at 139.49m

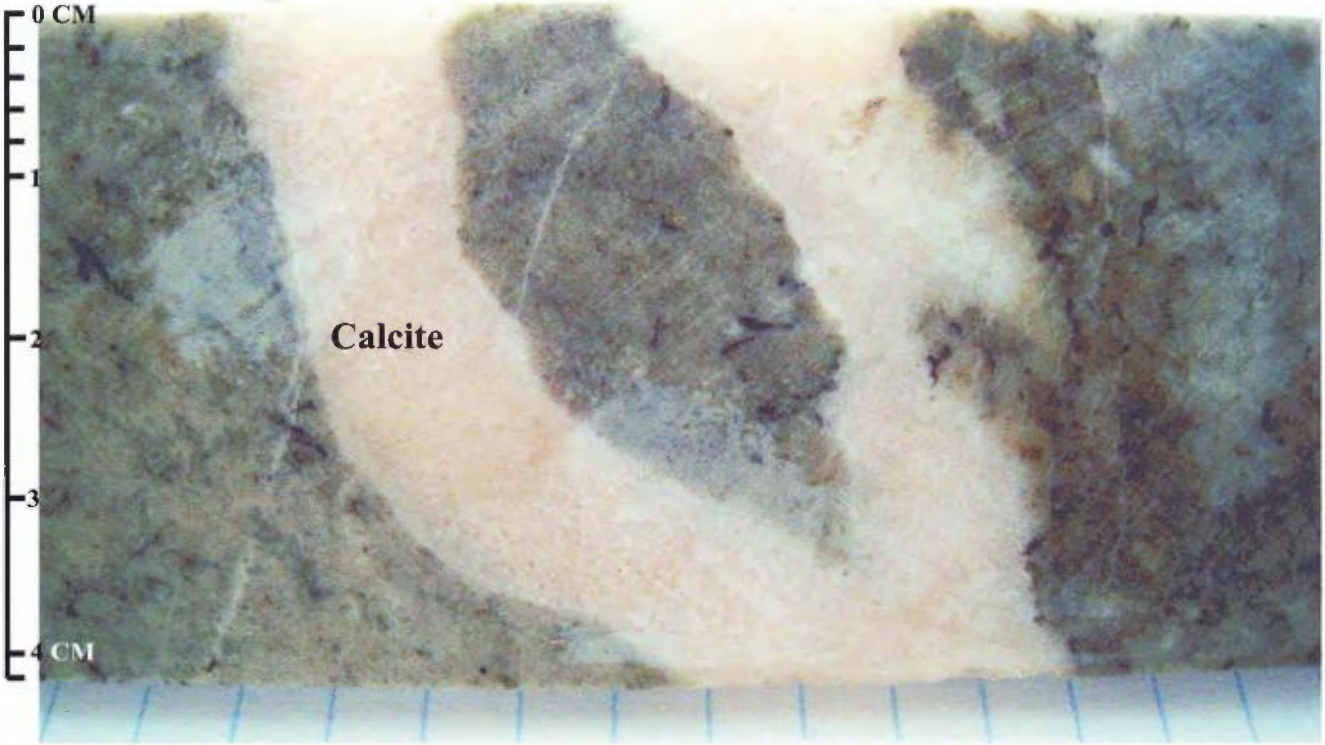


Fig.1 Dolomite carbonatite with remobilized calcite vein. P_2O_5=3.95%, Nb=844.3ppm, Ta=32.4ppm, REE+Y=0.18%

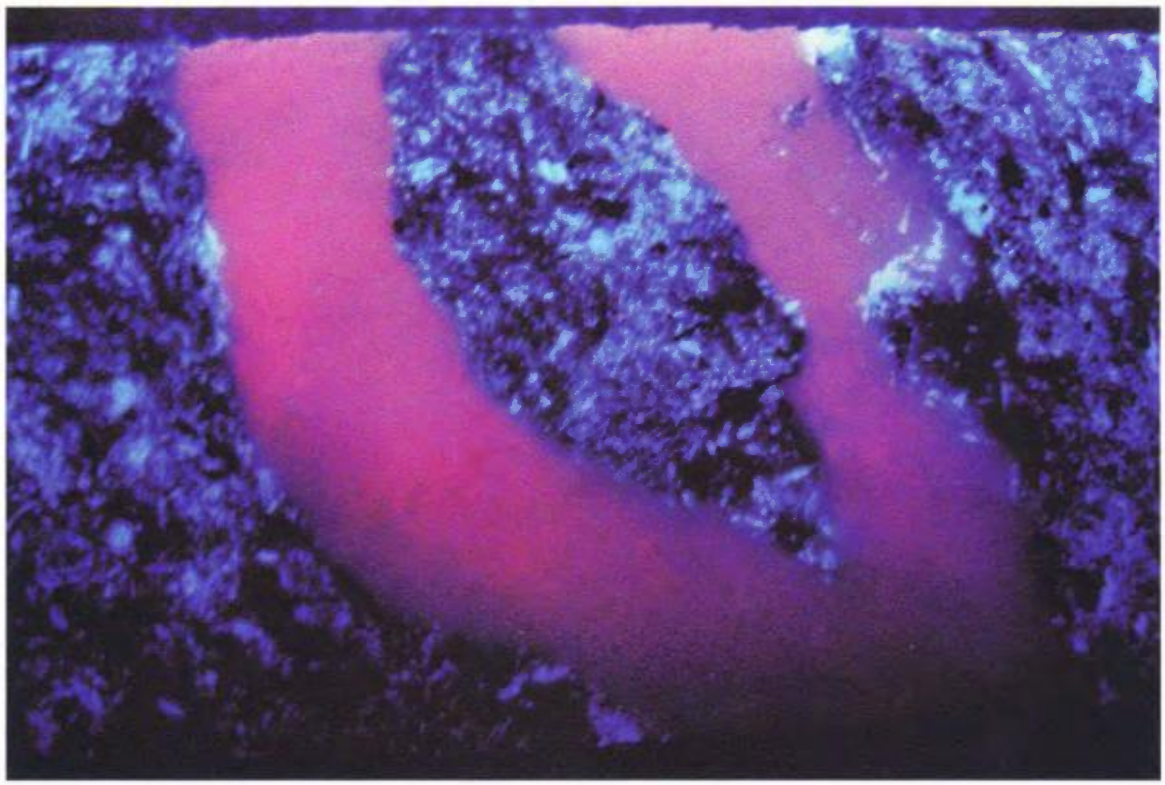


Fig. 2 EC08-001 139.49m under midrange UV light showing re-mobilized calcite (red) & apatite (blue-white)

continued ...

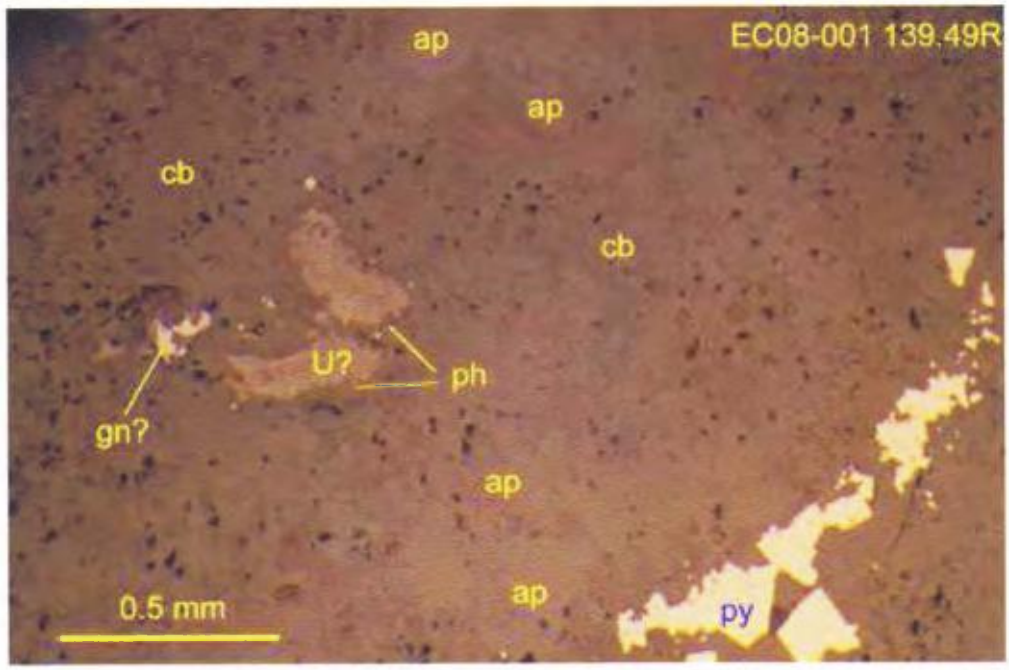


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-001 139.49m, cb=carbonate, ap=apatite, U?=unidentified radioactive mineral, gn?=galena? ph=phlogopite, py=pyrite. Reflected light, uncrossed polars

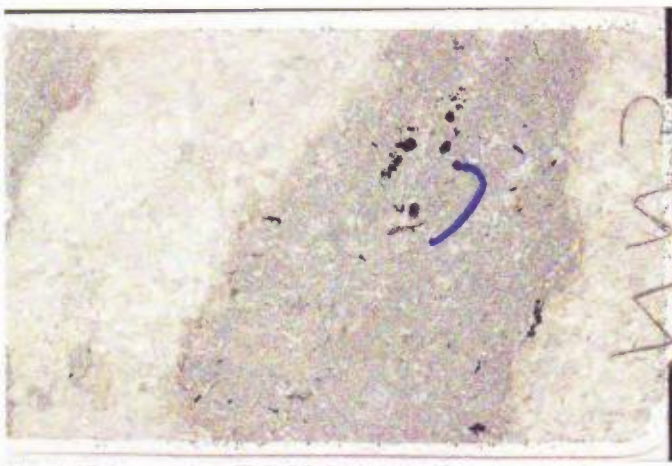


Fig.4 Thin section EC-08 001 139.49m plane polars

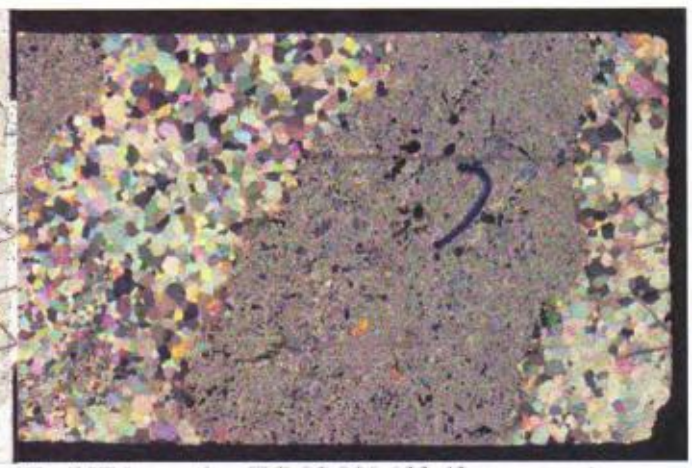


Fig.5 Thin section EC-08 001 139.49m cross polars

This sample shows a re-mobilized carbonate vein in a dolomite carbonatite host. Analytical results are typical for this grey-green magnesio-carbonatite. Further work is required to identify potential economic mineral phases.

Dolomite Carbonatite with Fe-dolomite vein

EC08-002 at 188.04m

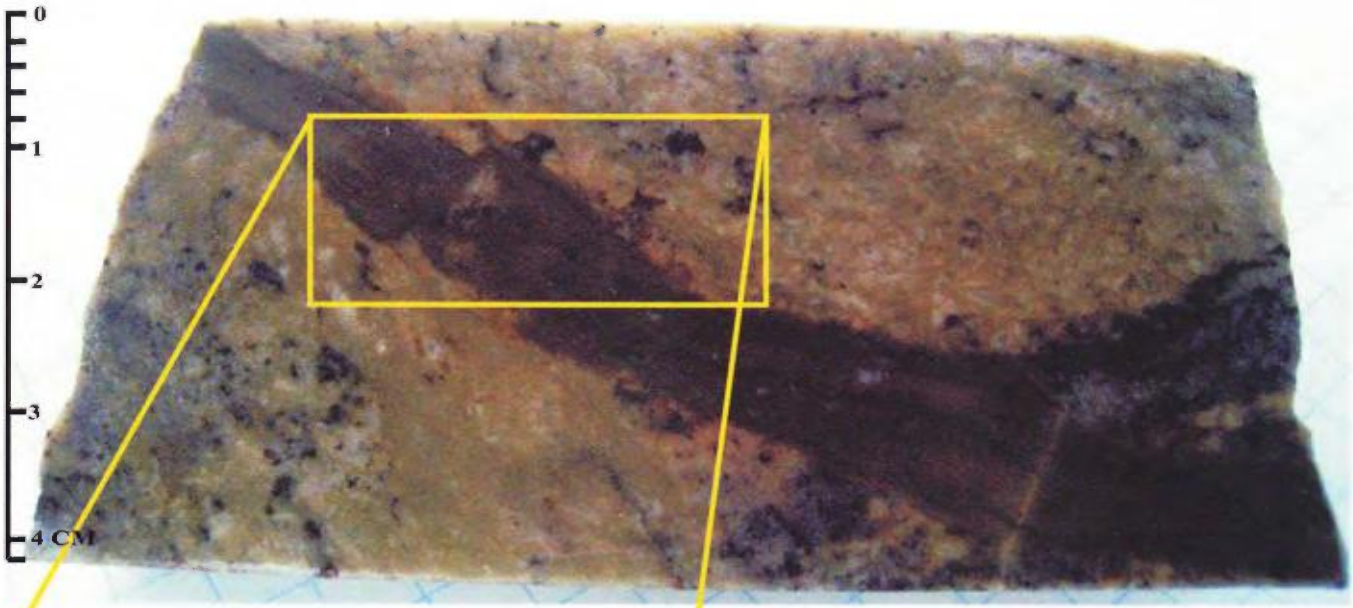


Fig.1 Dolomite carbonatite The remobilized, crosscutting vein is Fe-dolomite. P_2O_5=6.44%, Nb=1620.4 ppm, Ta=157.9 ppm, REE+Y=0.31%

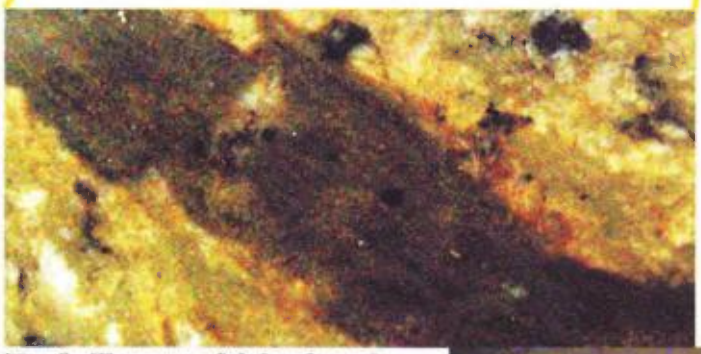


Fig. 2 Close-up of dolomite vein.

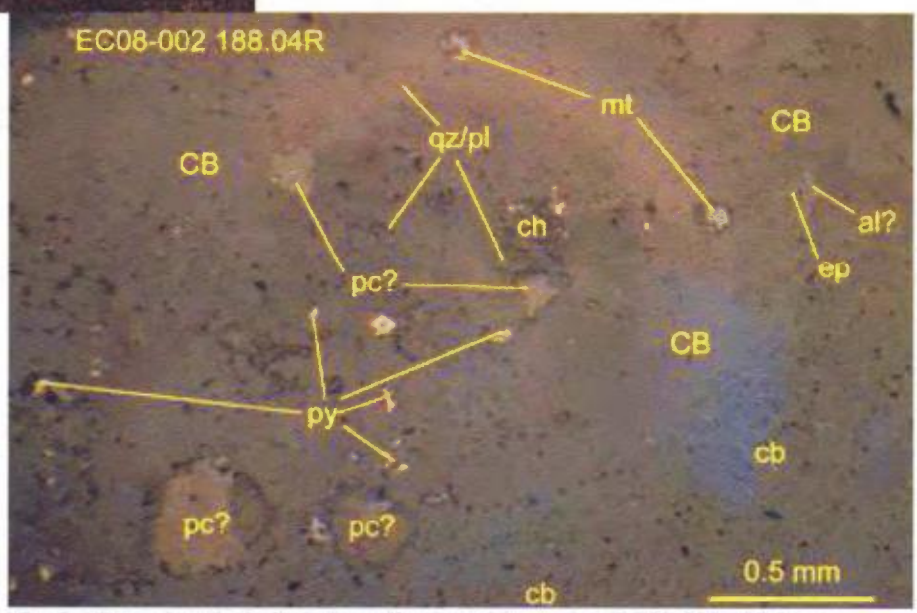


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-002 188.04m, py=pyrite, pc?=pyrochlore, cb,CB=carbonate, al?=allanite?, qz/pl=quartz/plagioclase, mt=magnetite, ep=epidote, ch=chalcopyrite. Reflected light, uncrossed polars.

continued ...

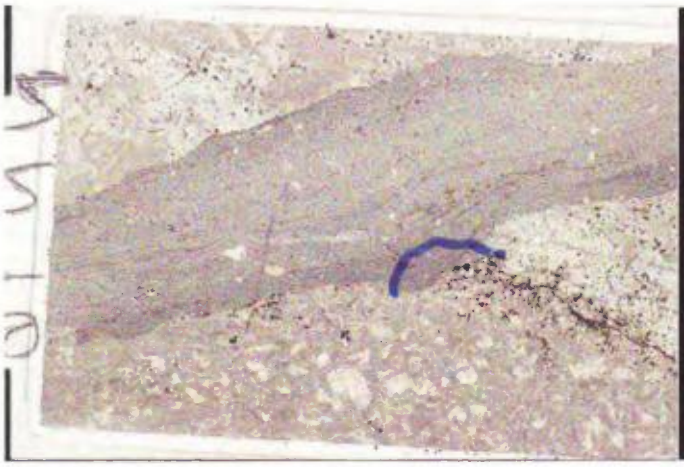


Fig.4 Thin section EC-08 002 188.04m plane polars

Fig.5 Thin section EC-08 002 188.04m cross polars

This sample shows a re-mobilized dolomite vein cutting dolomite carbonatite.

Dolomite Carbonatite with REE fluorocarbonates

EC08-003 at 144.96m

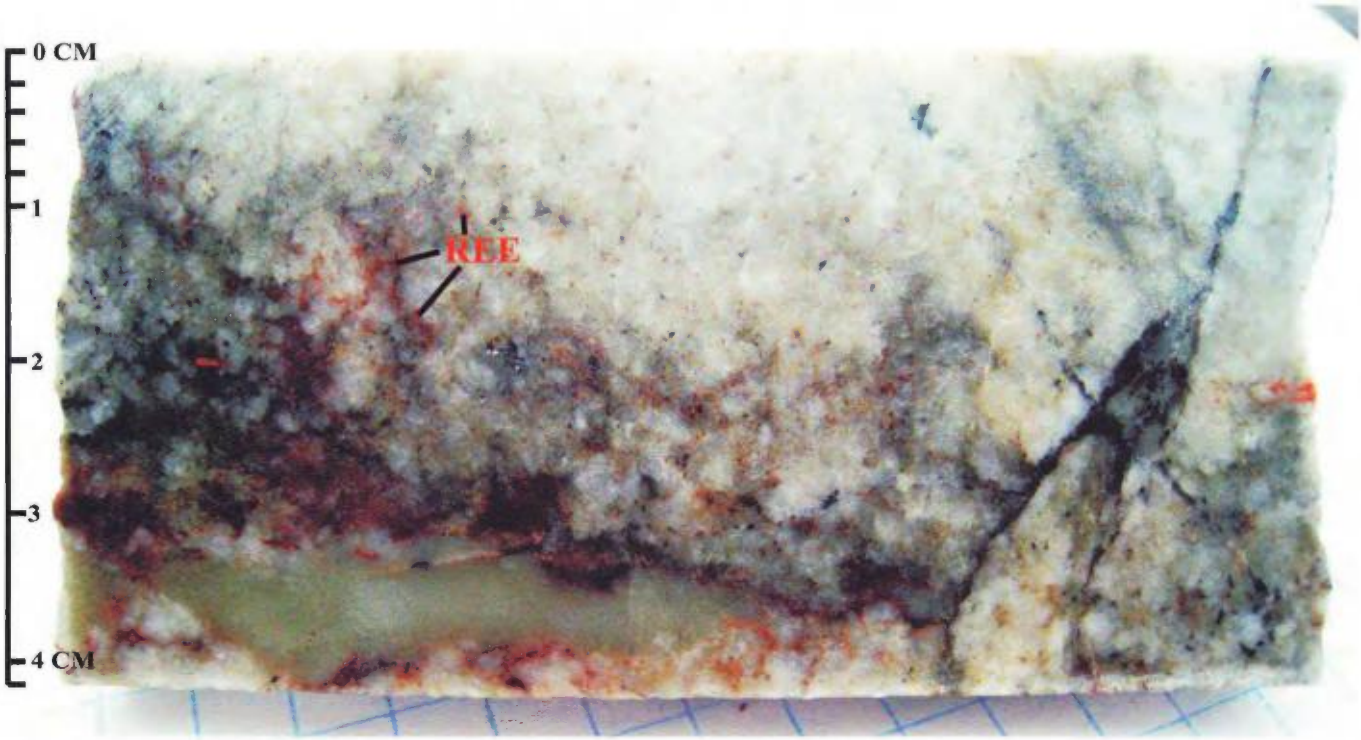


Fig.1 Dolomite carbonatite with red REE fluorocarbonates (REE). The interval that contained this intersection ran 14,885.65 combined REE's in analysis. Note the obvious red parisite. P_2O_5=0.84%, Nb=1856.8 ppm, Ta=17.8 ppm, REE+Y=1.49%

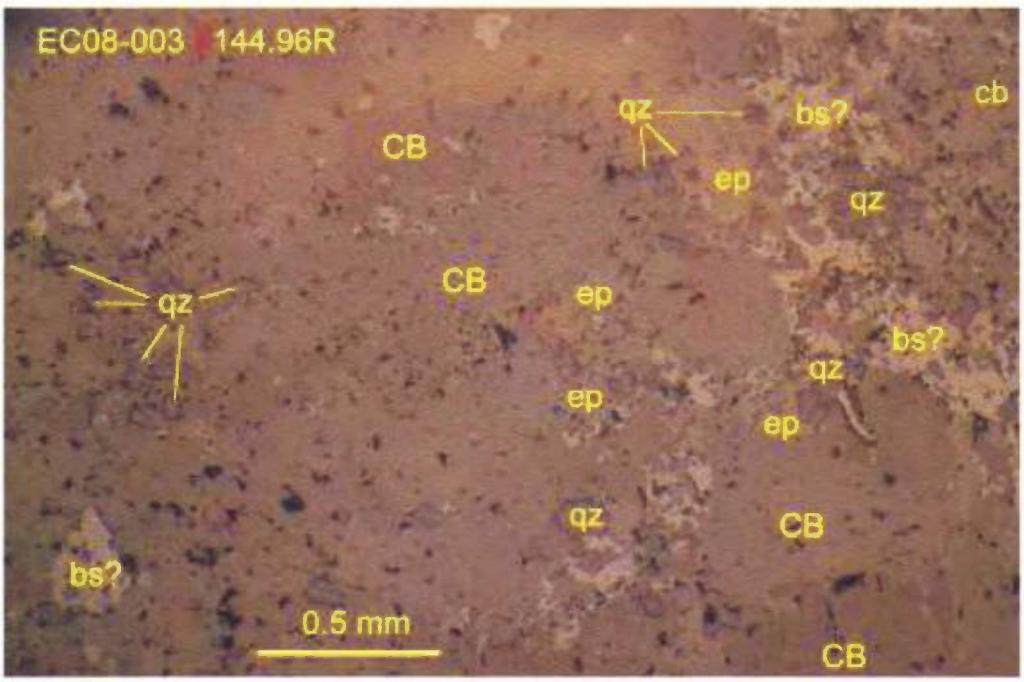


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-003 144.96m, CB=coarse-grained carbonate, cb=fine-grained carbonate, ep=epidote, qz=quartz, bs?=bastnaesite? Reflected light, uncrossed polars.

continued ...

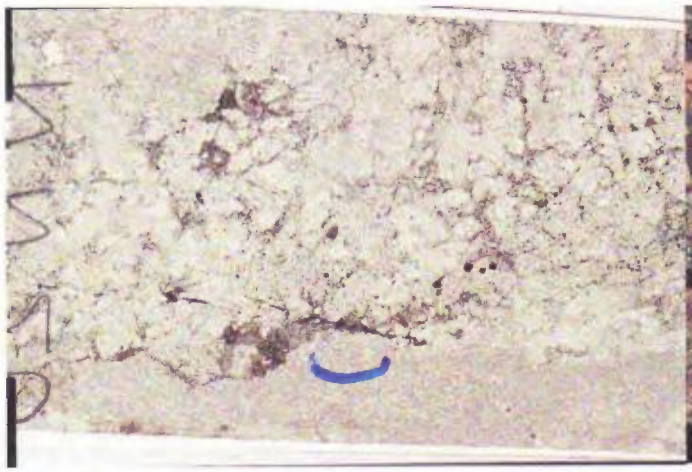


Fig.3 Thin section EC-08 003 144.96m plane polars

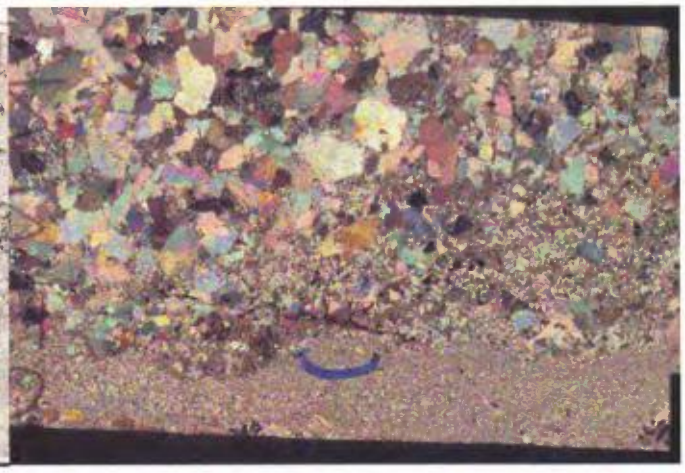


Fig.4 Thin section EC-08 003 144.96m cross polars

The total REE values for this interval are similar to the values found in the Ashram zone. I suspect this intersection is genetically related to the Ashram zone REE mineralization.

Grey Dolomite Carbonatite in contact with rusty porous dolomite carbonatite

EC08-003 at119.18m

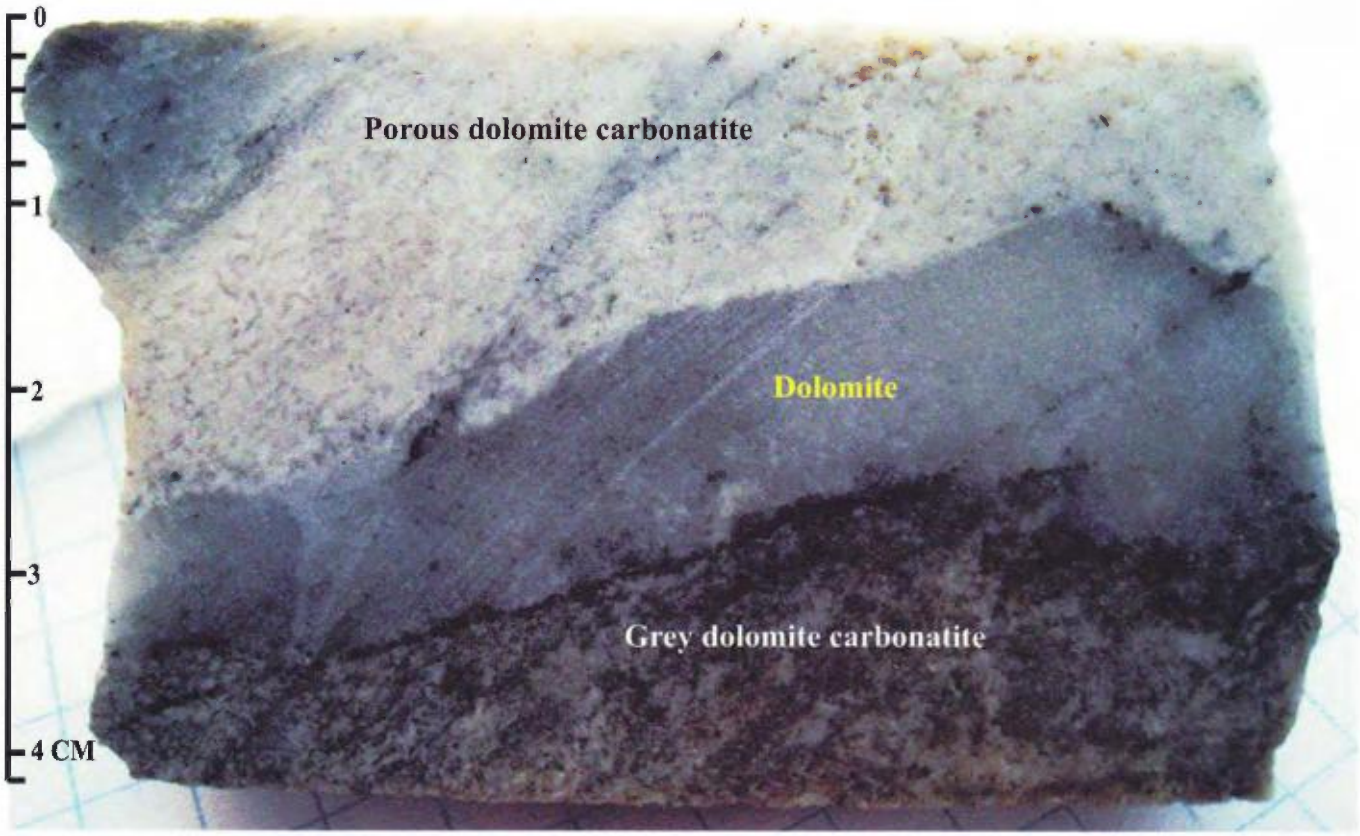


Fig.1 Grey dolomite carbonatite in contact with ?re-mobilized rusty, porous dolomite carbonatite. P_2O_5=2.10%, Nb=988 ppm, Ta=10.9 ppm, REE+Y=0.13%

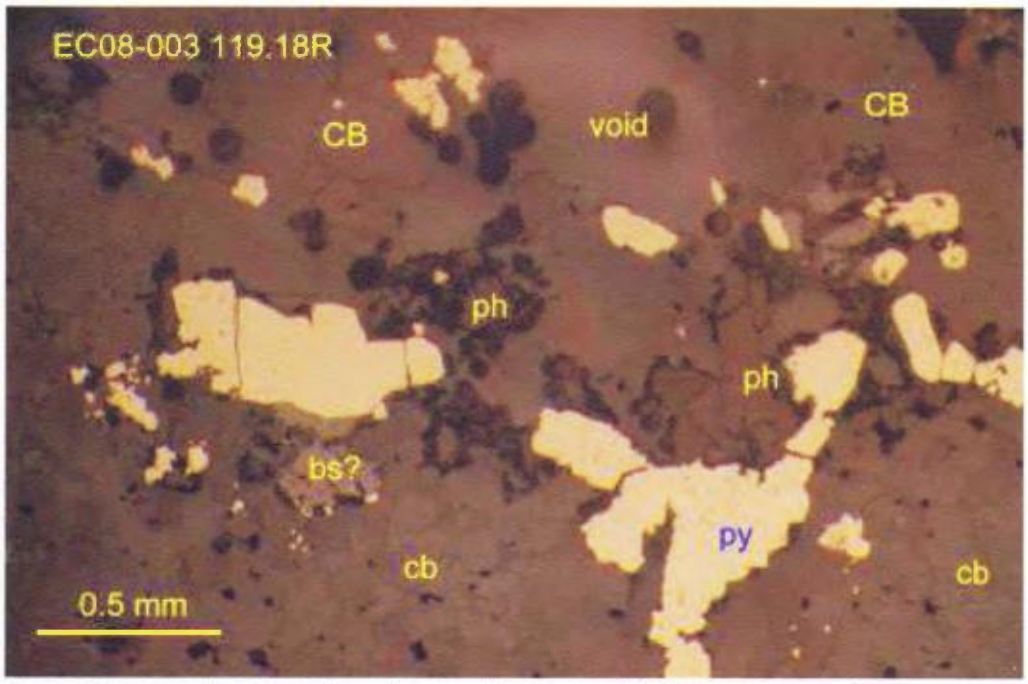


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-003 119.18m, cb=fine-grained carbonate,CB=coarse-grained carbonate, py=pyrite, bs?=bastnaesite?, ph=phlogopite. Reflected light, uncrossed polars.

continued ...

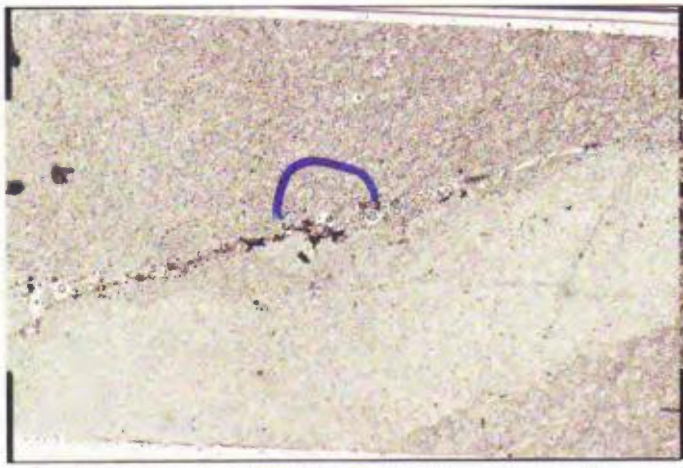


Fig.3 Thin section EC-08 003 119.18m plane polars

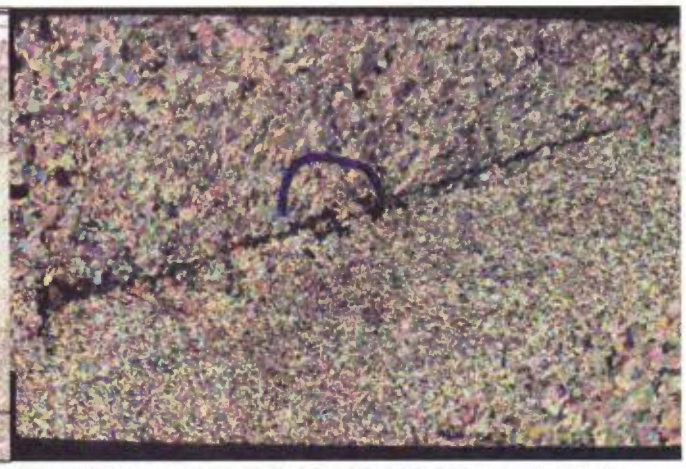


Fig.4 Thin section EC-08 003 119.18m cross polars

The rusty, vuggy carbonatite layer corresponds to low Sr values in our analyses (<1000ppm) and I believe this is remobilized carbonatite that has lost its characteristic high Sr signature. Apatite, sulphides and REE minerals can be found in the vuggy dolomite but they, too, have migrated and re-crystallized. The solid grey band (in the middle) is almost completely dolomite and I believe is re-mobilzed, re-crystallized dolomite intruding along the contact between the vuggy, re-mobilized, dolomite carbonatite and the grey dolomite carbonatite.

Rusty Porous Dolomite Carbonatite with dolomite vein

EC08-005 at 106.33m

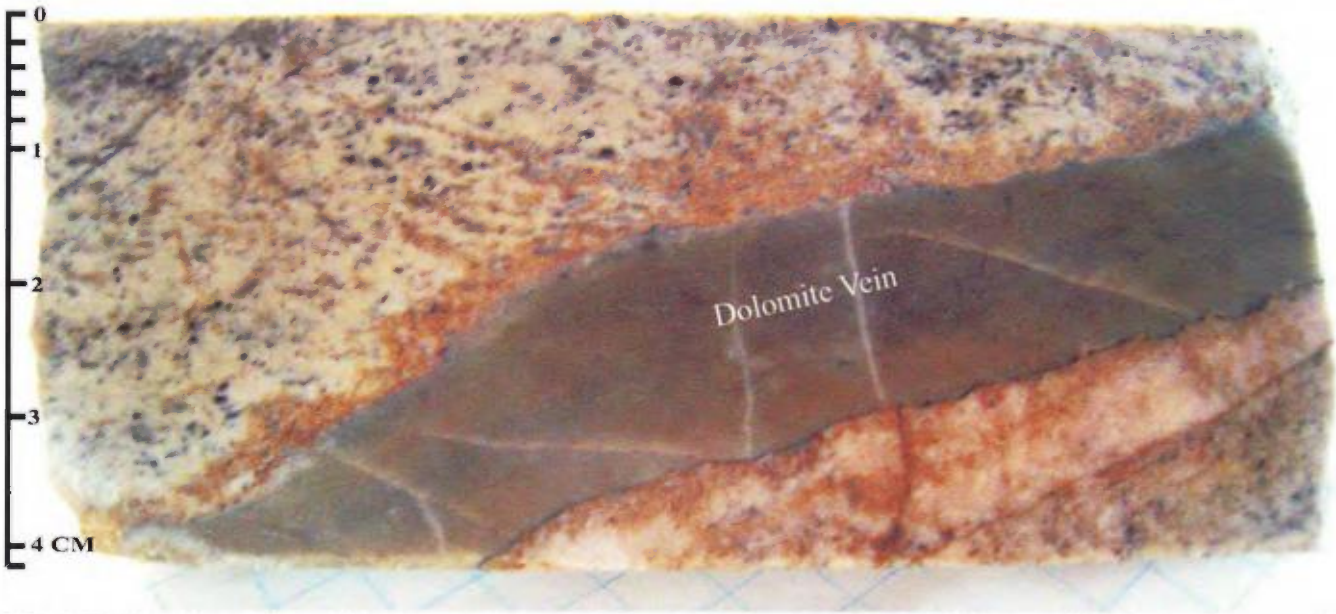


Fig.1 Dolomite carbonatite, rusty, vuggy with euhedral mineral assemblage and hydrocarbons cut by dolomite vein. P_2O_5=3.4%, Nb=1853.6 ppm, Ta=34.5 ppm, REE+Y=0.21%

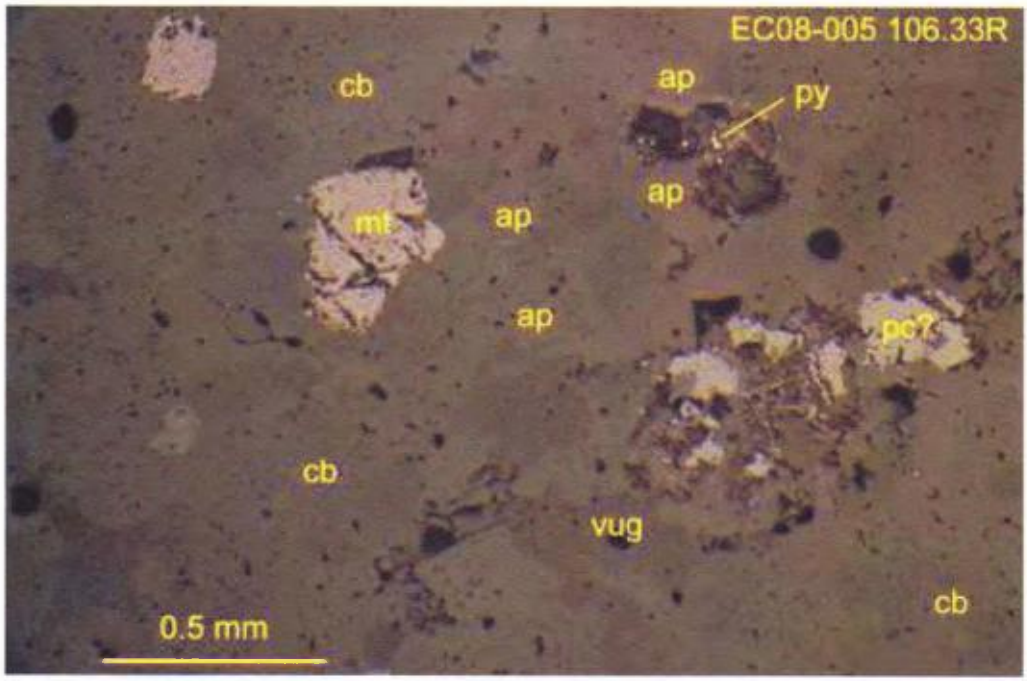


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-005 106.33m, cb=carbonate, ap=apatite, pc?=pyrochlore, mt=magnetite, vug=natural void, py=pyrite. Reflected light, uncrossed polars.

continued ...

Fig.3 Thin section EC-08 005 106.33m plane polars

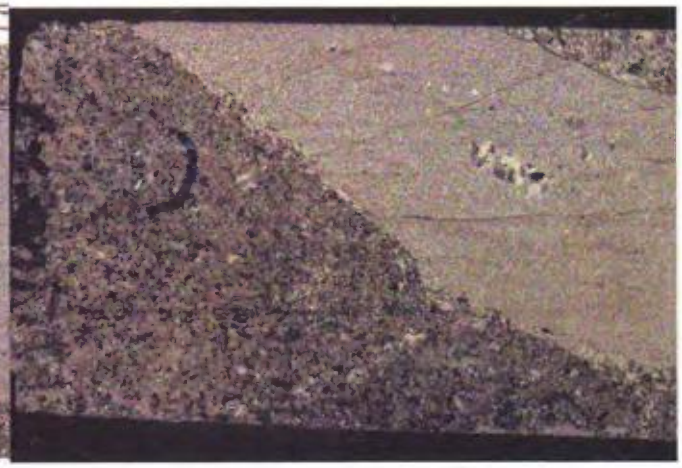


Fig.4 Thin section EC-08 005 106.33m cross polars

I found solid hydrocarbons in this porous, vuggy dolomite. Hydrocarbon is a very rare constituent of carbonatites. The only other alkaline-carbonatite complex with hydrocarbons that I am aware of is the Khibiny Complex in the Kola Penninsula of NW Russia (Niven, V. A. *et al.*, 2005). Apart from being an interesting mineralogical note on the Eldor Carbonatite, **these hydrocarbons may indicate the presence of dangerous hydrocarbon gas.**

Rusty, Vuggy Dolomite Carbonatite

EC08-005 at 114.36m

Fig.1 Dolomite carbonatite, rusty, vuggy with euhedral mineral assemblage and hydrocarbons. P_2O_5=4.48%, Nb=2078.4 ppm, Ta=25.5 ppm, REE+Y=0.16%

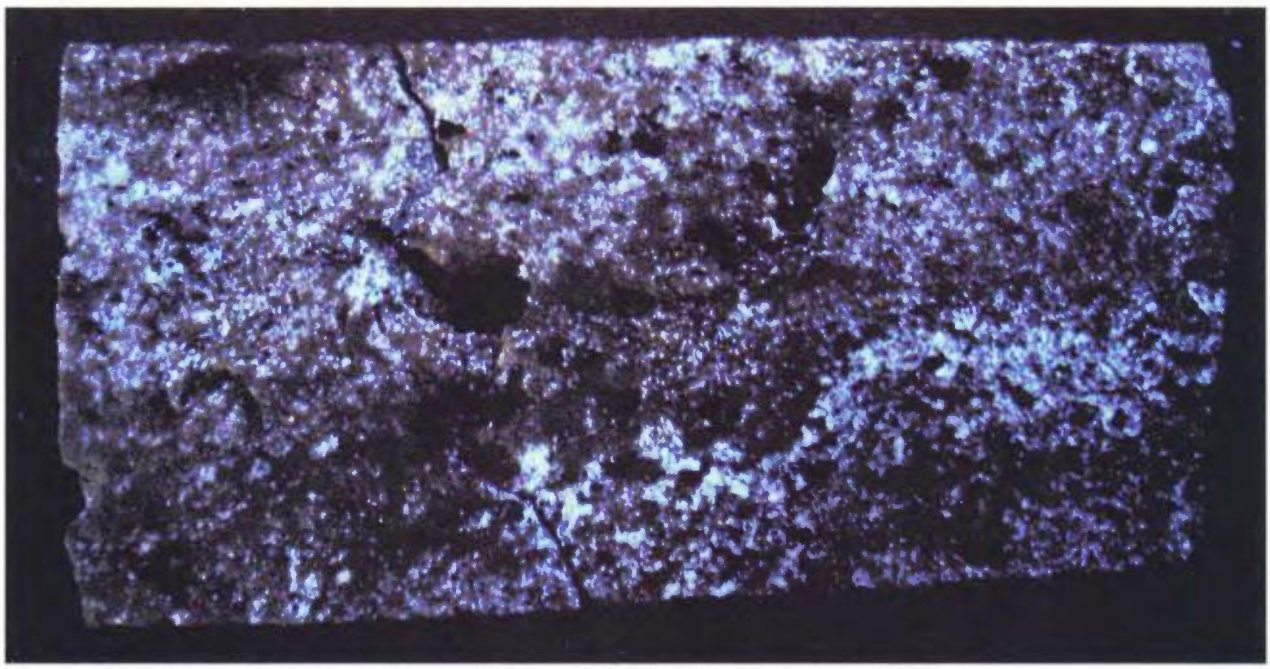


Fig. 2 Vuggy dolomite carbonatite in midrange UV light. Blue-white is apatite.

continued ...

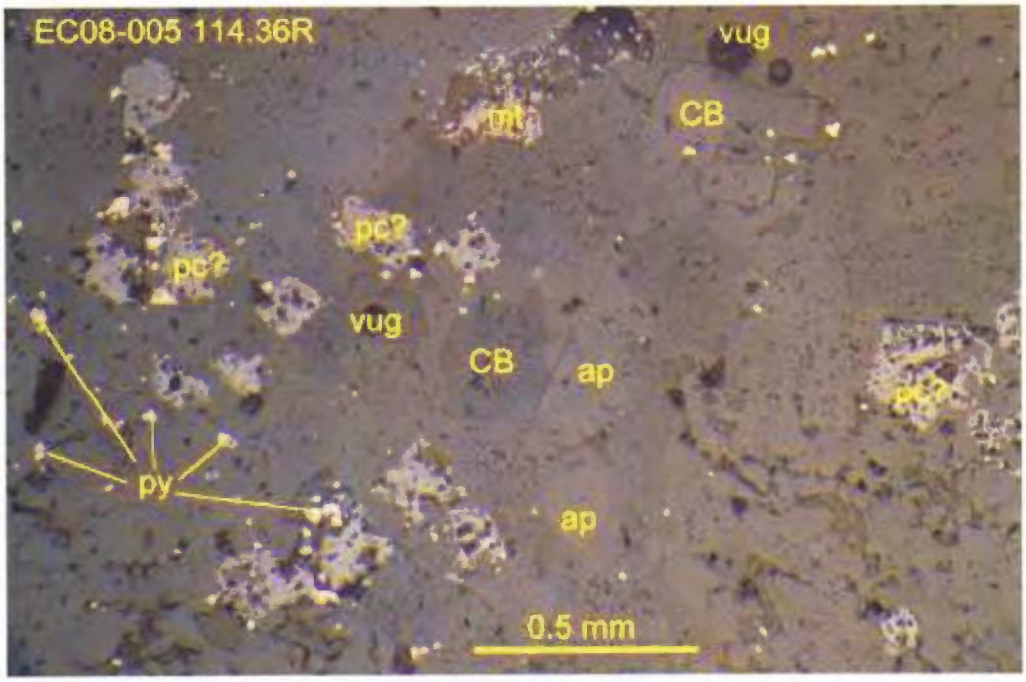


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-005 114.36m, vug=natural void, CB=carbonate, ap=apatite, pc?=pyrochlore, py=pyrite.. Reflected light, uncrossed polars.

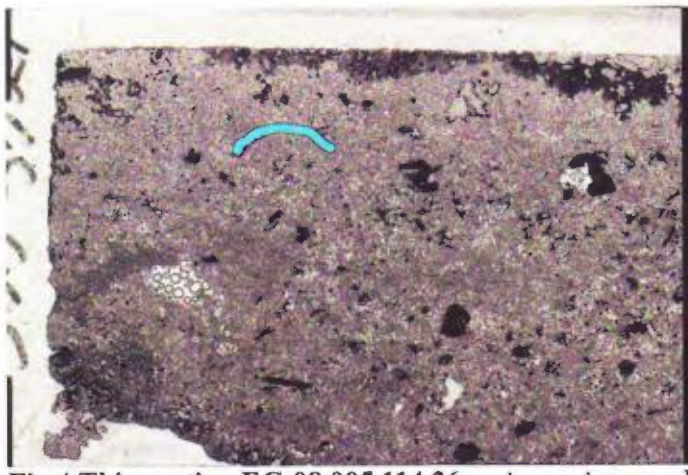


Fig.4 Thin section EC-08 005 114.36m plane polars

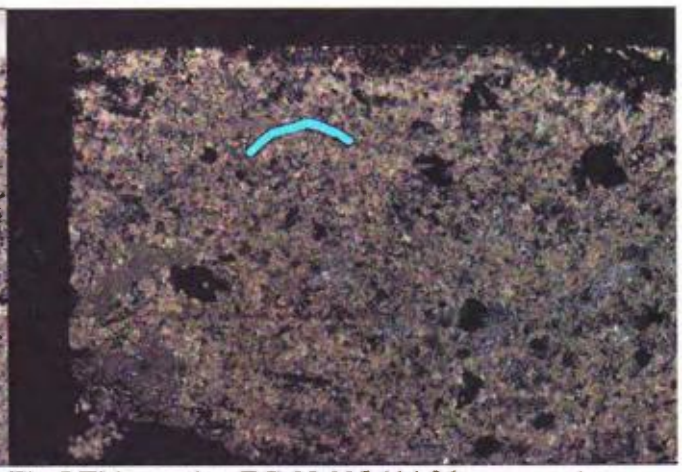


Fig.5 Thin section EC-08 005 114.36m cross polars

This is the same low-Sr-value porous dolomite thaat was found in EC08-005 at 106.33m, with the same hydrocarbons but contained in larger vugs. Note that Dr. Craig Lietch did not find hydrocarbon, quartz or sphalerite in this thin section. These minerals occur in the vugs and it is conceivable that they 'plucked' during thin section preparation.

Dolomite Carbonatite with altered pyrochlore

EC08-005 at 99.44m

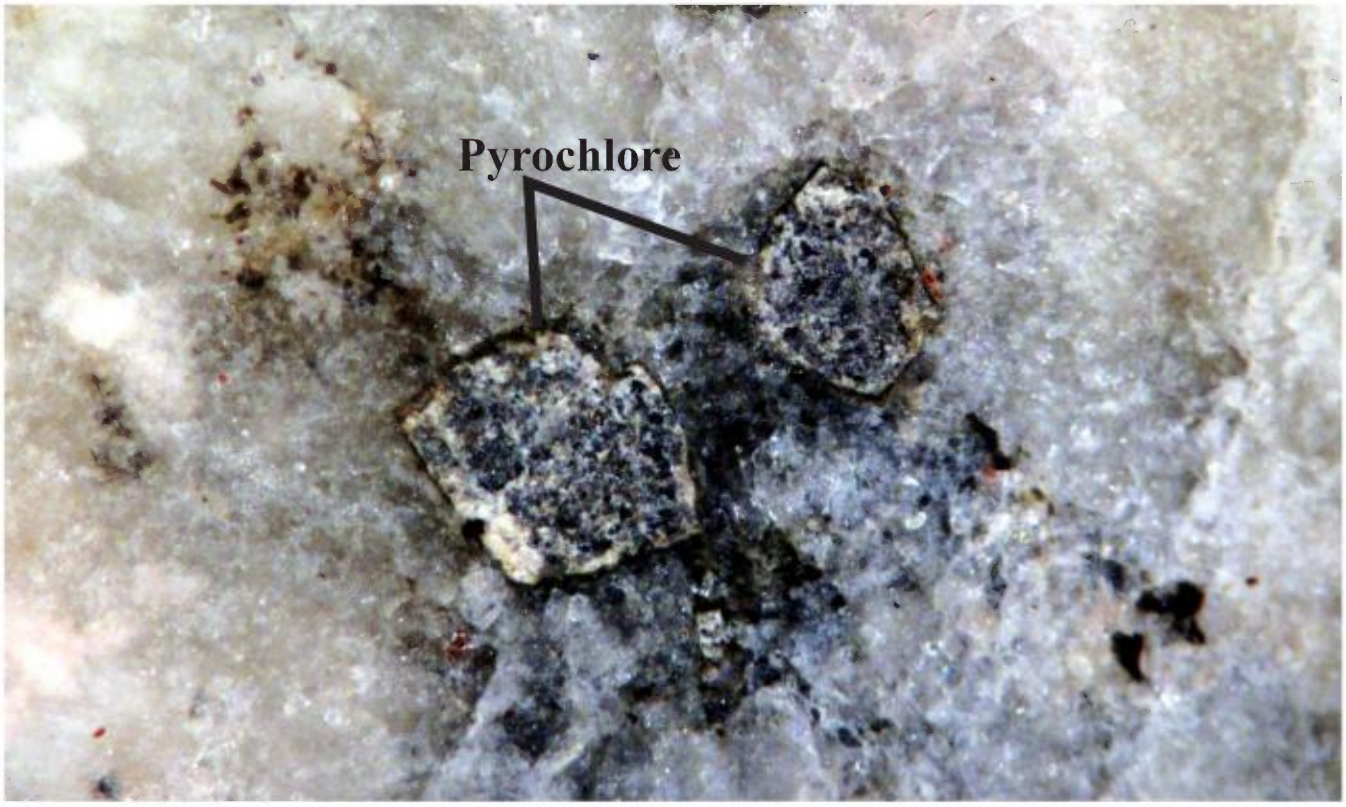


Fig.1 Micro-photo of dolomite carbonatite with altered pyrochlore. P_2O_5=3.09%, Nb=1162.3 ppm, Ta=26.5 ppm, REE+Y=0.22%

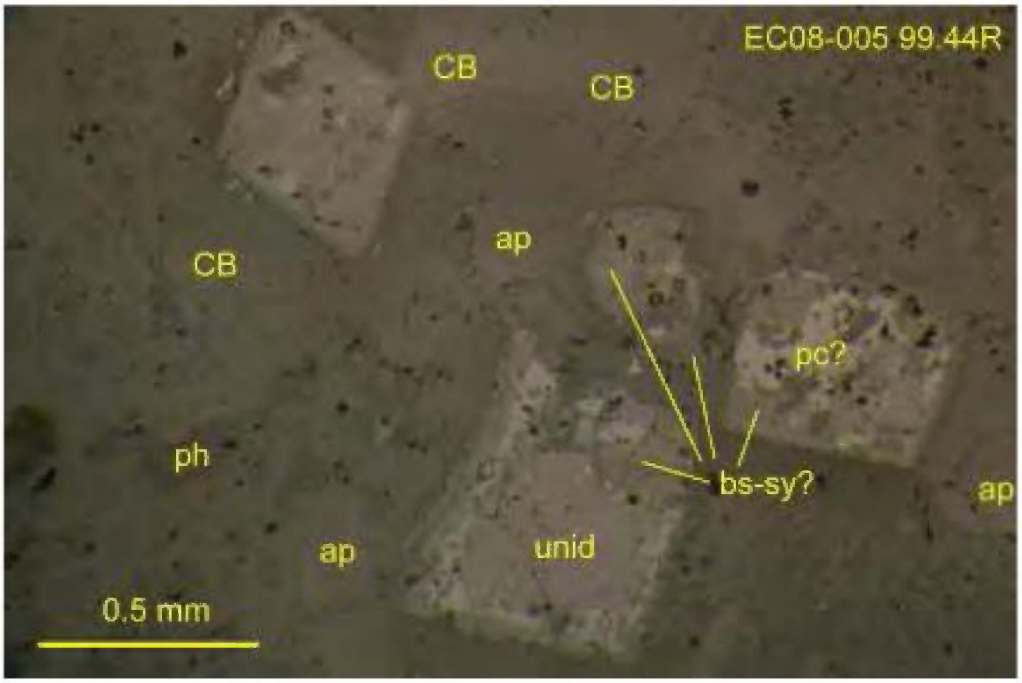


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-005 99.44m, CB=carbonate, ph=phlogopite, unid=unidentified, bs-sy?=bastnaesite-synchesite?, pc?=pyrochlore?, ap=apatite. Reflected light uncrossed polars

continued ...

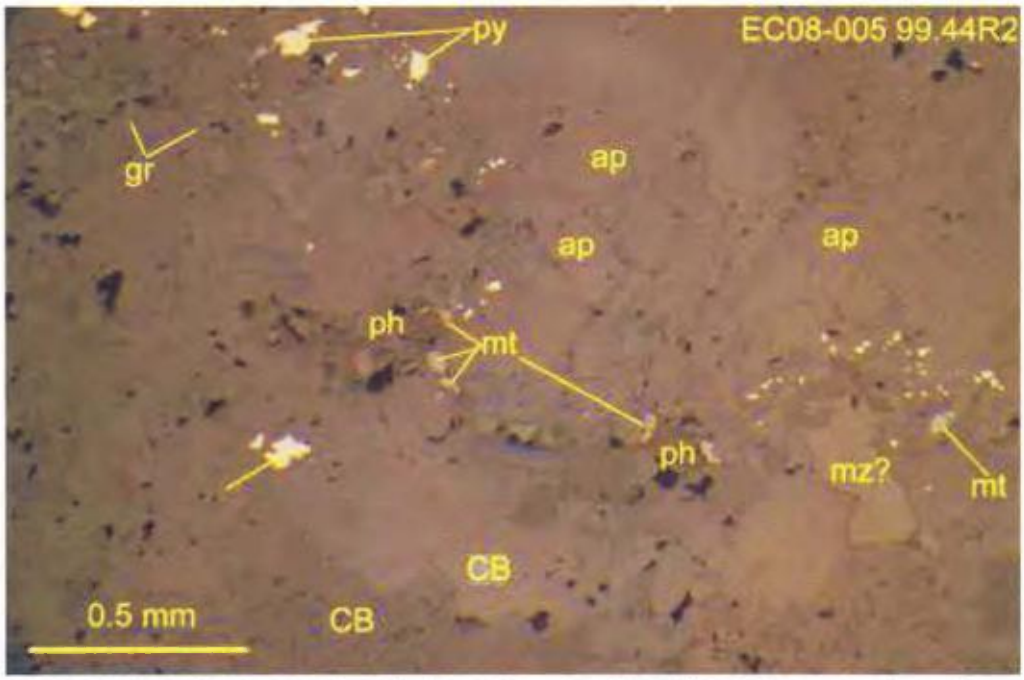


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-005 99.44m, ph=phlogopite, ap=apatite, mt=magnetite,mz?=monazite, CB=carbonate, py=pyrite, gr=graphite. Reflected light, uncrossed polars.

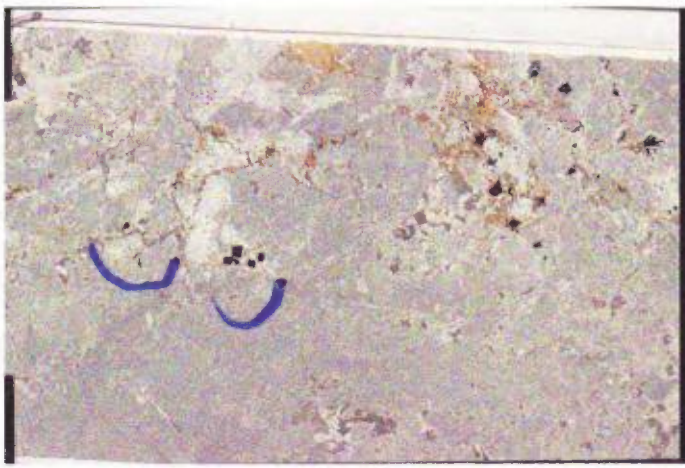


Fig.4Thin section EC-08 005 99.44m plane polars

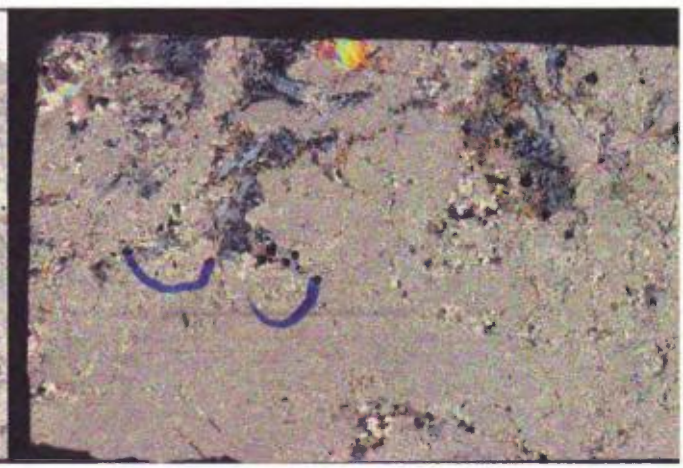


Fig.5 Thin section EC-08 005 99.44m cross polars

This sample requires further SEM/EMPA work to define its rare earth mineral assemblage and the different carbonate phases present.

Dolomite Carbonatite

EC08-006 at 100.24m

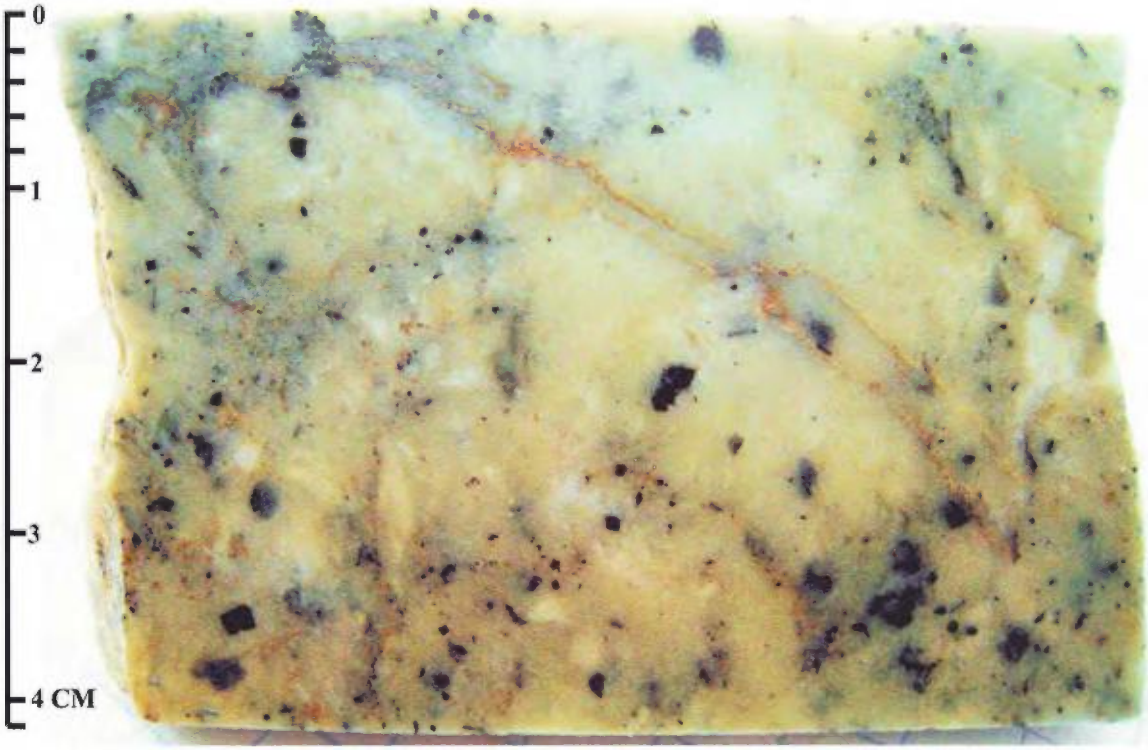


Fig.1 Magnesio-carbonatite P_2O_5=6.48%, Nb=2089.4 ppm,Ta=4.2 ppm, REE+Y=0.50%

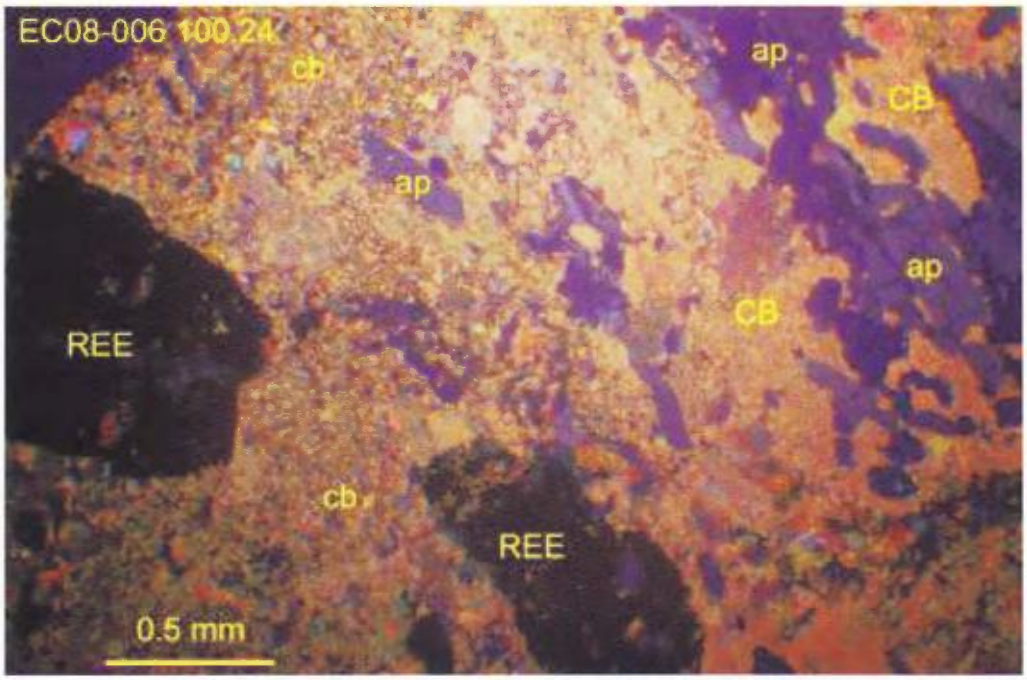


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-006 100.24m, cb=fine-grained carbonate, CB=coarse-grained arbonate, REE=unidentified REE mineral, ap=apatite. Transmitted light, crossed polars.

continued ...

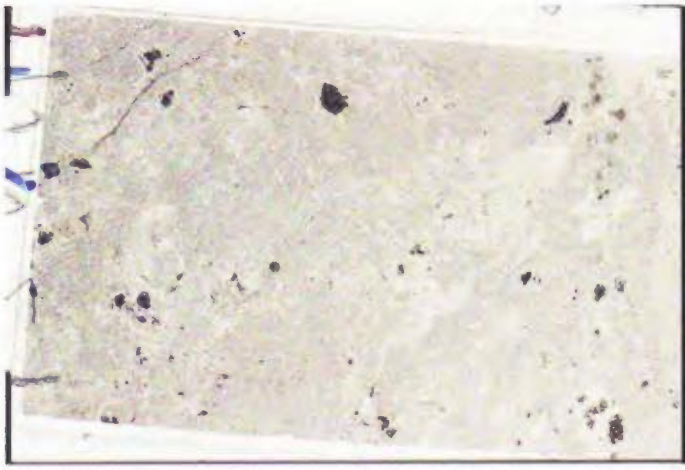


Fig.3 Thin section EC-08 006 100.24m plane polars

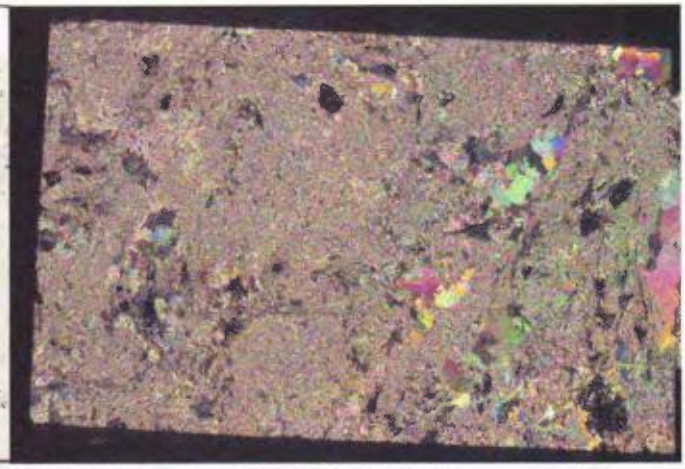


Fig.4 Thin section EC-08 006 100.24m cross polars

This magnesio-carbonatite shows the effects of some metamorphism. There are unidentified minerals in this section that require SEM/EMPA work to identify.

Dolomite Carbonatite with vug

EC08-014 at 31.32m

The following sample presents some of the diversity of euhedral minerals found in vugs at Eldor.

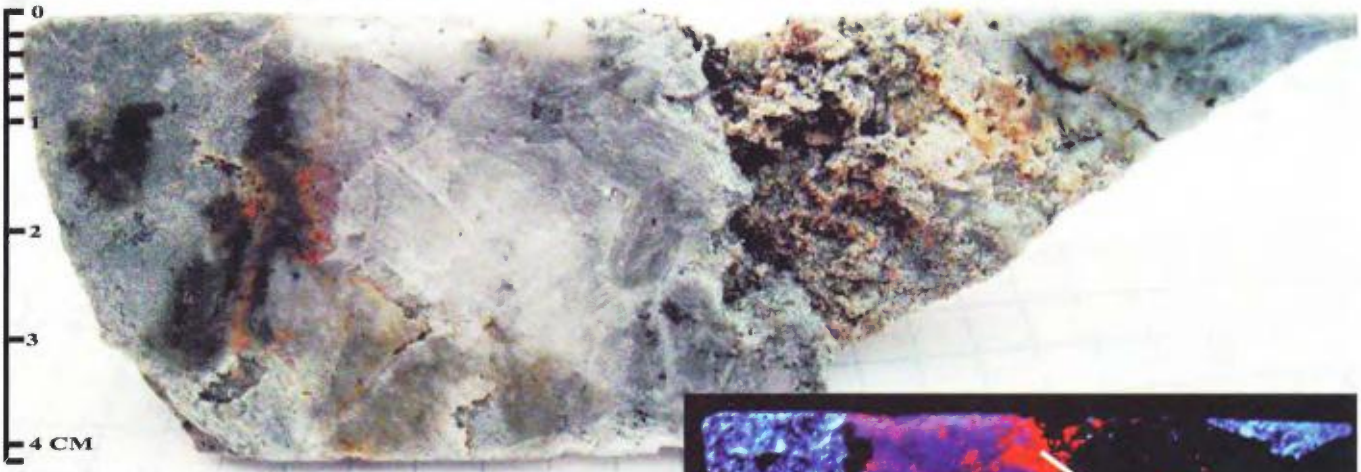


Fig.1 Dolomite carbonatite with well crystallized minerals in vug. P_2O_5=7.66%, Nb=1465.7 ppm, Ta=29.3 ppm, REE+Y=0.55%

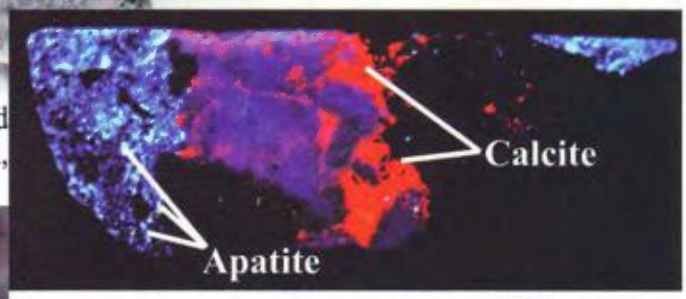


Fig. 2 Core sample under midrange UV. Blue-white is apatite, red is calcite, purple is reflected UV light.

Fig. 3 Micro-photo of siderite(?) with yellow REE? (REE) mineral

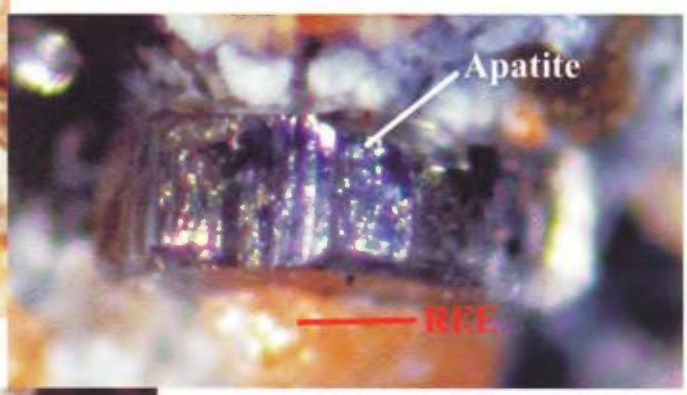


Fig. 4 Micro-photo of apatite with yellow REE? (REE)mineral

Fig. 5 Micro-photo of calcite with yellow REE? mineral

continued ...

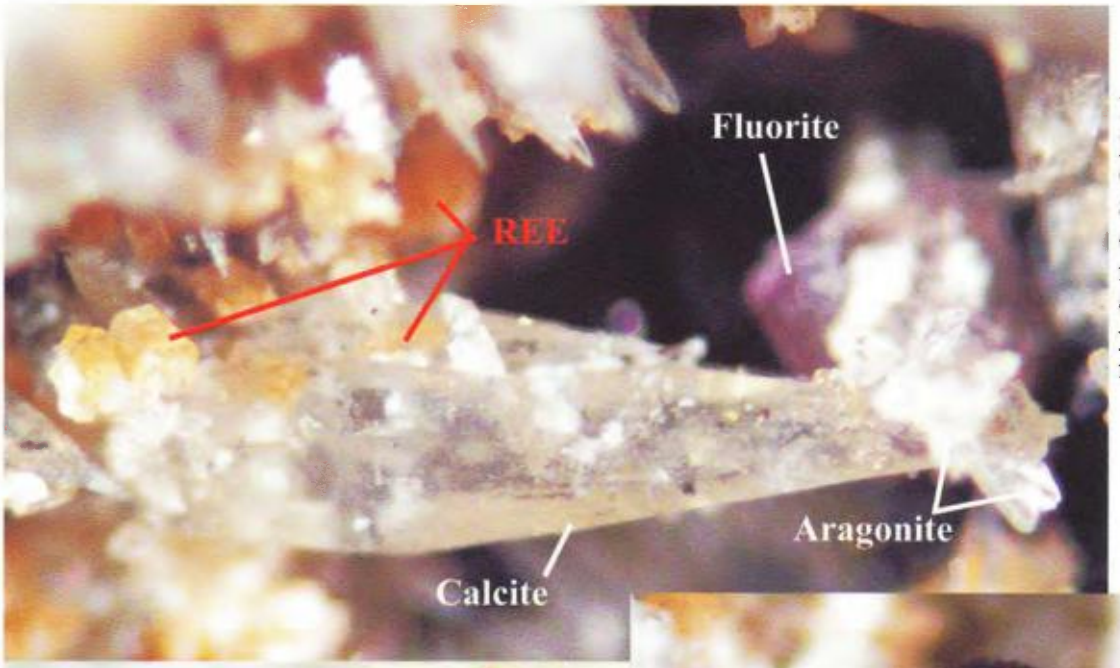


Fig. 6 Micro-photo of calcite (center) with aragonite (on tip of calcite, center right), fluorite (purple), and yellow REE? mineral.

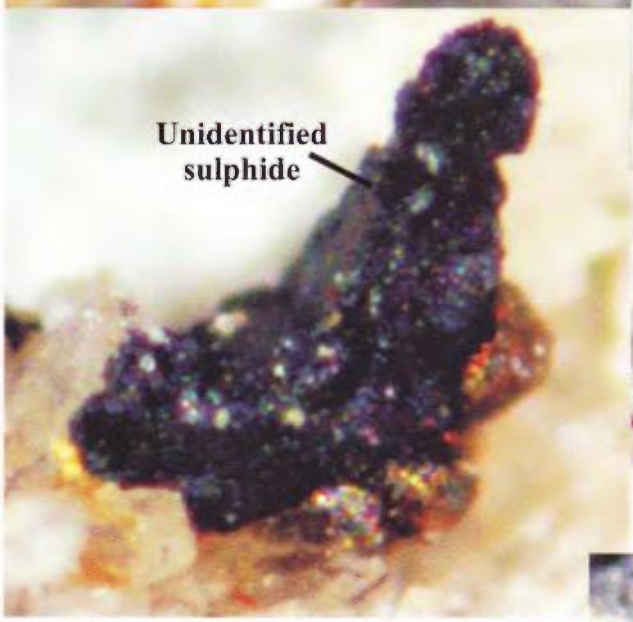


Fig. 8 Micro-photo of unidentified sulphide

Fig. 7 Micro-photo of botryoidal hydrocarbon with yellow REE? (REE) mineral

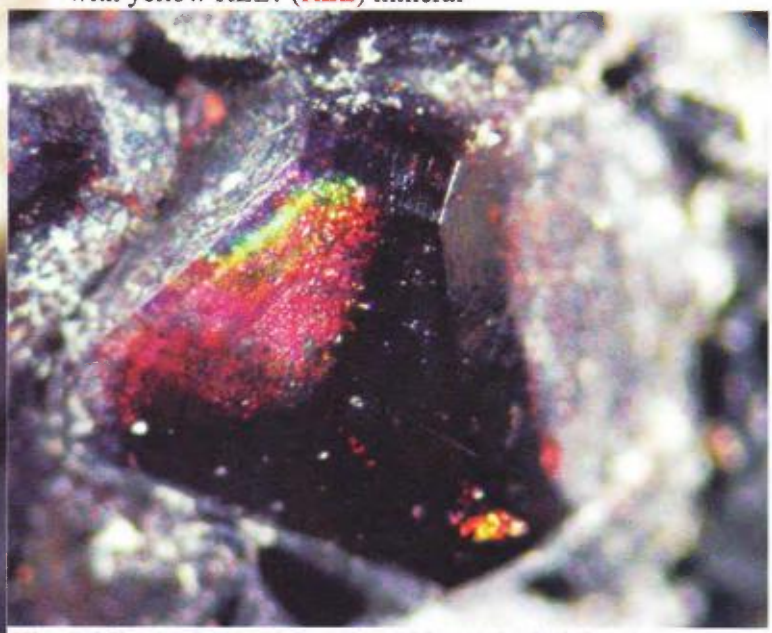


Fig. 9 Micro-photo of fluorite with octahedral faces.

Fig. 10 Micro-photo of aragonite on sphalerite

Dolomite Carbonatite with REE mineralization

EC08-015 at 49.54m

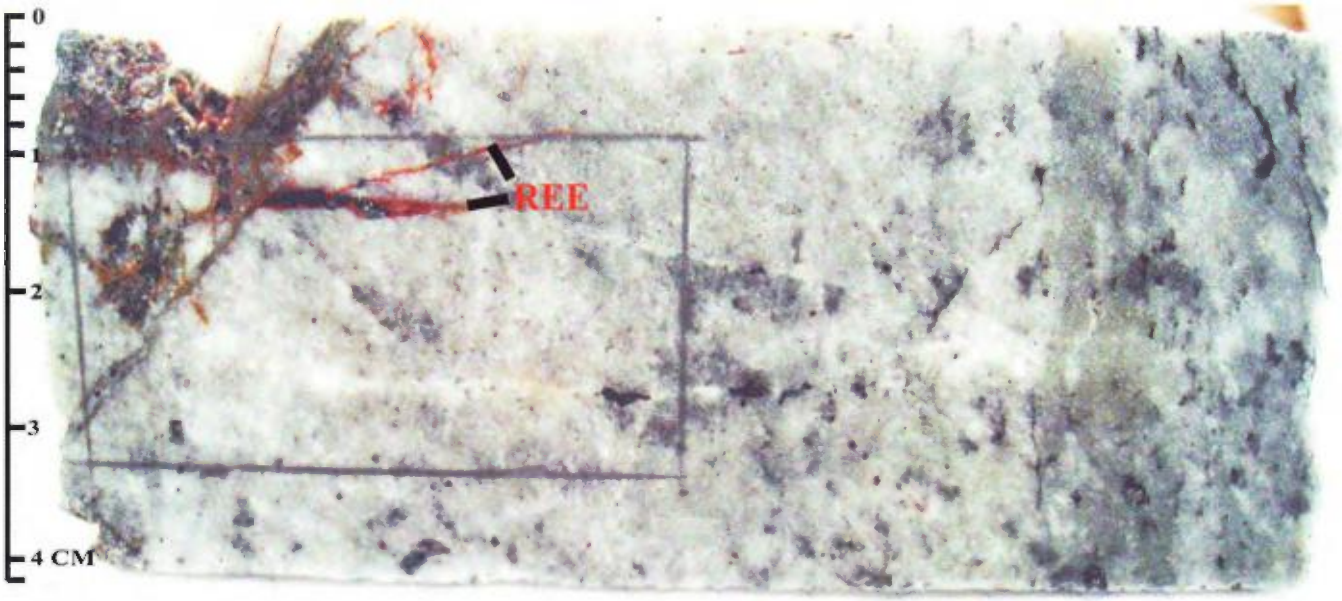


Fig.1 Red REE minerals (REE) in fractures and vug in dolomite carbonatite. P_2O_5=6.18%, Nb=2455.8 ppm, Ta=133 ppm, REE+Y=0.19%

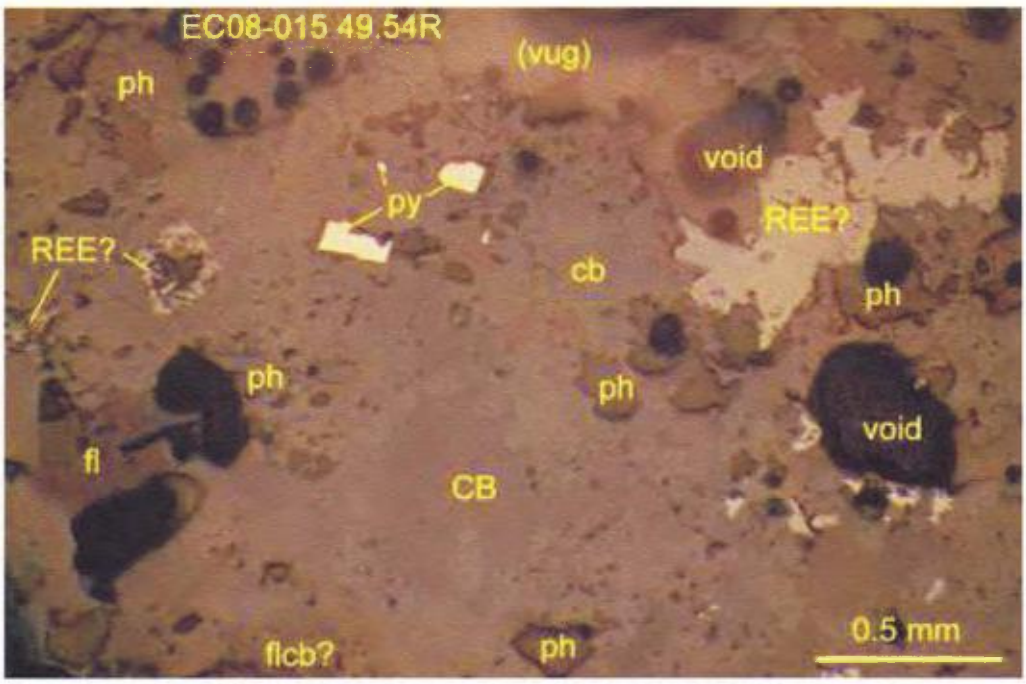


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-015 49.54m, ph=phlogopite, py=pyrite, REE?=unidentified REE? mineral, fl=fluorite, CB=coarse-grained carbonate, cb=fine-grained carbonate, flcb?=fluorocarbonate? Reflected light uncrossed polars.

continued ...

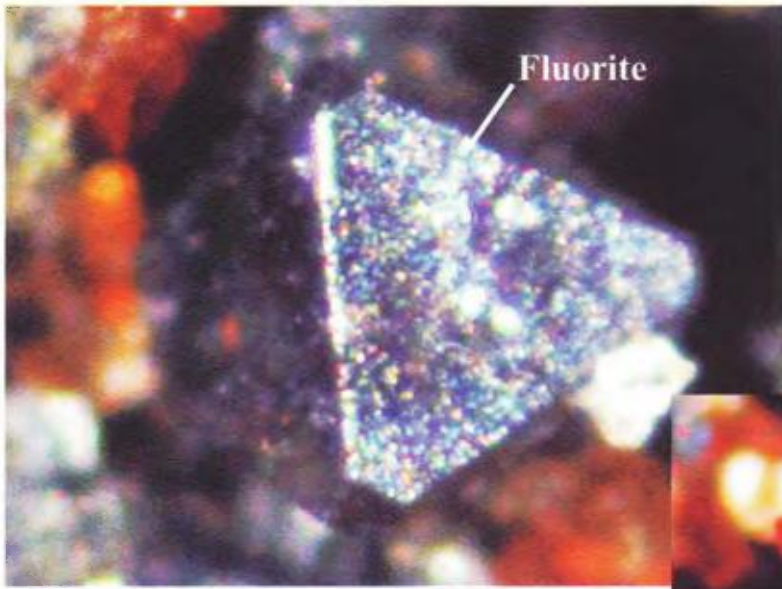


Fig. 3 Micro-photo of fluorite found in vug on sample EC08-015 49.54m.

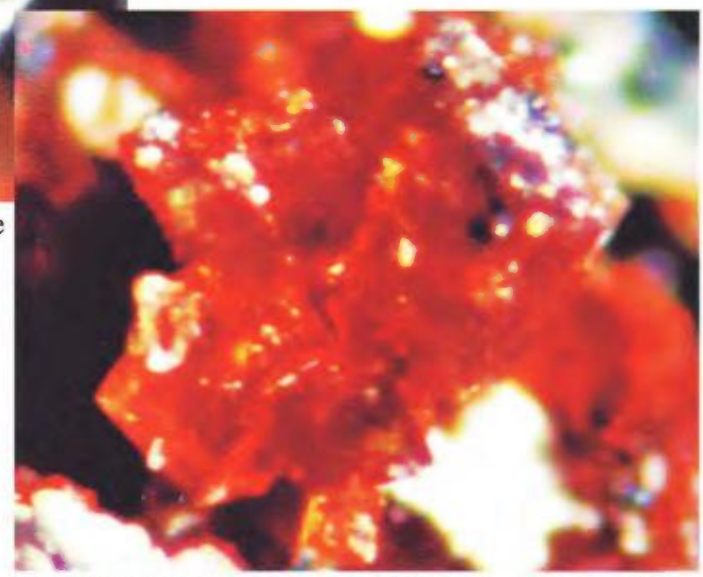


Fig. 4 Micro-photo of unidentified red mineral, - likely REE-bearing, found in vug on sample EC08-015 49.54m

Fig.5 Thin section EC-08 015 49.54m plane polars

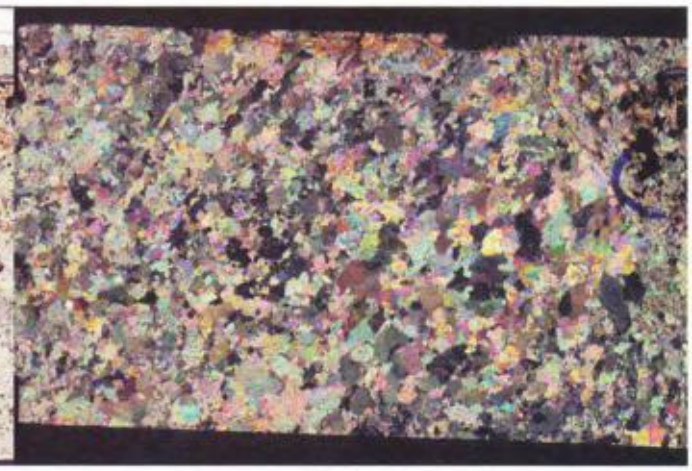


Fig.6 Thin section EC-08 015 49.54m cross polars

The REE? minerals and fluorite in Figs, 3 & 4 (above) tie this sample to the event that produced the Ashram REE zone.

Dolomite Carbonatite with vein of visible REE mineralization

EC08-016 at 111.93m

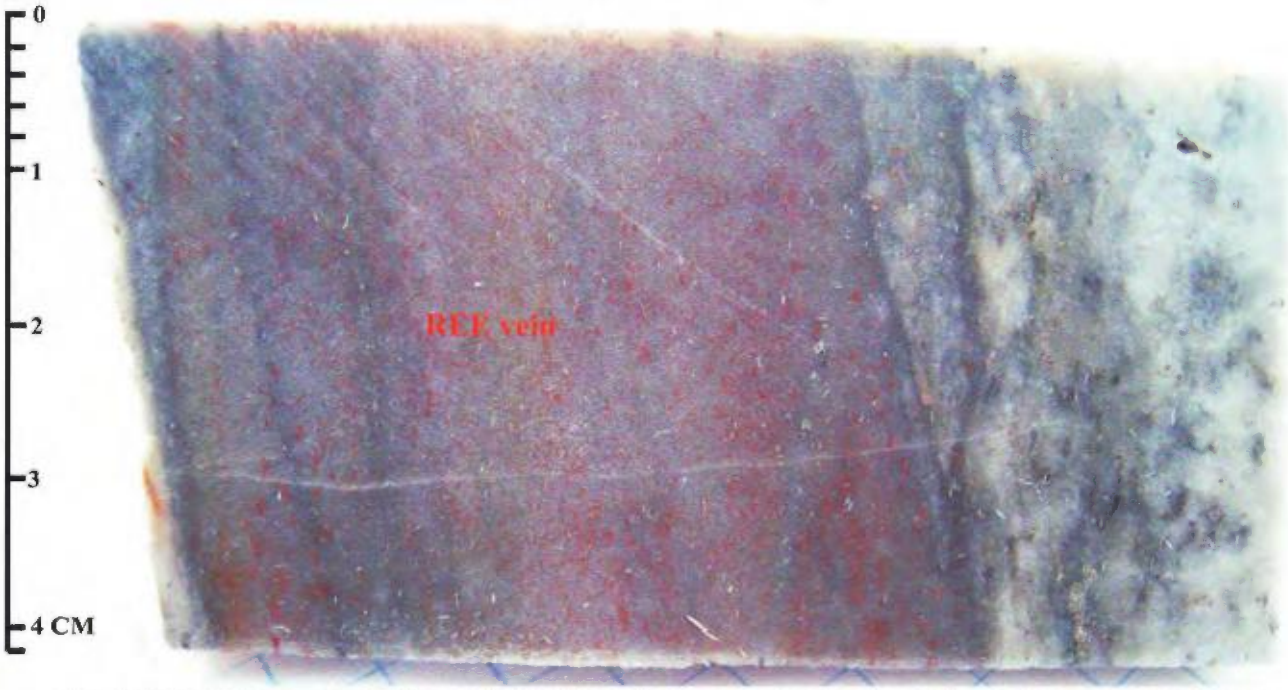


Fig.1 Dolomite carbonatite with REE (red) mineralized vein. P_2O_5=3.52%, Nb=2386.4 ppm, Ta=52 ppm, REE+Y=0.17%

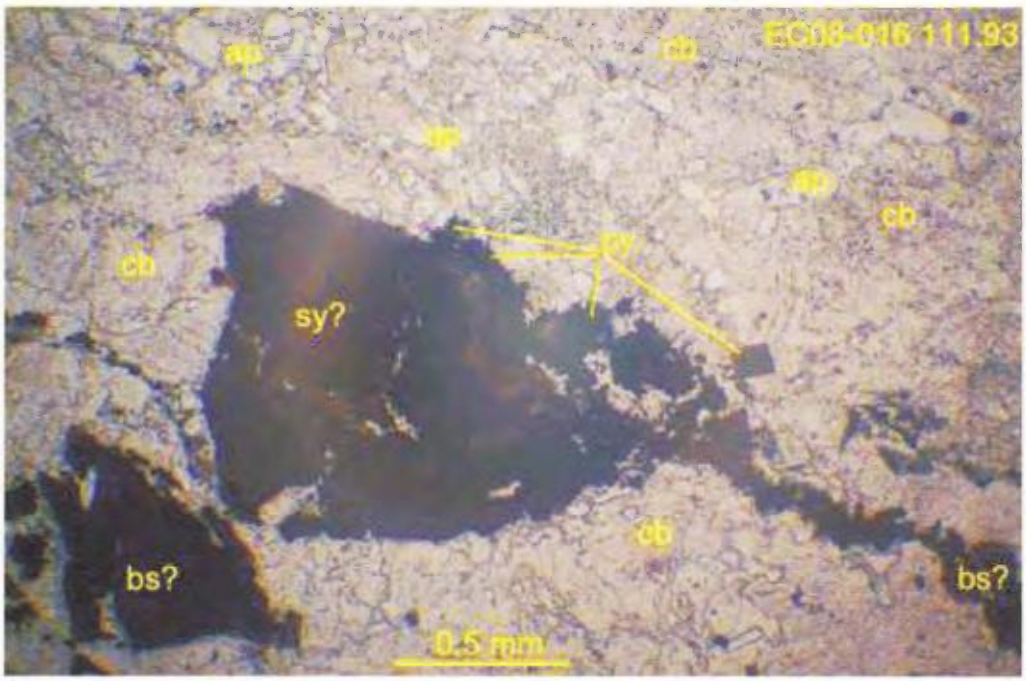


Fig. 2 Photo by Craig Leitch . sy?=synchesite, bs?=bastnaesite?, cb=carbonate, ap=apatite, py=pyrite. Transmitted plane light

Owing to time constraints at the University of Alberta, the thin section for EC08-016 111.93m was not scanned. This sample is not a REE-bearing dolomite carbonatite but a dolomite,/REE vein in contact with a typical dolomite carbonatite.

MARCASITE ON UNIDENTIFIED ORANGE, POSSIBLE REE MINERAL WITH DOLOMITE

PLATE IV. I discovered at least a dozen unidentified minerals in my work on the 2008 diamond drill core from Eldor. This micro-photo shows an unidentified, orange, possible REE mineral dotted with marcasite.

Dolomite Carbonatite Breccia

EC08-016 at 12.76m

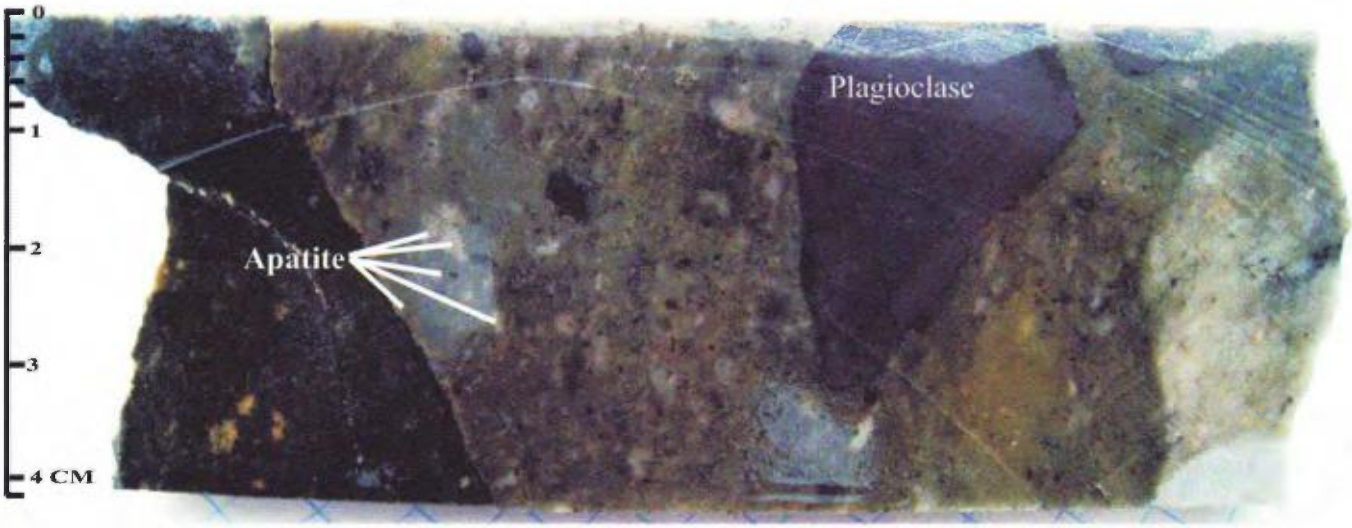


Fig.1 Dolomite carbonatite matrix with grey, largely plagioclase clasts. P_2O_5=2.89%, Nb=345.2 ppm, Ta=36.6 ppm, REE+Y=0.15%.

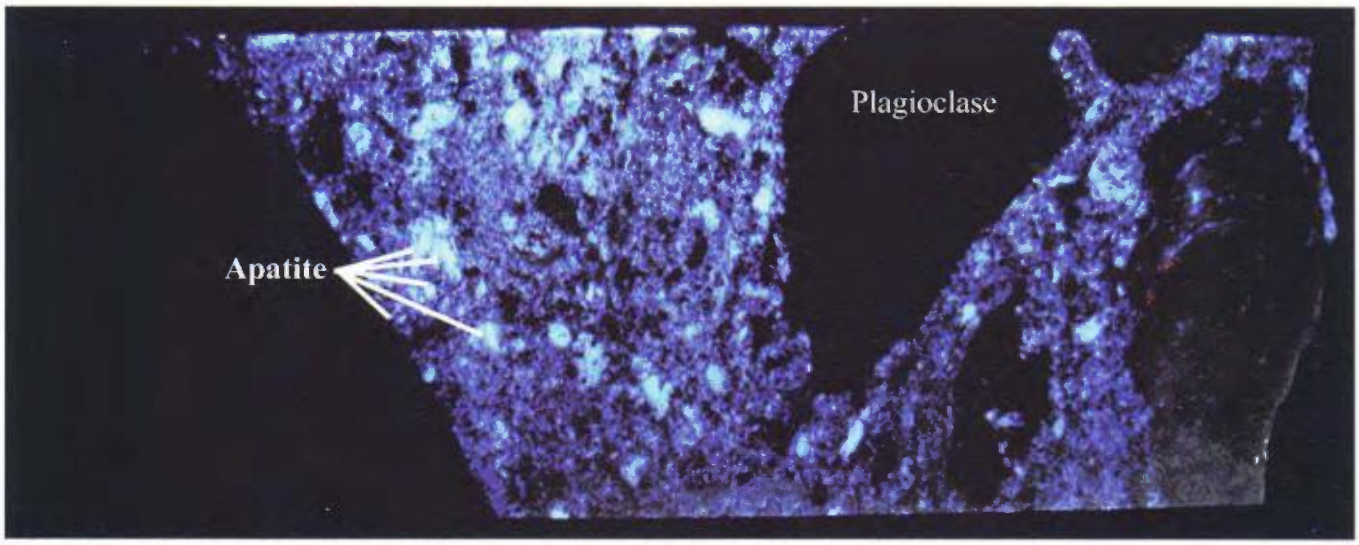


Fig. 2 EC08-016 12.76m under midrange UV. Blue-white is apatite.

continued ...

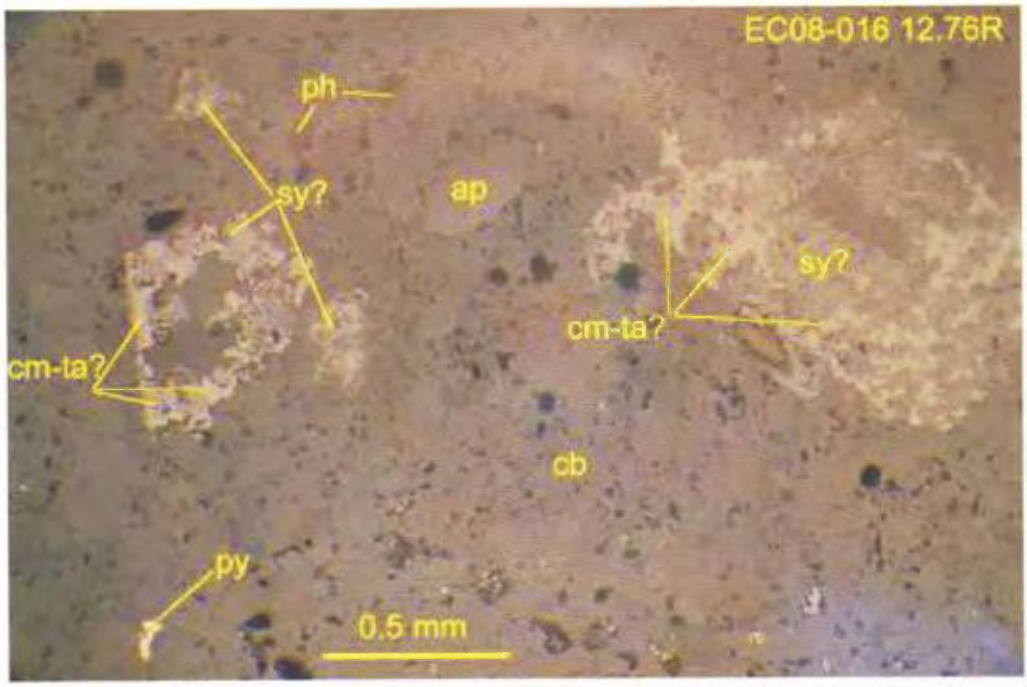


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-016 12.76m, ph=phloogpite, sy?=synchesite?, cmta?=columbite-tantalite?, py=pyrite,cb=carbonate.
Reflected light, uncrossed polars.

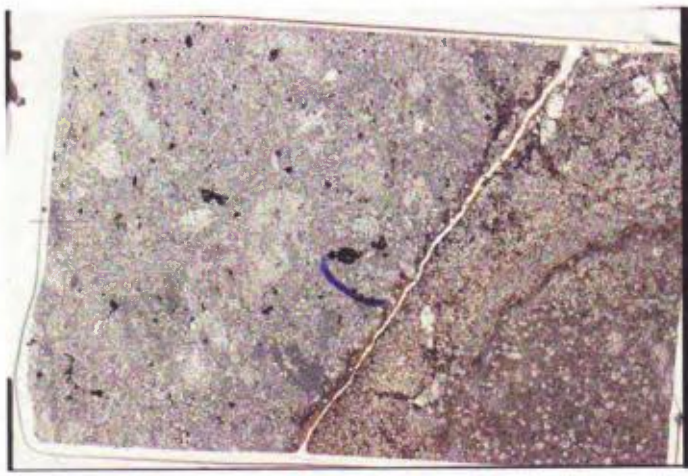


Fig.4 Thin section EC-08 016 12.76m plane polars

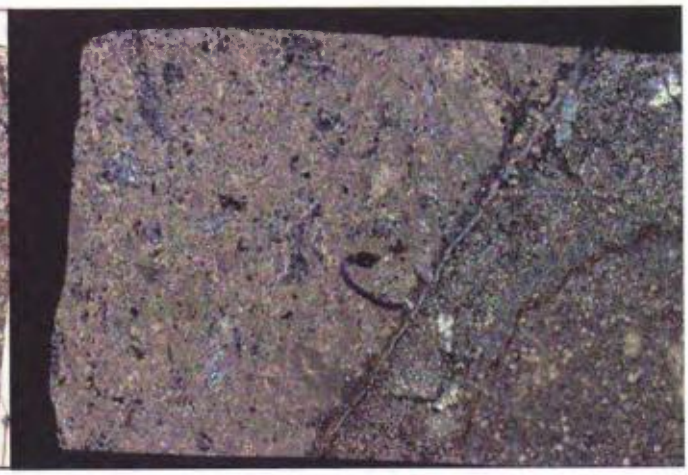


Fig.5 Thin section EC-08 016 12.76m cross polars

This is the same breccia found in EC08-014 at 74.90 metres.

Dolomite Carbonatite Breccia

EC08-014 at 74.90m

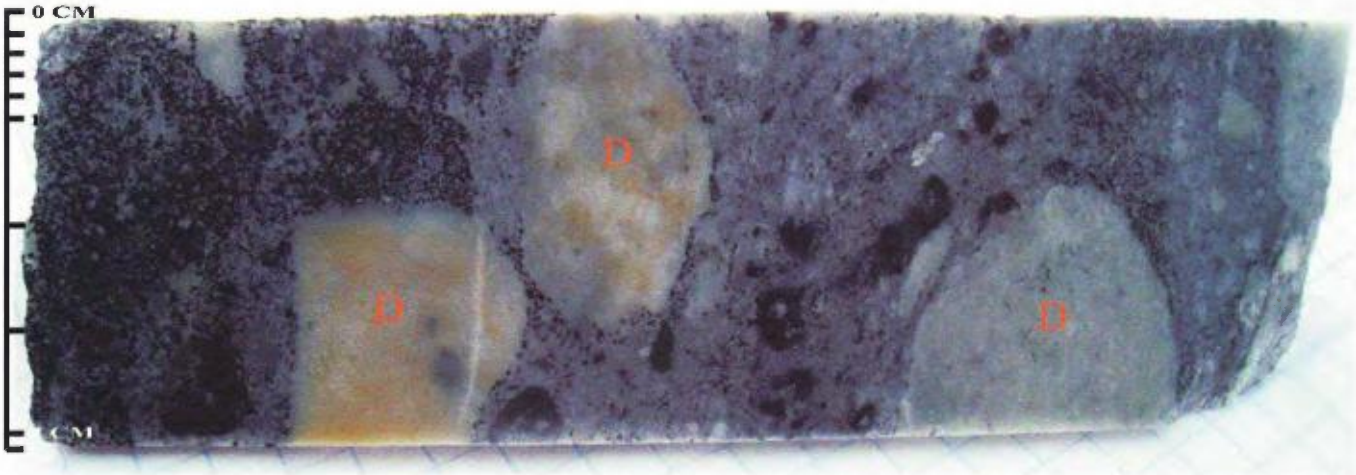


Fig.1 Large dolomite clasts (D) with smaller plagioclase clasts in matrix of dolomite carbonatite. P_2O_5=2%, Nb=2679.2 ppm, Ta=121.7 ppm, REE+Y=0.15%

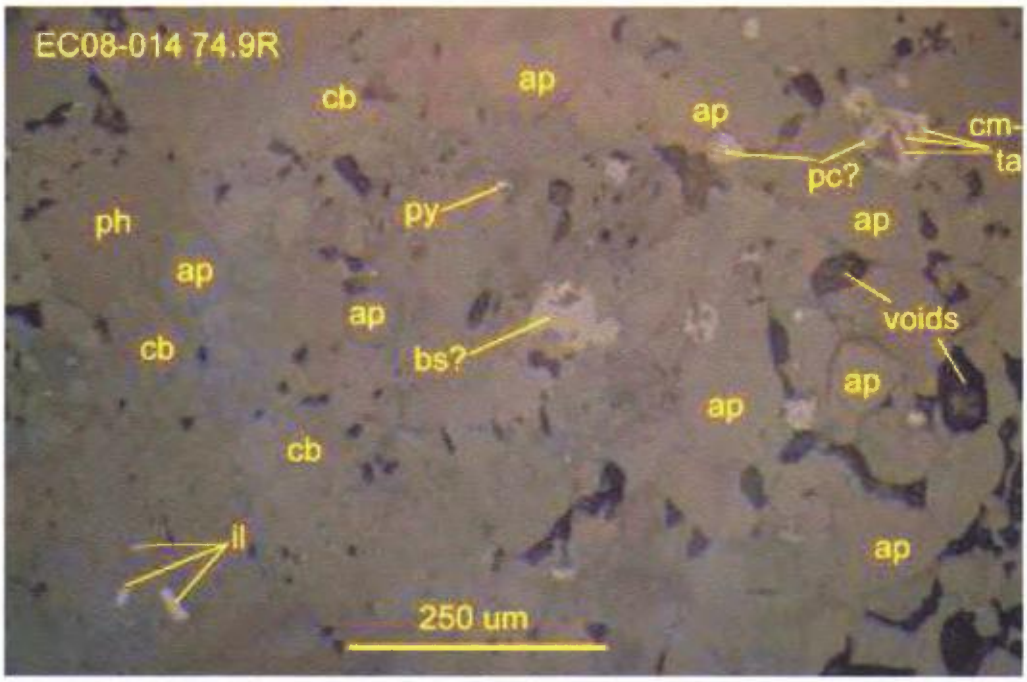


Fig. 2 Photo by Craig Leitch. cb=carbonate, ap=apatite, py=pyrite, pc?=pyrochlore?, cm-ta=columbite-tantalite, bs?=bastnaesite?, il=ilmenite. Reflected light, uncrossed polars.

continued ...

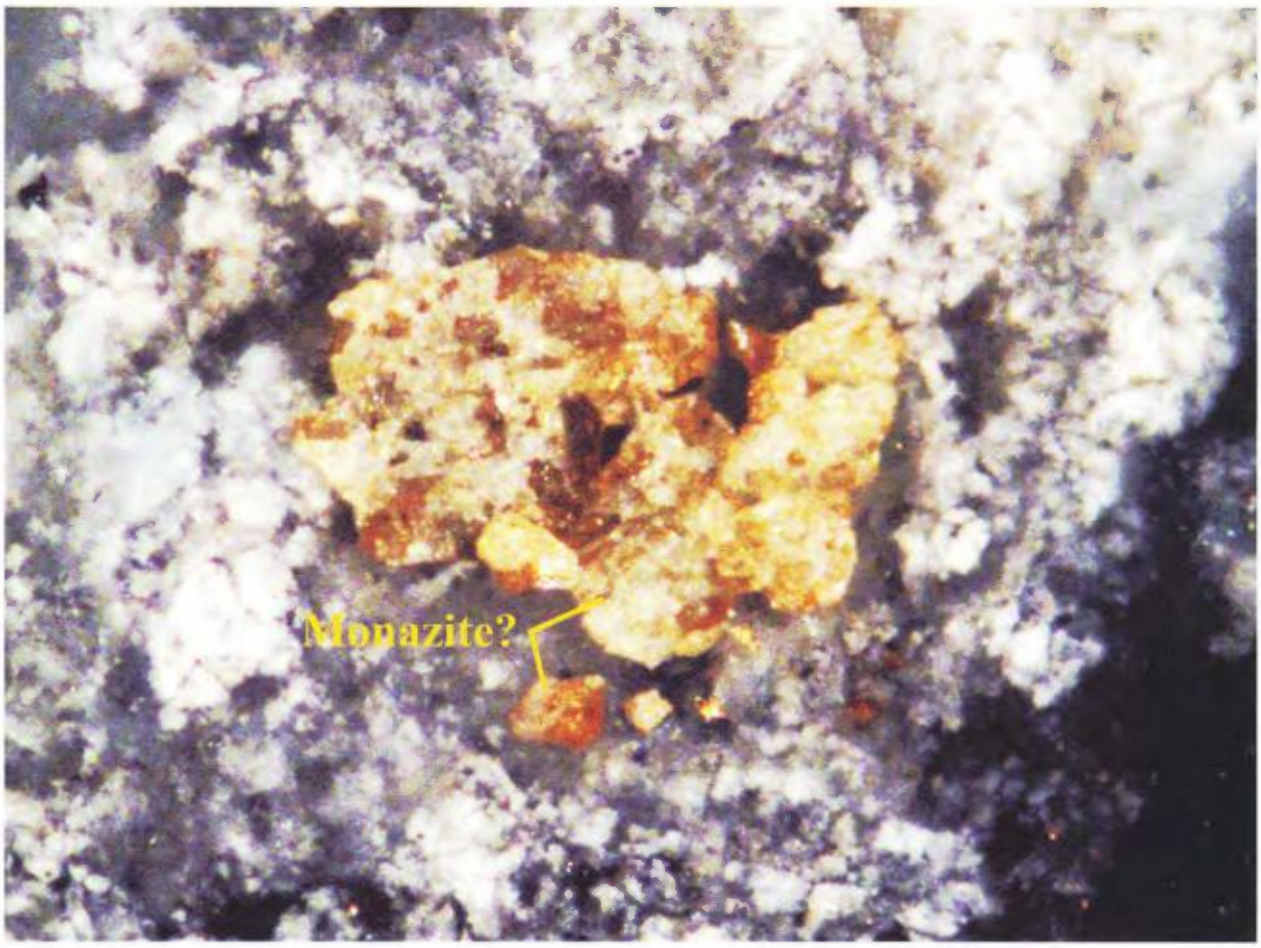


Fig. 3 Micro-photo of Monazite? in EC08-014 74.90m.

Owing to time constraints at the University of Alberta the thin section for this sample did not get scanned.

This sample is composed of clasts that are a) plain dolomite without inclusions of apatite, magnetite etc. and b) plagioclase in a matrix of *dolomite* carbonatite. The clasts likely represent two country rock types that have been brecciated by a dolomite carbonatite intrusion. The clasts could represent a sedimentary dolomite and a fine-grained tuff (metamorphosed to plagioclase). Often there is secondarily derived calcite (reacting strongly to Hcl) surrounding the clasts or in fractures in the breccia fragments and matrix. It is easy to mistake dolomite for calcite under these circumstances.

The REE? mineral in the close-up above is likely monazite but SEM work would be necessary to confirm this. Dr. Leitch also identified ilmenite in this sample and it would be good to check that identification as it could be baddeleyite.

Dolomite Carbonatite Breccia with pyrochlore(?) rich clast

EC08-014 at 28.69m

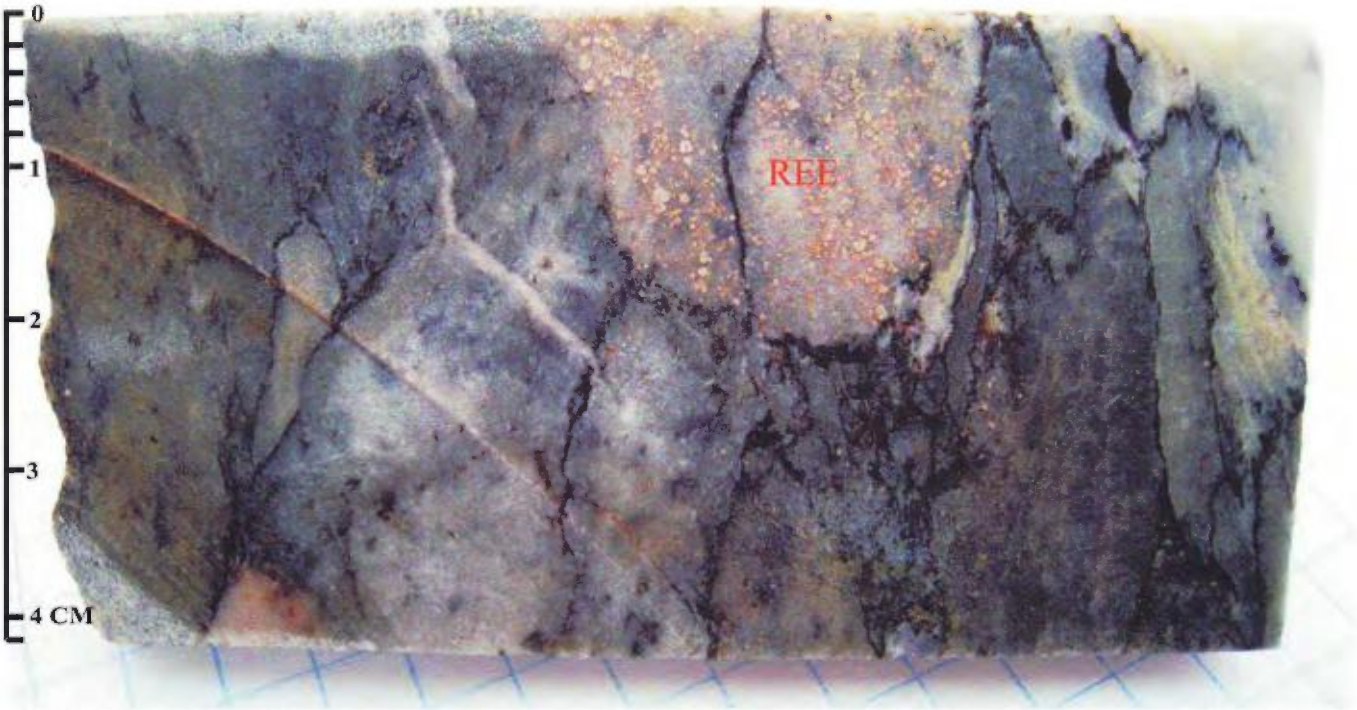


Fig.1 Dolomite carbonatite clast, rich in REE's (REE) in dolomite carbonatite matrix breccia. P_2O_5=4.37%, Nb=3909.6 ppm, Ta=78.9 ppm, REE+Y=0.30%

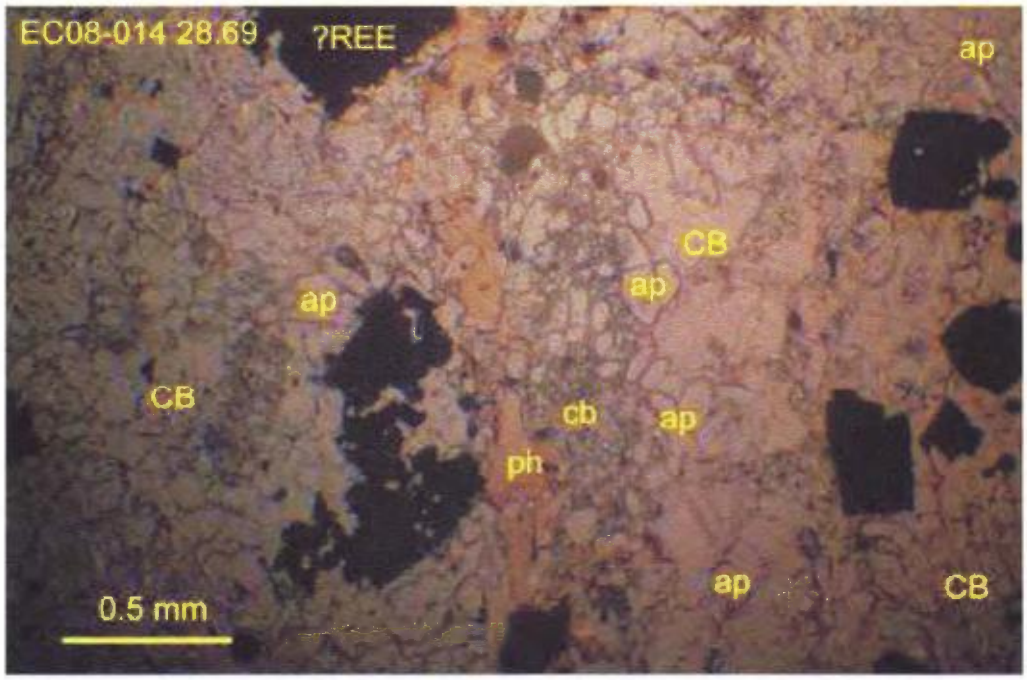


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-014 28.69m, CB=carbonate, ph=phlogopite, ap=apatite, ?REE=unidentified ?REE mineral. Transmitted plane light.

continued ...

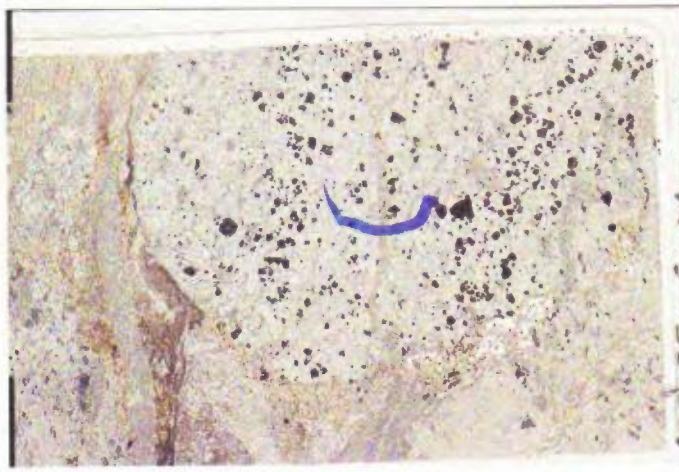


Fig.3 Thin section EC-08 014 28.69m plane polars

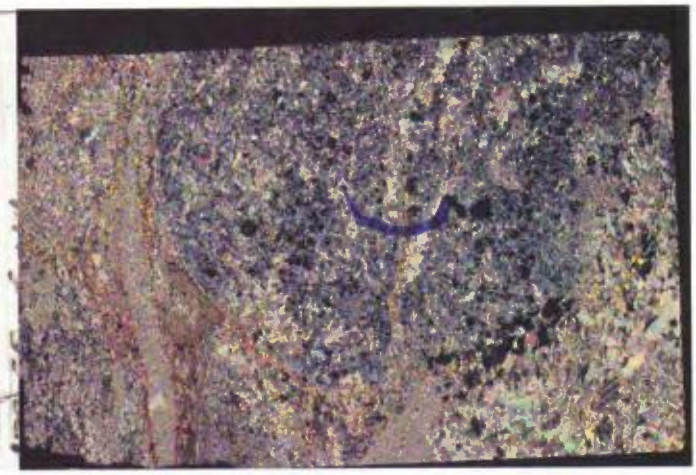


Fig.4 Thin section EC-08 014 28.69m cross polars

This sample presents solid evidence for two separate dolomite carbonatite intrusions. Without SEM/EMPA work on the pyrochlore(?) it is impossible to say if trying to find the source for this REE-rich clast is warranted. However, it is possible that a significant highgrade Nb zone may exist within the Eldor carbonatite.

Dolomite(?) Carbonatite Breccia with calcite clasts

EC08-008 at 46.23m

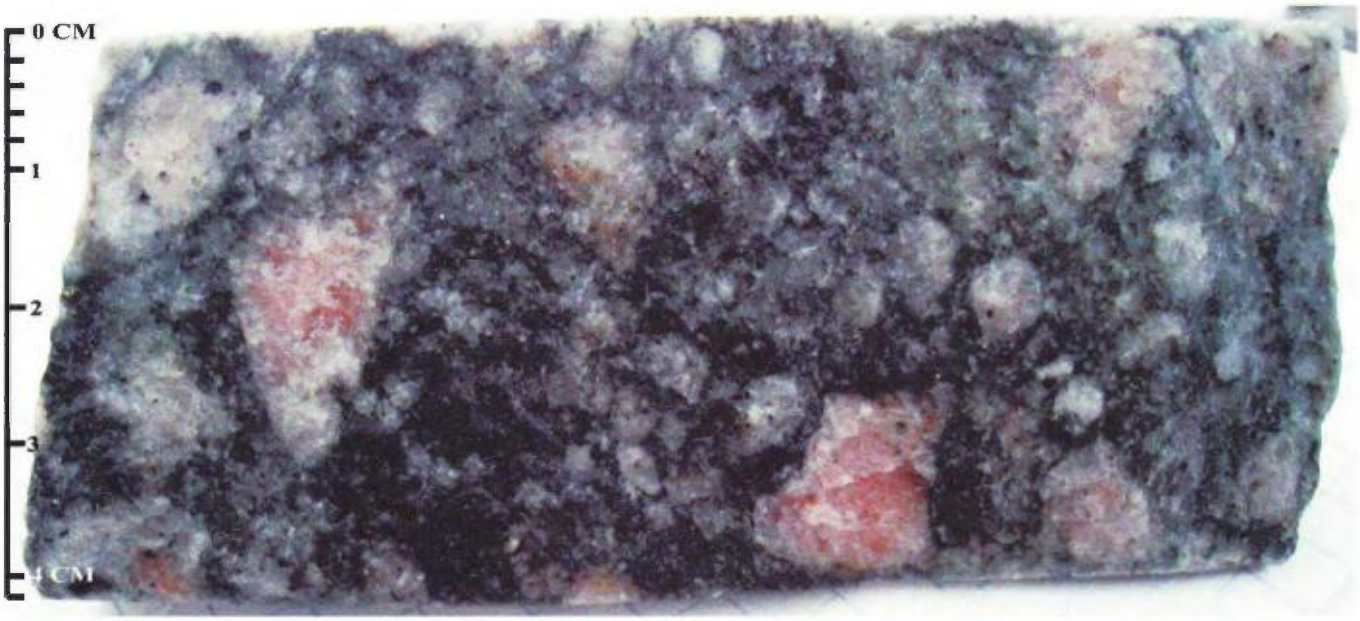


Fig.1 Pink calcite clasts in breccia. The matrix is likely Fe-dolomite with fragmental calcite. P_2O_5=4.57%, Nb=442.9 ppm, Ta=76.7 ppm, REE+Y=0.23%

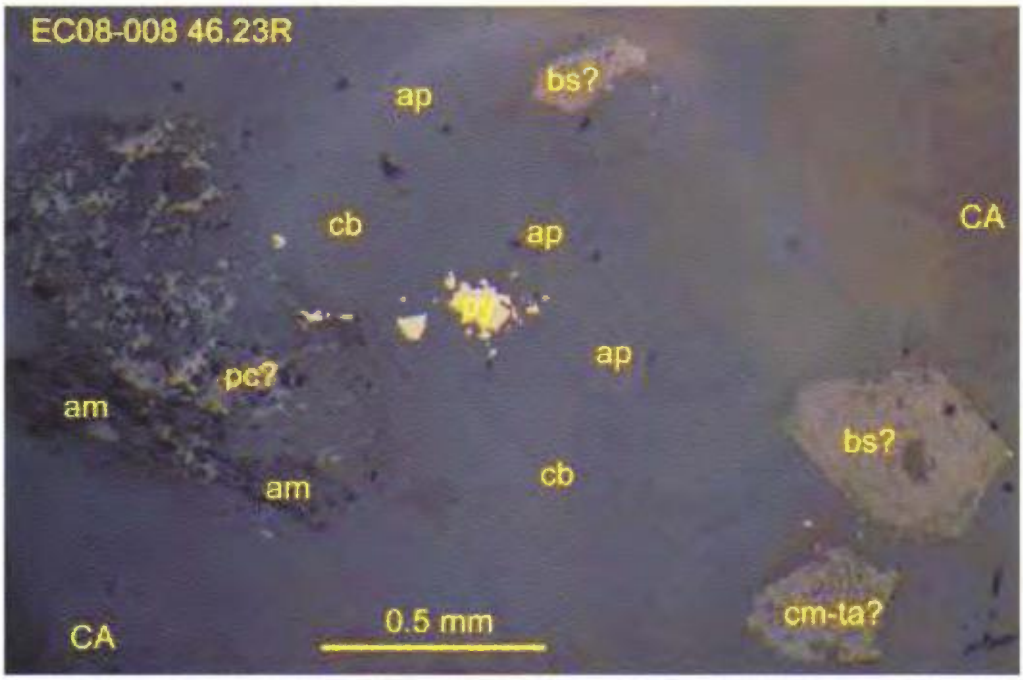


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-008 46.23m, ap=apatite, cb=carbonate, CA=calcite, bs?=bastnaesite?, cm-ta?=columbite-tantalite?, py=pyrite, pc?=pyrochlore?, am=amphibole. Reflected light, uncrossed polars

continued ...

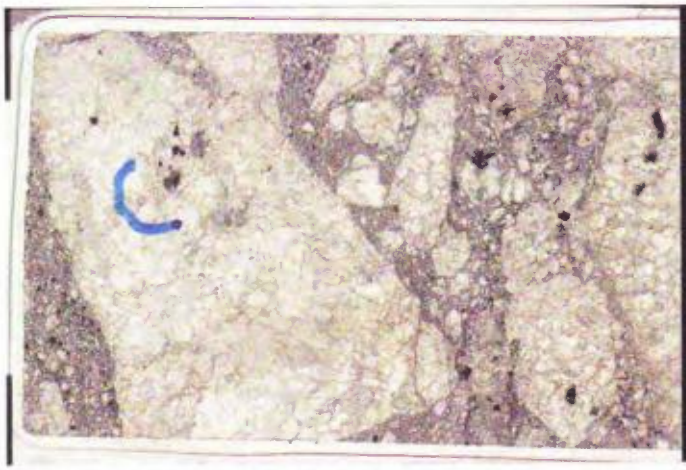


Fig.3 Thin section EC-08 008 46.23m plane polars

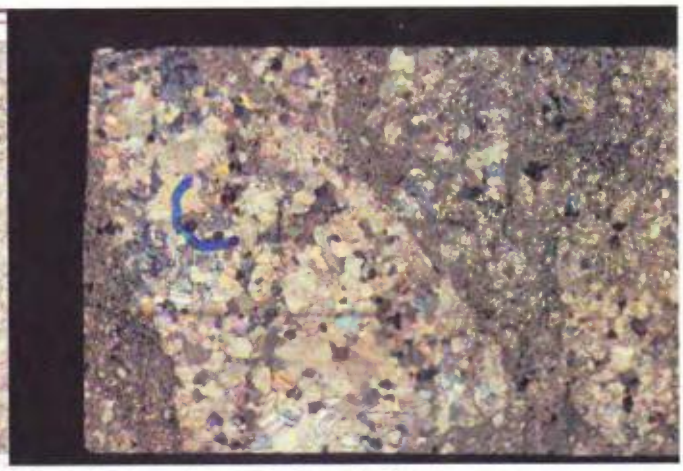


Fig.4 Thin section EC-08 008 46.23m cross polars

This sample shows calcite clasts in a matrix of Fe-dolomite carbonatite with included, fragmented calcite in the matrix. The origin of the calcite clasts is uncertain but the calcite has been intruded by the Fe-dolomite. SEM/EMPA work would be needed to sort out the carbonate phases in the matrix with confidence.

Dolomite Carbonatite Breccia with Fluorite

EC08-001 at 204.21m

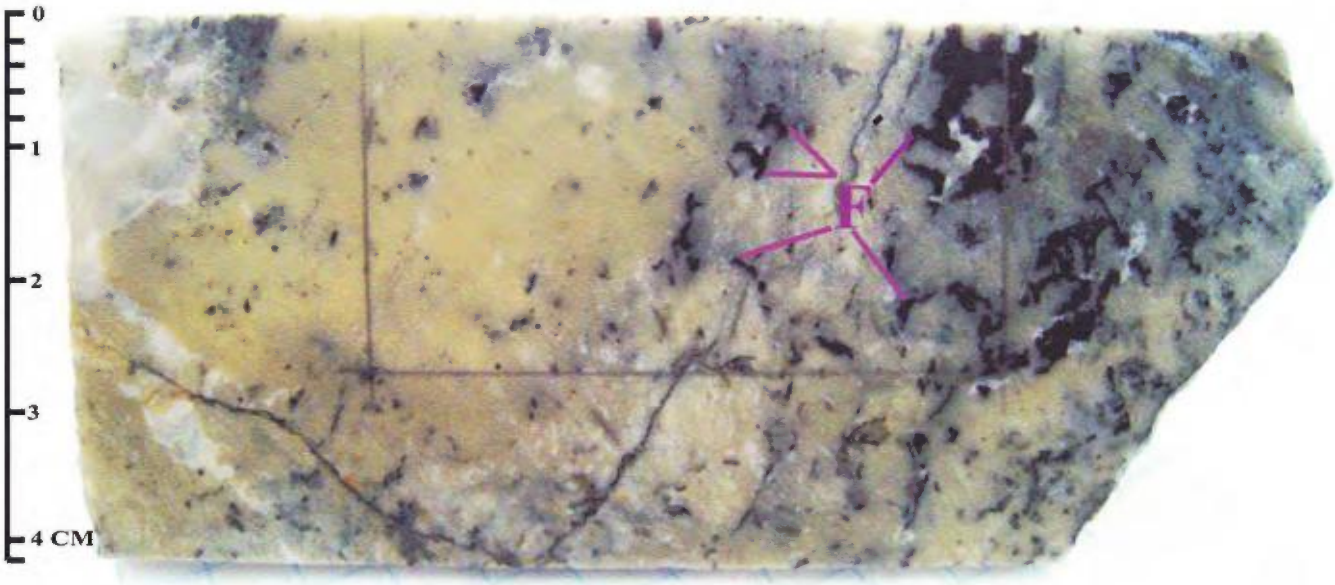


Fig.1 Brecciated dolomite carbonatite with veinlets of fluorite (F). P2O5=3.33%, Nb=2046.4ppm, Ta=27.3 ppm, REE+Y=0.18%

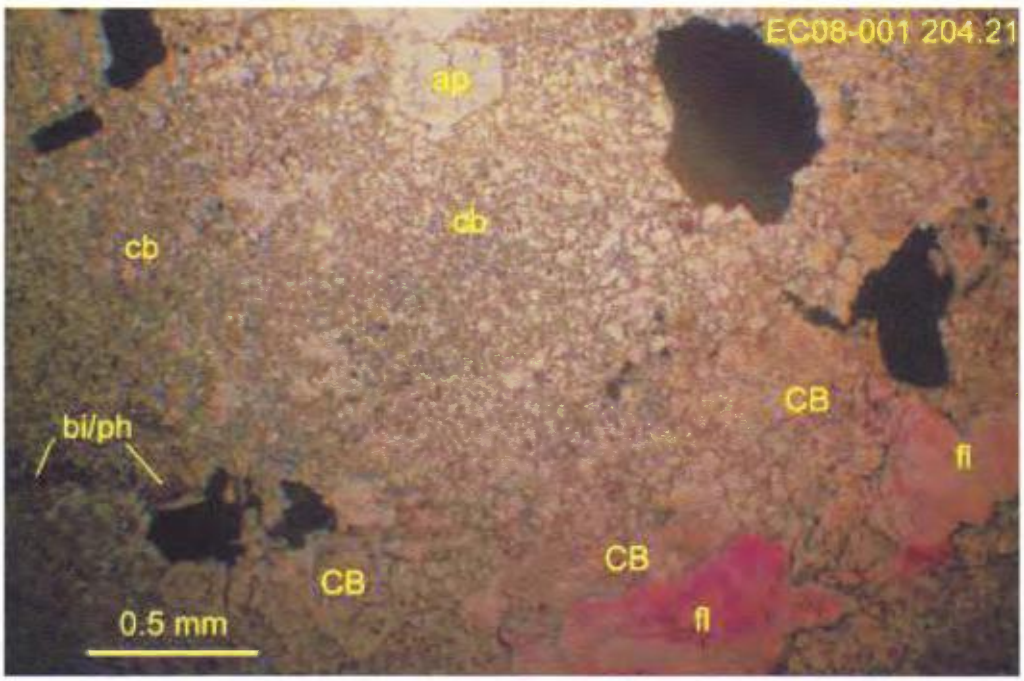


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-001 204.21m, cb=fine-grained carbonate, CB=coarse-grained carbonate, ap=apatite, fl=fluorite, bi/ph=biotite/phlogopite. Transmitted plane light

continued ...

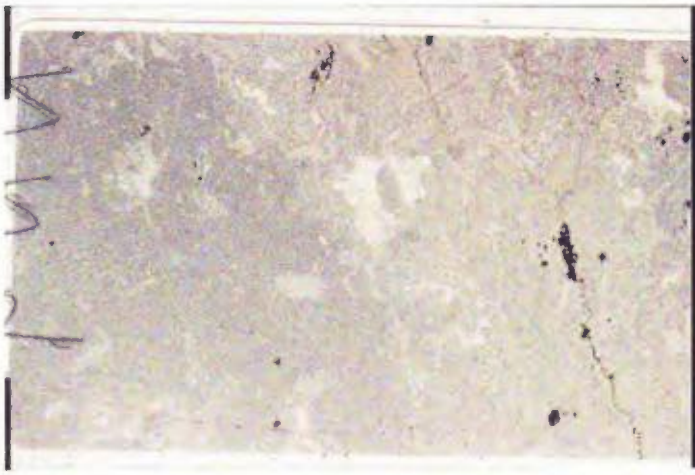


Fig.3 Thin section EC-08 001 204.21m plane polars

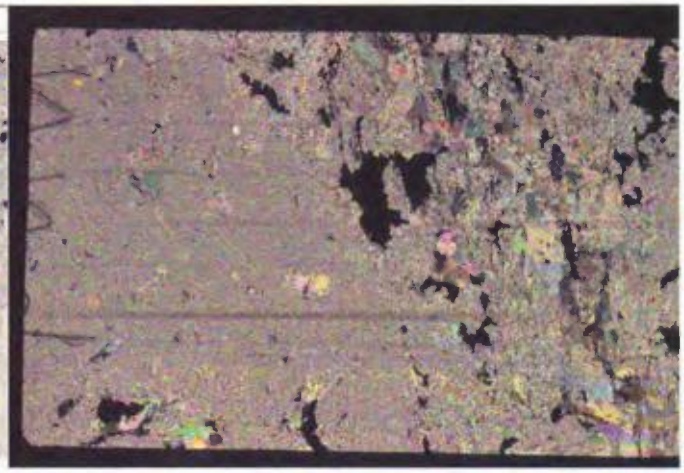


Fig.4 Thin section EC-08 001 204.21m cross polars

This section has a complex history, possibly brecciation with fluorite infill then metamorphic re-healing and aggregation of the fluorite followed by further brecciation. Dr. Lietch noted that the fluorite has two-phase fluid inclusions, most of which are decrepitated.

Three Phase Dolomite Carbonatite Breccia

EC08-001 at 152.25m

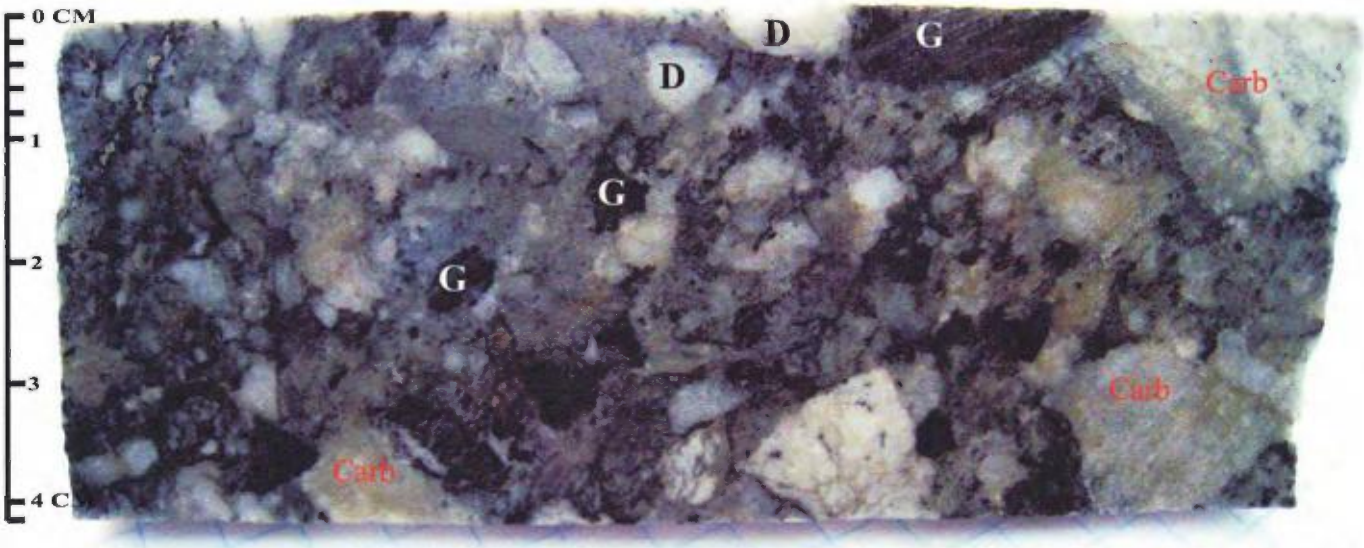


Fig.1 Glimmerite(G), Dolomite (D) and Apatite rich dolomite carbonatite clasts (Carb) in dolomite carbonatite matrix. P_2O_5=6.44%, Nb=2830.1ppm, Ta=147.4 ppm, REE+Y=0.34%

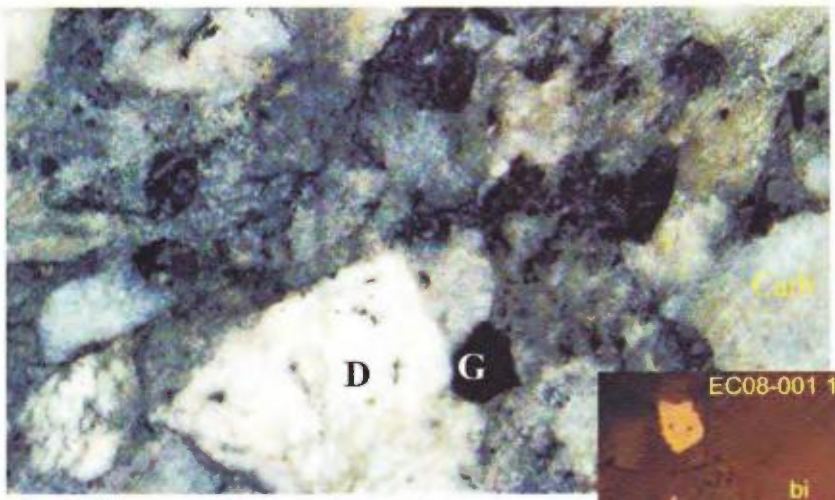


Fig. 2 Close-up of breccia fragments.

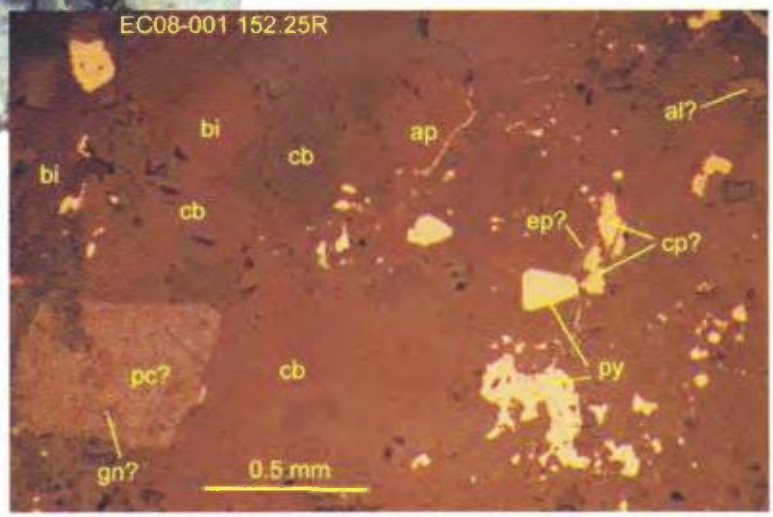


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-001 152.25m, pc?=pyrochlore?, ap=apatite, bi=biotite, ep?=epidote?, py-pyrite, cp?=chalcopyrite?, al?=allanite, gn?=galena? Reflected light, uncrossed polars.

continued ...

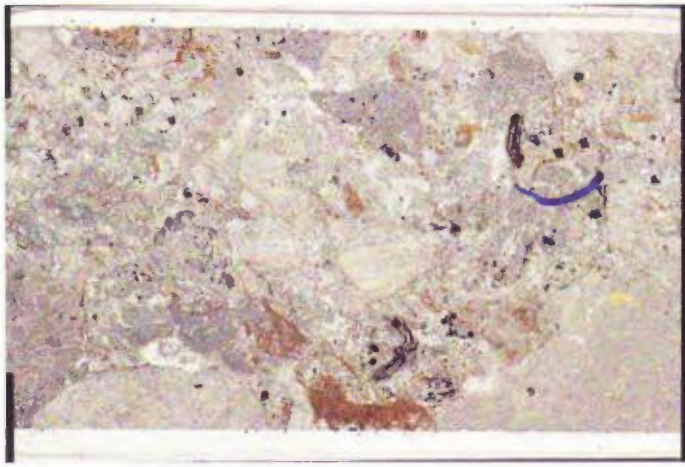


Fig.4 Thin section EC-08 001 152.25m plane polars

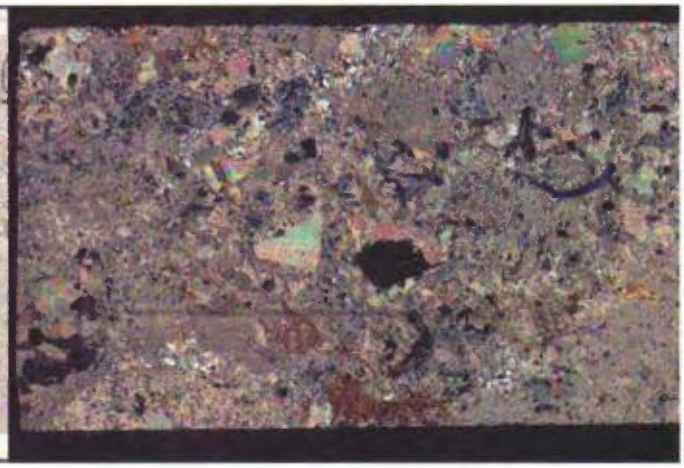


Fig.5 Thin section EC-08 001 152.25m cross polars

The dolomite clasts in this breccia are either a) re-mobilized, re-crystallized dolomite formed during a previous tectonic event or b) brecciated dolomite country rock. This is essentially the same breccia that was encountered at 141.34m and 151.12m, in this same diamond drill hole. **If these are intrusive breccias then this is evidence for a second dolomite carbonatite intrusive event.** The rare earth minerals in this section need SEM/EMPA work for identification of the phase(s) present and rare earth content.

Three Phase Dolomite Carbonatite Breccia

EC08-001 at 151.12m

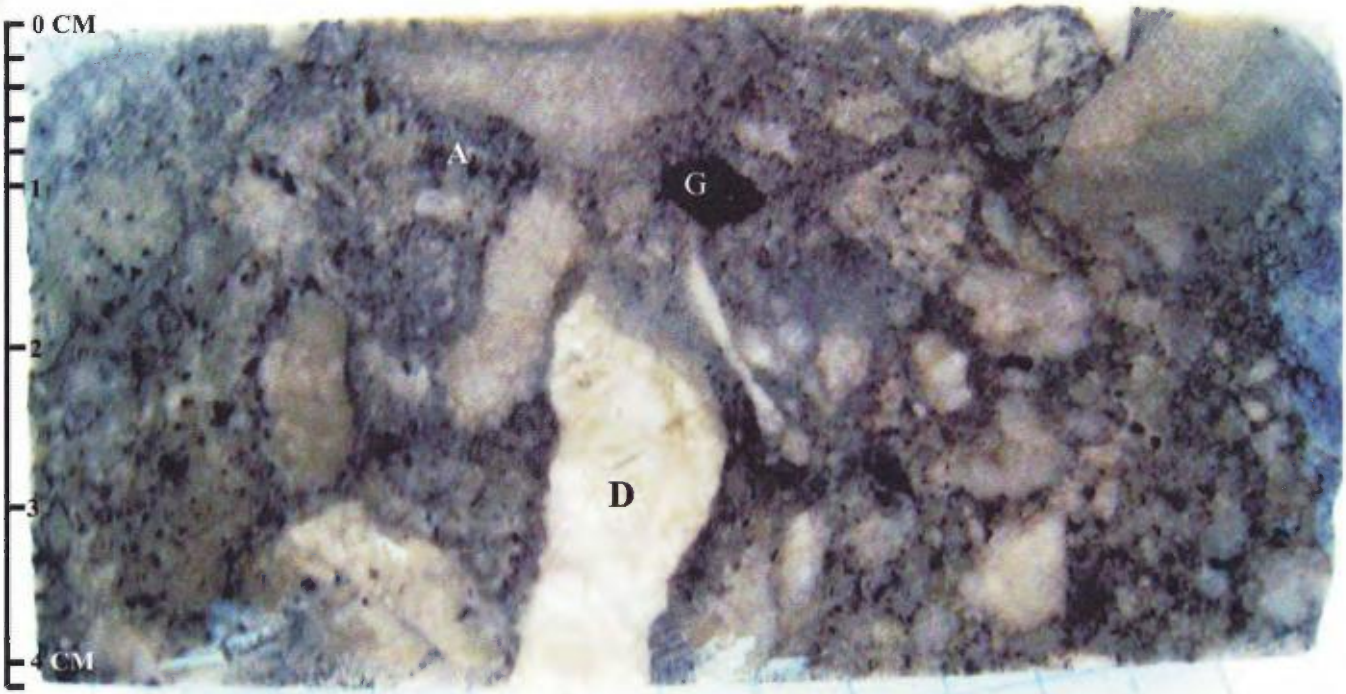


Fig.1 Glimmerite(G), Dolomite(D) and Apatite (A) rich dolomite carbonatite clasts in dolomite carbonatite matrix. P_2O_5=5.45%, Nb=1819.8ppm, Ta=85.5 ppm, REE+Y=0.20%

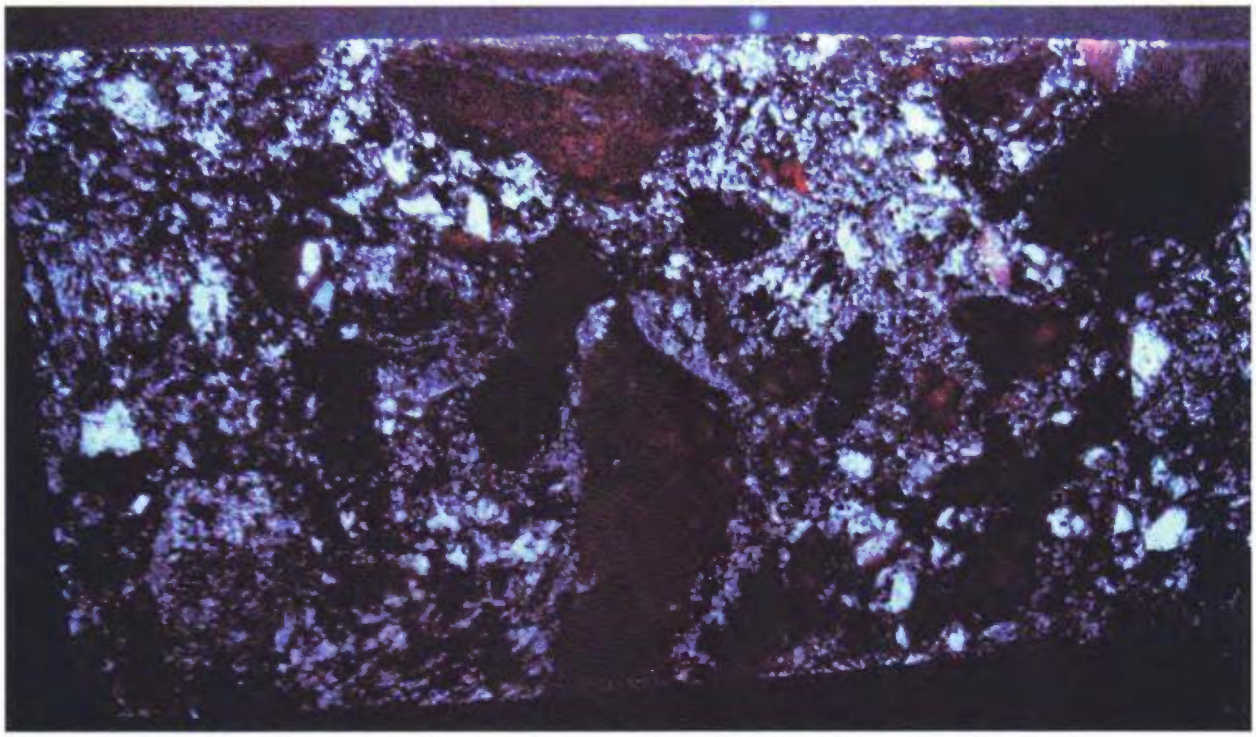


Fig. 2 EC08-001 151.12m under midrange UV light. Blue-white is apatite and red is calcite.

continued ...

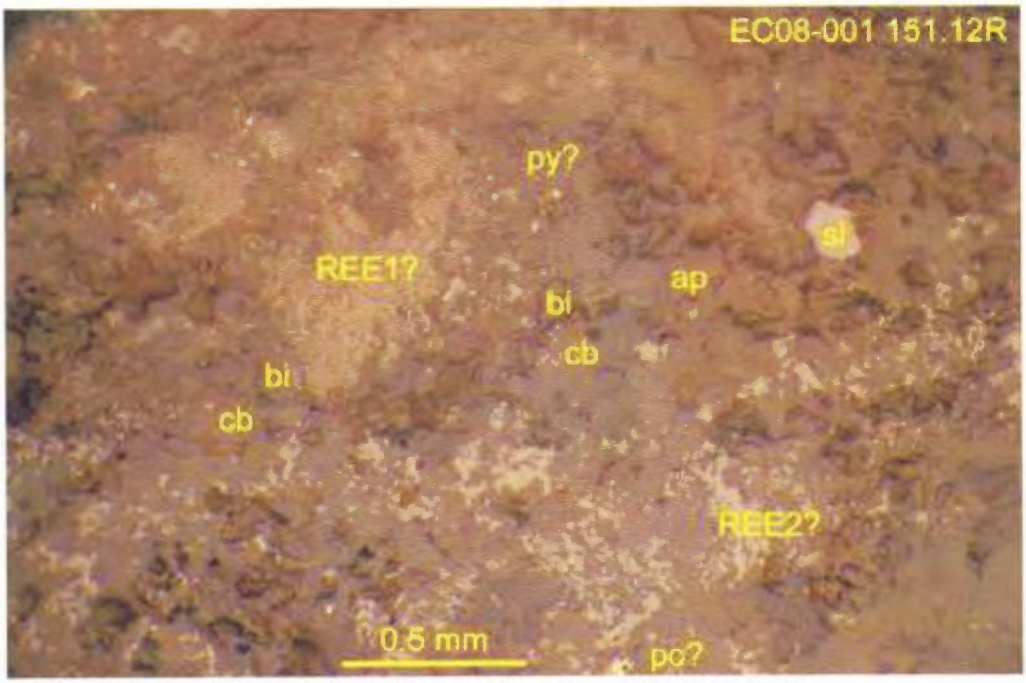


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-001 151.12m, REE1?=unidentified REE? mineral, REE2?=unidentified REE? mineral, bi=biotite, cb=carbonate, po?=pyrrhotite, ap=apatite. Reflected light, uncrossed polars

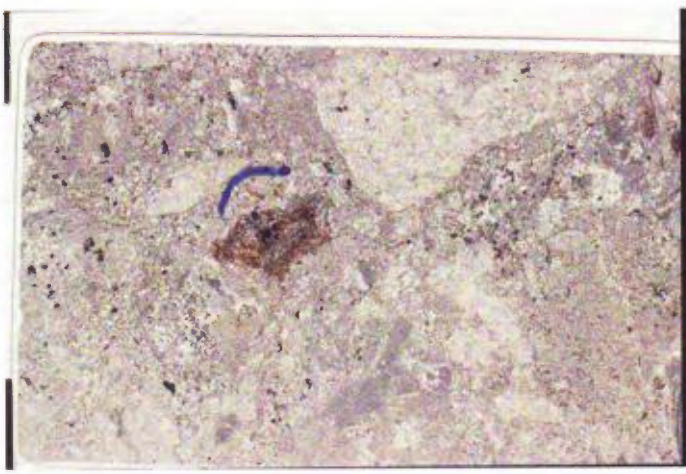


Fig.4 Thin section EC-08 001 152.25m plane polars

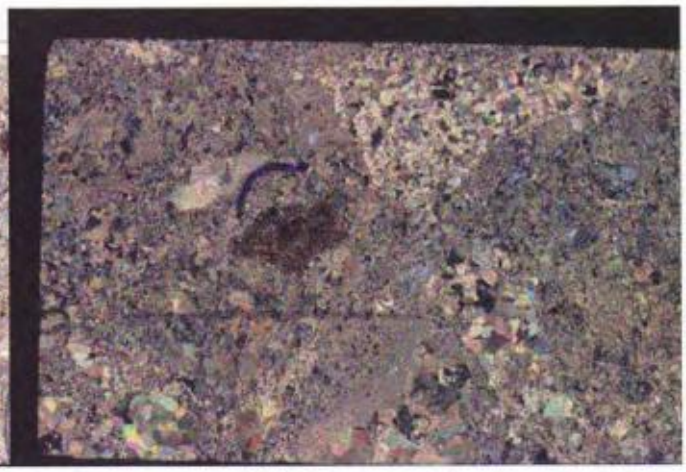


Fig.5 Thin section EC-08 001 152.25m cross polars

This sample is the same three-phase breccia as found at 152.25m and 141.34m in this diamond drill hole; **it is a distinctive breccia and may serve as a marker for structural purposes.**

UNIDENTIFIED ORANGE, POSSIBLE REE MINERAL WITH DOLOMITE & MARCASITE

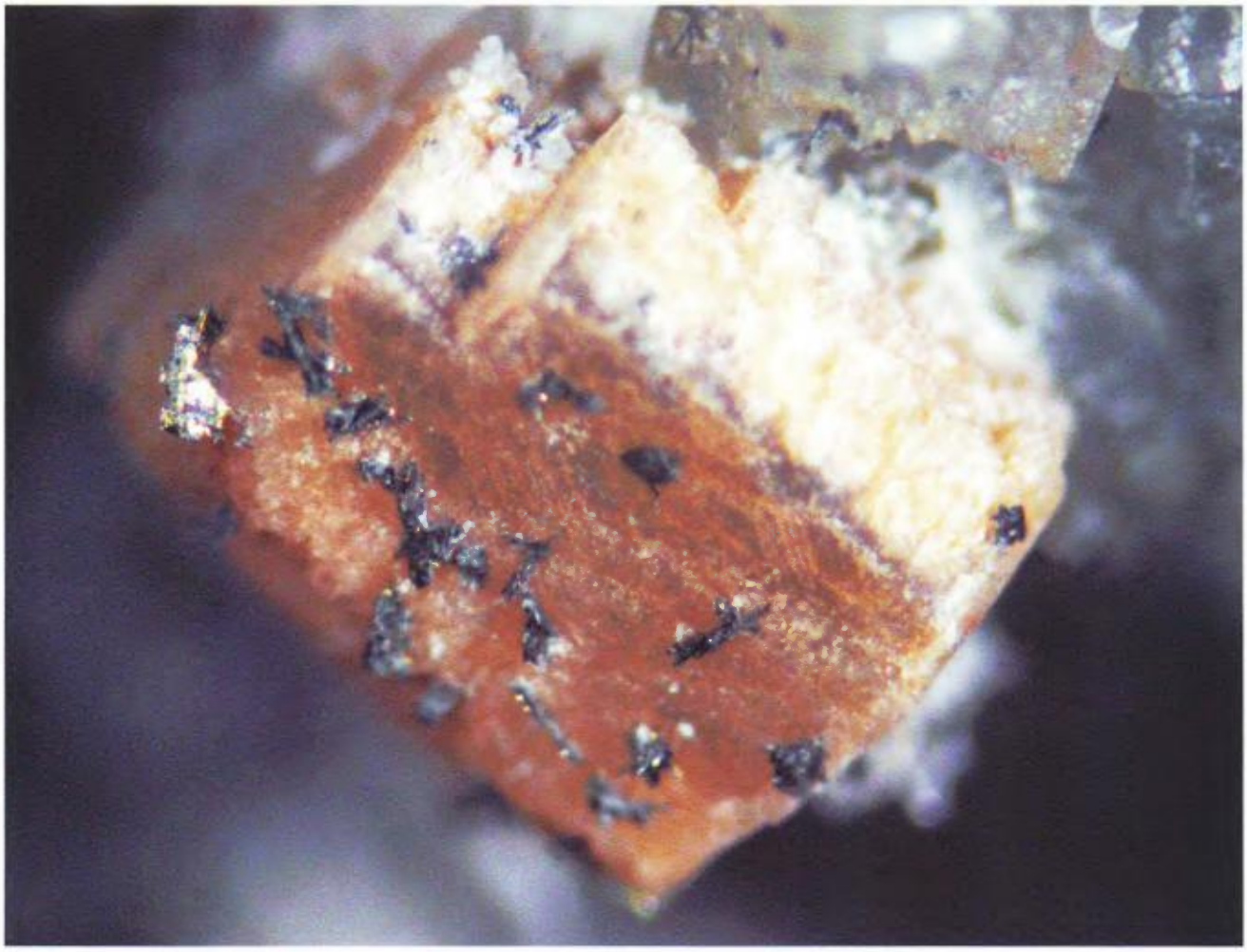


PLATE VII. This unidentified mineral could be the same species as the one on page 81. It is possibly REE-bearing and requires SEM/EMPA work to confirm.

BOTRYOIDAL HYDROCARBON WITH YELLOW UNIDENTIFIED, POSSIBLE REE MINERAL AND CALCITE

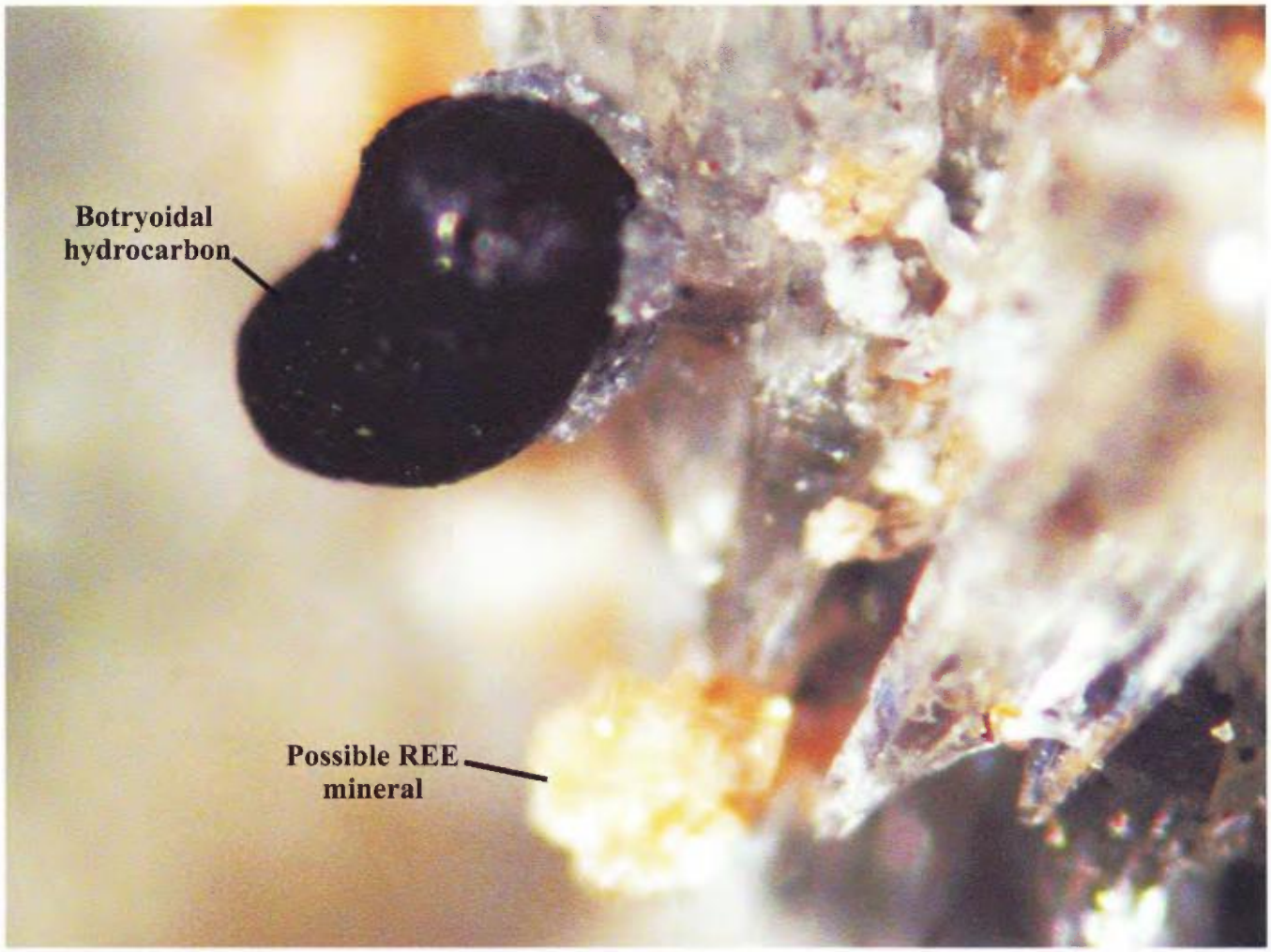


PLATE VIII. This micro-photo shows a yellow, possible REE-bearing mineral in close proximity to a botryoidal hydrocarbon. SEM/EMPA work is necessary to identify this possible rare earth mineral.

Dolomite Carbonatite ?Cumulate with apatite & REE minerals

EC08-015 at 182.30m

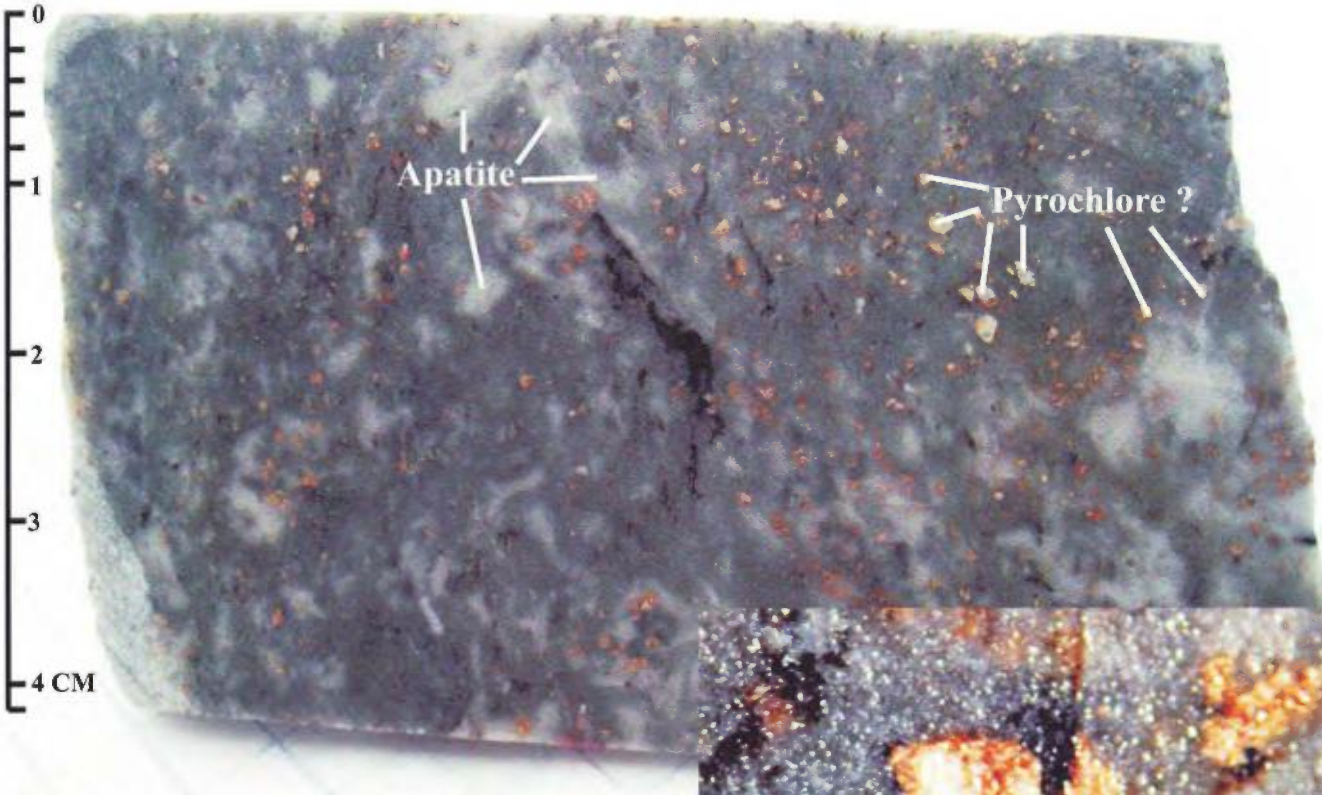


Fig.1 Apatite cumulate? with pyrochlore?.. P_2O_5=11.79%, Nb=6126 ppm, Ta=99.7 ppm, REE+Y=0.44%

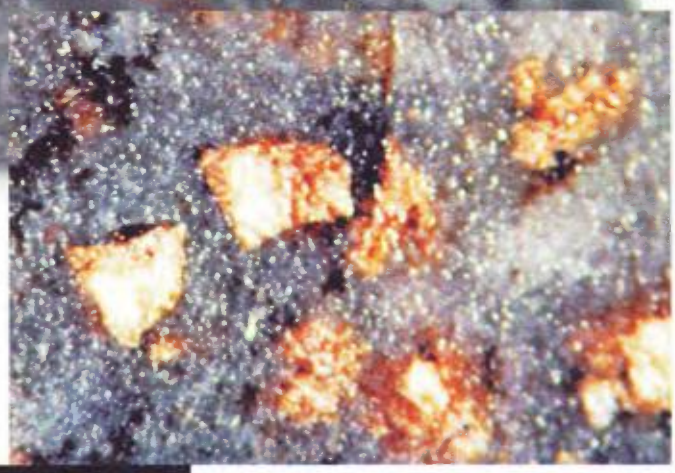


Fig. 2 Micro-photo of possible pyrochlore (brown crystals).

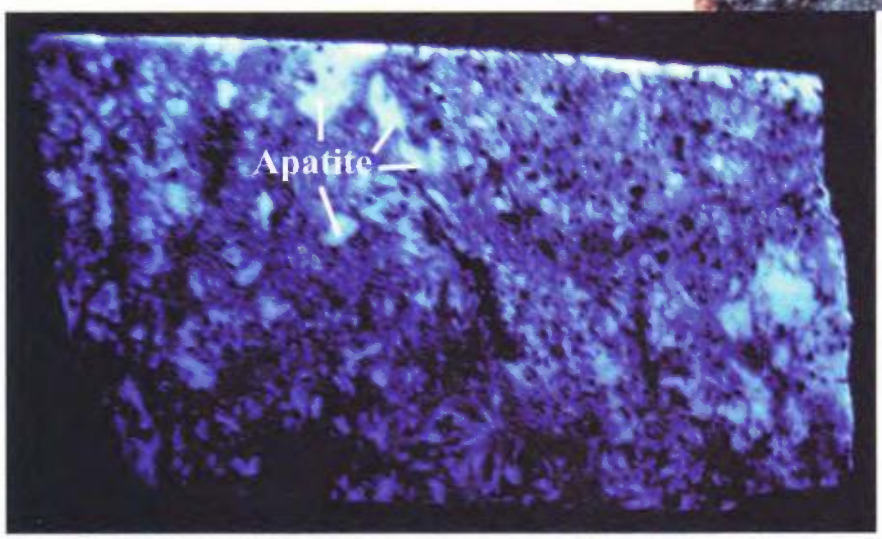


Fig. 3 EC08-015 182.30m under midrange UV light. Blue-white is apatite.

continued ...

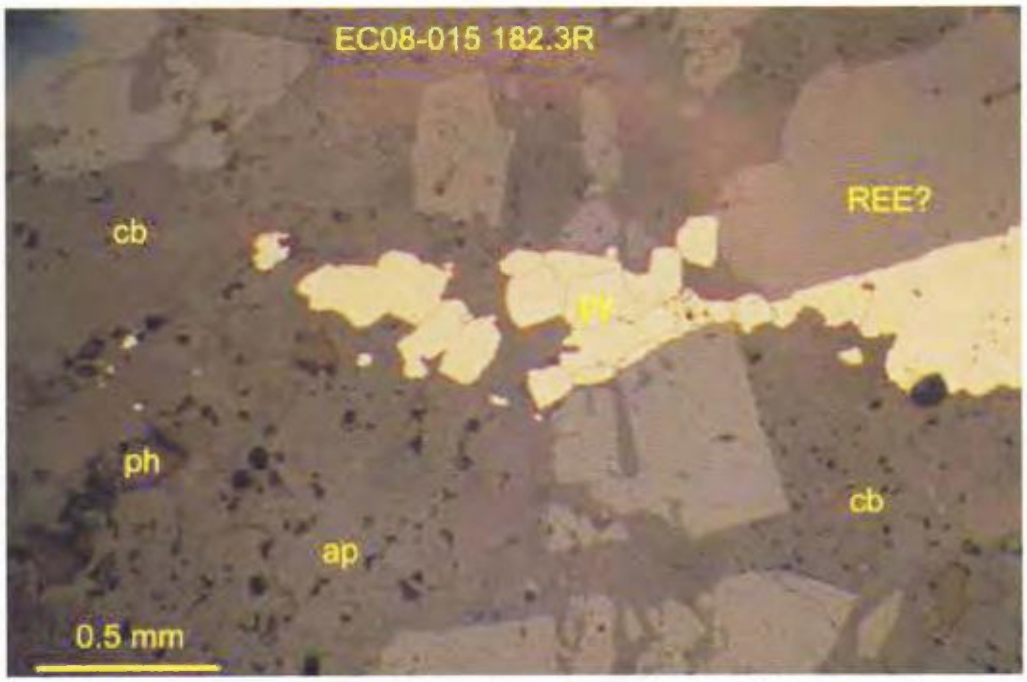


Fig. 4 Photo by Craig Leitch outlined on thin section EC08-015 182.30m, cb=carbonate, py=pyrite, REE?=unidentified REE? mineral, ap=apatite, ph=phlogopite.
Reflected light, uncrossed polars.

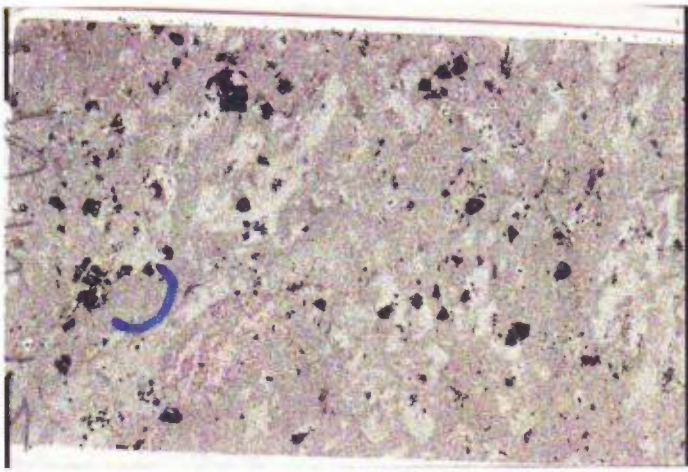


Fig.5 Thin section EC-08 015 182.30m plane polars

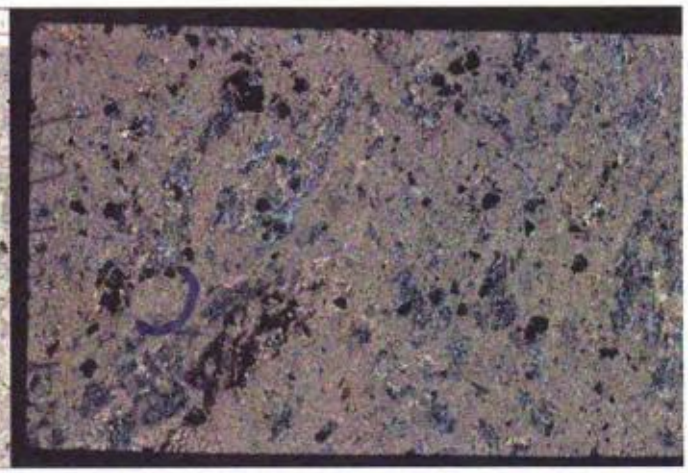


Fig.6 Thin section EC-08 015 182.30m cross polars

The presence of fluorite and the absence of magnetite suggest this sample is related to the late-stage fluorite-rich carbonatite intrusion and therefore not a cumulate in the traditional sense. At 11.79% the apatite in this interval is attractive as phosphate ore. **From 164m to 188m in this diamond drill hole there is a 24 metre interval averaging close to 9% P_2O_5.**

Further SEM/EMPA work is required to determine if the rare earth mineral in this thin section is pyrochlore.

Calcite Carbonatite Cumulate with magnetite, olivine, & apatite

EC08-019 at 263.70m

Fig.1 Cumulate with high apatite content. **P_2O_5=1.11%**, Nb=138.5 ppm, Ta=11.3 ppm, REE+Y=0.12% See discussion on page 98 of this report regarding the low assay value for phosphate reported here.

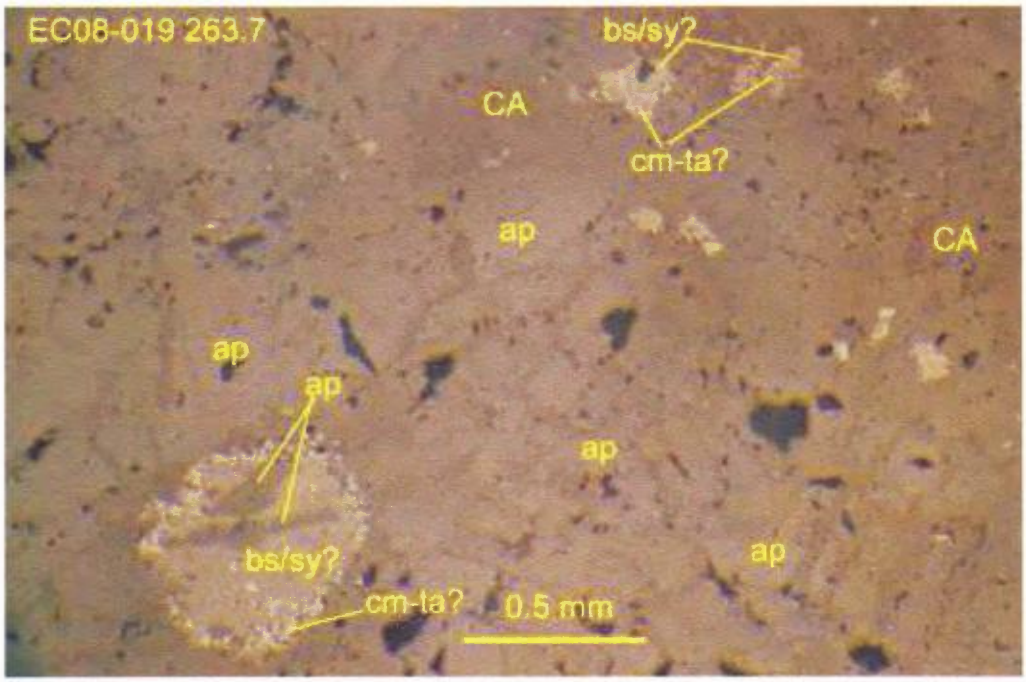


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-019 263.70m, CA=calcite, ap=apatite, bs/sy?=bastnaesite/synchesite?, cm-ta?=columbite/tantalite? Reflected light, uncrossed polars.

continued ...

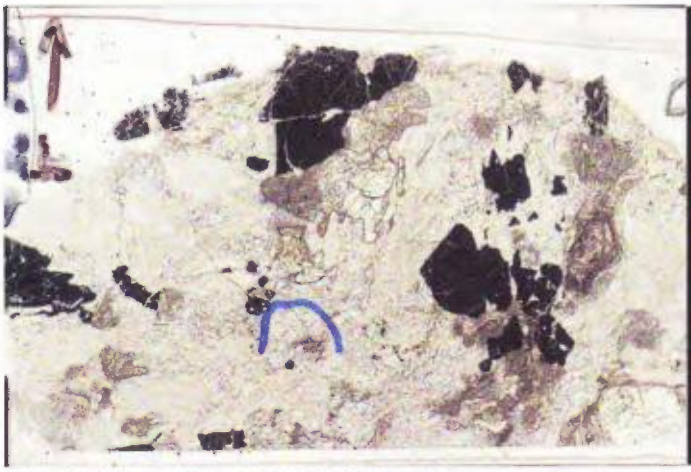


Fig.4 Thin section EC-08 019 263.70m plane polars

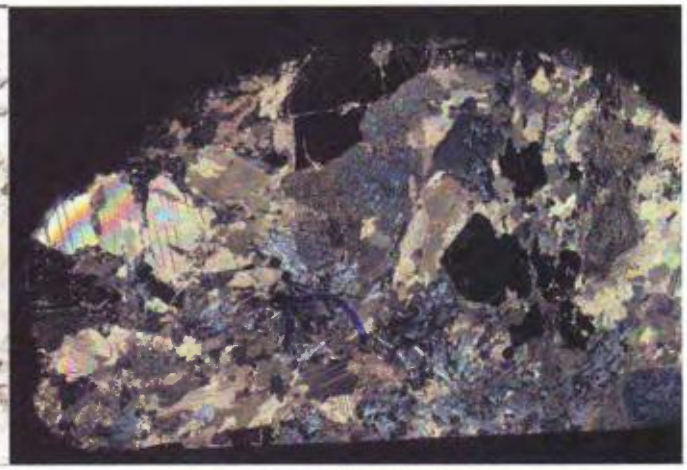


Fig.5 Thin section EC-08 019 263.70m cross polars

Both Dr. Leitch's and my observations confirm this sample as a true cumulate.

The whole rock assay reports 1.11% P_2O_5 when my observations with midrange UV light suggested 15-25% P_2O_5 and Dr. Leitch puts P_2O_5 at 20%. There are several possible reasons for this discrepancy (see "Possible sources of error", p.22).

Magnetite, Serpentine, Magnesite(?) Cumulate

EC08-006 at 65.60m

Fig.1 Magnesio-carbonatite cumulate. P_2O_5=7.07%, **Nb=7236.4 ppm**, Ta=113.1 ppm, REE+Y=0.19%

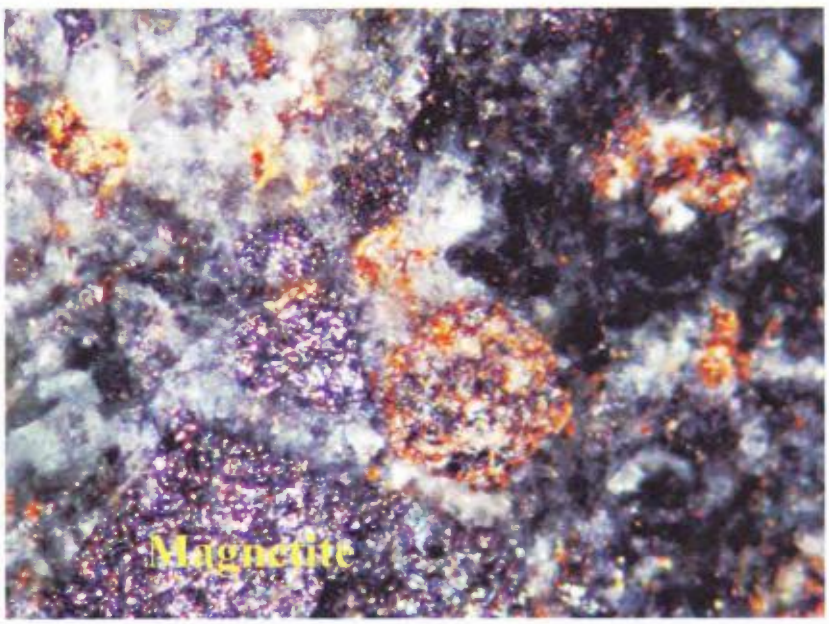


Fig. 2 Micro-photo of magnetite/serpentine/magnesite cumulate showing REE phase (orange-brown), possibly pyrochlore.

continued ...

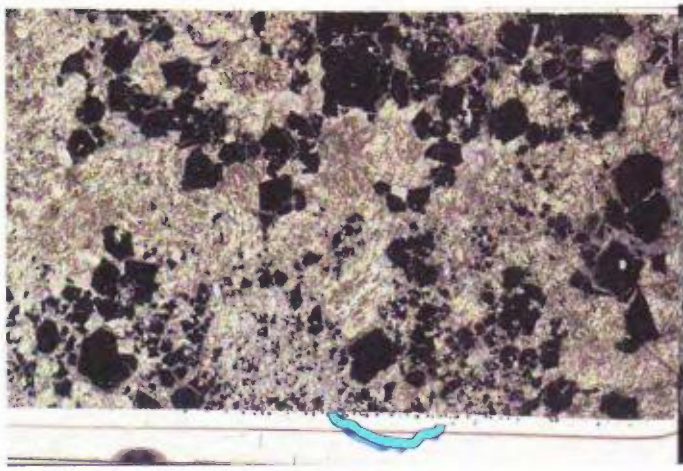


Fig.3 Thin section EC-08 006 65.60m plane polars

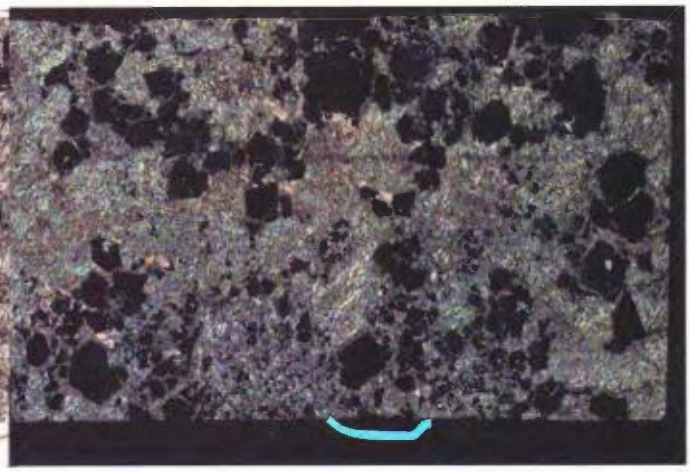


Fig.4 Thin section EC-08 006 65.60m cross polars

Dr. Leitch suggests the presence of magnesite in this sample (see Appendix B). The magnesian-carbonate is undoubtedly magmatic in origin. Tying the magnesian-carbonate to a particular ligthology will provide a means for separating different carbonatite intrusions.

Magnetite, Amphibole, Apatite Cumulate with carbonate vein

EC08-021 at 196.05m

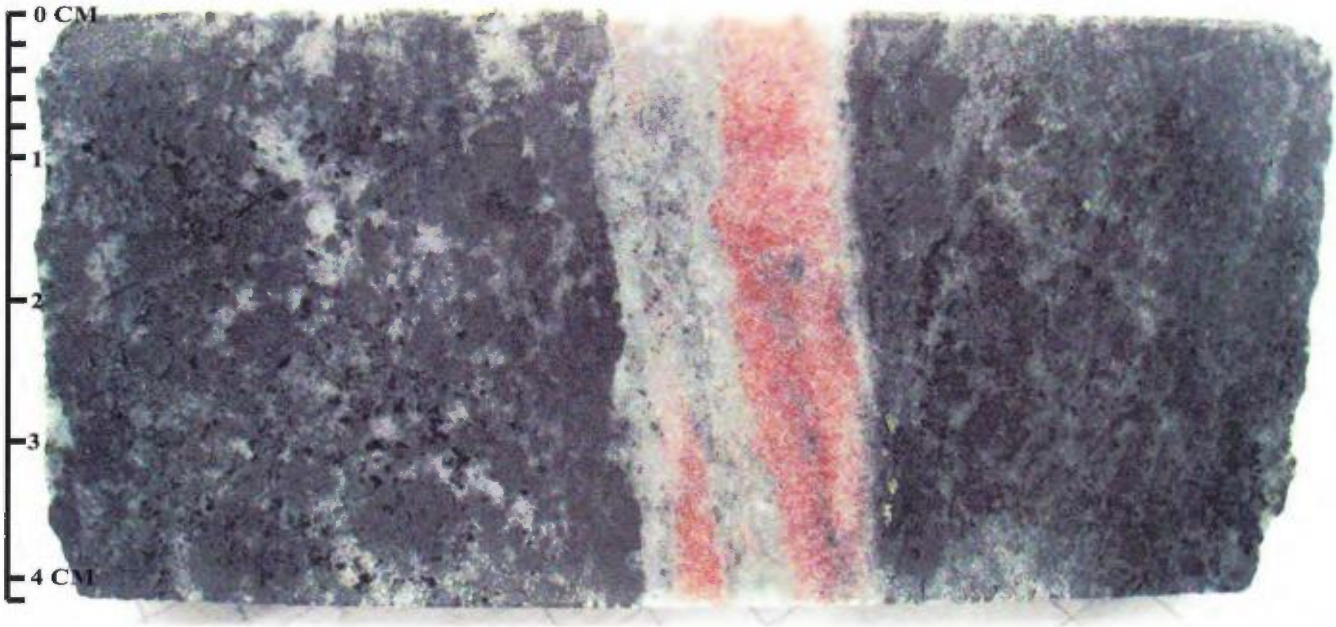


Fig.1 Cumulate with two-phase carbonate vein. P_2O_5=4.94%, Nb=6092.9 ppm, Ta=225.1 ppm, REE+Y=0.25%

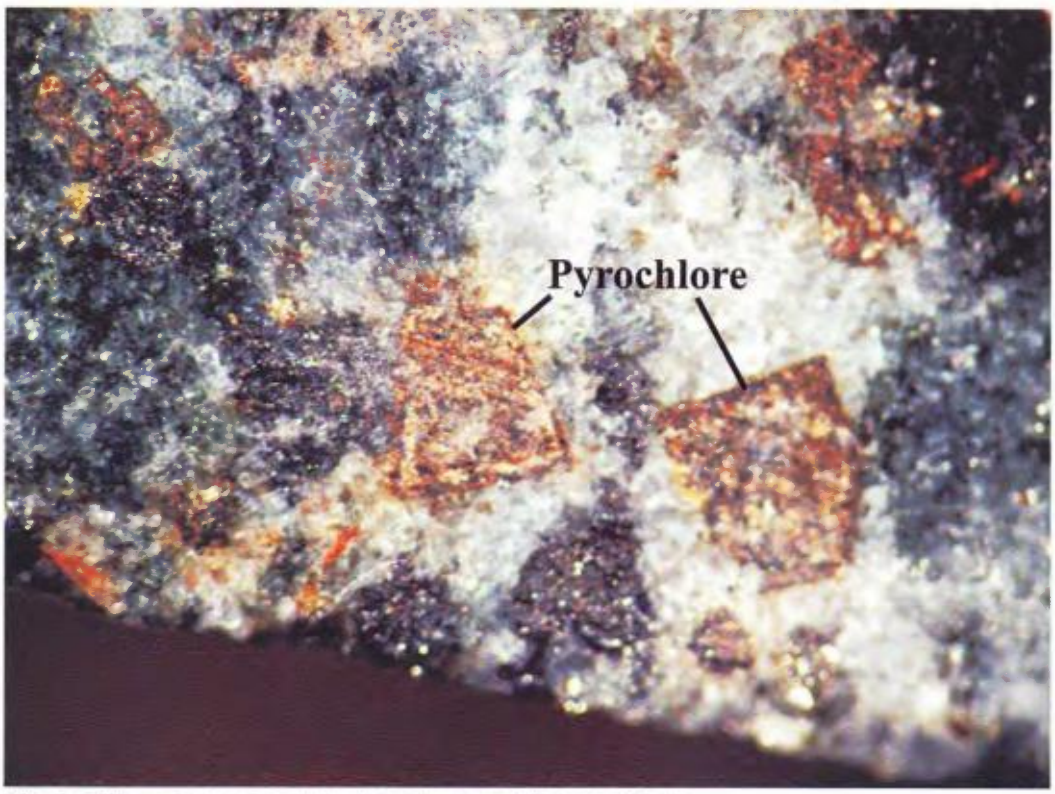


Fig. 2 Micro-photo of zoned pyrochlore crystals in cumulate.

continued ...

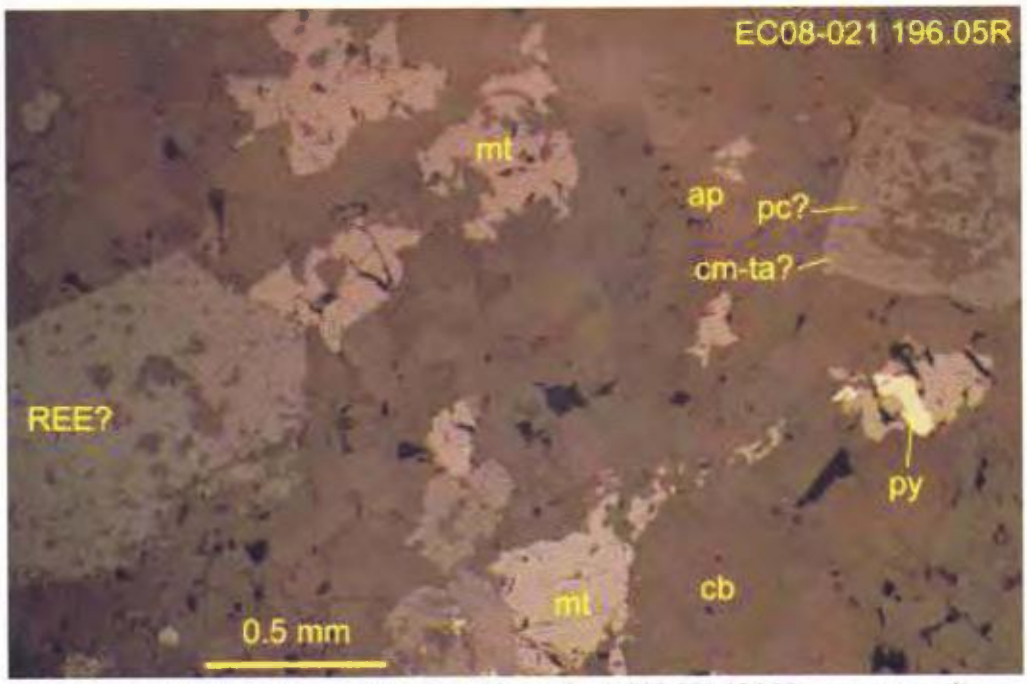


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-021 196.05m, mt=magnetite, ap=apatite, py=pyrite, REE?=unidentified REE bearing mineral, cb=cabonate, cm-ta?=columbite-tantalite?, pc?=pyrochlore? Reflected light, uncrossed polars.

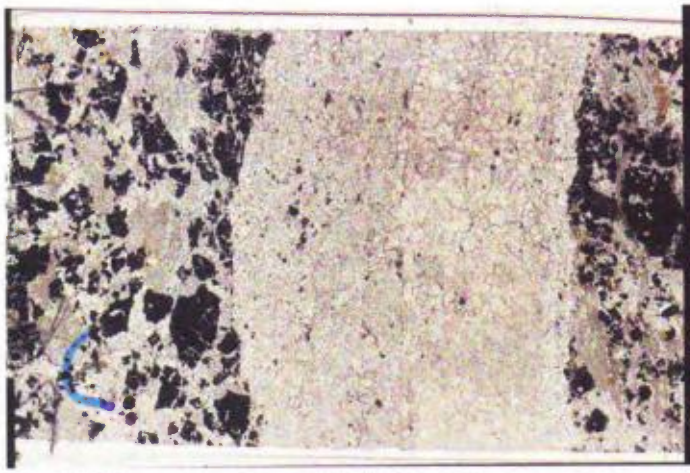


Fig.4 Thin section EC-08 021 196.05m plane polars

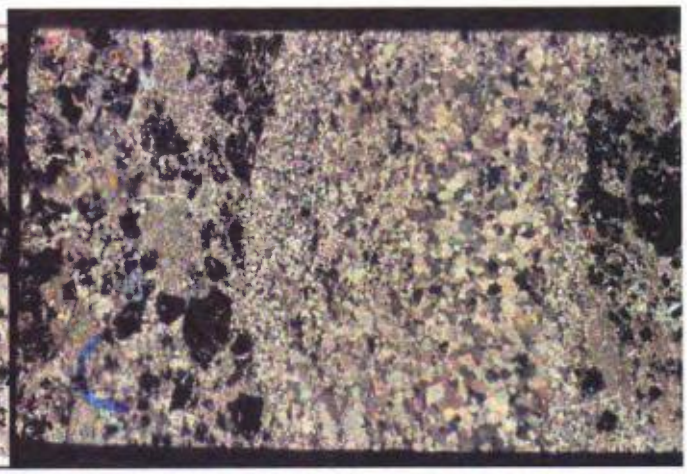


Fig.5 Thin section EC-08 021 196.05m cross polars

The amphibole and rare earth minerals in this section would require further SEM/EMPA work for identification.

Apatite Cumulate in contact with dolomite carbonatite

EC08-025 at 21.40m

Fig.1 Reddish apatite cumulate in contact with dolomite carbonatite. P_2O_5=17.03%, Nb=2550.4 ppm, Ta=629.2 ppm, REE+Y=0.18%

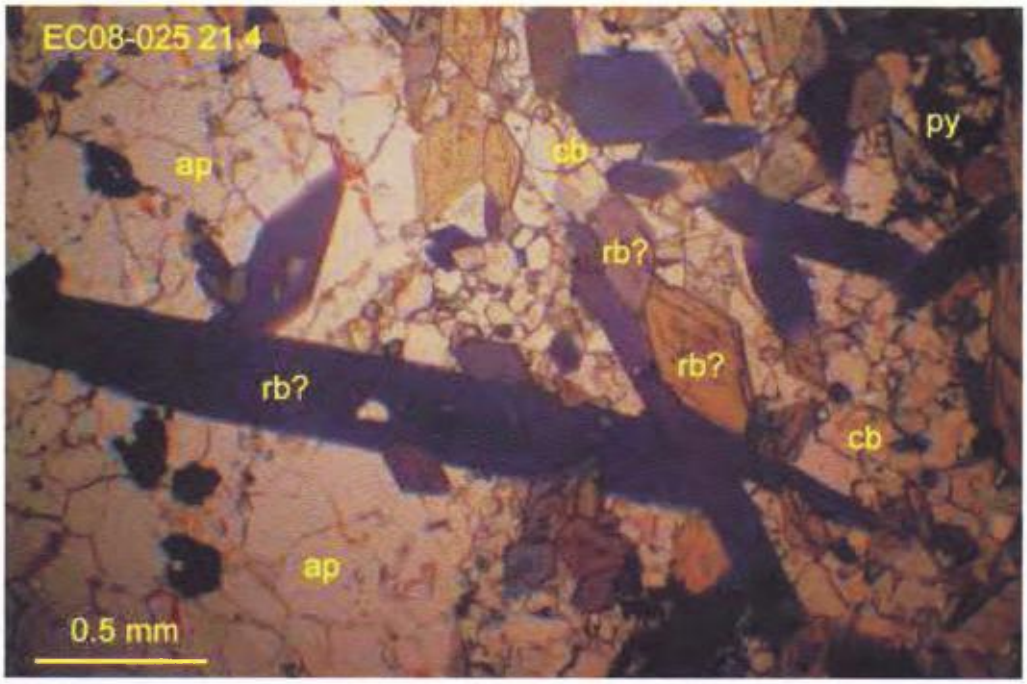


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-025 21.40. ap=apatite, py=pyrite, rb?=riebeckite? cb=carbonate. Transmitted plane light.

Owing to time constraints at the University of Alberta the thin section for this sample was not scanned.

Determining the amphibole and rare earth phases present would require further SEM/EMPA work.

TWINNED MARCASITE WITH YELLOW UNIDENTIFIED, POSSIBLE REE MINERAL

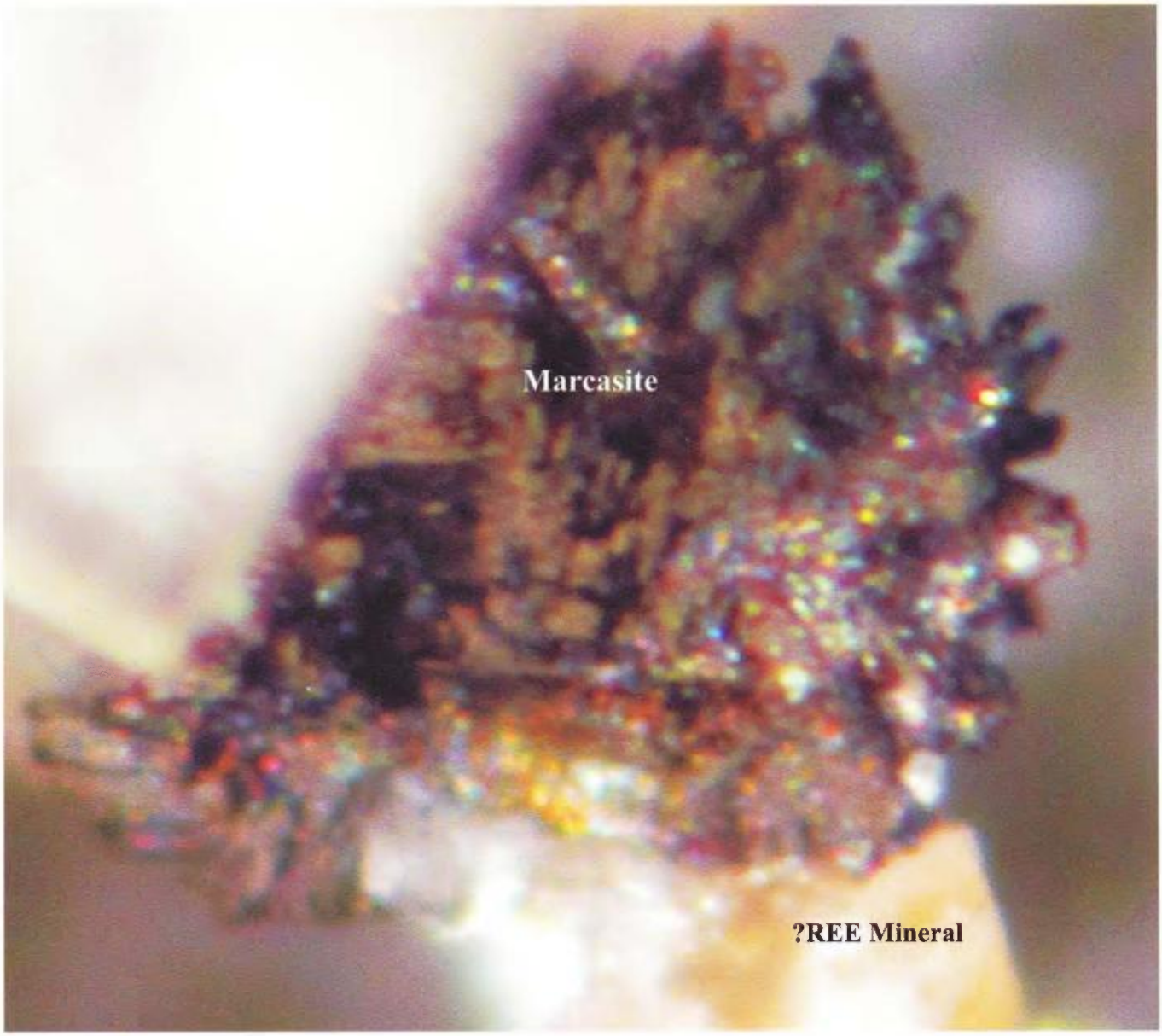


PLATE IX. This micro-photo shows a reticulated marcasite twin on a possible REE-bearing mineral (yellow coloured crystal at bottom). SEM/EMPA work would be necessary to identify this mineral.

Calcite Silico-Carbonatite

EC08-006 at 28.05m

Fig.1 Phlogopite silico-carbonatite. Note that the large dark lath-like crystals are phlogopite. P_2O_5=5.23%, Nb=257.5 ppm, Ta=8.5 ppm, REE+Y=0.19%

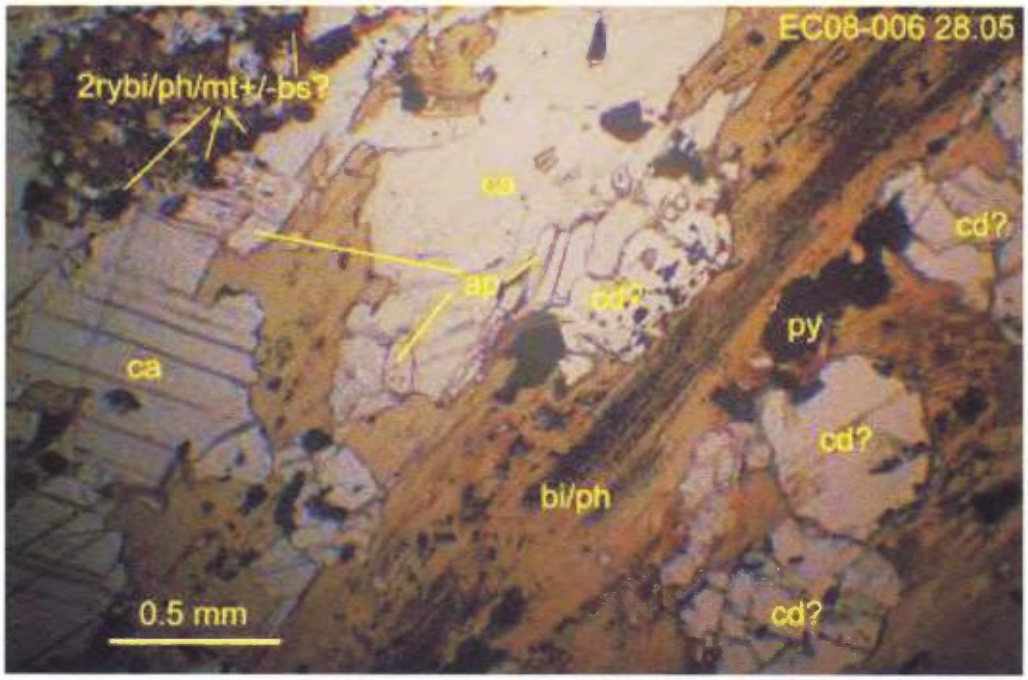


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-006 28.05m, ca=calcite, ap=apatite, bi/ph=phlogopite, cd?=cordierite?, py = pyrite. Photo and description by Craig Lietch. Transmitted plane light.

continued ...

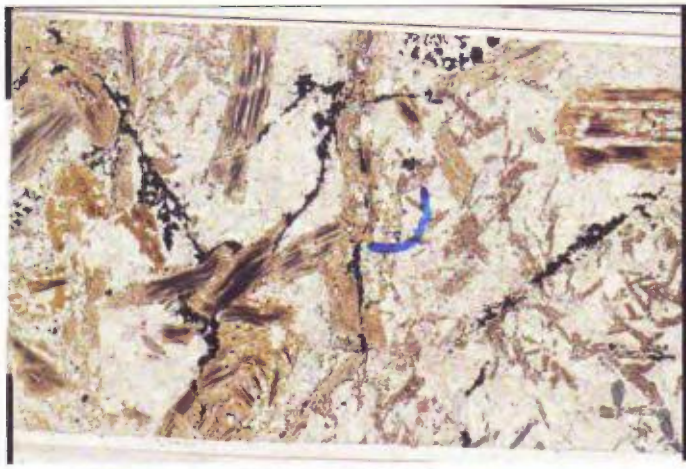


Fig.3 Thin section EC-08 006 28.05m plane polars

Fig.4 Thin section EC-08 006 28.05m cross polars

Dr. Leitch describes these phlogopite crystals as exhibiting blastic growth. If true, this is a primary igneous texture with minor metamorphic alteration. Dr. Leitch found titanite in this sample explaining the 1.32% TiO_2 in the whole rock assay. EMPA work would be necessary to determine all the TiO_2 phase(s) at Eldor. There are several intervals with TiO^2 in the 3-5% range but not consistent enough to be economically interesting.

Brecciated Glimmerite

EC08-001 at 10.25m

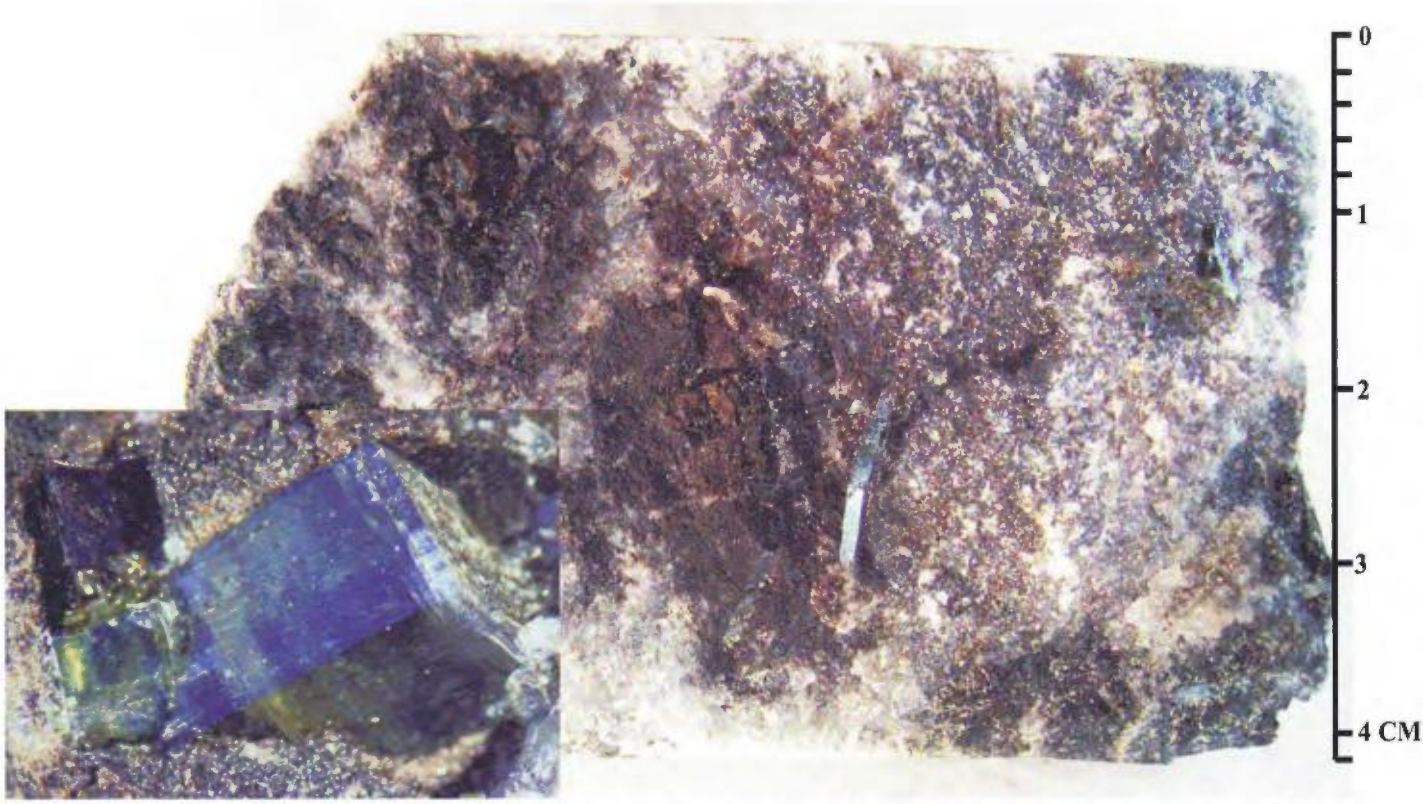


Fig.1 This ?fenetized, fine-grained volcanic or sedimentary rock is a glimmerite (brecciated) with large amphibole crystals (metamorphic?). P_2O_5 = 2.77%, Nb=695.8 ppm, Ta=10.9ppm, REE+Y=0.14%

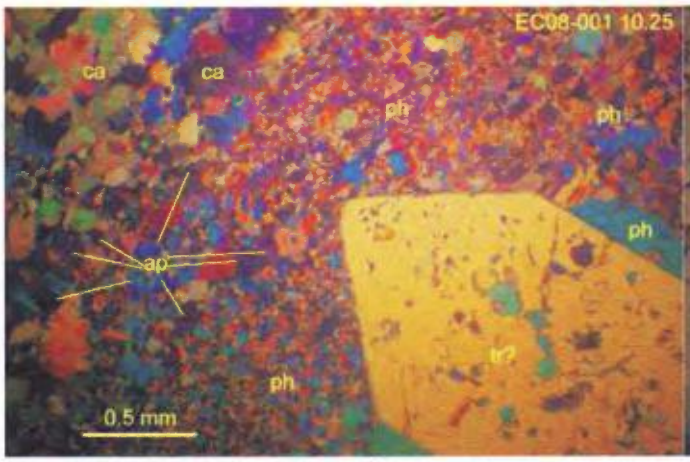


Fig. 2 Photo by Craig Leitch outlned on thin section EC08-001 10.25m. ph=phlogopite, ap=apatite, ca=calcite, tr?=tremolite.Transmitted light, crossed polars.

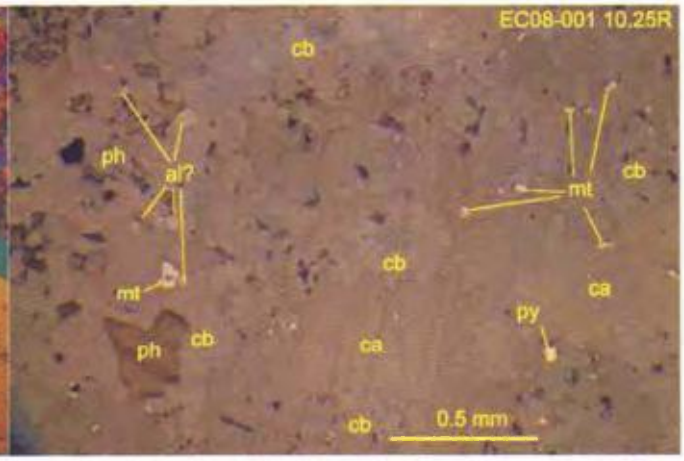


Fig. 3 Photo by Craig Leitch outlned on thin section EC08-001 10.25m. ph=phlogopite, ca=calcite, mt=magnetite, cb=Mg-Fe carbonate, py=pyrite, al?=allanite? Reflected light, uncrossed polars.

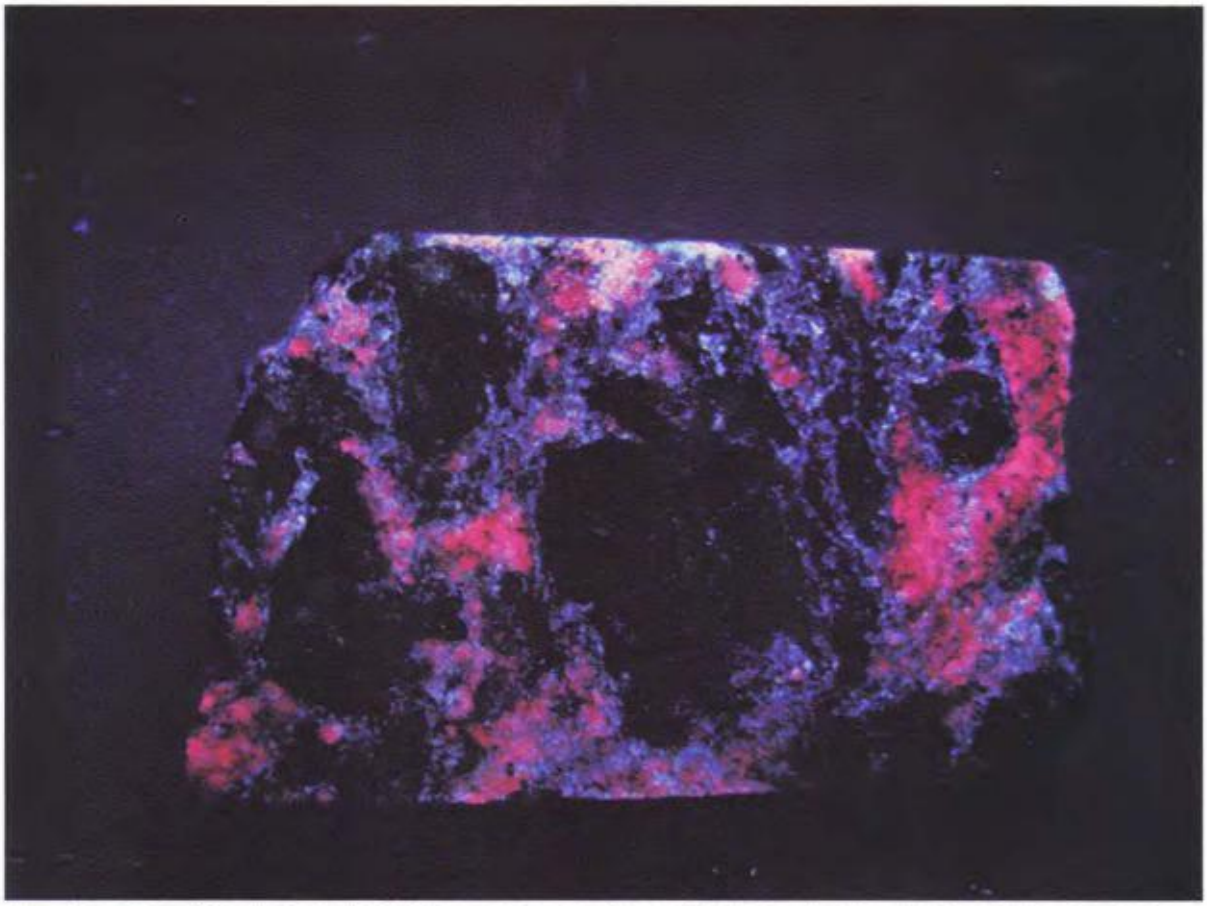


Fig. 4 Core section EC08-001 10.25 m under midrage UV light. Apatite is blue-white, calcite is red-orange.

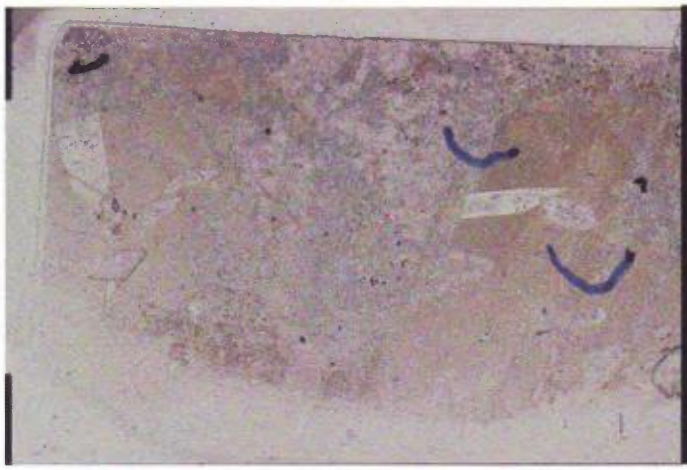


Fig.5 Thin section EC-08 001 10.25m plane polars

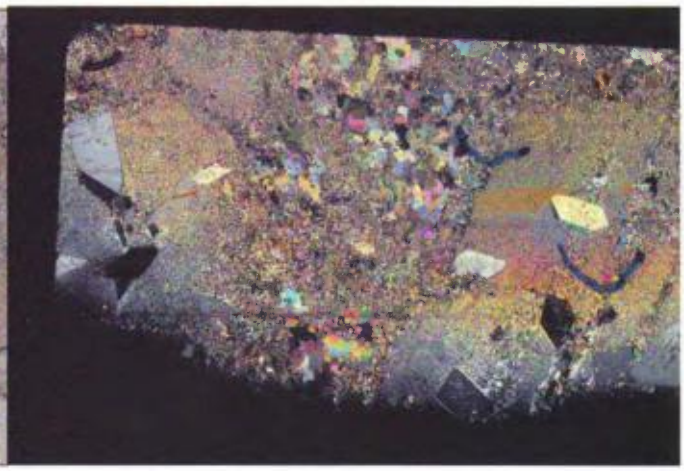


Fig.6 Thin section EC-08 001 10.25m cross polars

The coarse amphibole crystals in thin section EC08-001 at 10.25m are truncated by brecciation caused by the calcite carbonatite intrusion. Was the glimmerite formed by fenetization of a country rock type or a previous metamorphic event? EMPA analysis of the amphibole would aid in this determination.

Brecciated Glimmerite & Dolomite Carbonatite

EC08-001 at 141.34m

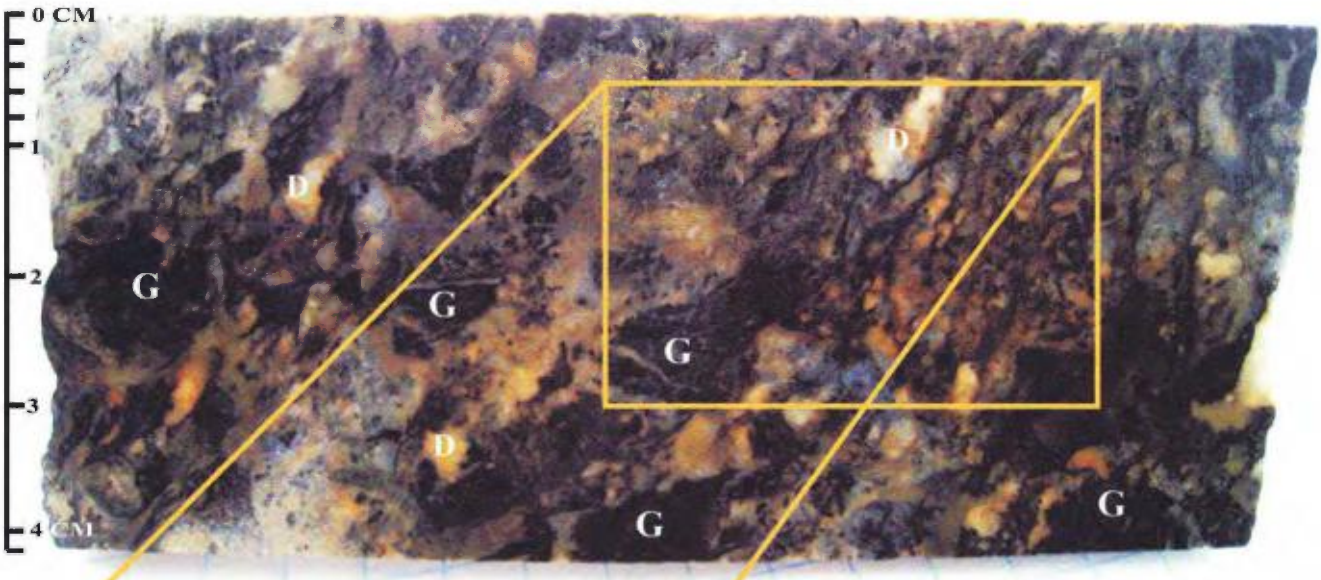


Fig.1 Glimmerite (G), dolomite (D) and apatite-dolomite carbonatite clasts in dolomite carbonatite matrix. P_2O_5=5.81%, Nb=2239ppm, Ta=155.7 ppm, REE+Y=0.25%

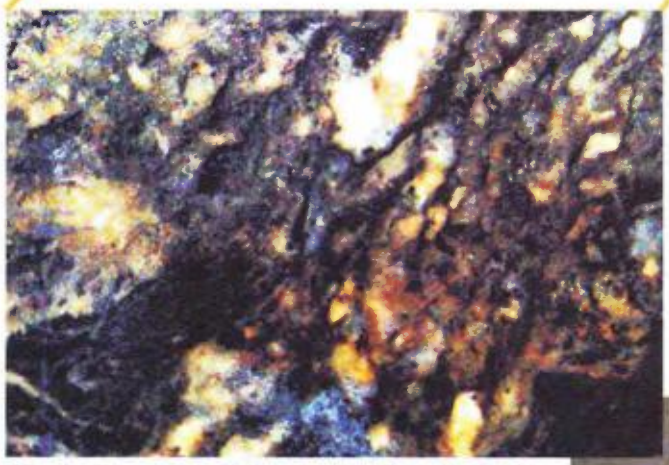


Fig. 2 Close-up of breccia showing elongation of glimmerite clasts

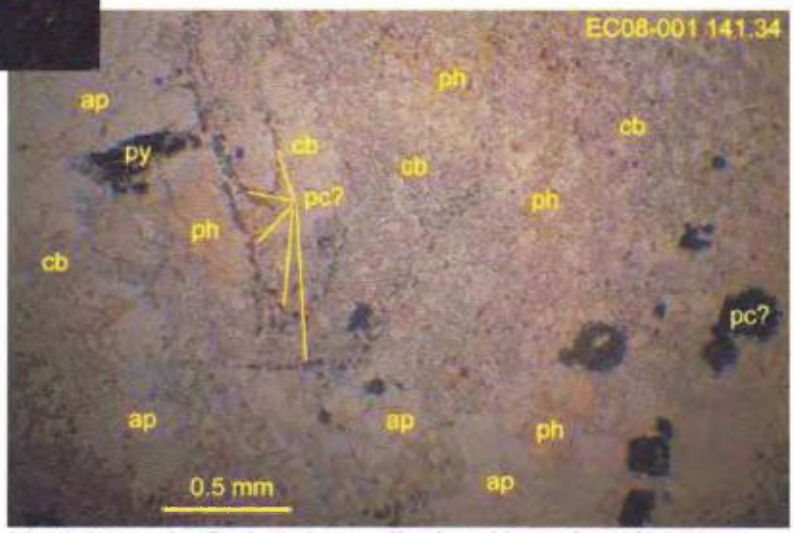


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-001 141.34m, pc?=pyrochlore?, cb=carbonate, ap=apatite, ph=phlogopite, py=pyrite. Transmitted plane light, uncrossed polars.

continued ...

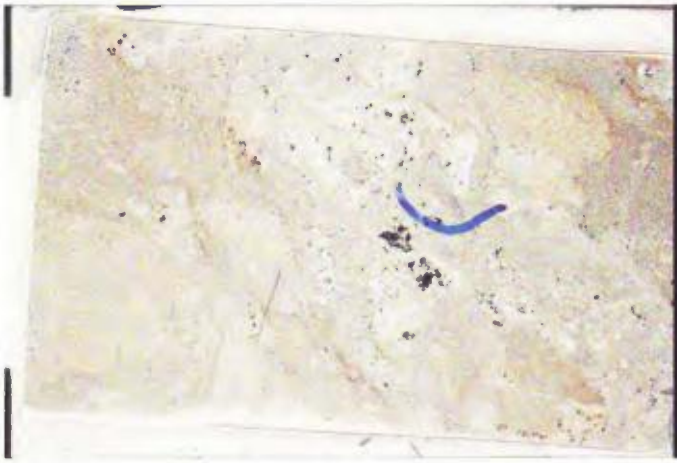


Fig.4 Thin section EC-08 001 141.34m plane polars

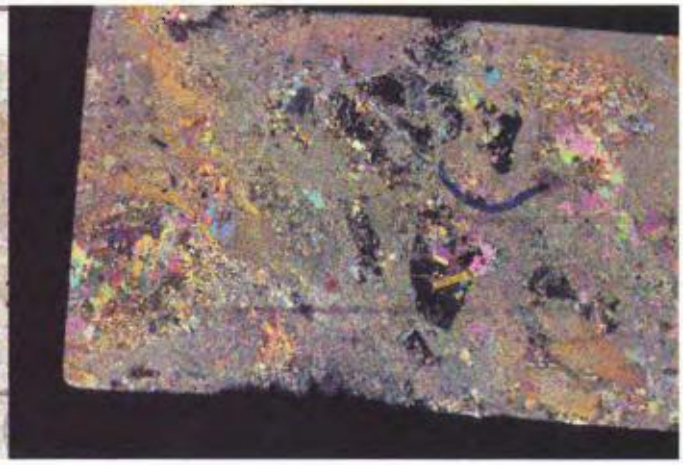


Fig.5 Thin section EC-08 001 141.34m cross polars

This sample may show the beginning of metamorphic foliation. If so, brecciation preceeded metamorphic alignment.

Glimmerite

EC08-002 at 38.25m

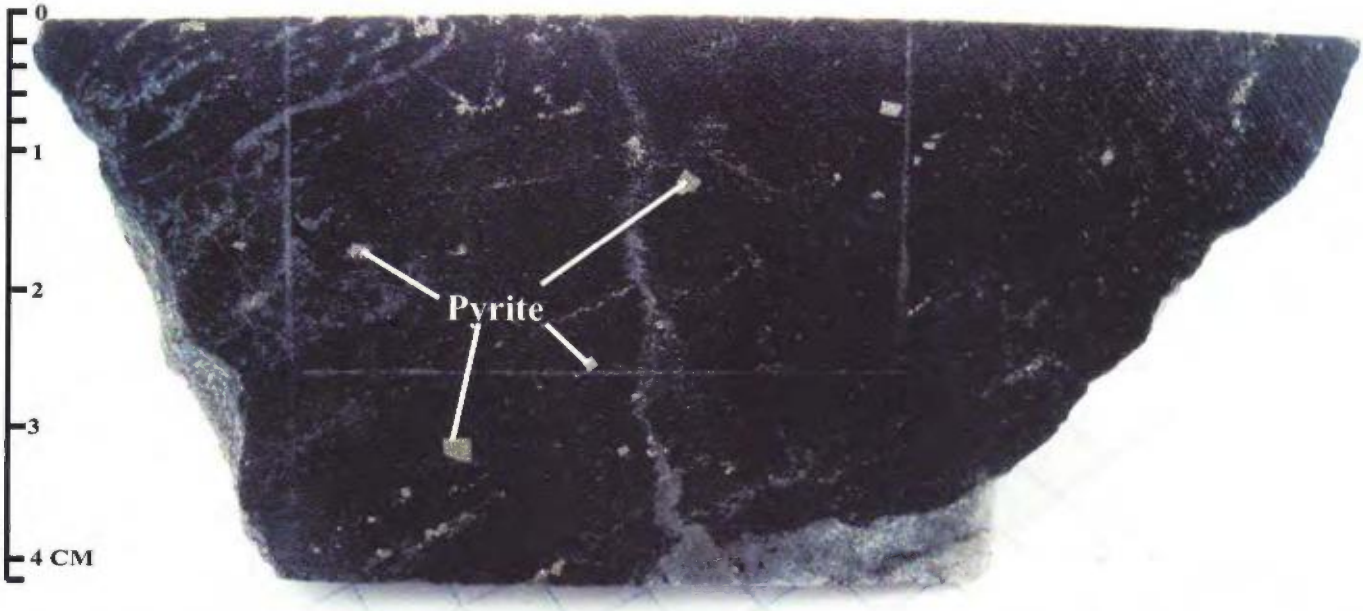


Fig.1 Glimmerite . This glimmerite shows weak metamorphic foliation. Foliation is highlighted by calcite, apatite, pyrite filled fractures & crosscut by remobilized calcite with pyrite. P_2O_5=1.68%, Nb=877.9 ppm, Ta=9.9 ppm, REE+Y=0.09%

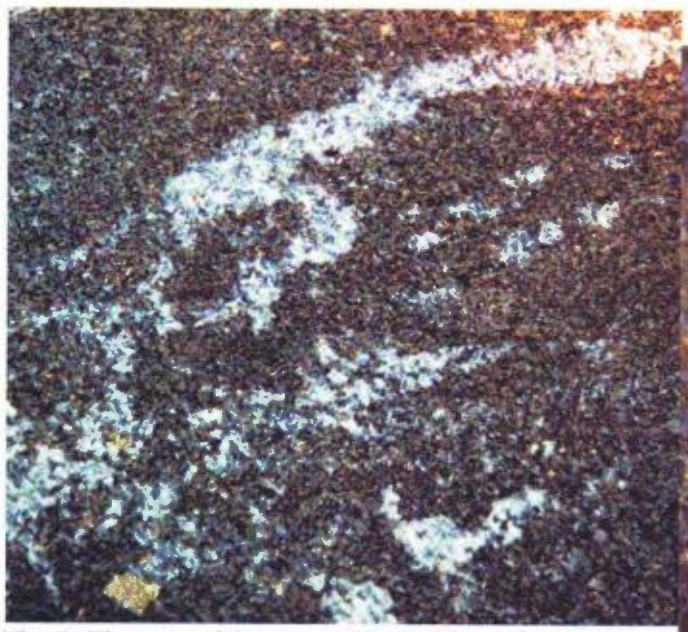


Fig. 2 Close-up of fractures filled with calcite, apatite and pyrite.

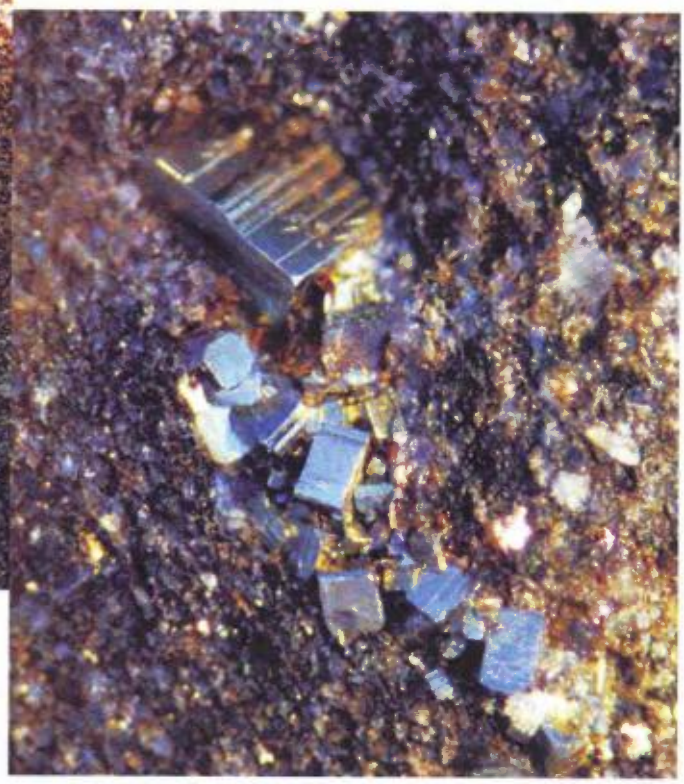


Fig.3 Micro-photo of euhedral pyrite in glimmerite.

continued ...

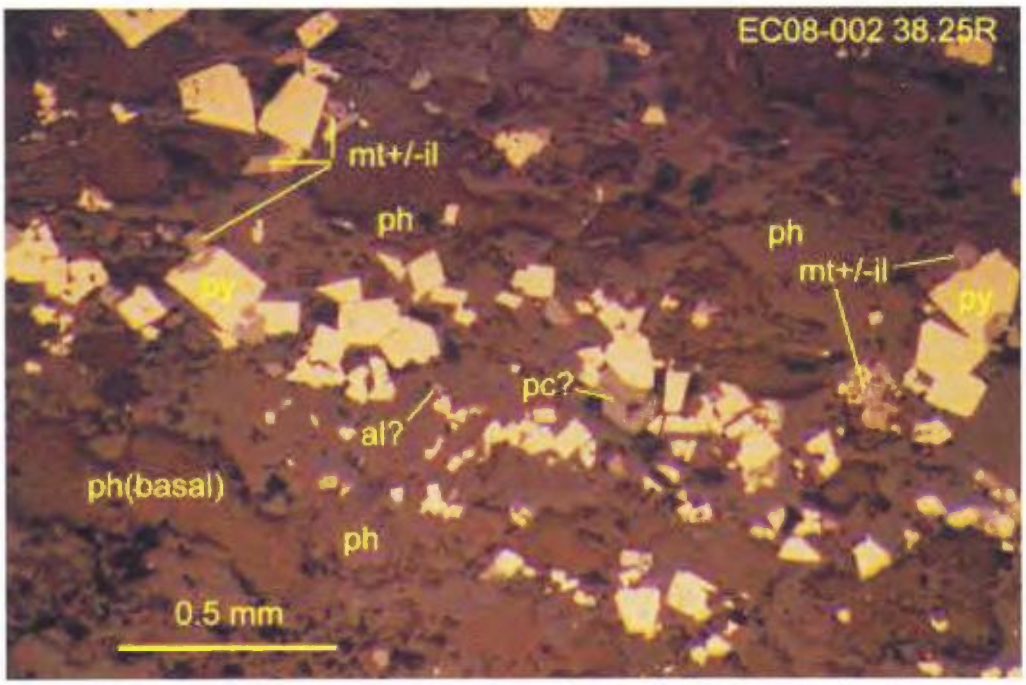


Fig. 4 Photo by Craig Leitch outlined on thin section EC08-002 38.25m, ph=phlogopite, pc?=pyrochlore, mt+/-il=magnetite/ilmente, py=pyrite, al?=allanite. Reflected light, uncrossed polars.

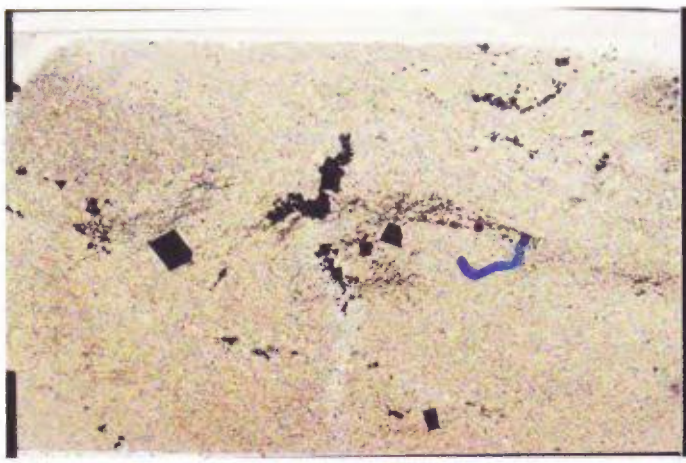


Fig.5 Thin section EC-08 002 5.1m plane polars

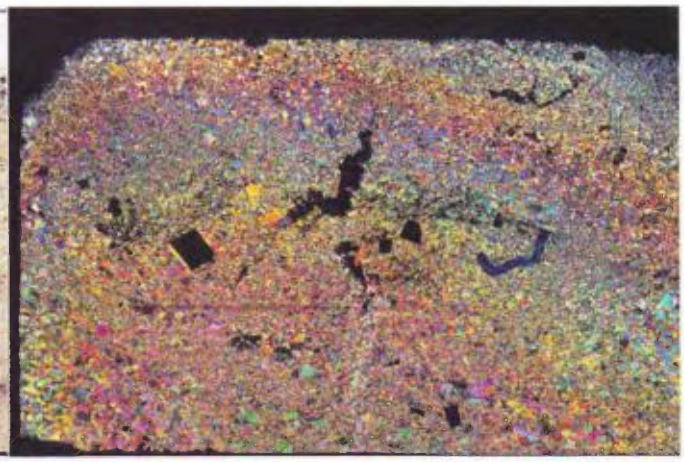


Fig.6 Thin section EC-08 002 5.1m cross polars

This sample demonstrates the weak metamorphic foliation found at Eldor. Note the low Nb value.

Altered Glimmerite

EC08-007 at 39.46m

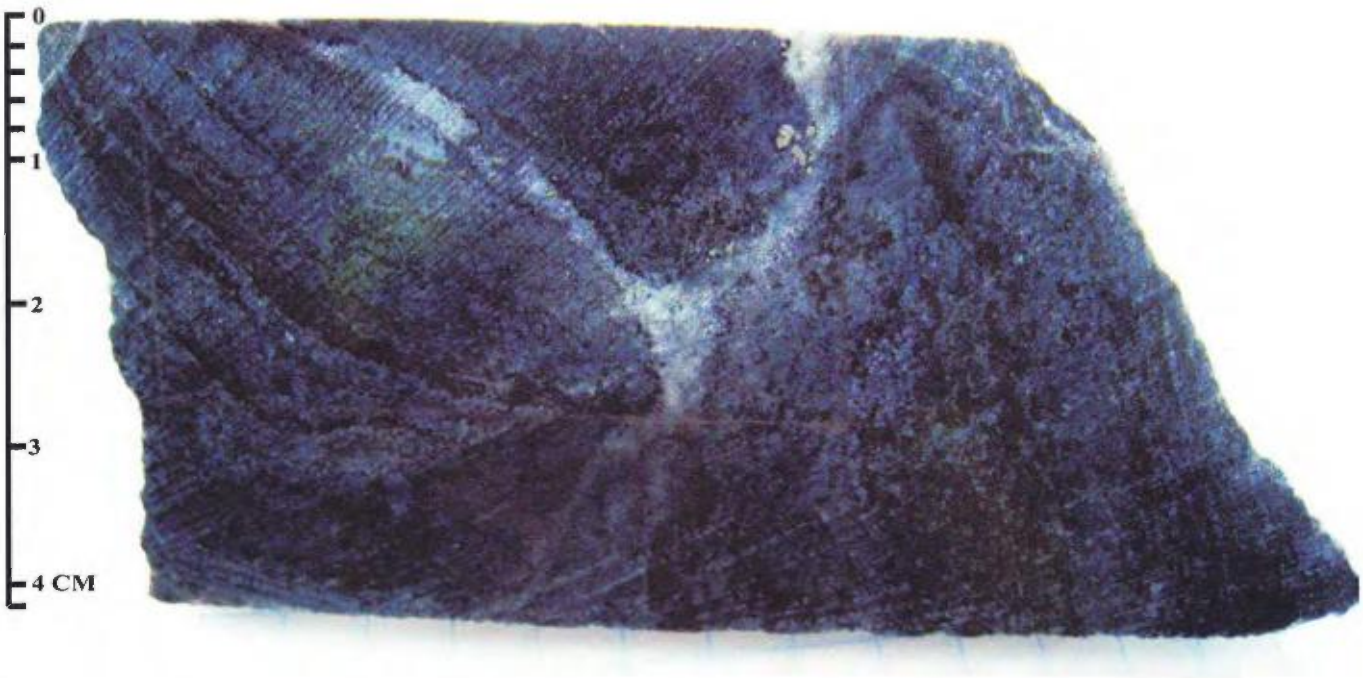


Fig.1 Glimmerite with blue amphibole. No assay results are available for this interval.

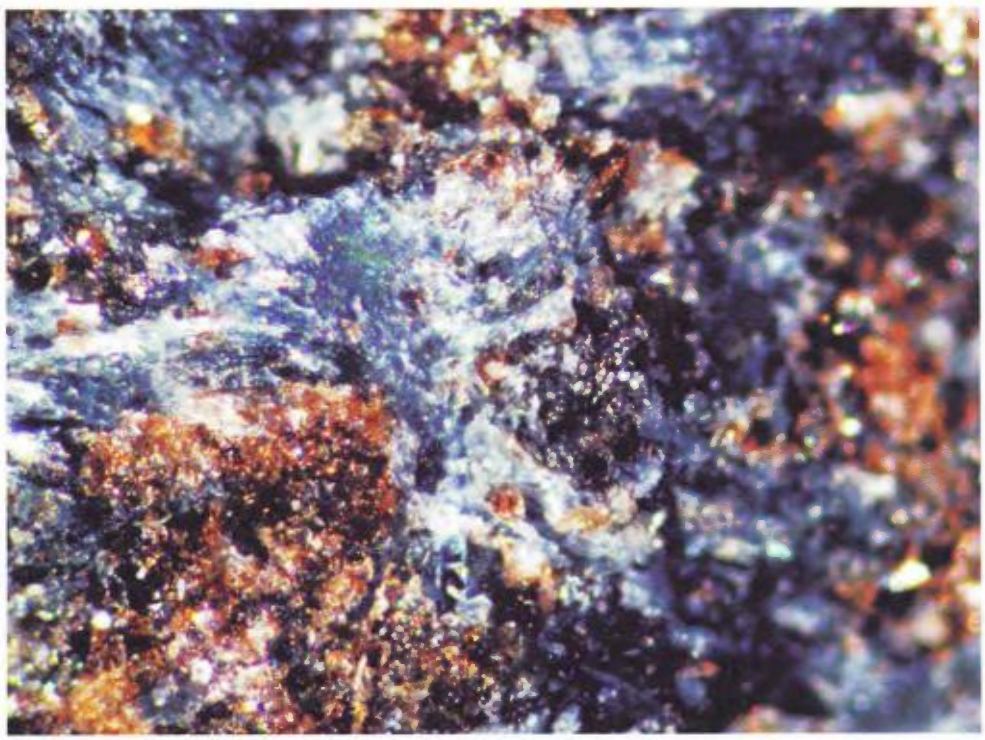


Fig. 2 Micro-photo of blue amphibole in phlogopite (brown).

continued ...

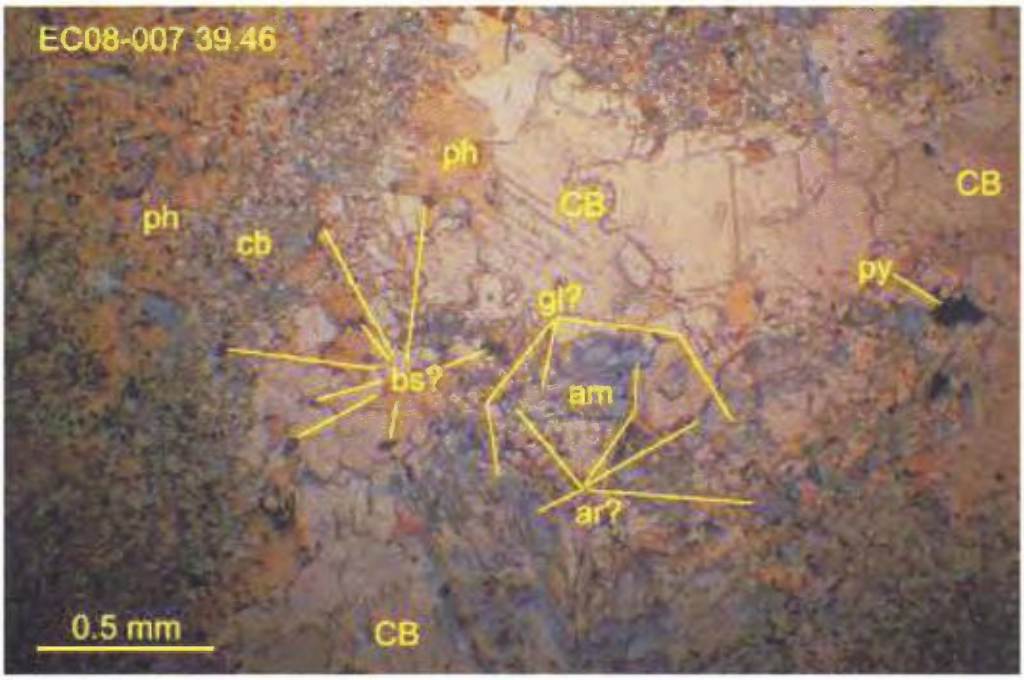


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-007 39.46m, ph= phlogopite, bs?=bastnaesite?, ar?=arfvedsonite, am=amphibole, cb=fine-grained carbonate, CB=coarse-grained carbonate, gl?=glaucophane. Transmitted plane light.

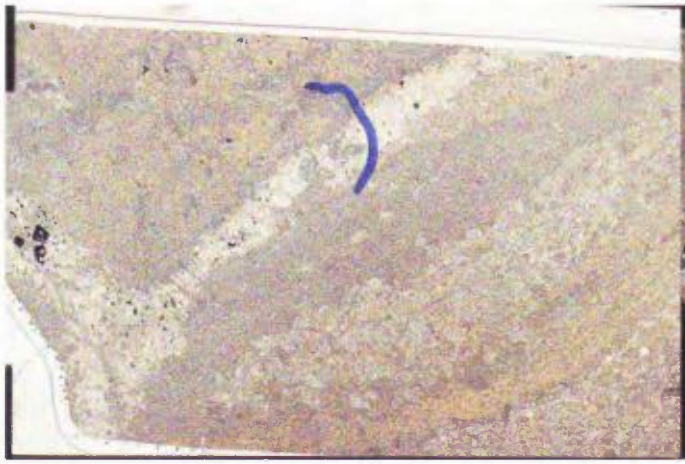


Fig.4 Thin section EC-08 007 39.46m plane polars

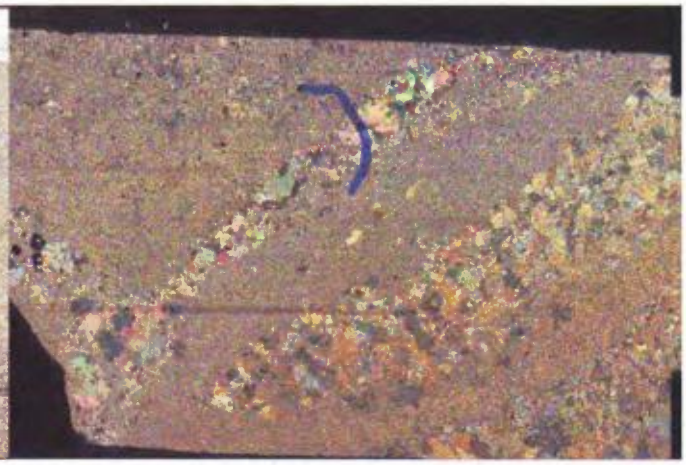


Fig.5 Thin section EC-08 007 39.46m cross polars

The name glaucophane has been used by Dr. Craig Lietch (see Appendix B) and by Allison Brandt (2009) in describing blue amphiboles from Eldor. Without EMPA work we can not tell for certain if they are right. There are many blue coloured amphiboles (riebeckite, arfvedsonite, richeterite and their FE/Mg alternates). The presence of glaucophane infers blue-schist which gives a specific paragenetic origin for this rock, which I doubt is accurate.

Note: Fibrous amphiboles like these can pose major health risks in a mining situation.

Glimmerite

EC08-025 at 140.0m

Fig.1 Dark brown glimmerite. No whole rock assays are available for this section.

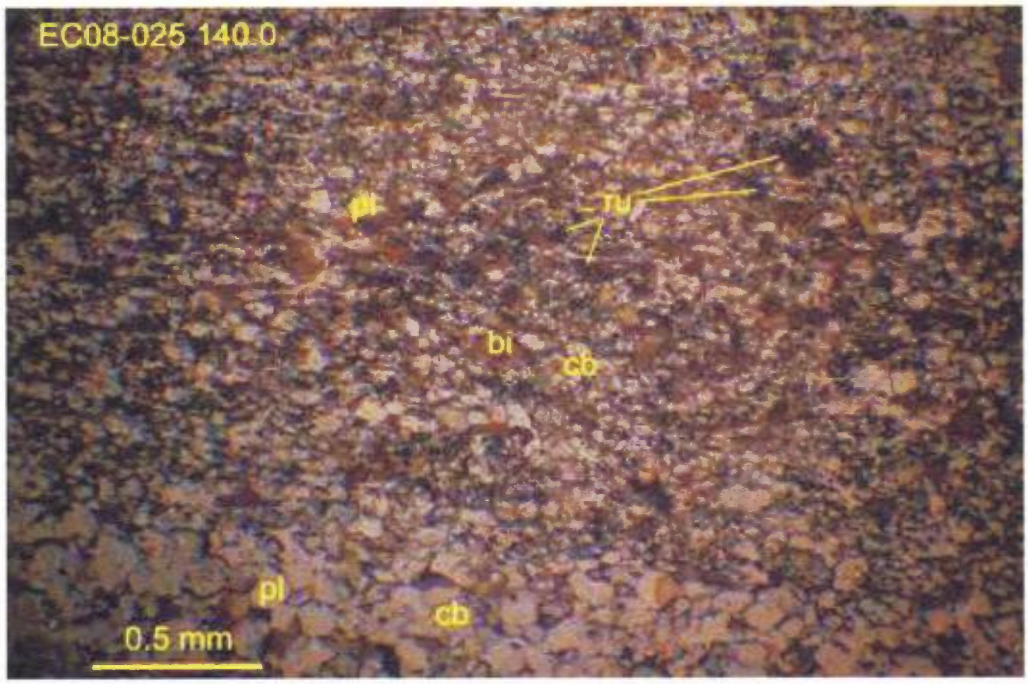


Fig. 2 Photo by Craig Leitch pl=plagioclase, cb=carbonate, ru=rutile, bi=biotite. Transmitted plane light.

Owing to time constraints at the University of Alberta the thin section for this sample was not scanned.

The foliated glimmerite is infused with dolomite carbonatite. The glimmerite could be a country rock fenetized by a dolomite carbonatite intrusion, or an unusual component of the dolomite carbonatite.

QUARTZ WITH UNIDENTIFIED WHITE MINERAL INCLUSION

PLATE X. Quartz is not a common mineral in carbonatites. This micro-photo shows a clear quartz crystal with a phantom created by an unidentified white mineral.

Metamorphosed Andesite

EC08-018 at 69.70m

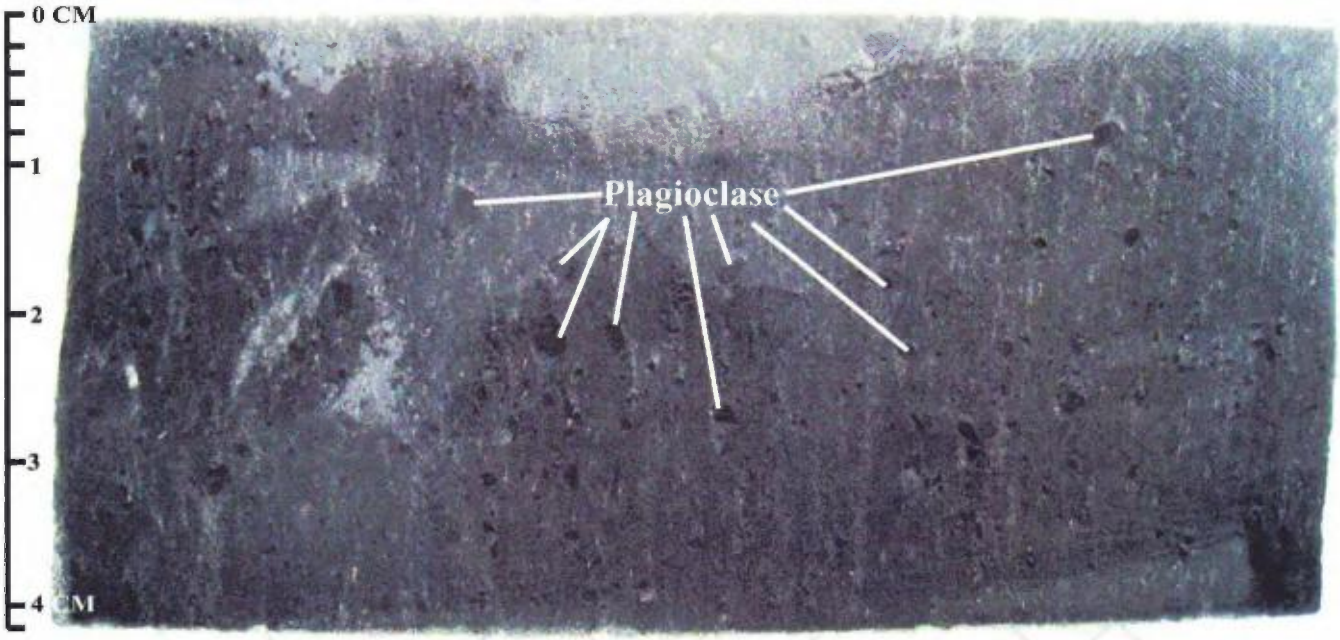


Fig.1 Volcanic country rock with chloritized mica and plagioclase porphyroblasts. P_2O_5=0.2%, Nb=63.2 ppm, Ta=2.6 ppm, REE+Y=0.02%

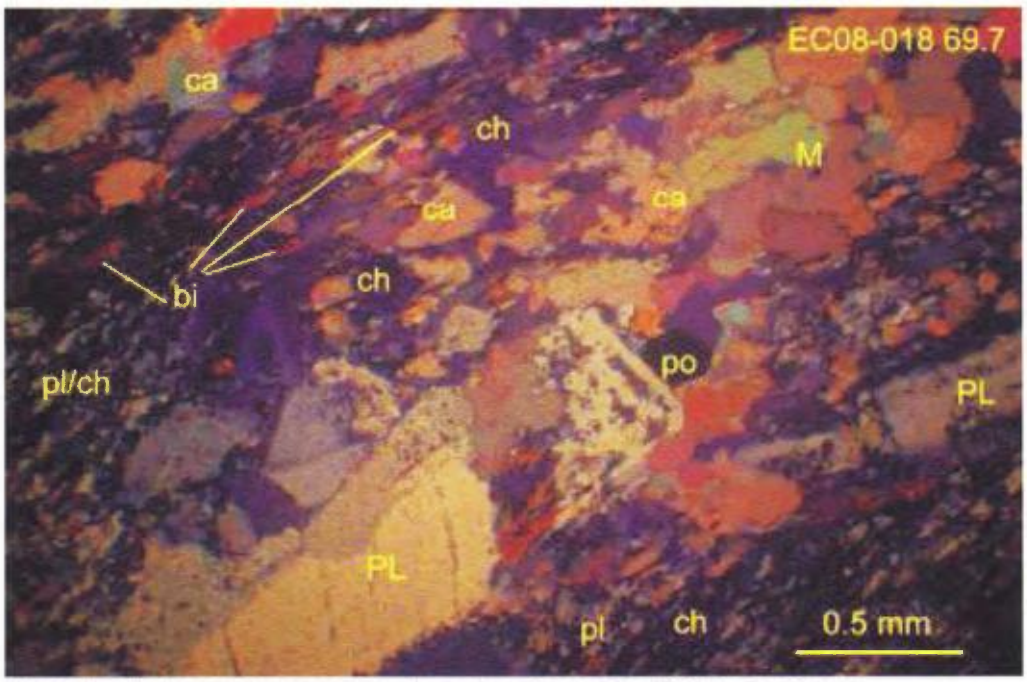


Fig. 2 Photo by Craig Leitch PL=plagioclase, M=unidentified mafic mineral, po=pyrrhotite, ch=chlorite, bi=biotite, ca=calcite. Trasmitted light, crossed polars.

Owing to time constraints at the University of Alberta the thin section for EC08-018 69.7m was not scanned. **This sample is one of the few distinct country rock types encountered in the 2008 drilling.**

Metamorphosed Andesite

EC08-019 at 209.40m

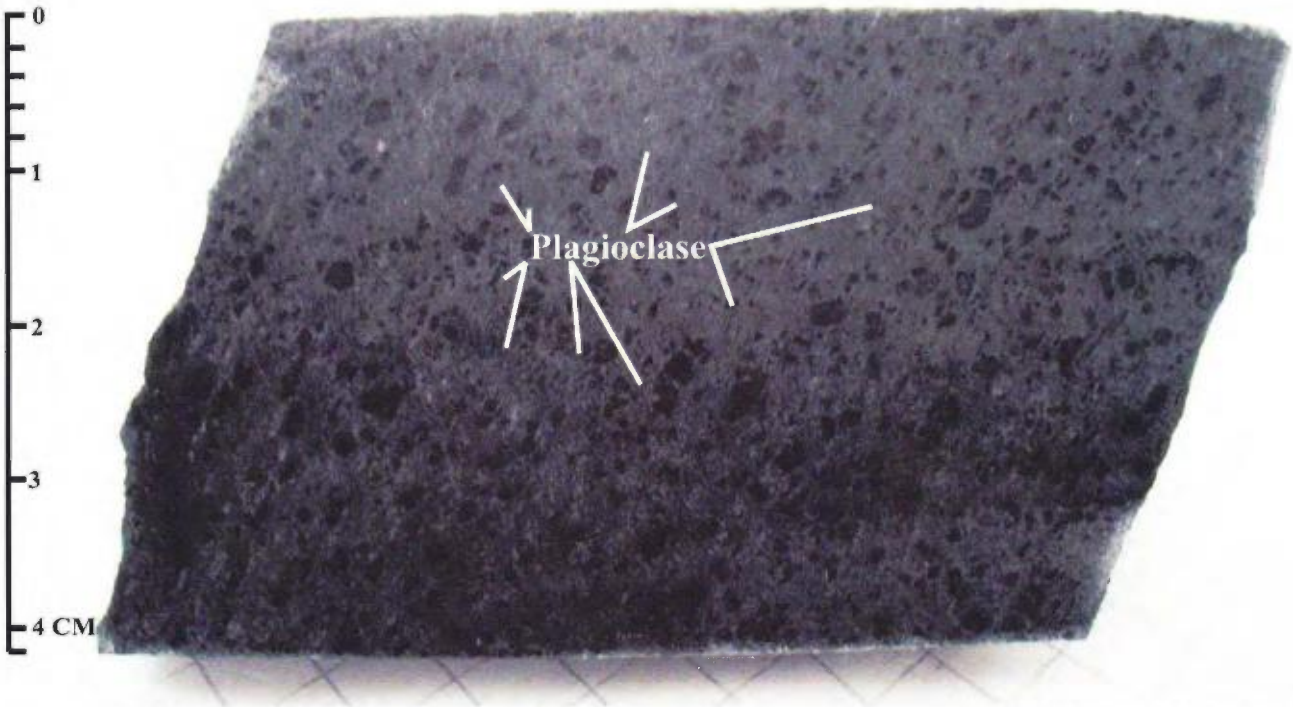


Fig.1 Dark plagioclase porphyroblasts in volcanic country rock . P_2O_5=2.97%, Nb=3279.3 ppm, Ta=79 ppm, REE+Y=0.18%.

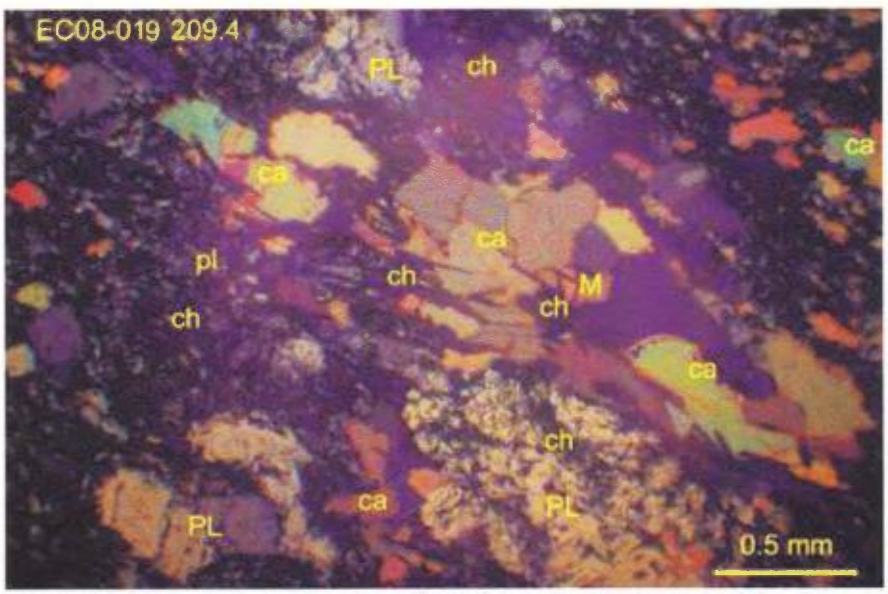


Fig. 2 Photo by Craig Leitch, PL=plagioclase, ch=chlorite, ca=calcite M=unidentified mafic mineral. Transmitted light, crossed polars.

The whole rock assay values for this sample do not fit well with this metamorphosed andesite. There is no apatite or Nb mineral present in this rock. This demonstrates that the assay sampling was not properly controlled lithologically. This is the second metamorphosed andesite country rock sample I noticed in the 2008 diamond drill core and identical to the sample EC08-018 at 69.70m.

Ultramafic Rock

EC08-009 at 213.25m

Fig.1 Digested country rock or unusual cumulate? P_2O_5=4.19%, Nb=427.6 ppm, Ta=13.2 ppm, REE+Y=0.15%

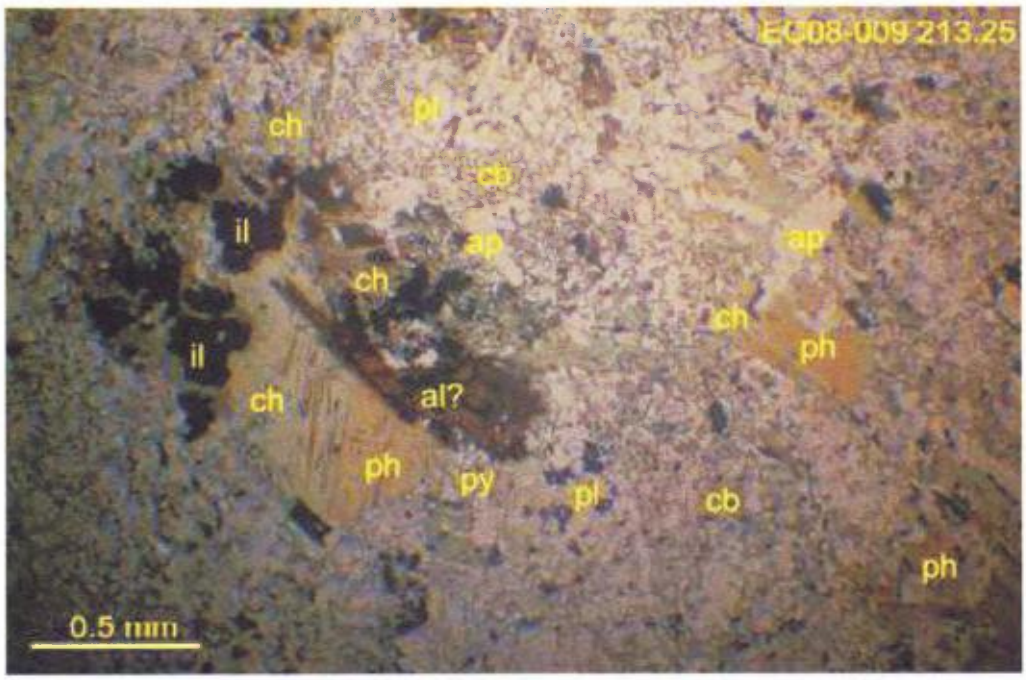


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-009 213.25m, il=ilmenite, pl=plagioclase, ph=phlogopite, cb=carbonate, ap=apatite, ch=chlorite. Transmitted plane light.

continued ...

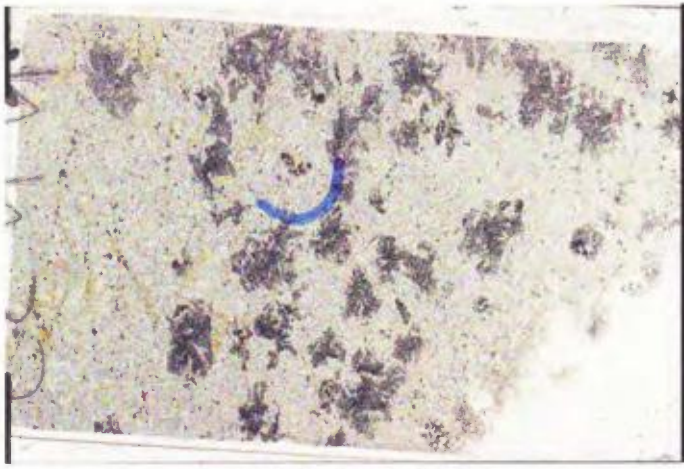


Fig.3 Thin section EC-08 009 213.25m plane polars

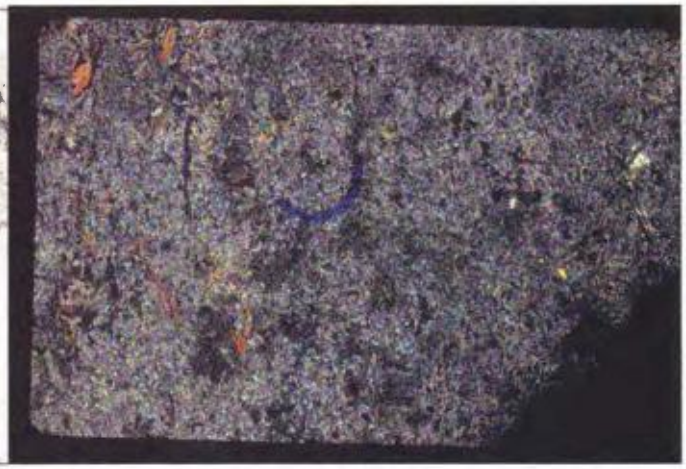


Fig.4 Thin section EC-08 009 213.25m cross polars

This is an unusual rock. Dr. Leitch's petrographic report shows that this sample is a heavily choritized rock with clots of chloritized phlogopite in a matrix of apatite-plagioclase-chlorite (Appendix B). I believe this is a carbonatite altered volcanic rock not dissimilar from the samples EC08-018 at 69.70m and EC08-019 at 209.4m.

Fluorite Vein in dolomite carbonatite?

EC08-021 at 74.30m

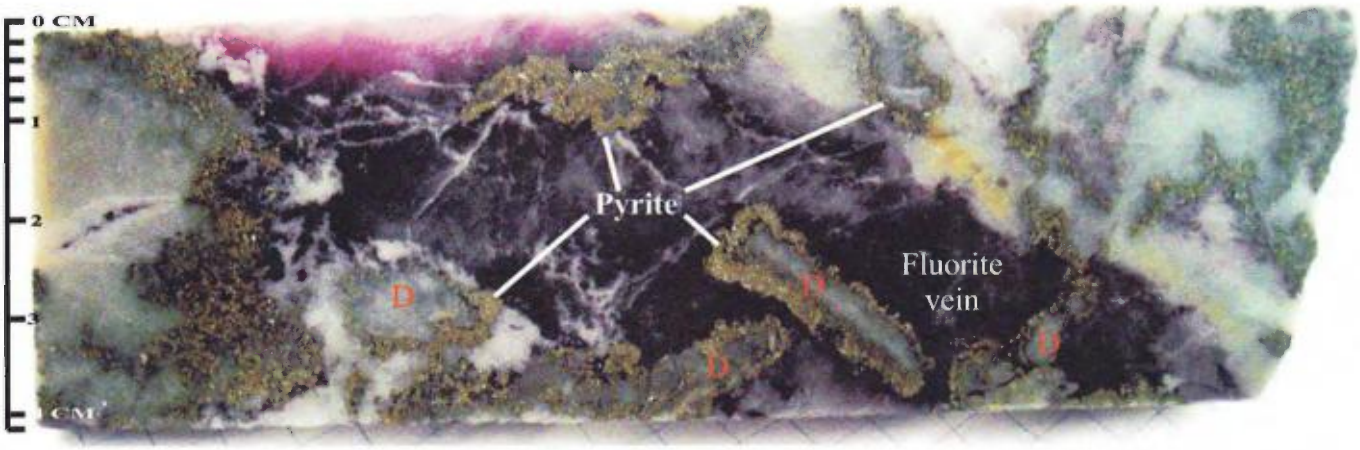


Fig.1 Large fluorite vein with pyrite rimmed dolomite (D) clasts.. P_2O_5=14.67%, Nb=2359.7 ppm, Ta=103.8 ppm, REE+Y=0.45%

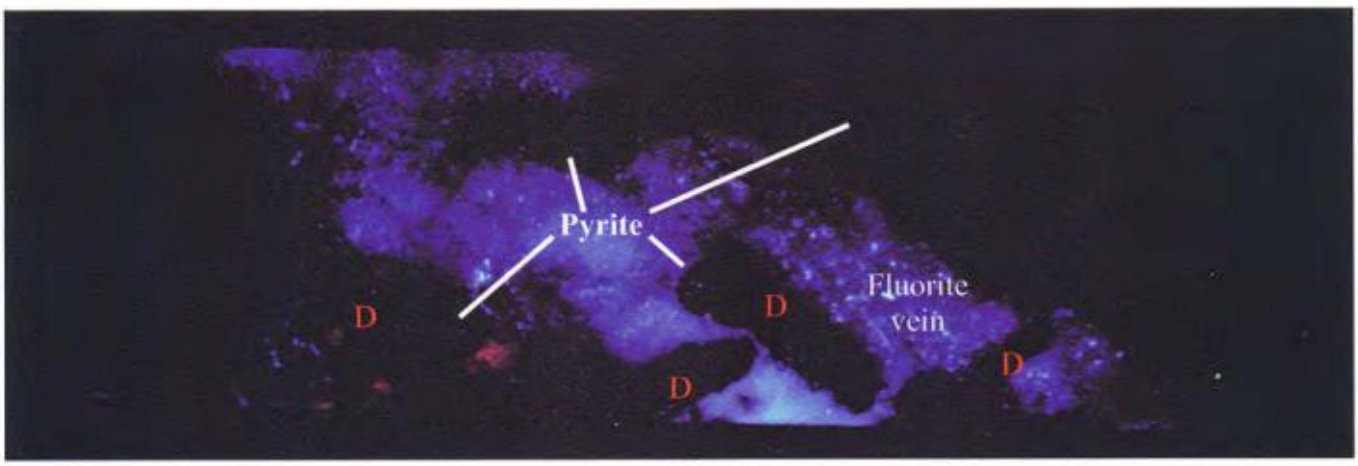


Fig. 2 Fluorescent fluorite in sample EC08-021 at 74.30m under midrange UV light. Most of the fluorite found at Eldor does not fluoresce. The red spot is calcite.

continued ...

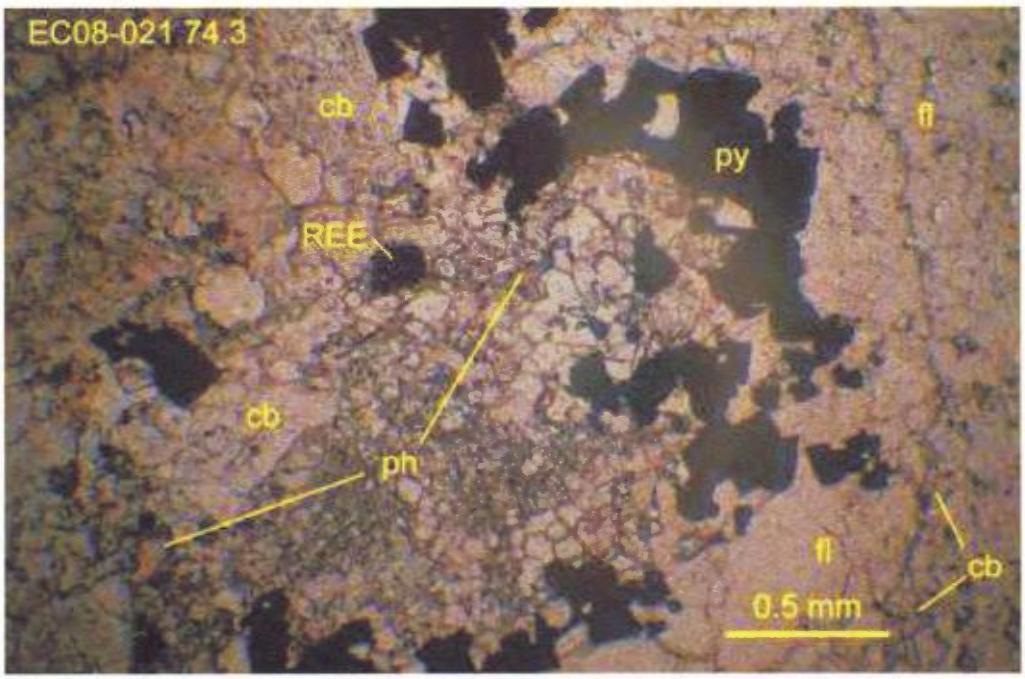


Fig. 3 Photo by Craig Leitch, fl=fluorite, ph=phlogopite, cb=carbonate, py=pyrite, REE=unidentified rare earth bearing mineral. Transmitted plane light.

Owing to time constraints at the University of Alberta the thin section for this sample was not scanned.

There is almost no apatite in this sample, which is at odds with the whole rock assay of 14.67% P_2O_5. I believe **the dolomite host for the fluorite vein is re-mobilized dolomite and not actually a carbonatite.** See page 22 in this section for a discussion of possible sources of incongruence in the whole rock assays.

Fluorite/Dolomite Vein in contact with dolomite carbonatite

EC08-014 at 169.81m

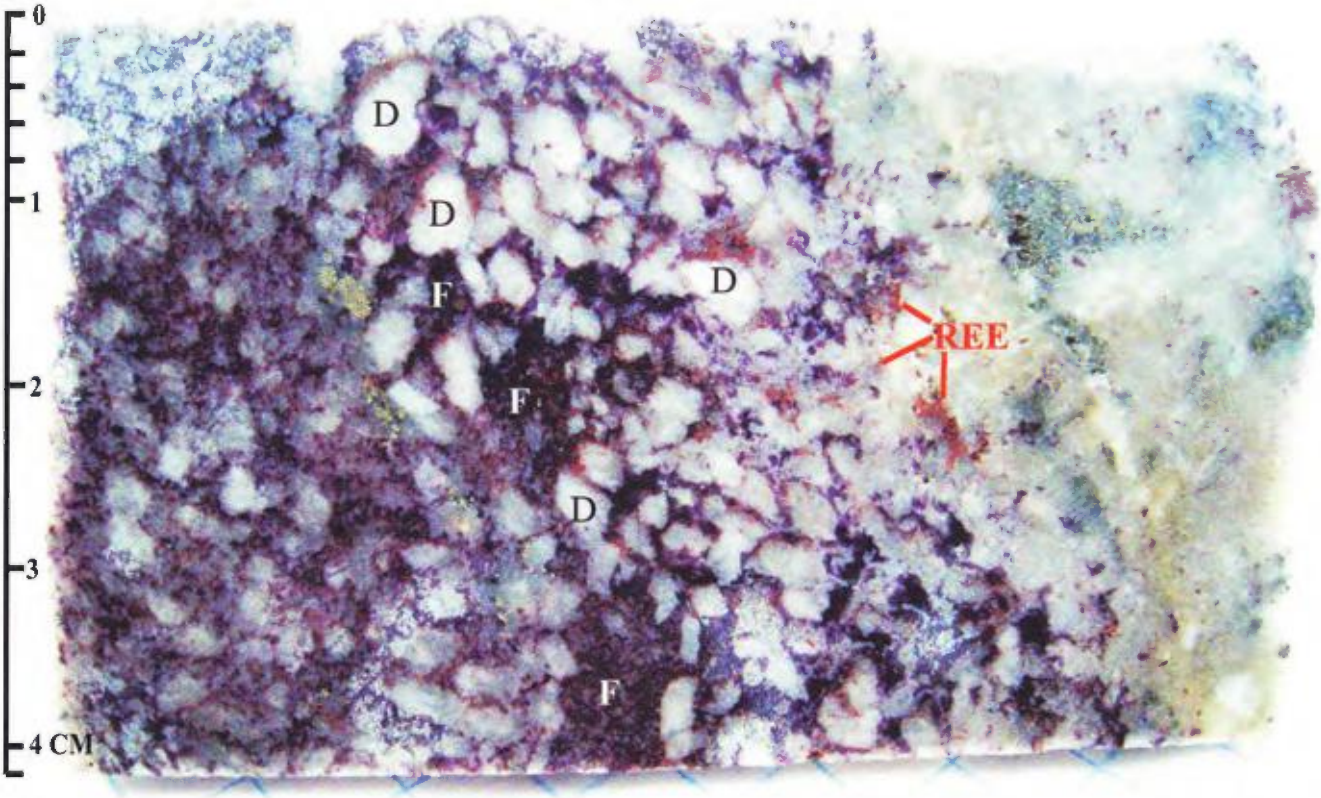


Fig.1 Dolomite porphyroblasts (D) in fluorite (F) with REE (REE) minerals. P_2O_5=2.3%, Nb=867.5 ppm, Ta=14 ppm, REE+Y=0.31%

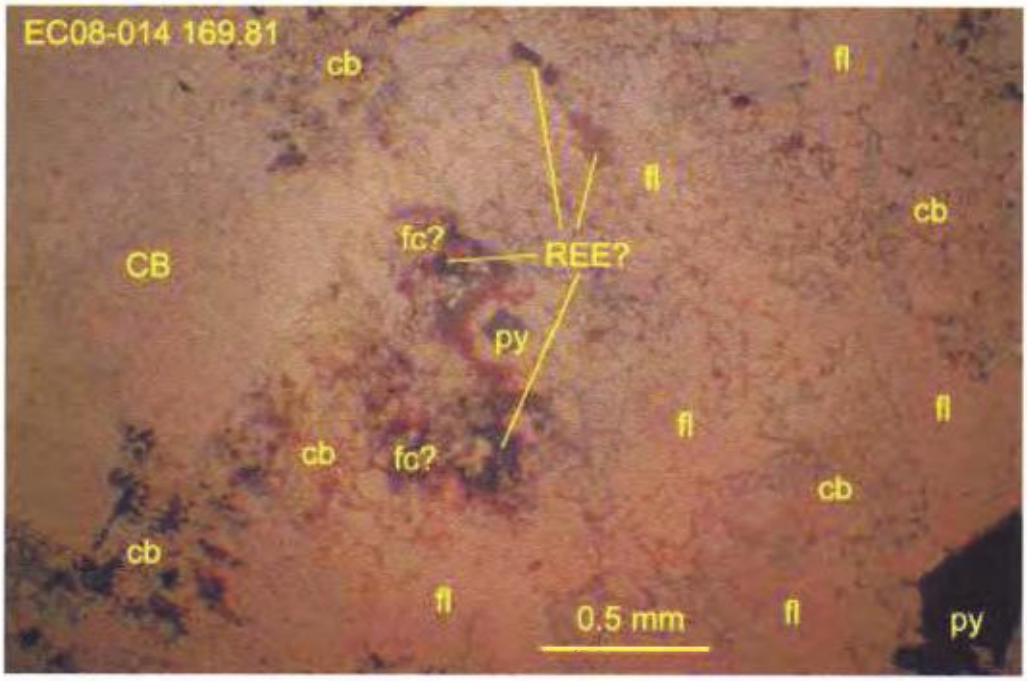


Fig. 2 Photo by Craig Leitch. CB=coarse-grained carbonate, cb=fine-grained carbonate, fl=fluorite, py=pyrite, fc?=fluorocarbonate?, REE?= unidentified REE mineral. Transmitted plane light.

continued ...

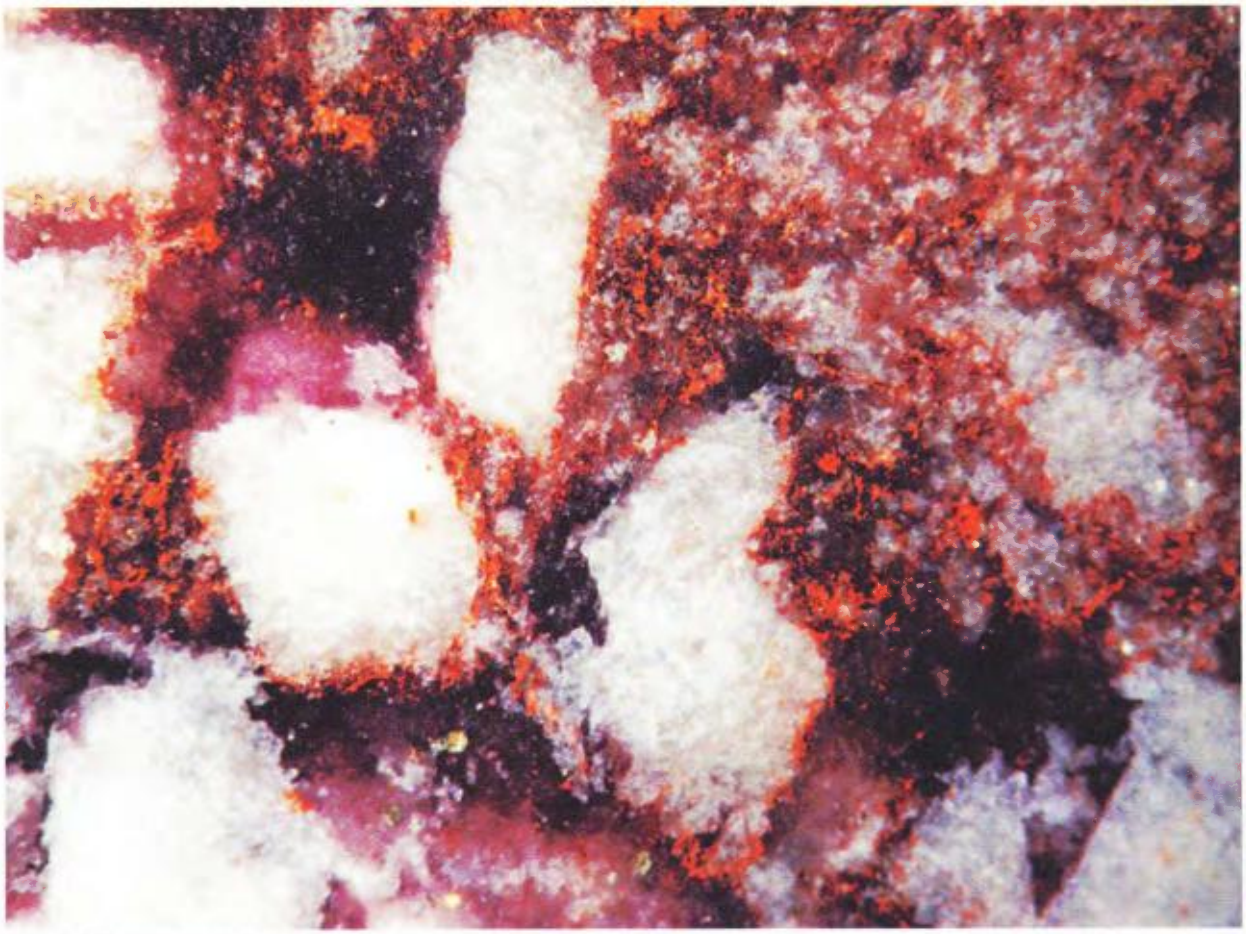


Fig. 3 Micro-photo of dolomite porphyroblasts and REE minerals (red) in fluorite/dolomite vein.

Owing to time constraints at the University of Alberta the thin section for this sample was not scanned.

Dr. Leitch's petrographic work shows the clasts in this sample are porphyroblastic dolomite without inclusions of apatite, magnetite etc., floating in a matrix of fluorite/dolomite/apatite/pyrite/REE minerals. The presence of apatite and REE minerals in the fluorite suggests this is a late stage fluorite/REE-rich carbonatite phase intruding the surrounding dolomite carbonatite.

The REE? mineral in the close-up above is likely parisite with bastnaesite but SEM work would be necessary to confirm this.

Banded Fluorite

EC08-014 at 25.24m

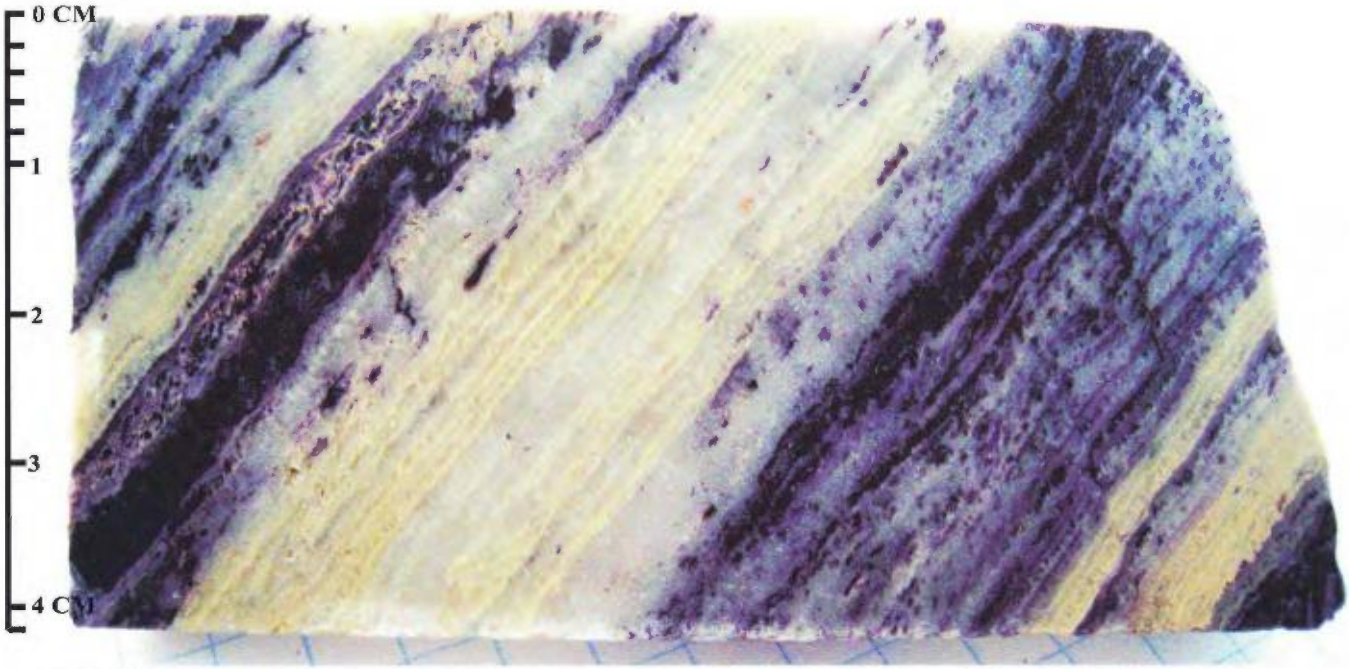


Fig.1 Banded purple fluorite with inter-layered cream coloured dolomite. P_2O_5=5.66%, Nb=2821.2 ppm, Ta=94 ppm, REE+Y=0.29%

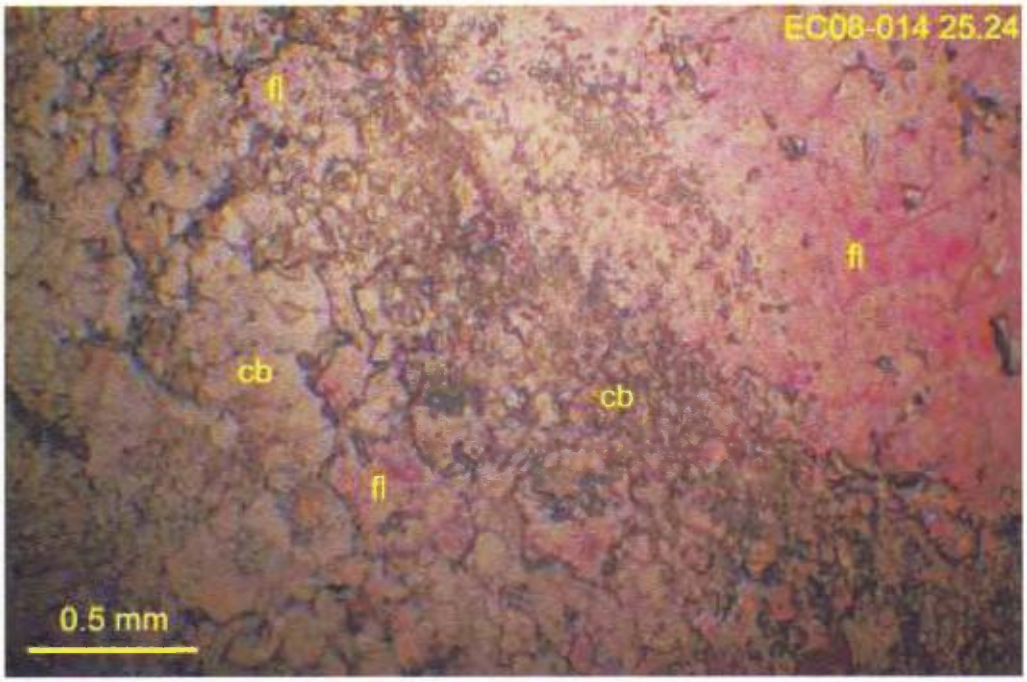


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-014 25.24m, fl=fluorite, cb=carbonate. Transmitted plane light.

continued ...

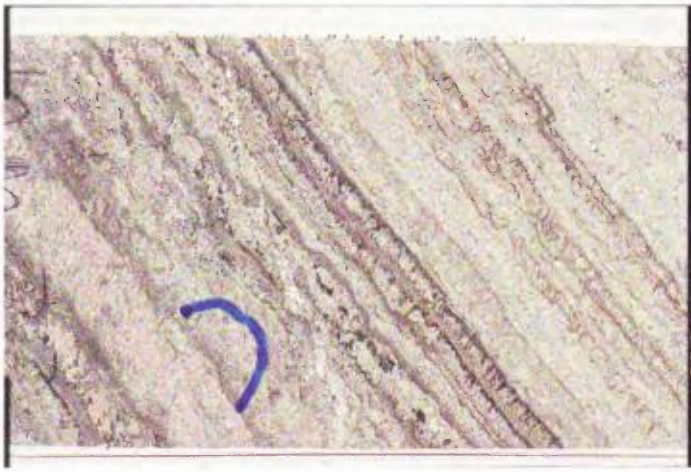


Fig.3 Thin section EC-08 014 24.25m plane polars

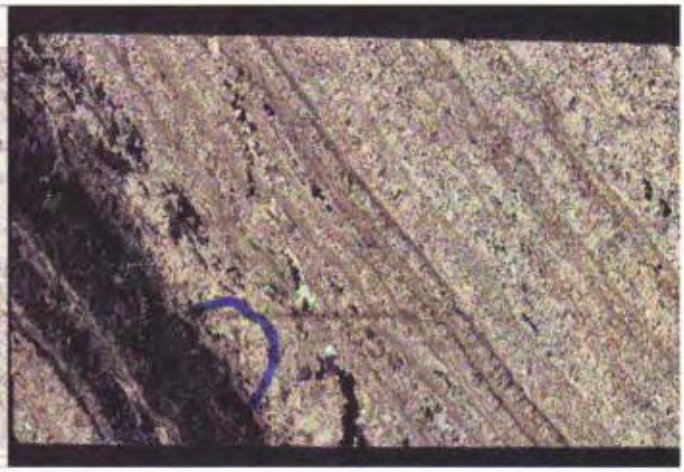


Fig.4 Thin section EC-08 014 24.25m cross polars

The assay values for the interval that includes this banded fluorite do not match the petrography. There is no apatite in this rock and yet the whole rock assay shows 5.66% P_2O_5. See the discussion on "Possible sources of error", p.22 of this section.

This banding of fluorite and dolomite is due to hydrothermal fluid activity.

Brecciated Fluorite

EC08-011 at 111.48m

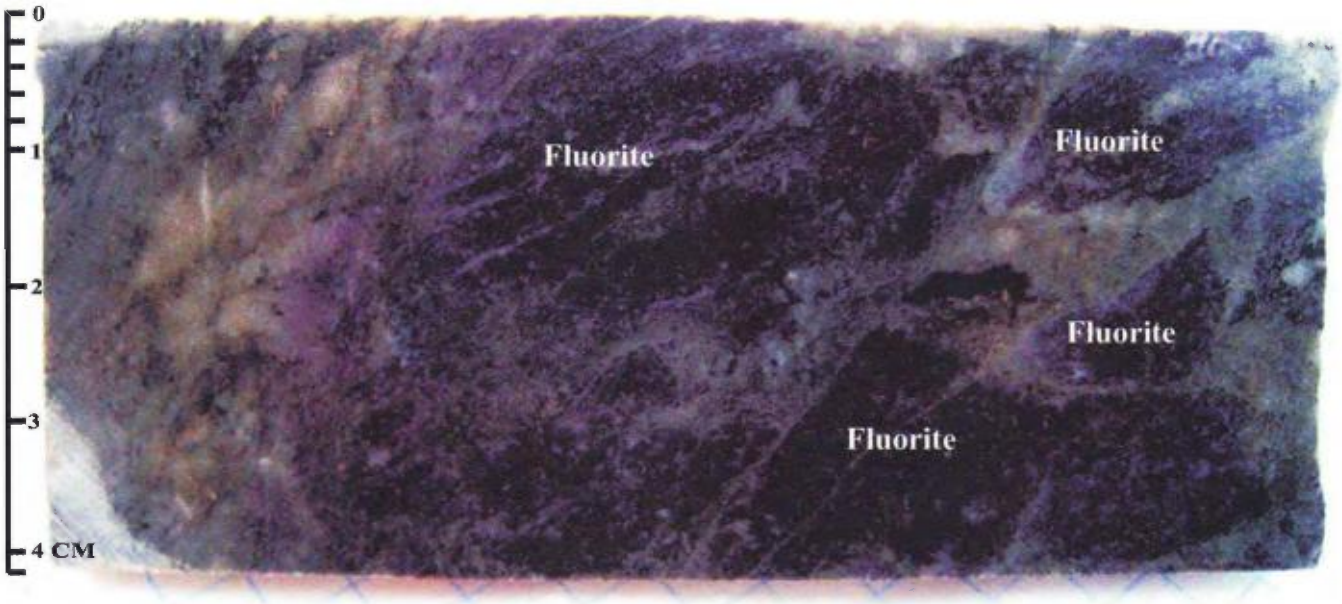


Fig.1 Brecciated fluorite with dolomite carbonatite matrix. P_2O_5=5.43%, Nb=557.2 ppm, Ta=47.8 ppm, REE+Y=0.15%

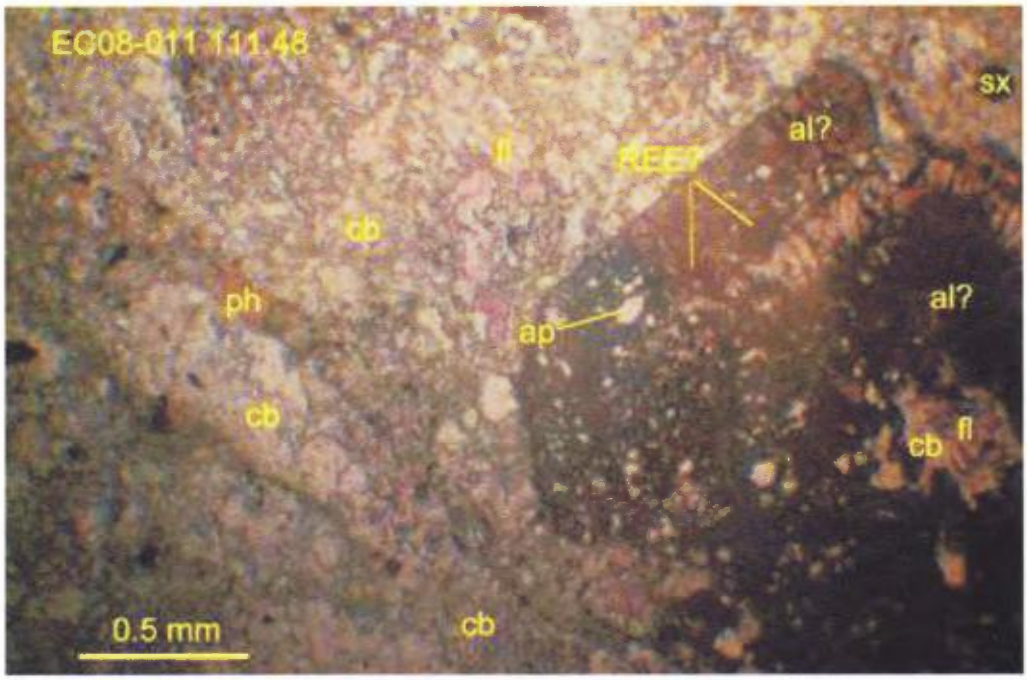


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-011 111.48m, cb=carbonate, ph=phlogopite, fl=fluorite, al?=allanite, ap=apatite, REE?=unidentified REE mineral. Transmitted plane light.

continued ...

Fig.3 Thin section EC-08 011 111.48m plane polars

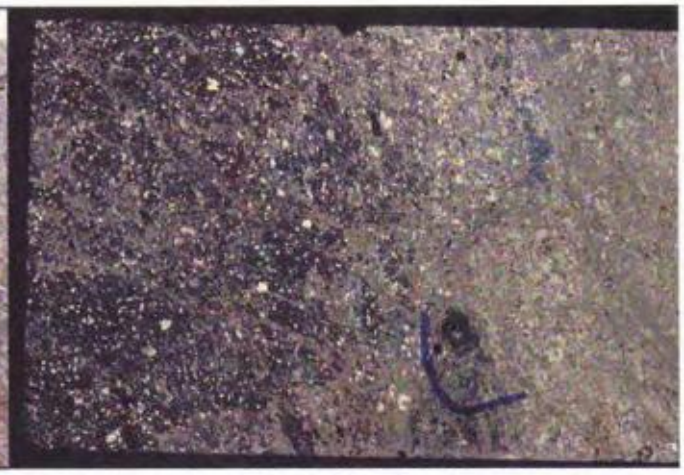


Fig.4 Thin section EC-08 011 111.48m cross polars

The REE-bearing fluorite clasts in this breccia have within them clasts of dolomite and apatite suggesting that the fluorite may be a late stage segregation of a dolomite carbonatite that was, in turn, intruded by a later dolomite carbonatite. **If so, this would place the fluorite event with the first dolomite carbonatite intrusion.** Currently I have the fluorite-REE event on its own, being unable to conclude that it was connected to either dolomite carbonatite intrusion.

Dolomite Breccia with fluorite and calcite

EC08-014 at 64.65m

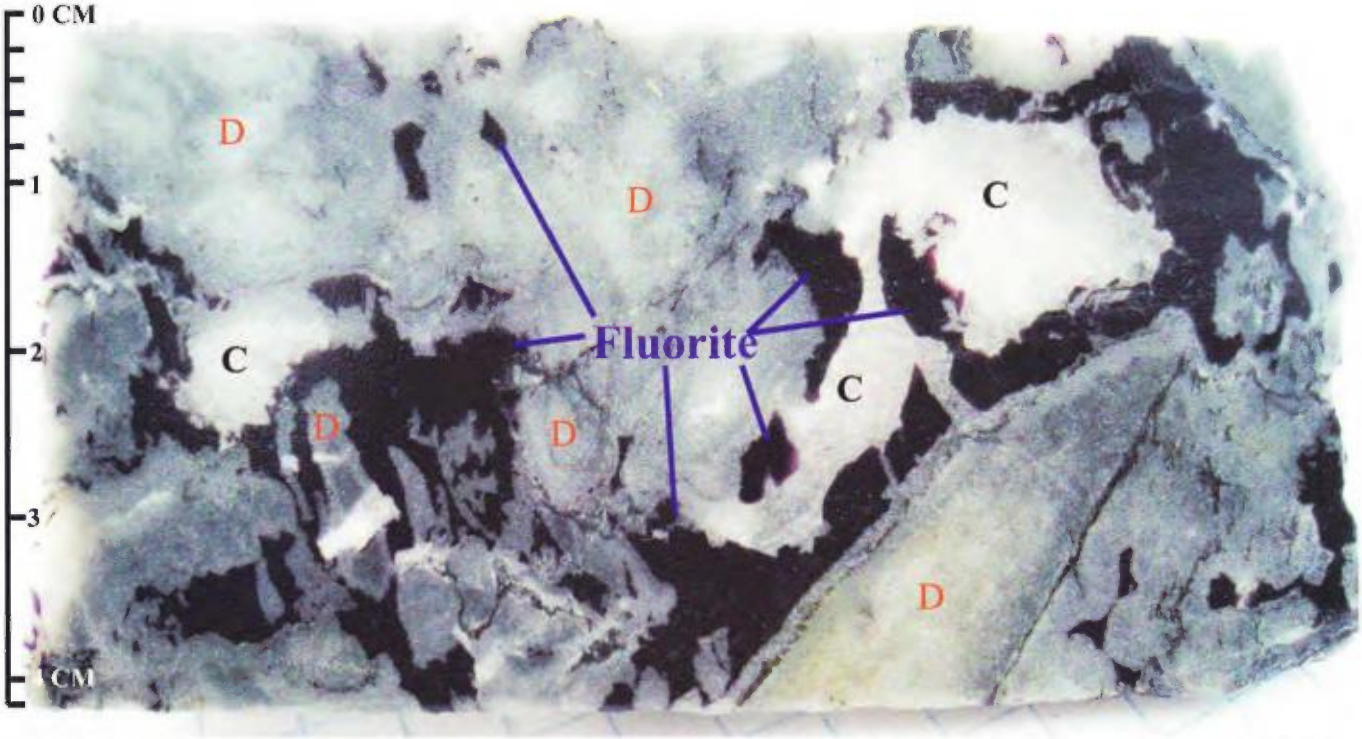


Fig.1 Dolomite clasts (D) with fluorite and calcite (C) infill. P_2O_5=3.51%, Nb=509.8 ppm, Ta=89.6 ppm, REE+Y=0.18%

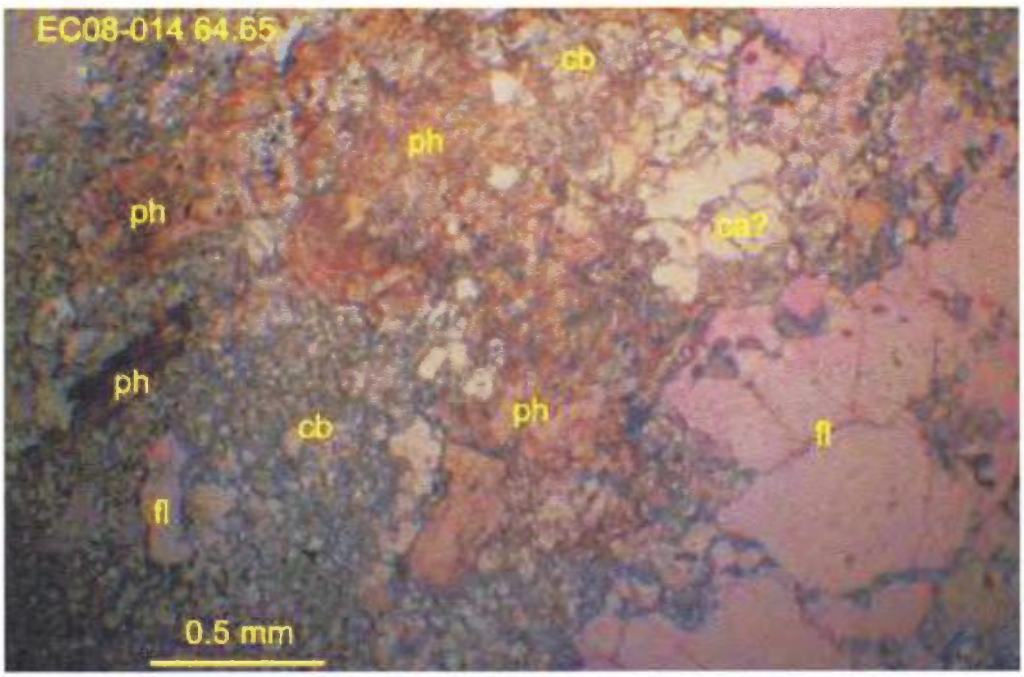


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-014 64.65m, ph=phlogopite, cb=carbonate, fl=fluorite, ca?=calcite? Transmitted plane light.

continued ...

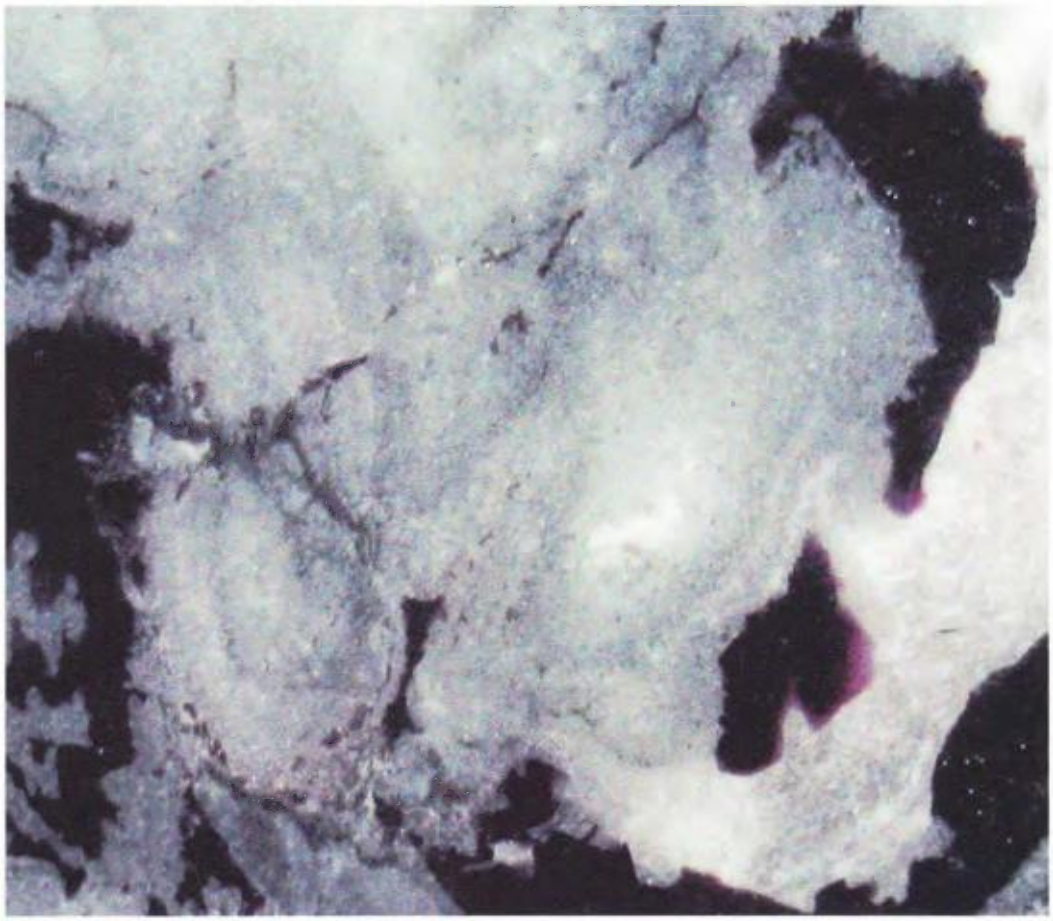


Fig. 3 Close-up of textures in EC08-014 64.65m. Note the unusual concentric textures in the dolomite clasts. Fluorite is black to dark purple in this photo.

Owing to time constraints at the University of Alberta the thin section for this sample was not scanned.

The assay for this interval has 3.51% P_2O_5, but there is no apatite in this sample. See the discussion on "Possible sources of error", p.22 of this section.

These clasts are devoid of apatite and other typical minerals associated with a carbonatite. The concentric textures noted in the close-up above represent minor chemical changes in the deposition of dolomite consistent with hydrothermal fluid activity.

Dolomite with REE mineralization

EC08-015 at 160.45m

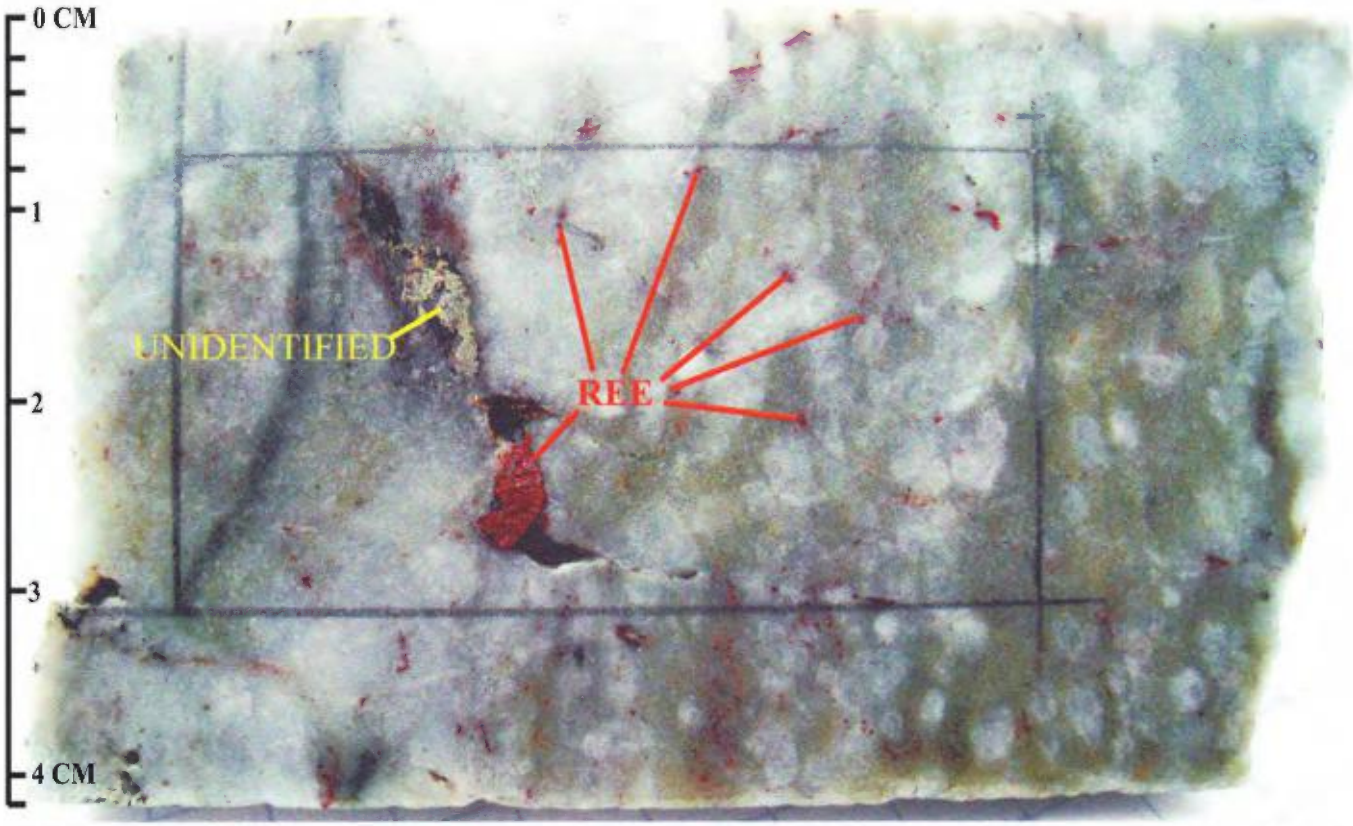


Fig.1 Red REE minerals (REE) and yellow unkidentified REE mineral in fractures in dolomite carbonatite. P_2O_5=3.93%, Nb=1904.4 ppm, Ta=4.7 ppm, REE+Y=0.23%

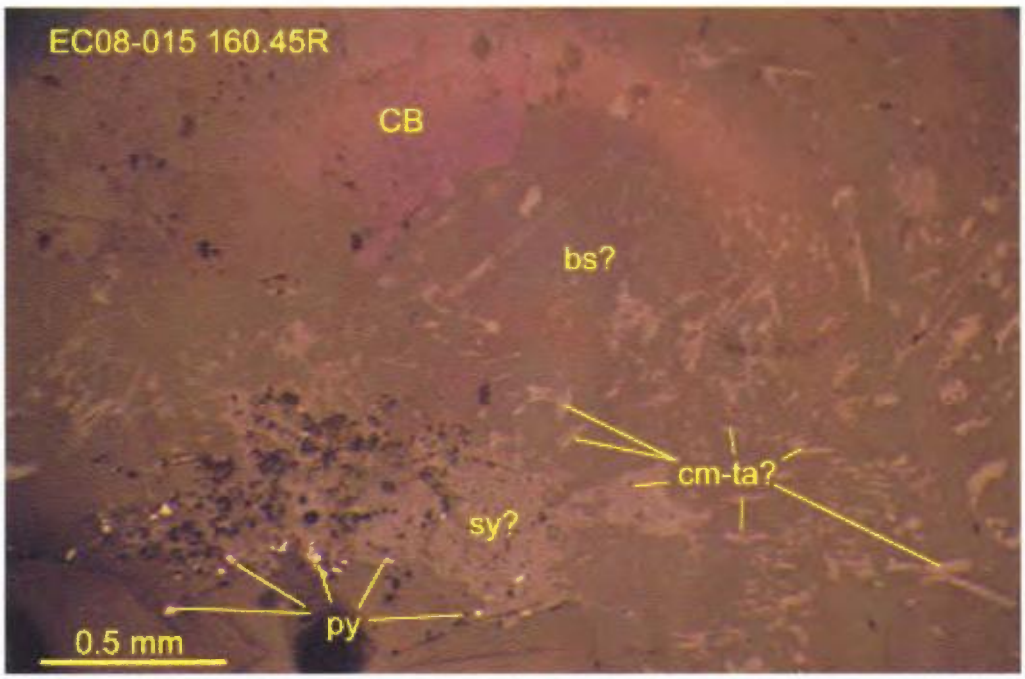


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-015 160.45m, CB=carbonate, cm-ta?=columbite-tantalite?, sy?=synchesite?, py=pyrite, bs?=bastnaesite. Reflected light, uncrossed polars.

continued ...

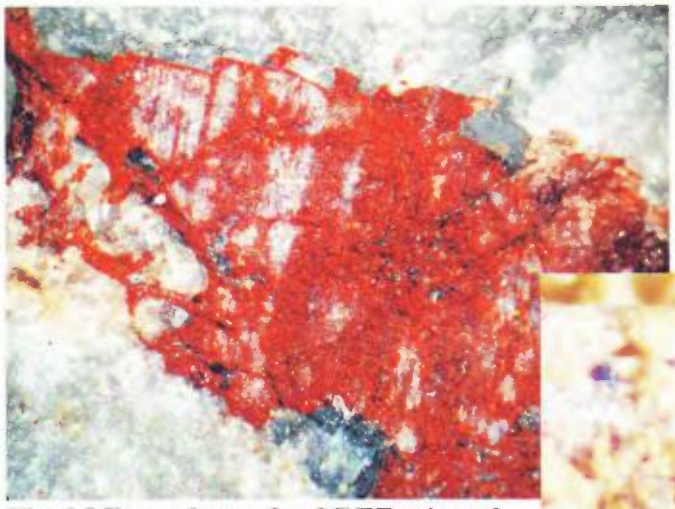


Fig. 3 Micro-photo of red REE mineral

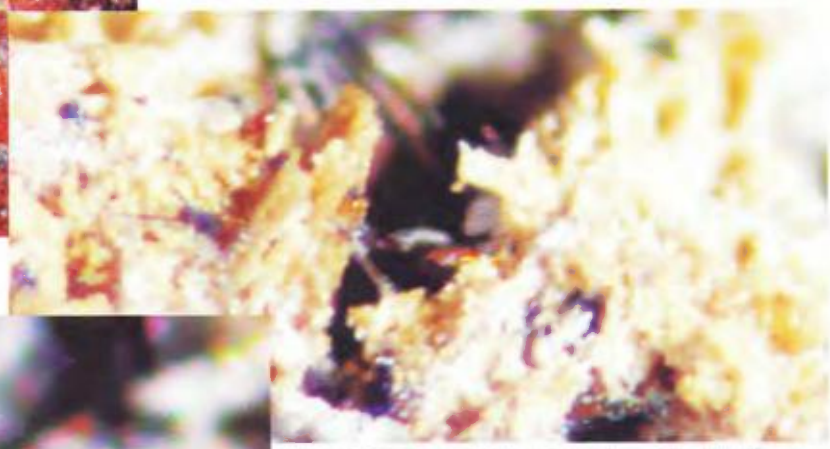


Fig. 4 Micro-photo of unidentified yellow REE bearing mineral

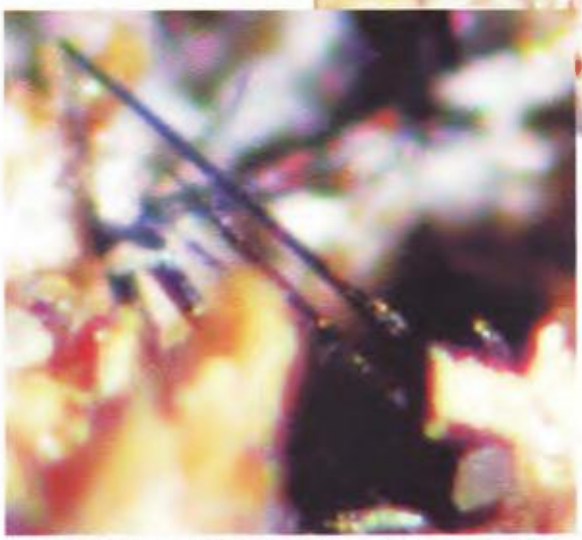


Fig. 5 Micro-photo of unidentified sulphide

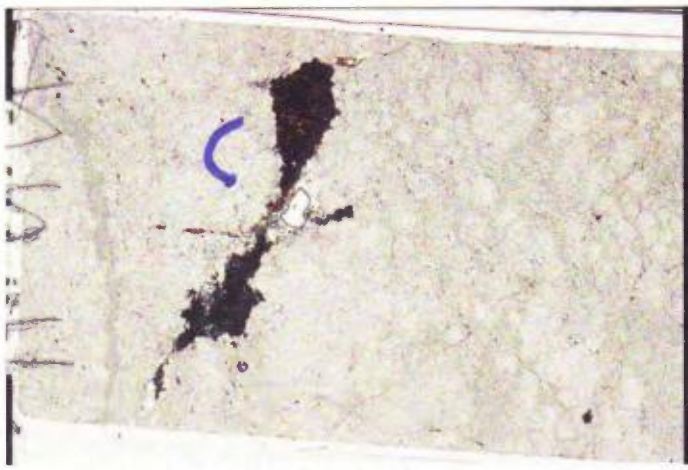


Fig.6 Thin section EC-08 015 160.45m plane polars

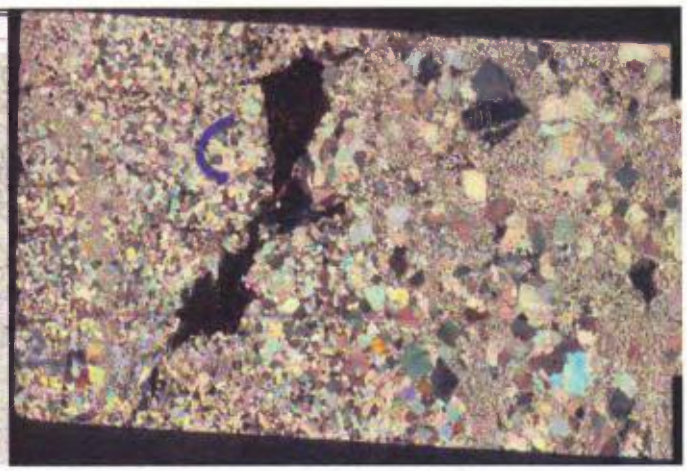


Fig.7 Thin section EC-08 015 160.45m cross polars

The complete lack of apatite, magnetite and phlogopite combined with the foliated texture shows that this is a remobilized mineral assemblage.

Dolomite, Fluorite rock type

EC10-027 at 78.05m

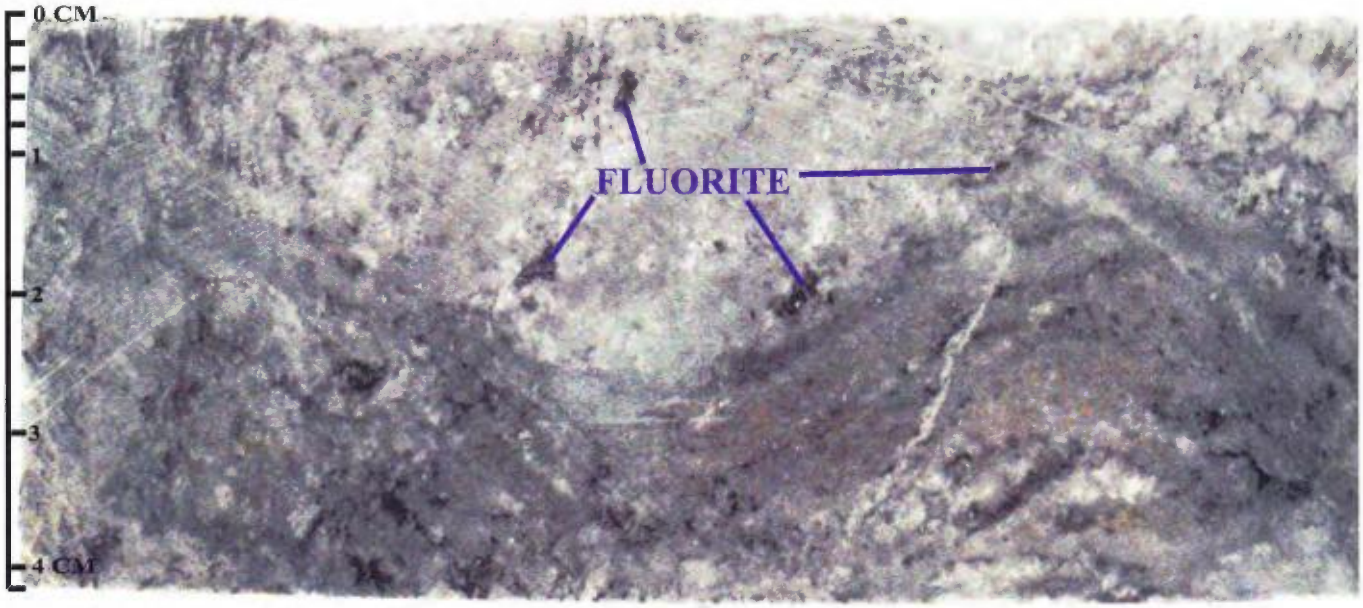


Fig.1 Dolomite with fluorite. No whole rock assay data is available for this interval.

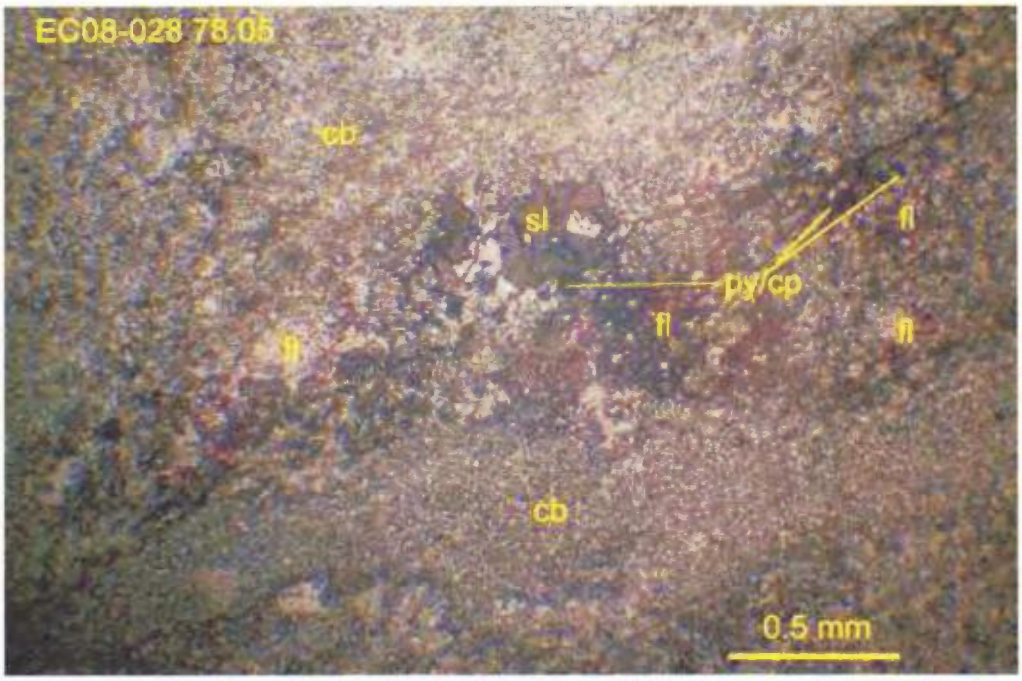


Fig. 2 Photo by Craig Leitch outlined on thin section EC10-027 78.05. cb=fine-grained carbonate, fl=fluorite, py/cp=pyrite/chalcopyrite, sl=sphalerite. Transmitted plane light. Note: Dr. Leitch attributed this sample to EC08-028 instead of EC10-027.

continued ...

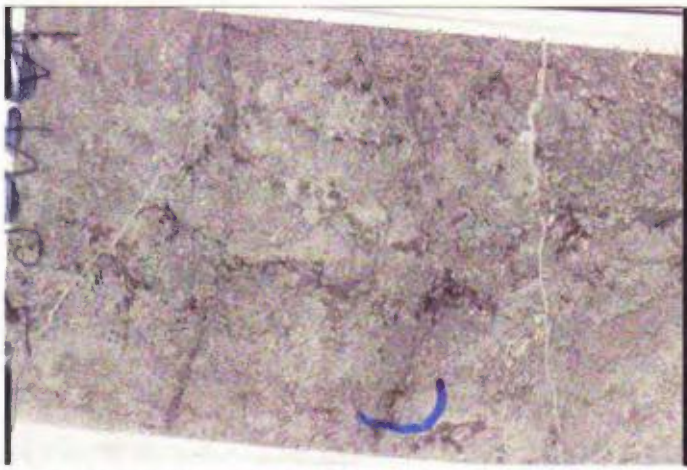


Fig.3 Thin section EC-10 027 78.05m plane polars

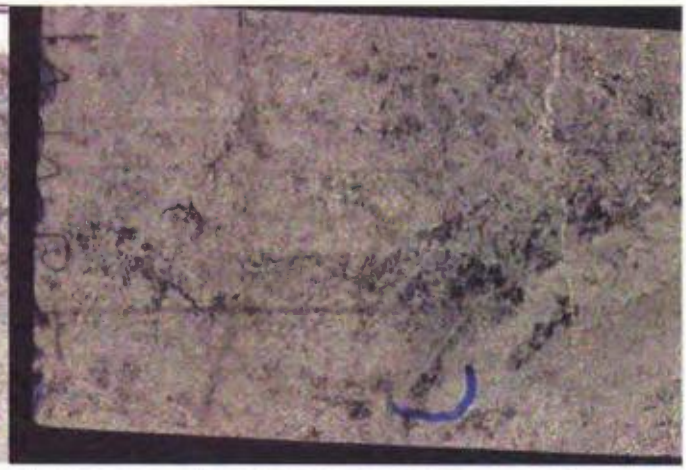


Fig.4 Thin section EC-10 027 78.05m cross polars

At first glance I took this sample to be a dolomite carbonatite. However, Dr. Leitch's petrographic report throws that interpretation into serious doubt. This sample is devoid of apatite and magnetite. I would classify this sample as a rheologic mineral assemblage with re-mobilized dolomite and fluorite as the major minerals present.

Hydrothermal Breccia with unusual textures

EC08-026 at 62.70m

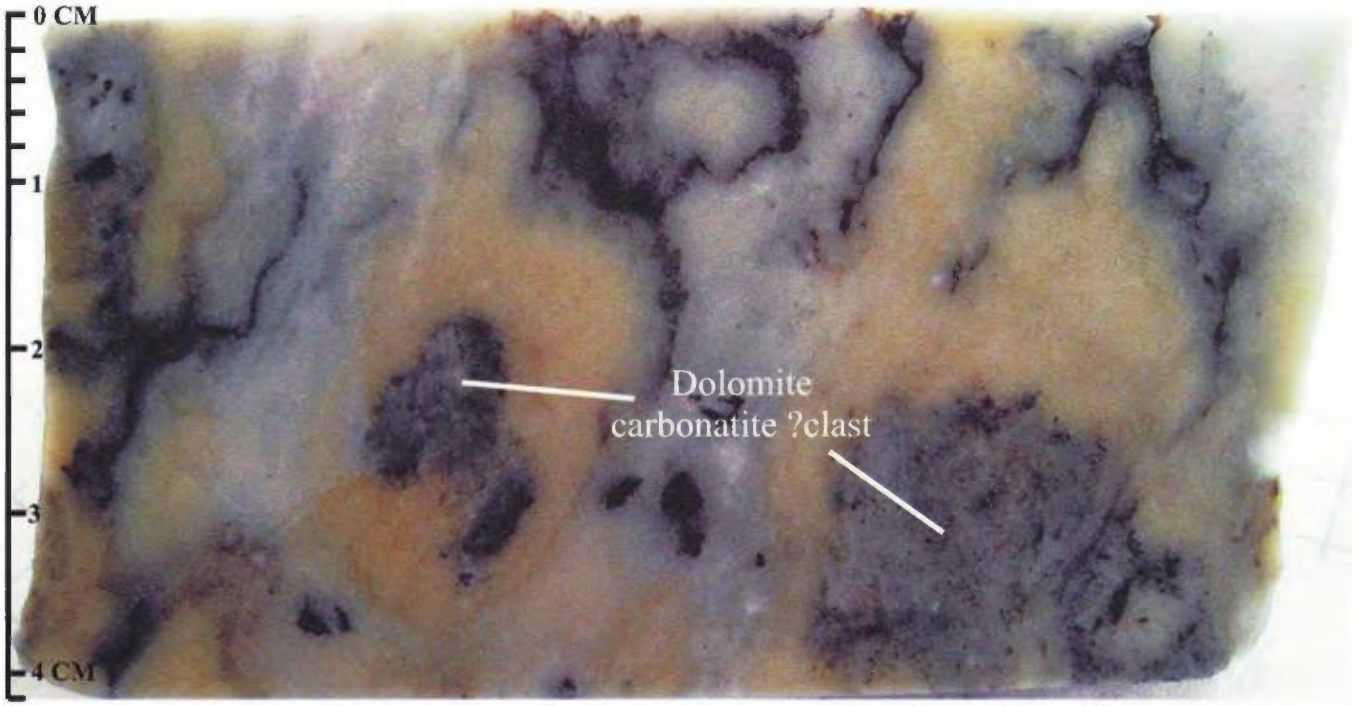


Fig.1 Dolomite carbonatite clasts in fluorite, dolomite and apatite matrix, with swirl textures in colours of grey and yellow-brown and dark, irregular partings containing phlogopite. P_2O_5=4.78%, Nb=1157.6 ppm, Ta=43.7 ppm, REE+Y=0.22%

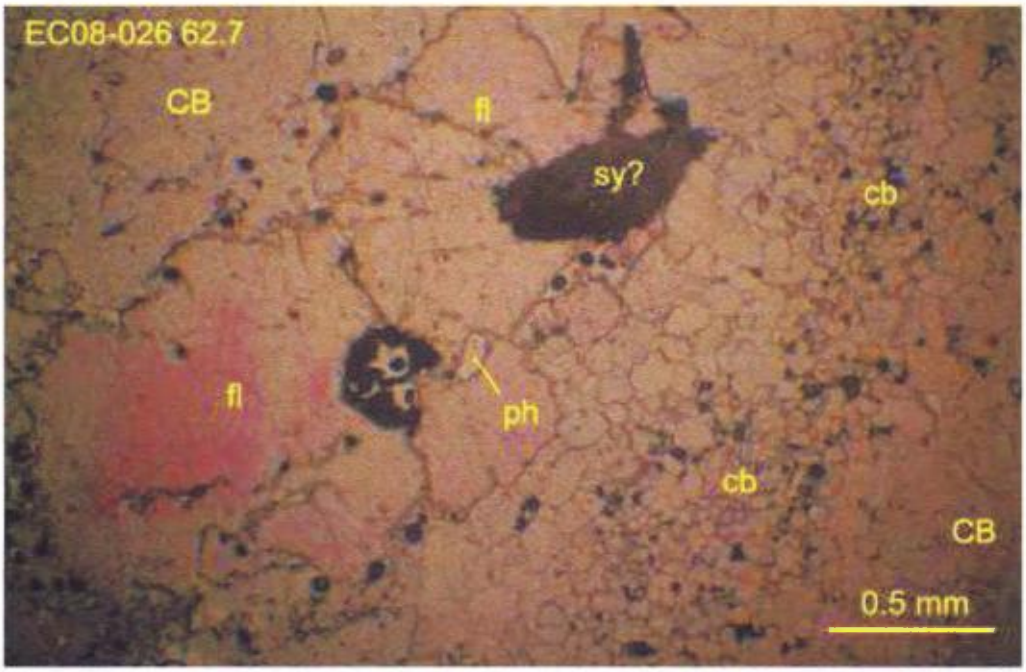


Fig. 2 Photo by Craig Leitch outlined on thin section EC08-026 62.70. sy?=synchesite?, cb=fine-grained carbonate, CB=coarse-grained carbonate, ph=phlogopite, fl=fluorite. Transmitted plane light.

continued ...

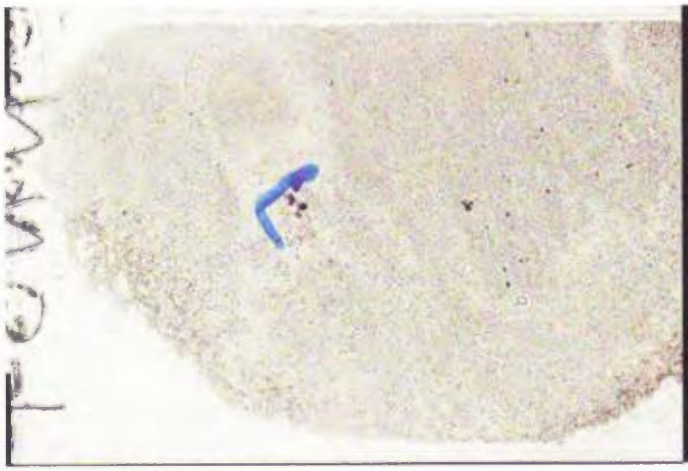


Fig.3 Thin section EC-08 026 62.70m plane polars

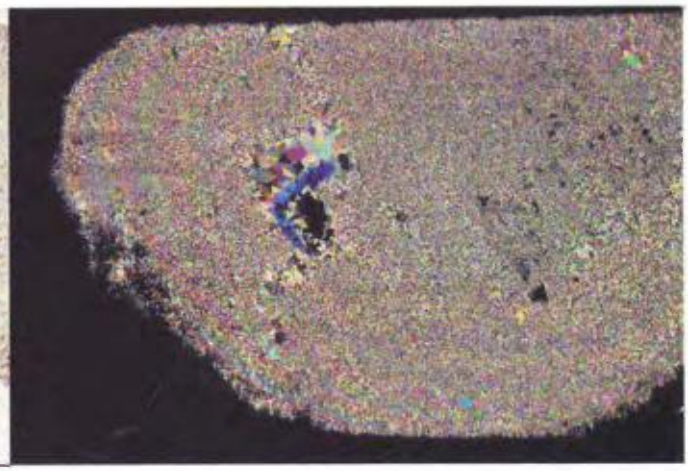


Fig.4 Thin section EC-08 026 62.70m cross polars

There are two inclusions that appear to be partially dissolved clasts of dolomite carbonatite in a late stage fluorite- and apatite-rich carbonatite that has subsequently been folded and metamorphosed.

Re-mobilized Dolomite with REE mineralization

EC08-021 at 102m

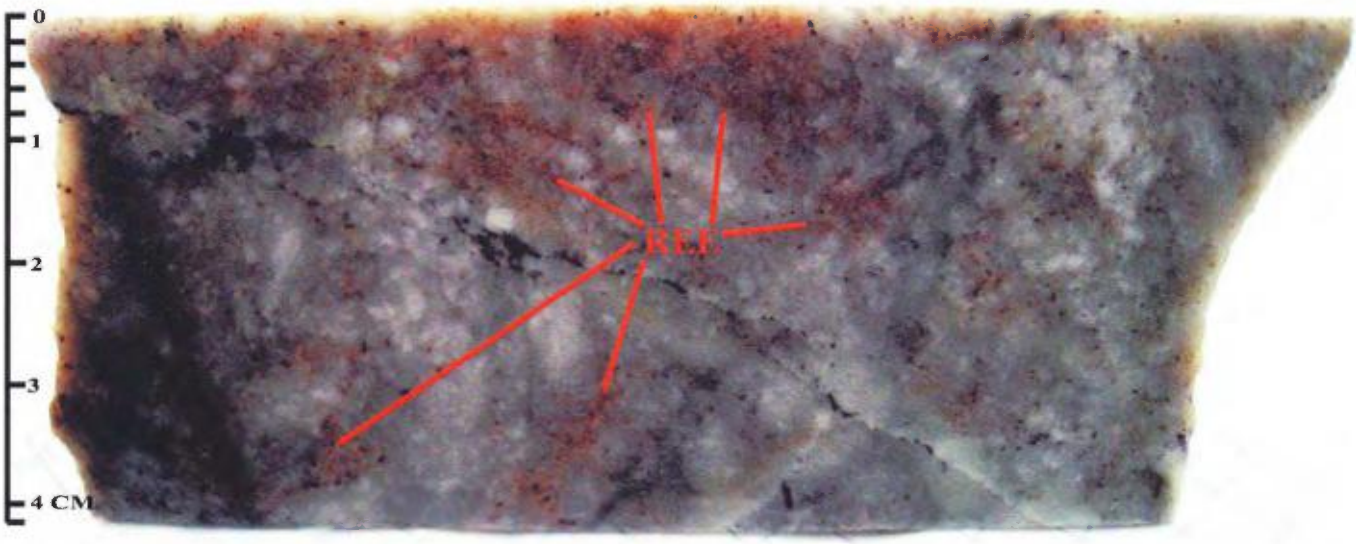


Fig.1 Red REE mineralization (REE) in dolomite carbonatite. P_2O_5=2.97%, Nb=1227.0 ppm, Ta=20.2 ppm, REE+Y=0.17%

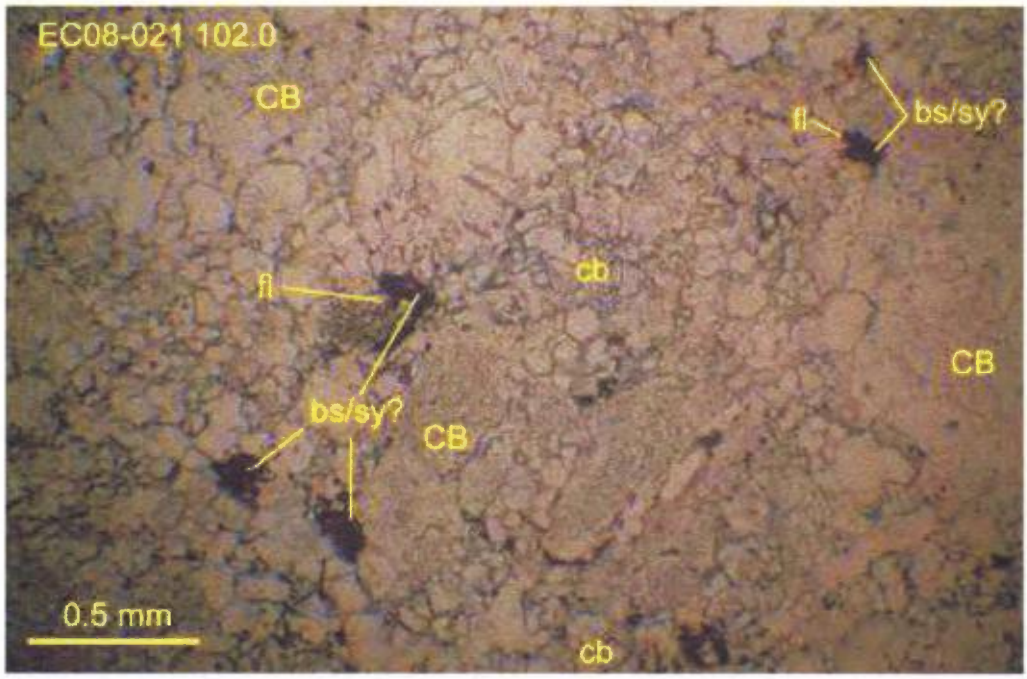


Fig. 2 Photo by Craig Leitch, CB=coarse-grained carbonate, cb=fine-grained carbonate, bs/sy?=bastnaesite/synchesite?. fl=fluorite,

Owing to time constraints at the University of Alberta the thin section for this sample was not scanned.

The absence of apatite and magnetite coupled with the presence of fluorite and the nature of the carbonate in this specimen leads me to conclude that this is a re-mobilized assemblage.

UNIDENTIFIED OXIDE

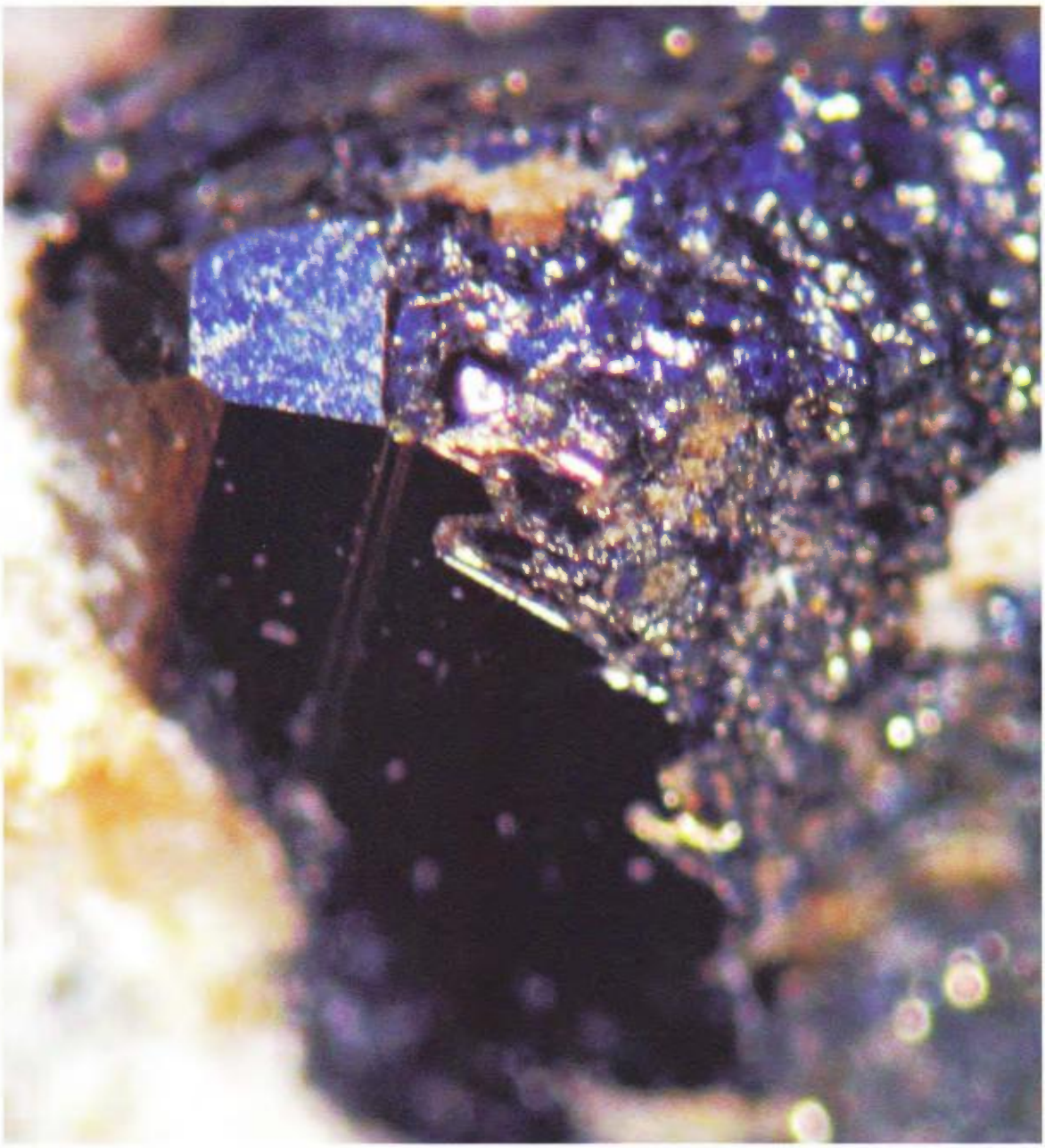


PLATE XI. This micro-photo is of another of the unidentified minerals from Eldor. It is an oxide and could be hematite or ilmenorutile. SEM/EMPA work would be required to identify this mineral.

Molybdenite Vein in dolomite carbonatite

EC08-002 at 69.75m

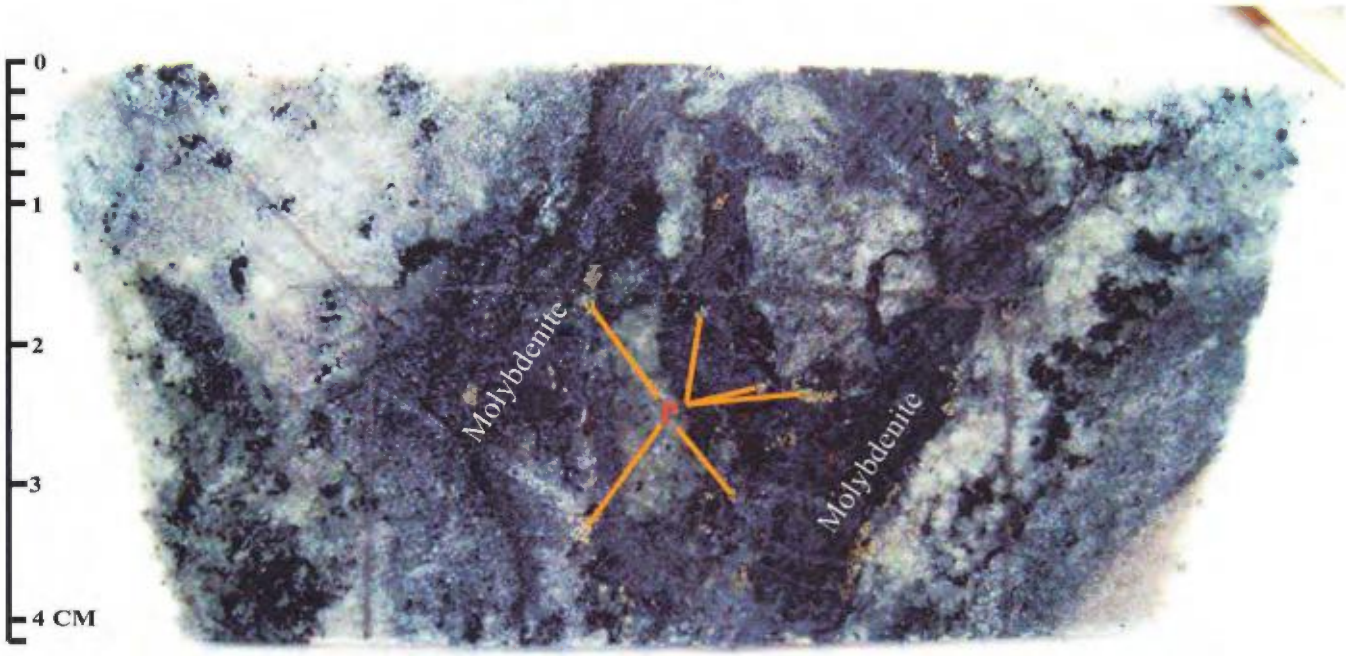


Fig.1 Molybdenite vein . The light brown mineral in the molybdenite vein might be pyrochlore (P). P_2O_5=4.01%, Nb=1324.5 ppm, Ta=64.7 ppm, Mo=>2%, REE+Y=0.16 ppm

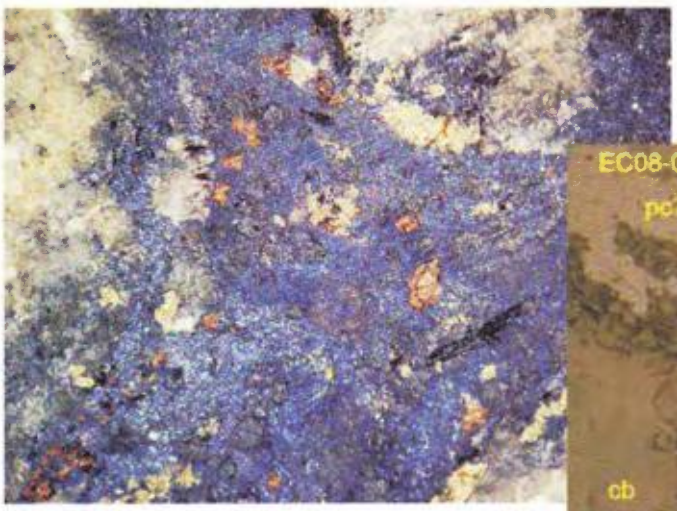


Fig. 2 Close-up of Molybdenite with possible pyrochlore (brown)

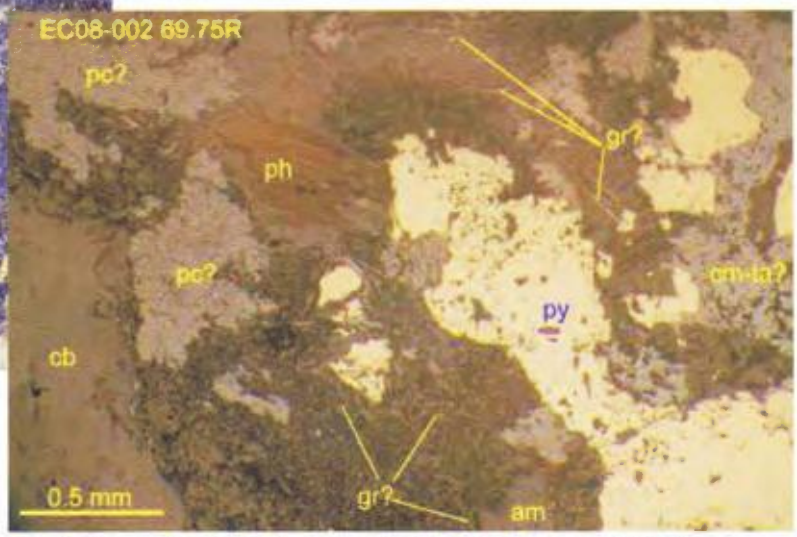


Fig. 3 Photo by Craig Leitch outlined on thin section EC08-002 69.75m, gr?=graphite?, ph=phlogopite, pc?=pyrochlore, am=amphibole, py=pyrite, cm-ta?=columbite-tantalite? Reflected light, uncrossed polars.

continued ...

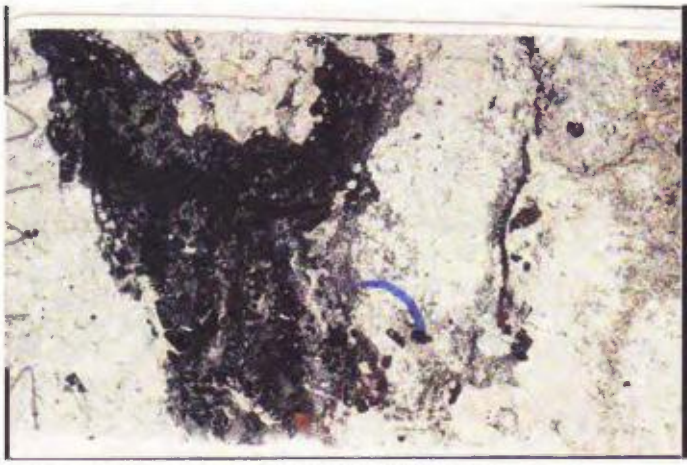


Fig.4 Thin section EC-08 002 69.25m plane polars

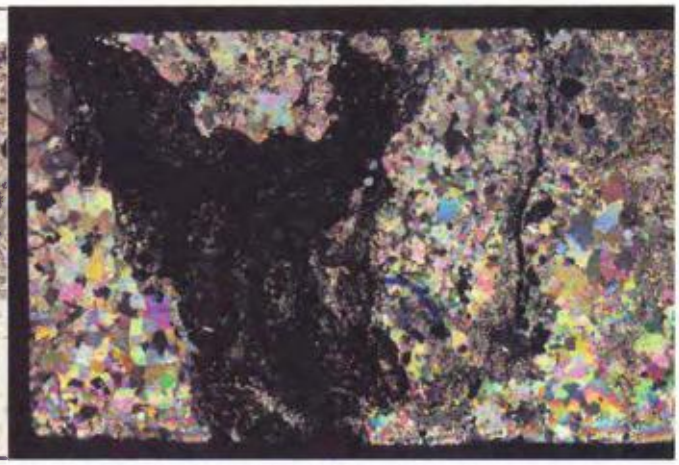


Fig.5 Thin section EC-08 002 69.25m cross polars

SEM/EMPA work would be necessary to identify the rare earth mineral in the molybdenite. I did not see much sulphide mineralization in the 2008 diamond drill core but this is a good intersection (>2% Mo).

Euhedral Minerals

EC08-016 at 128.95m

Fig. 1 Micro-photo of pyrite encrusted parisite crystal 0.7 cm in length.

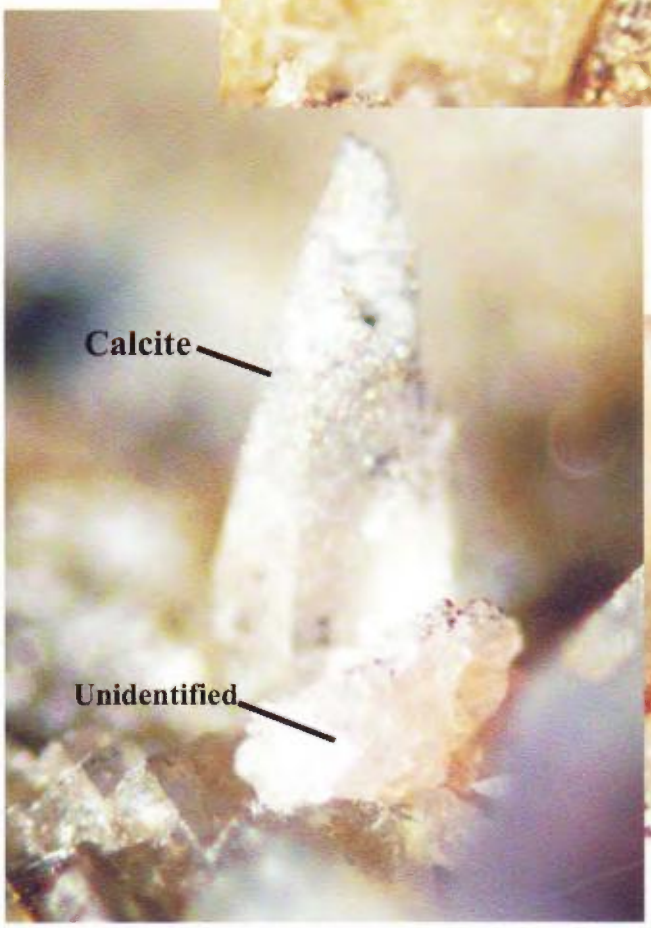


Fig. 3 Micro-photo of calcite scalenohedron with unidentified cream coloured mineral.

Fig. 2 Micro-photo of pyrrhotite crystal.

continued ...

Fig. 4 Micro-photo of unidentified sulphide or oxide from EC08-016 128.95m

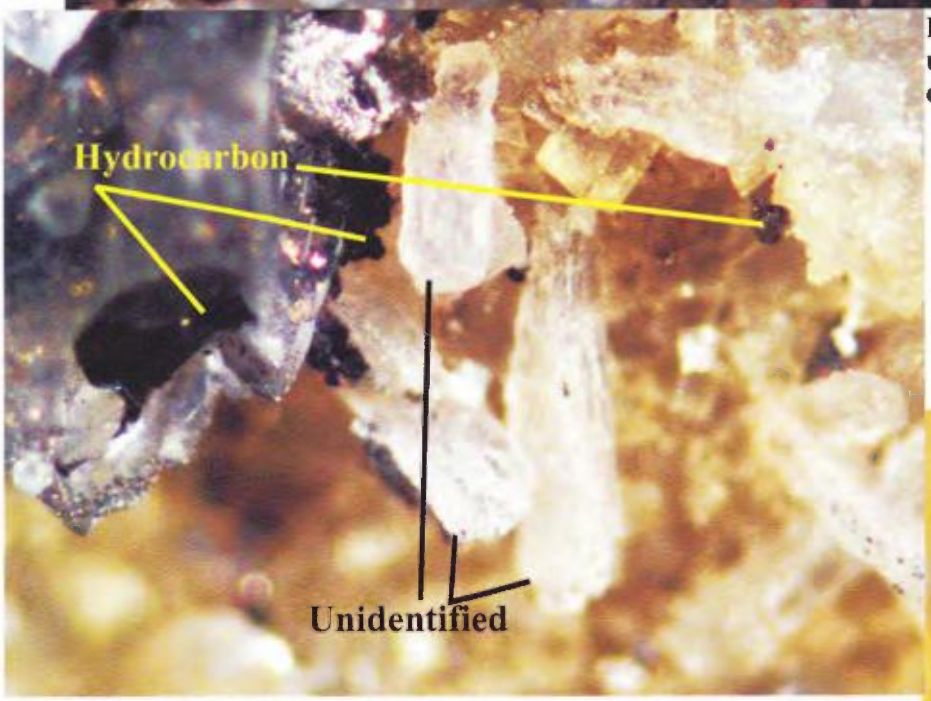


Fig. 5 Micro-photo of unidentified white mineral with black hydrocarbon found at EC08-016 128.95m

Fig. 6 Micro-photo of pyrrhotite crystal

The southeast area intersected by diamond drill holes EC08-014, 015, 016 is particularly vuggy and has many well crystallized minerals. **It also has the potential to produce some of the world's best well crystallized rare earth minerals.**

Euhedral Minerals

EC08-016 at 87.12m

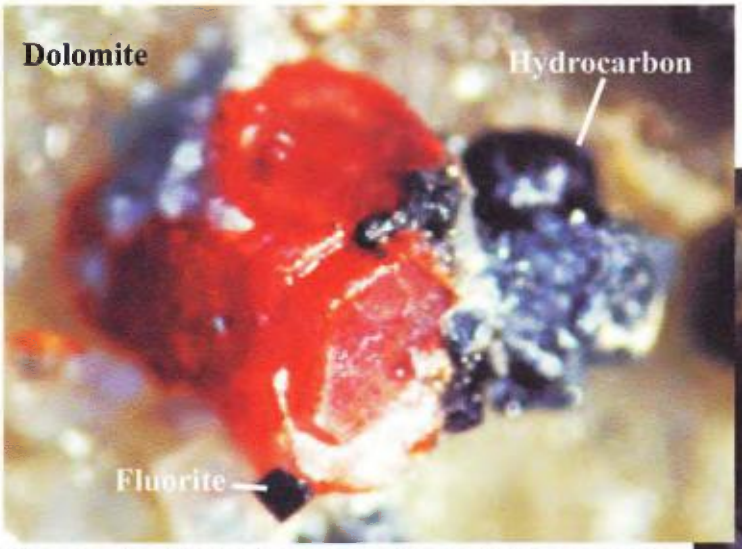


Fig. 1 Cover Photo: Micro-photo of parisite (orange) with fluorite and hydrocarbon from EC08-016 87.12m

Fig. 2 Micro-photo of unidentified white mineral from EC08-016 87.12m - Aragonite?

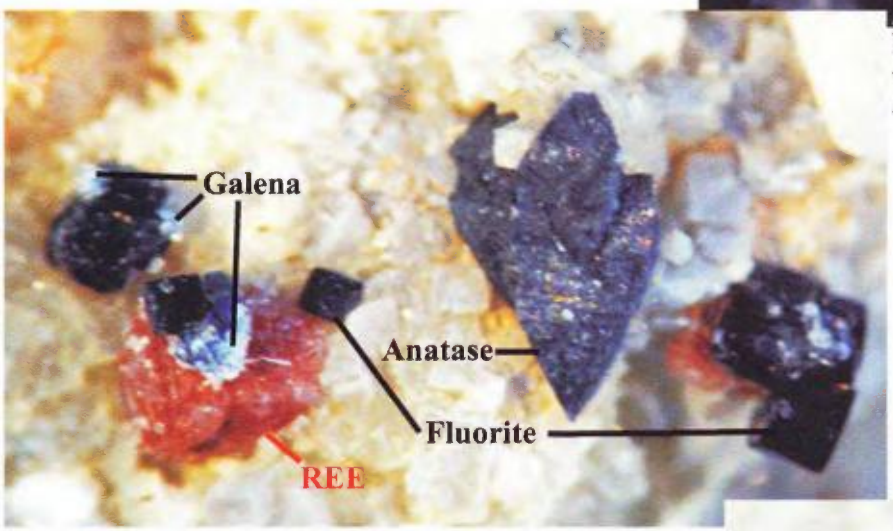


Fig. 3 Micro-photo of unidentified red mineral - likely REE bearing (REE) from EC08-016 87.12m with anatase (blue/black twinned crystal, center right), dolomite (white background crystals), fluorite (dark purple/black octahedra showing dodecahedral faces) and an unidentified silver/grey mineral (possibly galena?)

Fig. 4 Micro-photo of fluorite found at EC08-016

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Acknowledgments

I would like to acknowledge the following people in the Earth and Atmospheric Sciences department at the University of Alberta for their expertise and assistance with this report: Dr. Andy Dufresne for laser ablation dating; Dr. Larry Heaman for interesting and useful conversations about the zircon dating plots from the Eldor Carbonatite; De-Ann Rollings for her expertise on the SEM; and Dr. Andrew Locock for providing space & equipment for my work. I add a special thank you to Dr. Locock for reviewing this report.

Darren Smith, Dahrouge Geological Consulting, provided the core logs & photos, whole rock assays and maps used in this report.

Finally, I would like to thank my wife, Dr. Helen Tyson for her assistance in the technical preparation of this report.

PYRITE CUBE WITH OCTAHEDRAL MODIFICATIONS

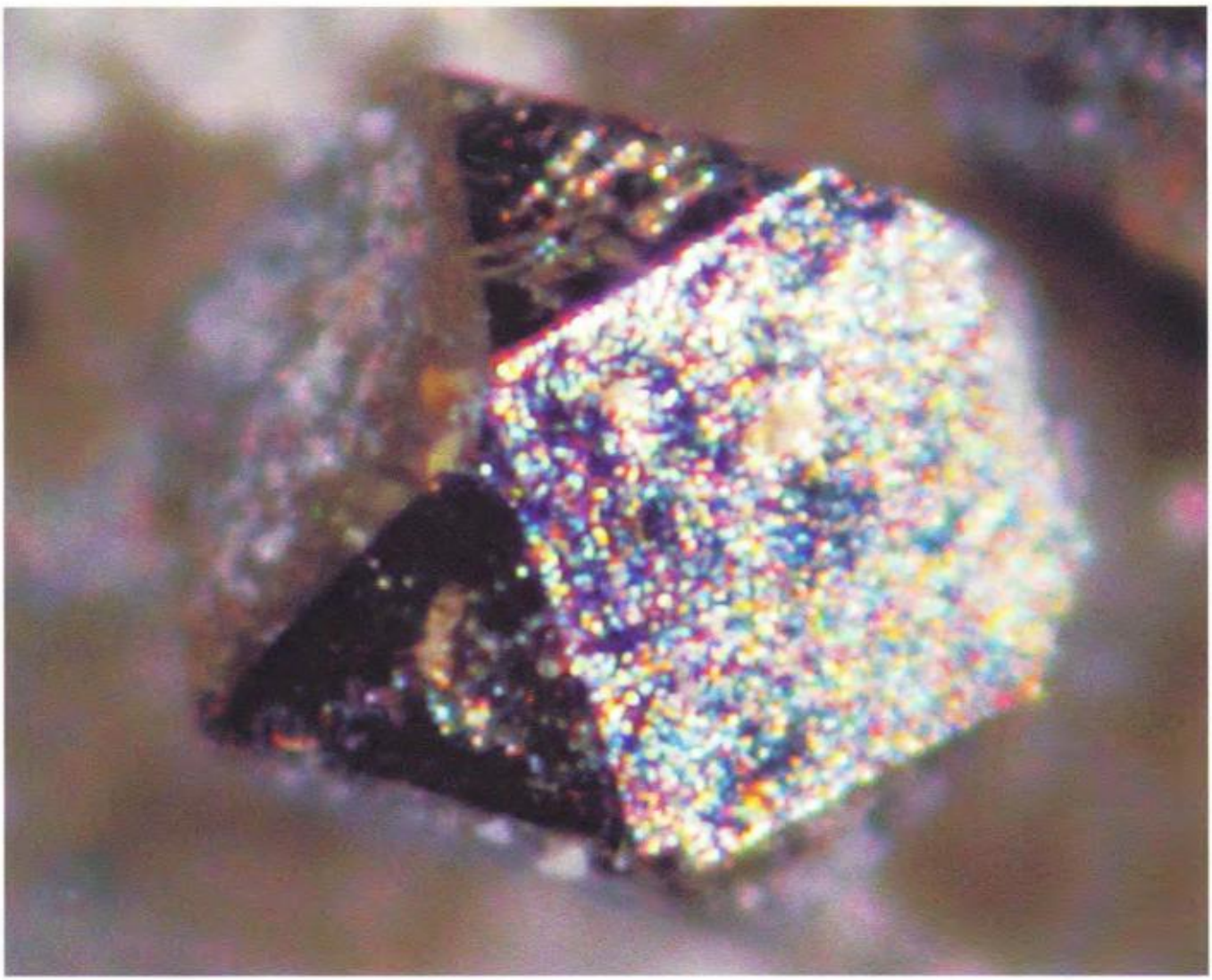
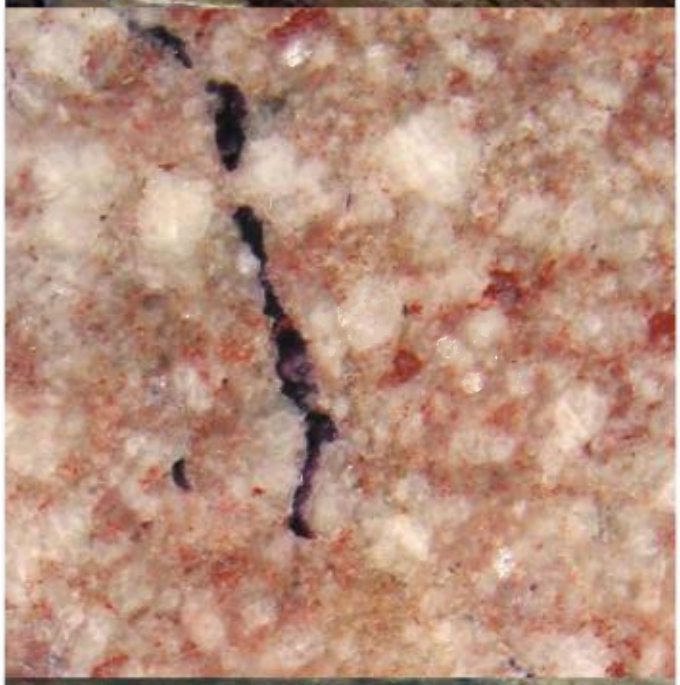


PLATE XII. Pyrite is the most common sulphide found at Eldor. It is often well crystallized, with cubes modified by octahedra and/or pyritohedra. This micro-photo shows a cube modified by octahedral faces.

THE ASHRAM RARE EARTH ZONE

EC10-027 115.62m



EC10-027 221.74m

EC10-027 230.77m

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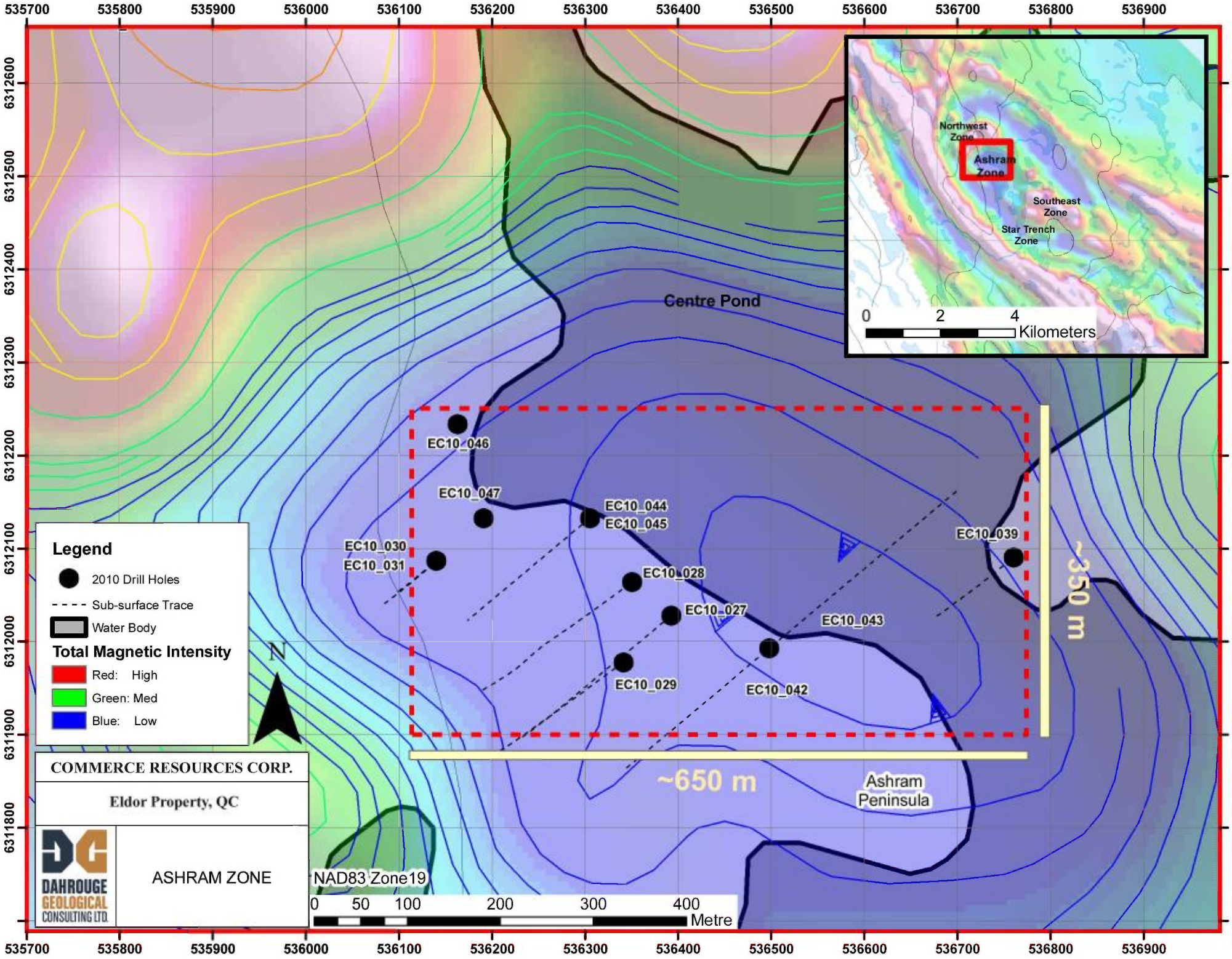
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Ashram Zone
Southeast Zone
Star Trench Zone
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EC10_028
EC10_027
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EC10_042
EC10_039
~350 m
~650 m
Ashram Peninsula
Legend
2010 Drill Holes
Sub-surface Trace
Water Body
Total Magnetic Intensity
Red: High
Green: Med
Blue: Low
N
COMMERCE RESOURCES CORP.
Eldor Property, QC
DAHROUGE GEOLOGICAL CONSULTING LTD.
ASHRAM ZONE
NAD83 Zone19
0 50 100 200 300 400 Metre

APPENDIX A

A COMPLETE LIST OF MINERALS FROM THE ELDOR CARBONATITE

The following list includes all mineral species named by different authors, many of which are doubtful. I have given a level of confidence for the occurrence of each species as low, medium, high. The sources for the occurrence of these species are included in the footnotes or appendices. There were two invalid species listed: breunnerite, a carbonate chemically midway between magnesite and siderite; and sphene a synonym for titanite, leaving sixty-one species listed as occurring in the Eldor Carbonatite.

MINERAL SPECIES	ORIGIN	DATA SOURCE	COMMENTS	LEVEL OF CONFIDENCE
Actinolite	thin section	VanPetro	Needs EMPA work	low
Aegirine	thin section	GamX, Almaz		high
Aeschynite	thin section	Almaz		high
Albite	thin section	Almaz		high
Allanite	thin section	VanPetro	confirmed by author on SEM at U of A.	high
Anatase	Crystal in core	Rod Tyson	See photo in section 4	high
Apatite	hand sample, core, thin section	Almaz, VanPetro, Dr. Locock	Fluorescent under midrange UV.	high
Aragonite	core	R. Tyson	Needs EMPA for certainty	high
Baddeleyite	thin section	Almaz	corroborated by R. Tyson at U of A on SEM and used in laser ablation dating of the Eldor carbonatite – see section on dating, SEM-EDS and BSE images	high
Bafertisite	thin section	Almaz		high
Barite	thin section	Almaz		high

Bastnaesite	thin section	Almaz, Dr. Locock	As exsolution lamellae in parasite – see SEM-EDS and BSE images	high
Biotite	thin section	VanPetro	Needs EMPA work	low
Breunnerite	thin section	Almaz	Invalid species – author also noted carbonate species midway between Magnesite and Siderite – Needs EMPA work	
Calcite	hand sample, core, thin section	Almaz, VanPetro	Fluorescent red with midrange UV	high
Chalcopyrite	thin section	VanPetro, Demers and Blanchet	Needs SEM-EDS work	medium
Chlorite	core, thin section	Almaz, VanPetro	Chlorite alteration of phlogopite is visible with binocular microscope	high
Columbite			See Ferrocolumbite	
Cordierite	thin section	VanPetro	Could be feldspar – needs EMPA work	low
Diopside	thin section	Almaz		high
Dolomite	hand sample, core, thin section	Almaz, VanPetro, Dr. Locock	Visible crystals in vuggy core – see photos.	high
Ferrocolumbite	thin section	Almaz, Dr. Locock	See SEM-EDS in Dr. Locock's report	high
Fersmite	thin section	Almaz		high
Fergusonite		Demers and Blanchet 2002		low
Fluocerite-Ce	thin section	Almaz		high

Fluorite	core – massive and xls, hand sample, thin section	Almaz, VanPetro, Dr. Locock	See SEM-EDS in Dr. Locock's report, see section 4	high
Galena	core, thin section	Almaz, VanPetro	Confirmed at U of A	high
Fuchsite		Demers and Blanchet 2002		medium
Glaucophane	thin section	VanPetro, Brandt	This species is found in blue schists and is not likely in a carbonatite but this would require EMPA work to be certain	low
Graphite	thin section	VanPetro	This would require EMPA to be certain	low
Hematite	thin section	VanPetro	This would require EMPA to be certain	low
Hydrocarbon	core, thin section	R. Tyson	See photos. This is very unusual in carbonatites and may be the graphite in the VanPetro report. Requires EMPA work to be certain in thin section.	high
Ilmenite	thin section	Almaz, VanPetro		high
Loparite		Demers and Blanchet 2002		low
Magnesioarfvedsonite	Core, thin section	Almaz, VanPetro	EMPA work required for certainty	high

Magnetite	hand sample, core – massive and euhedral crystals, thin section	Almaz, VanPetro	Strongly magnetic with no discernable Ti content	high
Marcasite	Euhedral crystals in core	R. Tyson	See photos	high
Melilite		GamX, Demers and Blanchet 2002		low
Molybdenite	Core, thin section	Almaz, VanPetro, Brand		high
Monticellite		Demers and Blanchet 2002	Would require EMPA for confirmation.	low
Monazite-Ce	Core, thin section	Almaz, VanPetro	Visible to the naked eye or with hand lens. See SEM-EDS	high
Muscovite	thin section	VanPetro	Would require EMPA work for certainty	low
Perovskite		Demers and Blanchet 2002		low
Plagioclase	thin section	VanPetro	Would require EMPA work for certainty	low
Olivine	Core, thin section	Almaz, VanPetro	Altered to other Mg bearing minerals	high
Orthoclase	thin section	Almaz		high
Parisite	Core – massive and euhedral crystals, thin section	Almaz, VanPetro, Dr. Locock, R. Tyson	See SEM-EDS and BSE images and photos, this is the observable bright orange-red mineral that has been confused for hematite stain	high
Phlogopite	hand sample, core, thin section	Almaz, VanPetro	Most common mineral in glimmerite phase	high

Pyrite	hand sample, core – as euhedral crystals, thin section	Almaz, VanPetro	Euhedral crystals to 0.5cm common	high
Pyrochlore	core, thin section	Almaz, VanPetro	Both U, Ta rich and non U, Ta rich varieties are present. Commonly altered/zoned & visible to the naked eye. See SEM-EDS and BSE images	high
Pyrophanite	thin section	Almaz		high
Pyrrhotite	core - massive and euhedral crystals, thin section	Almaz, VanPetro, R. Tyson	See photos	high
Quartz	core – euhedral crystals, thin section	Almaz, VanPetro	See photos	high
Riebeckite	thin section	VanPetro	Requires EMPA for certainty	low
Rutile	Thin section	Almaz, VanPetro		high
Sphalerite	core – euhedral crystals, thin section	Almaz, VanPetro, R. Tyson	See SEM-EDS and photos	high
Sphene	Thin section	VanPetro	Not a valid species name. See titanite	
Synchisite	Thin section	Almaz		high
Thorite	Thin section	Almaz, R. Tyson	See SEM-EDS	high
Titanite	Thin section	VanPetro	Requires EMPA for confirmation	medium

Tremolite	thin section	VanPetro	Requires EMPA work for confirmation	medium
Xenotime	Thin section	Almaz		high
Y-thorogummite	Thin section	Almaz	Requires EMPA work for confirmation	low
Zircon	Thin section	Almaz, R. Tyson	See SEM-EDS and BSE images	high

UNIDENTIFIED MINERALS

There are a dozen minerals that remain unidentified and several species that need further work for a certain determination: actinolite, aragonite, biotite, cordierite, graphite, hematite, plagioclase, muscovite, riebeckite, titanite, and tremolite.

APPENDIX B

PETROGRAPHIC REPORT ON 59 SAMPLES FROM ELDOR PROJECT (LEMOYNE CARBONATITE, KUUIJJUAQ)

BY

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PETROGRAPHIC REPORT ON 59 SAMPLES FROM ELDOR PROJECT (LEMOYNE CARBONATITE, KUUIJJUAQ)

Report for: Rod Tyson, Dahrouge Geological Consulting,
c/o Commerce Resources Corp.
1450-789 West Pender Street
Vancouver, B.C. V6C 1H2 (604) 484-2700

Invoice 100592

Sept. 7, 2010.

SUMMARY:

Samples come from the LeMoyne carbonatite 130 km south of Kuuijjuaq, northern Quebec currently being explored for Nb, Ta and REE minerals in magnesio-carbonatites. Three samples (#31, 60-and 61) were missing from the shipment. Of the 59 samples studied, most samples (51) can be classified as carbonatite, either mainly calcite or dolomite/Fe-dolomite (roughly equal proportions). Four samples may be classified loosely as "glimmerite" (phlogopite-rich ultramafic rock with variable carbonate), two or possibly four as ultramafic/ultrabasic cumulates containing abundant magnetite, apatite, plagioclase, ilmenite, soda amphibole, and possible (serpentine-magnesite-secondary magnetite altered) relict olivine in a matrix of carbonate, and two as plagioclase-possible relict mafic phyric, intermediate/mafic volcanic.

Minerals identified in the suite are as follows, in roughly decreasing order of abundance:
Carbonate (calcite, probable dolomite or Fe-dolomite (ankerite?), minor magnesite?
Apatite
Amphibole (blue, sodic?, possibly including arfvedsonite, magnesio-arfvedsonite?, glaucophane?, riebeckite?) or (colourless, possibly tremolite-actinolite?)
Mica (mainly phlogopite, local biotite, chlorite, rarely muscovite or possibly colourless phlogopite)
Magnetite, local ilmenite, rarely sphene, rutile
Plagioclase (possibly mostly andesine or labradorite?)
Clinopyroxene (?) mostly altered to carbonate and amphibole
Serpentine, magnesite (?) likely after former olivine (?)
Fluorite
Sulfides (Pyrite, pyrrhotite, sphalerite, molybdenite in one sample; traces of galena, chalcopyrite)
Possible REE minerals (needs confirmation by SEM analysis, but could include columbite-tantalite, pyrochlore, fluorocarbonates such as bastnaesite, synchesite?). Monazite could be rarely present.
Epidote, possible allanite (?)
Quartz (rare). Possible cordierite (??)
Hematite, Graphite (both rare)

Capsule descriptions are as follows:

EC08-001 10.25: breccia of "glimmerite' clasts (composed of fine-grained phlogopite containing euhedral bladed amphibole, likely tremolite?) in matrix of carbonate (mainly calcite, possible Mg-Fe carbonate?), apatite, minor pyrite, magnetite and allanite or bastnaesite (?).

EC08-001 34.5: calcite-rich rock cut by a vein-like zone of dolomitic carbonate containing minor epidote/allanite?-phlogopite, with envelopes of dolomite-phlogopite-arfvedsonite?-plagioclase-quartz-apatite-pyrite-possible allanite or bastnaesite (?).

EC08-001 34.7: appears to be a mainly calcite-rich (minor dolomite?) carbonatite with accessory sulfides (pyrrhotite and pyrite) not closely associated with phlogopite, apatite and possible pyrochlore. No pyroxene was observed in the section.

EC08-001 43.5: somewhat layered carbonatite composed of alternating zones of relatively coarse-grained calcite and finer-grained apatite, with phlogopite mainly in the former and magnetite either in the latter or concentrated along its margins, with scattered pyrochlore (?) and minor pyrrhotite-pyrite.

EC08-001 139.49: appears to represent banded or layered coarse-grained calcitic carbonate hosting fine-grained ankeritic carbonate with accessory apatite, phlogopite, pyrite and an unidentified, possibly radioactive (?) mineral possibly associated with traces of galena (?).

EC08-001 141.34: breccia composed of clasts of variably phlogopite-, carbonate-, or apatite-minor pyrite-pyrochlore rich rock in a variably textured matrix of carbonate, lesser phlogopite, apatite, possible quartz or feldspar (plagioclase, rare microcline?) with local concentrations of pyrochlore (?).

EC08-001 151.12: breccia composed of clasts of carbonate-, apatite- or biotite-REE mineral rich rock in a variably textured matrix of carbonate, lesser biotite, apatite, minor plagioclase, with local concentrations of pyrite, pyrrhotite and REE mineral (?).

EC08-001 152.25: breccia of clasts of carbonate-, less common apatite- or biotite ±REE mineral-rich rock in a variably textured matrix of carbonate, lesser apatite, biotite, plagioclase, and minor sulfides, with minor local concentrations of REE minerals that may include pyrochlore, allanite/bastnaesite?

EC08-001 204.21: appears to be fine-grained Fe-dolomitic carbonatite with accessory apatite and minor phlogopite, disrupted by veinlets of fluorite-coarse carbonate-minor phlogopite or biotite (rarely chloritized)-pyrrhotite ±pyrite, possible REE minerals (?).

EC08-002 5.1: calcitic carbonatite with scattered disseminated crystals/aggregates of apatite, cut by narrow zones of blue-green arfvedsonite (?) associated with local possible REE minerals of uncertain identity partly oxidized to hematite and locally surrounded by reddish stains of amorphous hematite.

EC08-002 38.25: “glimmerite” (phlogopite-rich, minor calcite-trace magnetite bearing ultramafic rock with narrow local bands of apatite, pyrite, trace REE minerals-pyrochlore, allanite/bastnaesite?), cut by narrow irregular veins of calcite and coarse recrystallized pyrite sub-perpendicular to banding.

EC08-002 69.75: appears to represent Fe-dolomite carbonatite with bands of opaques (pyrite, molybdenite, possible REE minerals including columbite/tantalite?-pyrochlore?) associated with phlogopite-unidentified (pyroxene?)-minor arfvedsonite? SEM analysis required for identifications.

EC08-002 113.9: calcite carbonatite with accessory chlorite (pseudomorphous after some former ferro-magnesian mineral?), apatite, magnetite and minor sulfides (pyrrhotite, pyrite) and REE minerals (pyrochlore, allanite or bastnaesite?).

EC08-002 122.22: coarse-grained, “herring-bone” textured calcite carbonatite with streak or aggregates interstitial to the carbonate of apatite-soda amphibole (arfvedsonite?)-biotite or phlogopite-pyrite-pyrrhotite-magnetite-minor pyrochlore (?).

EC08-002 201.44: coarse calcite carbonatite with significant apatite, coarse euhedral magnetite and relict euhedral mafics (originally clinopyroxene?) now altered to tremolite-actinolite and chlorite plus

secondary magnetite, plus accessory biotite/phlogopite, trace pyrrhotite and REE minerals (possibly pyrochlore, allanite/monazite or bastnaesite?).

EC08-002 188.04: coarse dolomite carbonatite with vague layers of apatite-chlorite-pyrite/pyrrhotite-magnetite/hematite-REE minerals (columbite-tantalite-pyrochlore-allanite?)-local plagioclase/quartz, cut by vein zone of fine-grained Fe-dolomite carbonatite with trace epidote-allanite-bastnaesite?

EC08-003 6.24: layered calcitic carbonatite with zones or layers variably enriched in disseminated magnetite-pyrite-pyrochlore?-phlogopite-trace apatite, or tremolitic amphibole, or calcite, or coarse-grained magnetite-apatite-arfvedsonite-REE minerals-biotite/phlogopite, or pyrite, or calcite ±apatite.

EC08-003 15.82: banded/layered carbonatite composed of either calcite-Fe dolomite (minor magnetite-pyrite-bastnaesite?-phlogopite/muscovite with relict clinopyroxene altered to carbonate-chlorite or tremolite, or fine-grained Fe dolomite (?) with magnetite-pyrite-phlogopite-muscovite-apatite-columbite/tantalite?±pyrochlore.

EC08-003 119.18: banded (or layered) dolomitic carbonatite with variable grain size correlating with variable amounts of accessory minerals (apatite, biotite or phlogopite, pyrite, REE minerals including possible synchesite and bastnaesite or locally columbite-tantalite (?).

EC08-003 144.96: coarse-grained Fe-dolomite carbonatite well-mineralized by irregular narrow anastamosing intergranular veinlets/zones of epidote?-secondary quartz-REE minerals (possibly bastnaesite±synchesite, pyrochlore?)-minor chloritized phlogopite?-trace pyrite-magnetite?, cut by fine-grained carbonatite with only scattered bastnaesite (?)

EC08-004 63.46: coarse-grained, dolomitic carbonatite invaded and brecciated by fine-grained, Fe-dolomite carbonatite with accessory arfvedsonite, clinopyroxene/tremolite?, phlogopite, REE-mineral that could be synchesite (?) intergrown with traces of epidote, plus pyrite, trace sphalerite and galena.

EC08-004 71.64: contact between coarse to medium grained Fe-dolomite carbonatite, with local zones of concentrated pyrite, phlogopite/biotite, quartz and plagioclase, REE minerals (such as bastnaesite, monazite and pyrochlore?) and minor arfvedsonite, especially along the contact.

EC08-005 98.08: coarse-grained calcite carbonatite with significant magnetite-apatite-unidentified (relict olivine altered to iddingsite-serpentine-secondary magnetite?)-minor phlogopite-pyrrhotite/pyrite-REE minerals (pyrochlore-bastnaesite-synchesite?).

EC08-005 99.44: fine-grained dolomitic carbonatite with irregular inclusions or vein-like zones of coarse, euhedral, either magnesite or ankerite carbonate associated with variable phlogopite-apatite-REE minerals (relict pyrochlore?-monazite?)-minor magnetite-clinopyroxene?-pyrite-graphite.

EC08-005 114.36: medium-grained dolomitic carbonatite with disseminated coarse magnetite, and zones of apatite-significant REE mineral (mainly pyrochlore?) and minor pyrite-trace pyrrhotite associated with vugs in the carbonate.

EC08-005 106.33: medium-grained, Fe-dolomite carbonatite with significant apatite associated with small vugs-accessory magnetite-pyrite-REE minerals? (mainly pyrochlore, minor unidentified?) or locally limonite (?), cut by fine-grained, also likely Fe-dolomite carbonatite with only minor pyrite.

EC08-006 28.05: coarse calcite carbonatite with significant large blastic biotite/phlogopite, minor partly recrystallized soda amphibole, apatite, possible cordierite?, magnetite, pyrite, sphene and traces of REE mineral (bastnaesite?).

EC08-006 65.6: may represent strongly serpentine-Mg carbonate altered, possibly relict olivine-magnetite-apatite rich cumulate ultramafic rock, with minor but significant REE mineral (possibly bastnaesite?) associated with the magnetite, and containing traces of possible galena (?).

EC08-006 100.24: fine-grained dolomitic (or Fe-dolomitic) carbonatite altered and recrystallized along vein-like zones to coarse, locally calcitic, carbonate, apatite and minor phlogopite, pyrite and possible epidote (±cordierite, chlorite?), associated with REE minerals that may include columbite-tantalite (?), pyrochlore (?) and bastnaesite (?) locally intergrown with Mg-chlorite (?).

EC08-007 39.46: banded/layered ultramafic rock composed mainly of phlogopite, blue-green (sodic) amphibole, and carbonate (possibly mostly dolomite or locally coarse calcite?) in vein-like zones with minor pyrite, chalcopyrite, and trace REE mineral (bastnaesite?).

EC08-007 70.97: MISSING (NO SECTION)

EC08-008 46.23: breccia composed of subrounded clasts of calcite in a matrix of finer calcite, Fe-dolomite, apatite, minor amphibole and quartz, with significant REE minerals (possibly bastnaesite, columbite/tantalite, pyrochlore?) and minor pyrite/pyrrhotite, trace phlogopite/biotite.

EC08-009 213.25: ultrabasic rock ($SiO2<18\%$) composed of plagioclase-carbonate-chlorite with significant clotty concentrations of phlogopite (partly chloritized)-apatite-ilmenite-minor ilmeno-magnetite, pyrite-chalcopyrite, possible allanite (?) and traces of REE minerals.

EC08-011 111.48: appears to be multiple brecciated, carbonate-fluorite-apatite-minor biotite-phlogopite-pyrrhotite ±pyrite, quartz, possible allanite-REE mineral bearing rock.

EC08-014 25.24: banded fluorite-dolomitic carbonate rich rock with traces of opaques (possibly REE minerals) and pyrite.

EC08-014 28.69: breccia of "spotted" dolomite carbonatite clasts with significant apatite and yellow-brown possible REE mineral, in a somewhat foliated matrix of finer-grained, mostly dolomitic carbonate (minor local calcite?), with streaks or lenses of phlogopite and apatite, minor pyrite and traces of similar possible REE minerals.

EC08-014 64.65: appears to represent breccia composed of carbonate (dolomite or Fe-dolomite, local calcite) clasts with minor phlogopite, trace pyrite and rare REE minerals, in a matrix of purple fluorite, but the "clasts" may actually reflect porphyroblastic growth of glomeratic carbonate.

EC08-014 74.9: breccia of fine-grained large rounded clasts of dolomitic carbonate-trace pyrite and smaller clasts of plagioclase, in matrix of carbonate-phlogopite-plagioclase-minor apatite-ilmenite-sphene/monazite?-REE minerals.

EC08-014 169.81: breccia composed of coarse rounded clasts or small subhedral porphyroblasts of carbonate (Fe-dolomite?) in partly vuggy matrix of purple fluorite, fine-grained carbonate, minor apatite, pyrite and local concentrations of fluorocarbonate? REE mineral(s).

EC08-015 49.54: dolomitic carbonatite with minor apatite and pyrite, partly recrystallized along (partly vuggy) veinlets of carbonate-fluorite-partly chloritized phlogopite-possible fluorocarbonate (?) REE mineral(s).

EC08-015 160.45: confirmed as dolomitic carbonatite cut by significant veins of possible REE minerals and fluorocarbonate(s) (possibly including bastnaesite, synchesite and minor opaque pyrochlore, columbite-tantalite cores). Minor pyrite occurs both within the fluorocarbonate and partly within carbonate (possibly partly along cryptic vuggy veinlets that also contain REE minerals).

EC08-15 182.3: dolomitic carbonatite with significant, somewhat banded/layered (possibly tectonic?) concentrations of apatite-REE minerals?-fluorite-pyrite-phlogopite. The identity of the possible REE mineral is not known, but concentrations are significant and the crystals are well-formed and coarse-grained (readily visible with the naked eye).

EC08-016 12.76: breccia (clasts of plagioclase-carbonate-phlogopite-ilmenite or locally carbonate) in matrix of dolomitic carbonatite with significant apatite, minor pyrite-REE mineral (columbite-tantalite in synchesite?), cut by veinlets of carbonate-phlogopite-rare muscovite.

EC08-016 111.93: somewhat banded or layered, coarser-grained dolomitic carbonatite (with apatite, visible pyrite and REE mineral, trace phlogopite) in contact with finer-grained but also somewhat foliated, carbonate-minor minute pyrite-hematite-trace REE mineral.

EC08-018 145.98: confirmed as calcite carbonatite with significant streaks or lenses (locally vein-like?) of more concentrated apatite, sulfides (pyrite, minor pyrrhotite), magnetite, phlogopite and possible REE minerals (possibly synchesite, trace columbite-tantalite?).

EC08-018 69.7: appears to represent originally plagioclase-mafic? phyric intermediate volcanic rock now altered to chlorite-calcite, with accessory ilmenite and pyrrhotite concentrated in relict mafic sites and in the groundmass of plagioclase-chlorite-relict biotite.

EC08-019 209.4: originally plagioclase-mafic? phyric intermediate/mafic volcanic rock now altered to chlorite-calcite, with accessory sphene mainly concentrated in relict mafic sites in the groundmass of plagioclase-chlorite.

EC08-019 263.7: relict (serpentine-carbonate-trace secondary magnetite altered) olivine, coarse magnetite, and patches of apatite (with associated possible fluorocarbonate REE minerals rimmed by opaque REE minerals?) plus trace pyrite, pyrrhotite in a matrix of coarse calcite carbonatite.

EC08-021 74.3: dolomitic carbonatite with coarse bladed pyrite rimmed-carbonate cored pseudomorphs of some former mineral, cut by a major vein of purple fluorite-minor phlogopite; REE minerals (fluorocarbonate?) only occur in the cores of the pseudomorphs.

EC08-021 102.0: dolomitic carbonatite with trace amounts of possible REE minerals (possibly mainly fluorocarbonate, bastnaesite/synchesite?), purple fluorite, hematite (?) and pyrite.

EC08-021 181.5: relict spinifex-textured cumulate ultramafic altered to coarse bladed carbonate (mainly calcite) in a matrix of finer carbonate (also likely calcite) with variable apatite, magnetite, amphibole (blue-green sodic or very pale tremolitic), possible REE mineral (mainly pyrochlore?), minor phlogopite and pyrite.

EC08-021 196.05: possible magnetite-apatite-amphibole (±biotite/phlogopite)-carbonate-minor REE mineral?-trace sulfide cumulate rock cut by or interlayered with carbonatite (calcite and dolomite?) carrying minor REE minerals and pyrrhotite-pyrite-grace galena (?).

EC08-021 265.7: appears to represent partly resorbed fragments of serpentine-magnesite (?) altered olivine?-apatite-magnetite-phlogopite-minor possible REE mineral-pyrrhotite-sphalerite-trace pyrite-chalcopyrite bearing ultramafic rock, cut and invaded by a matrix of calcite carbonate.

EC08-022 18.6: appears to represent relict olivine (?) crystals now altered to Fe-dolomite, and associated with apatite, minor phlogopite, pyrite and lesser ilmenite, plagioclase, sphalerite, possible traces of REE minerals (?) in a matrix of dolomite carbonate.

EC08-025 21.4: contact between dolomitic carbonatite (minor pyrite) and apatite-riebeckite?-pyrite rich ultrabasic rock with very minor possible REE minerals (possibly pyrochlore partly altered to fluorocarbonate?).

EC08-025 140.0: very fine-grained, foliated, carbonate-plagioclase-biotite/phlogopite rich rock, with minor apatite and accessory rutile, trace chalcopyrite.

EC08-026 187.85: lensy aggregates of amphibole-apatite-fine magnetite (possibly after former olivine?) and loose aggregates of magnetite-pyrite-pyrrhotite-phlogopite-rare bastnaesite (?) in a matrix of coarse calcite.

EC08-026 188.65: similar to (but possibly more sheared/deformed than) the previous sample from 187.85m, this sample consists of lensy aggregates of amphibole-apatite and local coarse phlogopite-minor bastnaesite?-trace pyrrhotite-rare magnetite, in a matrix of very coarse calcite.

EC08-26 62.7: appears to represent magnesio-carbonatite (dolomite and local Fe-dolomite or ankerite?) possibly cut by deformed veins of carbonate-fluorite-REE mineral and stylolitic zones of apatite-phlogopite-minor pyrite-possible REE mineral (mainly synchesite?).

(Note: both samples from EC08-27, at 115.62m and 220.59m, are MISSING (NO SECTIONS.)

EC08-28 78.05: very fine-grained, dolomitic carbonatite with local concentrations or stylolitic partings of fluorite-phlogopite-sphalerite-pyrite/trace chalcopyrite, possible REE mineral.

Detailed petrographic descriptions and photomicrographs are appended (on CD). If you have any questions regarding the petrography, please do not hesitate to contact me.

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EC08-001 10.25: BRECCIA: "GLIMMERITE" CLASTS (PHLOGOPITE WITH EUHEDRAL TREMOLITE?) IN MATRIX OF CALCITE (AND MG-FE CARBONATE?), APATITE, MINOR PYRITE-MAGNETITE-ALLANITE OR BASTNAESITE (?)

Described as euhedral amphibole (magnesio-arfvedsonite in very fine-grained, brecciated glimmerite with significant calcite and apatite matrix); hand specimen shows fine-grained, dark grey-brown mafic rock that is readily scratched by steel, forming fragments in a matrix of grey-white carbonate. The rock is locally magnetic, shows strong reaction to cold dilute HCl in the carbonate portions, and mainly red stain for calcite in the etched and stained offcut (which also highlights the bladed crystals of amphibole?). Modal mineralogy in polished thin section is approximately:

Phlogopite	45%
Carbonate (mainly calcite, minor Mg-Fe carbonate?)	35%
Amphibole (tremolite?)	10%
Apatite	8-10%
Pyrite	<1%
Magnetite	<1%
Allanite or bastnaesite (?)	<1%

This sample consists of what appear to be fragments of brown phlogopitic rock containing euhedral bladed colourless amphibole crystals, cut and cemented by a breccia matrix of carbonate and lesser phlogopite and apatite with very minor sulfides (mainly pyrite, lesser magnetite).

In the fragments, which have subangular outlines up to about 5 cm across, abundant pale-coloured mica forms randomly oriented, sub- to euhedral flakes mostly <50 um, but grading in places up to 0.5 mm (particularly near the carbonate-rich matrix, or near the enclosed amphibole crystals, where euhedral flakes to nearly 2 mm long coat the amphibole). Pleochroism is from X=pale yellowish brown to Z= very pale greenish, the axial angle is small (2V probably <10° and negative) and extinction angle is small (5°). These optical characteristics fit phlogopite. Amphibole crystals are perfectly euhedral, up to at least 6 mm long (where terminated by being cut off by the carbonate matrix). They display absolutely no colour or pleochroism, and are length-slow, with extinction angle about 15°, suggestive of tremolite (magnesium amphibole) rather than arfvedsonite (Na-amphibole) which is length-fast, with strong distinctive bluish pleochroism. The amphibole crystals contain inclusions of phlogopite, carbonate and trace magnetite all mostly <0.15 mm in diameter.

In the matrix, carbonate forming subhedral to irregular anhedral crystals up to about 1 mm in diameter is likely mostly calcite to judge by the strong, vigorous reaction to cold dilute HCl in hand specimen, and red stain in the offcut. However, in places finer-grained carbonate with noticeably higher reflectivity and possibly higher refractive indices, forming rounded subhedra <0.2 mm in size, could be Mg-Fe carbonate such as magnesite or siderite (breunnerite?), typically associated with minor opaques (see below). Around the margins of the enclosed phlogopitic fragments, apatite is common as small rounded sub- to euhedral stubby prisms rarely over about 0.35 mm long. Pyrite forms euhedral cubic crystals up to 0.7 mm (aggregates to 1 mm) and magnetite forms euhedra to 0.25 mm (aggregates to 0.5 mm). Phlogopite crystals included in the matrix areas locally show anomalous darker greenish brown pleochroism in haloes around minute red-brown crystals of possible allanite (Ce-bearing epidote) mostly <50 um in size and mostly isotropic (metamict?); these would require SEM analysis to identify them with certainty, but could be the locus of REE (and possibly U?) in the sample.

In summary, this appears to represent breccia of "glimmerite' clasts (composed of fine-grained phlogopite containing euhedral bladed amphibole, likely tremolite?) in matrix of carbonate (mainly calcite, possible Mg-Fe carbonate?), apatite, minor pyrite, magnetite and allanite (?).

EC08-001 34.5: CALCITE-RICH ROCK CUT BY VEIN-LIKE ZONE OF DOLOMITE WITH ENVELOPES OF DOLOMITE-PHLOGOPITE?-ARFVEDSONITE?-PLAGIOCLASE-QUARTZ-APATITE-PYRITE-ALLANITE OR BASTNAESITE?

Described as calcite carbonatite with apatite exhibiting flow banding, cut by very fine grained yellow-grey-brown dolomitic carbonatite vein 1.5 cm wide; hand specimen shows white calcite-rich rock (vigorous reaction to cold dilute HCl) cut by zone or vein of grey-brown possibly dolomitic carbonate (slower reaction to HCl) flanked by envelopes with minor dark brown/black mica and traces of pyrite or other opaques. The rock is slightly magnetic in the envelopes, and shows red stain for calcite and purple stain (Fe-dolomite) in the vein (in the etched offcut). Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite, host rock)	45%
(possible Fe-dolomite, vein zone)	40%
Biotite/phlogopite (envelope)	5-7%
Apatite	1-2%
Amphibole (arfvedsonite?)	1-2%
Plagioclase (albite?)	1-2%
Quartz (secondary)	1-2%
Pyrite, trace chalcopyrite inclusions	1-2%
Allanite or bastnaesite (?)	1%
Magnetite	trace

This sample consists of a vein-like zone of relatively fine-grained dolomitic carbonate, surrounded by envelopes of similar fine-grained carbonate associated with minor biotite/phlogopite, dark amphibole, plagioclase, secondary quartz, pyrite, allanite? and magnetite developed in the adjoining relatively coarse-grained calcite wallrock.

In the vein-like zone, fine-grained, possibly dolomitic carbonate forms interlocking subhedra mostly <50 um in diameter, with sucrosic granular texture. Very minor inclusions of greenish brown pleochroic, altered mica mostly <0.15 mm in diameter (possibly phlogopite?) locally coat subhedral ragged (corroded?) elongated crystals <0.2 mm in length of epidote (?) that grade in places to red-brown, somewhat coarser (up to 0.3 mm long) rounded corroded crystals of allanite or bastnaesite (?). In both cases the surrounding phlogopite shows distinct darker pleochroic haloes suggestive of radiation damage, and the allanite (?) is partly metamict (isotropic), also suggestive of radiation damage from U or Th possibly contained in addition to Ce and other REEs.

In the wallrock, calcite forms coarse, mainly subhedral crystals up to 1 mm in diameter, increasingly mixed as the vein zone is approached with lesser, finer-grained dolomitic (?) carbonate similar to that in the vein, apparently forming an envelope or halo to the vein zone. With this carbonate there are lesser amounts of dark minerals including biotite or phlogopite as pale brown to greenish brown ragged subhedral flakes <1.5 mm in diameter in patches with irregular outlines up to almost 1 cm across, and amphibole as euhedral crystals <1 mm long. The amphibole shows blue-green pleochroism and length-fast character with extinction angle around 16°, typical of arfvedsonite. Also included in the cores of the phlogopitic patches are aggregates of either plagioclase (extinction on 010 around 15° may suggest albite?) or quartz (?) both as sub/euhedra up to 0.6 mm in size. Apatite forms rounded stubby prismatic crystals mostly <0.25 mm long. Minor pyrite forming aggregates to 2 mm long of <0.3 mm porous sub/euhedra (possibly after marcasite?), and aggregates with subhedral, ragged outlines to 1 mm of red-brown allanite or bastnaesite (?) typically surrounded/coated by radiation-damaged phlogopite are also present in the envelope. Traces of chalcopyrite (<25 um in size) are included within pyrite.

In summary, this appears to represent calcite-rich rock cut by a vein-like zone of dolomitic carbonate containing minor epidote/allanite?-phlogopite, with envelopes of dolomite-phlogopite-arfvedsonite?-plagioclase-quartz-apatite-pyrite-possible allanite or bastnaesite (?).

EC08-001 34.7: CALCITE CARBONATITE WITH ZONES OF PYRRHOTITE±PYRITE, OR DOLOMITIC CARBONATE?-PHLOGOPITE-APATITE-PYROCHLORE?

Described as medium-grained calcite carbonatite with euhedral pyrite associated with anhedral pyrrhotite, minor euhedral pyrochlore and light green pyroxene (diopside or aegirine?); hand specimen shows pale grey-white rock that stains red for calcite and generally reacts strongly to cold dilute HCl except in darker grey zones partly associated with sulfides, which react slowly unless scratched. The rock is only weakly magnetic near the pyrrhotite (could be hexagonal?). Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite; minor dolomite?)	75%
Pyrrhotite	15%
Phlogopite	5%
Apatite	3%
Pyrite	1%
Pyrochlore (?)	1%

This sample consists essentially of relatively coarse-grained carbonate (likely mainly calcite to judge by the red stain in etched offcut, and vigorous reaction to HCl in hand specimen) with coarse blotchy irregular patches of pyrrhotite and minor euhedral pyrite, and areas of finer-grained carbonate, phlogopite, apatite partly associated with scattered euhedral pyrochlore (?) crystals.

Carbonate, likely mainly calcite, forms mainly sub- to locally euhedral crystals up to almost 2 mm in diameter, with random orientations (granular mosaic). Finer-grained carbonate (interlocking subhedra mainly <0.25 mm) is associated with apatite, phlogopite and locally pyrochlore (?) but generally not with sulfides in irregular zones mostly <2 mm thick that anastamose through the rock. This finer-grained carbonate could be dolomitic (?).

Pyrrhotite occurs in aggregates up to almost 2 cm across, composed of interlocking subhedra mostly <2 mm in size, or as disseminated subhedra mostly <1.5 mm, both intergrown or associated in places with minor pyrite as cubic euhedra to 4 mm or <0.5 mm respectively.

Phlogopite occurs as sub- to euhedral flakes up to 1.5 mm in size with pale yellowish- to greenish-brown pleochroism, in places intergrown with or containing inclusions of euhedral <0.2 mm pyrochlore (?) crystals.

Apatite occurs as stubby rounded prisms up to 0.6 mm long, in places aggregating to 3 mm across. The crystals are typically fractured, and separated by traces of phlogopite and carbonate.

The mineral tentatively identified as pyrochlore (?) occurs as euhedral crystals up to 2 mm across with a blastic appearance (aggregates of small euhedral crystallites mostly <0.1 mm; abundant inclusions of carbonate, minor phlogopite). Although the material making up the aggregate crystals is deep red-brown to black (only partly transparent) and mainly isotropic, somewhat similar to the mineral tentatively identified as allanite (?) in previous slides, phlogopite adjacent to it does not appear to show pleochroic haloes, suggesting U/Th are not present and therefore it is a different mineral although its associations are similar. Alternatively, the mineral identified as allanite could be pyrochlore with minor U/Th content.

In summary, this appears to be a mainly calcite-rich (minor dolomite?) carbonatite with accessory sulfides (pyrrhotite and pyrite) not closely associated with phlogopite, apatite and possible pyrochlore. No pyroxene was observed in the section.

EC08-001 43.5: LAYERED CARBONATITE (COARSE CALCITE, LESSER APATITE) WITH ACCESSORY MAGNETITE-PHLOGOPITE-PYROCHLORE?-PYRRHOTITE-PYRITE

Described as medium grained white to light grey calcite carbonatite with segregations of apatite with magnetite showing flow banding and locally abundant anhedral pyrochlore to 5 mm; hand specimen shows vaguely banded pale grey-white rock due to concentrations of apatite, magnetite and possible pyrochlore, rare sulfides and minor greenish phlogopite (?). The rock is strongly magnetic, shows intense reaction to cold dilute HCl, and red stain for calcite in the etched offcut (except for apatite-rich zone which etches white). Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite?)	75%
Apatite	15%
Magnetite	5%
Phlogopite	3%
Pyrochlore (?)	1%
Pyrrhotite	1%
Pyrite	<1%

This sample consists essentially of granular but somewhat foliated, calcitic carbonate and poorly defined layers of apatite-magnetite-minor pyrochlore (?)-sulfides; both contain minor mica (likely mainly phlogopite). The zones of apatite-rich rock are up to about 1 cm thick and roughly sub-parallel to a weakly developed foliation and layering in the rock defined by concentrations of fine-grained magnetite.

Carbonate, probably mostly calcite, forms mainly subhedral interlocking crystals of 1-2 mm size (but locally optically continuous for up to3 mm).

Apatite forms mainly short, somewhat rounded, prismatic crystals <0.5 mm long generally strongly aligned with the layering/foliation (elongation 2:1 to 3:1). The crystals are somewhat fractured, with minor very fine-grained carbonate located along these microfractures.

Magnetite occurs as either relatively coarse-grained, somewhat irregular but generally subhedral aggregates up to 6 mm across, or smaller, subhedral crystals mostly <1 mm in size disseminated in carbonate along the margins of the apatite rich zone.

Phlogopite occurs as subhedral flakes up to about 1.5 mm in diameter intergrown with carbonate or less commonly apatite near the border with carbonate. The crystals have rounded outlines and are zoned, with cores showing apparently unusual, reversed pleochroism from X= pale reddish brown to Y= very pale greenish, and rims showing the opposite (Y= bright pale green) suggestive of possible chloritization around the margins.

The mineral tentatively identified as pyrochlore (?) occurs as blastic aggregates with euhedral outlines up to 2 mm across composed of randomly oriented euhedra mostly <0.25 mm long with variable bright red-brown to pale golden brown colour (the latter apparently anisotropic under crossed polars). Reflectance is about right (in the 12-16 % range) and there is no obvious anisotropism in reflected light. As in the previous sample, although this material resembles the mineral tentatively identified as allanite (?) in samples 1 and 2, nearby phlogopite in this sample does not show radiation damaged pleochroic haloes.

Pyrrhotite occurs as irregular masses up to 2 mm long composed of subhedra <0.5 mm, locally associated with cubic pyrite to ~1 mm in diameter.

In summary, this appears to be somewhat layered carbonatite composed of alternating zones of relatively coarse-grained calcite and finer-grained apatite, with phlogopite mainly in the former and magnetite either in the latter or concentrated along its margins, with scattered pyrochlore (?) and minor pyrrhotite-pyrite.

EC08-001 139.49: BANDED/LAYERED CALCITIC CARBONATE, AND ANKERITIC (?) CARBONATE WITH ACCESSORY APATITE-PHLOGOPITE-PYRITE-TRACE UNIDENTIFIED MINERAL AND GALENA (?)

Described as medium-sized grains of phlogopite and pyrite in groundmass of apatite (+?) "island" in calcite carbonatite; hand specimen shows irregular grey layer (?) of dolomitic carbonate (slow reaction to cold dilute HCl compared to very strong reaction of calcite in adjacent white layer) that hosts the phlogopite and pyrite. The rock is not magnetic, but shows red stain for calcite in the white layers and possible purple stain in the grey layers of the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite)	50%
(mainly ferroan dolomite?)	40%
Apatite	5%
Phlogopite	2-3%
Pyrite, trace chalcopyrite (?)	2-3%
Unidentified	<1%
Galena (?)	<<1%

This sample consists mainly of interlayered calcitic carbonate and dolomitic or ankeritic (?) carbonate, the latter with increased concentrations of accessory apatite, phlogopite, pyrite and unidentified mineral (possibly Nb-Ta or REE-bearing?).

Calcite rich layers or zones are up to at least 2 cm thick, composed of interlocking sub- to euhedral crystals of calcite up to 2 mm in diameter, with random orientation (granular habit). These layers are virtually monomineralic.

Ferroan dolomite (ankerite?) rich layers are of similar thickness with non-parallel (tapering, lensoid) shapes and consist of finer-grained, mainly <0.35 mm, subhedra of (presumed) dolomite since it only reacts slowly to cold dilute HCl in hand specimen, and does not stain for calcite in the offcut. Significant apatite occurs as scattered to locally concentrated subhedral crystals forming stubby prisms up to 0.7 mm across, associated with phlogopite as ragged, somewhat bent (deformed) flakes up to 1.5 mm in diameter with pale greenish brown normal pleochroism (Y=darkest).

Pyrite forms aggregates up to several mm long composed of subhedra mostly <1.5 mm in diameter, rarely associated with an unidentified mineral that shows low reflectance (10-15%?) in somewhat anisotropic (bireflectant) zones of aggregates with subhedral outlines mostly <0.4 mm long, associated with what could be galena (?) <0.1 mm in size, and rimmed by what may be phlogopite showing radiation damage (dark greenish brown). Rarely, the pyrite contains traces of chalcopyrite (?) <10 um thick, or a grey phase similar to the unidentified mineral, <40 microns thick (the latter could also be rutile?). This mineral would require SEM analysis to help identify it.

In summary, this appears to represent banded or layered coarse-grained calcitic carbonate hosting fine-grained ankeritic carbonate with accessory apatite, phlogopite, pyrite and an unidentified, possibly radioactive (?) mineral possibly associated with traces of galena (?).

EC08-001 141.34: BRECCIA: PHLOGOPITE-, CARBONATE-, OR APATITE (±PYRITE)-RICH CLASTS IN MATRIX OF FE-DOLOMITE-PHLOGOPITE-MINOR APATITE-QUARTZ OR PLAGIOCLASE?-KSPAR? AND LOCAL PYROCHLORE (?)

Described as brecciated dolomite carbonatite with fragments of glimmerite and dolomitic carbonate; hand specimen shows breccia of small (mostly <few cm) ragged irregular to lensoid clasts of dark brown mica-rich rock in matrix of buff-white carbonate. The rock is not magnetic, shows only slow reaction to cold dilute HCl, and purple stain for Fe dolomite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Phlogopite	40%
Carbonate (mainly Fe dolomite?)	40%
Apatite	15%
Quartz (or plagioclase?)	1-2%
Pyrite, trace pyrrhotite	1-2%
Pyrochlore (?)	1-2%
K-feldspar (microcline?)	<1%

This sample consists of ill-defined areas (clasts?) that are generally fine-grained and mica-rich (or in places carbonate- or apatite-rich), in a poorly defined matrix of coarser-grained carbonate, apatite, local quartz or plagioclase (?), minor pyrite, pyrochlore and rare Kspar (?).

Mica-rich ("glimmerite") clasts have irregular-shaped outlines mainly <2 cm in diameter, and consist of randomly oriented, subhedral flakes of phlogopite mostly <0.25 mm with variable but generally sub-equal amounts of carbonate (dolomite?) as mainly interstitial subhedra <0.3 mm in size, poikilitically enclosing mica crystals, and local apatite as stubby euhedral prisms mostly <0.15 mm long. The clasts are locally cut by veinlets of carbonate <0.5 mm thick.

Carbonate-rich clasts composed of relatively coarse-grained dolomite as interlocking ragged subhedra to 2 mm across are difficult to distinguish in places from matrix. Rarely the clasts consist of single carbonate crystals up to 2 mm long. The carbonate clasts typically contain lesser amounts of phlogopite as subhedral flakes up to 0.5 mm in diameter.

Apatite rich clasts tend to be either very coarse, optically continuous ragged subhedra up to 7 mm long (with large sub/euhedral inclusions of phlogopite up to 2.5 mm, and ragged carbonate subhedra to 1.5 mm), or relatively fine-grained aggregates of <0.25 mm prismatic euhedra. Pyrite is common within these clasts, occurring as aggregates with irregular shapes up to 2 mm across of subhedra mostly <1 mm, locally associated/intergrown with ragged euhedral crystals of pyrochlore (?) mostly <0.5 mm in diameter and traces of pyrrhotite as ragged, filamentous sub/anhedra rarely over50 um in size, surrounding/rimming the pyrochlore (?). The colour of the (isotropic) pyrochlore crystals is generally only pale brown, but this may be due to an unusually thin section (<20 um thick).

The matrix consists mainly of variably sized, variable mixtures of carbonate (dolomite, forming subhedra ranging from <0.2 mm to ~2 mm), lesser phlogopite (rounded subhedra mostly <0.25 mm), apatite (generally euhedral prisms <0.3 mm), local quartz or plagioclase feldspar (simple twinning locally seen in sub/anhedral crystals <0.2 mm in size; local "grid" twinning seen in some crystals suggests the possible presence of Kspar, variety microcline?). The mineral tentatively identified as pyrochlore (?) is most common in the matrix, typically forming ragged (corroded-looking; possibly merely plucked) euhedral crystals <0.25 mm that are concentrated along "streaks" sub-parallel to vein matrix walls, with phlogopite crystals mostly <0.5 mm but rarely up to 1.5 mm (showing small, <5-10°, negative 2V).

In summary, this is confirmed as likely breccia composed of clasts of variably phlogopite-, carbonate-, or apatite-minor pyrite-pyrochlore rich rock in a variably textured matrix of carbonate, lesser phlogopite, apatite, possible quartz or feldspar (plagioclase, rare microcline?) with local concentrations of pyrochlore (?).

EC08-001 151.12: BRECCIA: CARBONATE-, APATITE (±PYRITE)- OR REE-MINERAL RICH CLASTS IN MATRIX OF FE-DOLOMITE-BIOTITE-APATITE-PLAGIOCLASE? AND LOCAL REE MINERALS (?)

Described as calcite carbonatite agglomerate (angular fragments of calcite carbonatite suspended in matrix of apatite, phlogopite plus some REE minerals?); hand specimen shows breccia composed of angular white or buff-beige coloured clasts mostly <2 cm in diameter, in a darker grey, carbonate-mica-minor sulfide-REE mineral matrix. The rock is locally slightly magnetic, shows major (but slow) reaction to cold dilute HCl and purple stain for Fe-dolomite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly Fe-dolomite?)	70%
Apatite	15%
Biotite/phlogopite	10%
REE mineral (?) partly rimmed by allanite or bastnaesite?	1-2%
Plagioclase (albite?)	1-2%
Pyrite	1-2%
Pyrrhotite	<1%
Sphalerite	trace

This sample consists of about 50% angular clasts up to 2 cm across composed mainly of carbonate (white or buff in hand specimen) or rarely apatite or mainly biotite and REE minerals (dark; not common in hand specimen), in a matrix of carbonate, apatite, biotite, minor plagioclase, sulfides, and possible REE minerals. Distinction between clasts and matrix is not always obvious.

In the carbonate clasts, carbonate (mainly dolomite to judge by both the rate of reaction in hand specimen and the purple stain in etched offcut) forms interlocking subhedral crystals either mostly <1 mm in diameter, or in some cases optically continuous up to 2 mm. In the latter case the coarse, more euhedral crystals are brownish (likely Fe-dolomite) and commonly rimmed or veined/partly replaced by minor fine-grained clear carbonate (calcite?) as euhedra mostly <0.2 mm in size. Apatite-rich clasts are difficult to define, but contain large crystals with optical continuity up to almost 2 mm long set in/veined and/or replaced by carbonate. In the dark, biotite-rich clasts, which are smaller (<1 cm), dark brown pleochroic biotite forming randomly oriented, subhedral flakes mostly <0.25 mm in diameter intergrown with lesser, interstitial brownish carbonate (Fe-dolomite?) <0.15 mm, euhedral apatite <0.15 mm long, opaque to virtually opaque possible REE minerals (could possibly be columbite-tantalite?) in irregular shaped aggregates up to 1 mm across, and trace pyrite or yellow-brown (low Fe) sphalerite as rounded subhedra <0.2 mm. The possible REE minerals (one with lower and one with higher reflectivity) are locally surrounded by a mineral with even lower reflectivity and yellow-green/brown colour (almost isotropic?) that could be allanite or bastnaesite (?), in part surrounded by dark pleochroic haloes in adjacent biotite.

In the matrix, fine-grained carbonate (mostly subhedral, <0.2 mm Fe-dolomite?) and lesser apatite (rounded sub/euhedra up to 0.8 mm across) and biotite (subhedral flakes to 0.5 mm) plus local sulfides are set in finer-grained carbonate (mostly subhedral, <50 um). Sulfides are mostly either pyrite (aggregates <1 mm across of subhedra mostly <0.25 mm) or less common pyrrhotite (aggregates to 0.75 mm of <0.2 mm subhedra), locally associated with or in places partly replacing (?) similar-sized aggregates of opaque, possible REE-bearing minerals of uncertain identity. Local plagioclase forming rounded euhedra/subhedra up to 1 mm long displays polysynthetic twinning with extinction Y^010~13 degrees, suggestive of albite or oligoclase (An5 or An30?).

In summary, this is breccia composed of clasts of carbonate-, apatite- or biotite-REE mineral rich rock in a variably textured matrix of carbonate, lesser biotite, apatite, minor plagioclase, with local concentrations of REE minerals (?).

EC08-001 152.25: BRECCIA: CARBONATE-, APATITE- OR BIOTITE (±REE-MINERAL)-RICH CLASTS IN MATRIX OF FE-DOLOMITE-APATITE-BIOTITE-PLAGIOCLASE? AND LOCAL SULFIDES, REE MINERALS (?)

Described as brecciated dolomite carbonatite (angular fragments of glimmerite and dolomite carbonatite with apatite infills; hand specimen shows breccia composed of angular white or buff-beige coloured clasts mostly <2 cm in diameter, in a darker grey, carbonate-mica-minor sulfide-REE mineral matrix. The rock is locally very slightly magnetic, shows major (but slow) reaction to cold dilute HCl and purple stain for Fe-dolomite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly Fe-dolomite?)	70%
Apatite	10%
Biotite/phlogopite	10%
Plagioclase (albite?)	5%
Pyrite	2-3%
Pyrochlore (?) partly rimmed by epidote, allanite or bastnaesite?	1-2%
Chalcopyrite, trace pyrrhotite, galena?	<1%

This sample consists of about 65% angular clasts up to 2 cm across composed mainly of carbonate (white or buff in hand specimen) or rarely apatite or mainly biotite and REE minerals (dark), in a matrix of carbonate, apatite, biotite, minor plagioclase, sulfides, and possible REE minerals. Distinction between clasts and matrix is not always simple.

In the carbonate clasts, carbonate (mainly dolomite to judge by both the rate of reaction in hand specimen and the purple stain in etched offcut) forms interlocking subhedral crystals either mostly <1 mm in diameter, or in some cases optically continuous up to 2 mm. In the latter case the coarse, more euhedral crystals are brownish (likely Fe-dolomite) and are commonly rimmed or veined by minor fine-grained clear carbonate (calcite?) as subhedra mostly <0.2 mm in size with central stylolitic (?) partings. Apatite-rich clasts (if present) are difficult to separate from the matrix, since they consist of small euhedral crystals mostly <0.5 mm long set in/veined and/or replaced by carbonate. In the dark, biotite-rich clasts, which are smaller (<1 cm), dark brown pleochroic biotite forming randomly oriented, subhedral flakes mostly <0.25 mm (but up to almost 1 mm) are intergrown with minor interstitial brownish carbonate (Fe-dolomite?) <0.15 mm, euhedral apatite <0.2 mm, clots of plagioclase (subhedra mostly <0.15 mm, likely similar in composition to those in the matrix (see below), and trace opaque to virtually opaque possible REE minerals in irregular shaped aggregates <0.5 mm long. The possible REE minerals (one with lower and one with higher reflectivity) are locally associated with a mineral with even lower reflectivity and red/brown colour (partly isotropic?) that could be metamict allanite or bastnaesite (?), in part surrounded by dark pleochroic haloes in adjacent biotite.

In the matrix, fine-grained carbonate (mostly subhedral, <0.5 mm Fe-dolomite?) and lesser apatite (prismatic euhedra up to almost 1 mm long) and biotite (subhedral flakes to 0.75 mm) plus local sulfides are set in finer-grained carbonate (mostly subhedral, commonly <50 um). Local plagioclase forming rounded euhedra/subhedra up to 1 mm long displays polysynthetic twinning with extinction Y^010~15 degrees, suggestive of albite or oligoclase (An0-5 or An35?). Sulfides are mostly pyrite (aggregates <1 mm across of subhedra mostly <0.25 mm) or locally minor chalcopyrite (aggregates to 0.3 mm of <0.15 mm subhedra), locally associated with euhedral aggregates up to 2 mm across of mostly opaque, minor transparent possible REE-bearing minerals of uncertain identity (columbite-pyrochlore?) or rarely bladed colourless epidote or red-brown and partly isotropic, possibly metamict allanite (?) <0.2 mm long. The former contains rare traces of galena (?) as subhedra <20 um in size and is associated with traces of pyrrhotite <25 um in size.

In summary, this is breccia composed of clasts of carbonate-, less common apatite- or biotite ±REE mineral-rich rock in a variably textured matrix of carbonate, lesser apatite, biotite, plagioclase, and minor sulfides, with minor local concentrations of REE minerals that may include pyrochlore and allanite or bastnaesite (?).

EC08-001 204.21: FINE-GRAINED FE-DOLOMITIC CARBONATE, ACCESSORY APATITE-PHLOGOPITE WITH CLOTS/VEINLETS OF FLUORITE-COARSE CARBONATE-BIOTITE-PHLOGOPITE/CHLORITE, PYRRHOTITE±PYRITE, REE MINERALS?

Described as fine-grained magnesio-carbonate (<0.1 mm) groundmass with apatite, dark purple fluorite in irregular masses with interstitial calcite, pyrrhotite, phlogopite and sphalerite?; hand specimen shows pale greenish-buff, fine-grained carbonate rock with disseminated phlogopite, clots of purple fluorite/white carbonate and narrow veinlets of a black unidentified mineral in part associated with sulfides. The rock is locally weakly magnetic, shows major slow reaction to cold dilute HCl and purple stain for Fe dolomite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly Fe-dolomite?)	85%
Fluorite	10%
Phlogopite, minor biotite (veinlets), rare chlorite	2-3%
Apatite	1-2%
Pyrrhotite	1%
Pyrite	<1%
REE minerals (pyrochlore, columbite/tantalite??)	<1%

As described, this sample consists mainly of fine-grained carbonate with minor phlogopite and apatite, cut by discontinuous clotty veinlets or concentrations of purple fluorite, coarser-grained carbonate, minor (rarely chloritized) biotite or phlogopite, sulfides, and traces of REE mineral (?).

The bulk of the slide consists of fine to very fine-grained (0.1 to <25 um) interlocking sub- to anhedral crystals of carbonate, likely mostly Fe-dolomite to judge by the purple stain in the offcut. Apatite occurs as scattered euhedral prismatic crystals up to almost 1 mm long, with random orientations, or locally in aggregates up to 1.5 mm across. Phlogopite occurs as pale brown pleochroic subhedral flakes up to 0.5 mm in diameter, more commonly near or along the narrow veinlets and clotty concentrations of fluorite.

Along these concentrations, fluorite forming subhedral crystals mostly <2 mm in size, with ragged, corroded margins, occur in aggregates up to 0.5 cm across. Purple colouration is unevenly distributed in the crystals, but concentric zones are highlighted by fluid inclusions (most of which are opened/decrepitated but a few <10 um in size show a vapour bubble with V/L ratios in the 5-10% range). Coarse-grained carbonate forms sub- to euhedral crystals up to 1.5 mm in size with pale brownish colour suggestive of ankerite, intergrown with the fluorite. Crystals of phlogopite up to 1.5 mm are locally intergrown with (or replaced by?) chlorite as subhedra t0 0.75 mm with pale green pleochroism and length-fast, anomalous greenish birefringence indicative of Fe:Fe+Mg, or F:M, ratio near 0.4-0.5 (?). Along the narrow (stylolitic?) veinlets, dark brown biotite forms subhedral flakes mostly <0.1 mm in size, associated with sulfides and minor possible REE-minerals (?).

Sulfides are mostly pyrrhotite, forming rounded subhedra up to 0.7 mm in diameter (elongated aggregates along the veinlets up to 3 mm) or less commonly pyrite as sub/euhedral cubic crystals to almost 1 mm. Possible REE minerals are mostly fine-grained aggregates with euhedral outlines up to 0.5 mm, isotropic in both transmitted and reflected light, with opaque portions (euhedra <30 um long) having higher reflectance and brownish portions (similar sized subhedra) having lower R values (possibly mixtures of columbite-tantalite with pyrochlore, but would require SEM analysis to identify).

In summary, this appears to be fine-grained Fe-dolomitic carbonatite with accessory apatite and minor phlogopite, disrupted by veinlets of fluorite-coarse carbonate-minor phlogopite or biotite (rarely chloritized)-pyrrhotite ±pyrite, possible REE minerals (?).

EC08-002 5.1: COARSE CALCITE CARBONATITE WITH SCATTERED APATITE, VEINLETS OF ARFVEDSONITE?-MINOR REE MINERAL?-HEMATITE

Described as containing unusual red streaks in calcite carbonatite; hand specimen shows relatively coarse-grained, white to pale buff-coloured carbonate rock with dark veinlets or short discontinuous strips/layers (sub-parallel to weakly developed foliation) surrounded by pale reddish haloes (likely hematite?). The rock is not magnetic, shows intense reaction to cold dilute HCl, but only pale weak reddish stain for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite?)	90%
Apatite	2-3%
Amphibole (arfvedsonite?)	1-2%
REE mineral (?) oxidized to hematite	<1%
Hematite (amorphous stain)	<1%

This sample consists, as described, of calcitic carbonate (with scattered disseminated crystals or aggregates of apatite) cut by narrow zones of blue-green amphibole associated with local possible REE minerals of uncertain identity partly oxidized to hematite and partly surrounded by reddish stains of amorphous hematite.

Carbonate, likely mainly calcite to judge by the intensity of reaction to cold dilute HCl in hand specimen, in spite of the pale weak red stain in the offcut, forms interlocking sub- to euhedral crystals up to about 2 mm in diameter, with random orientations (granular mosaic).

Scattered crystals or aggregates of apatite have euhedral to subhedral outlines up to 1 mm long and 2 mm across respectively. The apatite crystals are commonly fractured and the fractures partly filled with minor very fine-grained carbonate that is brownish compared to the matrix carbonate.

In the narrow veinlet zone, elongated euhedral crystals of amphibole up to 1 mm long with distinctive blue or blue-green pleochroism and length-fast character, indicative of Na-amphibole (likely arfvedsonite?), are locally mixed with traces of opaque to red-brown, possible REE minerals or hematite, surrounded by weakly developed haloes of hematite as amorphous stains in intergranular boundaries between carbonate crystals. Scattered euhedral crystals or pseudomorphs up to1 mm across may be composed of REE mineral such as columbite/tantalite and/or pyrochlore (?), now largely replaced by hematite (?)

In summary, this sample appears to represent calcitic carbonatite with scattered disseminated crystals/aggregates of apatite, cut by narrow zones of blue-green arfvedsonite (?) associated with local possible REE minerals of uncertain identity partly oxidized to hematite and locally surrounded by reddish stains of amorphous hematite.

EC08-002 38.25: "GLIMMERITE" (FOLIATED PHLOGOPITE-MINOR CALCITE-TRACE MAGNETITE ±ILMENITE ROCK WITH BANDS OF APATITE-PYRITE ±REE MINERALS, CUT BY CALCITE-COARSE PYRITE VEINS)

Described as glimmerite with calcite/apatite fracture fillings imparting distinct foliation to the glimmerite; hand specimen shows dark grey/blackish brown, fine-grained ultramafic rock as described, with coarse cubic pyrite disseminated along the apatite-calcite rich streaks. The rock is very weakly magnetic, shows minor vigorous reaction to cold dilute HCl, and minor red stain for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Phlogopite	75%
Carbonate (mainly calcite?)	10%
Pyrite	8-10%
Apatite	5%
Magnetite, trace ilmenite	<1%
REE minerals (pyrochlore, allanite or bastnaesite?)	<1%

This sample consists of weakly foliated/banded phlogopite with the banding marked by increased concentrations of apatite and carbonate (calcite) plus fine-grained pyrite and local minor magnetite plus traces of REE minerals (allanite?) marked by pleochroic haloes in the mica. Both calcite and pyrite are coarsened and remobilized into cross-cutting veinlet zones sub-perpendicular to banding.

Phlogopite forms mostly subhedral, <0.5 mm flakes with weak alignment defining the foliation, locally containing larger (recrystallized?) crystals up to 1.5 mm long, typically associated with the bands along which the apatite occurs, or with coarse pyrite/calcite veinlets. Pleochroism is from X=very pale reddish brown, Z=very pale greenish brown, except around minute (<40 um long) euhedral prismatic crystals of possible REE mineral with bright red-brown colour that are possibly anisotropic (allanite?) where dark red-brown pleochroic haloes occur.

Along the thin (<1 mm thick) paler coloured bands, apatite occurs as stubby prismatic crystals mostly <0.2 mm long, locally in aggregates up to 1.5 mm long.

Carbonate (likely mainly calcite to judge by the strong reaction to HCl in hand specimen, and red stain in offcut) is generally more widely distributed throughout the sample, forming subhedral crystals mostly <0.3 mm, locally in lensoid aggregates up to 0.6 mm long (typically aligned sub-parallel to the banding). More carbonate (also likely calcite) occurs along veins sub-perpendicular to banding, forming subhedra to 0.5 mm long with antitaxial texture (oblique to the vein)

Pyrite occurs as a) very fine-grained euhedra (mainly <0.25 mm) in bands parallel to the apatite-rich zones, and locally but not everywhere associated with the apatite, or b) coarse cubic crystals up to 2.5 mm in diameter, either along carbonate veins or in places along the banding. Minor possible REE mineral (bright red-brown, but apparently isotropic; could be pyrochlore?) or locally magnetite and ilmenite form euhedral cubic crystals <0.2 mm in size intergrown with the fine-grained pyrite along banding in places.

Very minor magnetite occurs as disseminated very fine euhedra mostly <0.1 mm (aggregates to 0.2 mm) away from the pyritic bands. Some of the magnetite crystals are intergrown with very minor ilmenite (subhedra <25 um in size) or with traces of possible pyrochlore (?) as described above forming euhedra <0.1 mm.

In summary, this is confirmed as "glimmerite" (phlogopite-rich, minor calcite-trace magnetite ±ilmenite bearing ultramafic rock with narrow local bands of apatite, pyrite, magnetite/ilmenite, trace REE minerals such as pyrochlore and allanite or bastnaesite?), cut by narrow irregular veins of calcite and coarse recrystallized pyrite sub-perpendicular to banding.

EC08-002 69.75: DOLOMITIC CARBONATITE/LAYERS PYRITE-MOLYBDENITE-PHLOGOPITE-REE MINERALS?-UNIDENTIFIED (PYROXENE?)-MINOR ARFVEDSONITE?

Described as unusually large (4 cm) vein of galena with sphalerite in carbonatite; hand specimen shows ptygmatically folded veins <2 cm thick composed of what appear to be mainly oxides (REE minerals?) with minor pyrite, in mainly dolomitic carbonatite. The rock is not magnetic, shows major but slow reaction to cold dilute HCl, and purple stain for Fe-dolomite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly Fe-dolomite?)	60%
Molybdenite (high Mo, >2000 ppm in assays)	10%
Phlogopite	10%
Columbite-tantalite (?)	10%
Unidentified (possibly pyroxene?)	5%
Pyrite	2-3%
Sphalerite or pyrochlore (?)	1-2%
Amphibole (arfvedsonite?)	1%

This sample is mineralogically complex and would have to be subjected to further (SEM and/or XRD) study to confidently identify the mineral phases present, particularly the possibly REE-bearing phases. It consists of ptygmatically folded and interlayered carbonate (minor phlogopite) carbonatite and mainly opaque minerals, the latter consisting of finely flaky graphite or molybdenite (?) intergrown with carbonate, apatite, pyrite, and two possible REE minerals (one with similar characteristics to sphalerite, possibly pyrochlore?) and one opaque (possibly columbite-tantalite?).

In the carbonate-rich portions of the slide, carbonate (likely mostly Fe-dolomite to judge by the purple stain in etched offcut, and slow reaction to HCl in hand specimen) forms interlocking sub- to locally euhedral crystals up to about 2 mm in diameter. The carbonate is locally mixed with phlogopite (subhedral flakes mostly <0.5 mm in diameter, with random orientations); in these areas it is also typically mixed with the opaque phases characteristic of the mainly opaque layers, as described below (graphite or molybdenite?-REE minerals?). The unidentified mineral forms large barrel-shaped euhedral crystals up to 2 mm long, with very pale green colour but no appreciable pleochroism, low birefringence (first order grey), and oblique extinction in the 30-40 degree range, somewhat like pyroxene, but the interference figure indicates 2V is small (or zero, i.e. uniaxial) and negative. Amphibole forms euhedral prismatic crystals up to 2 mm long generally associated with the margins of opaque-dominated zones, intergrown with phlogopite. Pleochroism in the amphibole varies from pale green (length-slow: tremolite-actinolite series?) to pale blue (with length-fast character: possibly Na-amphibole such as arfvedsonite?).

In the opaque layers, fine-grained molybdenite (?) forming slender, somewhat bent/deformed euhedral flakes mostly <0.2, but in places up to 0.4, mm in size are intimately mixed with carbonate (subhedra mainly <0.2 mm) and local phlogopite (sub/euhedra mainly <0.1 mm). Scattered through this carbonate-molybdenite matrix are mainly euhedral, porphyroblastic-looking crystals or aggregate crystals of possible REE minerals with euhedral outlines mainly in the 2 mm size range. These minerals are either transparent, with distinct red-brown colour (grading to orange-brown around the rims), or opaque. The former tend to have somewhat botryoidal/collomorphic texture, with cores that are isotropic in transmitted light whereas rims show apparent birefringence, which argues against sphalerite (also, the ~12% reflectance, or R value, seems to be too low). This mineral appears isotropic in reflected light, and could be pyrochlore (?). The latter shows higher R values possibly in the 16-18% range (below Re of the molybdenite?), with distinct anisotropism in shades of grey (could be columbite-tantalite?). Thus tentatively I would say neither sphalerite nor galena appears to be present in the sample (this could be checked by geochemistry, to see if there are significant REE values and low Zn and Pb values). Pyrite forms subhedral crystals up to 2 mm.

In summary, this appears to represent Fe-dolomite carbonatite with bands of opaques (pyrite, molybdenite, possible REE minerals including columbite/tantalite?-pyrochlore?) associated with phlogopite-unidentified (pyroxene?)-minor arfvedsonite?

EC08-002 113.9: CALCITE CARBONATITE WITH ACCESSORY CHLORITE PSEUDOMORPHS, APATITE, MAGNETITE, PYRRHOTITE/PYRITE, REE MINERALS?

Described as calcite carbonatite with chlorite, pyrite, pyrrhotite, magnetite and pyrochlore; hand specimen shows pale greenish grey-white, medium-grained carbonate rich rock with clotty to disseminated dark minerals (opaque oxides) and minor sulfides. The rock is strongly magnetic, shows intense reaction to cold dilute HCl, and red stain for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite)	70%
Chlorite	10%
Apatite	10%
Magnetite, trace ilmenite	7-8%
Pyrrhotite, minor pyrite	1%
REE mineral (pyrochlore?/trace allanite or bastnaesite?)	1%

This sample consist mainly of medium-grained granular carbonate with accessory chlorite, apatite, magnetite and traces of REE mineral and sulfides, partly distributed along vaguely defined linear zones or in clotty concentrations where the dark minerals may make up 15% of the rock.

Carbonate appears to be mainly or entirely calcite, to judge by the intensity of reaction to cold dilute HCl in hand specimen, and prominent red stain in etched offcut. The crystals are mainly sub- to locally euhedral and range up to about 2 mm in diameter, although they are smaller (mainly <0.5 mm) where intergrown with fine-grained chlorite along linear zones. However, in these intergrowths, the carbonate tends to be brownish, with apparently higher relief, so there may be minor dolomites.

Chlorite occurs both as randomly to radially oriented sub/euhedral flakes mainly <0.25 mm in diameter in the aggregates along discontinuous linear zones (with the brownish carbonate; possibly representing pseudomorphs after some former Fe-Mg mineral), or as discrete euhedral but somewhat rounded single hexagonal crystals up to 1.6 mm in diameter with very small, negative 2V (that may also represent pseudomorphs of former mafic minerals). Other pseudomorphs consist of randomly oriented matted small subhedral flakes mostly <50 um in size; however, most chlorite appears to have optical characteristics (very weak green colour, no pleochroism, length-slow weak anomalous blue birefringence) suggestive of F:M around 0.5 (?). The pseudomorphs of fine-grained chlorite show fractures of fine-grained carbonate, suggestive of former olivine or pyroxene (?) crystals.

Apatite forms slender to stubby euhedral prisms up to about 1 mm long, with random orientations or in clusters up to 2 mm across, commonly associated with magnetite and with chlorite or chloritized pseudomorphs.

Magnetite forms mostly subhedral crystals up to about 1 mm in diameter, or locally aggregates to 2 mm. Very minor sulfide is closely associated, and appears to be mainly pyrrhotite as subhedra <1 mm in size, locally intergrown with euhedral pyrite <1 mm in diameter. Possible REE minerals loosely associated with the magnetite forming euhedral crystals with cubic outlines are mostly red-brown and sensibly isotropic, suggestive of pyrochlore; rare cores of anisotropic, dark red-brown pleochroic material forming bladed euhedra to 0.1 mm long could be allanite or bastnaesite (?). The REE minerals are rarely intergrown with tabular ilmenite (?) <0.1 mm long.

In summary, this is confirmed as calcite carbonatite with accessory chlorite (pseudomorphous after some former ferro-magnesian mineral?), apatite, magnetite and minor sulfides (pyrrhotite, pyrite) and REE minerals (pyrochlore, allanite or bastnaesite?).

EC08-002 122.22: COARSE BLADED CALCITE CARBONATITE WITH STREAKS OF APATITE-ARFVEDSONITE?-MINOR PYRITE-PYRHOTITE-BIOTITE/PHLOGOPITE-MAGNETITE-PYROCHLORE?

Described as calcite carbonatite with large lath-like crystal textures rimmed by apatite (commonly radial), magnesio-arfvedsonite, phlogopite, pyrite, pyrrhotite, and pyrochlore; hand specimen shows "herringbone" structure of very coarse (3-5 cm long) white lath-like crystals at roughly 90 degrees to each other with interstices between laths marked by pale greenish grey (apatite?) and minor opaque oxides and sulfides. The rock is locally magnetic, shows intense reaction to cold dilute HCl, and red stain for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite)	75%
Apatite	20%
Amphibole (arfvedsonite?)	2%
Pyrite	1-2%
Phlogopite or biotite (slightly chloritized)	<1%
Pyrrhotite	<1%
Magnetite	<1%
REE minerals (mainly pyrochlore?)	<1%

This sample consists mainly of coarse bladed carbonate crystals with streaks of accessory minerals (apatite, minor amphibole, sulfides, phlogopite/biotite, magnetite, possible REE minerals?) concentrated in vaguely defined, elongated zones interstitial to the carbonate crystals.

Carbonate, likely mostly calcite to judge by the intensity of reaction to cold dilute HCl in hand specimen and the red stain in etched offcut, forms somewhat rounded to bladed sub- to euhedral crystals up to 3 mm long except in the streaks of accessory minerals, where the carbonate minerals are fine-grained (<0.2 mm) and mixed with apatite, phlogopite/biotite, and opaques. Carbonate in these areas is clouded with abundant inclusions (mostly solid, opaque, <5 um in diameter, too small to identify properly), but is also likely mostly calcite.

Apatite forms slender elongate euhedral prisms up to 5 mm long, aligned with the carbonate crystals or in radiating habit. It is intergrown with amphibole and mica plus opaque oxides and sulfides.

In the streaks of opaque and dark coloured minerals, amphibole forming mainly euhedral lath-like crystals up to 0.5 mm long displaying strong blue, pale green, and purplish blue pleochroism and (length-fast) extinction angle about 16 degrees, is likely arfvedsonite (soda amphibole). If it is magnesian, this would have to be determined by SEM or microprobe analysis. It is locally mixed with a little phlogopite or biotite forming sub/euhedral flakes mostly <0.5 mm in diameter with strong dark brown pleochroism (locally due to radiation damage near REE minerals?). The mica is locally altered to bright green chlorite around the margins.

Pyrite occurs as elongated aggregates up to almost 1 cm long of sub- to euhedral cubic crystals mostly <1 mm in diameter, typically intergrown with minor pyrrhotite (subhedra to 1.5 mm with lamellar texture highlighted by incipient oxidation), magnetite (aggregates with ragged outlines to 0.5 mm composed of <0.1 mm sub/euhedra) and minor REE minerals that may be mostly pyrochlore (?) as subhedra with sub-cubic outlines mainly <0.25 mm in size.

In summary, this is confirmed as coarse-grained, "herring-bone" textured, calcite carbonatite with streak or aggregates interstitial to the carbonate of apatite-soda amphibole (arfvedsonite?)-biotite or phlogopite-pyrite-pyrrhotite-magnetite-minor pyrochlore (?).

EC08-002 201.44: COARSE CALCITE CARBONATITE WITH EUHEDRAL MAGNETITE, MAFIC RELICS (CLINOPYROXENE ALTERED TO TREMOLITE-ACTINOLITE, CHLORITE, SECONDARY MAGNETITE), PHLOGOPITE, MINOR PYRRHOTITE, PYROCHLORE?

Described as coarse euhedral magnetite in medium-grained calcite carbonatite, accessory apatite, chlorite and pyrite; hand specimen shows white carbonate rock containing coarse euhedral magnetite and similar sized, dark green (chloritic?) mafic relics. The rock is very strongly magnetic, shows intense reaction to cold dilute HCl, and red stain for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite)	60%
Magnetite (trace ilmenite inclusions)	15%
Apatite	15%
Chlorite (after amphibole, clinopyroxene?)	5%
Amphibole (tremolite-actinolite, after pyroxene?)	2-3%
Biotite/phlogopite	1-2%
Relict clinopyroxene	1%
Pyrrhotite	<1%
REE mineral (?pyrochlore, trace allanite/monazite?)	<1%

This sample consist of coarse-grained carbonate with streaks or lenses of apatite, containing very coarse euhedral magnetite and relict mafic crystals (clinopyroxene altered to amphibole and chlorite) plus traces of sulfide and possible REE minerals.

Carbonate (likely mainly calcite to judge by the intense reaction to HCl in hand specimen and red stain in etched offcut) forms interlocking, coarse, rounded to locally bladed subhedral crystals up to almost 5 mm long, with random orientations.

Apatite occurs in lensy aggregates mostly <1 cm thick by 2 cm long, composed of more or less randomly oriented, fractured, slender to stubby prismatic euhedra up to 2 mm long. It is associated with magnetite and with mafic minerals (biotite/phlogopite, relict pyroxene sites).

Magnetite occurs mainly as very large euhedra up to almost 1 cm in diameter (commonly composite crystals of euhedra <0.5 cm typically with inclusions of carbonate and apatite). Minor ilmenite occurs as tabular euhedral inclusions up to 0.5 mm long. Traces of a mineral with lower reflectivity (~12%; could be pyrochlore?) forming subhedra <0.15 mm in size are locally included within or associated with the magnetite. Rarely these are included within a euhedral mineral <0.15 mm in size with pale yellow colour and lower reflectivity (8-10%) that might be epidote/allanite or bastnaesite, or possibly monazite (?).

Relict mafic crystals, likely originally clinopyroxene, display coarse euhedral outlines up to about 1 cm in diameter. They now consist largely of small relict crystals <0.5 mm long of clear, colourless clinopyroxene with large extinction angle (diopside or augite?) mostly replaced by fibrous, sub/euhedral colourless amphibole (tremolite/actinolite?) crystals up to 1.5 mm long, or by chlorite as matted to radial pale green (but non-pleochroic) flakes mostly <0.1 mm in diameter, with weakly anomalous blue-grey, length-slow birefringence suggestive of F:M around 0.5 (?). Carbonate is common, as is very fine-grained opaque oxides accompanying the alteration, concentrated along former cleavages, grain boundaries or fractures and appear to be mostly secondary magnetite as sub/euhedra in two size ranges either mostly <20 um or <0.15 mm in diameter.

Other mafics are mostly ragged to subhedral or rounded (corroded?) mica crystals up to 3.5 mm in size, with pale brown rims grading to dark red-brown cores (phlogopite to biotite?). They are typically surrounded by rims of apatite.

Minor pyrrhotite forms rounded to ragged subhedra mostly <0.5 mm in size generally closely associated with (partly a replacement of?) magnetite.

In summary, this is confirmed as coarse calcite carbonatite with significant apatite, coarse euhedral magnetite and relict euhedral mafics (originally clinopyroxene?) now altered to tremolite-actinolite and chlorite plus secondary magnetite, plus accessory biotite/phlogopite, trace pyrrhotite and REE minerals (possibly pyrochlore, allanite/monazite or bastnaesite?).

EC08-002 188.04: DOLOMITIC CARBONATITE (APATITE-CHLORITE-PLAGIOCLASE-QUARTZ-MAGNETITE-PYRITE/PYRRHOTITE-REE MINERALS) CUT BY FE-DOLOMITE

Described as fine-grained magnesian carbonate vein cutting medium-grained magnesian carbonatite that contains apatite, trace phlogopite, sulfide and magnetite; hand specimen shows only slow reaction to cold dilute HCl in both the vein and the adjacent wallrock, and the vein appears to cut off lensy or layered concentrations of apatite and dark minerals in the wallrock. The rock is slightly magnetic, and shows purple stain mainly in the fine-grained vein (mainly absent in the wallrock, suggesting it may be mostly dolomite as opposed to Fe-dolomite in the vein). Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite?; Fe-dolomite in vein)	80%
Apatite	15%
Chlorite (after biotite/phlogopite?)	1-2%
Plagioclase	1%
Quartz (secondary?)	1%
Magnetite	<1%
Pyrite, lesser pyrrhotite	<1%
Hematite	<1%
Epidote , possible allanite or bastnaesite (?)	<1%
Pyrochlore (?) possibly replacing columbite-tantalite?	<1%

This sample consists of relatively coarse- to medium-grained carbonate with irregular streaks or lenses of apatite, minor chlorite (after biotite or phlogopite?), traces of plagioclase, quartz, fine-grained magnetite and sulfide, with local minor hematite and possible REE and epidote minerals, cut by a vein-like area of finer-grained carbonate with minor epidote (?).

In the vein, minute interlocking carbonate crystals are mostly <50 um in size (but contains scattered sub/anhedral carbonate up to 0.35 mm), with only rare pyrite (euhedra to 0.25 mm), and streaks in which minor epidote (?) occurs to break the monotony. This carbonate is likely mainly Fe-dolomite to judge by the purple stain in the etched off cut. The mineral tentatively identified as epidote (?) forms ragged subhedra mostly <75 um in size, with distinct yellow- to very pale reddish-brown colour locally intergrown with dark greenish-brown material, suggestive of epidote/allanite or bastnaesite (?) now partially metamict due to radiation damage. This would require SEM study.

In the wallrock, the carbonate (possibly dolomite since it does not stain purple as much as the carbonate in the vein) forms either interlocking subhedra up to 1 mm in size, in aggregates with lensoid outlines up to 3 mm long sub-parallel to the vein, or finer-grained material (rounded subhedra mostly <0.1 mm) as a matrix to the aggregates. Small interstitial aggregates of chlorite, opaques (sulfides, magnetite, possible REE minerals) are mostly <1 mm, apparently concentrated in vaguely defined streaks within apatite-rich zones or layers oriented oblique to (and cut by) the vein. Apatite forms somewhat rounded subhedra <1.2 mm long. Most sulfide is pyrite, forming ragged somewhat elongated aggregates up to 0.5 mm long of sub/euhedra <0.2 mm, or less commonly pyrrhotite as subhedra mainly <0.1 mm. Magnetite forms subhedra mostly <0.2 mm difficult to distinguish from REE minerals, especially where partly oxidized to hematite. Chlorite forms subhedral, greenish brown flakes rarely over 40 um in size with weakly anomalous blue-grey, length-slow birefringence suggestive of F:M 0.5-0.6 (?), and possibly radiation-damaged by proximity to U/Th bearing minerals (high Th, U in assays). The possible REE minerals occur as euhedral aggregates with cubic outlines up to 0.3 mm, composed of opaque rims (columbite-tantalite?) around transparent, red-brown isotropic cores with lower R-values (possibly pyrochlore?). Carbonate interstitial to the apatite and associated with the possible REE minerals is commonly slightly stained by amorphous iron oxides (mainly hematite?). Local plagioclase and quartz form rounded subhedra mostly <0.35 mm.

In summary, this appears to represent coarser-grained dolomite carbonatite with vague layers of apatite-chlorite-pyrite/pyrrhotite-magnetite/hematite-REE minerals (possibly columbite-tantalite, pyrochlore and allanite?), local plagioclase and quartz, cut by a vein zone of finer-grained Fe-dolomite carbonatite containing traces of epidote-allanite or bastnaesite?

EC08-003 6.24: LAYERED (?) CALCITE CARBONATITE (DISSEMINATED MAGNETITE-PYRITE-PYROCHLORE?-PHLOGOPITE), ZONES OF TREMOLITE, APATITE-MAGNETITE-ARFVEDSONITE?-COLUMBITE/TANTALITE?-BIOTITE/PHLOGOPITE, PYRITE, CALCITE

Described as fine-grained grey magnesio-carbonatite in contact with calcite carbonatite; hand specimen shows fine-grained, grey carbonatite (with disseminated dark minerals) in contact with somewhat layered white and dark-mineral rich calcitic carbonatite. Both rock types are strongly magnetic, shows intense reaction to cold dilute HCl, and red stain for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite?)	65%
Apatite	10%
Magnetite	10%
Amphibole (tremolite?)	5-7%
(arfvedsonite?)	2-3%
Pyrite, minor pyrrhotite	2-3%
REE minerals (columbite-tantalite, pyrochlore?)	2-3%
Biotite/phlogopite	1-2%

This sample consists of fine-grained, likely actually calcitic carbonatite with significant disseminated magnetite-sulfide-REE mineral separated from a coarse-grained, calcite carbonatite by border zones/layers rich in tremolitic amphibole, or magnetite-apatite ±Na amphibole-phlogopite-sulfides-REE minerals.

In the fine-grained rock, carbonate (likely mainly calcite to judge by the intense reaction in hand specimen and red stain in offcut) forms interlocking, randomly oriented, somewhat rounded subhedra mostly <1 mm in diameter. Magnetite is heavily disseminated as sub/euhedral crystals mostly <0.2 mm, locally associated with similarly distributed but lesser pyrite as euhedral cubic crystals <0.3 mm, and intergrown with sub/euhedral crystals or aggregates of opaque columbite-tantalite (?) and possible pyrochlore (?) up to 0.4 mm in diameter, the later with dark red-brown colour and isotropic character. Locally rounded subhedral flakes of pale yellow-brown phlogopite up to 0.35 mm, or apatite as rounded subhedral prisms to 0.3 mm long, are intergrown with the opaque minerals.

In the marginal zones, a layer rich in almost colourless amphibole with extinction angle about 16 degrees (tremolite?) forms randomly oriented bladed sub/euhedral crystals up to 0.7 mm long (this zone is deficient in opaque oxides and sulfides) separated by a calcite-rich layer <3 mm thick from a layer rich in magnetite (subhedra to 1 mm), apatite (prismatic sub/euhedra to 0.7 mm), aggregates of pale blue-purplish amphibole (arfvedsonite?) as euhedral bladed crystals <0.6 mm long surrounded by medium brown biotite/phlogopite as ragged subhedral flakes <0.3 mm, which is separated by another coarse calcite-rich layer <2 mm thick from a layer ~1.5 mm thick rich in pyrite as elongated subhedra up to 2 mm long. REE minerals in these zones appear to comprise opaque (columbite-tantalite?) as euhedra mostly <0.5 mm locally associated with fine-grained aggregates of dark red-brown pyrochlore (?) mostly <0.1 mm in size, both typically intergrown with magnetite.

In the final zone of the section, coarse-grained calcite forms interlocking randomly oriented sub/euhedral crystals up to 2 mm in diameter, with minor included euhedral apatite crystals mostly <0.2 mm long.

In summary, this appears to represent somewhat layered calcitic carbonatite with zones or layers variably enriched in disseminated magnetite-pyrite-columbite/tantalite-pyrochlore?-phlogopite-trace apatite, or tremolitic amphibole, or calcite, or coarse-grained magnetite-apatite-arfvedsonite-REE minerals-biotite/phlogopite, or pyrite, or calcite-minor apatite.

EC08-003 15.82: LAYERED CALCITE/FE DOLOMITE CARBONATITE LOCALLY RICH IN MAGNETITE, PHLOGOPITE-MUSCOVITE, APATITE, PYRITE, REE MINERALS, RELICT CLINOPYROXENE

Described as magnetite-apatite vein or banded layer (midrange UV suggests a cumulate?) in contact with fine-grained grey calcite-carbonatite; hand specimen shows dark grey-black magnetite-apatite rich band or layer separated from grey calcite-rich (minor magnetite) carbonatite by thin coarse-grained calcite layer. The rock is strongly to intensely magnetic, shows strong reaction to cold dilute HCl in the carbonatite layer, and reddish/purplish stain for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (calcite, Fe-dolomite?)	60%
Magnetite	20%
Phlogopite/muscovite	10%
Apatite	5%
REE-minerals	2-3%
Pyrite	1-2%
Relict clinopyroxene (?)	1-2%

This sample consists of a thick band or layer of coarse-grained, either clear (calcitic) or brownish (dolomitic?) carbonate, separated by a coarse-grained band of carbonate from a band or layer of magnetite, fine-grained carbonate, accessory phlogopite or colourless muscovite, apatite, pyrite and REE minerals.

In the carbonate-rich layer, carbonate forming rounded subhedral crystals up to about 1.5 mm in diameter is mainly either clear or distinctly brownish (due mainly to abundant, minute solid/fluid inclusions <15 um and <10 um respectively). The former is likely calcite and the latter may be Fe-dolomite, as suggested by the indeterminate reddish/purplish stain in etched offcut. Disseminated magnetite, pyrite and minor REE minerals are locally associated with minor mica, relict pyroxene (largely altered to fine-grained carbonate and phlogopite or chlorite). Magnetite forms mainly euhedral crystals <0.2 mm, locally associated with pyrite as cubic euhedra to 0.35 mm and minor bright red-brown to yellow-brown, sub/euhedral, anisotropic crystals of bastnaesite/synchesite (?) up to 0.5 mm in size. Mica is mainly pale yellowish (phlogopite?) or colourless (muscovite) as rounded subhedral flakes <0.2 mm. Relict clinopyroxene (?) forms ragged, corroded sub/anhedra up to almost 1 mm in size with extinction about 40 degrees to cleavage and lack of colour suggestive of diopside (?), generally replaced by fine-grained (<0.1 mm) sub/anhedral dolomitic carbonate and minute radiating flakes of phlogopite or chlorite (or possibly tremolite?) mostly <100 um long.

In the magnetite-rich layer, magnetite forms sub- to euhedral crystals mainly in the 0.5-1.0 mm size range, locally in loose aggregates to about 2 mm, associated with lesser pyrite as sub- to euhedral cubic crystals rarely over 0.5 mm, set in a matrix of mica and fine-grained carbonate <0.1 mm in size (possibly Fe-dolomite since it may be purple stained in the offcut). Mica forming sub- to euhedral flakes up to about 0.6 mm in size is either pale yellow-brown (phlogopite?) or colourless (muscovite?); the two locally occur intergrown and so are likely separate mineral species, not a gradation from one to the other. Minor apatite forms stubby rounded prisms mainly <0.35 mm. Most REE-mineral in this portion of the sample appears to be opaque, forming ragged sub/euhedral crystals up to 0.5 mm across only just barely lower in R value than magnetite, and apparently anisotropic; they could be columbite-tantalite (?) but contain inclusions <40 um in size with much lower R values (~12%) and possibly isotropic under crossed polars, that could be pyrochlore (?).

In summary, this is likely banded/layered carbonatite composed of either calcite-Fe dolomite (minor magnetite-pyrite-bastnaesite?-phlogopite/muscovite with relict clinopyroxene altered to carbonate-chlorite or tremolite, or fine-grained Fe dolomite (?) with magnetite-pyrite-phlogopite-muscovite-apatite-columbite/tantalite?±pyrochlore.

EC08-003 119.18: FINE-MEDIUM-COARSE GRAINED LAYERED DOLOMITE CARBONATITE WITH ACCESSORY APATITE-PHLOGOPITE-PYRITE-REE MINERALS

Described as contact zone with fine-grained grey magnesio carbonatite and rusty dolomite; hand specimen shows fine-grained, pale grey-white carbonatite with zones of increased, finely disseminated dark minerals (locally concentrated along narrow streaks or fractures?). The rock is not magnetic, shows only slow reaction to cold dilute HCl (mainly where scratched), and purplish stain for Fe-dolomite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly Fe-dolomite?)	90%
Apatite	5%
Biotite/phlogopite	2-3%
Pyrite	1-2%
REE mineral (synchesite, bastnaesite?)	<1%

This sample consists of vaguely banded/layered coarse-, fine- and medium-grained carbonatite composed mainly of carbonate with minor apatite and accessory amounts of biotite/phlogopite, sulfide and REE mineral(s).

Coarse-grained carbonate layers consist of interlocking sub- to euhedral crystals up to almost 2 mm in diameter, with random orientations. The crystals are generally either clear or relatively brownish (clouded by minute inclusions of solid or liquid, mostly <20 um in size), possibly representing mainly Fe-dolomite (as indicated by the staining tests) and minor calcite. Minor sulfides mostly concentrated along the boundary with the adjacent finer-grained carbonatite, appear to be mostly pyrite, forming subhedra rarely over 0.15 mm in diameter. Very minor possible REE minerals locally associated with the pyrite form fine-grained aggregates with subhedral outlines <0.2 mm across of yellow-brown, fine-grained material that could be synchesite (?).

In the fine-grained layer (or vein?), carbonate forms interlocking rounded subhedra mainly <0.5 mm, likely mainly Fe-dolomite. Only traces of pyrite occur in this zone, and then mainly near the margin, where subhedra to 0.75 mm long occur concentrated along a narrow (<1.5 mm thick) zone. Along this zone, which marks the boundary with the adjacent medium-grained zone, minor dark to pale brown biotite/phlogopite forms randomly oriented, sub/euhedral flakes <0.25 mm that locally appear to show radiation-damaged dark haloes near concentrations of dark red-brown REE minerals (bastnaesite or pyrochlore?) in aggregates up to 0.4 mm across.

In the medium-grained layer, carbonate forms interlocking sub/euhedral crystals mostly<1 mm in diameter that are mostly brownish and likely Fe-dolomite. Interstitial areas are either filled with fine-grained apatite (stubby euhedral prisms mostly <0.2 mm long, with random orientations) or minor phlogopite (subhedral pale yellow-brown flakes <0.15 mm), locally associated with minor pyrite (euhedra <0.15mm) and possible REE mineral as subhedra <0.1 mm with dark yellow-brown to red-brown aspect (could be bastnaesite/synchesite) as euhedra mostly <50 um in diameter. However, there are also opaque crystals with subhedral outlines <0.1 mm in diameter that have lower R than expected for magnetite (and the rock is not magnetic) so these could be columbite-tantalite

In summary, this appears to represent banded (or layered) dolomitic carbonatite with variable grain size correlating with variable amounts of accessory minerals (apatite, biotite or phlogopite, pyrite, REE minerals including possible synchesite and bastnaesite or locally columbite-tantalite (?).

EC08-003 144.96: COARSE FE-DOLOMITE CARBONATITE WITH NETWORK OF QUARTZ-EPIDOTE-REE MINERAL-MINOR CHLORITE-TRACE PYRITE CUT BY FINE DOLOMITIC CARBONATITE

Described as 14,885.65 combined REE in magnesio-carbonatite with fluorite, bastnaesite and pyrochlore; hand specimen shows pale buff-grey coloured carbonatite cut by narrow brownish veinlets in contact with finer-grained carbonatite. The rock is locally slightly magnetic, shows only minor slow reaction to cold dilute HCl, and purple stain for Fe-dolomite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly Fe-dolomite?)	~90%
Epidote (?)	3%
Quartz (mainly secondary?)	2%
Bastnaesite (±synchesite?)	2%
Pyrochlore (?)	1-2%
Chlorite (after phlogopite/)	1%
Pyrite	<1%
Magnetite (?)	trace

This sample consists mainly of relatively coarse-grained carbonate with abundant narrow, irregular, anastamosing fractures partly filled by epidote?-secondary quartz-REE minerals (mainly bastnaesite and pyrochlore?)-chlorite-trace pyrite, magnetite, cut by a zone of fine-grained carbonatite that contains only scattered disseminated REE mineral (mainly bastnaesite?)..

In the main, coarse-grained portion of the sample, carbonate forms mainly euhedral to subhedral crystals up to almost 4 mm in diameter that show slight undulose extinction indicative of deformation. The carbonate is likely mainly Fe-dolomite (ankerite) since it reacts only slowly to HCl in hand specimen and shows purple stain in the etched offcut. All the other minerals in this portion of the slide occur along intergranular boundaries between carbonate grains, grading to irregular veinlets where best developed. The mineral tentatively identified as epidote forms ragged anhedra mostly <0.7 mm (but locally optically continuous up to 1 mm) with strong positive relief, bright second/third order interference colours, and only pale yellow colour (non-pleochroic) implying low Fe content. It is intergrown with secondary quartz as rounded sub/anhedra mostly <0.5 mm in size, and (especially along the irregular fractures) REE minerals that appear to be mostly dark red-brown bastnaesite (?) locally mixed with or cored by opaque (pyrochlore?). The mineral tentatively identified as bastnaesite forms aggregates to 1 mm long of subhedral crystals that are anisotropic, with strong positive relief, extinction parallel to a well-developed basal parting, and locally rimmed by pale yellowish-brown phase that may be synchesite (?). In some areas, the red-brown mineral is cored by an opaque phase forming rounded sub/euhedra that appear isotropic in reflected light, which may be pyrochlore (?). Alternatively, there may be only bastnaesite with the opacity at the cores due to increased thickness of the mineral. Minor chlorite or chloritized phlogopite occurs as aggregates to 0.3 mm of randomly oriented subhedral flakes <50 um in size with greenish brown pleochroism. Relatively rare pyrite forms euhedra up to 0.2 mm; trace magnetite is inferred on the basis of local slight magnetism, but is not directly observed. Locally, some bastnaesite (?) occurs as minute subhedra <25 um intimately intergrown with fine-grained carbonate (might be difficult to recover).

In the fine-grained portion (vein, since it cuts off the mineralization in the main portion), carbonate forms interlocking, somewhat flattened, foliated subhedra mostly <0.1 mm in diameter. Dark red-brown bastnaesite (?) occurs as somewhat rounded aggregates mostly <0.2 mm associated with secondary quartz to 0.3 mm, suggestive of accidental inclusions of the well-mineralized wallrock to the vein.

In summary, this is coarse-grained Fe-dolomite carbonatite well-mineralized by irregular narrow anastamosing intergranular veinlets/zones of epidote?-secondary quartz-REE minerals (possibly bastnaesite±synchesite, pyrochlore?)-minor chloritized phlogopite?-trace pyrite-magnetite?, cut by fine-grained carbonatite with only scattered bastnaesite (?)

EC08-004 63.46: COARSE DOLOMITIC CARBONATITE BRECCIATED BY FINE FE-DOLOMITIC CARBONATITE WITH ACCESSORY ARFVEDSONITE-CLINOPYROXENE-TREMOLITE-PHLOGOPITE-SYNCHESITE?-PYRITE-SPHALERITE-GALENA-EPIDOTE

Described as coarse clastic textured magnesio-carbonatite in contact with medium-grained yellowish magnesio-carbonatite; hand specimen shows pale buff-grey coloured, finer-grained carbonatite in contact with coarse-grained, white carbonatite. The rock is locally slightly magnetic, shows only minor slow reaction to cold dilute HCl in both phases, and purple stain for Fe-dolomite in the fine-grained portion of the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (coarse-grained dolomite/Fe-dolomite?)	65%
(fine-grained Fe-dolomite?)	25%
Amphibole (arfvedsonite?) partly altered to chlorite	1%
(tremolite-actinolite?)	1%
REE-mineral (synchesite?)	1%
Pyrite	1%
Clinopyroxene (?)	<1%
Phlogopite (locally chloritized)	<1%
Sphalerite, rare galena	<<1%
Epidote (?)	<<1%

This sample consists mainly of coarse-grained or fine-grained carbonate, with minor scattered bluish Na-amphibole, colourless amphibole, phlogopite, yellow-brown possible REE mineral (synchesite?), pyrite, clinopyroxene (?) and rare sphalerite ±galena, trace epidote.

In the coarse-grained portion, carbonate (likely dolomite or Fe-dolomite) forms euhedral to subhedral crystals up to almost 6 mm in diameter, although most show sub-domains with undulose extinction and sutured grain boundaries or bent cleavage lamellae, all indicative of strain. The contact with the fine-grained portion is somewhat gradational since fine-grained carbonate (rounded subhedra mostly <50 um, locally containing scattered anhedra to 0.2 mm) appears to invade the coarse-grained carbonate along grain boundaries.

Both portions, but primarily the finer-grained matrix to coarse-grained carbonate, contain accessory amphibole (mainly distinctive Na-amphibole arfvedsonite with blue-green to purplish-blue pleochroism, locally partly chloritized (replaced along cleavages/fractures by almost colourless chlorite? as subhedral flakes to 0.35 mm with grey-blue birefringence; F:M not obvious). Alternatively, mixtures of almost colourless clinopyroxene (?) and tremolite-actinolite (?) forming bladed crystals up to 0.5 mm long with large extinction angle near 40 degrees, or mostly <0.15 mm long, with small (<20 degree) extinction angle respectively, are present. In places the latter minerals are associated with minor pale brown phlogopite as rounded subhedra to 0.5 mm, rarely altered to chlorite. Some arfvedsonite crystals are also partly replaced by a yellow-brown, high positive relief mineral with fibrous, fine-grained habit <0.1 mm long that could be synchesite (?). This mineral is rarely intergrown with traces of a pale yellow mineral with lower R-value that may be epidote (?), forming sub/euhedra <50 um long.

Pyrite forms small euhedra mostly <0.4 mm in size, rarely associated with colourless to pale yellowish (low Fe) sphalerite as rounded sub/euhedra <0.1 mm in diameter or rare galena (?) as irregular subhedra to 0.2 mm.

In summary, this appears to represent coarse-grained, dolomitic carbonatite invaded and brecciated by fine-grained, Fe-dolomite carbonatite, the latter associated with accessory arfvedsonite, clinopyroxene/tremolite?, phlogopite, REE-mineral that could be synchesite (?) intergrown with traces of epidote, plus pyrite, trace sphalerite and galena.

EC08-004 71.64: MEDIUM/COARSE FE DOLOMITIC CARBONATITE, LOCAL ZONES OF PHLOGOPITE-PLAGIOCLASE-QUARTZ-PYRITE-REE MINERALS-ARFVEDSONITE

Described as contact between medium-grained calcite carbonatite and medium-grained yellowish magnesio-carbonatite; hand specimen shows irregular contact zone between white calcite rich carbonatite (reacts intensely to cold dilute HCl) and greenish-beige Fe-dolomite rich carbonatite (reacts only very slowly to HCl and stains purple in etched offcut). The contact is marked by an irregular (stylolitic looking) zone of dark (oxide, sulfide, mafic) minerals, and similar hairline veinlets cut the rest of the dolomitic carbonatite. Along the contact, a lensy zone of very fine-grained yellow-greenish carbonate occurs. The rock is locally very slightly magnetic; modal mineralogy in polished thin section is approximately:

Carbonate (mainly Fe-dolomite?)	~90%
Phlogopite	2-3%
Plagioclase (oligoclase, An30?)	2-3%
Quartz (mainly secondary?)	1-2%
Pyrite	1-2%
REE minerals (bastnaesite, monazite, pyrochlore?)	1-2%
Amphibole (arfvedsonite?)	<1%

This sample consists mainly of carbonate, apparently mostly Fe-dolomite to judge by the (mostly purplish) stain in the etched offcut; the contact with the calcite-rich carbonatite may not have been sampled in the thin section. Carbonate forms either very coarse sub- to euhedral crystals up to about 5 mm in diameter (locally glomeratic to 7 mm), or interlocking subhedra mostly <2 mm in diameter, separated by a zone of much finer-grained carbonate (0.1 mm or less) along a veinlet-like zone, mixed with dark brown biotite/phlogopite, accessory pyrite, possible REE minerals, minor quartz and plagioclase feldspar, and rare amphibole. Similar veinlet-like zones also extend to other parts of the sample.

Phlogopite or biotite forms somewhat rounded to ragged, subhedral flakes up to 0.5 mm in diameter that are locally slightly chloritized (interleaved by flakes of similar size with lower birefringence and pale greenish brown colour). Plagioclase forming somewhat rounded sub- to anhedral crystals mostly <0.35 mm in diameter that are only distinguishable from quartz by rare twinning (with extinction on 010 up to 11 degrees) and interference figure (with negative optic sign?) suggestive of oligoclase around An25-30. Quartz is only confidently identified (rounded subhedra <0.5 mm) by uniaxial positive interference figure, so the relative proportions of the two minerals are not readily estimated.

Pyrite forms mainly euhedral crystals <0.7 mm in diameter, loosely associated with minor amounts of a high positive relief, moderate to high birefringence but clear, colourless mineral as subhedra <0.25 mm that could be monazite (?) but only SEM analyses would confirm this. It is locally associated with rare bladed euhedral crystals <0.6 mm long of Na-amphibole (length-fast, likely arfvedsonite?). In the main (contact zone) veinlet, phlogopite and pyrite are also locally associated with dark red-brown bastnaesite (?) as aggregates to 0.2 mm of subhedra <0.1 mm in size. Also, there are local aggregates with sub/euhedral outlines up to 0.5 mm long of fine-grained yellow-brown (synchesite?) around cores of red-brown (bastnaesite?) or opaque (pyrochlore?), generally surrounded/rimmed by greenish chlorite or chloritized phlogopite (?).

In summary, this appears to represent a contact between coarse to medium grained Fe-dolomite carbonatite, with local zones of concentrated pyrite, phlogopite/biotite, quartz and plagioclase, REE minerals (such as bastnaesite, monazite and pyrochlore?) and minor arfvedsonite, especially along the contact.

EC08-005 98.08: COARSE CALCITE CARBONATITE, SIGNFICANT MAGNETITE, APATITE, RELICT (SERPENTINE-IDDINGSITE ALTERED?) OLIVINE, MINOR PHLOGOPITE, PYRITE-PYRRHOTITE±GALENA, REE MINERALS

Described as calcite carbonatite with apatite, unknown orange mineral (monazite?>) in crystals to 0.5 mm, phlogopite, magnetite, pyrrhotite, forsterite, pyrite, pyrochlore; hand specimen shows coarse/medium-grained, somewhat foliated, white/grey carbonatite with scattered clots or lenses of dark minerals along the foliation. The rock is strongly magnetic, shows intense reaction to cold dilute HCl, and red stain for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite?)	60%
Magnetite	15%
Apatite	12%
Unidentified (partly serpentinized olivine?)	10%
Phlogopite (chloritized?)	1-2%
Pyrrhotite	1%
Pyrite, trace galena (?)	<1%
REE minerals (pyrochlore, trace bastnaesite?)	<1%

This sample consists of coarse-grained carbonate with scattered, lensy clots of magnetite, apatite, an unidentified orangey mineral (possibly partly serpentinized, relict olivine?), and minor phlogopite, sulfides and REE minerals.

Carbonate (likely mainly calcite to judge by the intensity of reaction to HCl in hand specimen and the red colour of the stain in etched offcut) forms mainly coarse subhedral to rounded crystals mainly <3 mm in diameter but in places optically continuous for up to almost 8 mm.

Magnetite occurs as coarse, irregular to subhedral crystals or composite crystals up to almost 1 cm in diameter, displaying well-developed octahedral parting and veined by carbonate ±minute REE minerals (red-brown bastnaesite?), or as minor very fine-grained , likely secondary, sub/euhedral crystals <70 um in size within and around the relict olivine (?) crystals.

Apatite forms mainly slender acicular to stubby prismatic euhedral crystals up to about 2 mm long, with random orientations, concentrated in and around the coarse-grained magnetite aggregates.

The unidentified, or tentatively identified, mineral with the prominent orange colour occurs as partly serpentinized pseudomorphs with mainly euhedral outlines up to about 2 mm (but glomeratic to about 3 mm). They grade from remnant cores that are almost colourless, with moderate to high birefringence and positive relief, through zones of pale to bright orange colour that is slightly pleochroic, with maximum absorption parallel to the fast ray (perpendicular to the cleavage), altered at rims and along partings by serpentine as subhedral very pale greenish flakes mostly <35 um in size, oriented perpendicular to the parting. The orange mineral typically occurs as aggregates of finely crystalline material, precluding observation of an interference figure, but given the association with serpentine and secondary magnetite, the setting in a carbonatite, and the form of the relict crystals, it seems possible that it may be iddingsite, a know alteration product of olivine. It seems unlikely that they are monazite, which is not a coloured mineral and has distinct optical properties.

Minor phlogopite associated with the orange mineral relics and the magnetite-apatite forms rounded sub/euhedral crystals <0.7 mm, with pale yellowish or greenish colour possibly suggestive of chloritization. Sulfides are mostly pyrrhotite as subhedra to 0.75 mm, but locally pyrite forms sub/euhedra to 0.6 mm, and there are traces of galena (?) <15 um in size associated with REE minerals. REE minerals may include mainly pyrochlore (relatively opaque, euhedral crystals to 0.75 mm) locally associated with or including dark red-brown bastnaesite (?) as rounded subhedra <0.2 mm, and lesser pale yellow-brown synchesite (?) as fine-grained aggregates <0.2 mm.

In summary, this appears to be coarse-grained calcite carbonatite with significant magnetite-apatite-unidentified (relict olivine altered to iddingsite-serpentine-secondary magnetite?)-minor phlogopite-pyrrhotite/pyrite-REE minerals (pyrochlore-bastnaesite-synchesite?).

EC08-005 99.44 FINE-GRAINED DOLOMITIC CARBONATITE WITH IRREGULAR ZONES OF COARSE MG-FE CARBONATE-PHLOGOPITE-APATITE-REE MINERALS-MAGNETITE-CLINOPYROXENE-PYRITE-GRAPHITE

Described as fine-grained magnesio-carbonatite (<0.1 mm groundmass) with apatite, altered euhedral pyrochlore, phlogopite and pyrite; hand specimen shows pale greenish very fine-grained carbonatite with inclusions of pale pink mineral, and common streaks or irregular concentrations of dark minerals and sulfides. The rock is locally magnetic, shows only slow reaction to cold dilute HCl, and reddish-purplish stain for carbonate (calcite, Fe-dolomite?) in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite, minor Fe dolomite?)	65%
(ankerite/magnesite?)	10%
Phlogopite	10%
Apatite	10%
REE mineral (relict pyrochlore?)	2%
(monazite?)	<1%
Magnetite	<1%
Clinopyroxene (?)	<1%
Pyrite	<1%
Graphite (?)	<1%

This sample consists of very fine-grained carbonate with local anastamosing zones of coarser, either clear or brownish, carbonate that in places are further associated with irregular vein-like zones of phlogopite-apatite-REE minerals-minor magnetite-clinopyroxene?-pyrite-graphite.

In the bulk of the slide, very fine-grained carbonate (likely mainly dolomite since it reacts only slowly to HCl and is relatively unstained in etched offcut) forms tightly interlocking, subhedral crystals mainly in the 50 um (but locally to 0.1 mm) size range. This is the pale greenish carbonate in hand specimen. The pale pinkish areas in hand specimen correspond to irregular areas of coarser, sub/euhedral carbonate crystals up to almost 1 mm in size that are either clear or distinctly brown and are respectively unstained and purplish in etched offcut, suggesting they may be magnesite and ankerite (?).

In the irregular vein-like zones, concentrations of dark minerals are mainly phlogopite (ragged subhedral flakes mainly <0.6 mm but up to 3 mm, with pale to medium brown pleochroism locally interleaved by pale green chlorite), apatite (euhedral prismatic crystals to 1 mm long), relict pyrochlore (?) as euhedral rectangular or cubic crystals up to almost 1 mm diameter described in more detail below), possible clinopyroxene (ragged euhedra <0.2 mm long with 45 degree extinction and pale yellowish colour) or in places monazite (similar appearing ragged euhedra with pale yellowish colour but small, <5 degree, extinction), minor magnetite (sub/euhedra mostly <0.1 mm) and traces of sulfide (mainly pyrite as small sub/euhedra <0.25 mm) and graphite (minute euhedral flakes mostly <50 um in diameter with random orientations).

In the relict pyrochlore crystals, a core area (~80% of the crystal) consists of a phase with low R (~12%) that is sensibly isotropic, surrounded by a zone of higher R (~16%; like that of magnetite) but with distinct anisotropy in shades of grey, and then by an irregular outer rim of lower R (~10%) that is partly transparent (red- or yellowish-brown) and could be bastnaesite and synchesite (?).

In summary, this appears to be fine-grained dolomitic carbonatite with irregular inclusions or vein-like zones of coarse, euhedral, either magnesite or ankerite carbonate associated with variable phlogopite-apatite-REE minerals (relict pyrochlore?-monazite?)-minor magnetite-clinopyroxene?-pyrite-graphite.

EC08-005 114.36: DOLOMITIC CARBONATITE WITH MAGNETITE, ZONES OF APATITE AND PYROCHLORE-MINOR PYRITE±PYRRHOTITE ASSOCIATED WITH VUGS

Described as vuggy, yellow-brown dolomite with sphalerite, botryoidal hydrocarbon, bipyramidal quartz and white-blue fluorescent calcite as well crystallized minerals in the vugs whereas black patches of magnetite 1-5 mm in size comprise 10% of the rock but do not occur as crystals in the vugs; hand specimen shows beige-coloured vuggy carbonate with disseminated black magnetite. The rock is strongly magnetic, shows only slow reaction to cold dilute HCl, and weak purplish stain for dolomite/Fe dolomite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite and Fe-dolomite?)	70%
Apatite	15%
Magnetite	10%
REE minerals (relict pyrochlore?	3%
Pyrite	1%
Pyrrhotite	<1%

This sample consists mainly of medium-grained carbonate, commonly coarser around and near the vugs, with abundant disseminated apatite and lesser relatively coarse magnetite that are not closely associated with the vugs, where possible REE minerals and minor sulfides are common. Quartz, hydrocarbon and sphalerite are not seen.

The carbonate forms mostly rounded or barrel-shaped sub- to euhedral crystals up to almost 1 mm in diameter that is mostly distinctly brown (cloudy) in thin section; this together with the slow reaction to HCl in hand specimen and the faint purplish stain in etched offcut suggest it is likely mostly dolomite or Fe-dolomite (ankerite). Vugs are up to 3 mm across and are associated with some of the darkest brown carbonate (ankerite?), the apatite and the possible REE-mineral.

Apatite forms mainly euhedral, stubby prisms <0.5 mm long with random orientations that appear to correlate better with the vugs and REE minerals than with the magnetite.

Magnetite occurs as relatively coarse, commonly plucked-out (fractured) and/or poorly polished crystals up to 2 mm in diameter.

Possible REE minerals are difficult to distinguish at first glance from the magnetite, due to similarity in R-values (only slightly below that of magnetite, i.e. in the 16% region). This plus the opaque character in transmitted light is suggestive of pyrochlore (?), although in places there are textures similar to those described for the previous sample (from 99.44m), with rims of lower R-value material that are partly transparent (dark brown or yellow-brown) and could represent alteration of pyrochlore (?) to rims of bastnaesite and synchesite (?).

Minor sulfides are mostly pyrite as small to minute sub- to euhedral crystals mostly <0.1 but locally up to 0.5 mm in diameter, or rarely pyrrhotite as aggregates to 0.6 mm of bladed sub/euhedra mostly <0.2 mm long.

In summary, this is confirmed as medium-grained dolomitic carbonatite with disseminated coarse magnetite, and zones of apatite-significant REE mineral (mainly pyrochlore?) and minor pyrite-trace pyrrhotite associated with vugs in the carbonate.

EC08-005 106.33: MEDIUM-GRAINED FE-DOLOMITE CARBONATITE WITH APATITE, MINOR VUGS-MAGNETITE-PYRIET-REE MINERAL-LIMONITE

Described as rusty dolomite with minute vugs and magnetite, pyrite and quartz, cut by very fine-grained magnesio-carbonatite dyke; hand specimen shows medium-grained, brownish-buff carbonatite cut by fine-grained grey carbonatite traversed by narrow white fractures. The wallrock is weakly magnetic, and both types show slow reaction to cold dilute HCl, and purplish stain for Fe-dolomite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly Fe-dolomite?)	80%
Apatite	15%
Magnetite	2%
Pyrite	2%
REE minerals (pyrochlore?)	<1%
Limonite (goethite?)	<1%

This sample consists, as described, of somewhat coarser-grained carbonate with disseminated apatite, minor magnetite and pyrite, partly oxidized to limonite along the contact with a cross-cutting dikelet of finer-grained carbonate containing minor very fine-grained pyrite but no magnetite.

In the coarser-grained wallrock, carbonate typically forms somewhat rounded subhedral crystals <0.5 mm in diameter, mostly cloudy and brownish but locally clear, suggestive of mostly Fe-dolomite (ankerite?) or locally dolomite. Apatite forms stubby euhedral but ragged (corroded?) prisms mostly <0.25 mm long, commonly in small clusters up to about 0.5 mm across that are associated with magnetite, pyrite, vugs, limonite and possible REE minerals (?).

Magnetite forms sub/euhedral crystals up to about 0.5 mm in diameter that are typically fractured, and may be associated with pyrite as subhedra of similar size, or with what may be REE minerals as broken, highly fractured subhedra to 0.3 mm that have virtually the same R-value as magnetite but are in part (especially near rims) weakly but distinctly anisotropic, and are in part (at cores) red-brown, transparent but isotropic. These characteristics suggest cores of pyrochlore and rims of an unidentified REE mineral. The pyrite appears to be locally partly oxidized (?) to deep red-brown or opaque limonite (?) although with the possible REE minerals present, and the depth of the sample, this seems rather unlikely.

In the fine-grained portion (dikelet), carbonate forms tightly interlocking subhedra mostly <50 um in diameter (also likely mostly Fe-dolomite or dolomite), with accessory interstitial pyrite as cubic crystals mostly <35 um in diameter.

In summary, this represents medium-grained, Fe-dolomite carbonatite with significant apatite associated with small vugs and accessory magnetite, pyrite, and possible REE minerals (mainly pyrochlore, minor unidentified?) or locally limonite (?), cut by fine-grained, also likely Fe-dolomite carbonatite with only minor pyrite.

EC08-006 28.05: CALCITE CARBONATITE WITH COARSE BLASTIC PHLOGOPITE-MINOR APATITE-MAGNETIET-PYRITE-AMPHIBOLE-CORDIERITE?-SPHENE-REE MINERALS

Described as siliceous carbonatite with coarse crystals of phlogopite to 2 cm forming 25-30% of this calcite carbonatite (also containing apatite, pyrite, arfvedsonite, high TiO2, P2O5, Sr=3700 ppm, combined REE=1866 ppm); hand specimen shows coarse bladed dark mica crystals with random orientations in grey-white matrix of calcite, minor amphibole and pyrite. The rock is magnetic, shows strong reaction to cold dilute HCl, and red stain for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite?)	55%
Biotite/phlogopite	30%
Apatite	5%
Magnetite	3%
Pyrite	3%
Amphibole (Na-bearing?)	1-2%
Cordierite (?) mostly within large mica crystals	1-2%
Sphene	<1%
REE minerals (bastnaesite?)	<1%

This sample consists, as described, of very large blastic crystals of biotite/phlogopite (smaller examples are strongly recrystallized to secondary biotite/phlogopite, apatite, magnetite; larger ones are veined by pyrite or magnetite), plus local smaller blue-green amphibole, in a matrix of calcite.

Carbonate forms mostly rounded, sub/anhedral interlocking crystals up to almost 3 mm in diameter, likely mostly calcite to judge by the reaction in hand specimen and red stain in the etched offcut. The carbonate tends to be finer-grained in contact with the mica crystals, or where apparently replacing the smaller mica crystals. Apatite, forming euhedral prismatic crystals up to 1.3 mm long commonly with rounded minute (sub-microscopic) inclusions, is also most common in and around the mica (and in places magnetite) crystals.

The largest mica crystals, up to almost 2 cm in diameter with random orientations, and contain significant inclusions of an unidentified mineral (possibly cordierite?), apatite and locally carbonate as sub/euhedral crystals up to 1 mm long aligned along the cleavages, suggestive of blastic growth. The mineral tentatively identified as cordierite forms rounded to possibly pseudohexagonal colorless crystals up to 1.2 mm with first-order white birefringence, relief negative compared to carbonate, large (+) 2V, local cleavage partly altered to chlorite or serpentine. Colour of the mica porphyroblasts varies from cores of medium/blackish brown (the opacity due to abundant sub-microscopic needle-like opaques aligned with the cleavage) to paler greenish-brown at rims; it may be biotite or more likely phlogopite. The smaller mica crystals mostly <3 mm in size are strongly recrystallized or altered to fine-grained secondary biotite/phlogopite as matted randomly oriented subhedral flakes <0.1 mm in size, mixed with lesser similar sized carbonate, apatite and magnetite (note: these might represent altered amphibole crystals; see below).

Relict amphibole crystals have ragged subhedral outlines up to 2 mm long, mainly replaced by fine-grained blue-green amphibole, local carbonate, apatite, secondary biotite/phlogopite and magnetite as for smaller mica (?) crystals. Lack of blue or purple pleochroism and length-slow character suggest a lower Na content than in typical arfvedsonite.

Pyrite occurs mainly as euhedral crystals <1 mm in diameter along veins mostly <1 mm thick crossing the slide, locally associated with (or possibly replacing?) magnetite as somewhat elongated sub/euhedra up to 1 mm long. In places the magnetite is partly coated by small sub/euhedral crystals of sphene (?) mostly <0.1 mm long (which would explain the high TiO2). Along the line of the pyrite veinlets, minor red-brown REE mineral (possibly bastnaesite?) forms sub/euhedra mostly <50 um in size.

In summary, this is coarse calcite carbonatite with significant large blastic biotite/phlogopite, minor partly recrystallized soda amphibole, apatite, possible cordierite?, magnetite, pyrite, sphene and traces of REE mineral (bastnaesite?).

EC08-006 65.6: SERPENTINE-CARBONATE ALTERED RELICT OLIVINE (?)-MAGNETITE-APATITE-MINOR REE MINERAL ULTRAMAFIC CUMULATE (?)

Described as brecciated magnetite cumulate with high Nb (7200 ppm); hand specimen shows dark greenish black medium-grained magnetite rich rock. The rock is intensely magnetic, shows only slow, minor reaction to cold dilute HCl, and no visible stain for carbonate species in the etched offcut. Modal mineralogy in polished thin section is approximately:

Magnetite	30%
Serpentine (after olivine?)	30%
Carbonate (minor dolomite, mainly magnesite?)	30%
Apatite	7%
REE mineral (bastnaesite?)	2%
Galena (?)	trace

This sample consists of coarse euhedral magnetite and accessory apatite as clots and separate crystals locally associated with minor clear carbonate and significant REE mineral, in a matrix of serpentine-fine grained magnesium carbonate (possibly after original olivine).

Magnetite occurs as large, somewhat rounded sub/euhedra up to 4 mm in diameter (locally in crude aggregates to 7 mm) generally associated with apatite (stubby prismatic euhedra up to 0.5 mm long, somewhat aligned around the magnetite concentrations) and relatively coarse, clear carbonate (sub/euhedral crystals up to 1 mm in diameter that could be dolomite?).

The matrix to magnetite consists of aggregates of serpentine and slightly lesser carbonate, with rounded to subhedral outlines up to about 3 mm across that are suggestive of former olivine (?) crystals. Serpentine typically occurs as more or less randomly or locally reticulate oriented, euhedral flakes up to 0.5 mm in diameter with pale yellowish-green colour and length-slow character (antigorite/). Carbonate forms fine-grained (<30 um) ragged subhedral brownish crystals that are however generally optically continuous for up to 1 mm, similar to the carbonate around the magnetite. Lack of reaction to HCl in hand specimen, and lack of stain in etched offcut, suggest it could be magnesite (?) as suggested by an ultramafic precursor rock. Minor secondary magnetite forms minute subhedra <0.1 mm in size within the presumed olivine relics.

The REE minerals are generally closely associated with the magnetite, forming sub/euhedral crystals up to 0.5 mm across with dark brown or red-brown colour (mainly anisotropic in transmitted light), suggestive of bastnaesite (?). In reflected light, the REE mineral aggregates have distinctly lower R-value than adjacent magnetite, and appear to be sensibly isotropic except on a small scale and around the margins, where anisotropism of small fibrous crystals <25 um long is visible at very high magnification. Rare traces of sulfide (possibly galena, <15 um in size) are locally included in the REE minerals.

In summary, this appears to represent strongly serpentine-Mg carbonate altered, possibly relict olivine-magnetite-apatite rich cumulate ultramafic rock, with minor but significant REE mineral (possibly bastnaesite?) associated with the magnetite, and containing traces of possible galena (?).

EC08-006 100.24: FINE-GRAINED DOLOMITIC CARBONATITE WITH ZONES OF COARSE CALCITE-APATITE-REE MINERAL-PHLOGOPITE-PYRITE-EPIDOTE?-CORDIERITE?-CHLORITE

Described as yellowish fine-grained magnesio carbonatite with 15% apatite and disseminated magnetite; hand specimen shows grey-white carbonatite with disseminated dark minerals (oxides, sulfides). The rock is almost non-magnetic, shows slow but steady reaction to cold dilute HCl, and mainly faint purplish (rare local red) stain for dolomite and local calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite, minor Fe-dolomite?)	75%
(calcite?)	5%
Apatite	10%
REE mineral (mainly columbite-tantalite, ± pyrochlore, bastnaesite?)	2%
Phlogopite	1%
Pyrite	1%
Epidote	<1%
Cordierite (?)	<1%
Unidentified (Mg-chlorite?)	<1%
Chlorite (after epidote, cordierite?)	trace

This sample consists of mainly fine-grained carbonate, with local clotty concentrations of coarse, relatively clear carbonate, apatite, REE mineral(s) locally mixed with an unidentified mineral, plus phlogopite, local pyrite, possible epidote and cordierite (?).

The bulk of the sample consists of carbonate in the <50 um to locally 0.2 mm size range, likely mostly dolomite or lesser Fe-dolomite to judge by the lack of stain or minor purplish stain in the etched offcut. This carbonate is commonly cut by irregular, anastamosing veins or veinlets up to 3 mm thick of much coarser, somewhat clearer carbonate as interlocking subhedra up to 3 mm in diameter that grade in places to clots of similar carbonate (some of which stain red in the offcut, indicative of calcite).

Apatite is found throughout the sample, forming somewhat broken, corroded looking but mainly euhedral prismatic crystals up to 2 mm long, but it is commonly concentrated near the coarser carbonate veins and clots, where it too appears to be commonly recrystallized (to irregular sub-domains <0.5 mm in size).

Phlogopite occurs as scattered, pale brown subhedral or rounded flakes up to 0.5 mm concentrated with the apatite and recrystallized carbonate.

Most of the pyrite (subhedra <0.5 mm in elongated aggregates up to 2 mm long) and much of the REE mineral are also associated with these coarser carbonate-apatite recrystallized zones. The REE mineral typically occurs as mainly opaque or less commonly semi-opaque to dark red-brown, rarely yellow-brown, isotropic (rarely anisotropic), subhedral crystals <0.2 mm in size but in aggregates with sub/euhedral outlines up to 2 mm long. The main opaque mineral is anisotropic in reflected light, suggestive of mainly columbite-tantalite (?); there may be minor pyrochlore (?) (rare bastnaesite?). These minerals are in places intergrown with an unidentified mineral forming colourless, bladed euhedral lath-like crystals <0.1 mm long with weak first-order orange-yellow, but length-fast, birefringence (could be Mg-rich chlorite with F:M around 0.2-0.3?). Rarely, minor pale yellow mineral forming euhedra to almost 1 mm long is suggestive of epidote (?), apparently partly altered to what may be cordierite (?) as rounded sub-hexagonal crystals <0.25 mm with chloritic alteration along partings (the possible epidote also shows alteration to chlorite around its margins).

In summary, this appears to represent fine-grained dolomitic (or Fe-dolomitic) carbonatite altered and recrystallized along vein-like zones to coarse, locally calcitic, carbonate, apatite and minor phlogopite, pyrite and possible epidote (±cordierite, chlorite?), associated with REE minerals that may include columbite-tantalite (?), pyrochlore (?) and bastnaesite (?) locally intergrown with Mg-chlorite (?).

EC08-007 39.46: BANDED PHLOGOPITE-NA AMPHIBOLE-CARBONATE ULTRAMAFIC ROCK WITH VEIN ZONES OF CARBONATE-MINOR PYRITE±CHALCOPYRITE-REE MINERALS

Described as altered glimmerite (blue amphibole, possibly magnesio-riebeckite, in fine-grained phlogopite, not assayed); hand specimen shows bluish-grey and brown, vaguely layered/banded rock with minor clotty pyrite, local white carbonate streaks. The rock is locally slightly magnetic, shows only slow reaction to cold dilute HCl, but reddish/purplish stain for calcite/Fe-dolomite or dolomite in the carbonate streaks in etched offcut. Modal mineralogy in polished thin section is approximately:

Phlogopite	40%
Amphibole (possibly "abnormal glaucophane")	35%
Carbonate (mainly (Fe-) dolomite, local calcite?)	20%
Pyrite	1-2%
Chalcopyrite	<1%
REE mineral (bastnaesite?)	<1%

This sample consists mainly of intimately intermixed phlogopite mica and blue-green amphibole in vaguely banded/layered zones up to about 1 or 2 cm thick, separated by vein-like zones <1 cm thick both parallel to and sub-perpendicular to layering, with abundant fine-or coarse-grained carbonate and minor pyrite, trace REE minerals.

In the mica-rich layers, phlogopite forms mainly randomly oriented, matted flakes <0.2 mm in diameter with pale brown pleochroism. The flakes are typically almost massive where most concentrated, but elsewhere are generally mixed with variable amounts of very fine-grained, interstitial carbonate as sub/euhedra <0.1 mm in size, or interspersed with coarser amphibole as ragged subhedra to 1.5 mm.

In the amphibole-rich layers, amphibole forms more or less randomly oriented irregular subhedral to rarely euhedral crystals with ragged terminations, up to about 2 mm long. Pleochroism in shades of bluish green, bluish purple, and length-slow extinction (~22 degrees) indicates it is not likely riebeckite or arfvedsonite, but some other Na-amphibole (could be so-called "abnormal glaucophane, which has Z^c around 22 degrees and bluish green pleochroism). The amphibole is typically intergrown with interstitial phlogopite and lesser carbonate both mostly <0.5 mm in size.

Carbonate in the vein-like zones forms somewhat rounded subhedra mainly either <0.1 mm, or up to about 1 mm, and may be mostly dolomite, or could locally include clear calcite, especially in the coarse-grained portions. Ragged amphibole and phlogopite inclusions in the fine-grained carbonate and along the margins of the coarse carbonate are mostly <0.75 mm in size. Some amphibole crystals in the latter are distinctly blue-purple and length-fast and may be arfvedsonite (?); they locally appear to surround or rim the blue-green amphibole (glaucophane?).

Pyrite occurs mostly as sub/euhedral crystals up to 1 mm in size (aggregates to 2 mm) locally with atoll texture, or inclusions of chalcopyrite up to 0.5 mm. Minor REE minerals found within the carbonate zones, associated with the pyrite, are mostly subhedra <0.1 mm (aggregates to 0.2 mm) with blades habit, bright red-brown colour and distinct anisotropism, suggestive of bastnaesite (?) although locally there are semi-opaque crystals suggestive of columbite/tantalite or pyrochlore (?) in clusters <0.1 mm across.

In summary, this appears to be banded/layered ultramafic rock composed mainly of phlogopite, blue-green (sodic) amphibole, and carbonate (possibly mostly dolomite or locally coarse calcite?) in vein-like zones with minor pyrite, chalcopyrite, and trace REE mineral (bastnaesite?).

EC08-008 46.23: BRECCIA: CLASTS OF CALCITE IN MATRIX OF CALCITE-FE DOLOMITE-APATITE-REE MINERALS-AMPHIBOLE-QUARTZ-PYRITE-PYRRHOTITE-PHLOGOPITE

Described as medium-grained pink calcite carbonatite clasts in agglomerate (~2300 ppm combined REE); hand specimen shows subrounded pink calcite clasts up to 3 cm diameter in a grey, finer-grained matrix with minor dark (sulfide, oxide) minerals. The rock is locally slightly magnetic, shows major, intense reaction to cold dilute HCl in the clasts but less in the matrix, and strong red stain for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite?)	75%
(Fe-dolomite?)	10%
Apatite	10%
REE minerals (columbite/tantalite, pyrochlore, bastnaesite?)	2-3%
Amphibole (tremolite?)	1%
Quartz (secondary)	1%
Pyrite, trace pyrrhotite	<1%
Phlogopite/biotite	<1%

This sample consist, as described in the field, of clasts of coarse-grained calcite in a finer-grained (comminuted) matrix of calcite and/or dolomite, with significant apatite and accessory opaque oxides (partly REE minerals), amphibole, quartz, minor sulfides and mica.

In the clasts, carbonate (likely mainly calcite) forms interlocking rounded subhedra up to 2.5 mm in diameter. Small patches of finer-grained carbonate, commonly with minor opaque oxides, included within the clasts may be expressions of the matrix cut by the two-dimensional surface of the polished section.

In the matrix, carbonate (possibly calcite and locally dolomite or Fe-dolomite, as suggested by total FeO around 7% and MgO around 5%, the somewhat slower reaction to HCl in hand specimen, and possibly purplish colour in etched offcut) generally forms subrounded clast-like subhedra <0.5 mm that are clear (likely calcite, comminuted from the clasts) amidst 10-50 um sized brownish carbonate that could be either comminuted calcite or partly dolomite/Fe dolomite (?). Contributing to the dark colour of the finer-grained portion of the matrix are microscopic to sub-microscopic opaques, mostly oxides of uncertain composition (see below).

Apatite forming somewhat rounded, subhedral stubby prismatic crystals up to 0.5 mm long is common in the matrix, but perhaps not as abundant as the ~4.6% P2O5 would suggest. Minor colourless amphibole (subhedra <0.1 mm with extinction angle around 15 degrees; likely tremolite?) and quartz (rounded subhedra mostly <0.2 mm) are also locally present in the matrix.

Oxides occur in both aggregates with sub/euhedral, cubic to rectangular outlines up to 2 mm long, and as very finely disseminated material interstitial to carbonate and apatite in the matrix. In the aggregates with cubic shapes, possible REE minerals forming rounded subhedral crystals mostly <40 um in size are either opaque or very dark red- to yellowish brown and anisotropic in transmitted light, suggestive of bastnaesite (?) or are opaque with distinct anisotropism, suggestive of columbite-tantalite (?). The elongated aggregates consist of euhedral <0.1 mm isotropic opaques, suggestive of pyrochlore (?) and are partly replaced by pyrite and minor pyrrhotite, which form mostly euhedral crystals <0.1 mm (pyrite also forms subhedra to 1 mm elsewhere). Rarely, minor dark brown biotite (or radiation-damaged phlogopite?) forms euhedral flakes to 0.1 mm rimming the oxides/sulfides.

In summary, this appears to represent breccia composed of subrounded clasts of calcite in a matrix of finer calcite, Fe-dolomite, apatite, minor amphibole and quartz, with significant REE minerals (possibly bastnaesite, columbite/tantalite, pyrochlore?) and minor pyrite/pyrrhotite, trace phlogopite/biotite.

EC08-009 213.25: PLAGIOCLASE-CARBONATE-CHLORITE-APATITE-ILMENITE-MINOR PYRITE-CHALCOPYRITE-ILMENOMAGNETITE-ALLANITE?-REE MINERAL ROCK

Described as unusual cumulate rock with abundant chlorite, phlogopite and unknown oxide (18% SiO_2, 7% Al_2O_3, 16% total FeO, 9% MgO, 3% TiO_2, 4% P_2O_5, but only 1500 ppm combined REE); hand specimen shows dark grey, medium-grained mafic/ultramafic rock with abundant dark oxides. The rock is locally weakly magnetic, shows moderately strong but slow reaction to cold dilute HCl, and weak purplish stain for Fe-dolomite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Plagioclase (andesine?)	25%V
Chlorite (2 varieties)	20%
Phlogopite (partly chloritized)	10%
Apatite	10%
Ilmenite	7%
Pyrite, minor chalcopyrite	1%
Magnetite	1%
Allanite (?), minor REE minerals	1%

This sample consists of clotty aggregates of phlogopite ((largely chloritized), apatite and fine-grained Fe-Ti oxides plus local allanite?-sulfides, in a matrix of fine-grained carbonate-plagioclase-chlorite.

In the aggregates, which make up perhaps 20-25% of the sample, coarse bladed euhedral to subhedral phlogopite (with ragged terminations) is up to almost 3 mm in diameter, with pale brown pleochroism, generally partly interleaved to almost wholly altered by pale green but virtually non-pleochroic chlorite pseudomorphing it. The chlorite, which forms mainly euhedral flakes to 1.5 mm, has near-zero to weakly anomalous green, length-fast birefringence suggestive of F:M around 0.4-0.5 (?) except for minor amounts of brownish green, Fe-rich chlorite as aggregates to 0.2 mm of random matted <25 um flakes with length-slow, anomalous blue-grey birefringence (F:M ~0.6?). Apatite forms slender euhedral but somewhat fractured prismatic crystals up to 1 mm long. Oxides appear to be mostly ilmenite, forming aggregates up to 0.5 cm across composed of tabular subhedra commonly <0.1 but locally up to 0.5 mm in diameter, in places mixed with a little magnetite or ilmeno-magnetite (?) as subhedra to 0.2 mm, pyrite and lesser chalcopyrite as subhedra <0.2 mm, and in places what is tentatively identified as allanite (?) as ragged sub/euhedra up to almost 1 mm long, with brownish pleochroism and low (partly metamict?) birefringence, surrounded by dark pleochroic haloes in adjacent mica, and containing minute inclusions of sulfide (mainly pyrite, irregular sub/anhedra <70 um in size). The allanite may be the source of some of the REE found in this sample (?), although there are also local minute (<35 um) low-R phases with red-brown colour present that could be bastnaesite and/or pyrochlore (?).

In the matrix, plagioclase forming ragged subhedra mostly <0.5 mm in size, with poorly developed twinning showing ~15 degree extinction on 010 (no magmatic zoning preserved) possibly suggestive of an intermediate composition around andesine, An30 (likely secondary, due to metamorphism?). Carbonate forms mostly subhedral crystals <0.25 mm in diameter that could be Fe-dolomite to judge by the slower reaction in hand specimen and purple stain in etched offcut. Chlorite (possibly mostly after former phlogopite?) forms sub/euhedral flakes mainly <0.2 mm in size with similar optical properties and F:M as described above except for aggregates of the more Fe-rich chlorite. Apatite similar to that described above also occurs in the matrix, adjacent to the clots.

In summary, this is an ultrabasic rock (SiO_2<18%) composed of plagioclase-carbonate-chlorite with significant clotty concentrations of phlogopite (partly chloritized)-apatite-ilmenite-minor ilmeno-magnetite, pyrite-chalcopyrite, possible allanite (?) and traces of REE minerals.

EC08-011 111.48: MULTIPLE BRECCIATED, CARBONATE-FLUORITE-APATITE-MINOR BIOTITE/PHLOGOPITE-PYRRHOTITE±PYRITE, ALLANITE?-REE MINERAL-QUARTZ ROCK

Described as brecciated fluorite with magnesio-carbonate infill (MgO 14%, Fe2O3 6%, CaO 332%, P2O5 5.4%, 1500 ppm combined REE); hand specimen shows purple fluorite cut and brecciated by grey carbonate. The rock is locally weakly magnetic, shows only slow reaction to cold dilute HCl, and no stain for carbonate in the etched offcut (although confusing due to purple fluorite). Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite?)	45%
Fluorite	30%
Apatite	15%
Biotite/phlogopite	5%
Pyrrhotite, minor pyrite	2%
Allanite (?)	1%
REE minerals (columbite-tantalite, pyrochlore?)	1%
Quartz (secondary?)	1%

This sample consists of what appears to be fluorite matrix infilling and surrounding small clasts of carbonate or in places apatite, subsequently cut by finer-grained carbonate-minor apatite-phlogopite-minor pyrite-REE mineral-possible allanite (?) as scattered small to large euhedral crystals.

The fluorite matrix consists of fine-grained sub/anhedral purple crystals mainly <0.1-0.2 mm in diameter, containing inclusions of carbonate mostly either <20 um or up to ~1 mm in diameter and thus appearing to be an infilling between brecciated carbonate. However, this fluorite-carbonate mixture is also cut by veinlets of fine-grained brownish carbonate (mixed with a little phlogopite mica) suggesting a later stage of carbonate-mica brecciation and infilling, as seen on a macro-scale in hand specimen. The carbonate clasts are relatively clear but have apparently high relief compared to that expected for calcite, suggesting (with slow reaction to HCl in hand specimen, and lack of stain in etched offcut) that it may be mostly dolomite, and the later veinlet carbonate may be mostly Fe-dolomite (?).

Apatite occurs as stubby, subhedral to rounded crystals up to 0.5 mm in diameter, locally in aggregates to 1.5 mm, mostly intergrown with fluorite or in the fluorite-rich section of the rock.

In the carbonate-rich section of the sample, carbonate (mainly dolomite?) forming interlocking subhedra up to 0.35 mm is intergrown with minor biotite/phlogopite as subhedral dark brown flakes mostly <0.15 mm in size, associated with accessory pyrrhotite (sub/euhedral crystals mostly <0.2 mm) and a little quartz (subhedra <0.15 mm).

Possible REE minerals are found in both fluorite- and carbonate-rich portions of the sample, forming small cubic or rectangular euhedra up to about 0.5 mm in diameter with opaque cores (possibly columbite-tantalite; weakly anisotropic and with higher R-value than dark brownish (also anisotropic) rims suggestive of pyrochlore (?) since they are isotropic in transmitted light, although they seem transitional to larger (up to 2.5 mm) euhedral, zoned pale to dark brownish crystals tentatively identified as allanite (?) on the basis of their high birefringence; they contain abundant inclusions of, or are altered at the core to, carbonate (and minor apatite). However, SEM analysis would be needed to identify these phases.

In summary, this appears to be multiple brecciated, carbonate-fluorite-apatite-minor biotite-phlogopite-pyrrhotite ±pyrite, quartz, possible allanite-REE mineral bearing rock.

EC08-014 25.24: BANDED FLUORITE-DOLOMITIC CARBONATE RICH ROCK WITH TRACES OF REE MINERAL?-PYRITE

Described as well-banded fluorite in magnesio-carbonatite (5% Fe_2O_3, 13% MgO, 39% CaO, and 5.66% P_2O_5, 2900 ppm combined REE); hand specimen shows thinly banded fluorite and beige/white carbonate. The rock is not magnetic, shows slow reaction to cold dilute HCl, and weak purplish stain for Fe-dolomite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite?)	60%
(Fe-dolomite, i.e. ankerite?)	15%
Fluorite	~25%
Opaque (partly REE minerals?)	<1%
Pyrite	trace

This sample consists of thinly banded, interlaminated fluorite and carbonate (the latter both clear and brownish) with only traces of opaque material (mainly along stylolitic-looking partings along banding in carbonate) and sulfide.

Carbonate occurs in bands up to about 0.5 cm thick that vary from almost clear (composed of interlocking subhedra mostly <0.5 mm in diameter that show faint purplish stain in etched offcut and so may be Fe-poor dolomite) to distinctly brown (the crystals are finer, in the <20 um to 0.15 mm range, commonly curving with antitaxial texture within the band, and coloured by minute to sub-microscopic inclusions that may be partly fluid, mostly <5 um in size, and partly opaque, rarely up to 15 um in size). This carbonate shows very faint, purplish to pinkish stain in the etched offcut and may be mostly dolomite (?). The coarser bands locally show vugs that are partly filled with fluorite.

Fluorite forms mainly subhedral crystals up to about 0.5 mm in diameter, with pale purple colouring irregularly distributed, mainly in the cores of the crystals. It appears to have invaded the carbonate (this could be merely a metamorphic feature) and commonly contains small to minute inclusions of carbonate within it.

In spite of the whole-rock value of nearly 6% P_2O_5 recorded in the Excel table, there is no apatite visible in the section. Perhaps the sample is not representative of the entire assayed interval, because it is difficult to see where all that phosphorus could fit into this sample as sectioned.

Opaque matter, mainly concentrated in the brownish carbonate, is very fine-grained (fibrous subhedra <20 um long) to amorphous in nature, with common botryoidal texture and dark brown to yellowish brown character. Some of it may be synchesite (?) to judge by the colour and anisotropic character, but it is too fine-grained to identify properly. Traces of pyrite are locally included within the mineral as subhedra <5 um in size, or occurs separately as aggregates of sub/anhedra <0.1 mm in size.

In summary, this is, as described in the field, a banded fluorite-dolomitic carbonate rich rock with traces of opaques (possibly REE minerals) and pyrite.

EC08-014 28.69: BRECCIA OF DOLOMITIC CARBONATITE CLASTS (WITH APATITE, YELLOW-BROWN REE MINERAL?) IN FOLIATED MATRIX OF FE-DOLOMITE WITH PHLOGOPITE, APATITE, ACCESSORY PYRITE AND MINOR REE-MINERAL?

Described as unusual spotted clast in magnesio-carbonatite breccia (5% Fe_2O_3, 14% MgO, 32% CaO, and 4.37% P_2O_5, 3000 ppm combined REE); hand specimen shows brecciated greenish beige/white carbonate. The rock is not magnetic, shows very slow reaction to cold dilute HCl, and rare faint purplish (or rare reddish) stain for Fe-dolomite (or rare calcite) in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite?)	70%
(calcite?)	5%
Apatite	10%
Phlogopite	10%
REE mineral (unidentified, minor synchesite?)	5%
Pyrite	1-2%

This sample consists of a large (2-3 cm diameter) clast of carbonate, apatite and possible REE mineral(s) plus rare pyrite, in a weakly foliated matrix of carbonate, phlogopite, less apatite and more common pyrite but with less common or less obvious REE minerals.

In the clast, carbonate (likely dolomite?) forming ragged irregular subhedra mostly <0.5 mm in diameter is intergrown with abundant apatite as stubby to locally slender prismatic euhedra up to about 1 mm long that are commonly broken or fractured, and unusually abundant euhedral crystals of what may be REE minerals (?). These crystals have mostly euhedral, cubic or octahedral outlines up to 1.5 mm in diameter (they are the "spots" seen in the clast in hand specimen) and vary from almost opaque at cores to semi-opaque or even dark yellowish-brown (mainly at rims or where thinned). All phases however appear to be isotropic in both transmitted and reflected light and so if synchesite is present it must be minor. Thus the mainly unidentified mineral may be REE-bearing but would require SEM analysis to identify. Very minor pyrite is mostly <0.2 mm in diameter. Thin veinlets of similar composition to the matrix cut the clast.

In the matrix, carbonate (dolomite or Fe-dolomite mostly forming interlocked, somewhat flattened/elongated sub/anhedra mostly <0.1 mm in some layers/bands, but up to 0.25 mm in others), and in rare coarse lenses possibly calcite as subhedra to 0.5 mm, are interleaved with minor phlogopite (layers or seams <1.5 mm thick sub-parallel to foliation, composed of somewhat aligned pale brown flakes <0.2 mm in diameter) and some apatite (as described above). Pyrite forms subhedra up to almost 2 mm in diameter, locally associated with minor semi-opaque to dark yellowish-brown possible REE oxides with sub/euhedral cubic outlines up to 0.25 mm that are partly isotropic and partly anisotropic in both transmitted and reflected light; their identity is not certain, but could include minor synchesite (?).

In summary, this appears to represent breccia of "spotted" dolomite carbonatite clasts with significant apatite and yellow-brown possible REE mineral, in a somewhat foliated matrix of finer-grained, mostly dolomitic carbonate (minor local calcite?), with streaks or lenses of phlogopite and apatite, minor pyrite and traces of similar possible REE minerals.

EC08-014 64.65: MAINLY DOLOMITE-MINOR PHLOGOPITE-TRACE PYRITE-RARE REE MINERAL (LOCAL CALCITE) CLASTS OR PORPHYROBLASTS IN MATRIX OF FLUORITE

Described as magnesio-carbonatite with interstitial dark fluorite (4% Fe_2O_3, 17% MgO, 31% CaO, and 3.5% P_2O_5, 1800 ppm combined REE); hand specimen shows breccia of pale grey or locally white carbonate in matrix of dark purple fluorite. The rock is not magnetic, shows very slow reaction to cold dilute HCl in most clasts but intense reaction in white clasts, and faint purplish (or locally red) stain for Fe-dolomite (or locally calcite) in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite?)	55%
(calcite?)	15%
Fluorite	25%
Phlogopite	~5%
Pyrite	<1%
REE mineral (bastnaesite?)	trace

This sample consists mainly of angular clasts of carbonate (both dolomite and calcite)-minor phlogopite-trace pyrite, REE mineral in a matrix of purple fluorite.

The "clasts" (or possibly porphyroblasts?) have angular to possibly sub/euhedral (glomeratic) outlines up to about 2 cm in diameter, and consist of either slightly finer-grained, partly brownish dolomitic carbonate or (across a well-defined boundary, clearly visible in the etched offcut by different stains) relatively coarse-grained, brownish to clear calcite. The former occurs as zoned crystals from a central core of brown euhedra 1 mm surrounded by clear 1 mm euhedra, brownish fine-grained (<0.1 mm) subhedra, and a rim of clear 1-2 mm euhedra; the latter (calcite) occurs as somewhat elongate, sub-parallel aligned subhedra <1 mm long (oblique to the contact) with first pale brownish and then relatively clear character. In sum, the carbonate appears more likely to represent porphyroblastic growth (or recrystallization?) than clasts. Also, since there is a close relation between calcite and the matrix fluorite, it is possible that calcite was deposited late, at the time of the fluorite.

Fluorite occurs as somewhat rounded sub/euhedra up to about 5 mm in diameter with faint purple colour irregularly distributed in thin section, forming aggregates up to over 1 cm across. There are no other minerals within the fluorite matrix. As in the sample from 25.24, it is not clear what mineral hosts the 3.5% P_2O_5 in this sample.

Minor phlogopite forming sub/euhedral flakes with pale brown pleochroism mostly <0.5 mm in diameter, with random to locally aligned orientations, occurs mostly irregular clots or trails within the dolomitic portions of the sample only, apparently cut off by the fluorite matrix. Minor pyrite forming rounded sub/euhedra <0.3 mm in diameter is generally associated with the phlogopite, as are rare traces of red-brown possible REE mineral (possibly bastnaesite?) as minute sub/euhedra <20 um long.

In summary, this appears to represent breccia composed of carbonate (dolomite or Fe-dolomite, local calcite) clasts with minor phlogopite, trace pyrite and rare REE minerals, in a matrix of purple fluorite, but the "clasts" may actually reflect porphyroblastic growth of glomeratic carbonate.

EC08-014 74.9: BRECCIA OF LARGE ROUNDED CARBONATE AND SMALL PLAGIOCLASE CLASTS IN MATRIX OF CARBONATE-PHLOGOPITE-PLAGIOCLASE-MINOR APATITE-ILMENITE-SPHENE/MONAZITE?-REE MINERALS

Described as rounded magnesio-carbonatite clasts in a calcite carbonatite groundmass, with elongated grey quartz clasts full of black sulfide lapilli (?) (5% Fe_2O_3, 14% MgO, 23% CaO, 1.5% Na_2O, 2.3% K_2O and 2% P_2O_5, 1500 ppm combined REE); hand specimen shows breccia of large rounded pale greenish grey carbonate clasts and small, elongate dark grey quartz (?) rich clasts in matrix of grey fine-grained carbonate/mica. The rock is not magnetic, shows slow reaction to cold dilute HCl in large clasts and matrix, and faint purplish (locally pinkish) stain for Fe-dolomite in clasts and matrix in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly Fe-dolomite?)	65%
Plagioclase (andesine?)	15%
Phlogopite	15%
Apatite	2-3%
Ilmenite	1-2%
Sphene or monazite (?)	1%
REE minerals (columbite-tantalite, pyrochlore, bastnaesite?)	<1%
Pyrite	<1%

This sample consists of large rounded clasts of fine-grained granular carbonate (local minor pyrite) and smaller irregular clasts of plagioclase-rich rock in a matrix of fine-grained carbonate, phlogopite, apatite and accessory ilmenite, sphene/monazite?, REE minerals and trace pyrite.

In the large clasts, carbonate that is likely mostly Fe-dolomite to judge by the slow reaction to HCl and the weak purple stain in etched offcut, forms interlocking subhedra mostly in the 50-75 um size range. Locally, pyrite occurs as <0.5 mm aggregates of rounded subhedra mostly <0.2 mm.

In the small clasts, which have irregular outlines up to almost 1 cm long, plagioclase forms interlocking, very ragged to irregular (corroded?) lath-like crystals mostly <0.25 mm long. The composition is not directly determinable, but better crystallized examples in the adjacent matrix show twinning with extinction on 010 up to 15 degrees, which with the generally calcic composition of the rock suggests andesine, An30 (less likely albite, An5). Quartz is not identified in the sample.

In the matrix, carbonate forms either interlocking subhedra up to about 0.5 mm, or else fine-grained aggregates that appear similar to the clasts. This carbonate is also likely mostly Fe-dolomite. Phlogopite forms ragged to rounded subhedral flakes mostly <0.5 mm in diameter with pale brown pleochroism, and plagioclase forms subhedra mostly <0.25 mm that are quite unlike those in the feldspathic clasts (have likely been recrystallized). Apatite forms stubby prismatic euhedra up to 0.25 mm long in clusters up to 1.5 mm long.

The opaque mineral causing the dark colour of the matrix appears to be mainly ilmenite, forming very fine, tabular crystals mostly <30 um long with random orientations contained within plagioclase or carbonate crystals included in feldspathic clasts. In places there are also local concentrations of a high-relief, high birefringence mineral forming sub/euhedra <0.1 mm that could be sphene or possibly monazite (?). Sulfides are quite rare, principally within small clasts as aggregates to 0.1 mm of rounded subhedra mostly <50 um in size. REE minerals appear to be mostly aggregates up to 0.1 mm with euhedral outlines composed of bladed <65 um long columbite-tantalite (?) and minor isotropic pyrochlore, or in places fine-grained dark yellow/red-brown bastnaesite/synchesite (?) that are locally concentrated with apatite.

In summary, this appears to represent breccia of fine-grained large rounded clasts of dolomitic carbonate-trace pyrite and smaller clasts of plagioclase, in matrix of carbonate-phlogopite-plagioclase-minor apatite-ilmenite-sphene/monazite?-REE minerals.

EC08-014 169.81: BRECCIA: DOLOMITIC CLASTS/PORPHYROBLASTS IN MATRIX OF FLUORITE-CARBONATE-MINOR PYRITE-FLUOROCARBONATE REE MINERALS?

Described as fluorite filling in cataclastic textured magnesio-carbonatite with red areas in fluorite that are likely REE fluorocarbonate (6% Fe_2O_3, 17% MgO, 32% CaO, and 2.3% P_2O_5, 3000 ppm combined REE); hand specimen shows large rounded to small subhedral or rounded pale grey-white carbonate clasts or porphyroblasts (?) in matrix of purple-grey fine-grained fluorite/carbonate/mica. The rock is not magnetic, shows slow reaction to cold dilute HCl, and faint purplish stain for Fe-dolomite in large and small clasts (stronger in matrix, but possibly confused with fluorite?) in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly Fe-dolomite?)	75%
Fluorite	20%
Apatite	2-3%
Pyrite	2-3%
Fluorocarbonate REE minerals (unidentified, bastnaesite?)	<1%

This sample consists mainly of either large rounded or small sub/euhedral porphyroblastic crystals of carbonate in a partly vuggy matrix of fluorite, carbonate, local apatite, pyrite and minor REE fluoro-carbonate minerals (?). Carbonate throughout appears likely to be mostly Fe-dolomite rather than calcite, as indicated in field description.

Small clasts or porphyroblastic carbonate crystals show subhedral rectangular outlines up to 5 mm long composed of subhedral crystals mostly <1.5 mm in size but typically optically continuous for up to the entire size of the clast or porphyroblast. They tend to be clear compared to the carbonate in the matrix, which is brownish and forms interlocking sub/anhedra mostly <0.2 mm in size.

Large clasts have rounded to subrounded outlines up to 4-5 cm across and consist of either large subhedral to ragged carbonate (Fe-dolomite?) crystals up to1.5 mm long (with random orientations) or finer-grained, intervening crystals mostly <0.15 mm. It is not clear whether the pyrite is all associated with the matrix fluorite or if some actually occurs in these clasts.

In the matrix, which is locally vuggy (voids up to 3 mm across), fluorite forming subhedra mostly <0.5 mm in size, with local faint purple colour (mainly only strong near inclusions of reddish fluorocarbonate and/or REE minerals) is intergrown with carbonate as mostly fine-grained (<0.15 mm) tightly interlocking sub/anhedral crystals, and pyrite as subhedra up to 0.5 mm long. In places, the fluorite contains concentrations of fine-grained bright red-brown minerals that appear to include fluorocarbonate (?), with subhedral outlines mostly <25 um in size, mostly as red-brown coloured bastnaesite (?) or yellow-brownish, apparently isotropic (unidentified) REE mineral of similar size but aggregating to 0.2 mm. Apatite occurs locally as aggregates up to several mm across composed of interlocking, more or less randomly oriented, ragged irregular lath-like or subhedral prisms up to 1 mm long.

In summary, this is confirmed as breccia composed of coarse rounded clasts or small subhedral porphyroblasts of carbonate (Fe-dolomite?) in vuggy matrix of purple fluorite, fine-grained carbonate, minor apatite, pyrite and local concentrations of fluorocarbonate? REE mineral(s).

EC08-015 49.54: DOLOMITIC CARBONATITE WITH MINOR APATITE-PYRITE, CUT BY VEINS OF CARBONATE-FLUORITE-VUGS-PHLOGOPITE/CHLORITE-REE MINERALS?

Described as dolomitic carbonatite with late-stage hydrothermal veins containing fluorite, dolomite, hydrocarbon and possible REE fluorocarbonate (no whole rock or REE assay data available); hand specimen shows pale grey-white carbonate cut by narrow dark veinlets of pyrite and unidentified black minerals, or red-brown/yellow-brown, possible REE minerals. The rock is not magnetic except near the dark veinlets, shows slow reaction to cold dilute HCl, and faint local purplish stain for Fe-dolomite throughout the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite, minor ankerite?)	85%
Apatite	3%
Vugs/voids	2%
Fluorite (veins only)	2%
Phlogopite	2%
Fluorocarbonate (?bastnaesite/synchesite?)	2%
REE mineral (unidentified, pyrochlore?)s	2%
Pyrite, trace chalcopyrite	1%

This sample is composed of coarse-grained carbonate, with local minor apatite, cut by narrow mostly planar, locally vuggy veinlets of carbonate, chloritized phlogopite, fluorite, possible fluorocarbonate (?) and possible REE minerals of uncertain identity plus traces of pyrite.

In most of the slide, carbonate (mainly dolomite to judge by the slow reaction in hand specimen and very faint purplish stain in etched offcut) forms interlocking somewhat rounded to ragged subhedra up to about 2 mm in diameter, with random orientations, commonly containing small (<0.5 mm long) inclusions of apatite. Apatite is also concentrated in clotty aggregates up to 1.5 mm across, composed of stubby prismatic euhedra mostly <0.6 mm long, interstitial to the carbonate. Minor pyrite is locally associated with apatite, or concentrated along veinlet-like zones in the carbonate, and locally associated with minor REE-minerals forming sub-cubic crystals that are opaque and isotropic (could be pyrochlore?) or anisotropic and columnar (could be columbite-tantalite?), both partly rimmed by low-R, partly transparent phases. In some (linear) zones, carbonate is strongly Fe-stained and so is likely Fe-dolomite (ankerite).

In the veins, which are mostly planar and <1 mm thick, but locally expand at intersections to patches or areas up to almost 1 cm across, carbonate forms interlocking subhedra mostly <1 mm in size (basically recrystallized from the wallrock), with local vugs of similar size. Dark minerals within the veins are mostly phlogopite that is largely only remnant cores surrounded by chloritized zones. The phlogopite originally formed subhedral flakes to 0.6 mm in diameter with very pale brownish pleochroism, and is replaced by chlorite with pale green colour as minute flakes mostly <60 um in diameter with radiating or random orientations and mostly length-fast, grey anomalous birefringence suggestive of F:M around 0.4 (?). Fluorite occurs as rounded sub/euhedral crystals or botryoidal-textured aggregates up to 0.5 mm in size with local purple colour or rusty staining arranged in zonal fashion (the latter could in part be fluorocarbonate?). Adjacent bright rusty stained carbonate may be fluorocarbonate; both it and fluorite are mixed with phlogopite that is generally fresh (unchloritized). Possible REE minerals closely associated with the fluorite have mainly euhedral outlines up to 0.5 mm across, and are mostly dark yellow-brown to semi-opaque, with fine-grained internal structure and isotropic character (unidentified) or anisotropic character (suggestive of synchesite?) or locally dark red-brown, with coarser, fibrous structure and anisotropic, suggestive of bastnaesite (?).

In summary, this is dolomitic carbonatite with minor apatite and pyrite, partly recrystallized along (partly vuggy) veinlets of carbonate-fluorite-partly chloritized phlogopite-possible fluorocarbonate (?) REE mineral(s).

EC08-015 160.45: DOLOMITIC CARBONATITE CUT BY SIGNIFICANT REE MINERAL/REE FLUOROCARBONATE, MINOR PYRITE VEINLETS

Described as dolomite carbonatite with hydrothermal veins containing crystalline REE fluorocarbonates (no whole rock or REE assay data); hand specimen shows pale greenish grey-white to white, banded carbonatite cut by narrow purple-reddish veinlets oblique to banding. The rock is not magnetic, shows only slow reaction to cold dilute HCl, and only weak purple stain for Fe-dolomite in the etched offcut (the stain seems to be unevenly developed, i.e. weak near the center of the offcut and stronger around the margins). Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite/Fe-dolomite?)	90%
Fluorocarbonate REE mineral (bastnaesite?)	3-5%
(synchesite?)	3-5%
REE minerals (columbite-tantalite, pyrochlore?)	<1%
Pyrite	<1%

This sample consists almost entirely of carbonate, likely mainly dolomite or Fe-dolomite to judge by the reaction in hand specimen and the stain in etched offcut, with a somewhat banded/foliated structure caused by fine-grained carbonate in wispy zones wrapping around coarser-grained carbonate crystals. The carbonatite rock is cut by one major vein about 0.5 cm thick and other smaller, discontinuous, partly vuggy veinlets <0.25 mm thick along which significant fluorocarbonate(s) are developed, along with other partly opaque possible REE minerals and minor sulfides.

Fine-grained carbonate matrix generally consists of granular, interlocking sub/anhedra <0.2 mm in diameter. Coarse-grained carbonate generally forms somewhat flattened, elongated subhedra up to about 3 mm in long dimension (oriented sub-parallel, with length:width ratios in the 2:1 to rarely 3:1 range. Undulose extinction, sub-grain development and suturing of grain boundaries, particularly around the margins of these coarse crystals, plus the foliated nature of the fine-grained matrix, suggests that the banded/layered nature of this sample likely derives from deformation (i.e. is tectonic in origin). Minor pyrite occurs as euhedra to almost 1 mm within the carbonate, possibly associated with cryptic fluorocarbonate veinlets.

In the major vein, a large mass of bright yellow to yellow-brown, likely fluorocarbonate mineral is possibly synchesite (?) since although it is not distinctly anisotropic in transmitted light, it is an appropriate colour for this mineral. The aggregate is about 1 cm long, but consists in detail of relatively fine-grained, somewhat fibrous sub/euhedral crystals mostly <0.15 mm long with random orientations, and only local transparency. This mass contains local inclusions of pyrite (bladed-looking crystals of similar, 0.15 mm length to the synchesite (?), with crystal shape determined by the host mineral. Locally, there are also included masses of bright red-brown to partly opaque minerals that may represent bastnaesite (?) and pyrochlore (?) respectively. The large mass of red-brown mineral, of similar size to that of the synchesite (?), consists of strongly bladed, euhedral opaque mineral with distinct anisotropism in reflected light that could be columbite-tantalite (?), set in similar-sized fibrous crystals of bastnaesite that is transparent, red, and anisotropic.

In summary, this is confirmed as dolomitic carbonatite cut by significant veins of possible REE minerals and fluorocarbonate(s) (possibly including bastnaesite, synchesite and minor opaque pyrochlore, columbite-tantalite cores). Minor pyrite occurs both within the fluorocarbonate and partly within carbonate (possibly partly along cryptic vuggy veinlets that also contain REE minerals).

EC08-015 182.3: VAGUELY BANDED/LAYERED DOLOMITIC CARBONATITE WITH LENSY APATITE-REE MINERAL?-FLUORITE-PYRITE-PHLOGOPITE

Described as apatite cumulate (apatite is perhaps 50% of the rock) with cream coloured clasts (6% Fe_2O_3, 13% MgO, 37% CaO, and 12% P_2O_5, 4360 ppm combined REE); hand specimen shows vaguely defined, cream coloured clasts (?) containing pinkish-buff euhedral fluorocarbonate REE mineral crystals (?) and minor dark green/black mafic minerals (?) in finer-grained, grey matrix. The rock is not magnetic, shows slow reaction to cold dilute HCl, and only faint purplish stain for Fe-dolomite in the etched offcut (but this may be confused by the presence of fluorite). Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite?)	60%
Apatite	27%
REE mineral, possibly fluorocarbonate (?)	5-7%
Fluorite	3%
Pyrite	2%
Phlogopite	2%

This sample consists mainly of vaguely defined patches of apatite-REE mineral-sulfide rich rock, locally with significant fluorite or minor phlogopite, in a matrix of fine-grained carbonate-apatite.

In the matrix, carbonate (probably mostly dolomite or locally Fe-dolomite to judge by the slow reaction to HCl in hand specimen and the general lack of purple stain in the etched offcut) forms tightly interlocking, finely granular sub/anhedral crystals mostly <50 um (locally to 0.1 mm) in size, typically containing or mixed with significant apatite as small sub- to euhedral, stubby prisms mostly <0.2 mm (but up to 0.5 mm) long, with mainly random orientations. Minor amounts of possible REE minerals, pyrite and phlogopite are mainly associated with the apatite, grading to the vaguely defined patches of apatite and these minerals (described below).

In the apatite-rich patches, which have irregular outlines up to about 1.5 cm long by 2 mm thick and are generally aligned with a weakly developed foliation in the sample, apatite forms somewhat aligned, stubby prismatic euhedra mostly <0.25 (rarely to 0.65) mm long. Semi-opaque, possible REE minerals occur as aggregates up to almost 3 mm across of cubic/rectangular euhedra <2 mm in size typically with yellow-brown to reddish-brown internal reflections. Some grains are semi-transparent yellow to brownish, but appear to be isotropic under crossed polars (in both transmitted and reflected light), so may not be synchesite. However, the overall appearance in hand specimen suggests fluorocarbonate and fluorite is present, so possibly the section is simply too thick to see the transparent/anisotropic character of the mineral. Fluorite occurs in irregular shaped patches up to almost 1 cm long by 3 mm thick, along the same trend as the apatite patches and intergrown with them, also associated with the possible REE minerals. Pyrite is typically closely associated with the possible REE mineral, forming aggregates up to 2.5 mm long of euhedra <017 mm, generally aligned with the apatite patches and intergrown with the possible REE minerals and with local streaks of phlogopite forming subhedral pale brown flakes <0.25 mm in diameter.

In summary, this sample appears to represent dolomitic carbonatite with significant, somewhat banded/layered (possibly tectonic?) concentrations of apatite-REE minerals?-fluorite-pyrite-phlogopite. The identity of the possible REE mineral is not certain, but concentrations are significant and the crystals are well-formed and coarse-grained (readily visible with the naked eye).

EC08-016 12.76: BRECCIA: CLASTS OF PLAGIOCLASE-CARBONATE-PHLOGOPITE-ILMENITE IN MATRIX OF CARBONATE-APATITE-PYRITE-REE MINERAL?

Described as magnesio-carbonatite breccia with unusual grey rock type, groundmass high in apatite content (no whole-rock or REE assay data available); hand specimen shows pale greenish grey-white clasts (?) with rounded/irregular outlines up to at least 4 cm, and dark brownish grey, fine-grained clasts cut by a greenish grey matrix. The rock is locally very weakly magnetic, shows slow reaction to cold dilute HCl mainly in the pale coloured clasts and the matrix (not the grey clasts), and only faint purplish stain for Fe-dolomite in the etched offcut (except along narrow veinlets in both clast and matrix). Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite, minor Fe-dolomite?)	50%
Plagioclase (andesine or albite?)	25%
Phlogopite	10%
Apatite	10%
Pyrite	2%
REE mineral (columbite-tantalite in synchesite?)	1-2%
Ilmenite (clast only)	1-2%
Muscovite (?)	<1%

This sample consists essentially of one large and several small, grey clasts (plagioclase-carbonate-phlogopite with minute ilmenite) in carbonate-apatite-minor pyrite-REE mineral? matrix, both cut by narrow veinlets of carbonate-phlogopite-rare muscovite.

In the major (and to a lesser extent the minor) clasts, plagioclase forms feathery, irregular interlocking subhedra mostly <0.5 mm long with random orientations (locally in blastic crystals optically continuous for up to 1 mm). Twinning is vague except for a few crystals around the margins which have extinction on 010 up to about 15°, suggestive of either albite or andesine (no quartz to compare refractive indices with to make this choice). Carbonate intergrown with the plagioclase forms ragged subhedra mostly <0.25 mm in size, and is likely mostly dolomite to judge by the slow reaction to HCl in hand specimen and lack of purple stain in etched offcut, although the latter is difficult to evaluate given the dark colour of the clast, due to fine-grained phlogopite (0.25mm aggregates of subhedral <50 um medium brown pleochroic flakes) and minute opaques (mainly ilmenite as tabular sub/euhedra rarely over 40 um long). Although trace pyrite (subhedra <50 um) occurs in the clast, REE minerals appear to be absent.

In the matrix, carbonate forms interlocking sub/euhedra mostly <0.3 mm in diameter (but locally in clast-like coarse crystals or aggregates up to 2.5 mm across), likely mostly dolomite to judge by the slow reaction to HCl and lack of stain in etched offcut. It is intergrown with or contains abundant apatite as stubby euhedral prisms mostly <0.5 mm long (rarely up to 1 mm near veins). Apatite also occurs in irregular patches similar to those in the previous sample, containing or associated around the margins with significant opaque to partly semi-opaque (dark brown) possible REE minerals and pyrite. Pyrite forms aggregates up to 1.5 mm long of subhedra mostly <0.5 mm. The possible REE mineral occurs in euhedral aggregates with cubic to rectangular outlines up to 1.5 mm in diameter that are intergrowths of a higher R (light grey) phase that is strongly anisotropic in reflected light, with columnar euhedral habit (possibly columbite-tantalite, <0.2 mm long) and lower R (dark grey) semi-transparent, dark yellowish-brown phase that could be synchesite although they appear sensibly isotropic in transmitted light.

Veinlets <1 mm thick consist of central partings or carbonate (Fe-dolomite to judge by the purple stain in etched offcut) as subhedra <0.35 mm, with flanking selvages of dark brown phlogopite/biotite as subhedral flakes <0.25 mm and rare colourless muscovite as euhedral flakes to 0.2 mm, but are not associated with visible REE minerals.

In summary, this appears to be breccia (clasts of plagioclase-carbonate-phlogopite-ilmenite or locally carbonate) in matrix of dolomitic carbonatite with significant apatite, minor pyrite-REE mineral (columbite-tantalite in synchesite?), cut by veinlets of carbonate-phlogopite-rare muscovite.

EC08-016 111.93: BANDED/LAYERED COARSE/FINE DOLOMITIC CARBONATITE WITH VARIABLE APATITE, PYRITE, REE FLUOROCARBONATES, PHLOGOPITE, HEMATITE

Described as magnesio-carbonatite containing small red pin-head sized fluorocarbonate minerals (6% Fe_2O_3, 17% MgO, 31% CaO, and 3.5% P_2O_5, 1700 ppm combined REE); hand specimen shows buff-white coarse-grained, partly pyritic carbonatite and pale grey, fine-grained carbonatite with minute red possible REE minerals (unclear if either is clast or matrix). The rock is not magnetic, shows slow reaction to cold dilute HCl, and variable purplish stain for Fe-dolomite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (Fe-dolomite, dolomite?)	85%
Apatite	10%
Pyrite	2-3%
REE mineral (fluorocarbonate, bastnaesite/synchesite?)	1-2%
Phlogopite	<1%
Hematite (mainly earthy?)	<1%

This sample consists mainly of either relatively coarse-grained carbonate with significant apatite, minor pyrite, REE minerals and phlogopite, or fine-grained carbonate with minor very fine pyrite and earthy hematite. The pyrite is locally concentrated along carbonate veinlets <1 mm thick that cut across the boundary between the two rock types.

In the coarser-grained portion, carbonate (possibly Fe-dolomite or dolomite; hard to judge by the uneven faint purple staining in etched offcut) forms subhedral crystals mostly <1 mm long that are typically somewhat elongated/flattened into a plane of foliation sub-parallel to the contact between the two rock types. The coarser crystals are typically separated by anastamosing zones of interstitial, finer-grained (<0.25 mm) carbonate, commonly mixed with variable apatite as somewhat ragged, sub/euhedral stubby prisms <0.5 mm long. The apatite is locally concentrated in lensy zones up to 1 mm thick by several mm long, sub-parallel to the weakly developed foliation. Pyrite occurs as minute cubic crystals mostly <0.1 mm in size, associated with minor phlogopite as subhedral very pale brownish flakes <0.1 mm in diameter, in loosely defined aggregates with outlines up to 2 mm long that appear to pseudomorph some former mafic mineral (?). The REE mineral occurs in streaks along the foliation composed of minute (mainly <0.1 mm) bright red-brown sub/euhedra that are weakly anisotropic (bastnaesite?) associated with pyrite of similar size, or in larger aggregates with cubic or rhombohedral outlines up to2 mm across of dark yellow-brownish or opaque material that is only demonstrably anisotropic near thin edges, but has a lamellar/fibrous habit suggestive of synchesite (?).

In the finer-grained portion, carbonate (also likely Fe-dolomite or dolomite) forms interlocking, somewhat lath-like sub/euhedral crystals mostly <0.2 mm long, with long axes more or less aligned with the foliation and sub-parallel to the contact. Apatite is not apparent in this portion, but minor pyrite forms sub/euhedral crystals <0.1 mm in size, associated with similar-sized aggregates of red earthy hematite and locally possibly traces of red-brown REE mineral such as bastnaesite (?) that is difficult to distinguish from the hematite.

In summary, this appears to represent somewhat banded or layered, coarser-grained dolomitic carbonatite (with apatite, visible pyrite and REE mineral, trace phlogopite) in contact with finer-grained but also somewhat foliated, carbonate-minor minute pyrite-hematite-trace REE mineral.

EC08-018 145.98: CALCITE CARBONATITE WITH STREAKS/LENSES OF APATITE-PYRITE-PYRRHOTITE-MAGNETITE-PHLOGOPITE-REE MINERAL (FLUOROCARBONATE?)

Described as medium-grained white to light grey calcite carbonatite with yellow monazite (?) crystals (3% Fe_2O_3, 3% MgO, 51% CaO, and 3% P_2O_5, 1800 ppm combined REE); hand specimen shows buff-white coarse-grained, locally pyrite-magnetite-rich carbonatite associated with small yellowish possible REE minerals. The rock is distinctly magnetic, shows major rapid reaction to cold dilute HCl, and strong red stain for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite?)	85%
Apatite	5-7%
Pyrite, minor pyrrhotite	3-5%
Magnetite	2-3%
Phlogopite	1-2%
REE mineral (fluorocarbonate, mainly synchesite?)	1-2%

This sample consists of coarse calcitic carbonate with streaks and lensy concentrations (that could represent folded or deformed layers) of apatite, sulfide, magnetite, phlogopite and possible REE fluorocarbonate.

Carbonate (mainly calcite to judge by the intense reaction to HCl in hand specimen and the red stain in etched offcut) forms interlocking, sub- to locally euhedral crystals up to about 1.5 mm in diameter, generally lacking preferred orientation or obvious flattening, but in places showing a weak alignment sub-parallel to the lensy or streaky concentrations of apatite-phlogopite-sulfide-REE mineral.

In these concentrations, apatite forms stubby subhedral prisms mainly <0.2, but locally up to almost 0.5, mm long, with random orientations or locally partial alignment sub-parallel to the lens or streak. Pyrite forms coarse sub/euhedra up to 2 mm, in aggregates up to 3 mm long. Pyrite is locally associated with pyrrhotite as rounded subhedra up to almost 1 mm long, and in places with magnetite as ragged subhedra to 1 mm, or aggregates to 1.5 mm, and with phlogopite as euhedral flakes mostly <0.25 mm in diameter with unusual orange-brown pleochroism (note: maximum absorption is most unusual, occurring when the cleavage is perpendicular to the lower polarizer!).

Possible REE minerals forming rectangular to rhomb-shaped euhedral crystals up to 0.5 mm in diameter are typically closely associated with the apatite, sulfides, phlogopite, and to a lesser degree the magnetite. They are typically semi-opaque except on thin edges, where anisotropism is visible in transmitted light and the colour is yellow-brown, suggestive of synchesite (?). Birefringence appears to be too high, and the crystals too cloudy, to be typical monazite. However, the crystals or aggregates locally contain minor minute crystals <30 um in size of a higher R value, more opaque phase with distinct anisotropism (possibly columbite-tantalite that the fluorocarbonate has formed after?).

In summary, this is confirmed as calcite carbonatite with significant streaks or lenses (locally vein-like?) of more concentrated apatite, sulfides (pyrite, minor pyrrhotite), magnetite, phlogopite and possible REE minerals (possibly synchesite, trace columbite-tantalite?).

EC08-018 69.7: PLAGIOCLASE-RELICT MAFIC? PHYRIC INTERMEDIATE VOLCANIC ALTERED TO CHLORITE-CALCITE; ACCESSORY ILMENITE, PYRRHOTITE

Described as calcareous tuff (?) composed of fine-grained grey green groundmass (chlorite?) with phenocrysts of feldspar (?) to a few mm surrounded by calcite in foliated calcite-phlogopite (44% SiO_2, 17% Al_2O_3, 7% Fe_2O_3, 3.5% MgO, 9% CaO, and 6% Na_2O, 2% K_2O, only 170 ppm combined REE); hand specimen shows dark greenish grey, fine-grained, well foliated mafic/intermediate rock. The rock is weakly magnetic, shows local rapid reaction to cold dilute HCl, but it is not possible to evaluate the stain in the etched offcut. Modal mineralogy in polished thin section is approximately:

Plagioclase (andesine?)	55%
Chlorite (after biotite)	25%
Carbonate (mainly calcite?)	10%
Biotite (relict, chloritized)	5%
Ilmenite	2-3%
Pyrrhotite	2-3%

This sample consists of small, commonly glomeratic, relict plagioclase and much more altered barely recognizable (strongly chlorite-carbonate altered) mafic sites in a foliated groundmass of strongly aligned plagioclase and chloritized biotite plus accessory ilmenite and pyrrhotite.

Plagioclase phenocrysts making up about 20-25% of the sample have rounded-off, sub- to euhedral outlines mostly <1 mm (locally glomeratic to 3 mm). The larger examples are partly altered to carbonate (calcite subhedra to 0.5 mm) or fine-grained internal chlorite/biotite and show pressure shadows at the terminations filled with chlorite or chloritized biotite. Composition of plagioclase may be about andesine, An30, based on extinction Y^010 up to 18 degrees (no quartz present to compare refractive indices with, so could conceivably be albite, but unlikely given the setting).

Relict mafic sites have sheared out shapes up to about 2 mm long that are now represented by elongate patches of chlorite (minor relict biotite) and carbonate, in places with plagioclase also. Chlorite forms mainly euhedral flakes up to about 1 mm in size with optical character (weak but distinct pale green pleochroism, near-zero to slightly anomalous greenish grey, length fast birefringence) suggestive of F:M around 0.5 (?). Relict biotite forms subhedral medium brown flakes mostly <0.5 mm in diameter. Carbonate, likely mostly calcite, forms somewhat elongated subhedra up to 0.7 mm long in the plane of foliation.

In the groundmass, fine-grained plagioclase forms feathery ragged subhedra mainly <0.1 mm, but not uncommonly up to 0.2 mm long (typically aligned in the plane of the foliation, with length:width ratios in the 2:1 to 3:1 range), mixed with chlorite as strongly aligned flakes mostly <0.3 mm in diameter. Most of the opaques (oxide and sulfide) are contained within the relict mafic material of the sample.

Ilmenite forms minute tabular euhedra mostly <45 um long (locally in aggregates to 0.25 mm long), typically aligned sub-parallel to foliation. Pyrrhotite forms elongate subhedra up to 0.5 mm long also typically aligned sub-parallel to foliation, and rarely mixed with traces of chalcopyrite as subhedra <0.1 mm in size.

In summary, this appears to represent originally plagioclase-mafic? phyric intermediate volcanic rock now altered to chlorite-calcite, with accessory ilmenite and pyrrhotite concentrated in relict mafic sites and in the groundmass of plagioclase-chlorite-relict biotite.

EC08-019 209.4: PLAGIOCLASE-RELICT MAFIC PHYRIC INTERMEDIATE VOLCANIC ALTERED TO CHLORITE-CALCITE; ACCESSORY SPHENE

Described as silicate rock type(?) composed of fine-grained grey green groundmass (chlorite?) with phenocrysts of feldspar (?) to a few mm (1% Fe_2O_3, 2% MgO, 52% CaO, and 3% P_2O_5, 1817 ppm combined REE, although this analysis does not fit well with the petrography); hand specimen shows dark greenish grey, fine-grained, weakly foliated mafic/intermediate rock. The rock is not magnetic, shows local rapid reaction to cold dilute HCl, and local red stain for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Plagioclase (andesine?)	55%
Chlorite (after mafics, less after plagioclase)	30%
Carbonate (mainly calcite?)	10%
Sphene	2-3%
Sericite (after plagioclase)	2-3%

This sample consists of abundant (30-40%), commonly glomeratic, relict (lightly sericitized) plagioclase and barely recognizable (sheared-out, strongly chlorite-carbonate altered) mafic sites in a foliated groundmass of weakly aligned plagioclase and chlorite plus accessory sphene.

Plagioclase phenocrysts have rounded-off, sub- to euhedral outlines mostly <2 mm (but commonly glomeratic to 3 mm). Most crystals are partly altered to chlorite and lesser sericite (mainly euhedral flakes <45 um in diameter for both) or local carbonate (calcite subhedra <0.25 mm). Composition of plagioclase may be about andesine, An35, based on extinction Y^010 up to 20 degrees (no quartz present to compare refractive indices with, so could conceivably be albite, but unlikely given the setting). Note that this estimate of composition does not fit with the very high whole-rock CaO and very low Na_2O.

Relict mafic sites have elongated (sheared?) shapes up to about 3 mm long that are now represented by elongate patches of carbonate and lesser chlorite, in places with plagioclase also (accidental inclusions?). Chlorite forms mainly euhedral flakes up to about 1 mm in size with optical character (weak but distinct pale green pleochroism, near-zero to slightly anomalous greenish grey, length fast birefringence) suggestive of F:M around 0.5 (?). No relict biotite (as seen in the previous sample) remains. Carbonate, likely mostly calcite to judge by the reaction in hand specimen and red stain in etched offcut, forms somewhat elongated subhedra up to 0.6 mm long in the plane of foliation.

In the groundmass, fine-grained plagioclase forms feathery very ragged sub/anhedra mainly <0.1 mm, but not uncommonly up to 0.2 mm long (typically aligned in the plane of the foliation, with length:width ratios in the 2:1 to 3:1 range), intergrown with (partly replaced by?) chlorite as generally aligned, sub/euhedral flakes mostly <0.2 mm in diameter. Most of the sphene (aggregates to 0.2 mm of ragged sub/euhedral crystals <0.1 mm with weak brownish pleochroism) are contained within the relict mafic material of the groundmass. The abundance of sphene is similar to that of ilmenite in he previous sample, and also does not fit with the very low whole-rock TiO_2 reported for this sample.

In summary, this appears to represent originally plagioclase-mafic? phyric intermediate/mafic volcanic rock now altered to chlorite-calcite, with accessory sphene concentrated in relict mafic sites in the groundmass of plagioclase-chlorite.

EC08-019 263.7: COARSE RELICT (SERPENTINE-CARBONATE ALTERED) OLIVINE, MAGNETITE, AND APATITE (MINOR REE MINERAL) INCLUSIONS IN CALCITE CARBONATITE

Described as calcite carbonatite segregation with magnetite, altered olivine, apatite, pyrite and pyrochlore (5% Fe_2O_3, 1.5% MgO, 50% CaO, and 1% P_2O_5, 1150 ppm combined REE); hand specimen shows clast-like dark minerals (magnetite, relict olivine?) in matrix of white/grey carbonate that reacts intensely to cold dilute HCl and stains red for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite, minor magnesite?)	50%
Apatite	20%
Serpentine (after olivine?)	15%
Magnetite	13%
REE minerals (fluorocarbonate, columbite-tantalite?)	1-2%
Pyrite, pyrrhotite	<1%

This sample consists of ~15-20% each of coarse relict (serpentine-carbonate altered) olivine (?), clustered apatite, and magnetite crystals in a matrix of mostly coarse-grained calcite carbonatite.

The coarse-grained carbonate host forms interlocking, somewhat ragged/irregular subhedra up to about 3 mm in diameter (somewhat elongated in a weakly defined plane of foliation, with length:width ratios ~2:1). Intense reaction to cold dilute HCl in hand specimen, and strong red stain in etched offcut, indicates that this carbonate is mainly calcite.

Relict olivine (?) crystals show rounded, highly embayed/corroded irregular to locally subhedral outlines up to almost 0.5 cm diameter, now pseudomorphed by fine-grained serpentine (virtually colourless to palest yellow-greenish sub/euhedral, matted flakes mainly <0.25 mm) and variable carbonate (subhedral prismatic crystals or aggregates to 0.7 mm long with brownish colour that could be magnesite since they replace former olivine?), plus traces of very fine-grained secondary magnetite as minute subhedra mostly <40 um distributed along fractures or former partings).

Patches of apatite have irregular outlines up to at least 6 mm across, composed of randomly oriented to radiating sprays of mainly euhedral, slender prismatic crystals up to 2.5 mm long. The apatite is commonly closely associated with much of the REE mineral (see below) and the magnetite.

Magnetite occurs mostly as large sub/euhedral crystals or glomeratic aggregates up to about 1 cm in diameter, typically criss-crossed by narrow fractures filled with fine-grained carbonate of uncertain composition.

REE minerals occur as mainly euhedral shaped crystals or aggregates up to about 0.6 mm diameter with opaque rims and dark red-brown (locally bright red) transparent cores which, although they seem to be sensibly isotropic in transmitted light, may simply be too highly coloured to see the anisotropism, and thus are likely to be fluorocarbonate (bastnaesite and synchesite?), especially in light of the close association with apatite (in fact, inclusions of apatite are not uncommon). The opaque rims (<0.1 mm thick) appear, at high power, to be fine-grained mixtures of higher R, anisotropic columbite-tantalite (?) and lower R, isotropic pyrochlore (?). Rare pyrite and pyrrhotite form sub/euhedra mostly <0.3 mm in diameter.

In summary, this appears to represent relict (serpentine-carbonate-trace secondary magnetite altered) olivine, coarse magnetite, and patches of apatite (with associated possible fluorocarbonate REE minerals rimmed by opaque REE minerals?) plus trace pyrite, pyrrhotite in a matrix of coarse calcite carbonatite.

EC08-021 74.3: DOLOMITE CARBONATITE WITH LARGE BLADED PYRITE-CARBONATE-TRACE REE MINERAL PSEUDOMORPHS, CUT BY FLUORITE±PHLOGOPITE VEIN

Described as magnesio-carbonatite with fluorescent fluorite vein, pyrite crystallized around clasts before fluorite crystallized (no whole-rock or REE assay data); hand specimen shows major (3 cm thick) purple fluorite vein cutting white/grey carbonate (locally with rims of pyrite). The rock is not magnetic, shows slow reaction to cold dilute HCl and no stain for carbonate in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite?)	40%
Fluorite	40%
Pyrite	20%
Phlogopite	<1%
REE mineral (fluorocarbonate, synchesite?)	<1%

This sample consists mainly of a major vein of purple fluorite cutting a coarse-grained carbonatite with large elongated porphyroblastic aggregates of pyrite surrounding/pseudomorphing some former bladed mineral (?). Traces of possible REE mineral are located within the cores of these pseudomorphs.

In the vein, fluorite forms what appear to be sub/euhedral crystals up to 1 mm in diameter (hard to discern due to the isotropic character of the mineral) with common irregular to subhedral inclusions of carbonate mainly <0.2 mm in diameter, or rarely phlogopite as rounded subhedra to 0.15 mm in diameter.

The wallrock consists of very large bladed/lath-shaped pseudomorphs of pyrite with cores of carbonate (and trace local REE mineral?) in a matrix of carbonate. Carbonate throughout is likely mainly dolomite, to judge by the slow reaction to HCl in hand specimen, and the lack of coloured stain in the etched offcut. It mainly forms interlocking to somewhat rounded subhedra <0.5 mm in diameter that are essentially clear and colourless, or rarely pale brownish (the latter may be Fe-dolomite or ankerite?). In places the latter are difficult to separate from similar-sized sub/euhedral flakes of very pale brownish phlogopite.

Pyrite occurs as elongated aggregates up to 2.5 cm long of interlocking sub- to locally euhedral crystals up to about 2 mm in diameter. The pyrite crystals are typically somewhat fractured and contain inclusions of euhedral apatite or less commonly carbonate. They appear to have overgrown some former very large bladed crystal, the core of which is now replaced by fine-grained carbonate (interlocking subhedra mostly <0.3 mm in diameter, probably the same composition as the carbonate in the surrounding matrix).

In summary, this represents dolomitic carbonatite with coarse bladed pyrite rimmed-carbonate cored pseudomorphs of some former mineral, cut by a major vein of purple fluorite-minor phlogopite; REE minerals (fluorocarbonate?) only occur in the cores of the pseudomorphs.

EC08-021 102.0: RECRYSTALLIZED DOLOMITE CARBONATITE WITH TRACES OF REE (FLUOROCARBONATES?)-FLUORITE-HEMATITE?-PYRITE

Described as magnesio-carbonatite with micro-REE minerals (small red dots), assay data (11% Fe_2O_3, 15% MgO, 30% CaO, and 3% P_2O_5, 1738 ppm combined REE); hand specimen shows white/grey carbonate that reacts slowly to cold dilute HCl and only partly stains faint purple for Fe-dolomite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite/Fe dolomite?)	97+%
REE mineral (mainly fluorocarbonate, bastnaesite ±synchesite?)	1-2%
Fluorite	<1%
Hematite (?)	<1%
Pyrite	<1%

This sample consists almost entirely of relatively fine-grained (cataclasized?) carbonate, containing only traces of red or red-brown possible REE mineral (fluorocarbonate?) associated with minor purple fluorite, bright red hematite (?)s and trace pyrite.

Carbonate mostly forms either medium-grained subhedral crystals in the 0.5-1.0 (rarely to 3) mm range (possibly relict, unsheared crystals?), or a matrix of finer-grained, sucrosic (recrystallized?) sub/anhedral crystals mostly <0.1-0.2 mm in size. The carbonate is likely mostly dolomite or Fe-dolomite to judge by the slow reaction to HCl in hand specimen and the patchy, weak purple stain in the etched offcut.

Within the fine-grained (recrystallized, matrix) carbonate, interstices are commonly partly filled by minor bright red, or red-brown, minerals that could be mostly fluorocarbonate minerals, locally mixed with minor purple fluorite and bright red hematite plus rare pyrite. The possible REE mineral forms aggregates up to about 0.4 mm long composed of subhedra mostly <0.1 mm that are partly opaque to partly red-brown in colour, and may represent very fine-grained mixtures of relict pyrochlore (?) or columbite-tantalite (?) largely replaced by fluorocarbonate such as bastnaesite (?) or synchesite (?) particularly since they are commonly associated with traces of the bright purple fluorite as minute subhedra <35 um in size. It is hard to distinguish the possible earthy hematite (?) from the possible REE minerals since both are mostly red or red-brown. Pyrite occurs as widely scattered euhedra <0.2 mm in diameter.

In summary, this is confirmed as dolomitic carbonatite with trace amounts of possible REE minerals (possibly mainly fluorocarbonate, bastnaesite/synchesite?), purple fluorite, hematite (?) and pyrite.

EC08-021 181.5: RELICT SPINIFEX-TEXTURED ULTRAMAFIC ALTERED TO CALCITE-APATITE-MAGNETITE-AMPHIBOLE(S)-REE MINERAL?-PHLOGOPITE-PYRITE

Described as calcite carbonatite with relict magmatic (spinifex) crystal textures, assay data (6% Fe_2O_3, 9% MgO, 41% CaO, and 5% P_2O_5, 2671 ppm combined REE); hand specimen shows coarse bladed spinifex-like texture of pale pinkish-buff carbonate surrounded by dark minerals (green amphibole?-magnetite-pyrite). The rock is strongly magnetic, reacts intensely to cold dilute HCl and stains red for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite, minor magnesite?)	65%
Apatite	15%
Magnetite	10%
Amphibole (arfvedsonite/"abnormal glaucophane"?)	5%
(tremolite?)	3-5%
REE mineral (mainly pyrochlore (?)	1-2%
Phlogopite	<1%
Pyrite	<1%

This sample consists of coarse-grained carbonate (mainly calcite) in bladed pseudomorphs, presumably after former platy olivine (?) crystals, with lesser interstitial apatite, magnetite, amphibole (2 varieties), euhedral REE mineral and local minor phlogopite and pyrite.

Carbonate crystals replacing the former olivine (?) are generally very coarse, bladed sub- to euhedra up to almost 1 cm long, typically surrounded at the rims by fine-grained sucrosic/granular carbonate (rounded subhedra mostly <0.2 mm) that is commonly mixed with the surrounding or matrix apatite, magnetite and local colourless tremolitic amphibole (?) forming subhedra <1.5 mm long with high birefringence and moderate (20 degree) extinction angle, very pale green colour/faint pleochroism suggestive of a Mg-rich variety (?).

Apatite forms prismatic euhedra up to 2 mm long, generally (but not everywhere) aligned parallel to the length of the pseudomorphs. The crystals are typically cross-fractured.

Magnetite occurs as aggregates up to 5 mm long (aligned parallel to the margins of the pseudomorphs, forming subhedra mostly <2 mm in diameter).

Clots of blue-green (rarely bluish or purplish) amphibole with rounded outlines up to 3 mm across composed of sub/euhedral bladed to lath-shaped crystals mostly <0.7 mm long, surrounded by the fine-grained carbonate and local apatite, are probably mixtures of sodic amphibole that may include mainly "abnormal glaucophane" (?) which is length-slow with moderate (22 degree) extinction angle, and minor cores of arfvedsonite (?) which is length-fast, with small (<10 degree) extinction angle. Minor phlogopite forms small ragged brown subhedral flakes mostly <0.2 mm in diameter.

The possible REE mineral occurs as mainly euhedral, opaque crystals up to almost 1 mm in diameter that have much lower R than magnetite (which is locally intergrown with it) and is sensibly isotropic, suggesting it may be mainly pyrochlore (?). However, internal structure within the crystals suggests it is likely a secondary product after some other primary mineral (such as columbite-tantalite?). Pyrite locally associated, or intergrown with the mineral forms euhedral cubes up to 0.5 mm in size.

In summary, this does appear to represent relict spinifex-textured cumulate ultramafic altered to coarse bladed carbonate (mainly calcite) in a matrix of finer carbonate (also likely calcite) with variable apatite, magnetite, amphibole (blue-green sodic or very pale tremolitic), possible REE mineral (mainly pyrochlore?), minor phlogopite and pyrite.

EC08-021 196.05: COARSE MAGNETITE-AMPHIBOLE-PHLOGOPITE-APATITE-REE MINERAL WITH CALCITE/DOLOMITE CARBONATITE±REE MINERAL, SULFIDES

Described as magnetite-apatite cumulate cut by calcite carbonatite with apparent altered pyrochlore and possible sphalerite, assay data (14% Fe2O3, 8% MgO, 36% CaO, and 5% P2O5, 2536 ppm combined REE but only 56 ppm Zn); hand specimen shows coarse-grained dark greenish magnetite-amphibole (?) rich rock cut by a 2 cm thick pale pinkish-buff/pale greenish carbonate vein (or layer?). The rock is strongly magnetic, reacts strongly to cold dilute HCl and stains red for calcite in part of the carbonate layer of the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (calcite and dolomite?)	55%
Magnetite	20%
Amphibole (tremolite/actinolite or magnesio-arfvedsonite?)	10%
Apatite	5%
Biotite/phlogopite	5%
REE mineral (mainly relict pyrochlore (?)	3-5%
Pyrrhotite, minor pyrite, trace galena (?)	1%

This sample consists of coarse-grained magnetite and aggregates of pale greenish amphibole-apatite-minor biotite/phlogopite-REE mineral with trace sulfides in a matrix of carbonate, cut by/interlayered with mainly carbonate-minor sulfides-REE mineral(s).

In the former, magnetite making up almost 50% of the layer occurs as large (cm-sized) aggregates with sub/euhedral outlines composed of euhedra mainly <3 mm in size. Inclusions of carbonate, phlogopite and apatite up to 0.6 mm long are common, and carbonate occurs along narrow partings or fractures. Aggregates of amphibole have rounded, irregular outlines up to about 0.5 cm, composed of small subhedral lath-like crystals rarely over 1 mm long with long axes somewhat aligned to the layering or somewhat random. The extinction angle is close to 20 degrees and pleochroism is pale green without any blue tinge, suggestive of actinolite, but if magnesio-arfvedsonite has been determined by other means, it might be a possible alternative. Minor phlogopite (pale brown euhedral flakes to 0.5 mm) and carbonate (subhedra <0.2 mm) are intergrown with the amphibole; darker brown biotite/phlogopite also forms separate ragged subhedra up to 1 mm in size that are typically associated with apatite and locally partly chloritized around rims. Apatite forms slender to stubby prism up to 1.5 mm long. Possible REE minerals forming cubic crystals to 1 mm (aggregates to 2 mm) are either nearly opaque, with lower R than nearby magnetite (and divisible into lower-R, isotropic with very deep red-brown internal reflections that could be pyrochlore, or slightly higher R, anisotropic that could be columbite-tantalite?), or are red-brown to brown and isotropic to anisotropic; that may represent pyrochlore partly replaced by bastnaesite (?). Traces of pyrite occur as subhedra <0.25 mm intergrown with magnetite and REE.

In the carbonate band, calcite forms interlocking, somewhat rounded, relatively clear subhedra up to about 1 mm in diameter, and unstained carbonate (dolomite?) forms a mixture of somewhat corroded-looking, subhedral core crystals <0.75 mm in a matrix of clear sub/euhedra <0.3 mm in size. Sulfides, including pyrrhotite as rounded subhedra <0.5 mm and minor pyrite as euhedra of similar size, are disseminated in both carbonate types typically associated with possible REE minerals forming sub/euhedra with rhomb-shaped outlines up to 0.5 mm, bright red-brown colour and anisotropic character (bastnaesite?) rarely containing discrete brown euhedra <0.1 mm (synchesite?). Rarely, pyrrhotite contains inclusions of possible galena (?) <0.1 mm in size.

In summary, this is confirmed as possible magnetite-apatite-amphibole (±biotite/phlogopite)-carbonate-minor REE mineral?-trace sulfide cumulate rock cut by or interlayered with carbonatite (calcite and dolomite?) carrying minor REE minerals and pyrrhotite-pyrite-grace galena (?).

EC08-021 265.7: RELICT (SERPENTINE-MAGNESITE?) OLIVINE-APATITE-MAGNETITE-PHLOGOPITE-REE MINERALS?-SULFIDES IN CALCITE CARBONATITE MATRIX

Described as calcite carbonatite with inclusions of magnetite-pyrite, pyrrhotite, pyrochlore and possible (relict) olivine, assay data (5% Fe_2O_3, 3% MgO, 49% CaO, and 6% P_2O_5, 1900 ppm combined REE); hand specimen shows coarse-grained grey-greenish, more magnetite-amphibole (?) rich rock as inclusions in, or interlayered with, pale greenish-buff carbonate rock. The rock is magnetic, reacts strongly to cold dilute HCl and stains red for calcite in the matrix carbonate of the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mostly calcite, minor magnesite?)	55%
Serpentine (after olivine?)	25%
Apatite	10%
Magnetite	5%
Phlogopite	2-3%
REE mineral (mainly pyrochlore/bastnaesite (?)	1-2%
Pyrrhotite, minor sphalerite, trace pyrite, chalcopyrite	1-2%

This sample consists of aggregates of serpentinized relict mafic mineral (likely olivine)-apatite-magnetite-minor phlogopite-possible REE mineral-sulfides in a matrix of carbonate, minor apatite.

The matrix consists mainly of relatively coarse-grained carbonate as interlocking, somewhat rounded subhedra up to about 2 mm in diameter that are likely mainly calcite (to judge by the strong reaction to HCl in hand specimen, and the abundant red stain in etched offcut). Minor apatite is included within this carbonate as stubby sub/euhedral prisms mostly <0.5 mm long.

Possible relict olivine (?) crystal sites display irregular to locally sub or rarely euhedral outlines mostly <4 mm in diameter, but commonly in aggregates to about 1 cm containing inclusions of magnetite, apatite and possible REE minerals. The relics are pseudomorphed by fine-grained serpentine (subhedral flakes mostly <25, but up to 75 um) and possibly magnesite carbonate (subhedra mostly <35 um) plus traces of secondary magnetite (subhedra <30 um), the latter two mainly along former parting or fractures. In places these relics appear to have contained minor REE mineral (now mostly bright red-brown bastnaesite?) crystals to 1 mm which are cut by the carbonate (calcite) matrix.

Apatite associated with the olivine (?) relics occurs mostly as short stubby euhedral prisms <0.5 mm long tightly intergrown with the surrounding carbonate.

Phlogopite forms mainly euhedral pale brownish flakes up to almost 2 mm in diameter typically intergrown with apatite and magnetite.

Magnetite mainly occurs as ragged to irregular sub/euhedra <0.5 mm, commonly associated with minor REE-mineral or sulfides. The REE mineral typically occurs as euhedral shaped crystals or aggregates up to almost 1 mm in diameter, with low R value Sulfides are mostly pyrrhotite, forming aggregates up to 2.5 mm long made up of sub/euhedra <0.5 mm, locally intergrown with minor sphalerite (rounded subhedra <0.2 mm with orange to red colour indicative of low/moderate Fe content). Rare pyrite forms euhedra <0.1 mm and chalcopyrite rounded subhedra <20 um in size.

In summary, this appears to represent partly resorbed fragments of serpentine-magnesite (?) altered olivine?-apatite-magnetite-phlogopite-minor possible REE mineral-pyrrhotite-sphalerite-trace pyrite-chalcopyrite bearing ultramafic rock, cut and invaded by a matrix of calcite carbonate.

EC08-022 18.6: RELICT (FE-DOLOMITE ALTERED) OLIVINE (?) WITH APATITE-PHLOGOPITE-PYRITE-ILMENITE-SPHALERITE-PLAGIOCLASE IN DOLOMITE MATRIX

Described as grey magnesio-carbonatite with areas or inclusions of phlogopite and pyrite, assay data (6% Fe_2O_3, 12% MgO, 33% CaO, 1.3% TiO_2 and 12% P_2O_5, 2100 ppm combined REE, 514 ppm Zn); hand specimen shows coarse-grained grey-greenish carbonatite containing phlogopite crystals and disseminated or streaky pyrite. The rock not magnetic, reacts only slowly to cold dilute HCl and stains faintly purple or not at all for Fe-dolomite/dolomite respectively in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mostly Fe-dolomite, lesser dolomite?)	70%
Apatite	20%
Phlogopite	3-5%
Pyrite	3-5%
Ilmenite	1-2%
Plagioclase (andesine-labradorite?)	<1%
Sphalerite	<1%
REE mineral (?)	<1%

This sample has a texture reminiscent of (but more altered than) the previous sample, with darker (possibly Fe-dolomite?) carbonate relict sites possibly after former olivine associated with minor sulfides, ilmenite, phlogopite and trace REE mineral, in a matrix of possible dolomite carbonate.

The possible relics make up at least 50% of the sample and have rounded to subhedral outlines in the 2-3 mm size range, composed of carbonate that is relatively finer-grained (mostly <0.25 mm subhedra) and clouded by minute, mostly fluid (but also opaque, mainly ilmenite, <20 um) inclusions compared to the matrix carbonate. Traces of possible REE minerals occur within these aggregates as very fine-grained (<20 um) fibrous brownish material associated with the opaque ilmenite in places. The darker carbonate may be the portion showing purplish stain in etched offcut, and as such be Fe-dolomite (ankerite) which would fit with its darker colour, and also its possible derivation after serpentine and magnesite presumed to have replaced former olivine in the previous sample.

Carbonate of the matrix forms relatively clear, subhedral to rounded/irregular crystals up to 1 mm in size, likely dolomite to judge by the lack of stain in the etched offcut. This carbonate contains very little pyrite, phlogopite or possible REE minerals.

Apatite generally closely associated with the relict olivine (?) sites forms sub/euhedral prisms up to ~ 1 mm long with more or less random orientations.

Phlogopite occurs as aggregates with irregular outlines up to 2 mm across composed of interlocking randomly oriented matted euhedral, pale brown flakes mostly <0.4 mm in diameter that are commonly closely associated with pyrite.

Pyrite occurs as irregular shaped aggregates up to 1.5 mm across, locally concentrated along what appear to be discontinuous veinlets, composed of subhedra rarely over 1 mm locally intergrown with minor sphalerite (rounded subhedra up to 1.5 mm lacking colour, indicative of low Fe content). Rarely, minor plagioclase (ragged subhedra <0.25 mm with extinction on 010 up to 28 degrees suggestive of andesine-labradorite, An50), is associated with the sphalerite.

Ilmenite occurs as irregular-shaped aggregates up to 0.75 mm long composed of very fine-grained, tabular subhedral crystals mostly <50 um long, closely packed in random orientations.

In summary, this appears to represent relict olivine (?) crystals now altered to Fe-dolomite, and associated with apatite, minor phlogopite, pyrite and lesser ilmenite, plagioclase, sphalerite, possible traces of REE minerals (?) in a matrix of dolomite carbonate.

EC08-025 21.4: DOLOMITIC CARBONATITE IN CONTACT WITH ROCK RICH IN APATITE, RIEBECKITE (?), PYRITE AND TRACE REE MINERALS (?).

Described as contact of (two different coloured) apatite cumulates, cut by magnesio-carbonatite, assay data (30% Fe_2O_3, 6% MgO, 25% CaO, 0.7% Na_2O and 17% P_2O_5, 1800 ppm combined REE, 4000 ppm Zr, 835 ppm U); hand specimen shows red/pinkish grey or blackish apatite rich rock cut by or interlayered with greenish-buff carbonatite. The rock is weakly magnetic, reacts only slowly to cold dilute HCl and does not stain (dolomite?) in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite?)	55%
Apatite	20%
Amphibole (riebeckite?)	17%
Pyrite	7-8%
REE mineral (pyrochlore altered to fluorocarbonate?)	1%

This sample consists of one-half mainly apatite, deep blue soda amphibole, and sulfides (mainly pyrite) plus traces of possible REE mineral, and the other half mainly carbonate (minor sulfide).

In the carbonate-rich rock, the carbonate crystals are mostly interlocking subhedra either in the <0.2 mm or up to 0.6 mm size ranges, and are likely mostly dolomite to judge by the lack of stain in the etched offcut, and slow reaction to HCl in hand specimen. Some of the larger crystals have laminated internal structure suggestive of deformation lamellae. In places the finer-grained material is associated with minor pyrite (loose aggregates to 1 mm of subhedra mostly <0.2 mm).

In the apatite-rich rock, apatite forms irregular, embayed or corroded-looking euhedral prisms up to 1.5 mm long that are locally, but not everywhere, partly aligned with the contact between the two rock types. Small inclusions of carbonate are common both within the crystals and along their intergranular boundaries. Abundant carbonate present in this portion of the sample mainly occurs as

Amphibole forms slender, bladed euhedral crystals up to almost 3 mm long, generally with more or less random orientations, but locally concentrated in discontinuous layers sub-parallel to the contact, where they are more commonly aligned sub-parallel to each other and the contact. Intense dark indigo blue to purplish grey or yellowish green pleochroism and small, length-fast extinction angle <5 degrees are all suggestive of riebeckite, the Fe-rich member of the series with glaucophane, and this is supported by the high Fe content, low Mg content, and noticeable Na content of the rock.

Pyrite occurs as subhedral crystals rarely over 1 mm in size, but commonly rimmed by finer-grained overgrowths, and concentrated along the contact in aggregates up to several cm long by <1 cm thick. Pyrite is locally associated with minor amounts of possible REE mineral forming small sub/euhedral aggregates up to 0.3 mm in diameter, generally opaque except around thin edges where bright-red-brown or locally yellow-brown, somewhat fibrous and anisotropic phases as minute bladed crystals <30 um long. These aggregates have mainly low R, suggesting they could represent pyrochlore (?) altered around the rims to bastnaesite/synchesite?). The loci of the high Zr and U contents remain explained.

In summary, this is confirmed as a contact between dolomitic carbonatite (minor pyrite) and apatite-riebeckite?-pyrite rich ultrabasic rock with very minor possible REE minerals (possibly pyrochlore partly altered to fluorocarbonate?).

EC08-025 140.0: FINE-GRAINED MODERATELY FOLIATED CARBONATE-PLAGIOCLASE-BIOTITE/PHLOGOPITE-MINOR APATITE-ACCESSORY RUTILE-TRACE CHALCOPYRITE ROCK

Described as very fine-grained foliated biotite rich rock (brown "glimmerite") (no whole-rock or REE assay data available); hand specimen shows finely laminated/foliated pale brownish-grey rock. The rock is locally slightly magnetic, shows no reaction to cold dilute HCl, and only faint purplish stain for dolomitic or ankeritic carbonate in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (dolomite or ankerite?)	35%
Plagioclase	30%
Biotite/phlogopite	25%
Apatite	3-5%
Rutile, trace ilmenite (?)	1-2%
Chalcopyrite, trace pyrrhotite (?)	<1%

This sample consists of fine-grained, thinly laminated/banded, moderately foliated carbonate-plagioclase-biotite/phlogopite-minor apatite-accessory rutile rock with only traces of sulfide. Bands or laminae are mostly <1 mm thick and defined by variations in mineralogy or more precisely abundances of minerals, less commonly by variation in grain size.

Carbonate forms mainly euhedral to subhedral crystals <0.1 mm (rarely elongated or flattened in the plane of foliation to 0.3 mm long with length:width ratios about 2:1 t o3:1). They are likely mostly dolomite or Fe-dolomite (difficult to evaluate the stain for carbonate in this dark rock).

Plagioclase forms sub- to anhedral crystals mostly <0.1, but locally up to 0.3 mm in diameter (particularly in certain thin bands with coarser carbonate and local biotite/phlogopite, with only rare twinning (extinction on 010 up to about 15 degrees) and the negative relief compared to biotite confirming the identity. It is likely about andesine in composition based on the extinction but this is unconfirmed by more precise data.

Apatite forming somewhat rounded, subhedral to locally euhedral prismatic crystals is in places somewhat difficult to distinguish from intergrown plagioclase where it is subhedral.

Biotite/phlogopite forms mainly euhedral flakes up to about 0.25 mm diameter with pale to medium greenish brown pleochroism, typically closely associated with minute dark red-brown euhedral crystals of rutile mostly <30 um long (locally containing traces of opaques that could be ilmenite?).

Traces of sulfide are mostly chalcopyrite (subhedra mainly <0.1 mm in diameter) but may include traces of pyrrhotite to explain the local slight magnetism.

In summary, this is confirmed as very fine-grained, foliated, carbonate-plagioclase-biotite/phlogopite rich rock, with minor apatite and accessory rutile, trace chalcopyrite.

EC08-026 187.85: AGGREGATES OF AMPHIBOLE-APATITE-FINE MAGNETITE (AFTER OLIVINE?) OR COARSE MAGNETITE-PYRITE-PYRRHOTITE-PHLOGOPITE-TRACE REE MINERAL, IN MATRIX OF COARSE CALCITE

Described as calcite carbonatite with oriented patches of magnesio-arfvedsonite, assay data (3% Fe_2O_3, 3% MgO, 50% CaO, 0.2% Na_2O and 4% P_2O_5, 1900 ppm combined REE); hand specimen shows grey carbonatite with abundant greenish mafic (amphibole) inclusions. The rock is strongly magnetic, reacts intensely to cold dilute HCl and stains red for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite?)	55%
Amphibole (tremolite/actinolite?)	25%
Apatite	7%
Magnetite	5%
Phlogopite (slightly chloritized at rims)	5%
Pyrite, lesser pyrrhotite	2-3%
REE mineral (pyrochlore altered to fluorocarbonate?)	<1%

This sample is composed of lensy patches of amphibole-apatite-fine grained magnetite (probably after former mafic mineral sites) and scattered irregular patches of coarser-grained magnetite and sulfides locally associated with large phlogopite crystals, all in a matrix of carbonate.

In the relict mafic mineral sites, which have lensoid outlines up to 1.5 cm long by 5 mm thick and are oriented with long axes sub-parallel to a weakly developed foliation, amphibole forms slender lath-shaped euhedra mostly <1 mm long, commonly with long axes aligned parallel to the lens outlines and the foliation. Extinction angle around 22 degrees and very pale greenish or almost colourless pleochroism suggests it is likely tremolite-actinolite (although the extinction angle is permissive for magnesio-arfvedsonite). Apatite intergrown with the amphibole (and locally with adjacent carbonate matrix) forms stubby to slender euhedral prisms up to 1.5 mm long, typically with partly aligned or locally random orientations. Fine-grained magnetite (typical of replacement of former olivine) forms sub/euhedra mostly <50 um, but rarely up to 0.1 mm in size.

In the coarse-grained opaque patches which are up to almost 1 cm across, magnetite forms ragged irregular aggregates to 6 mm composed of sub/euhedra mostly <1 mm in diameter, commonly intergrown with lesser sulfides including pyrite as euhedra to 1.5 mm and pyrrhotite as subhedra to 1 mm (aggregates to 2 mm, locally partly altered at cores to fine-grained marcasite?). Phlogopite occurs as large (up to 1 cm) euhedral booklets or crystals with pale brown pleochroism but partly altered at rims to bright green chlorite, and loosely associated with the opaque aggregates. Very minor possible REE minerals are locally intergrown or associated with the magnetite, forming ragged aggregates <0.5 mm long composed mainly of bright red-brown possible fluorocarbonate (bastnaesite?).

In the matrix, carbonate (likely mainly calcite to judge by the intense reaction to HCl in hand specimen and the red stain in etched offcut) forms coarse rounded to irregular subhedra up to about 3 mm in diameter. Finer-grained carbonate, possibly also calcite, is intergrown with the amphibole and apatite in the lenses.

In summary, this sample consists of lensy aggregates of amphibole-apatite-fine magnetite (possibly after former olivine?) and loose aggregates of magnetite-pyrite-pyrrhotite-phlogopite-rare bastnaesite (?) in a matrix of coarse calcite.

EC08-026 188.65: AGGREGATES OF FIBROUS AMPHIBOLE-APATITE-COARSE PHLOGOPITE-TRACE REE MINERAL-PYRRHOTITE-MAGNETITE, IN MATRIX OF COARSE CALCITE

Described as blue-green fibrous amphibole in coarse calcite, with medium-grained calcite carbonatite, (no whole-rock or assay data available); no hand specimen remains (all used up in section preparation) but the offcut shows grey-white to greenish-buff carbonatite with abundant greenish mafic (amphibole, mica) inclusions. The rock is not magnetic, reacts intensely to cold dilute HCl and stains mostly red for calcite in the etched offcut. Modal mineralogy in polished thin section is approximately:

Carbonate (mainly calcite?)	65%
Amphibole (tremolite/actinolite?)	20%
Apatite	7-8%
Phlogopite (slightly chloritized at rims)	5%
REE mineral (mainly fluorocarbonate, bastnaesite?)	1%
Pyrrhotite	<1%
Magnetite	<1%

This sample is composed of lensy to irregular-shaped patches of amphibole-apatite-fine grained carbonate-trace possible REE minerals-magnetite-pyrrhotite (possibly after former mafic mineral sites?) and scattered coarse-grained phlogopite crystals, all in a matrix of very coarse-grained calcium carbonate.

In the possible relict mafic mineral sites, which have lensoid outlines up to 1.5 cm long by 3 mm thick and are oriented with long axes sub-parallel to a weakly developed foliation that wraps around coarse blocks of carbonate, amphibole forms slender lath-shaped euhedra up to 1.5 mm long, or extremely fine acicular crystals mostly <0.5 mm long, commonly with long axes aligned parallel to the lens outlines and the foliation. Extinction angle around 23 degrees and virtually colourless character (no pleochroism) suggests it is likely tremolite (although the extinction angle is permissive for magnesio-arfvedsonite). Apatite intergrown with the amphibole (and locally with adjacent carbonate matrix) forms stubby to slender, corroded-looking ragged euhedral prisms up to 1.5 mm long, typically with partly aligned or locally random orientations.

Phlogopite forms large (up to 0.5 cm) euhedral booklets or crystals with pale brown pleochroism. Minor possible REE minerals are locally intergrown or associated with the amphibole rich areas or with phlogopite, forming ragged aggregates <0.5 mm long composed mainly of bright red-brown possible fluorocarbonate (bastnaesite?). Minor sulfides are mainly pyrrhotite as subhedra to 0.2 mm (aggregates to 0.5 mm). Rare, fine-grained magnetite occurs as euhedra mostly <0.1 mm, but locally up to 0.2 mm in size.

In the matrix, carbonate (likely mainly calcite to judge by the intense reaction to HCl in hand specimen and the red stain in etched offcut) forms coarse rounded to irregular subhedra up to about 6 mm in diameter. Finer-grained carbonate, possibly also calcite, is intimately intergrown with the amphibole and apatite in the lenses. In places the needle-like fine-grained amphibole occurs as swarms of aligned inclusions within the coarse carbonate crystals, likely imparting the pale green colour to them in hand specimen.

In summary, similar to (but possibly more sheared/deformed than) the previous sample from 187.85m, this sample consists of lensy aggregates of amphibole-apatite and local coarse phlogopite-minor bastnaesite?-trace pyrrhotite-rare magnetite, in a matrix of very coarse calcite.

EC08-26 62.7: DOLOMITIC CARBONATITE WITH POSSIBLE DEFORMED VEINS OF CARBONATE-FLUORITE-APATITE AND STYLOLITES OF PHLOGOPITE-PYRITE (BOTH WITH REE MINERAL?)

Described as magnesio-carbonatite with unusual pattern of fluorite and apatite, assay data (5% Fe_2O_3, 16% MgO, 33% CaO and 5% P_2O_5, 2200 ppm combined REE); hand specimen shows pale greenish buff carbonatite with scattered dark greenish-black or brownish stylolitic (?) partings. The rock is not magnetic, reacts only slowly to cold dilute HCl and stains very faintly purplish for dolomite/Fe dolomite in the etched offcut (which also reveals minor purple fluorite and possible white apatite patches, the latter up to 1 cm long). Modal mineralogy in polished thin section is approximately:

Carbonate (mainly dolomite/Fe dolomite?)	85%
Apatite	5%
Phlogopite	5%
Fluorite	3%
Pyrite	1-2%
REE mineral (mainly fluorocarbonate, synchesite?)	<1%

This sample consists mainly of fine-grained carbonate hosting local zones or included areas of coarse-grained carbonate and minor apatite and fluorite, plus linear (stylolitic?) zones enriched in very pale phlogopite, both associated with minor sulfides and traces of possible REE mineral.

Most carbonate occurs as sucrosic, granular aggregates of sub/euhedral crystals <0.1 mm (locally <50 um) in diameter, likely mostly dolomite or Fe-dolomite to judge by the slow reaction to HCl in hand specimen, lack of or faintly purplish stain in etched offcut, and the whole-rock chemistry. In places there are linear to possibly ptygmatically folded zones of coarser carbonate (sub- to euhedral crystals up to 1.5 mm that may contain more Fe-dolomite, i.e. ankerite, judging by the somewhat darker purple stain in etched offcut). These zones may represent deformed veinlets, which is supported by their containing minor fluorite as aggregates to 3 mm of pale purple subhedra up to 1 mm in size (the fluorite locally containing possible REE minerals; see below).

Most apatite and phlogopite is found along the narrow anastamosing (stylolitic?) zones mostly <1 mm thick crossing the sample. Apatite occurs in aggregates up to 1 mm across as stubby sub/euhedral prismatic crystals mostly <0.25 mm long. Phlogopite occurs as very pale to faintly brownish, mainly euhedral flakes <0.2 mm in size, commonly oriented sub-parallel to the fracture zone.

Pyrite occurs as small cubic crystals mostly <0.25 mm in diameter generally found along the phlogopitic (±apatite-rich) zones, and locally associated with minor possible REE mineral. Most of this mineral is partly transparent, with distinctly yellow or yellow-brown colour suggestive of fluorocarbonate like synchesite (as is suggested by its association with fluorite within carbonate) but appears mostly isotropic under crossed polars (this could be due to its inclusion within fluorite or perhaps its thickness?). In reflected light, however, the aggregates of REE-mineral (mostly sensibly isotropic) contain some opaque phases as minute (<5 um sized) material or <10 um fibrous material locally intergrown with pyrite as ragged subhedra <0.1 mm and tabular columbite-tantalite (?) or ilmenite (?) as euhedral laths <30 um long.

In summary, this appears to represent magnesio-carbonatite (dolomite and local Fe-dolomite or ankerite?) possibly cut by deformed veins of carbonate-fluorite-REE mineral and stylolitic zones of apatite-phlogopite-minor pyrite-possible REE mineral (mainly synchesite?).

EC08-28 78.05: FINE-GRAINED DOLOMITIC CARBONATITE WITH CONCENTRATIONS OR STYLOLITIC PARTINGS OF FLUORITE-PHLOGOPITE-SPHALERITE-PYRITE-POSSIBLE REE MINERALS (?)

(Note: both samples from EC08-27 are missing); no description or whole-rock/REE assay data for this sample from EC08-28. Hand specimen shows medium-grained, dull grey-green carbonatite with included patches and areas of grey rock (containing concentrations of opaques and/or REE minerals?). The rock is not magnetic, shows only slow reaction to cold dilute HCl, and purplish stain for Fe-dolomite (?) in the etched offcut (note: could be in part confused by presence of purple fluorite?). Modal mineralogy in polished thin section is approximately:

Carbonate (mainly Fe-dolomite?)	~90%
Fluorite	5%
Phlogopite	3%
Sphalerite	1%
Pyrite, trace chalcopyrite	<1%
REE mineral (?)	<1%

This sample consists of fine-grained carbonate with small irregular areas of fluorite-minor phlogopite-sulfides and possible trace REE minerals (?); the latter (phlogopite, sulfides, and REE?) are also found along narrow, possibly stylolitic partings. There could be traces of apatite present but too fine to separate confidently from the carbonate matrix.

Carbonate typically forms very fine-grained (<25 um) or fine-grained (<0.1 mm) tightly interlocking, ragged irregular to subhedral crystals (likely mostly dolomite or Fe-dolomite to judge by the slow reaction to HCl in hand specimen and the purplish stain in etched offcut). Fluorite is typically associated with the slightly coarser (recrystallized) portions of the carbonate rock.

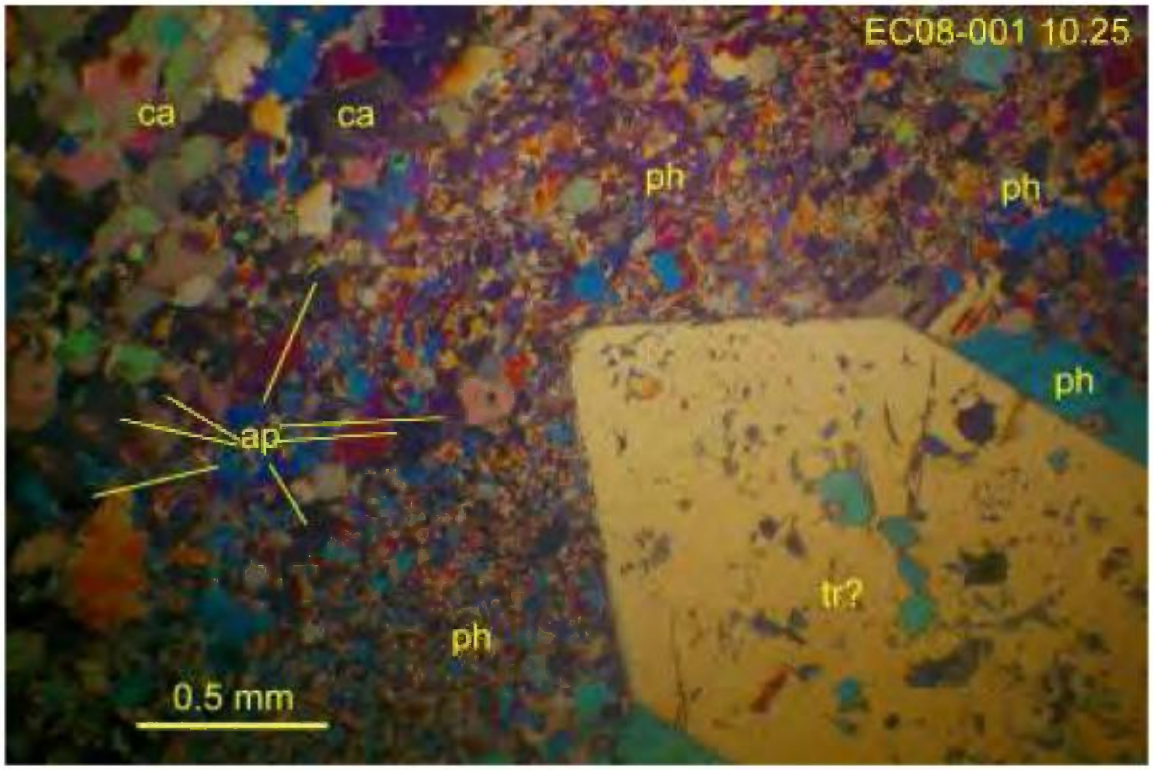
Fluorite occurs in highly irregular-shaped aggregates up to several mm across composed of interlocking, mainly deep, but locally variable, purple subhedra mostly <25 um in diameter, typically associated with sulfides and possible REE minerals (?).

Phlogopite forms very fine-grained, subhedral flakes mostly <65 um in diameter, commonly concentrated along what appear to be stylolitic partings that are mostly <0.1 mm thick, or rarely with fluorite.

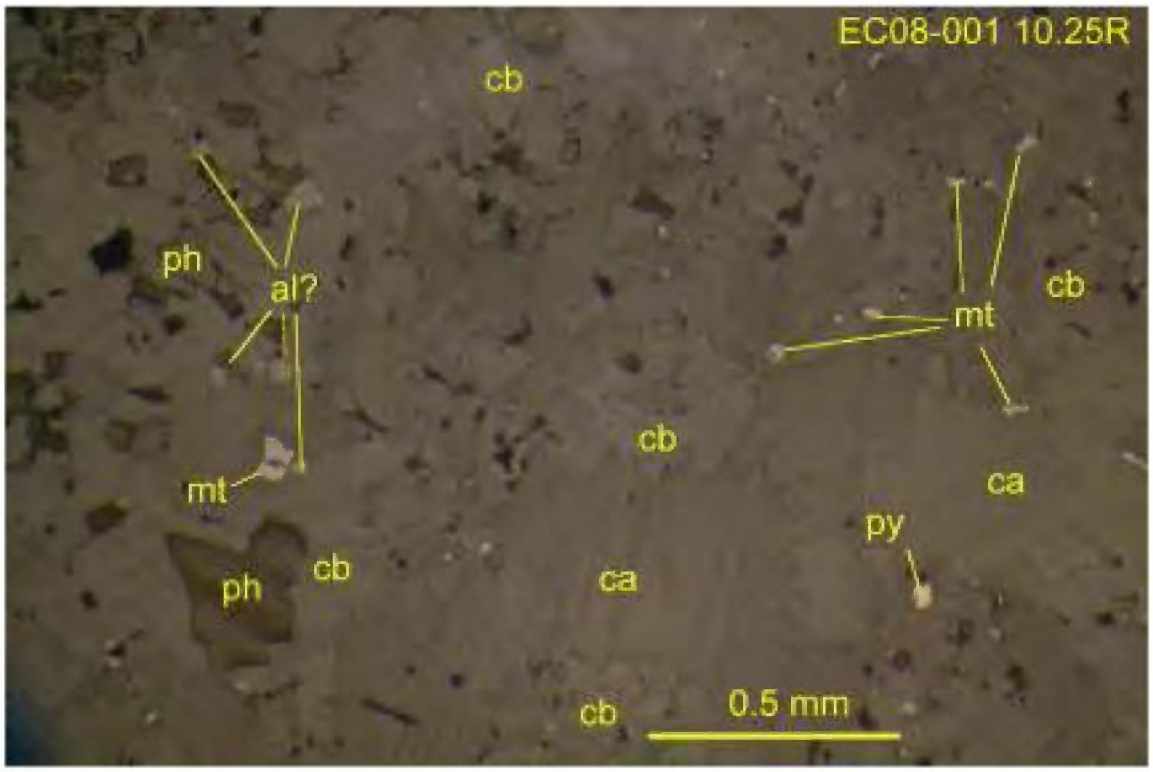
Sphalerite is actually the most abundant sulfide in this sample, forming somewhat rounded subhedra locally up to 0.5 mm across containing rare inclusions of pyrite or chalcopyrite (euhedra <30 um in size) and possible traces of magnetite (?) <10 um in size. Minor pyrite also forms separate euhedra mostly <0.1 mm in diameter, generally concentrated along the phlogopitic stylolitic partings.

The mineral tentatively identified as possible REE occurs as irregular shaped aggregates up to 0.2 mm long composed of minute (mainly <40 um long) sub/euhedral, somewhat tabular almost opaque crystals with distinct anisotropism that could indicate columbite-tantalite (?). Alternatively, since they are similar to nearby tabular opaque crystals up to 0.1 mm long also with strong anisotropy, they could both be merely ilmenite (?); if whole rock data is available, elevated TiO2 might confirm or reject this hypothesis.

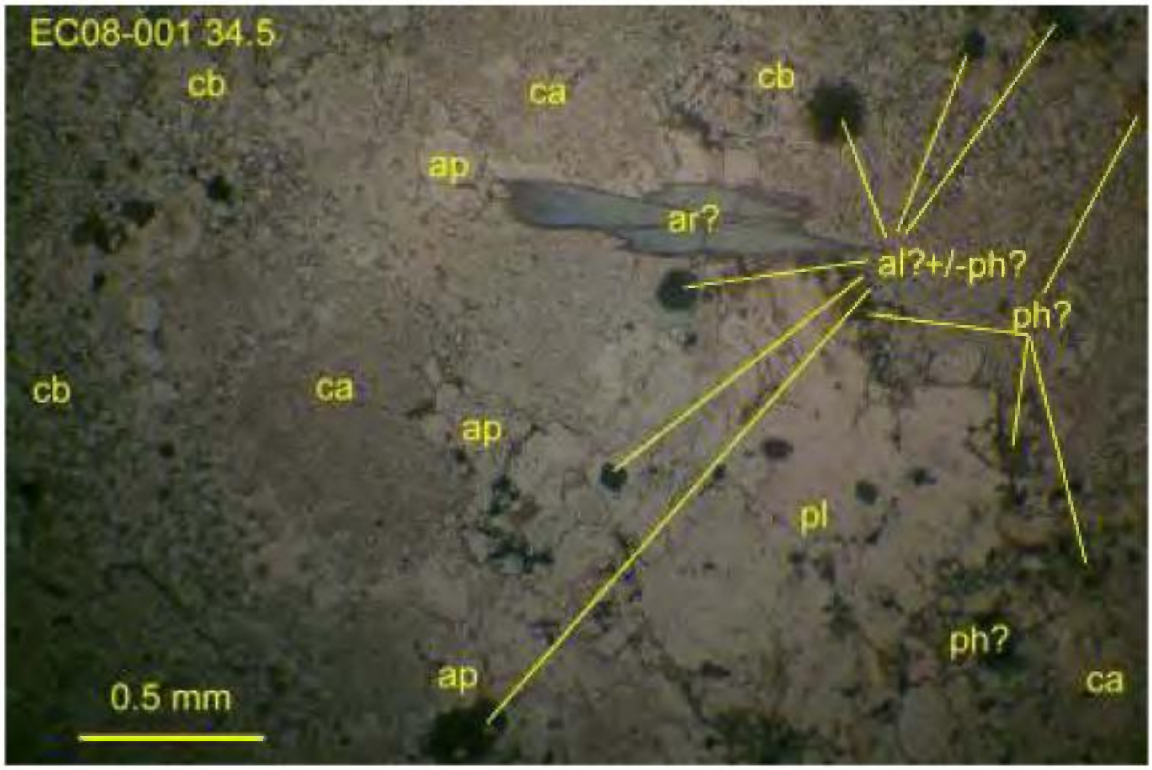
In summary, this appears to represent very fine-grained, dolomitic carbonatite with local concentrations or stylolitic partings of fluorite-phlogopite-sphalerite-pyrite/trace chalcopyrite, possible REE mineral.



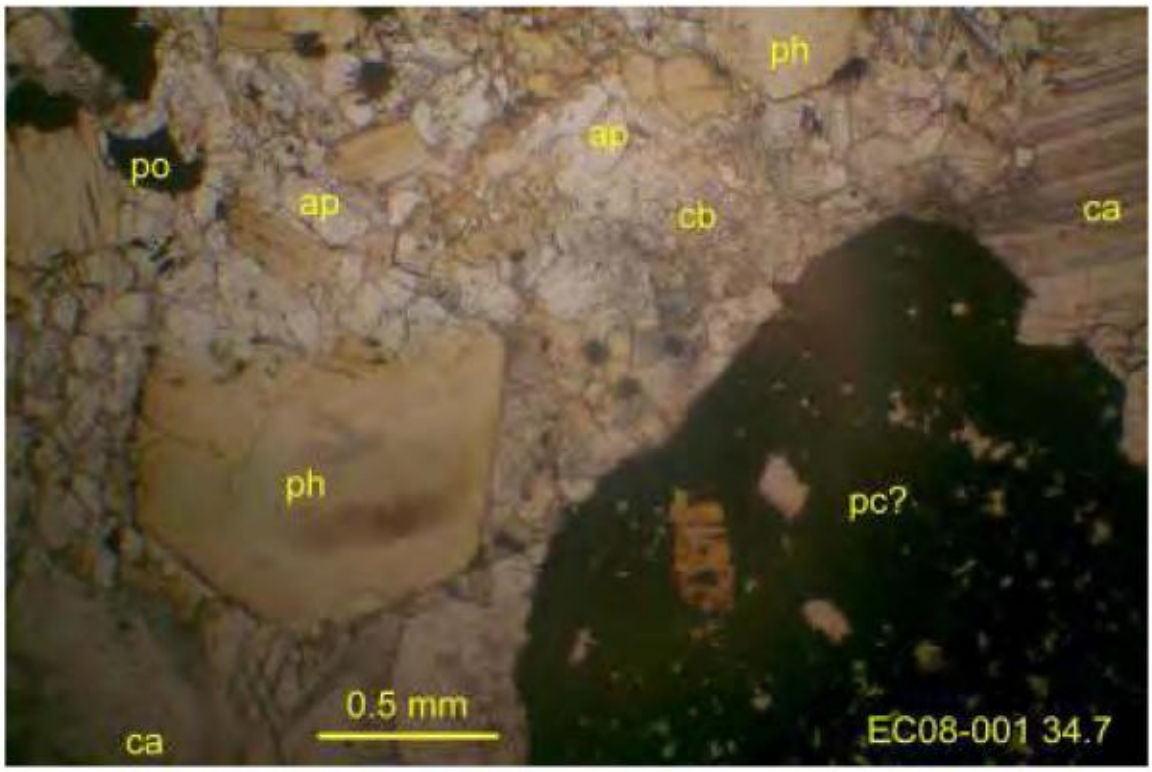
EC08-001 10.25: Euhedral tremolite (tr?) with inclusions of and coated by coarse phlogopite (ph) flakes, contained within fine-grained phlogopite of glimmerite (?) fragment cut by matrix of carbonate (ca). Note coarsening of phlogopite near matrix, and increase in apatite (ap) crystals. Transmitted light, crossed polars, field of view 3.0 mm wide.



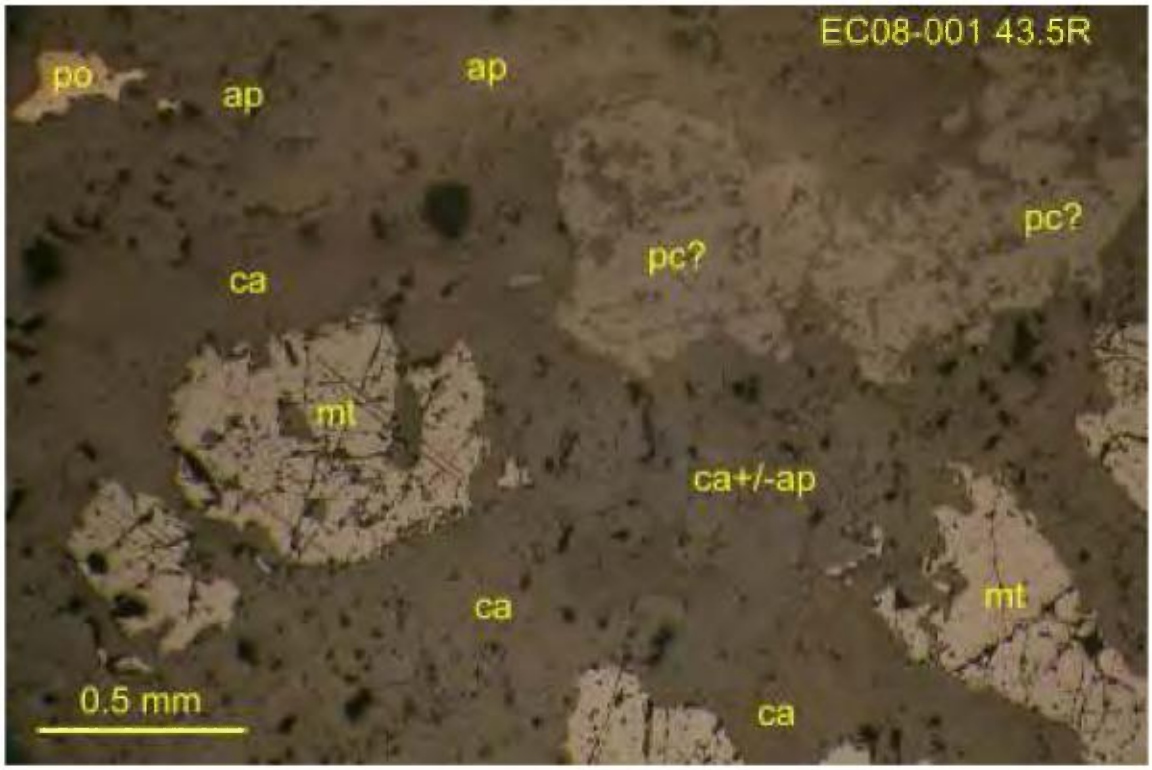
EC08-001 10.25R: Matrix composed of coarse-grained calcite (ca) and finer-grained possible Mg-Fe carbonate (cb) associated with minor magnetite (mt), pyrite (py) and possible allanite (al?) that is locally surrounded by pleochroic haloes in adjacent phlogopite (ph). Reflected light, uncrossed polars, field of view 2.25 mm wide.



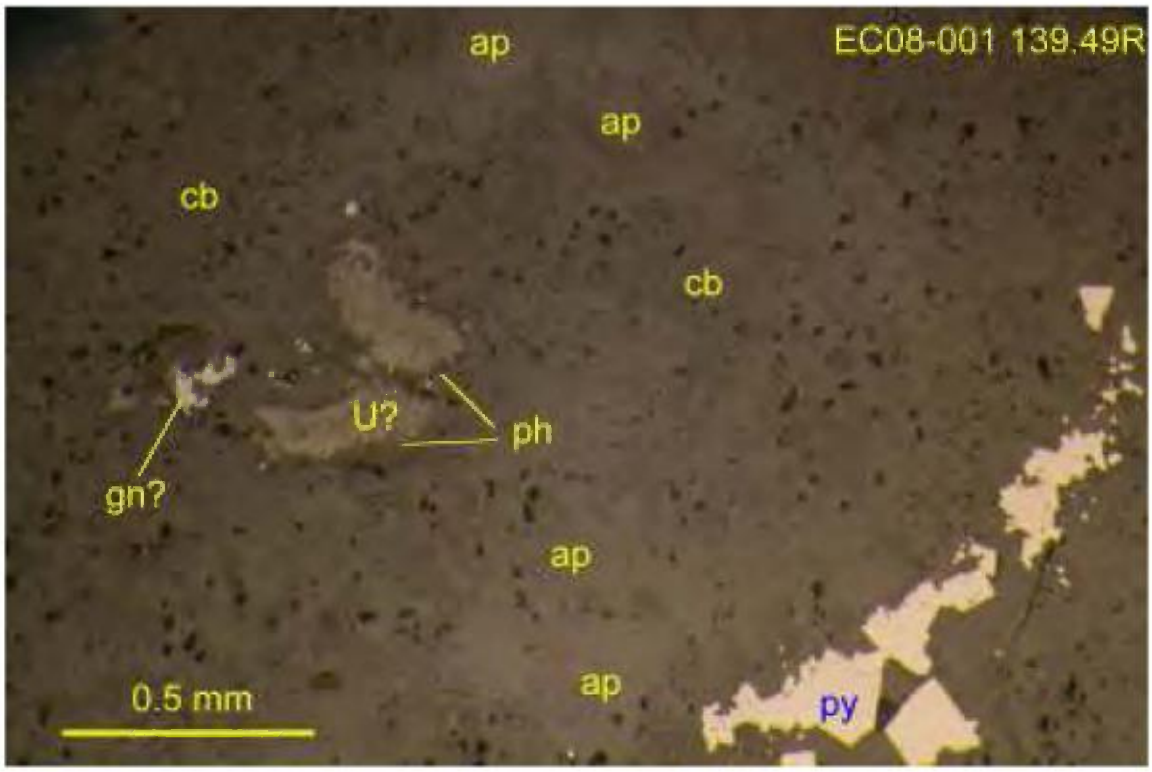
EC08-001 34.5: Marginal zone of vein composed of coarse calcite (ca) replaced by fine-grained dolomitic carbonate (cb), associated with minor bladed arfvedsonite (ar?), apatite (ap), plagioclase (pl), dark phlogopite or biotite (mainly radiation-damaged near rounded aggregates of allanite (al?). Transmitted plane light, field of view 3.0 mm wide.



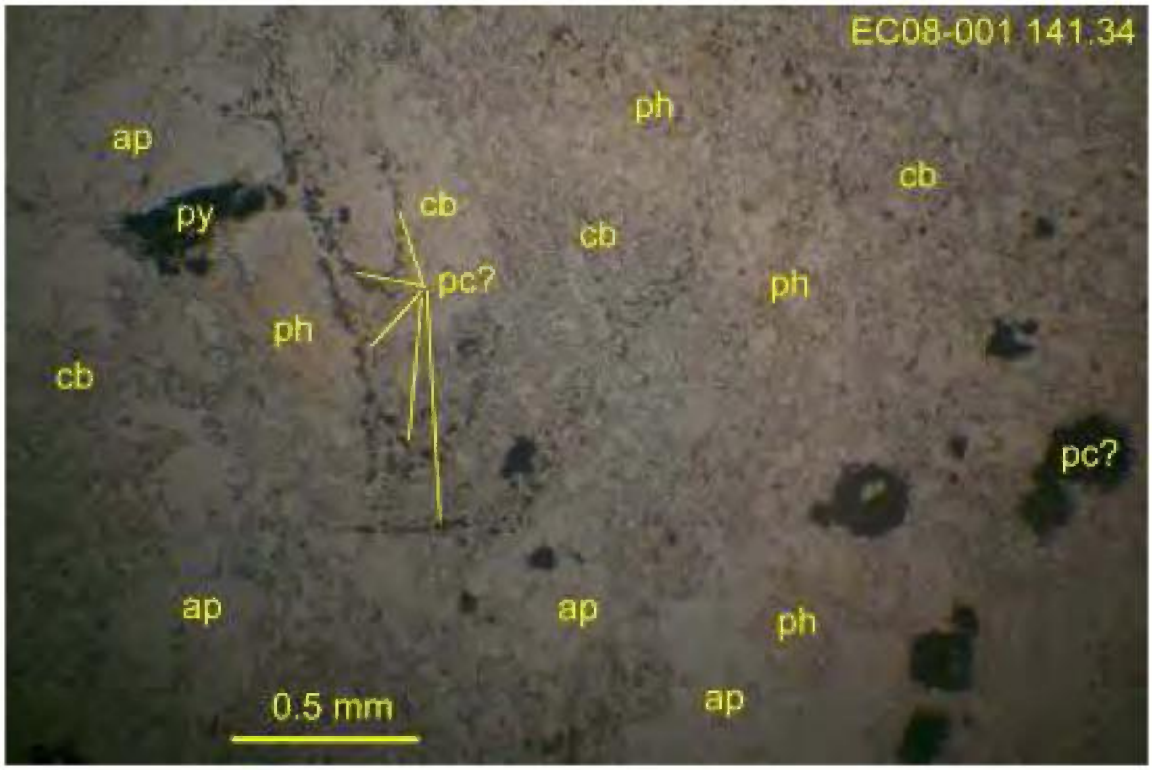
EC08-001 34.7: Euhedral blastic pyrochlore (pc?) crystal (virtually opaque unless in very strong light when red-brown internal reflections become evident) associated with phlogopite (ph), apatite (ap) and pyrrhotite (po) in fine-grained (ankeritic?) carbonate (cb) enclosed by coarse calcite (ca). Transmitted plane light, field of view 3.0 mm wide.



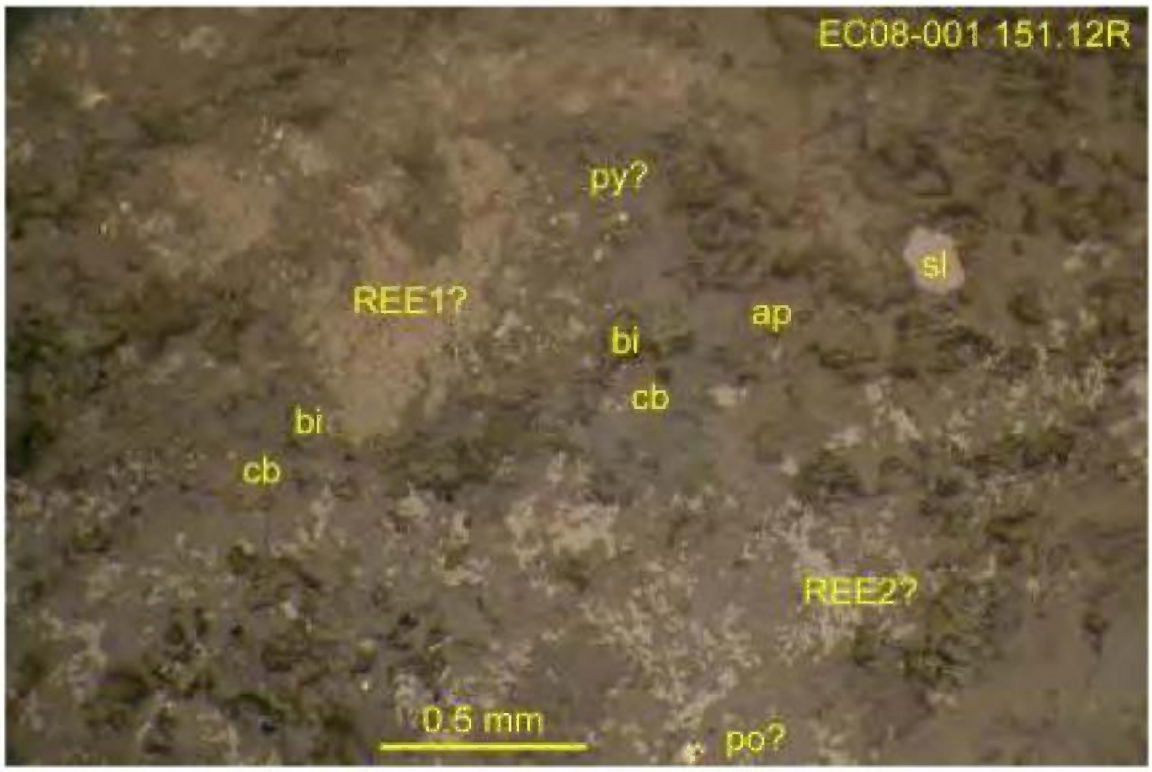
EC08-001 43.5R: Coarse-grained aggregates of magnetite (mt) associated with possible pyrochlore (pc?) and traces of pyrrhotite (po) along margin of layer of apatite (ap) with coarse-grained calcite (ca). Reflected light, uncrossed polars, field of view 2.75 mm wide.



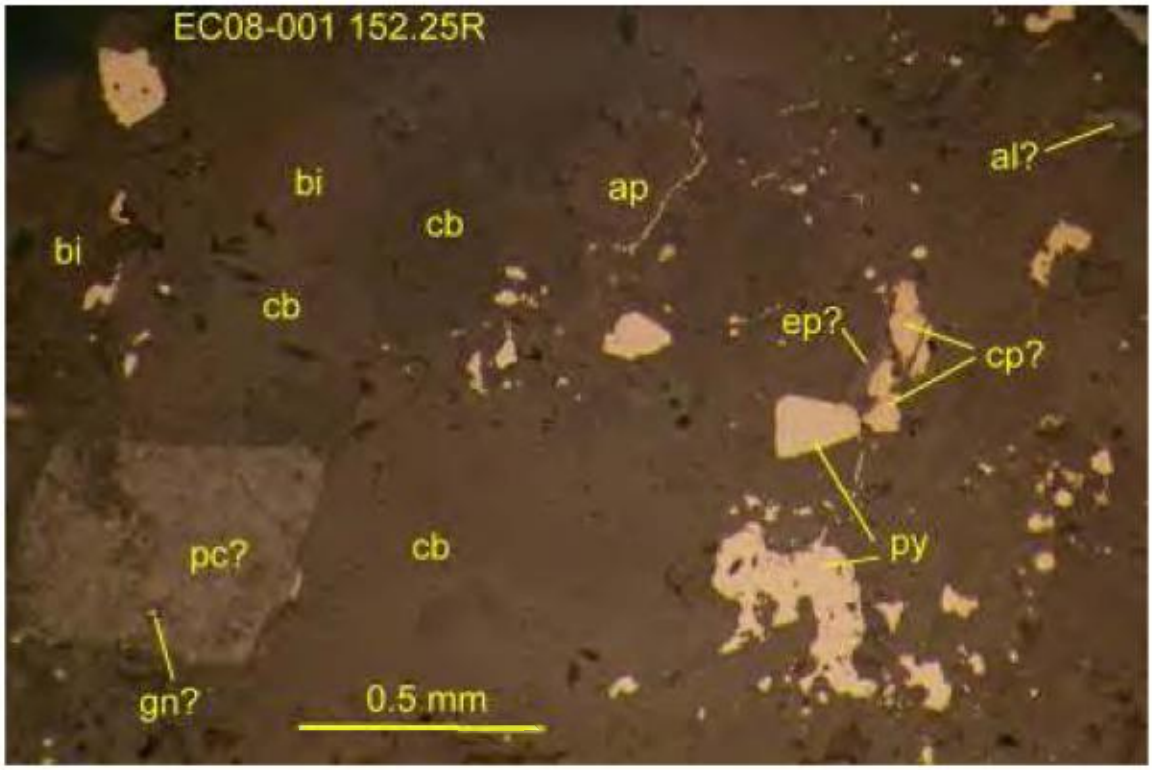
EC08-001 139.49R: Fine-grained ankeritic (?) carbonate (cb) with accessory apatite (ap), pyrite (py) locally associated with unidentified but possibly radioactive mineral (U, surrounded by rim of phlogopite, ph?) and minor galena (gn?). Reflected light, uncrossed polars, field of view 2.25 mm wide.



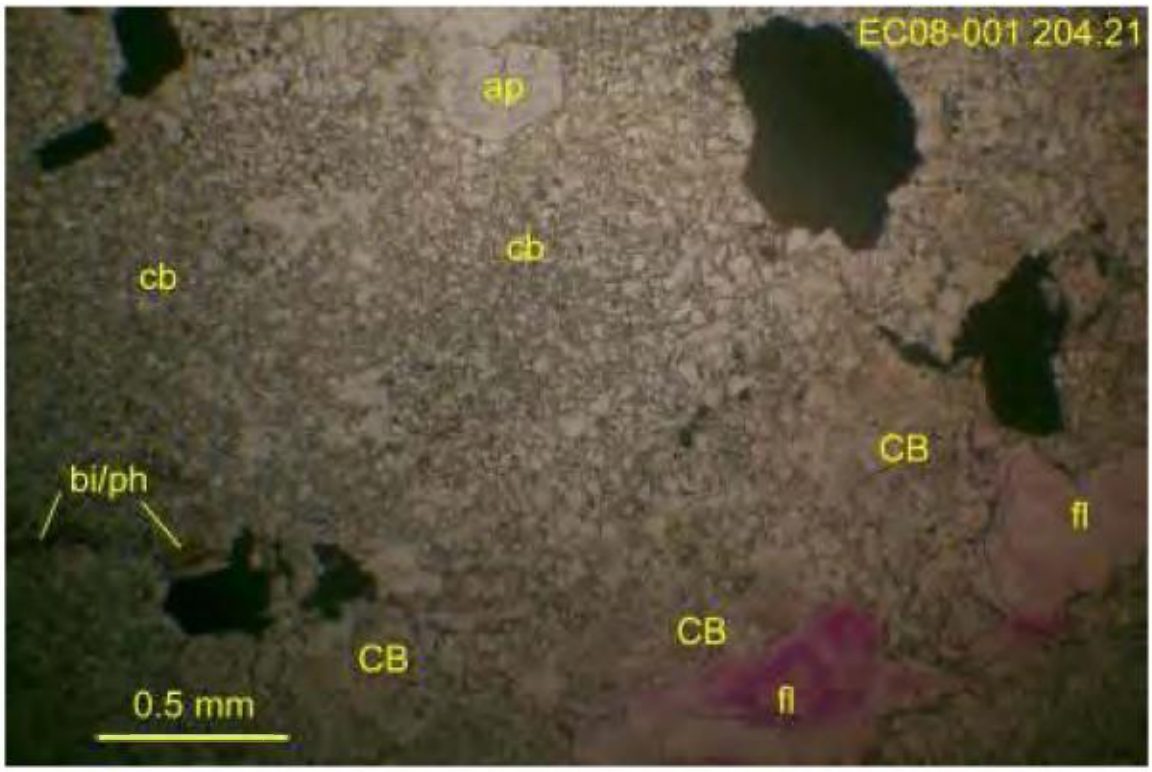
EC08-001 141.34: Pale brown (thin?) euhedral crystals of pyrochlore (pc?) associated with fine-grained carbonate-minor phlogopite matrix (banded; minor fine pyrochlore?) near clasts composed of optically continuous apatite (ap) containing minor pyrite (py), phlogopite (ph) and carbonate (cb) inclusions. Transmitted plane light, field of view 3.0 mm wide.



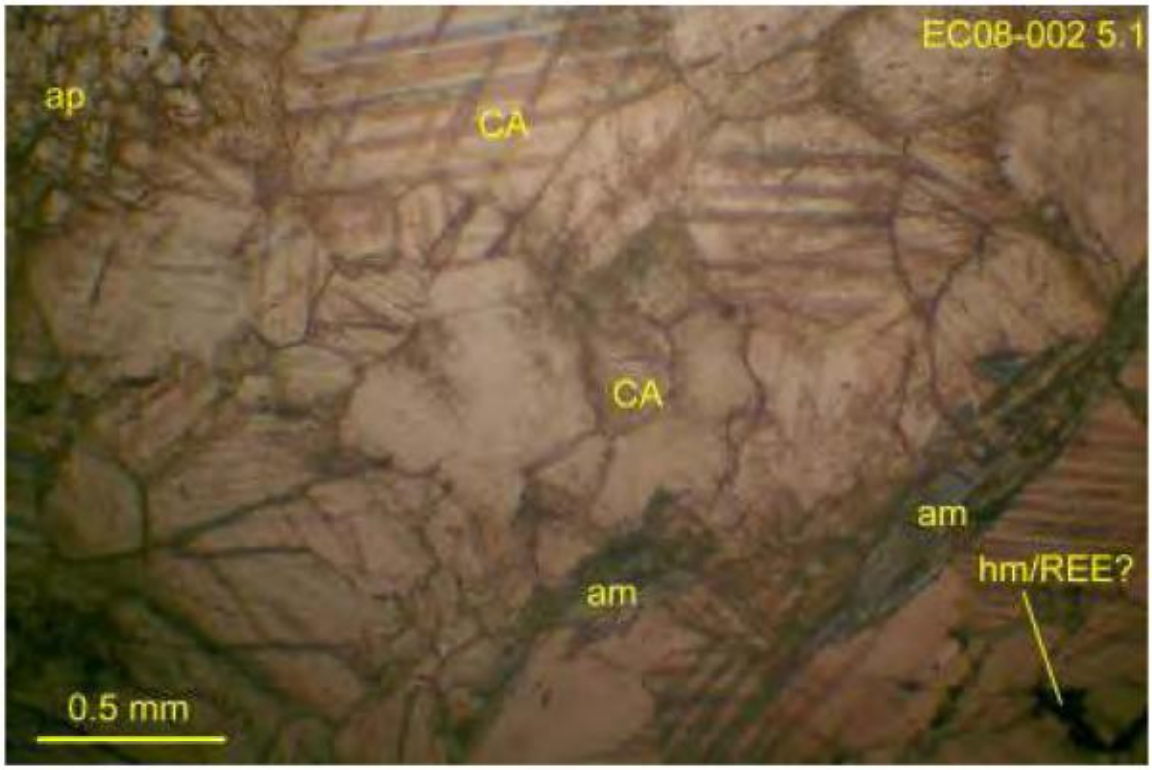
EC08-001 151.12R: Unusual concentrations of possible REE minerals (R values around 12-16) associated with traces of pyrite (py) or pyrrhotite (po) and rare sphalerite? (sl?), surrounded by biotite (bi) in carbonate (cb)-rich clast with minor apatite (ap). Reflected light, uncrossed polars, field of view 2.75 mm wide.



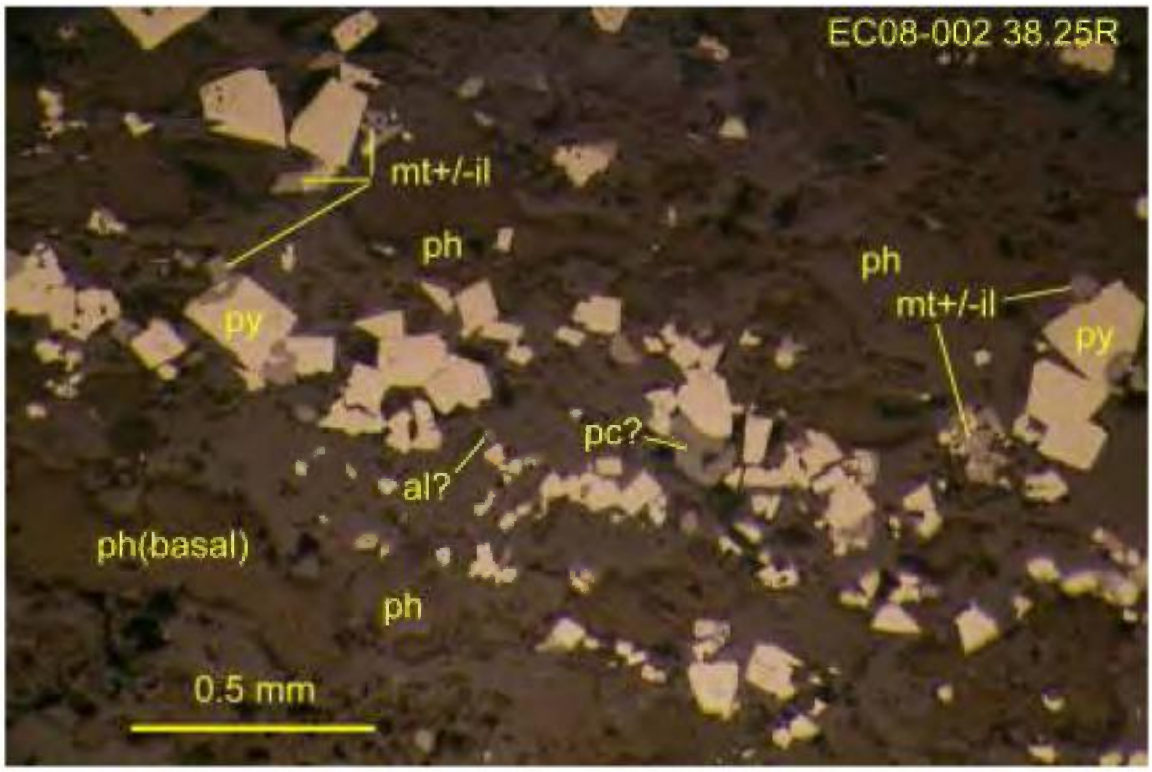
EC08-001 152.25R: Aggregate of possible REE mineral(s) with isometric outline suggestive of pyrochlore (?) associated with sulfides (pyrite, py; chalcopyrite, cp) and local epidote (ep) or in places allanite (al?), in matrix of carbonate (cb), apatite (ap) and biotite (bi). Reflected light, uncrossed polars, field of view 2.25 mm wide.



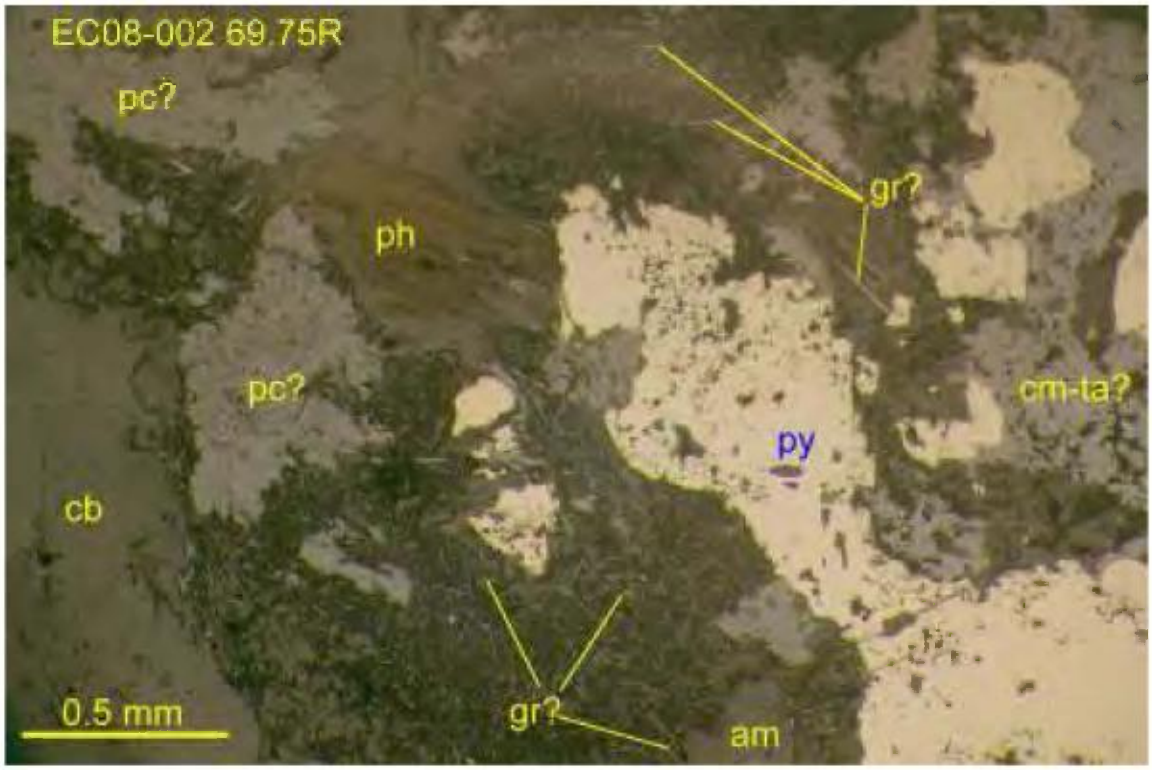
EC08-001 204.21: Fine-grained carbonate (cb) rock with scattered apatite (ap) cut by irregular veins/clots of purple, zoned fluorite (fl), coarse carbonate (CB) and local biotite/phlogopite (bi) and sulfides (opaque). Transmitted plane light, field of view 3.0 mm wide.



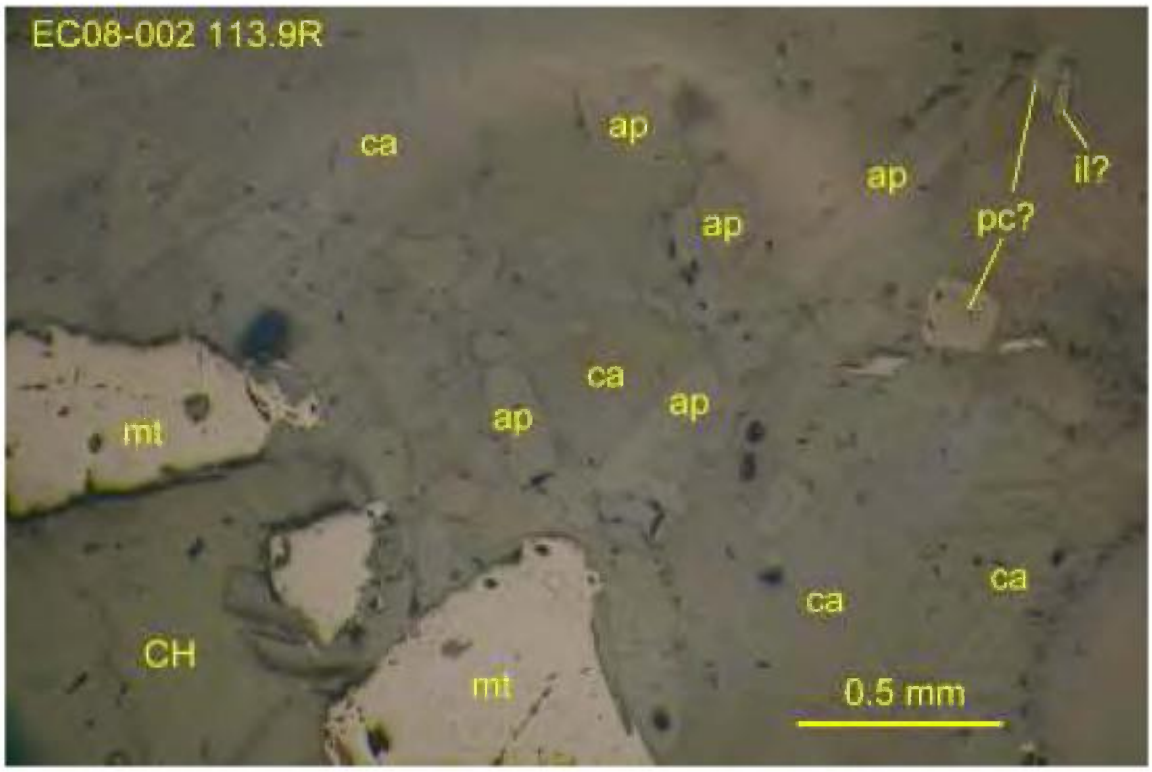
EC08-002 5.1: Coarse-grained, calcite (CA) rich rock with clotty aggregates of apatite (ap) in places, cut by veinlet-like zones of blue-green amphibole (am), likely arfvedsonite, locally associated with narrow veinlet-like concentrations of opaque oxides that could be in part hematized REE minerals (?). Transmitted plane light, field of view 3.0 mm wide.



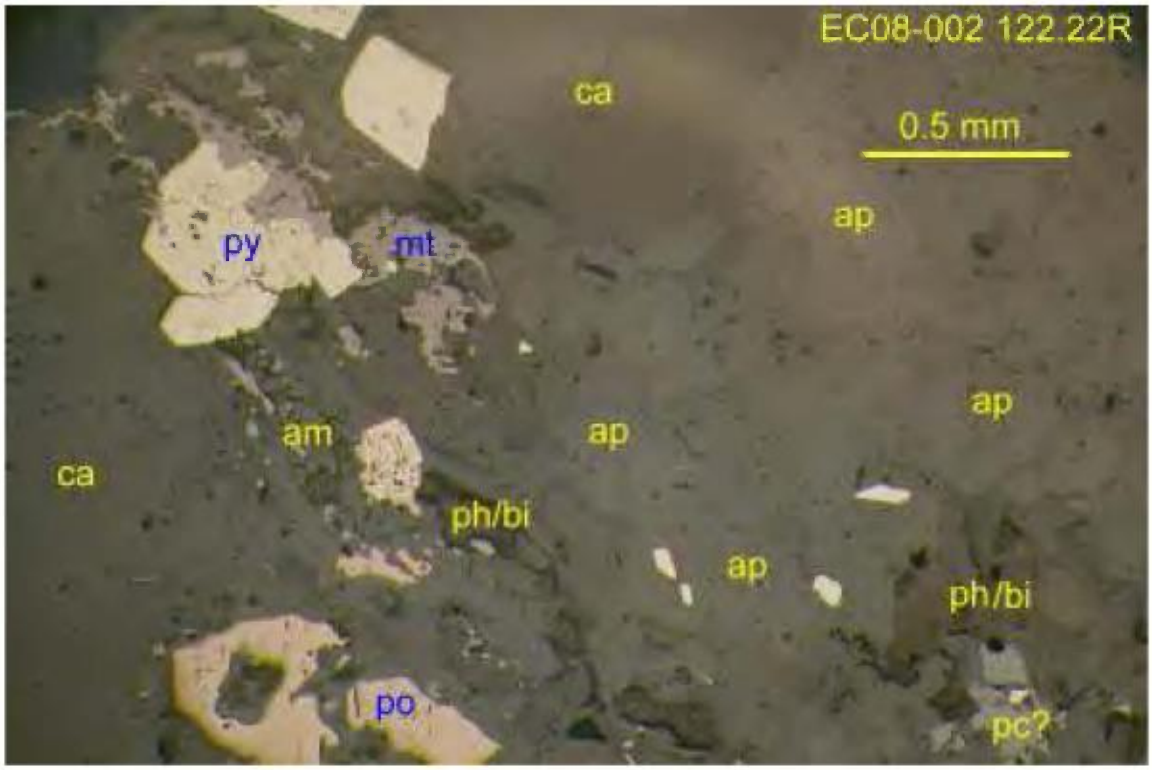
EC08-002 38.25R: Layer of fine-grained cubic pyrite (py) associated with minor magnetite/ilmenite (mt±il) and possible REE minerals such as pyrochlore (pc?) and allanite (al?), the latter showing dark pleochroic halo (not visible in this view) in the enclosing phlogopite (ph) making up the ultramafic host rock. Reflected light, uncrossed polars, 2.25 mm wide.



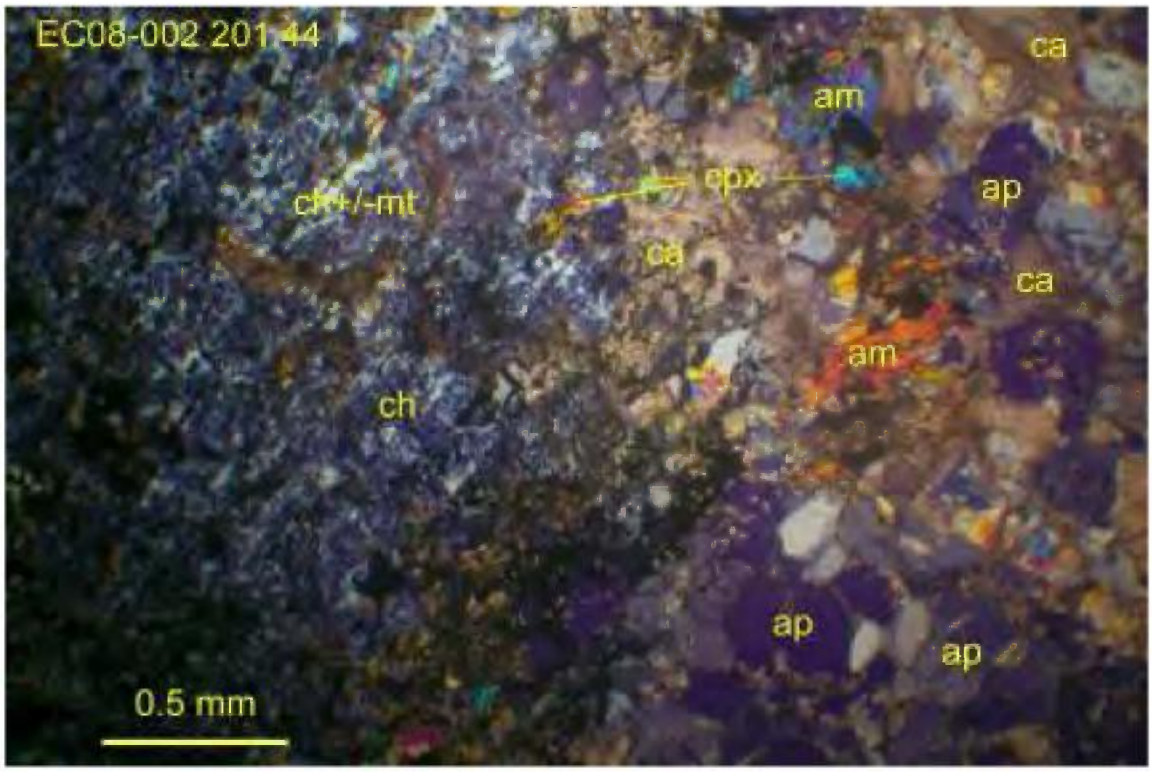
EC08-002 69.75: Border of opaque-dominated layer comprising pyrite (py), graphite (gr) intergrown with carbonate, sub- to euhedral ?REE minerals (collomorphic semi-transparent pyrochlore, pc?, and possible columbite-tantalite, cm-ta?) near carbonate (cb) layer along which amphibole (am) occurs. Reflected light, uncrossed polars, field of view 2.75 mm wide.



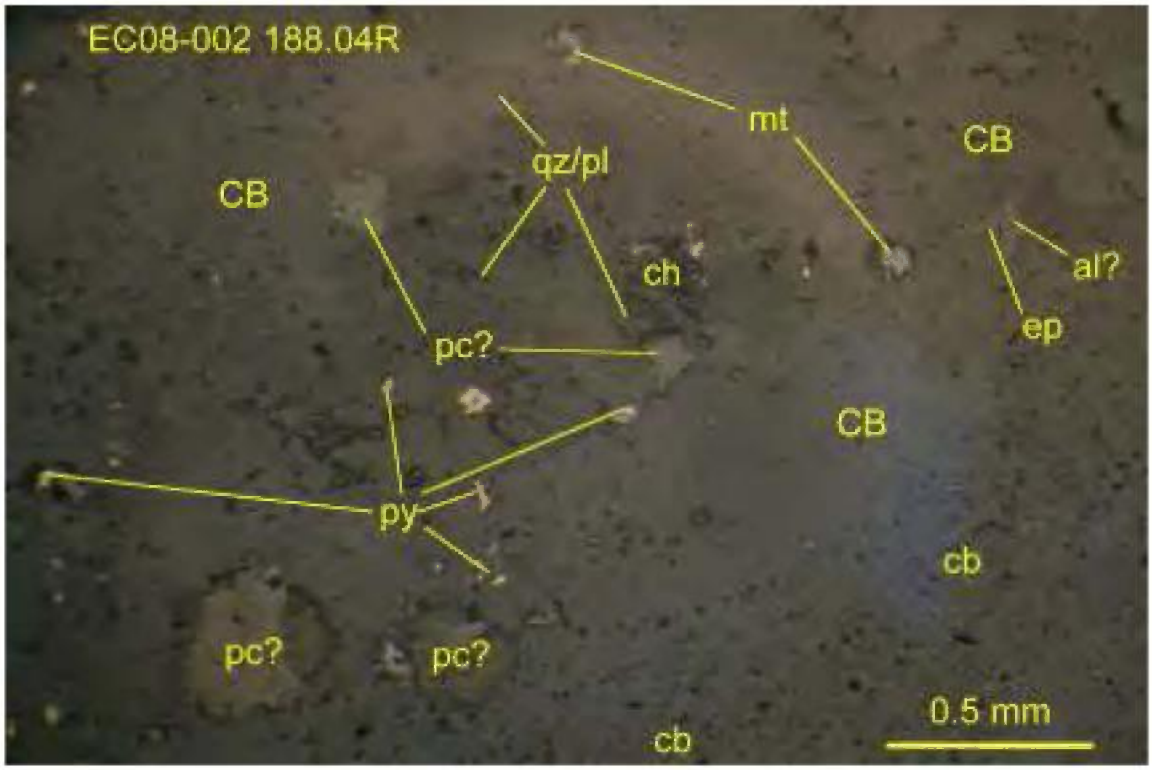
EC08-002 113.9R: Calcite carbonatite composed of calcite (ca), containing accessory magnetite (mt) associated with chlorite (CH) pseudomorphs after former mafic mineral (?), euhedral apatite (ap), and traces of possible REE mineral such as pyrochlore (pc?) with possible tabular ilmenite (il?). Reflected light, uncrossed polars, field of view 2.75 mm.



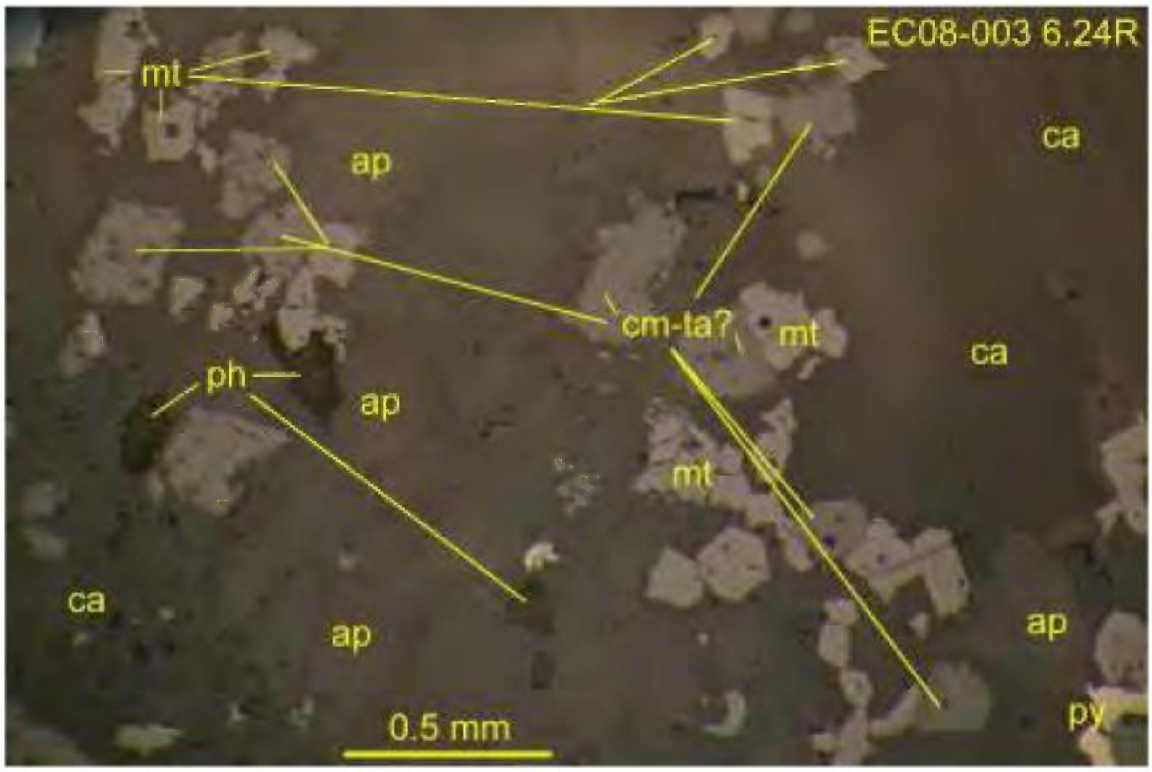
EC08-002 122.22R: Intergrown apatite (ap), phlogopite/biotite (ph/bi), minor arfvedsonite (am), pyrite (py), pyrrhotite (po) and traces of pyrochlore (pc?) along interstices between coarse calcite (ca) crystals. Reflected light, uncrossed polars, field of view 2.75 mm wide.



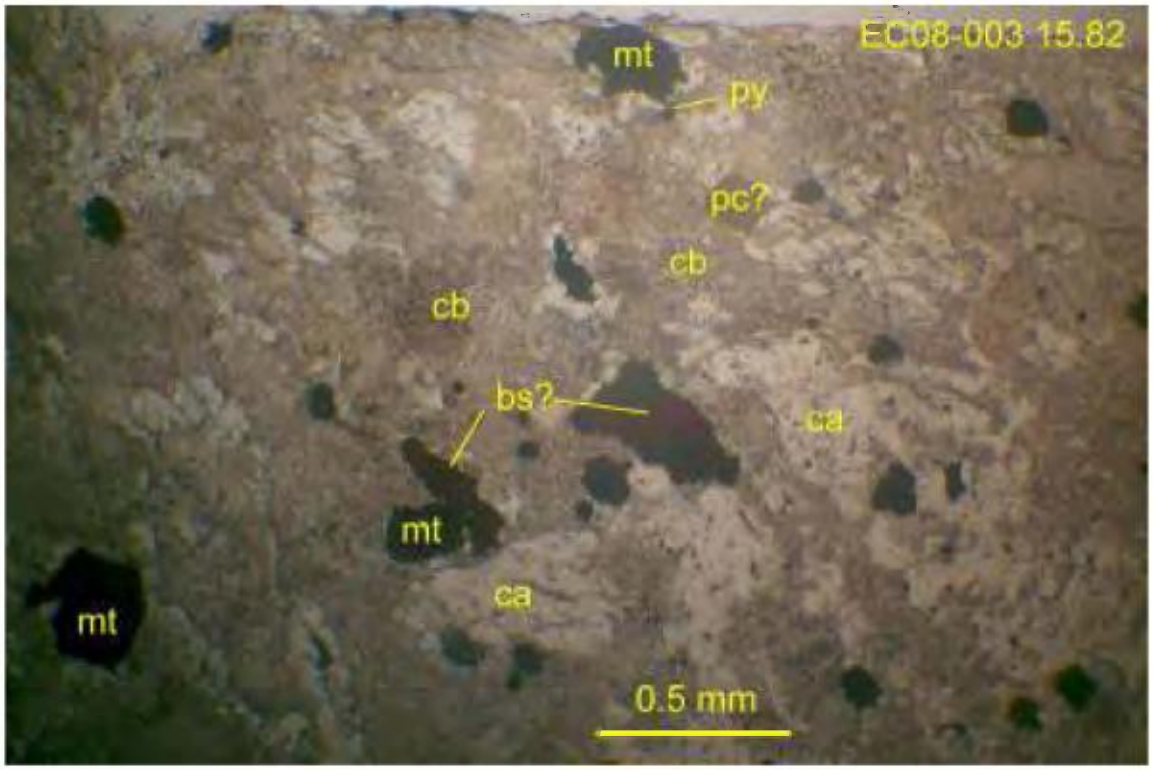
EC08-002 201.44: Relict mafic crystal (originally pyroxene?) now largely replaced by colourless, tremolitic amphibole (am) and matted chlorite (ch) plus carbonate (ca) and secondary magnetite (opaque), leaving only traces of clinopyroxene (cpx) and included crystals of apatite (ap). Transmitted light, crossed polars, field of view 3.0 mm wide.



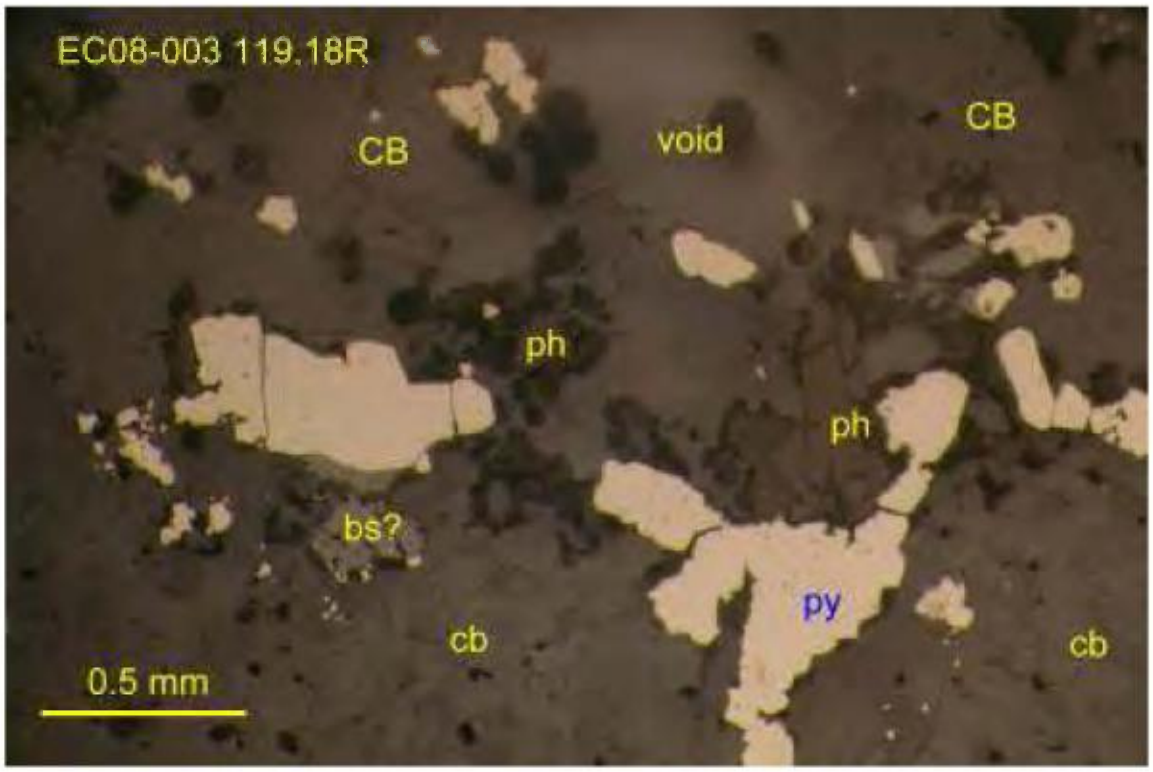
EC08-002 188.04R:Coarse-grained dolomitic carbonatite (CB) with concentrations of pyrite (py)-magnetite (mt)-possible pyrochlore (pc?)-epidote/allanite (ep, al), local quartz or plagioclase (qz/pl), chlorite (ch), cut by vein zone of finer-grained Fe-dolomitic carbonatite (cb). Reflected light, uncrossed polars, field of view 2.75 mm wide.



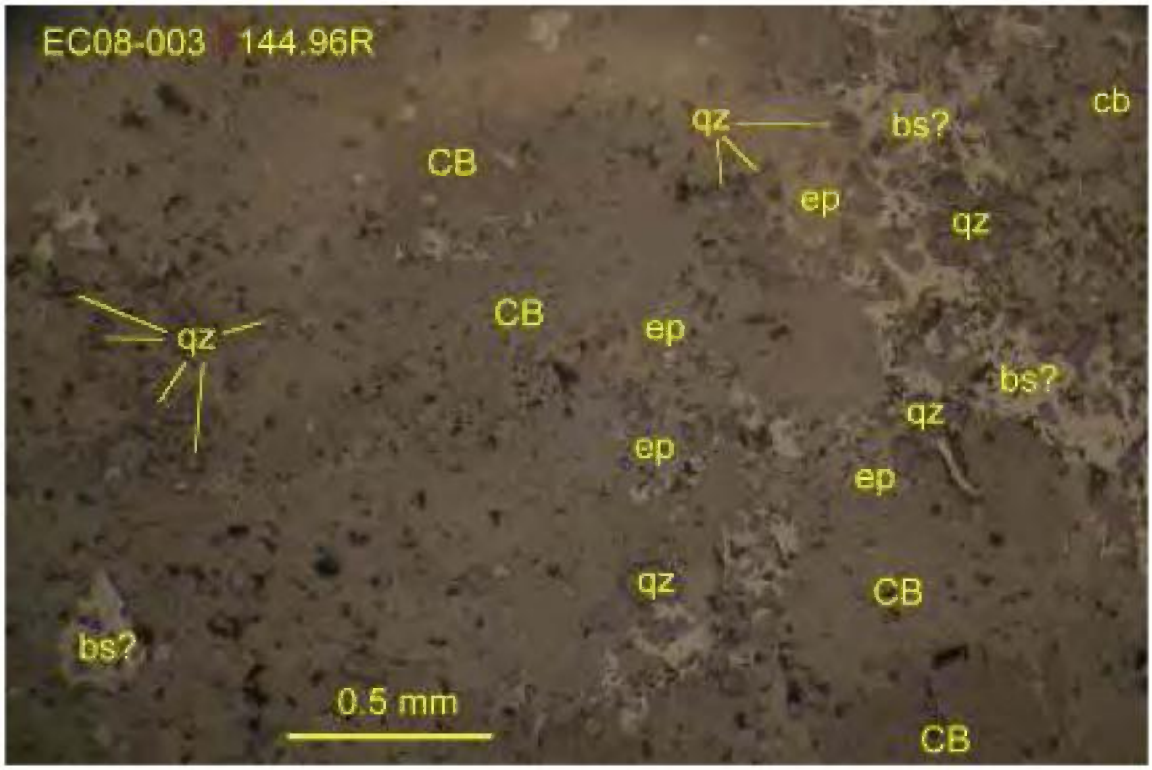
EC08-003 6.24R: Carbonatite with bands or layers enriched in calcite (ca), apatite (ap), magnetite (mt) or associated REE mineral (mainly columbite-tantalite, cm-ta?), minor biotite/phlogopite (ph), or pyrite (py). Reflected light, uncrossed polars, field of view 2.75 mm wide.



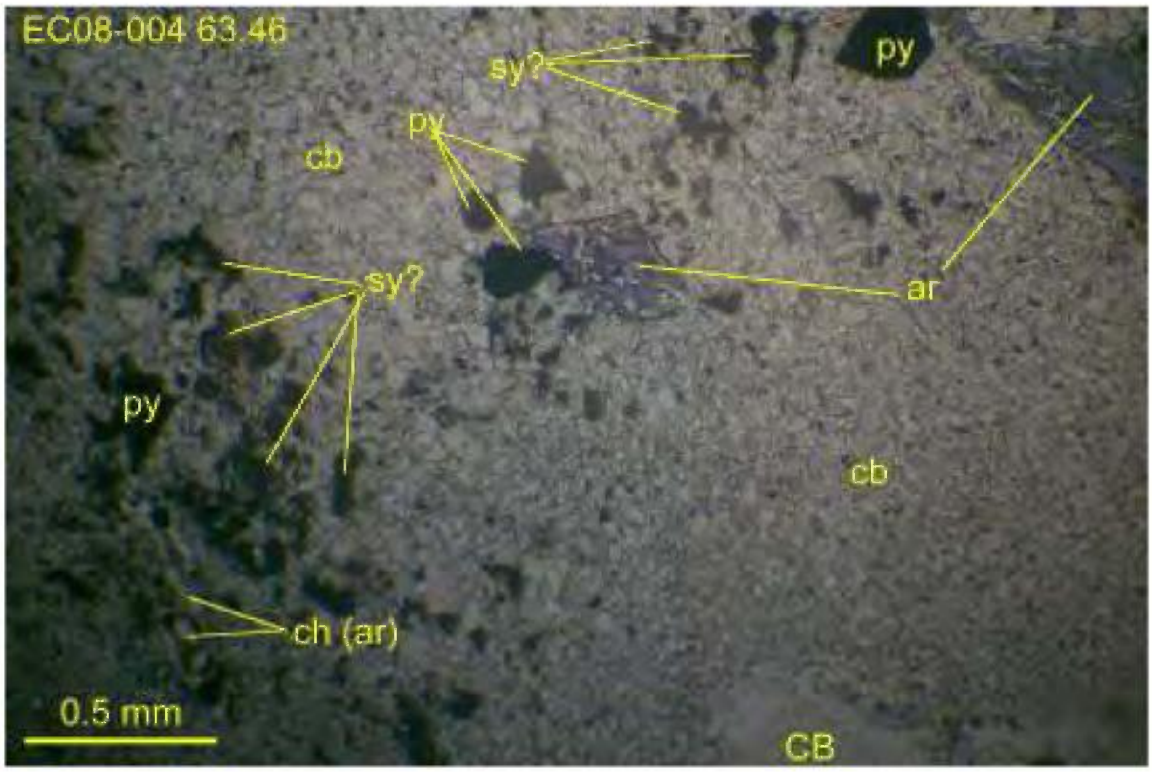
EC08-003 15.82: Clear calcite (ca) and brownish Fe-dolomite? (cb) hosting magnetite (opaque, mt; trace pyrite, py) and red-brown possible REE-mineral (pyrochlore, pc?, or bastnaesite, bs?). Transmitted plane light, field of view 3.0 mm wide.



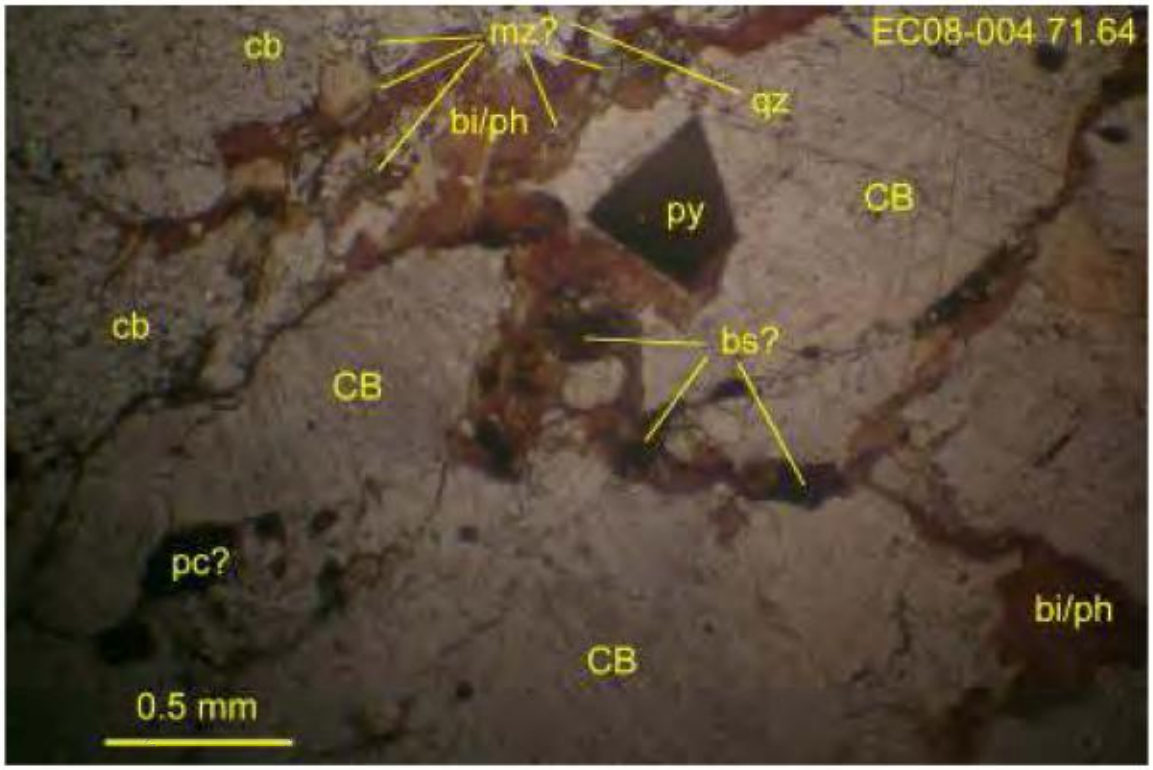
EC08-003 119.18R: Pyrite (py) and phlogopite (ph) associated with possible bastnaesite, bs?) along contact between fine-grained carbonate (cb) and medium-grained carbonate (CB) layers or zones in Fe-dolomitic carbonatite. Plucking of the zone has produced voids. Reflected light, uncrossed polars, field of view 2.75 mm wide.



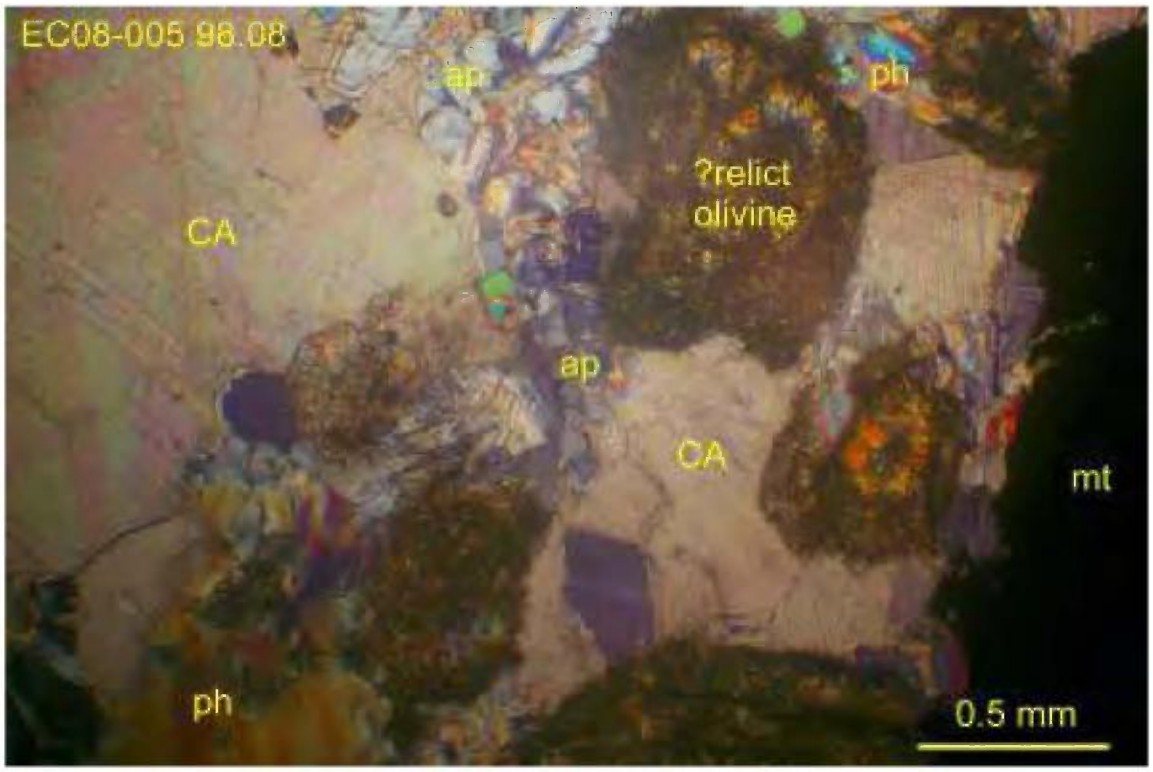
EC08-003 144.96R: REE-mineral (mainly bastnaesite, bs?) concentrated along veinlet-like zone at margin of coarse carbonatite (CB) in contact with fine carbonatite; similar bastnaesite (?) also occurs associated with secondary quartz (qz) and epidote (ep) along intergranular boundaries. Reflected light, uncrossed polars, field of view 2.75 mm wide.



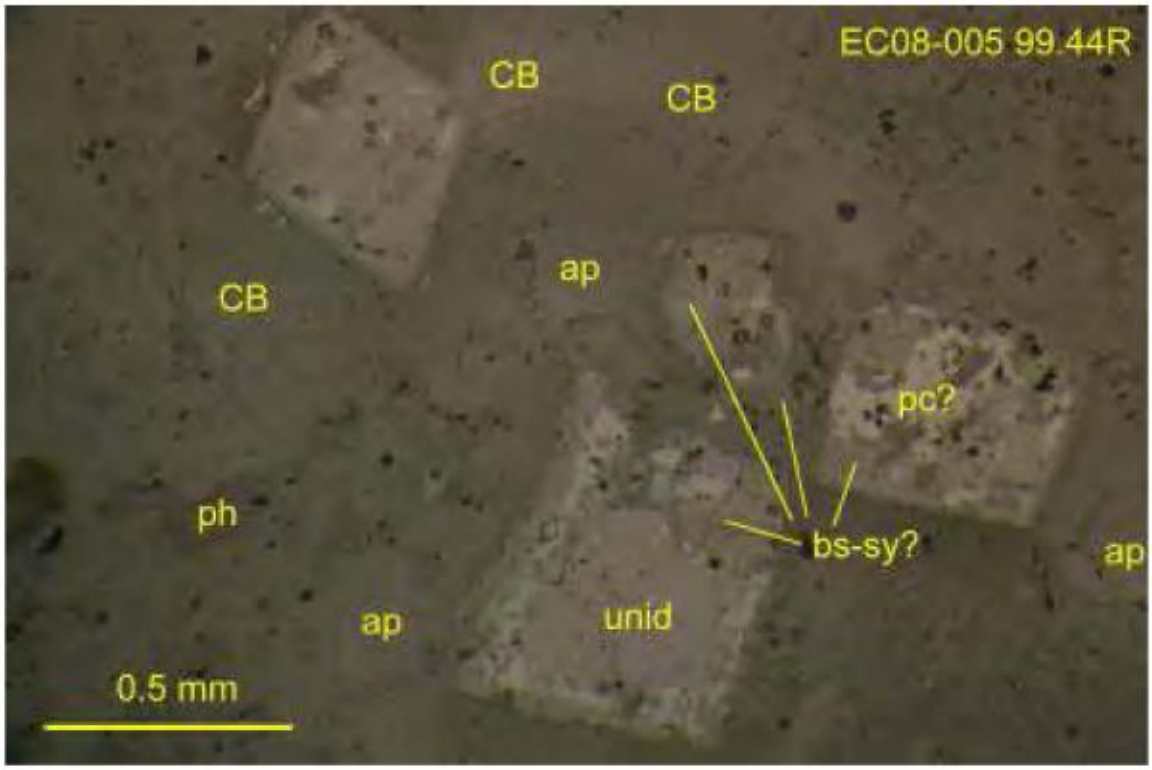
EC08-004 63.46: Coarse dolomitic carbonatite (CB) cut by matrix of fine Fe-dolomitic carbonatite (cb) with accessory blue-purple pleochroic Na-amphibole arfvedsonite (ar), pyrite (opaque, py), yellow-brown fibrous possible synchesite (sy?). Transmitted plane light, field of view 3.0 mm wide.



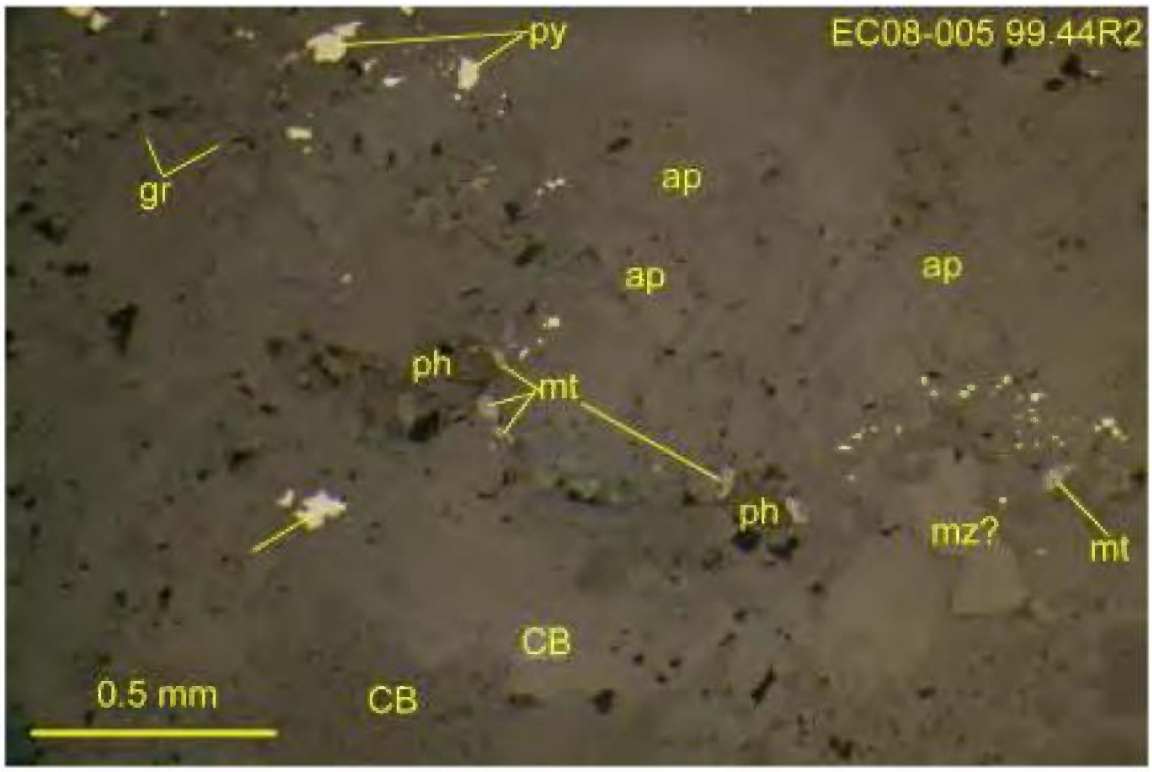
EC08-004 71.64: Contact zone between coarse carbonate (CB) and finer carbonate (cb) marked by concentrations of biotite/phlogopite (ph), euhedral pyrite (py), minor quartz (qz), and REE minerals (red-brown bastnaesite, bs?, clear or pale yellow monazite, mz?, opaque pyrochlore, pc?). Transmitted plane light, field of view 3.0 mm wide.



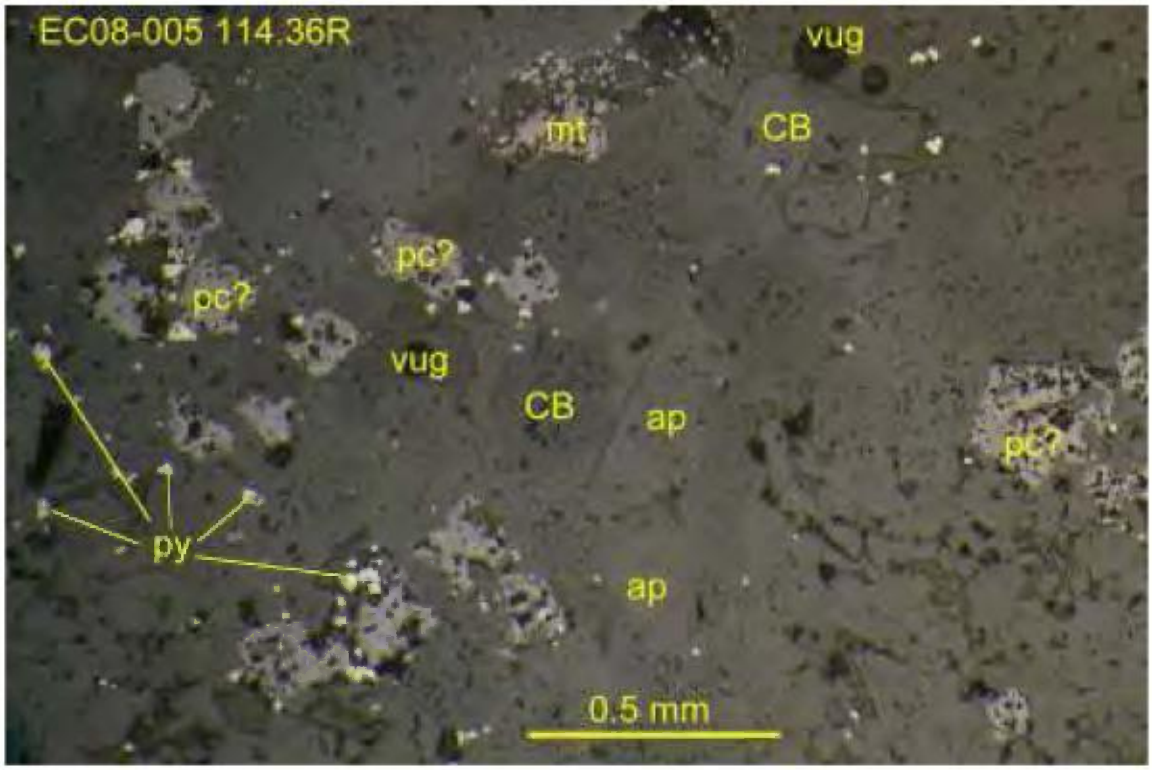
EC08-005 98.08: Coarse calcite (CA) carbonatite containing magnetite (mt) associated with unidentified orange mineral (relict olivine altered to iddingsite and serpentine?), prismatic apatite (ap) and minor phlogopite (ph). Transmitted light, crossed polars, field of view 3.0 mm wide.



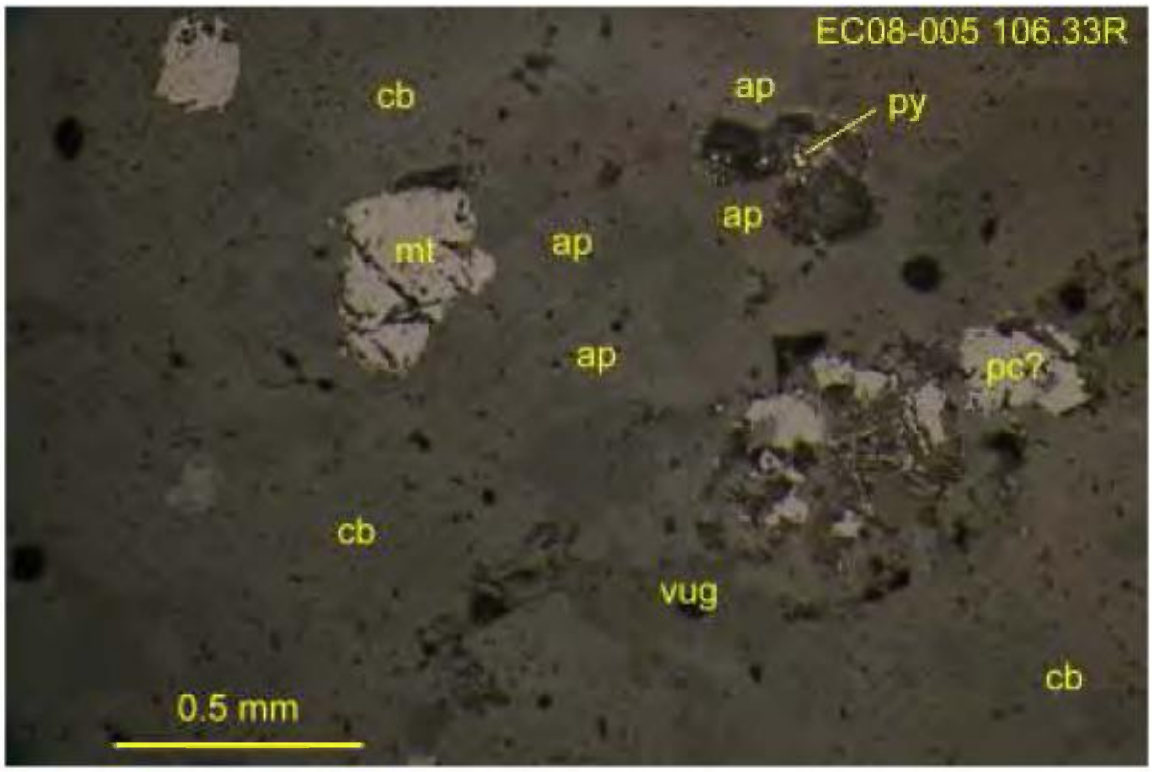
EC08-005 99.44R: Relict pyrochlore (?) with euhedral outlines possibly now composed of unidentified cores surrounded by irregular zones of higher –R pyrochlore (pc?), and lowest R rims of bastnaesite-synchesite? (bs-sy?), associated with apatite (ap) and phlogopite (ph) in carbonate (CB). Reflected light, uncrossed polars, field of view 2.25 mm wide.



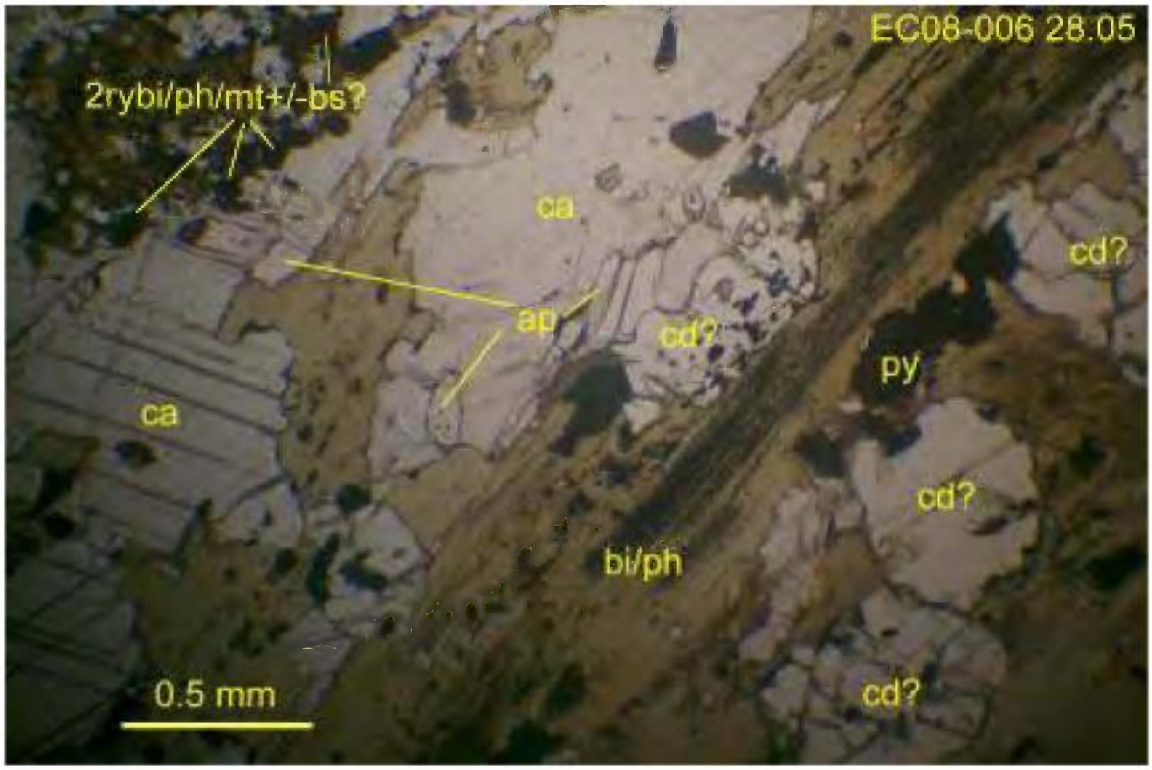
EC08-005 99.44R2: Vein-like zone of apatite (ap), phlogopite (ph), minor possible monazite (mz?), magnetite (mt), pyrite (py), and minute flakes of graphite (gr) associated with coarse-grained carbonate (CB). Reflected light, uncrossed polars, field of view 2.25 mm wide.



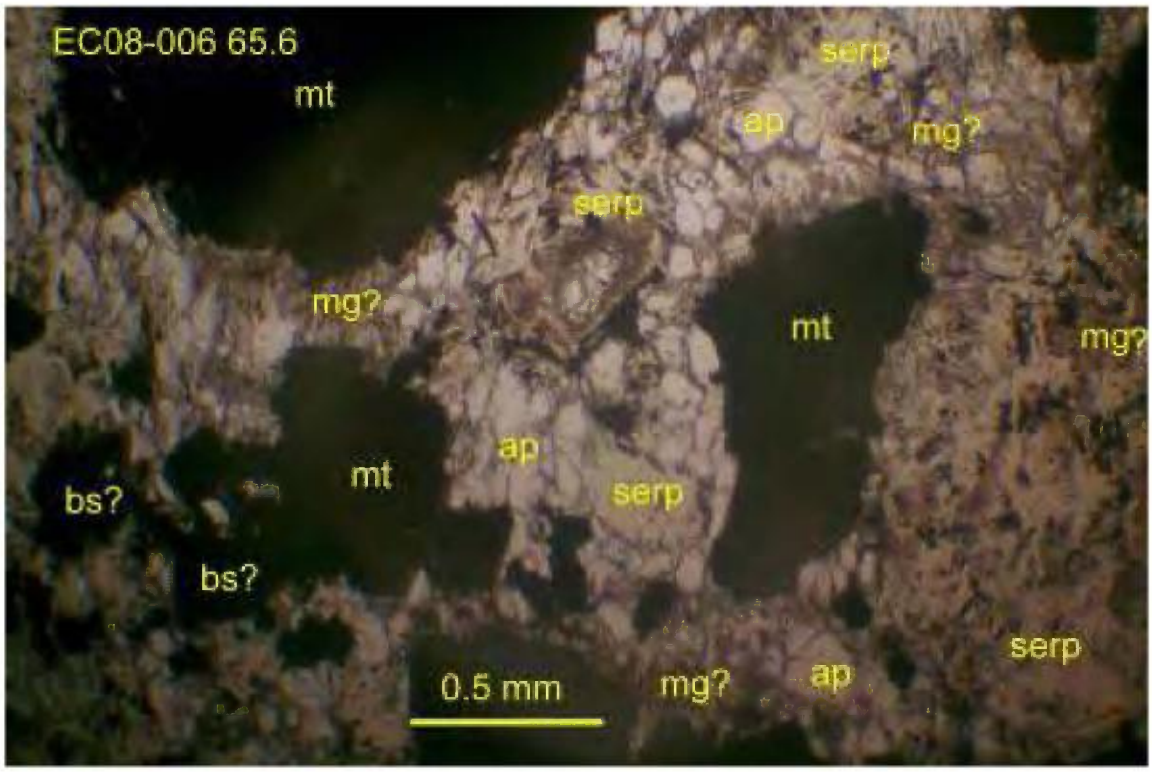
EC08-005 114.36R: Dolomitic carbonate (cb) containing euhedral magnetite (mt, with poor polish) and vuggy zones of REE-mineral (possibly mainly pyrochlore, pc?) associated with prismatic apatite (ap) and very fine-grained pyrite (py). Reflected light, uncrossed polars, field of view 2.25 mm wide.



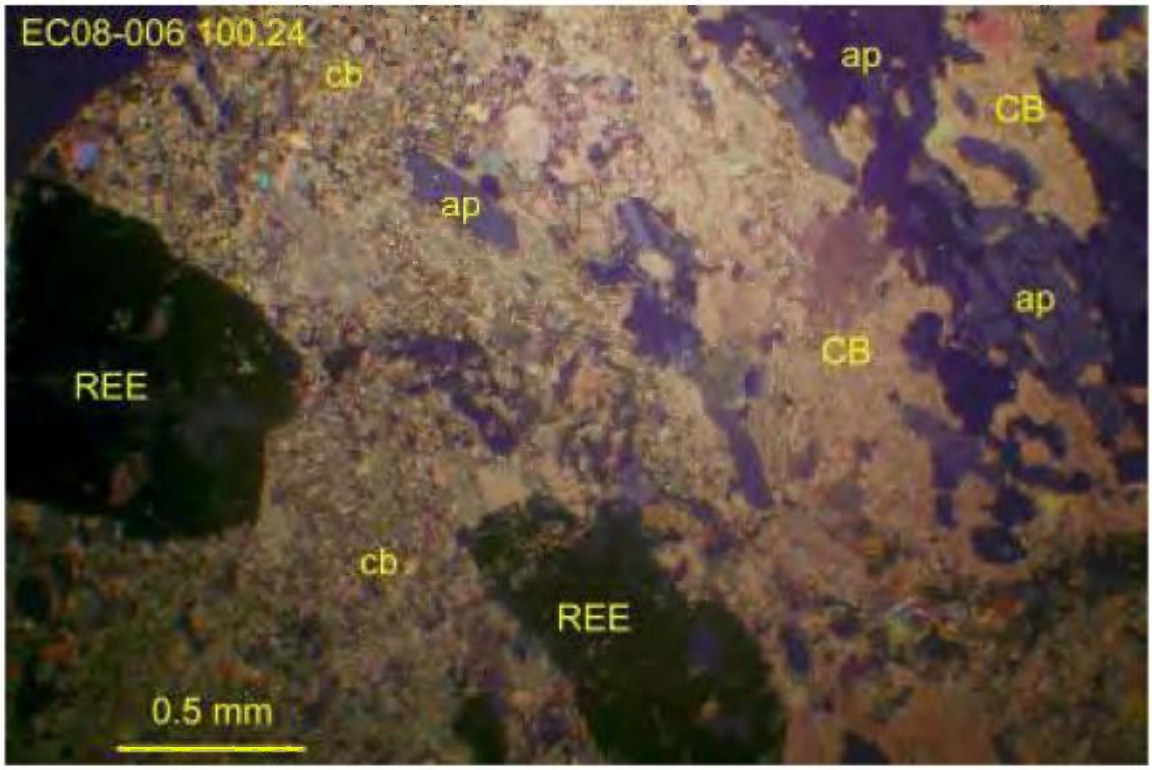
EC08-005 106.33R: Fe-dolomite carbonatite in which apatite (ap), magnetite (mt) and local possible REE minerals (mainly pyrochlore, pc?) are associated with vugs in the carbonate (cb). Reflected light, uncrossed polars, field of view 2.25 mm wide.



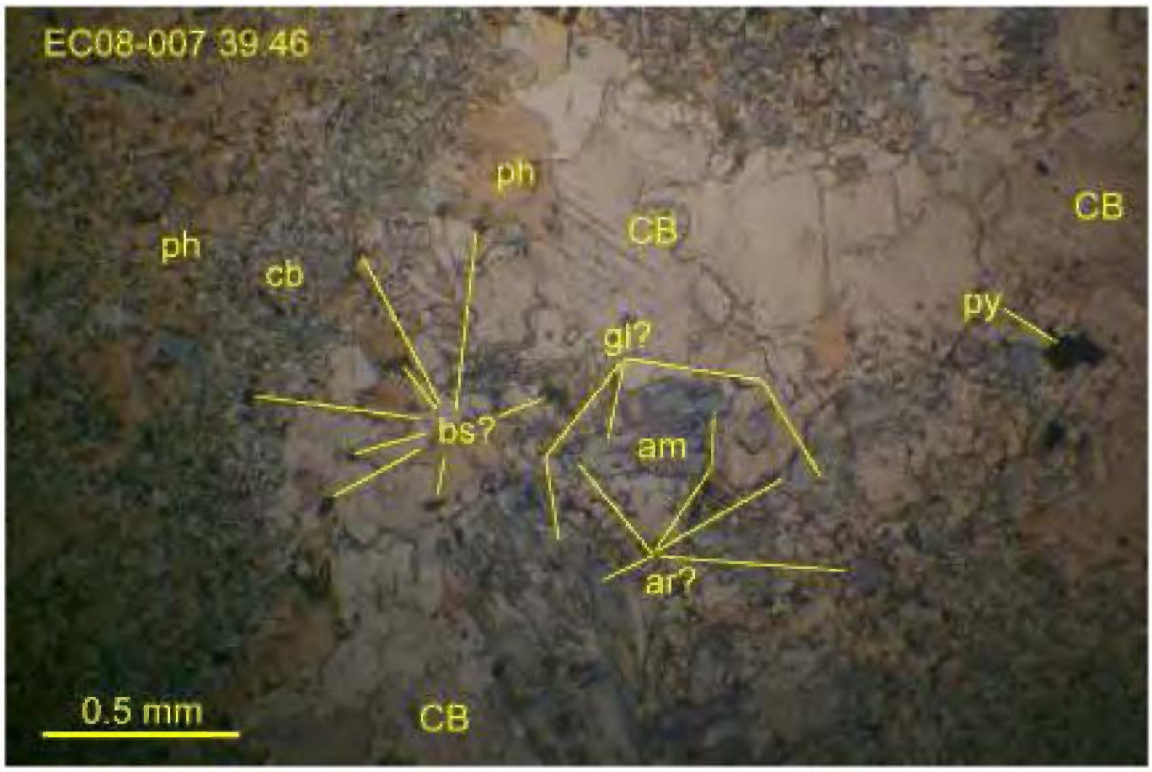
EC08-006 28.05: Coarse blastic mica (bi/ph) with inclusions of pyrite (py), possible cordierite (cd?) partly altered along cleavages to chlorite/serpentine, in matrix of calcite (ca) with minor apatite (ap), relict amphibole (replaced by secondary bi/ph, magnetite (mt), trace bastnaesite (bs?). Transmitted plane light, field of view 3.0 mm wide.



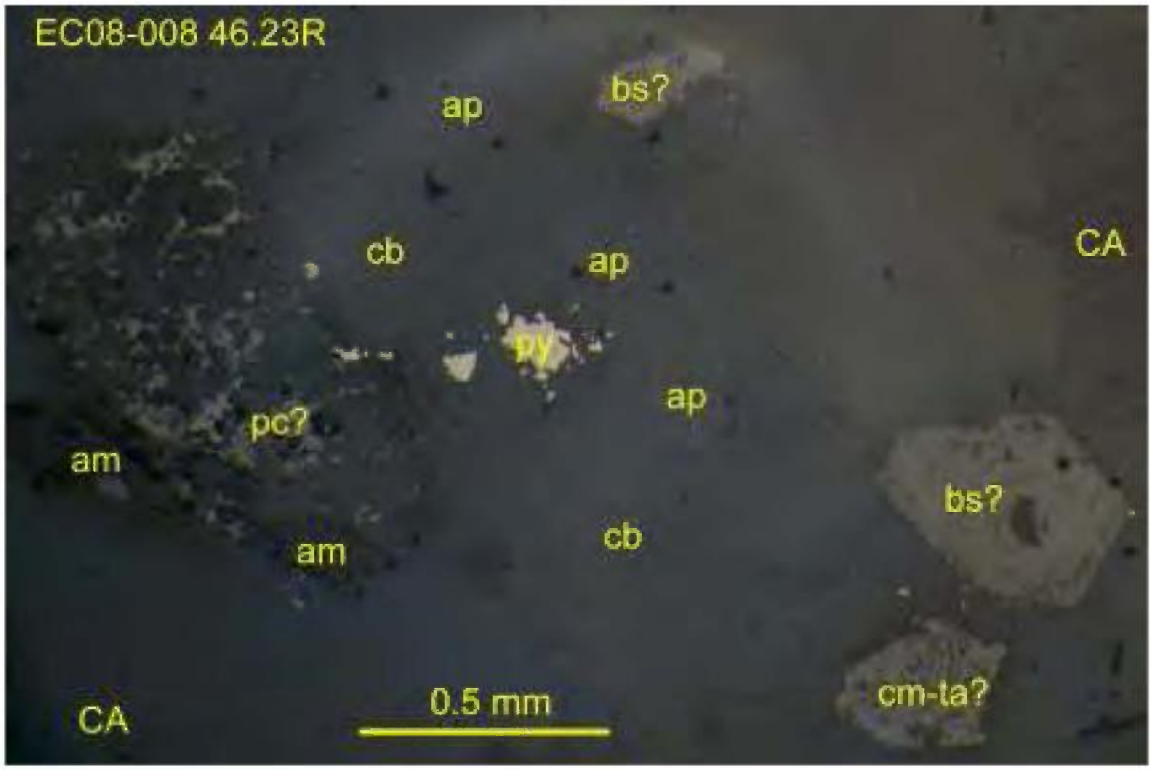
EC08-006 65.6: Ultramafic rock composed of coarse, possibly cumulate, magnetite (mt), minor REE mineral (possibly bastnaesite, bs?) and apatite (ap) in matrix of serpentine (serp)-Mg carbonate (mg?) altered possibly original olivine relicts. Transmitted plane light, field of view 3.0 mm wide.



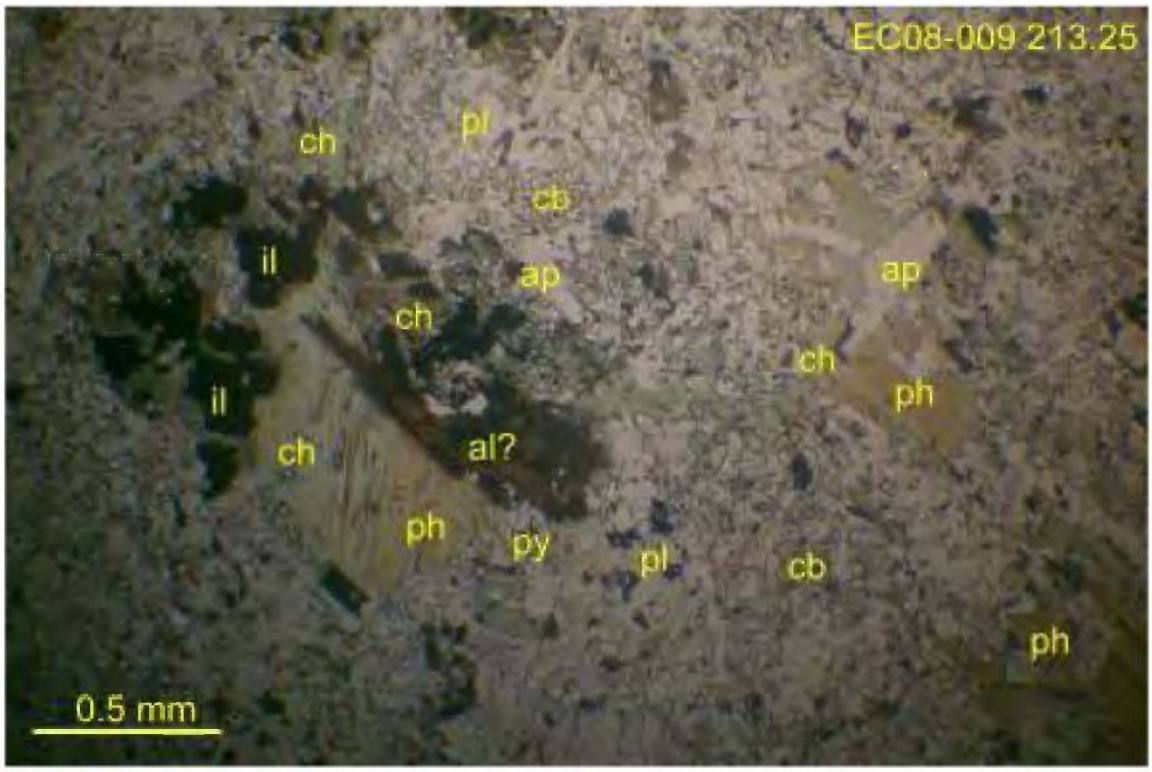
EC08-006 100.24: REE minerals (possibly mostly columbite-tantalite?) associated with coarser carbonate (CB) and apatite (ap) along vein-like zones in fine-grained dolomitic carbonatite (cb). Transmitted light, crossed polars, field of view 3.0 mm wide.



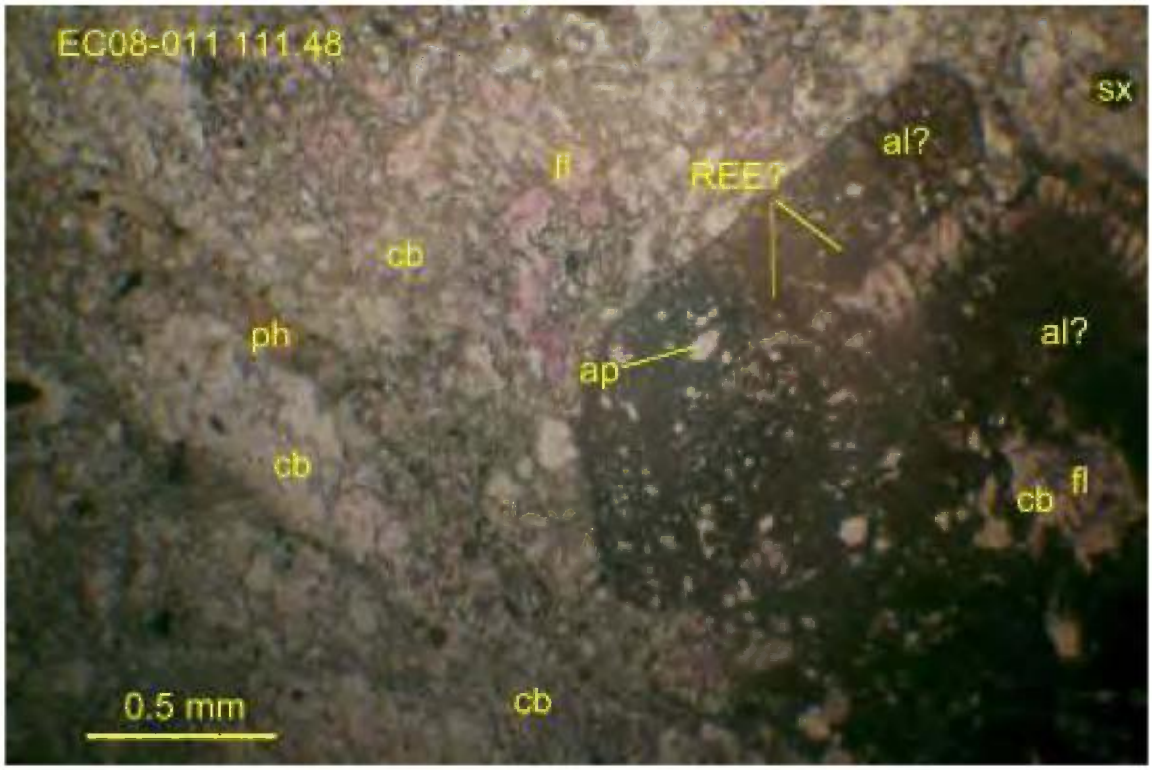
EC08-007 39.46: Coarse-grained carbonate (CB) with phlogopite (ph) and blue-green or bluish-purple Na amphibole (glaucophane, gl? cores and arfvedsonite, ar? rims) associated with pyrite (py) and traces of REE-mineral, possibly bastnaesite (bs?) in vein zone sub-parallel layering in fine-grained carbonate (cb)-phlogopite rock. Transmitted plane light, field of view 3.0 mm wide.



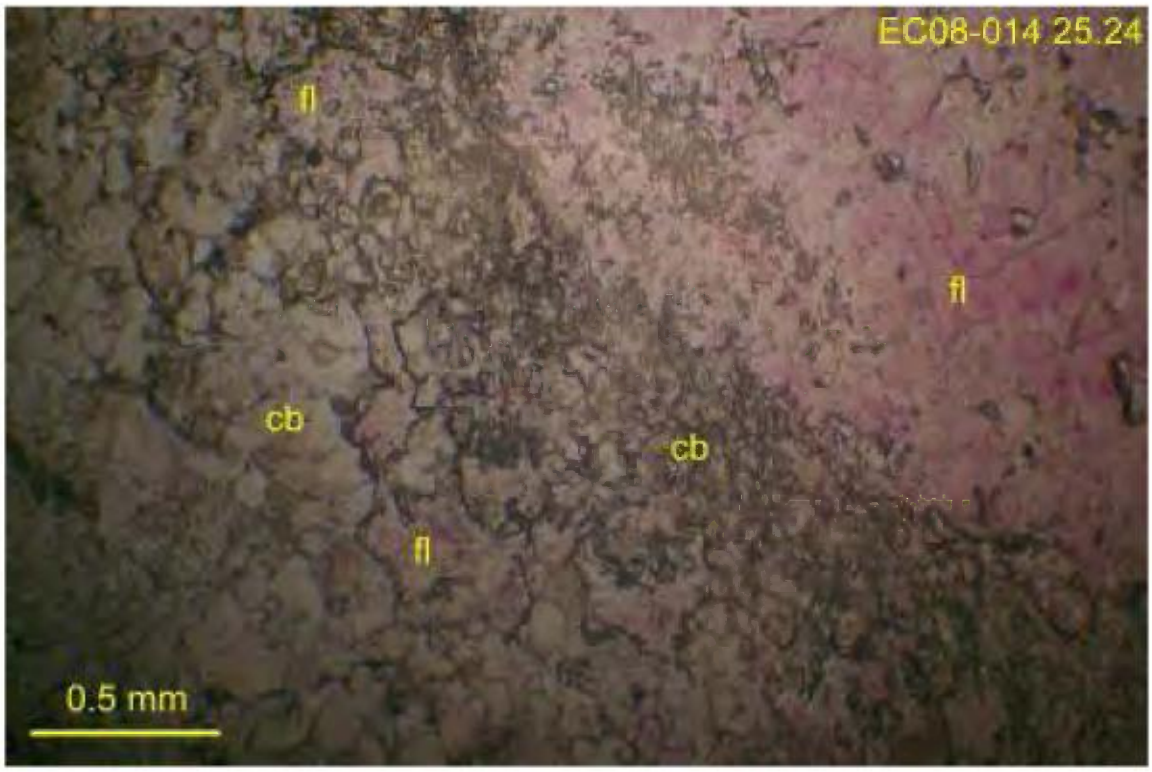
EC08-008 46.23: Matrix to calcite (CA) clasts, composed of carbonate (cb), apatite (ap), REE oxides (possibly bastnaesite, bs?, columbite-tantalite, cm-ta?, and pyrochlore, pc?) associated with minor amphibole (am) and trace pyrite (py). Reflected light, uncrossed polars, field of view 2.25 mm wide.



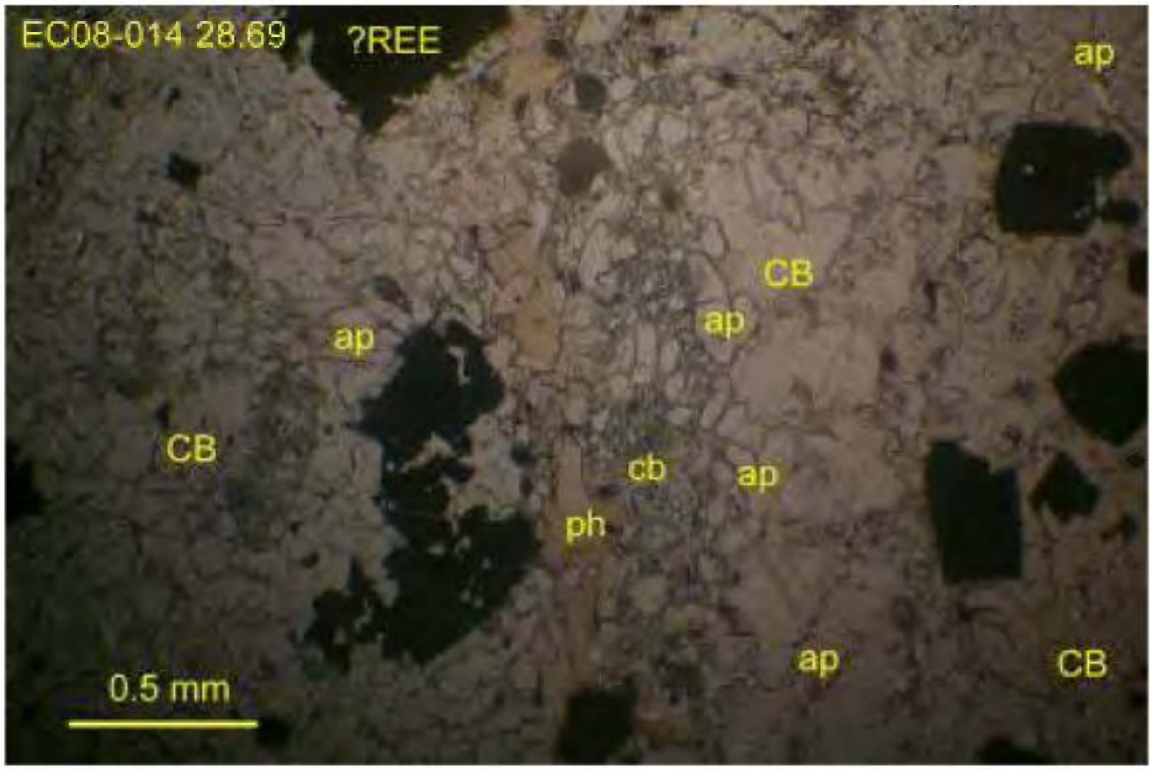
EC08-009 213.25: Clot of ilmenite (opaque, il), apatite (ap) and pale brownish phlogopite (ph) partly chloritized at margin or altered to brown radiation damaged halo around brown, possible allanite (al?) containing traces of pyrite (py), in matrix of plagioclase (pl)-carbonate (cb)-chlorite (ch). Transmitted plane light, field of view 3.0 mm wide.



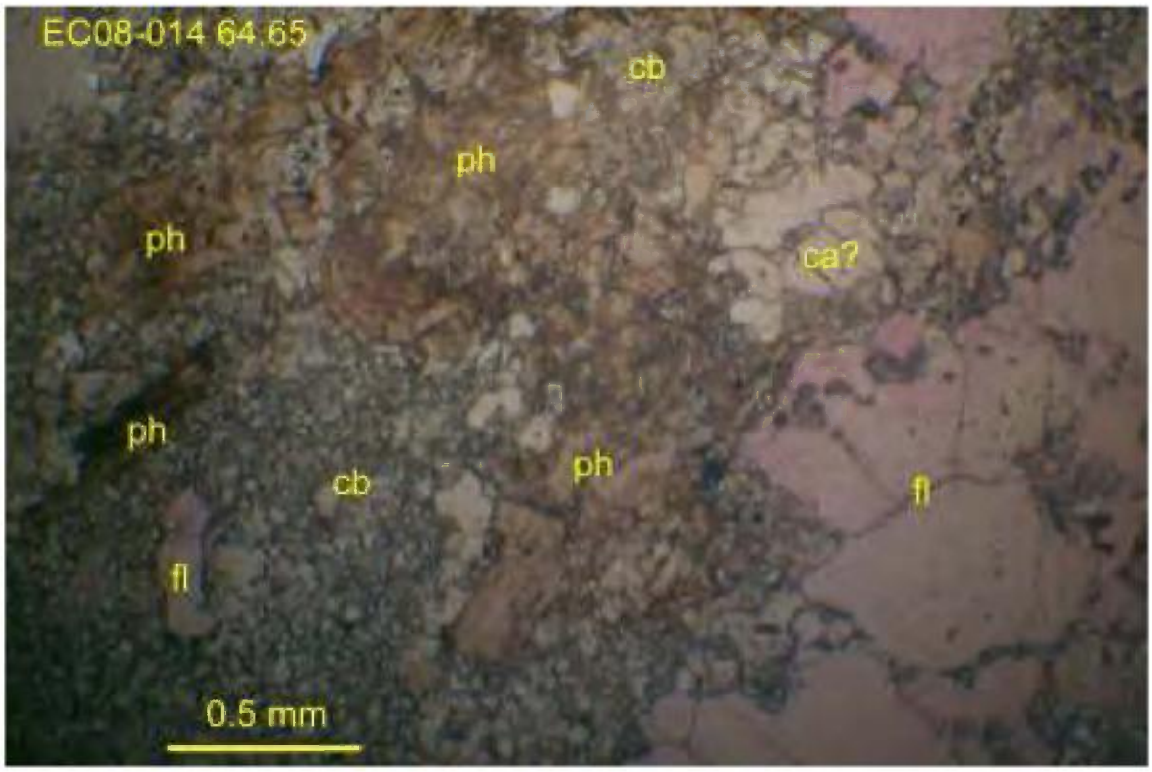
EC08-011 111.48: Large zoned possible allanite (al?) crystal in matrix of carbonate (cb), purple fluorite (fl), minor biotite or phlogopite (ph), and local sulfide (opaque). Minor apatite (ap) occurs as inclusions in the crystal, as do local crystals of possible REE mineral. Transmitted plane light, field of view 3.0 mm wide.



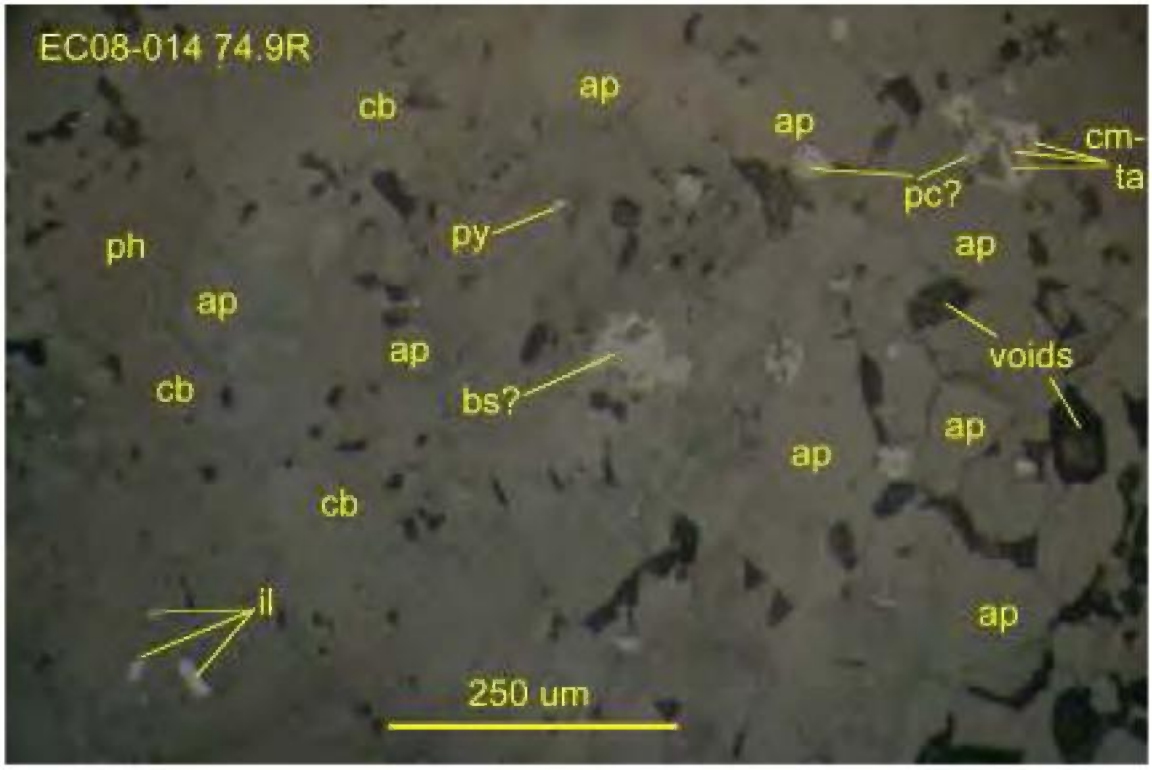
EC08-014 25.24: Interbanded pale purple fluorite (fl) and clear to brownish, fine-grained, carbonate. Note inclusions of carbonate within fluorite. Transmitted plane light, field of view 3.0 mm wide.



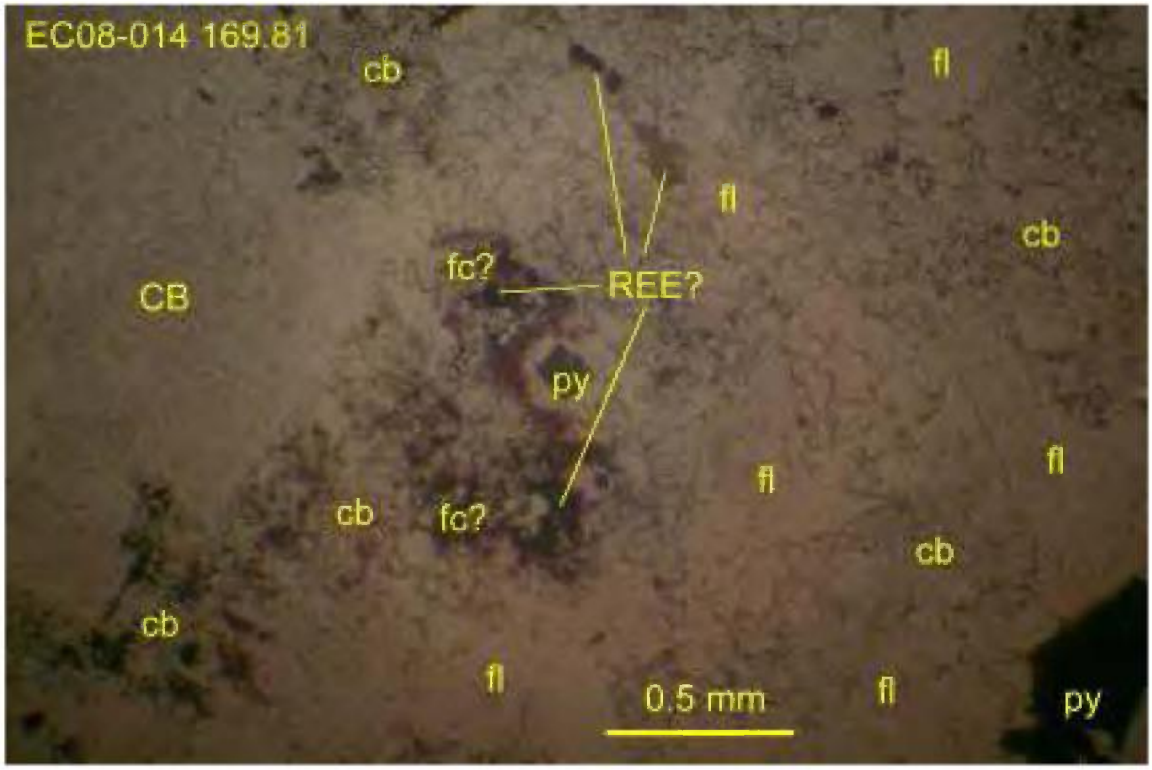
EC08-014 28.69: Carbonate (CB) rich clast containing abundant apatite (ap) and semi-opaque, possible REE mineral (?), cut by narrow veinlet of matrix material (with finer-grained carbonate, cb, and abundant phlogopite, ph). Transmitted plane light, field of view 3.0 mm wide.



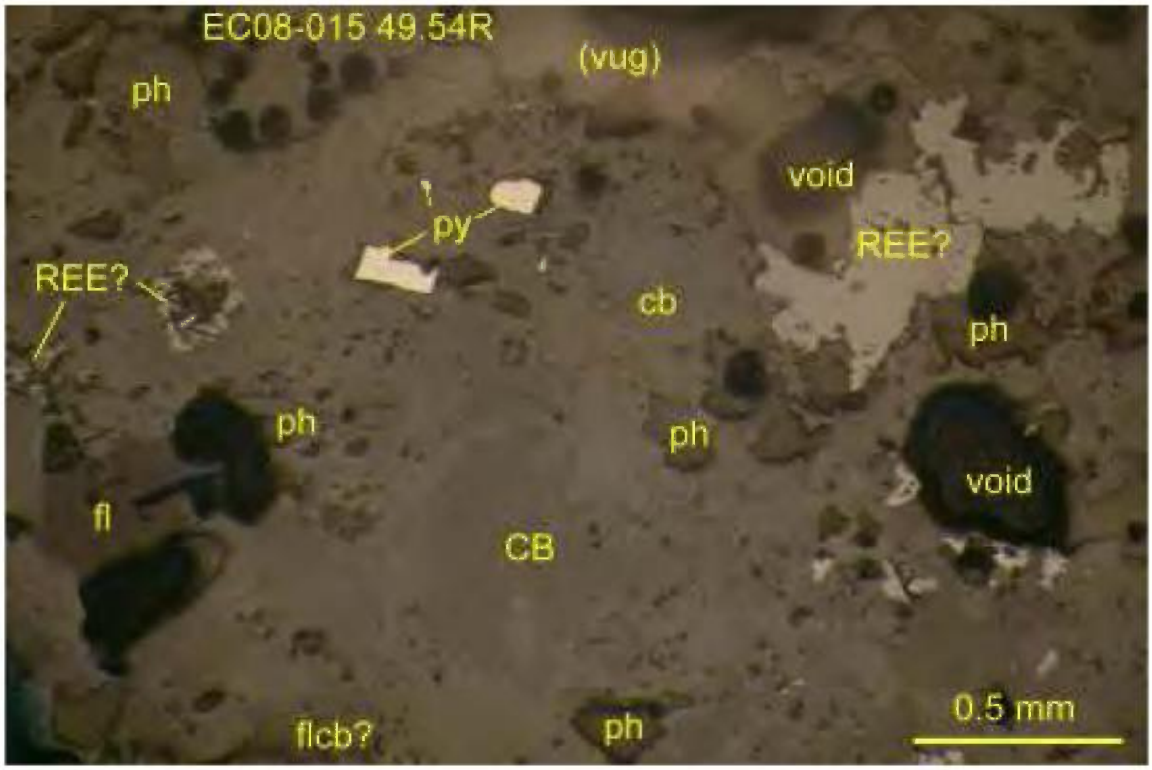
EC08-014 64.65: Clast (?) or porphyroblastic aggregate of dolomitic carbonate (cb) with ptygmatic folded (?) zone of phlogopite (ph) cut off by matrix of faintly purple fluorite (fl) locally associated with clear carbonate, possibly calcite (ca). Transmitted plane light, field of view 3.0 mm wide.



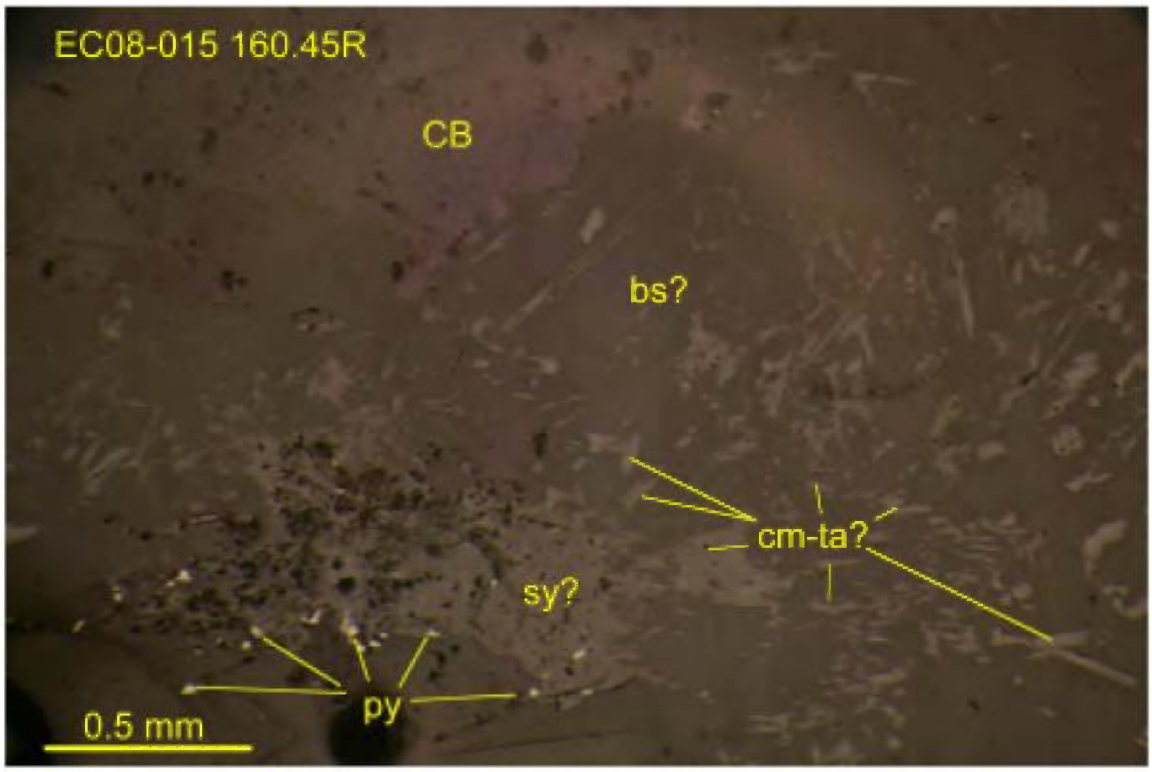
EC08-014 74.9R: Local concentration of apatite (ap) in matrix of carbonate (cb) and lesser phlogopite (ph), associated with minor ilmenite (il) and local REE minerals (columbite-tantalite, cm-ta?, pyrochlore, pc?, bastnaesite, bs?) plus trace pyrite (py). Reflected light, uncrossed polars; note field of view is only 1.0 mm wide.



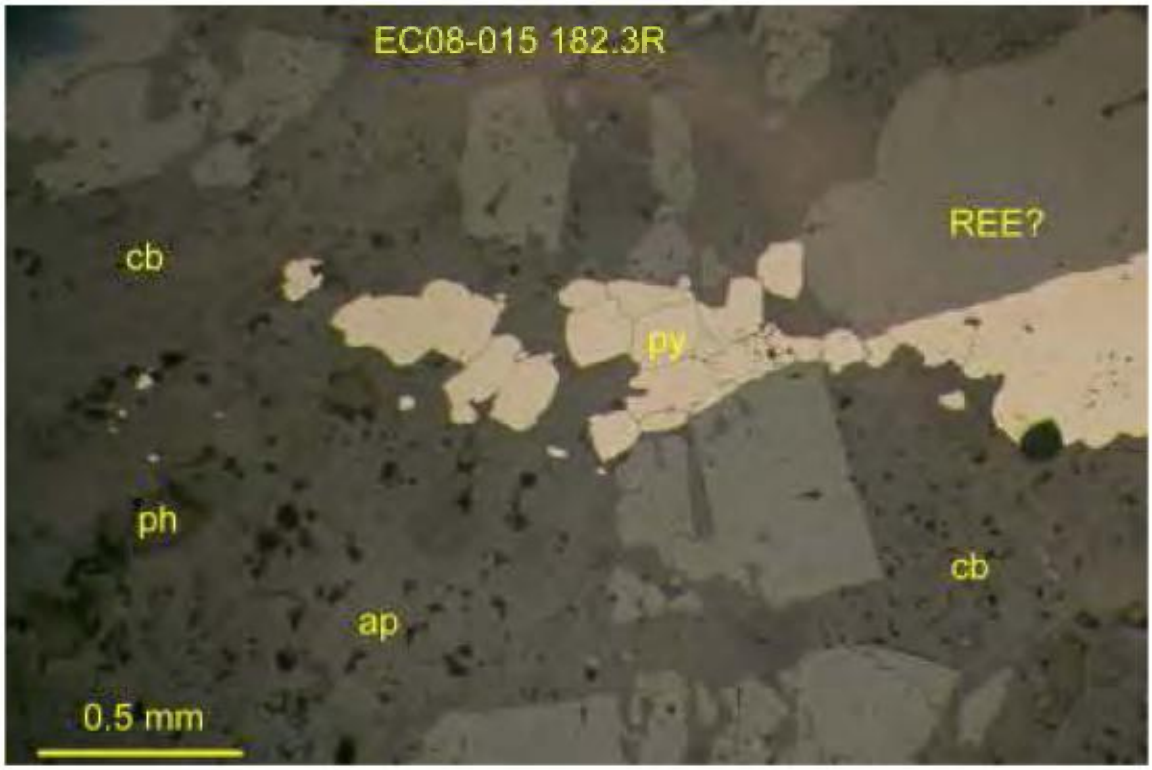
EC08-014 169.81: Coarse carbonate (CB) porphyroblasts/clasts in matrix of fine-grained carbonate (cb), fluorite (fl) with local concentrations of bright red-brown fluorocarbonate (?) and REE minerals plus pyrite (py, opaque). Transmitted plane light, field of view 3.0 mm wide.



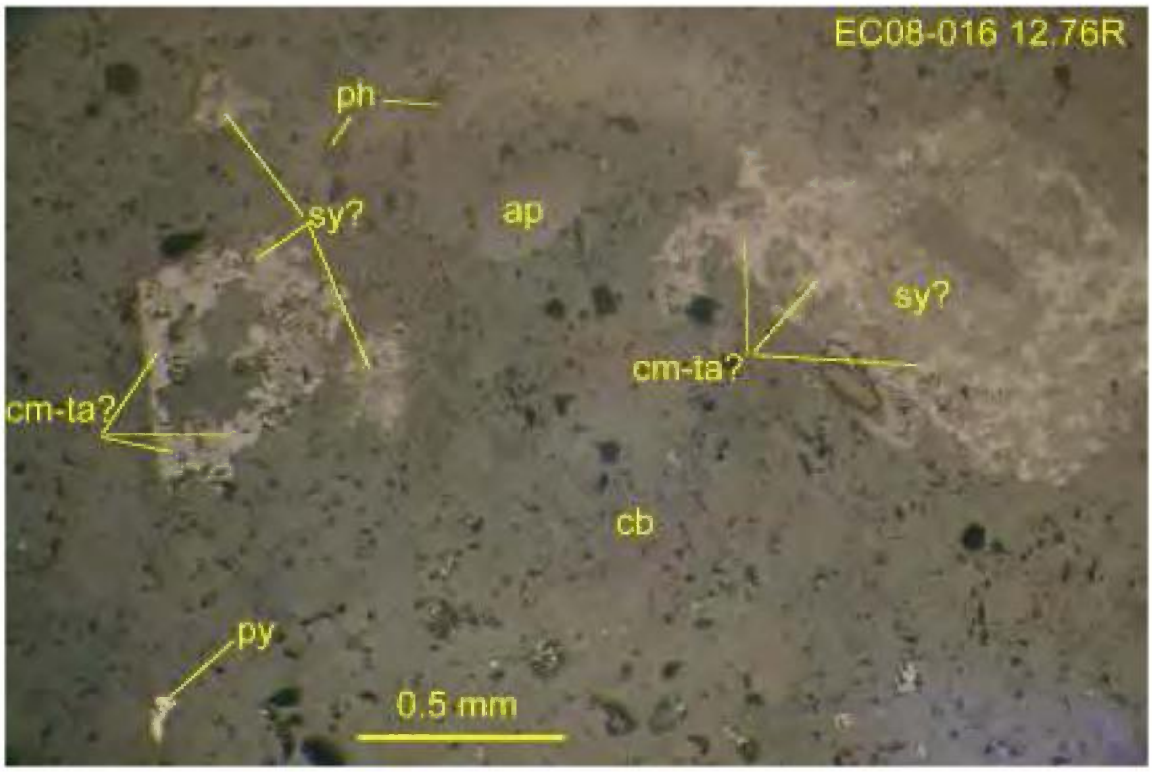
EC08-015 49.54R: Possible REE minerals of uncertain identity associated with fluorite (fl), phlogopite (ph) and minor pyrite (py) along vuggy vein zone in coarse/fine-grained carbonate (CB, cb) (vugs locally lined by possible unidentified fluorocarbonate, flcb?). Reflected light, uncrossed polars, field of view 2.75 mm wide.



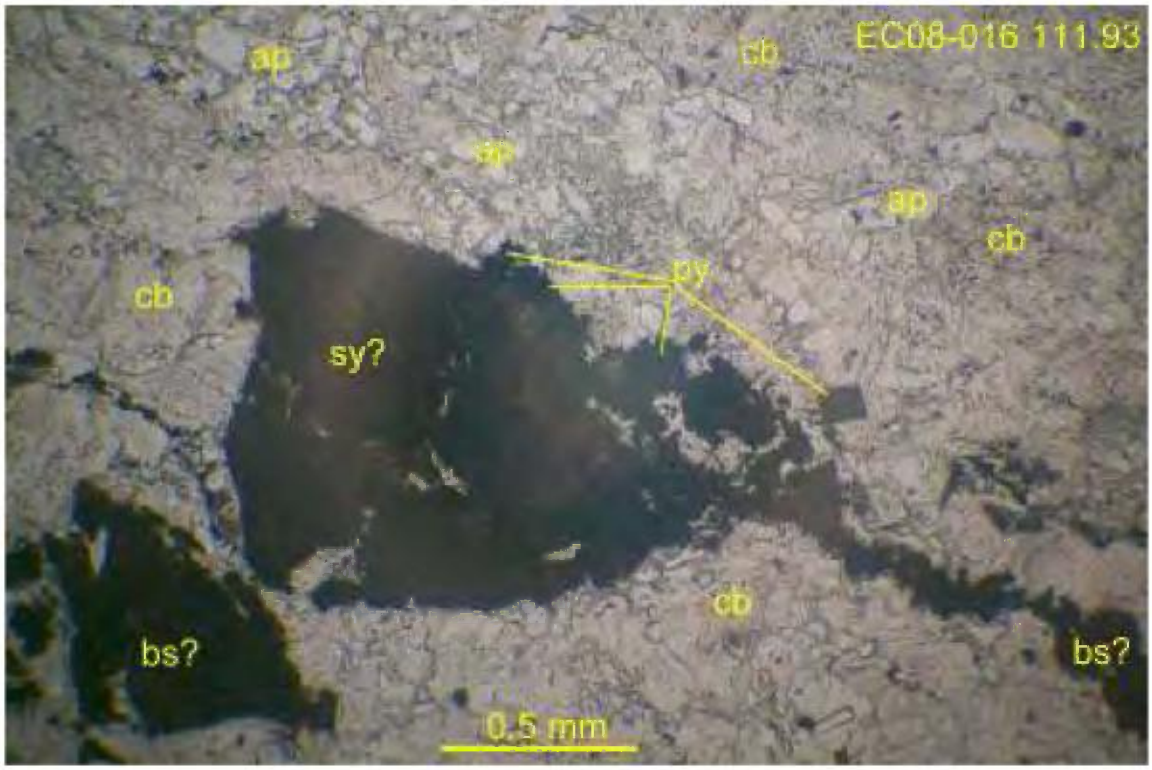
EC08-015 160.45R: Possible fluorocarbonate/REE minerals including bastnaesite (red-brown, bs?) containing acicular columbite-tantalite (cm-ta?), intergrown with possible synchesite (sy?) containing minute inclusions of pyrite (py), all cutting coarse-grained carbonate (CB) host. Reflected light, uncrossed polars, field of view 2.75 mm wide.



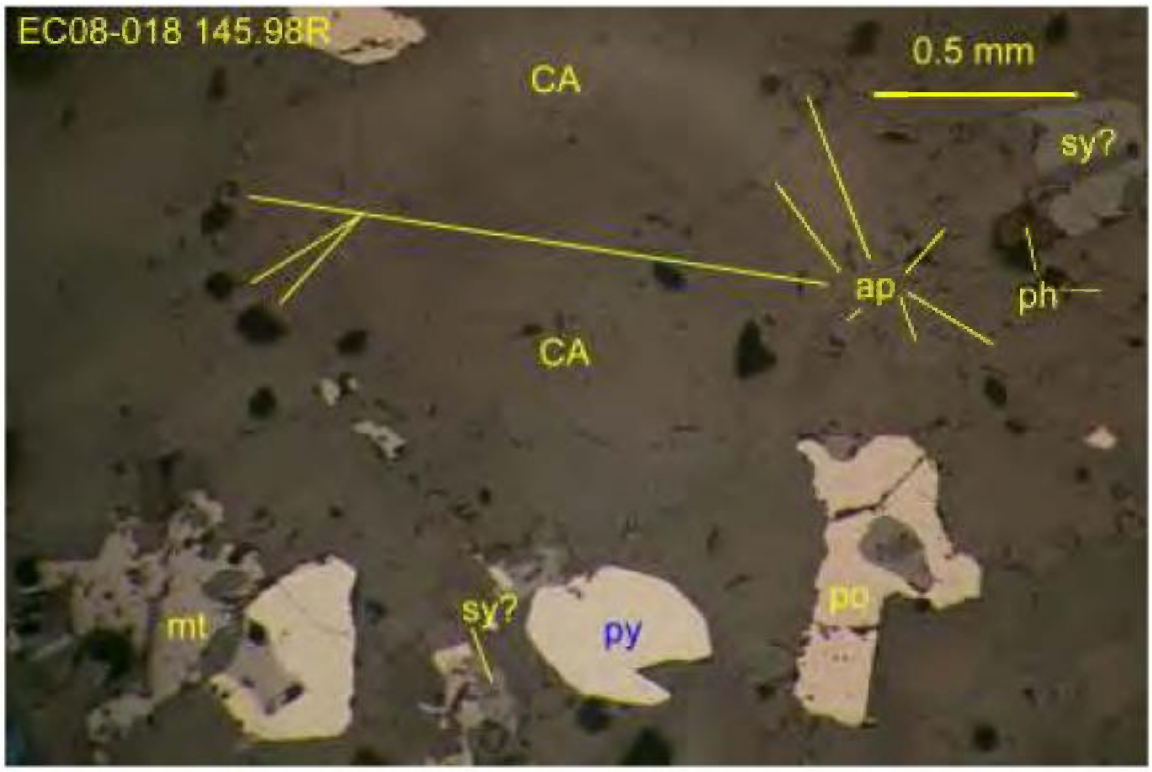
EC08-15 182.3R: Possible REE mineral (cubic/rectangular outlines, partly transparent/opaque with yellow-brown internal reflections, but isotropic) associated with pyrite (py) and apatite (ap) plus minor phlogopite (ph) in linear zone in matrix of carbonate (cb)-minor apatite. Reflected light, uncrossed polars, field of view 2.75 mm wide.



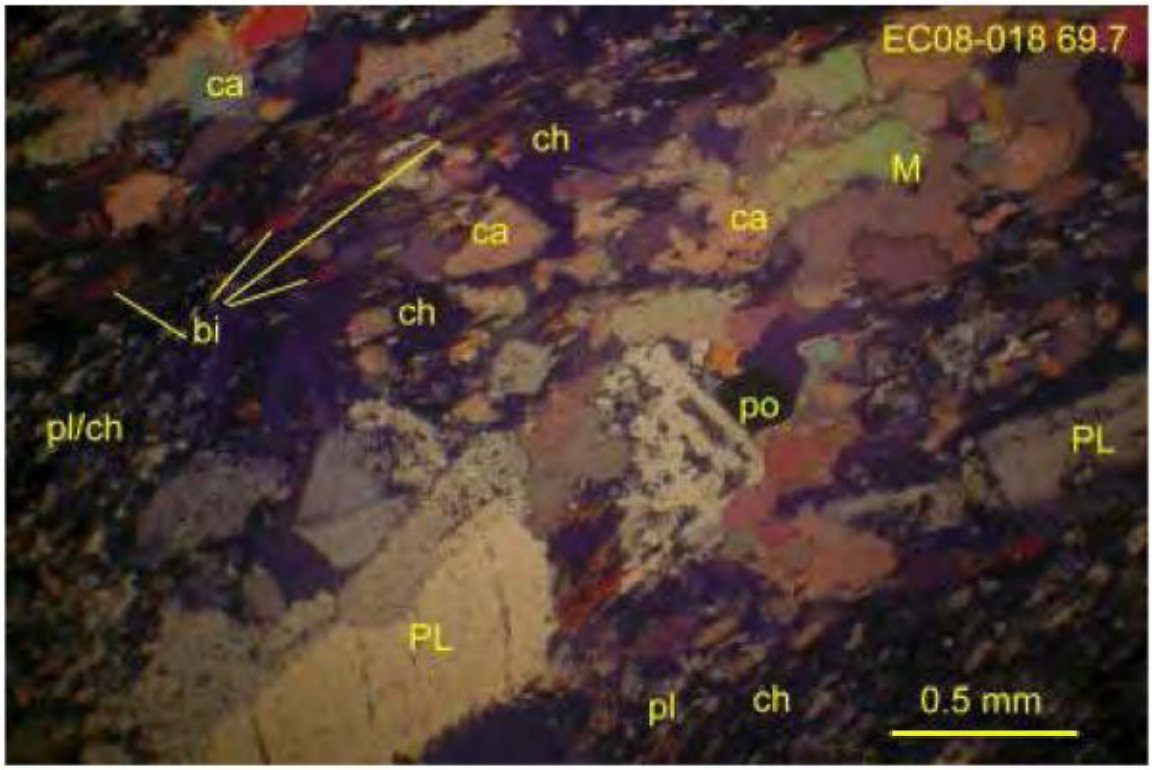
EC08-016 12.76R: Possible REE mineral (cubic/rectangular outlines, partly opaque and anisotropic, higher R, columbite-tantalite, cm-ta?, in host of lower R, semi-transparent, synchesite, sy?), associated with trace pyrite (py) and stubby apatite (ap) in matrix of carbonate (cb), minor phlogopite (ph). Reflected light, uncrossed polars, field of view 2.75 mm.



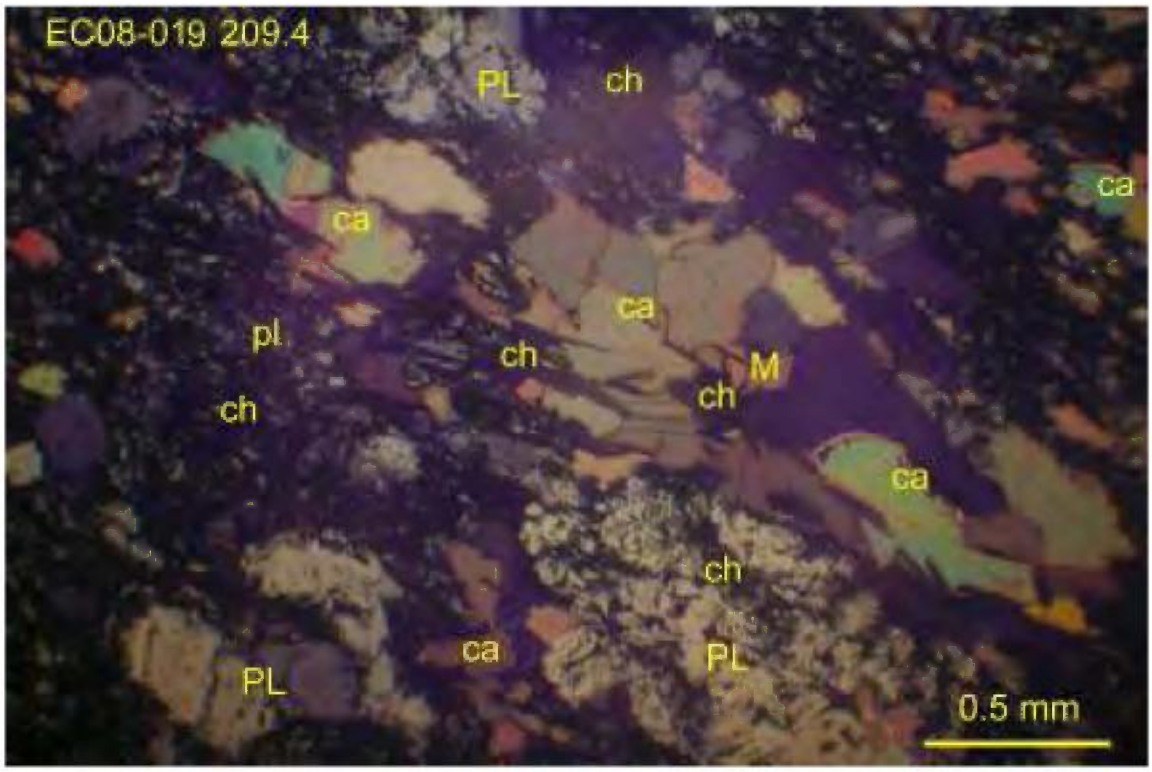
EC08-016 111.93: Coarse-grained carbonate (cb) with weakly foliated texture, intergrown with apatite (ap) along lensy zones sub-parallel to foliation, and with scattered possible REE fluorocarbonate (synchesite, sy?, or bastnaesite, bs?) with pyrite (opaque, py). Transmitted plane light, field of view 3.0 mm wide.



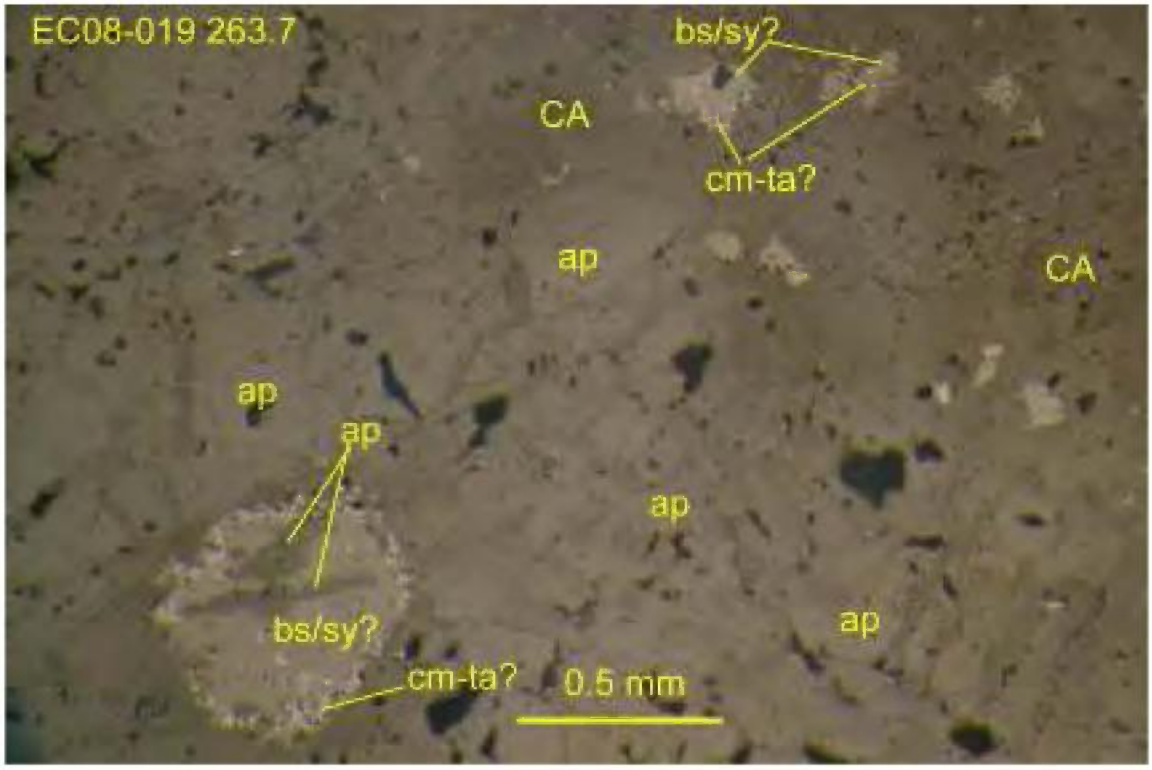
EC08-018 145.98R: Sulfides, including pyrite (py) and pyrrhotite (po) associated with magnetite (mt) and possible REE fluorocarbonate (synchesite, sy?) along zone with minor apatite (ap) and phlogopite (ph) in coarse-grained calcite (CA) carbonatite. Reflected light, uncrossed polars, field of view 2.75 mm wide.



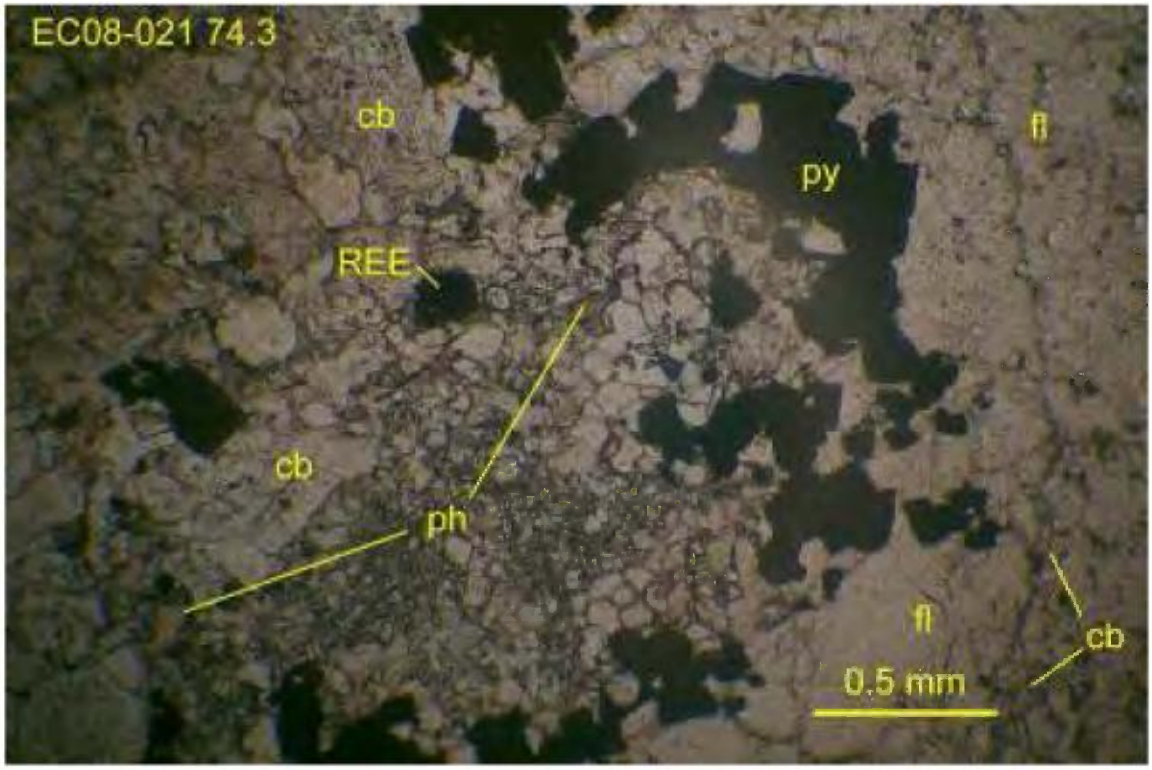
EC08-018 69.7: Relict plagioclase (PL) and possible mafic (M?) sites altered to carbonate (ca) and chlorite (ch), in foliated groundmass of chlorite (dark, partly after biotite, bi) and plagioclase (pl) plus opaques that are mostly ilmenite (very fine, in groundmass) and scattered pyrrhotite (po). Transmitted light, crossed polars, field of view 3.0 mm wide.



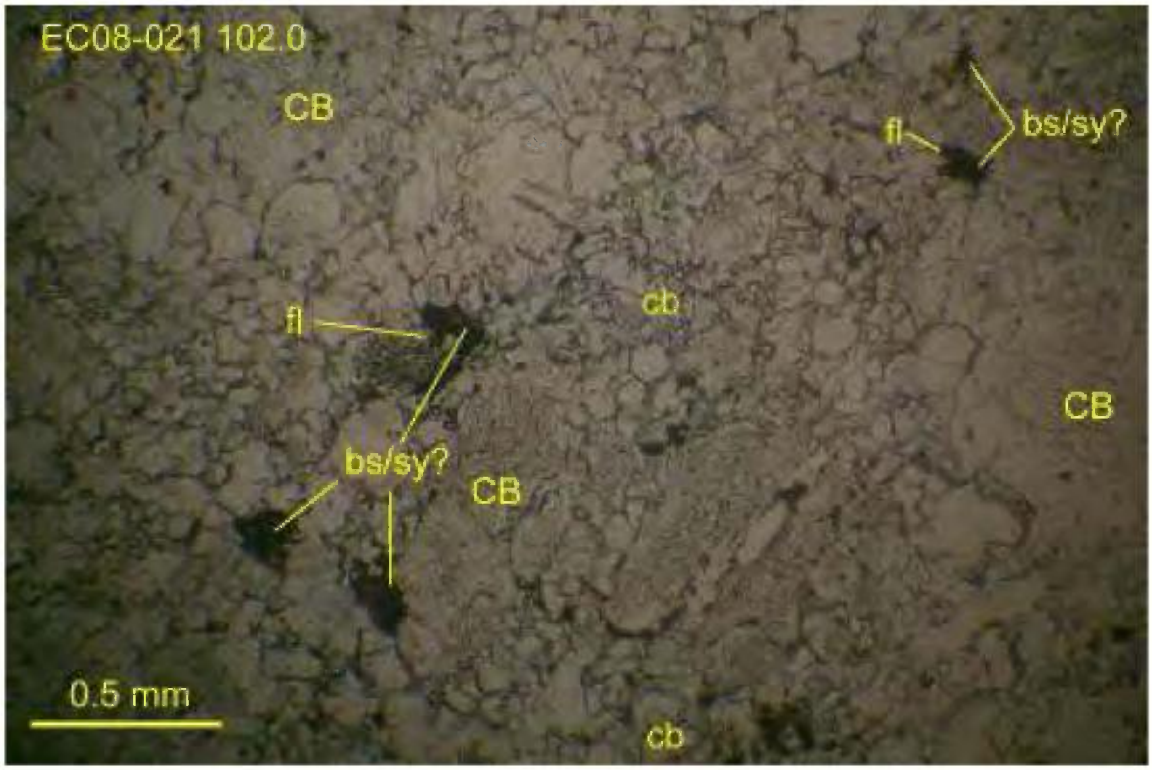
EC08-019 209.4 Relict, sheared plagioclase (PL) and possible mafic (M?) sites altered to carbonate (ca) and chlorite (ch), in foliated groundmass of chlorite (dark) and plagioclase (pl) plus accessory sphene (very fine, not readily visible in this view). Transmitted light, crossed polars, field of view 3.0 mm wide.



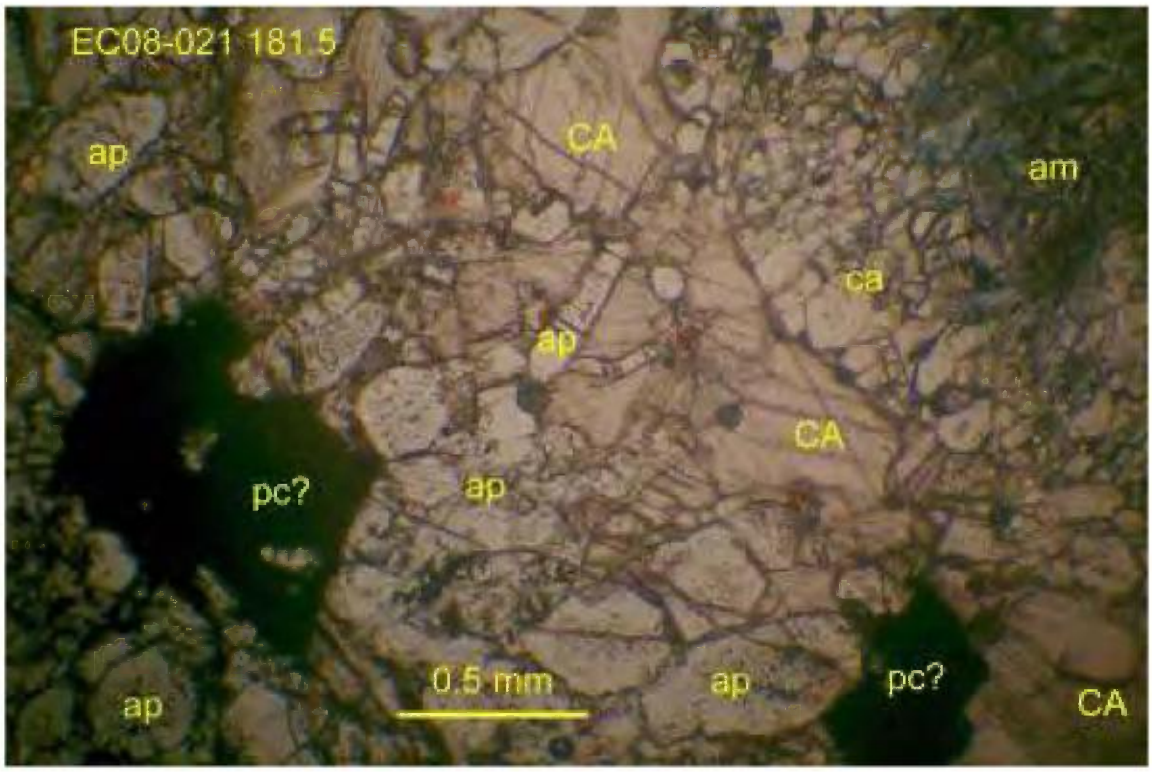
EC08-019 263.7: Possible REE minerals (cores of lower R, fluorocarbonate such as bastnaesite surrounded by rims of higher R columbite-tantalite?) associated with or including crystals of apatite (ap), in matrix of coarse calcite (CA) carbonatite. Reflected light, uncrossed polars, field of view 2.75 mm wide.



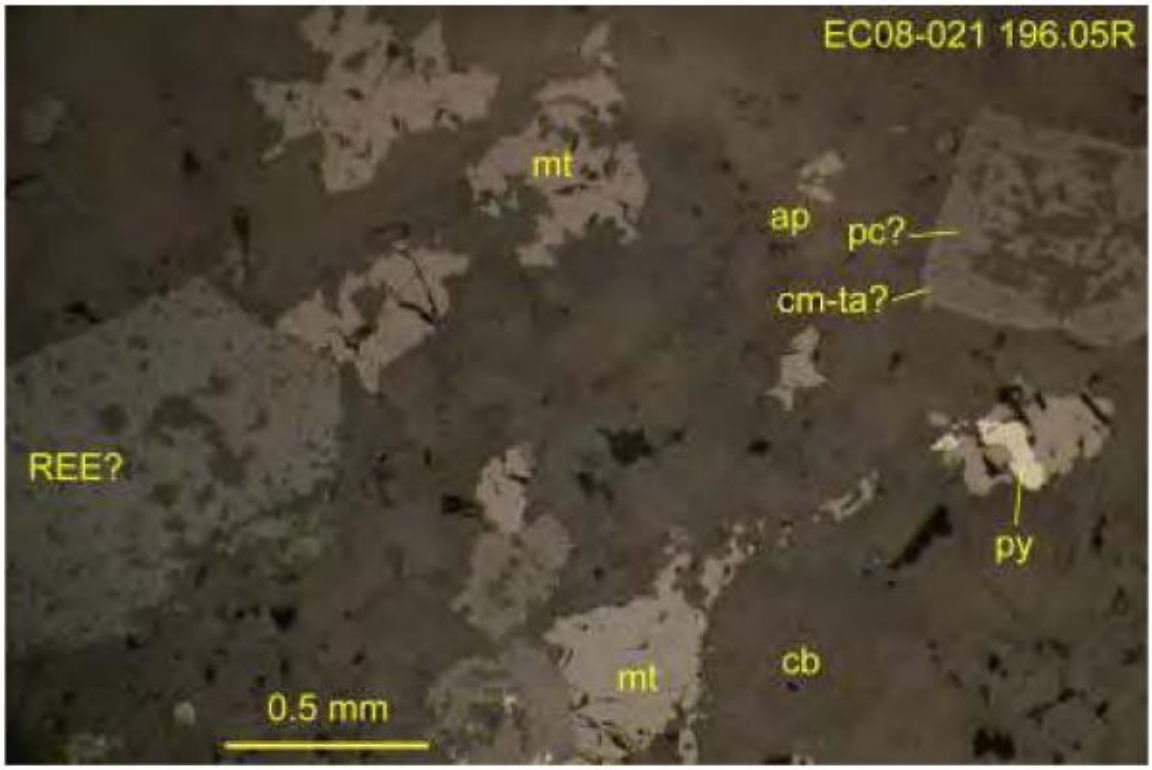
EC08-021 74.3: Bladed pseudomorph rimmed by pyrite (py, opaque) and cored by carbonate (cb) with minor phlogopite (ph) and rare REE mineral (fluorocarbonate?), cut by vein of fluorite (fl) with minor inclusions of carbonate. Transmitted plane light, field of view 3.0 mm wide.



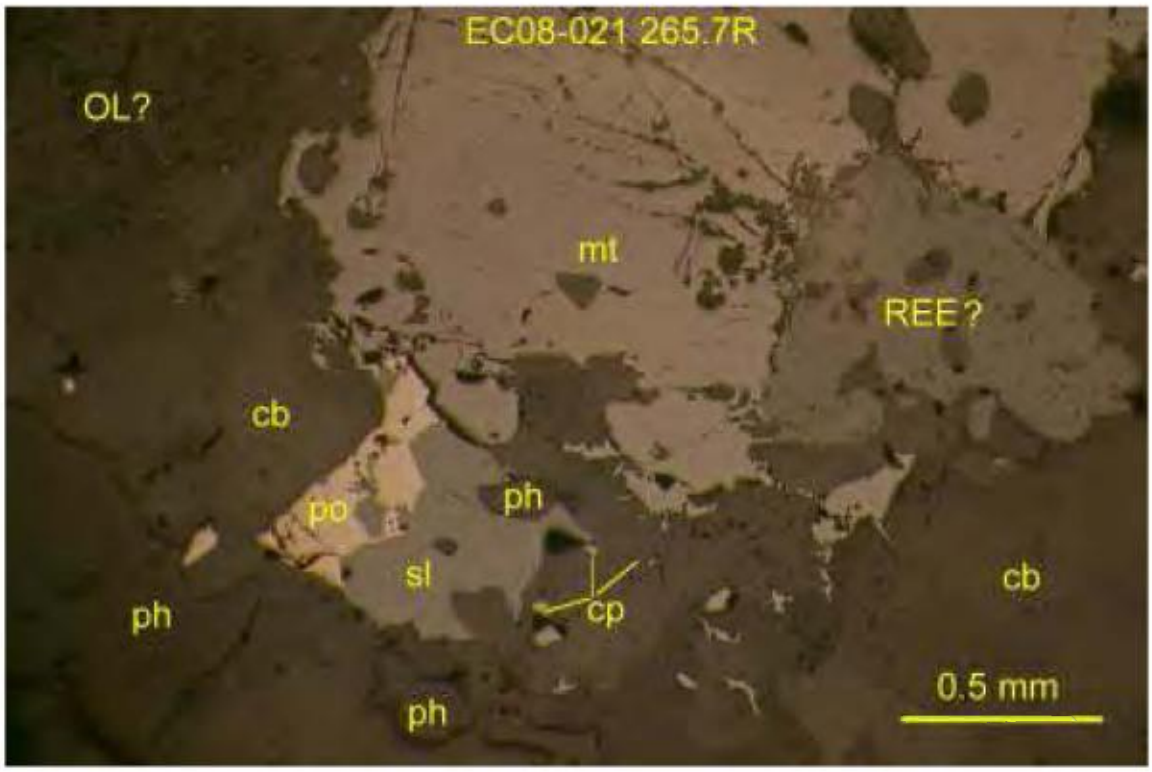
EC08-021 102.0: Recrystallized dolomitic carbonatite (coarse- and fine-grained carbonate, CB and cb), with minor interstitial red-brown REE fluorocarbonate (bs/sy?) associated with traces of fluorite (fl) and possible hematite. Transmitted plane light, field of view 3.0 mm wide.



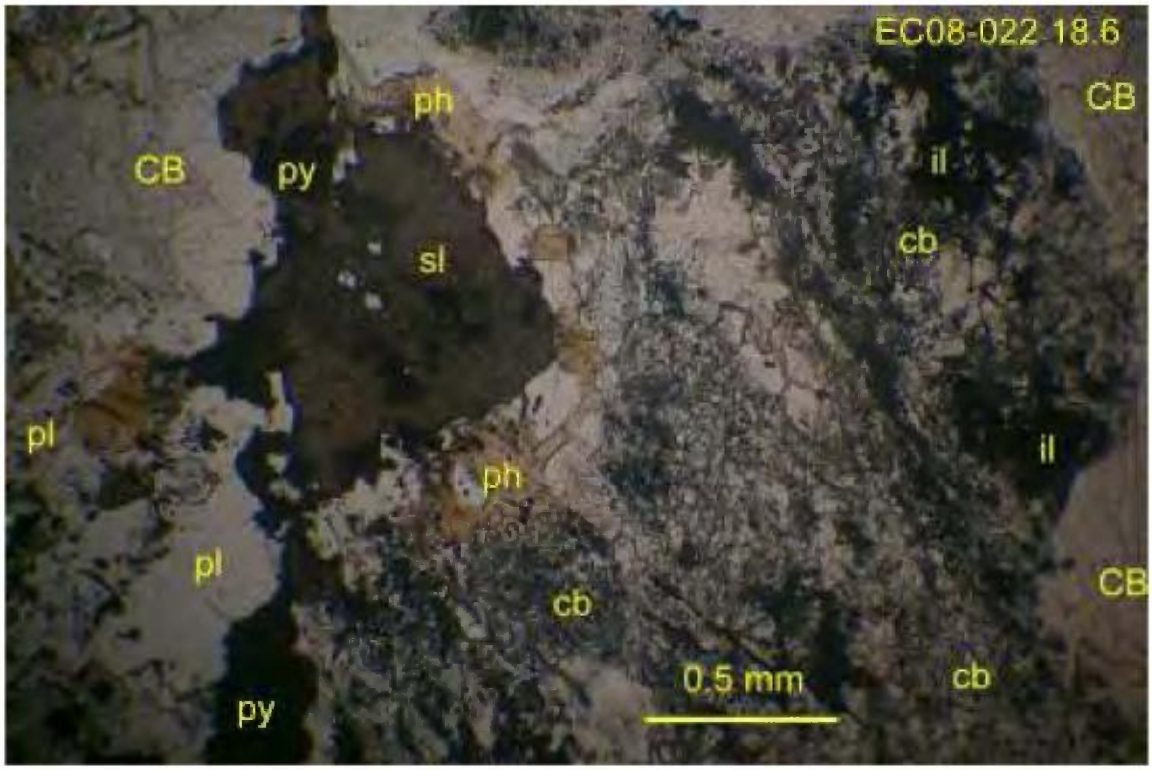
EC08-021 181.5: Possible REE minerals (opaque, pyrochlore, pc?) associated with apatite (ap) and blue-green (sodic?) amphibole (am) and fine calcite (ca) interstitial to coarse calcite (CA) aggregates presumably after former bladed olivine crystals (?). Transmitted plane light, field of view 3.0 mm wide.



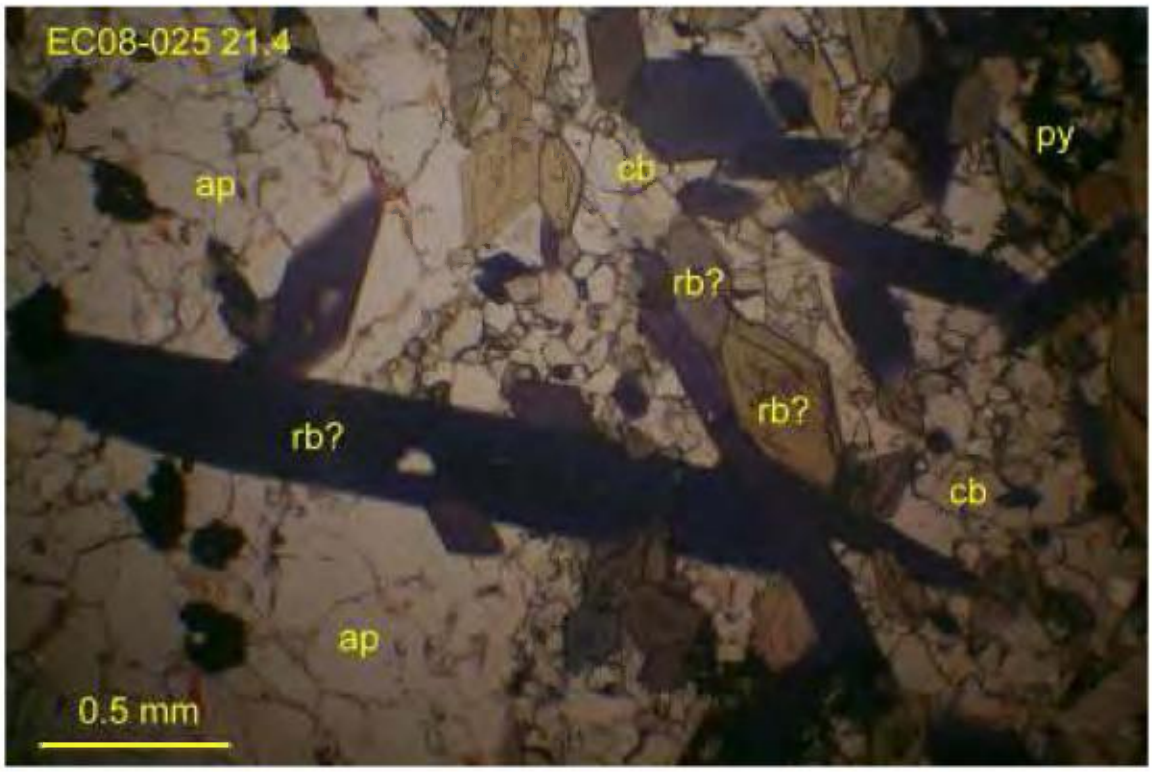
EC08-021 196.05R: Euhedral shaped aggregates of REE minerals (columbite-tantalite remnant rims altered to pyrochlore at cores?) associated with magnetite (mt) and trace pyrite (py), in matrix of carbonate and minor apatite. Reflected light, uncrossed polars, field of view 2.75 mm wide.



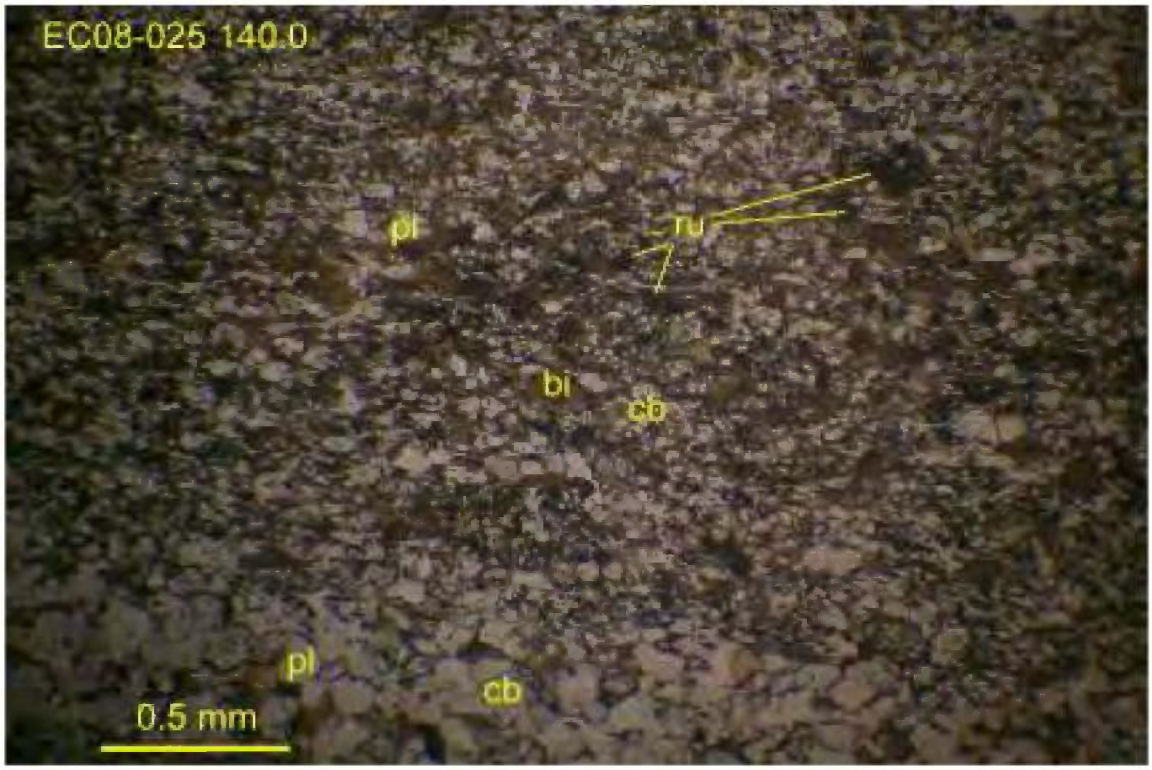
EC08-021 265.7R: Magnetite (mt) intergrown with possible REE mineral, minor pyrrhotite (po) and sphalerite (sl), trace chalcopyrite (cp), plus local phlogopite (ph) and relict olivine (OL?) now pseudomorphed by fine-grained serpentine-magnesite (?) in matrix of carbonate (cb). Reflected light, uncrossed polars, field of view 2.75 mm wide.



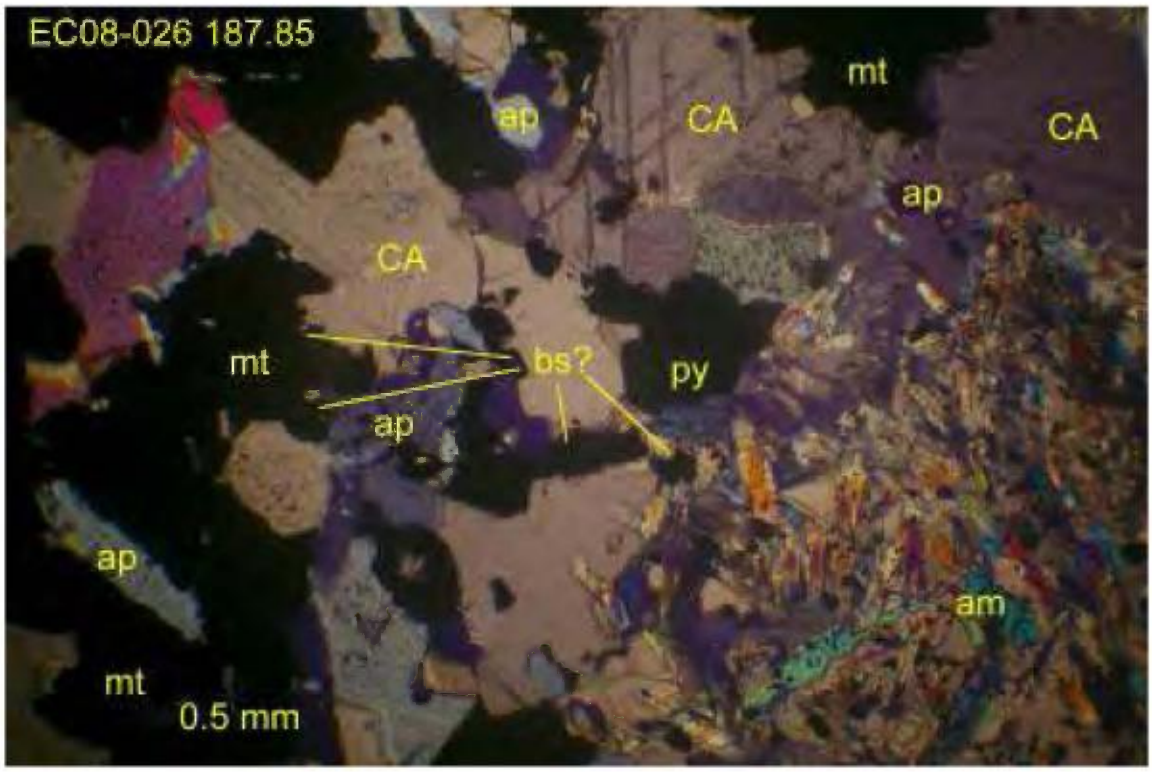
EC08-022 18.6: Aggregate of darker (ankeritic?) carbonate (cb) with included ilmenite (opaque, il) possibly after olivine (?), associated with phlogopite (ph), pyrite (py) and sphalerite (sl) plus plagioclase (pl), in matrix of coarser, clear carbonate (CB, possibly dolomite?). Transmitted plane light, field of view 3.0 mm wide.



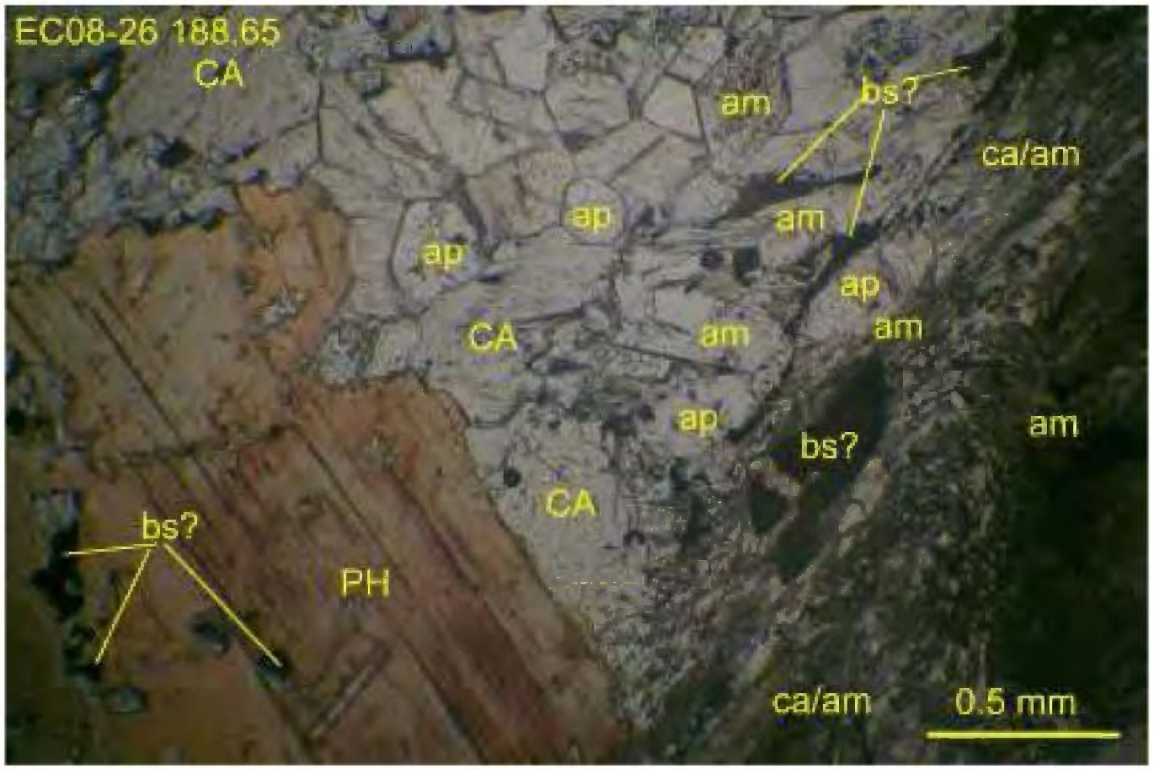
EC08-025 21.4: Bladed soda amphibole (riebeckite, rb?) with deep indigo to purplish or yellow-green pleochroism, intergrown with apatite (ap) and carbonate (cb) plus local pyrite (opaque, py) in ultrabasic rock. Transmitted plane light, field of view 3.0 mm wide.



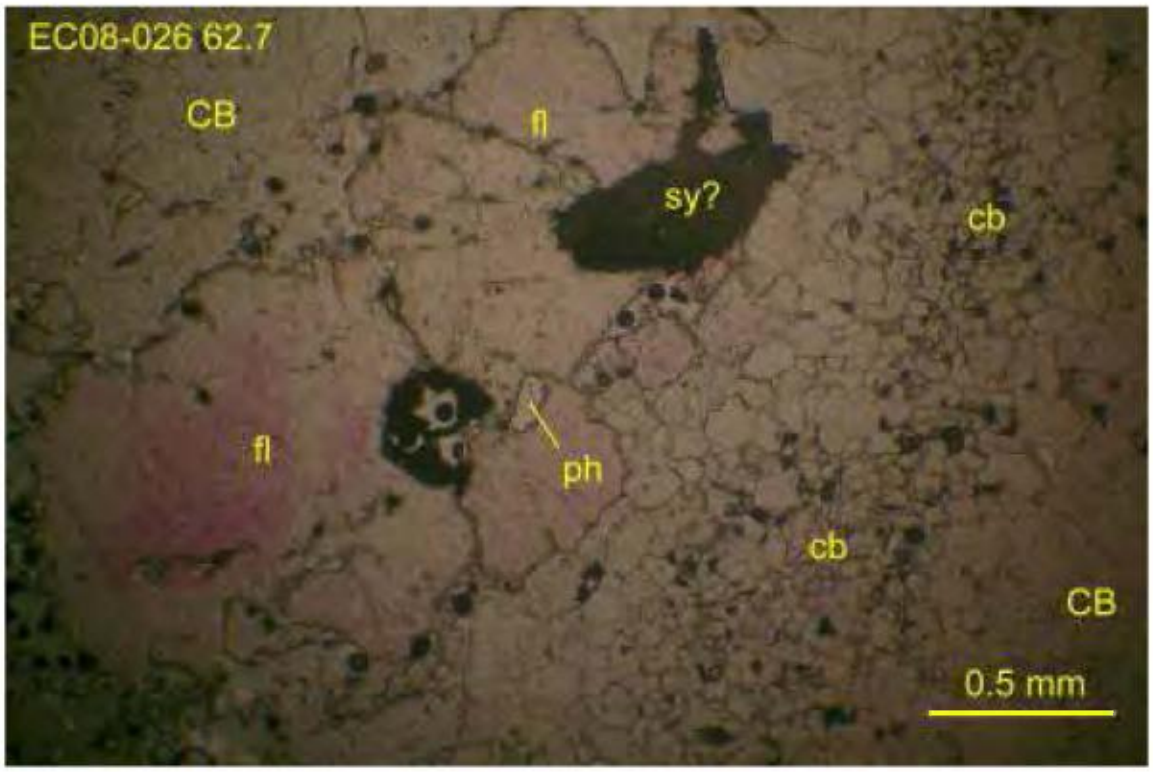
EC08-025 140.0: Very fine-grained, banded/laminated, moderately foliated rock composed of carbonate (cb), plagioclase (pl), biotite (bi) and accessory apatite (difficult to see in this view) and rutile (minute opaques, ru). Transmitted plane light, field of view 3.0 mm wide.



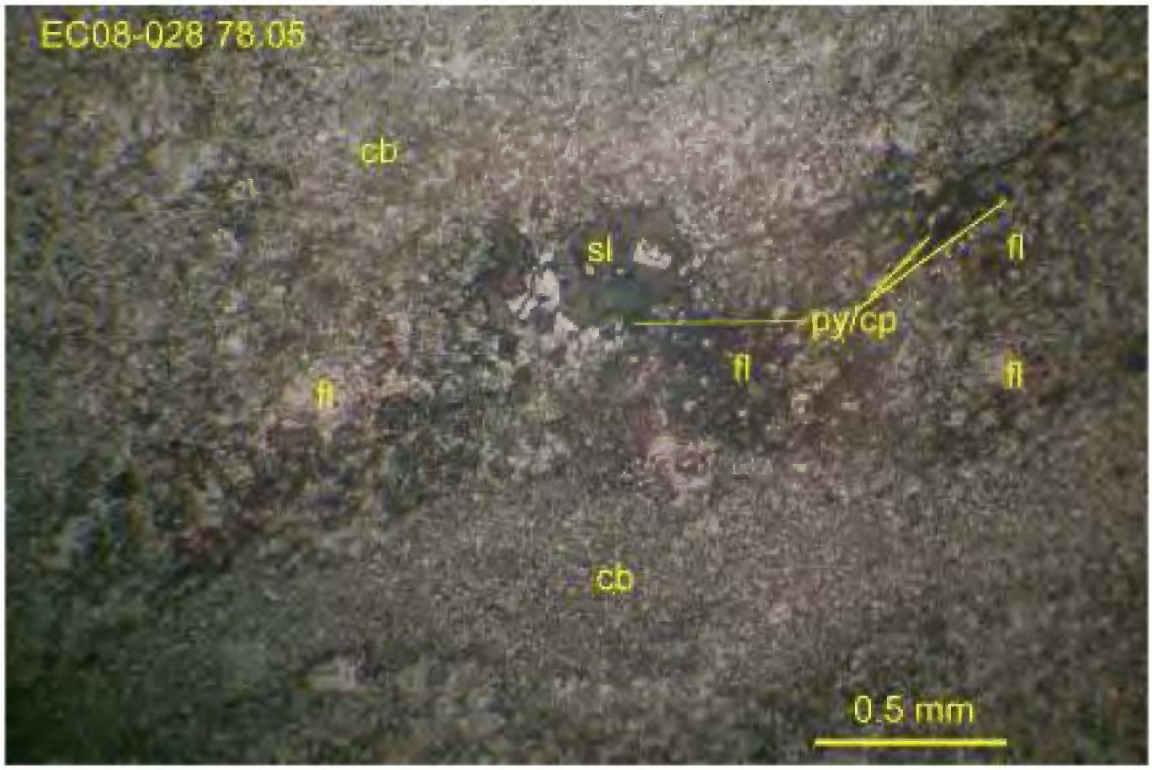
EC08-026 187.85: Lens of amphibole (am)-apatite (ap) and aggregate of magnetite (mt)-minor pyrite (py), phlogopite (ph) and trace REE mineral (bastnaesite, bs?) in matrix of coarse calcite (CA). Transmitted light, crossed polars, field of view 3.0 mm wide.



EC08-026 188.65: Lensy aggregates of lath-like or fibrous amphibole (am)-apatite (ap) and coarse brown phlogopite (PH), both with minor dark red-brown REE mineral (bastnaesite, bs?), in matrix of coarse calcite (CA). Transmitted light, uncrossed polars, field of view 3.0 mm wide.

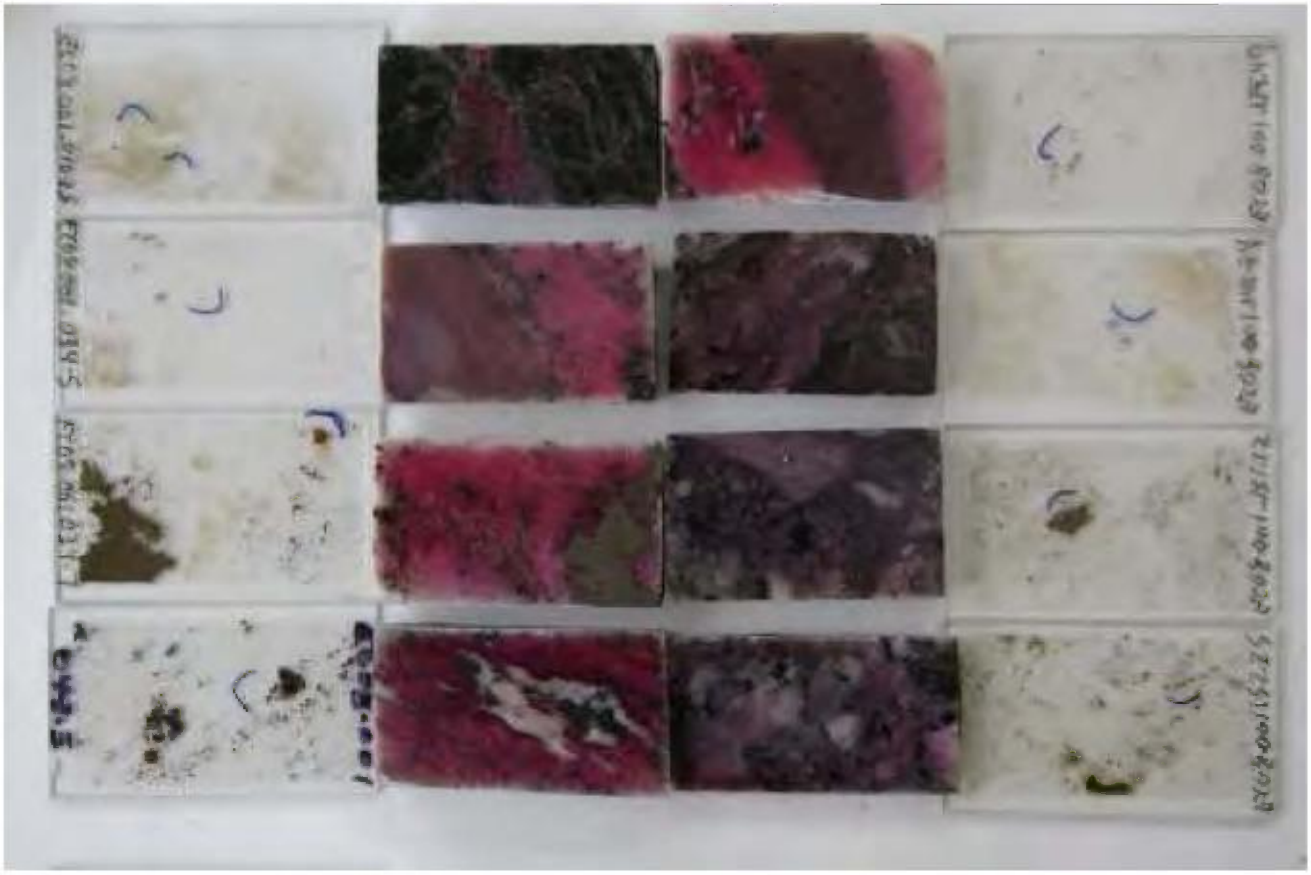


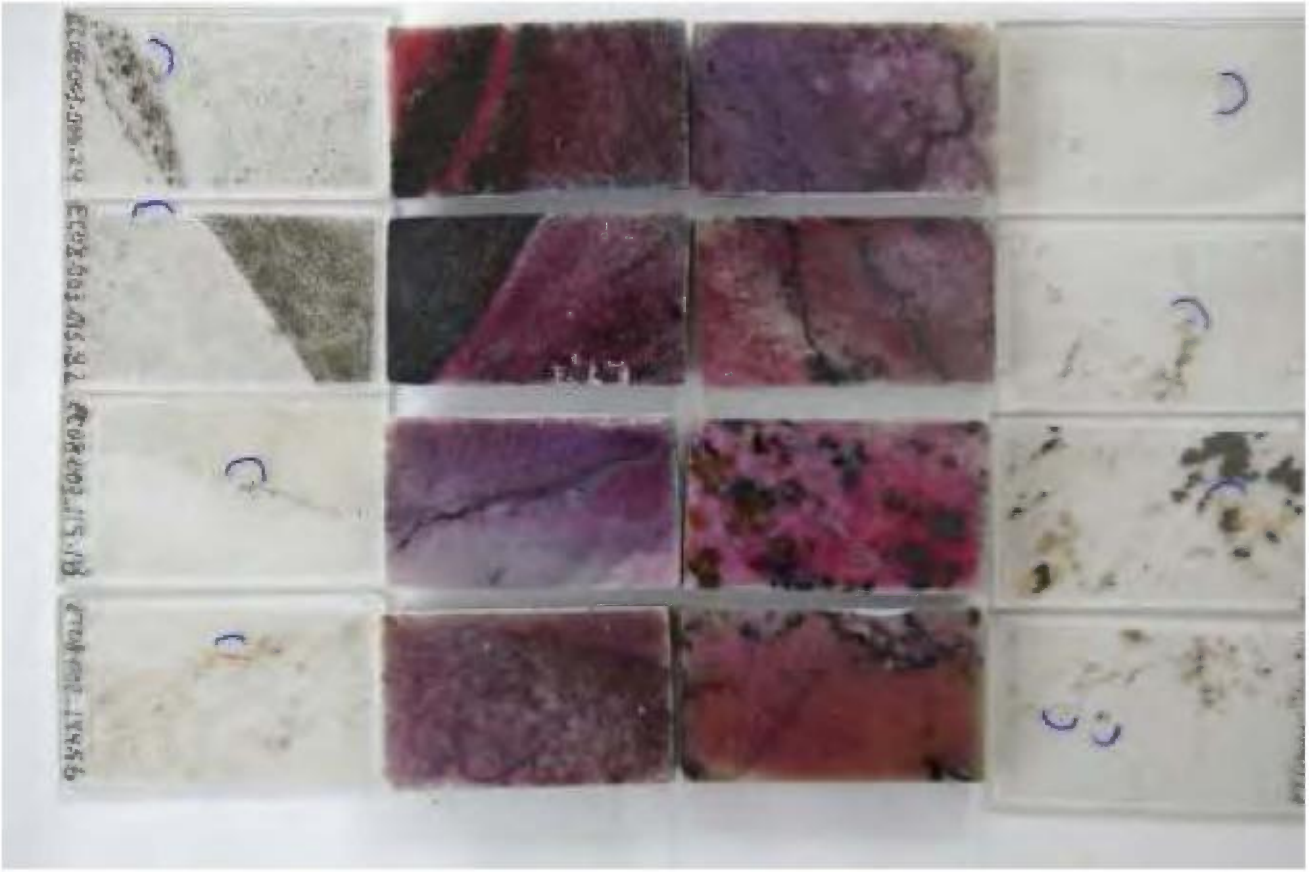
EC08-26 62.7: Coarse- and fine-grained carbonate (CB, cb) associated with area of faintly purple fluorite (fl) containing possible REE mineral (fluorocarbonate with dark yellow-brown colour, possibly synchesite, sy?) and minor phlogopite (ph). Transmitted plane light, field of view 3.0 mm wide.

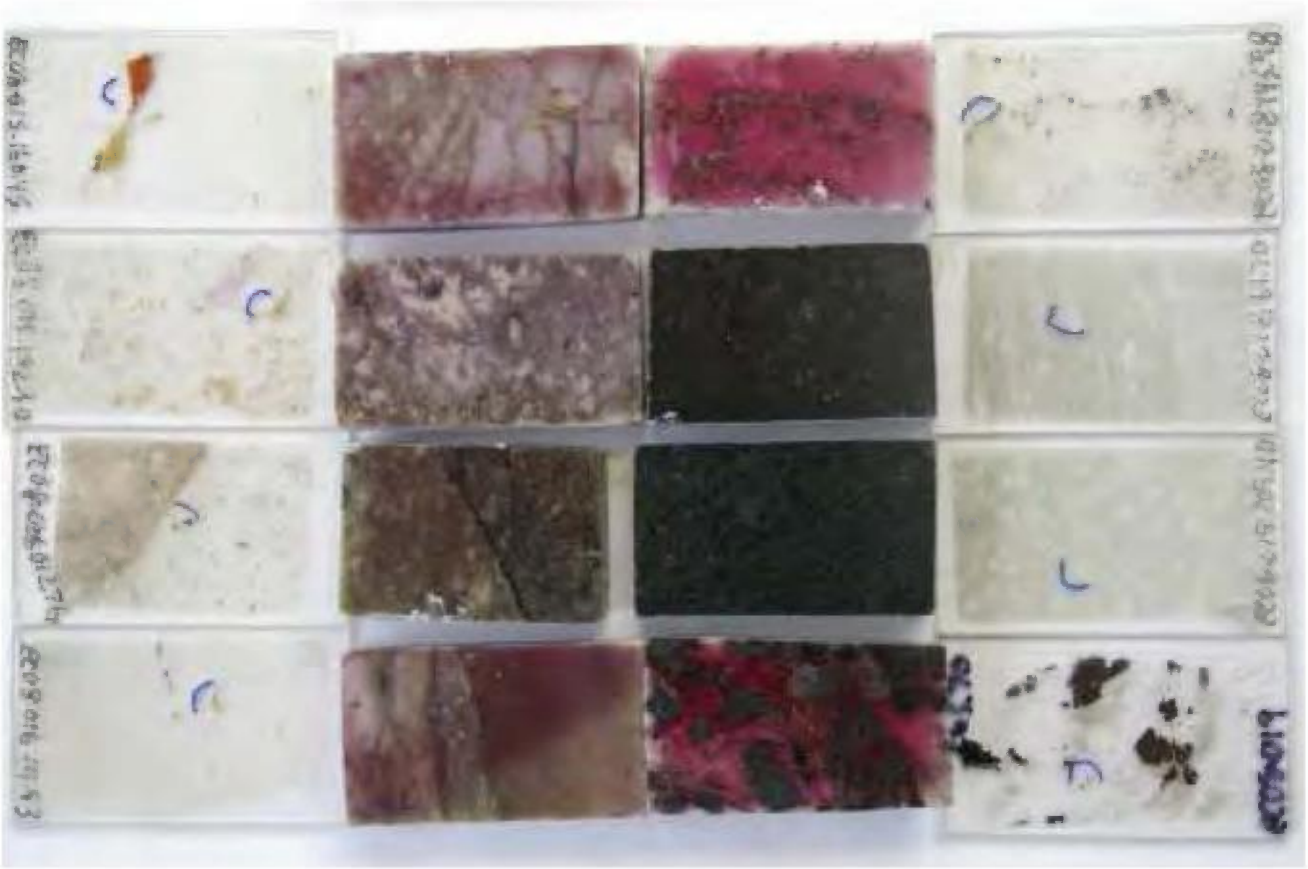


EC08-28 78.05: Zone of fluorite (fl) that is variably deep purple or colourless, associated with minor sphalerite (sl) and trace pyrite/chalcopyrite (opaque), in matrix of very fine-grained dolomitic carbonate (cb) of magnesio-carbonatite. Transmitted plane light, field of view 3.0 mm wide.

Overview of thin sections and offcuts (blue semi-circles mark photomicrograph locations).








78.05
EC10-028

APPENDIX C

REPORT ON ELDOR BILLET OF CARBONATITE

by

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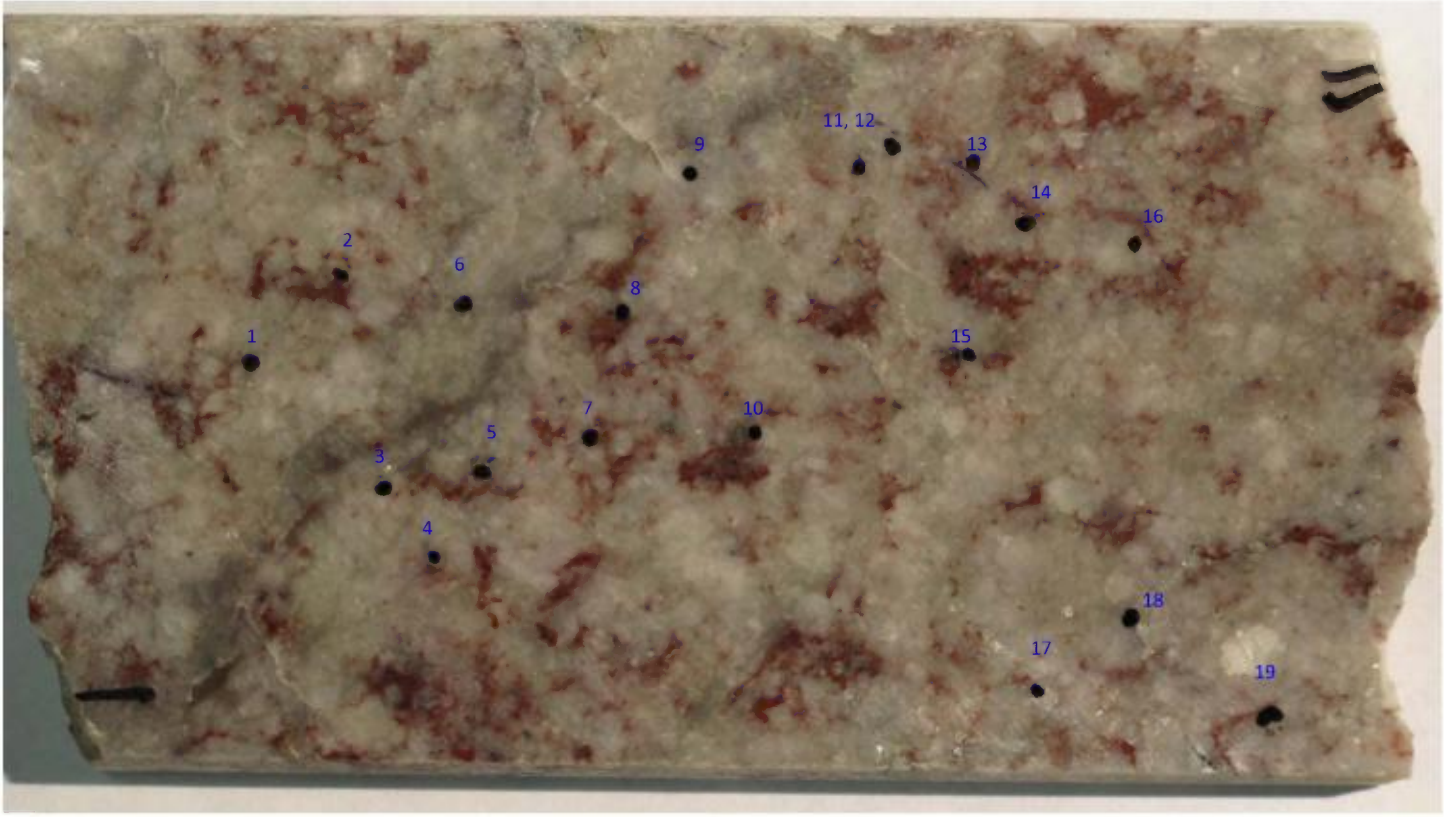
Department of Earth and Atmospheric Sciences
University of Alberta
Edmonton, AB

Eldor billet of carbonatite

supplied by Rod Tyson: EC10-027 320.59 m

Billing code 20007, Eldor



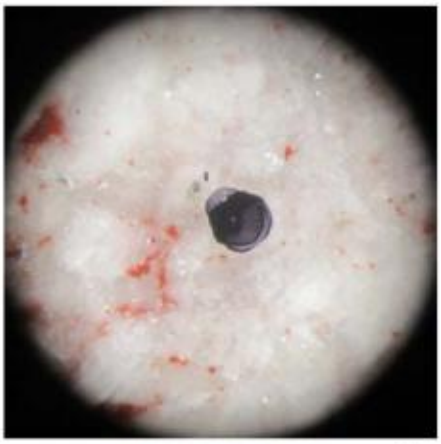
Billet (76 x 39 mm) polished with diamond, followed by 0.3 micron alumina in water.

Nineteen points of interest selected under binocular microscope for possible examination by scanning electron microscope; black dots placed on billet surface with felt pen, with reference marks at opposite corners.

Reference microphotographs (in colour) of each point of interest taken through the ocular of the binocular microscope. Black dot at approximate center of each image is felt pen; dot is about 1 mm in diameter. Microphotographs follow on next two pages.

Selected back-scattered electron (BSE) images and electron-dispersive X-ray (EDS) spectra are provided along with tentative identifications and interpretations of the mineralogy. As a result of time limitations (90 minute SEM session), only some of the points of interest were investigated.

> **Summary of results:** white ferroan **dolomite** matrix; red **parisite** with intergrown **bastnasite**, purple **fluorite**, black **ferrocolumbite** (**rutile** and **monazite** inclusions), dark **pyrochlore** (intergrown **apatite**), green **chlorite**
>
> **Recommendations:** undertake quantitative chemical analysis of whole rock; perform quantitative phase analysis by powder X-ray diffraction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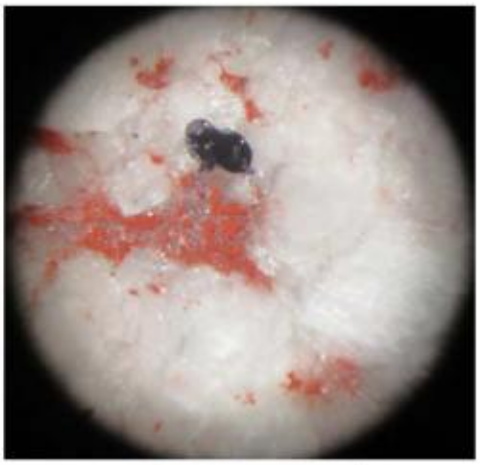
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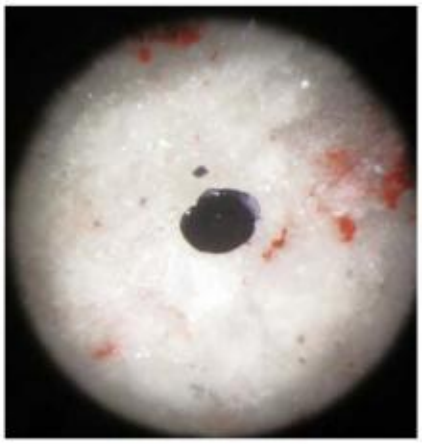
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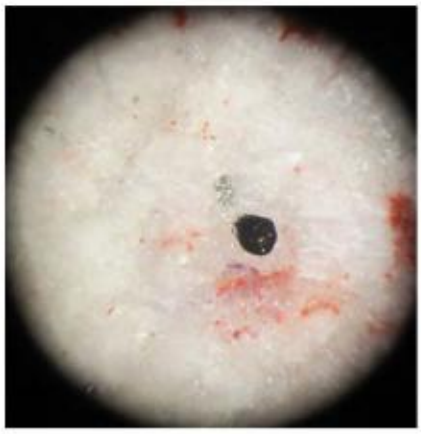

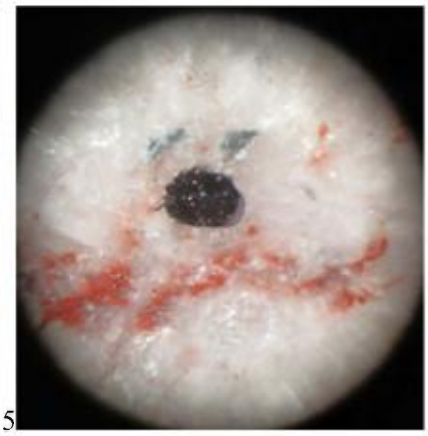
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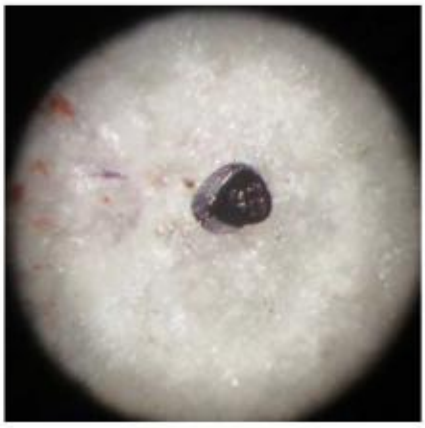
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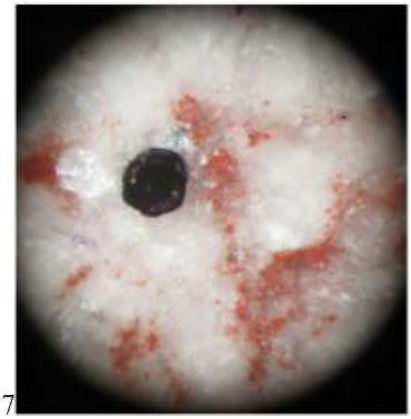
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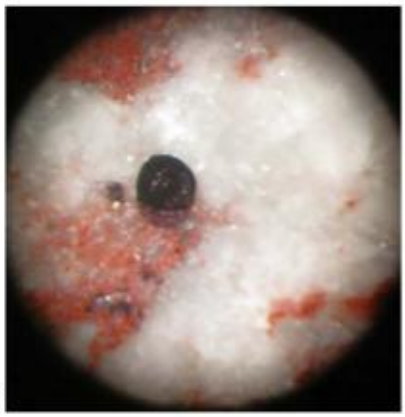
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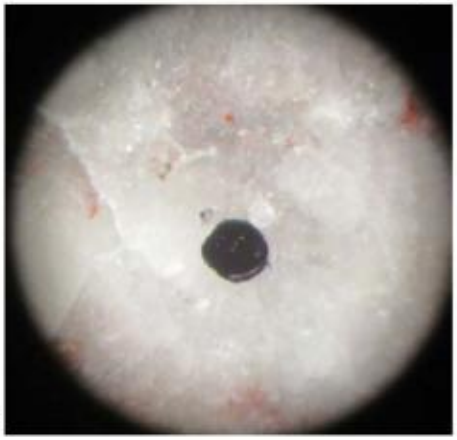
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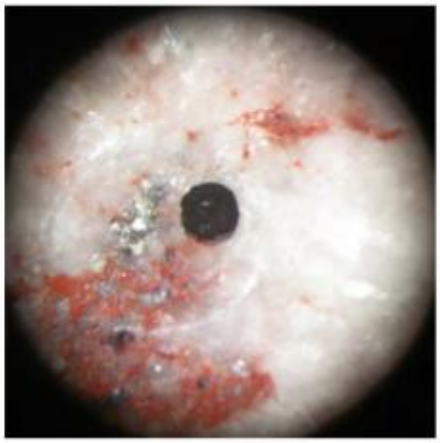
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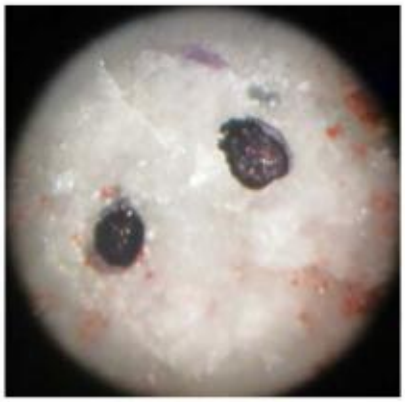
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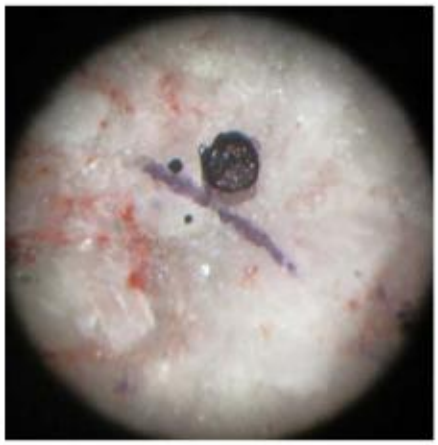
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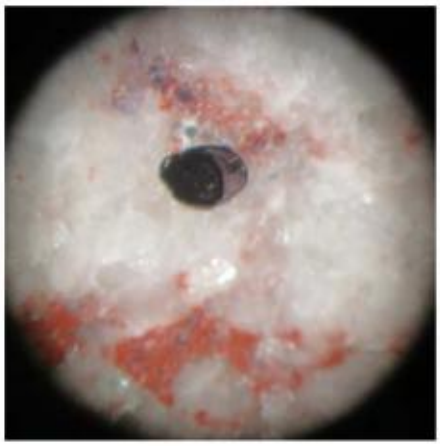
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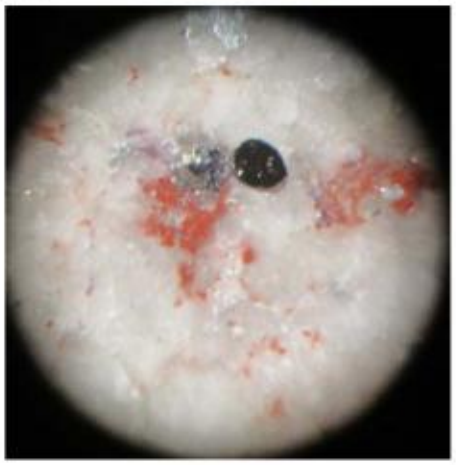
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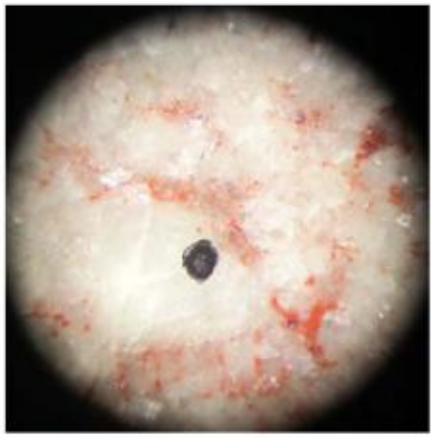
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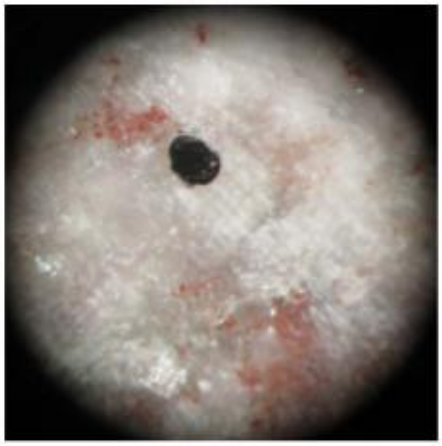
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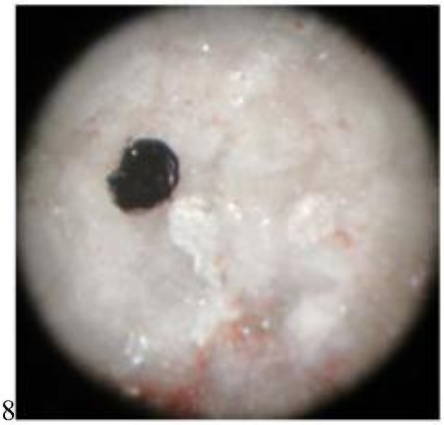

18

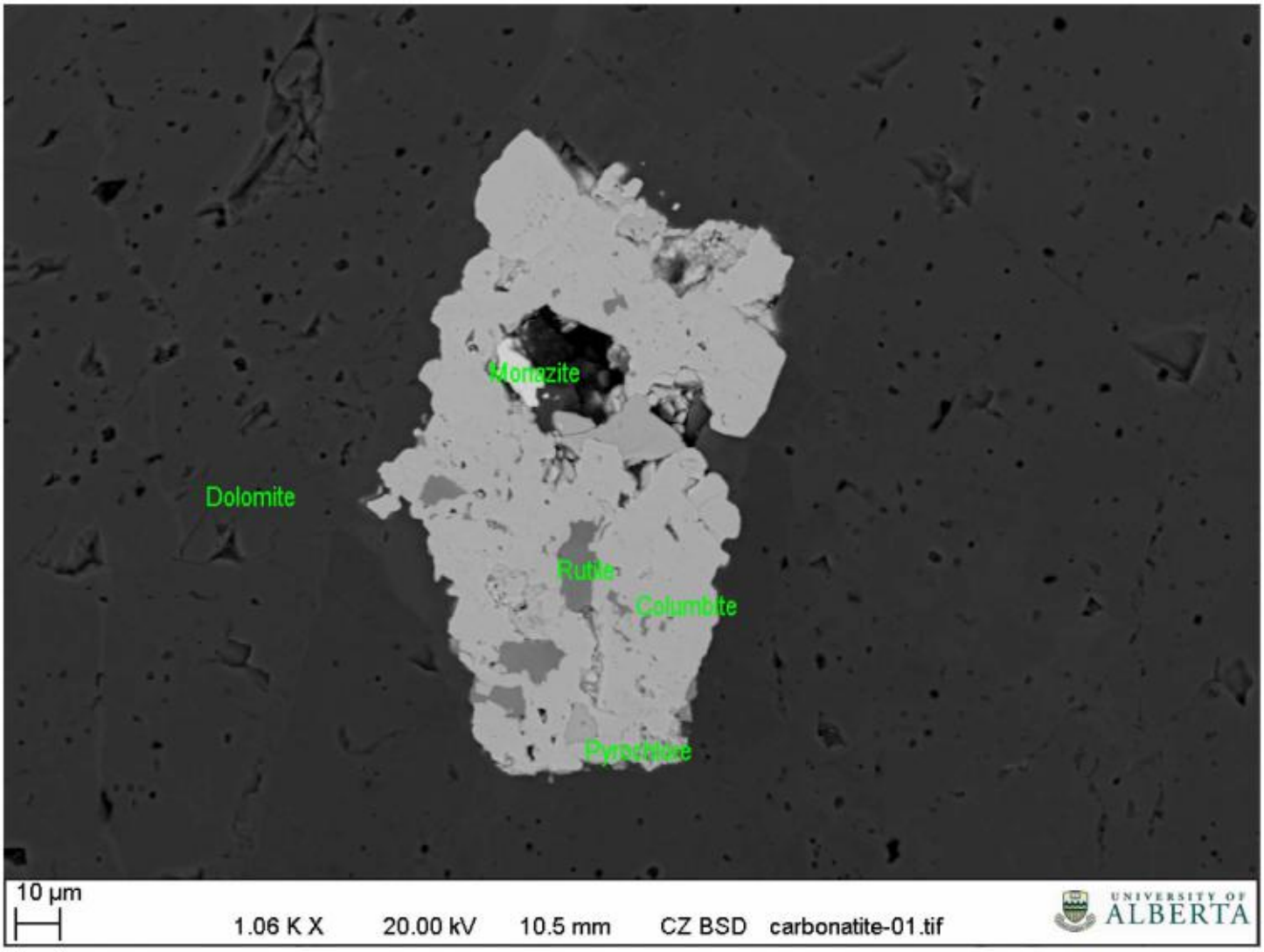

19

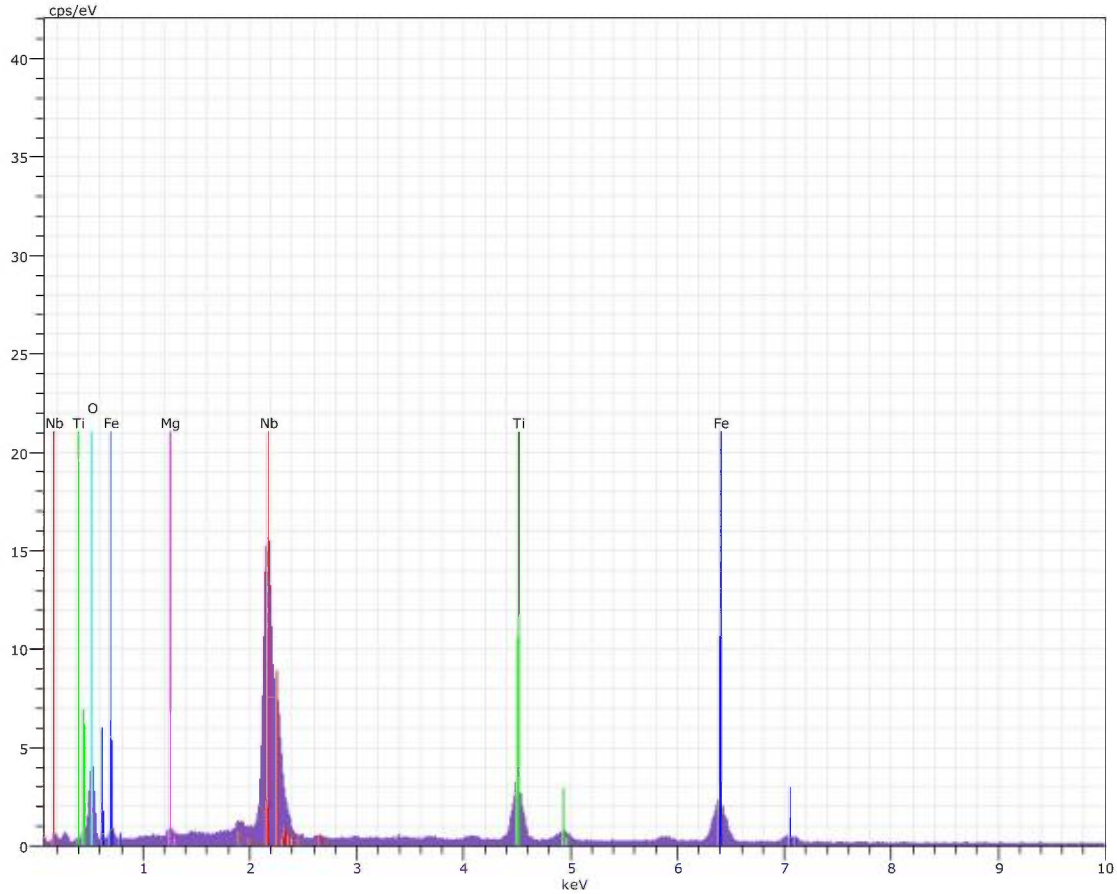
Point of Interest 1:

Small black grain located NW of felt pen dot (see microphotograph #1). As may be seen in the back-scattered electron (BSE) image immediately below, this grain consists mainly of ferrocolumbite, with inclusions of niobium-and-tin-bearing rutile, monazite-(Ce) and pyrochlore in a matrix of ferroan dolomite.

In BSE, monazite is whitest, columbite is pale gray, pyrochlore slightly darker gray, rutile is medium gray, dolomite is dark gray. Holes are black.

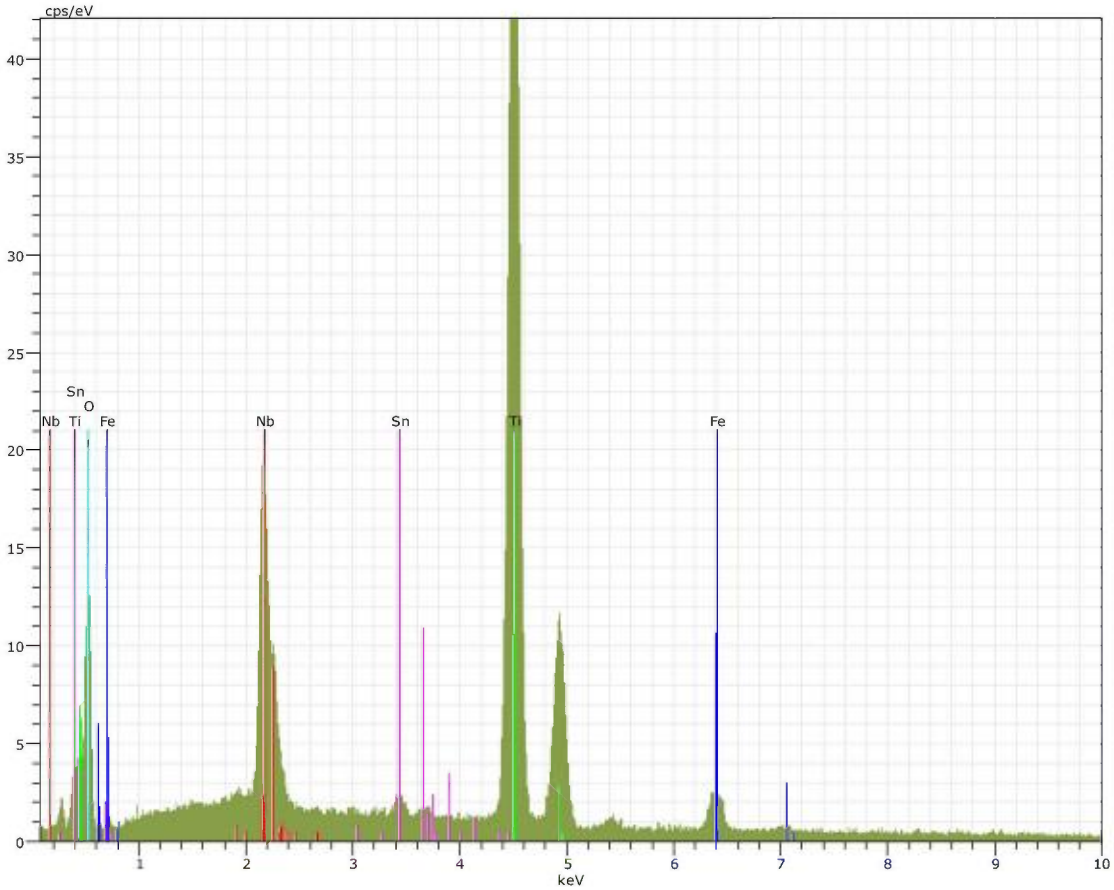
Energy-dispersive X-ray spectra (EDS) follow for each of these minerals. The peak heights are roughly proportional to the abundances of the elements.





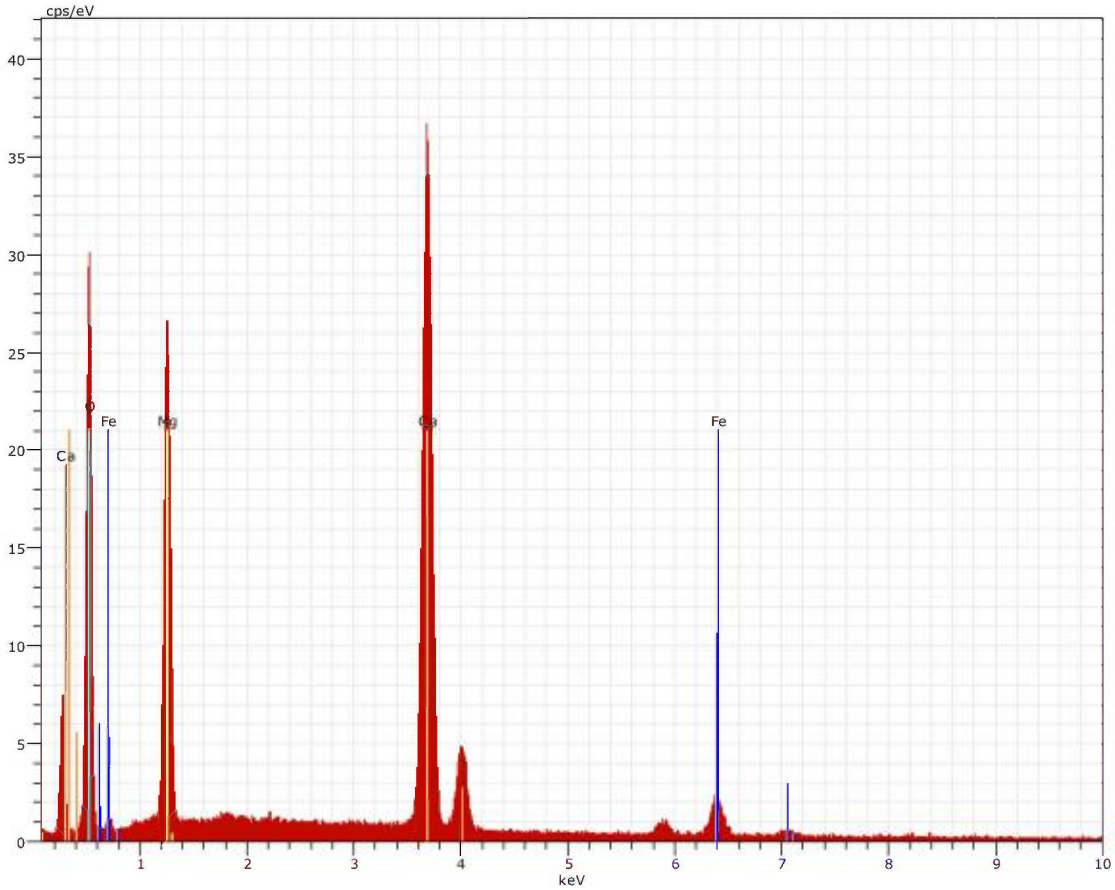
carbonatite_ 1 Date:7/20/2010 8:54:50 AM HV:20.0kV Puls th.:6.92kcps

Energy dispersive X-ray spectrum of Ferrocolumbite (major amounts of Fe, Ti and Nb). Markers of X-ray emission lines also shown at uniform heights for *K* and *L* lines. Note for example that Mg is very low abundance in spectrum, but marker is same height as that of Nb.



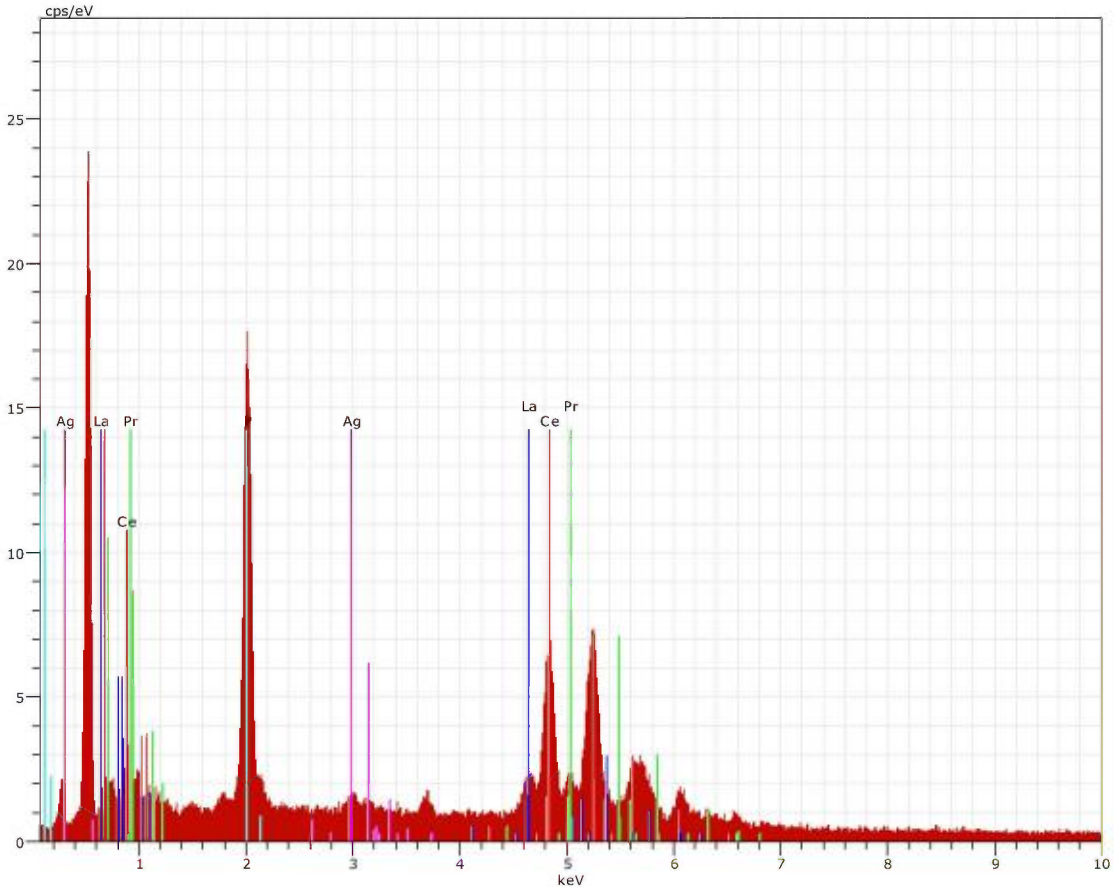
carbonatite_ 2 Date:7/20/2010 8:59:25 AM HV:20.0kV Puls

Rutile with minor amounts of Nb, Fe and Sn (tin).



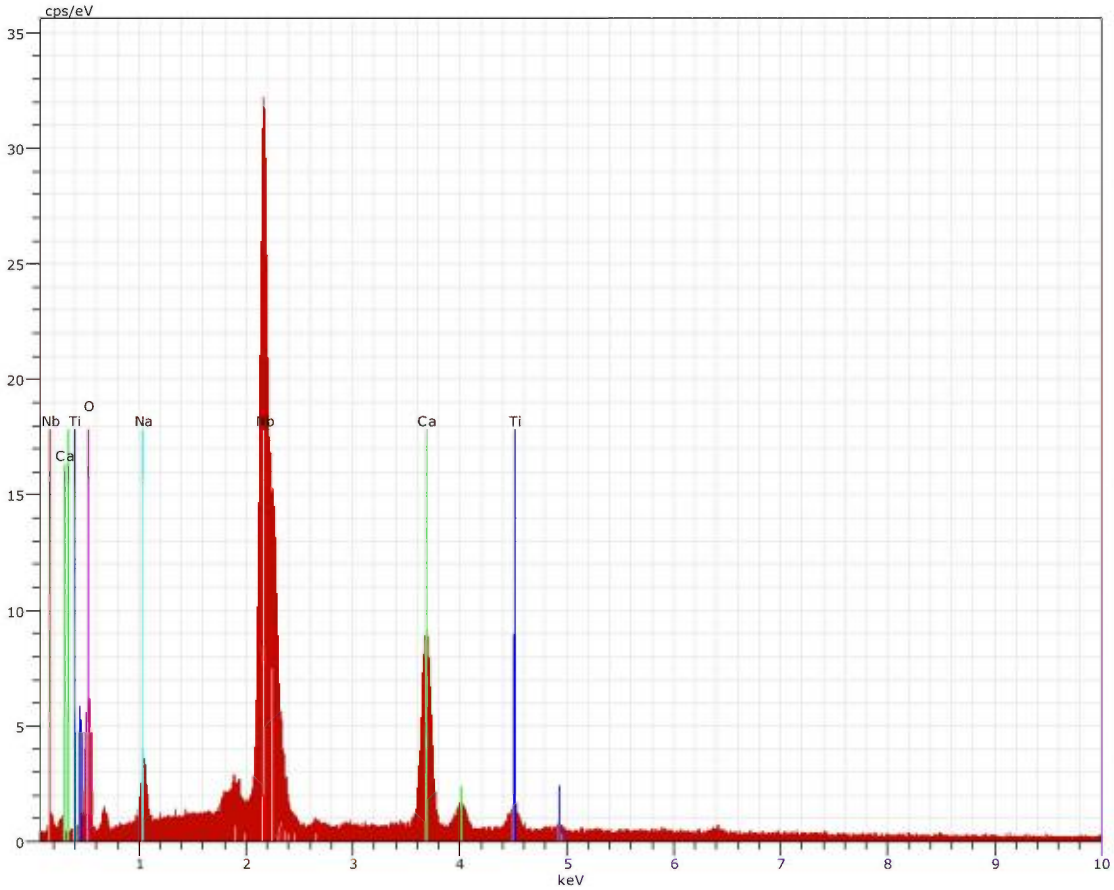
carbonatite_ 4 Date:7/20/2010 9:01:01 AM HV:20.0kV Puls

Dolomite (major amounts of Ca, Mg; minor Fe)



carbonatite_ 5 Date:7/20/2010 9:05:56 AM HV:20.0kV Puls

Monazite-(Ce): major amounts of Ce, La, P



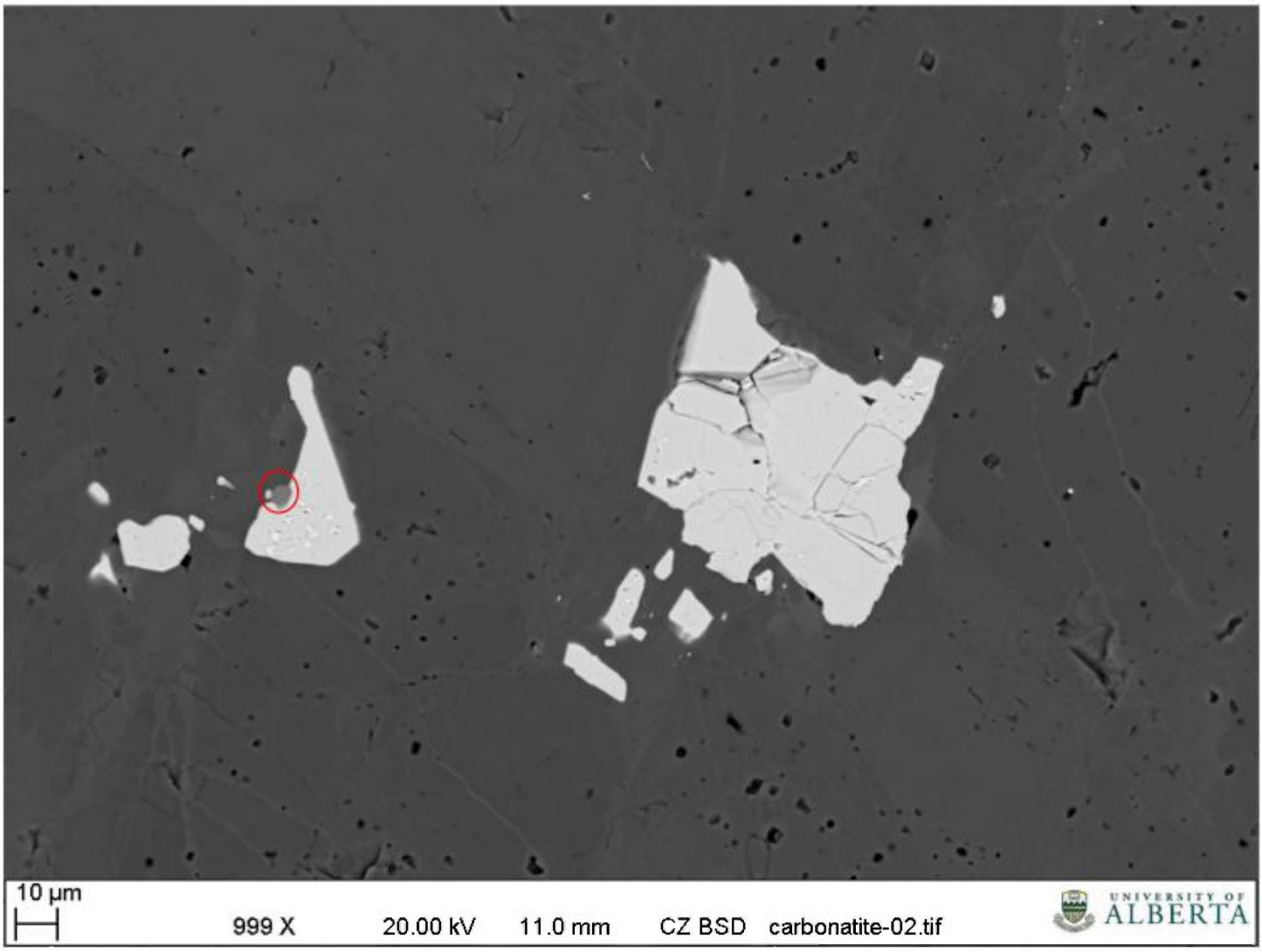
carbonatite_ 6 Date:7/20/2010 9:08:40 AM HV:20.0kV Puls

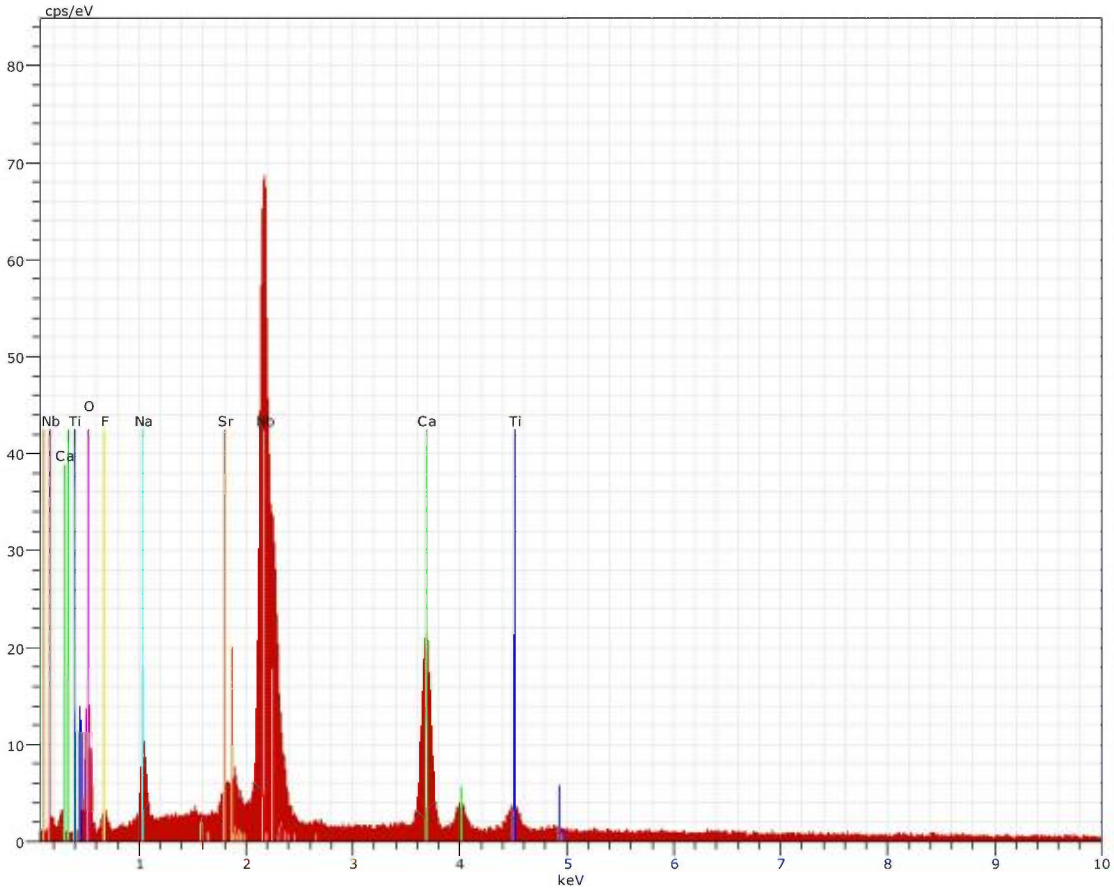
Pyrochlore: major amounts of Ca, Nb; less Ti, Na

Point of Interest 1:

Additional dark grains to WNW of felt dot.

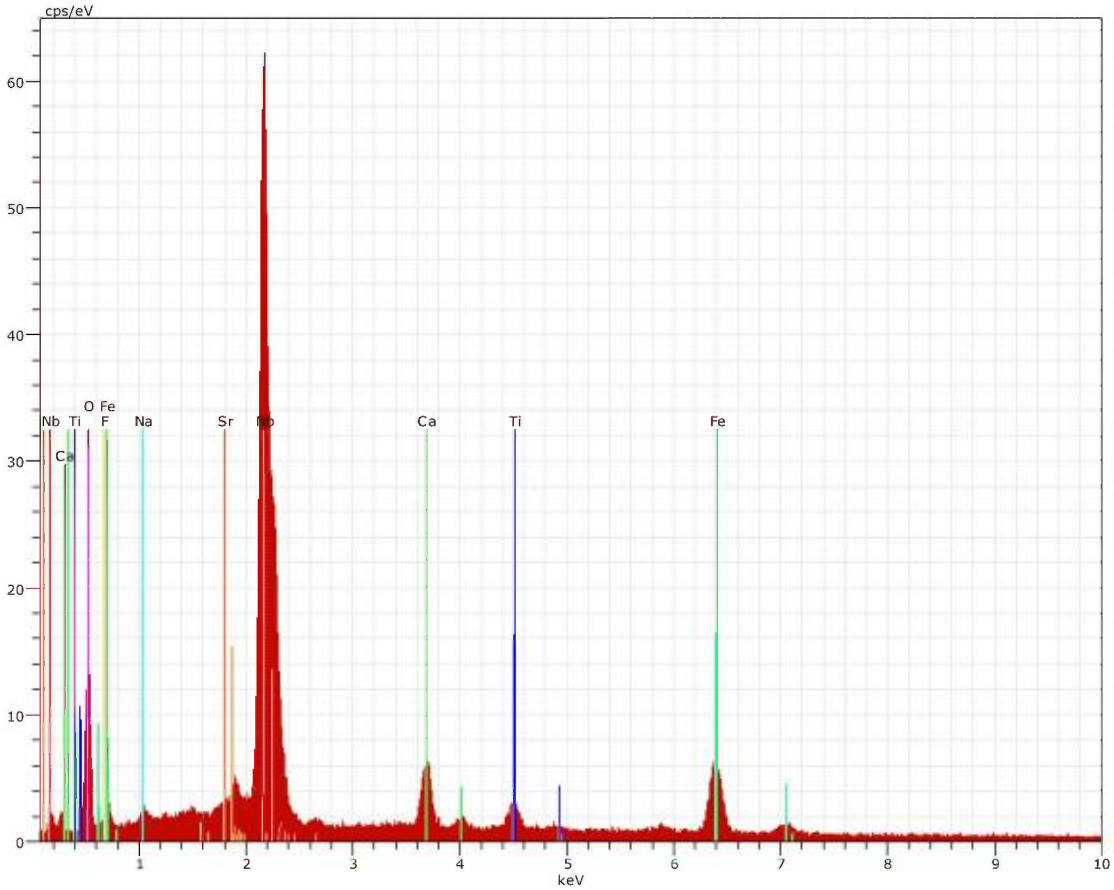
Sr-bearing pyrochlore with micron-scale inclusions of Ca-Fe-Nb oxide (brighter white), and intergrown apatite (medium gray and circled in red on BSE image below), all in dolomite matrix. EDS follows.





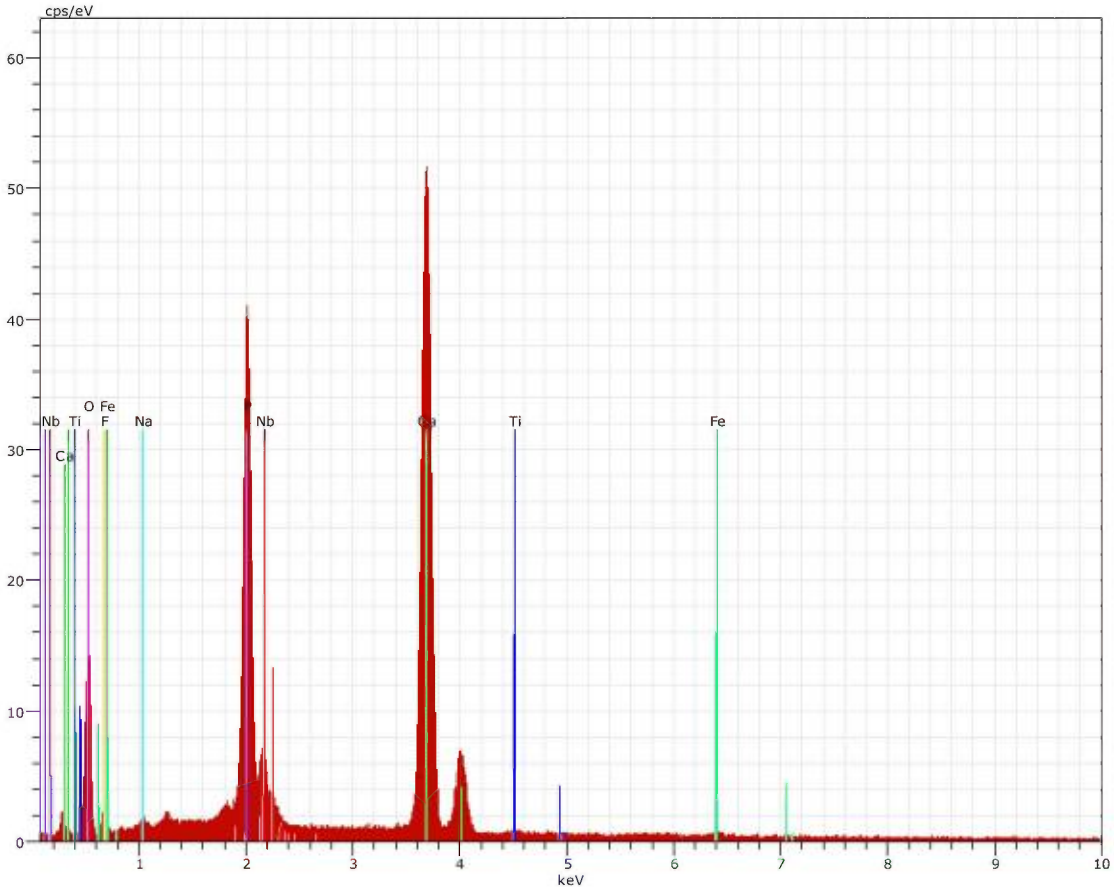
carbonatite_ 8 Date:7/20/2010 9:12:41 AM HV:20.0kV Puls

Strontium-bearing pyrochlore: major Ca, Nb; less Na, Ti, Sr



carbonatite_ 9 Date:7/20/2010 9:15:22 AM HV:20.0kV Puls

Ca-Fe-Nb oxide. May be ferrocolumbite with Ca signal from surrounding material?



carbonatite_ 11 Date:7/20/2010 9:16:56 AM HV:20.0kV Puls

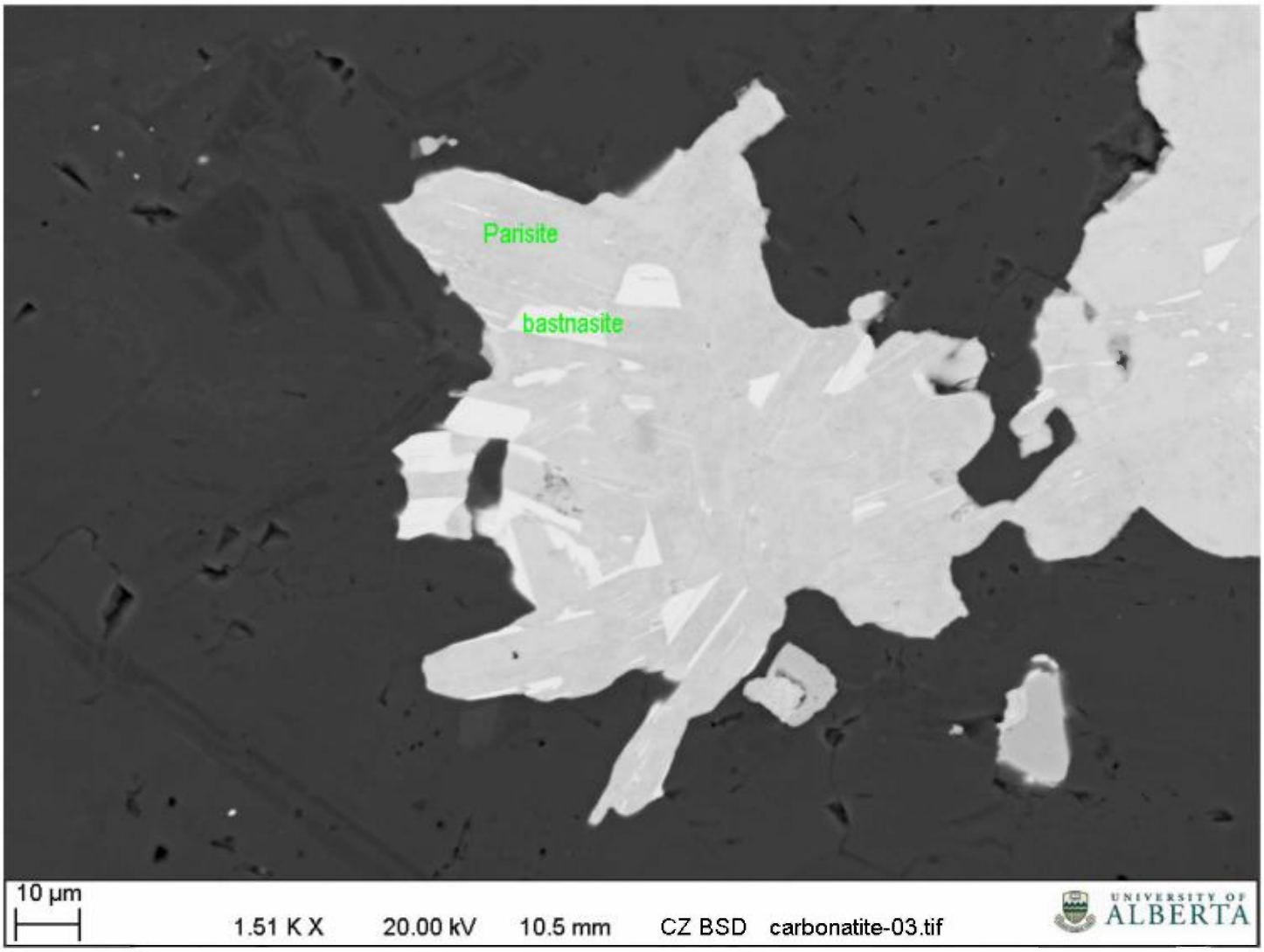
Apatite – major Ca, P

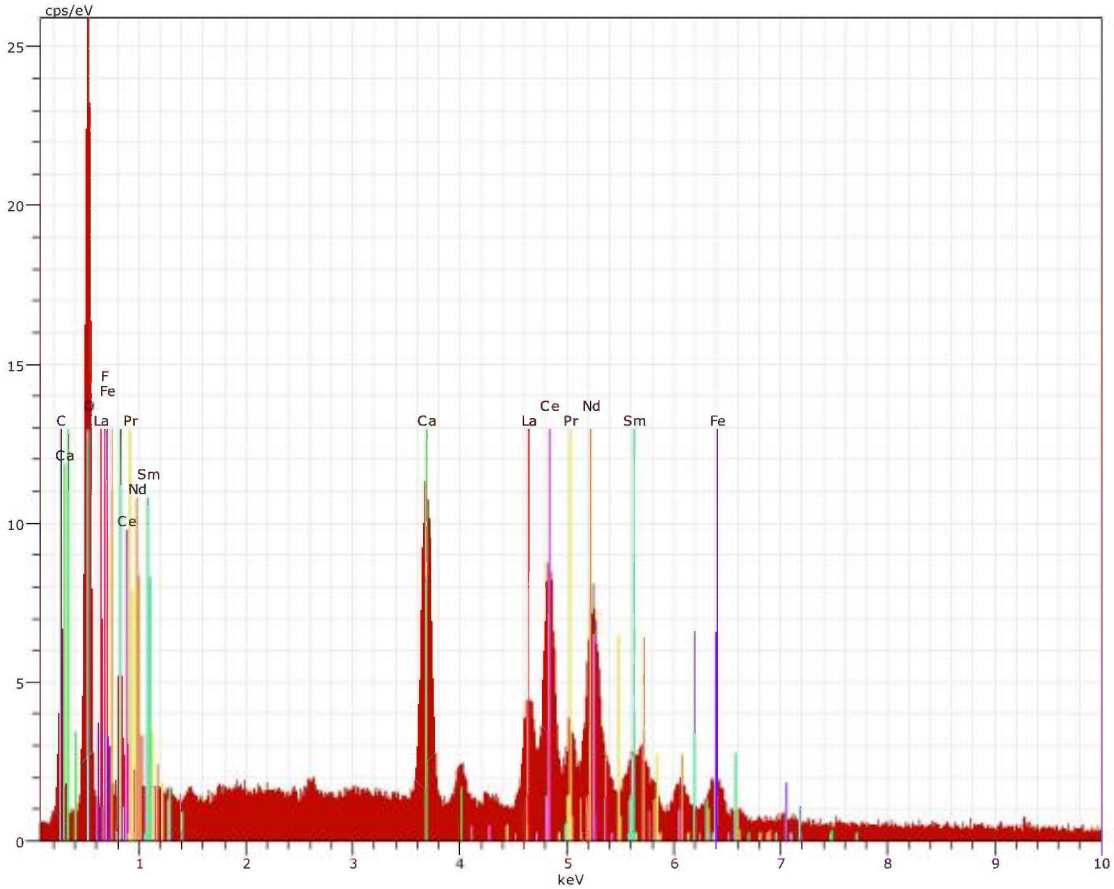
Point of Interest 1:

Red material due west of black felt dot.

Parisite (light gray in BSE image below), with syntactic intergrowth of bastnasite (white), all in dolomite matrix.

EDS spectrum of parisite follows.





carbonatite_ 15 Date:7/20/2010 9:30:38 AM HV:20.0kV Puls

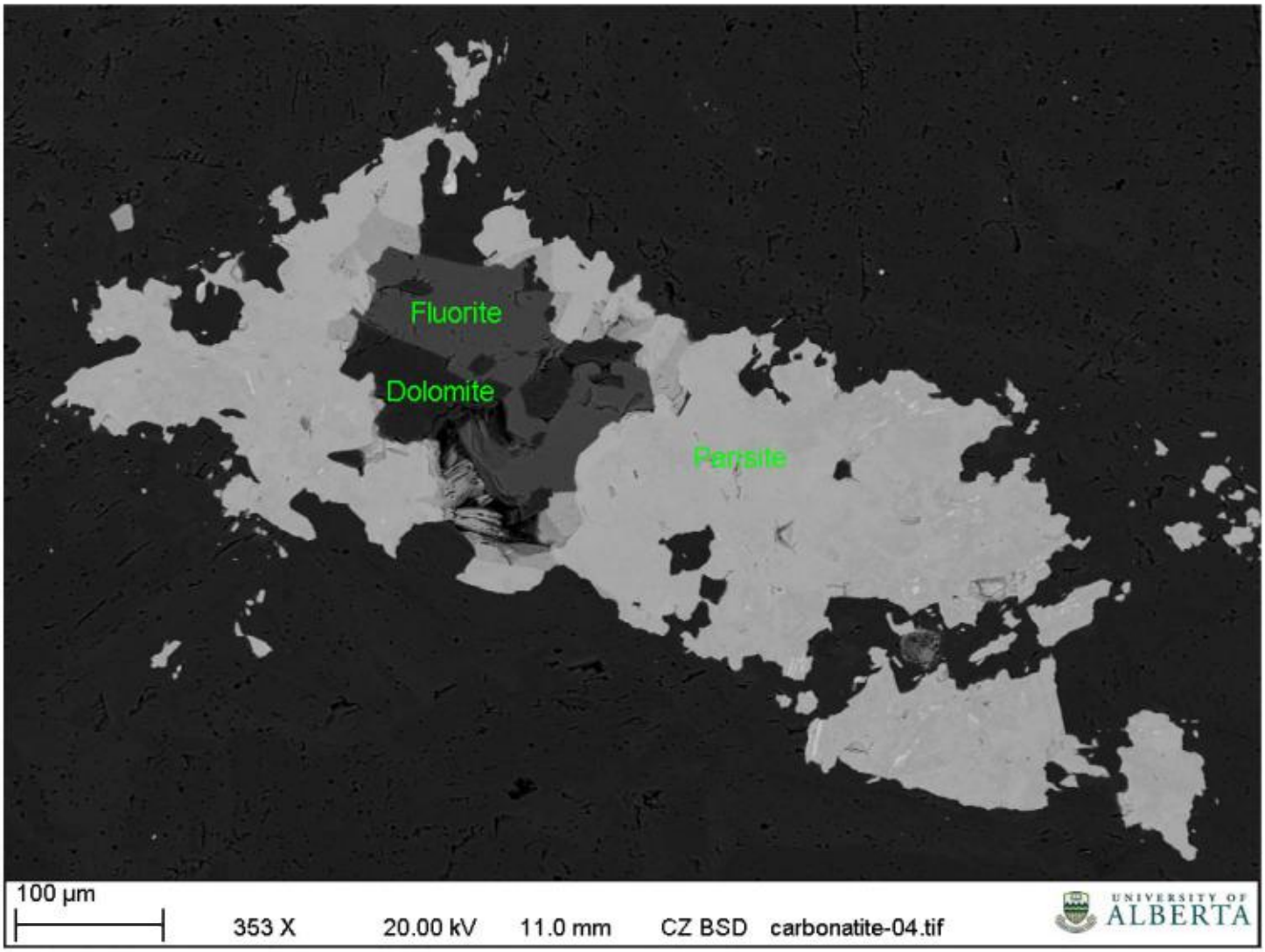
Parisite: major Ca, La, Ce

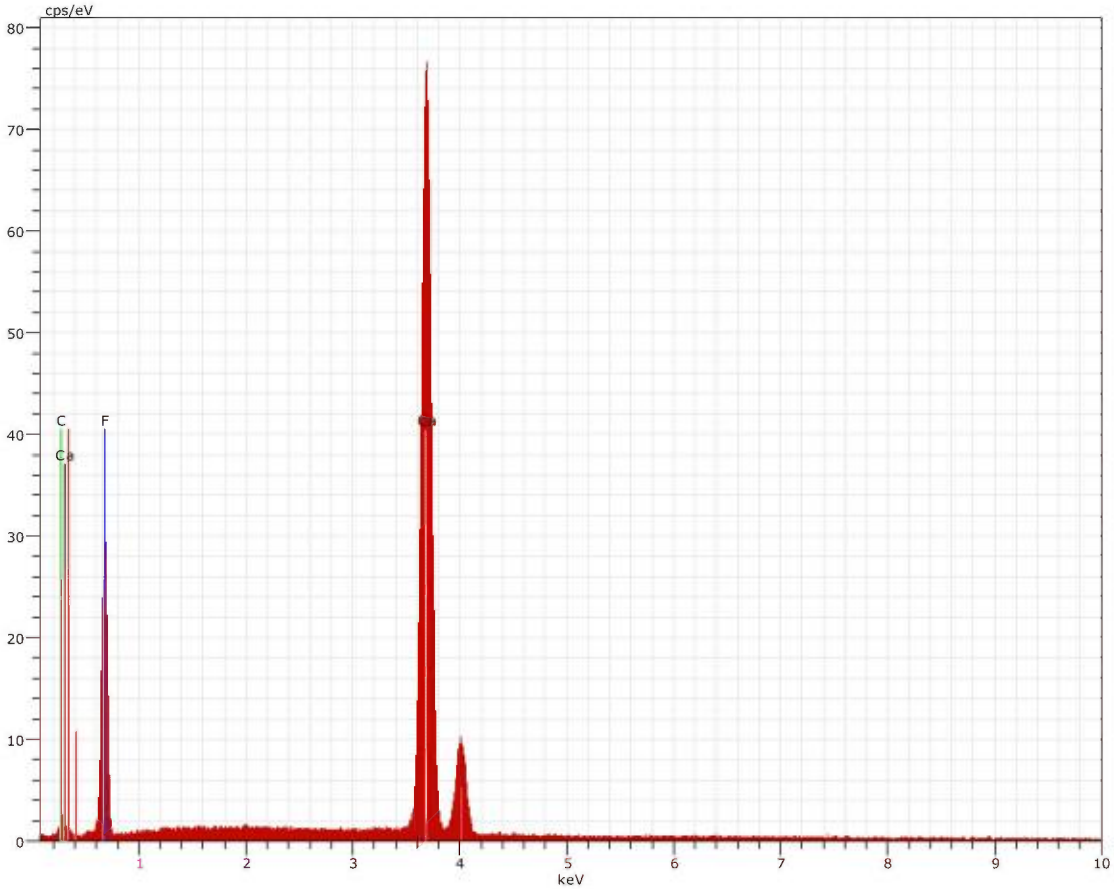
Bastnasite yields a very similar spectrum, but without Ca, just the REE.

Point of Interest 2:

Red and purple grains south of compound black felt pen dot.

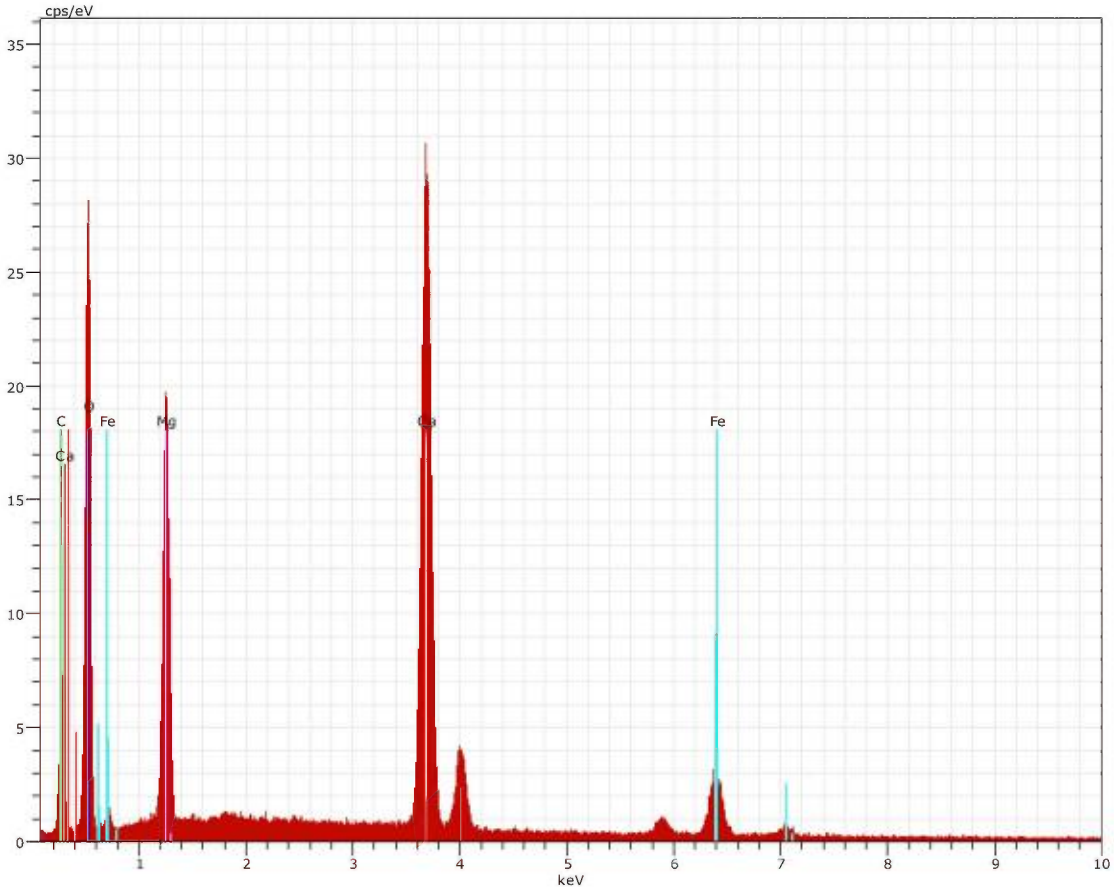
Red material is parisite with intergrown bastnasite. Purple is fluorite. Matrix is dolomite. EDS spectra follow.





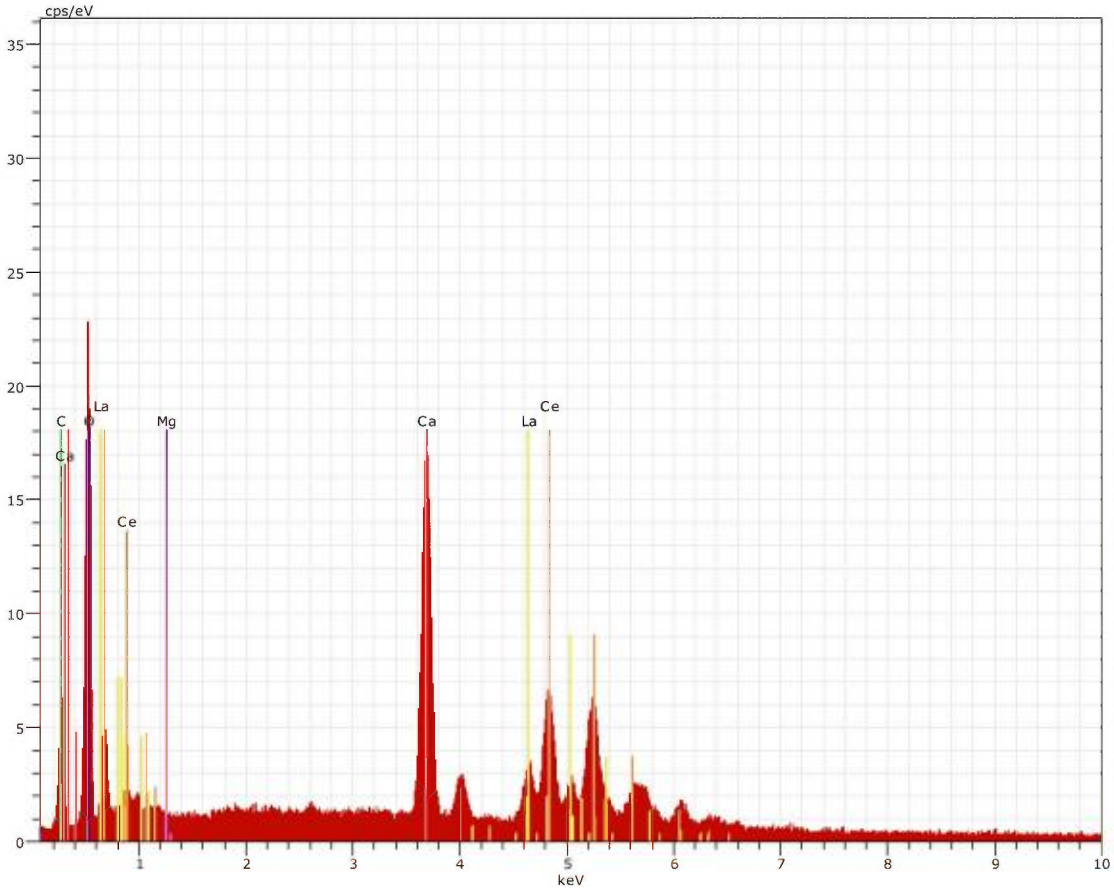
carbonatite_ 16 Date:7/20/2010 9:31:13 AM HV:20.0kV Puls

Fluorite – major Ca, F



carbonatite_ 17 Date:7/20/2010 9:31:51 AM HV:20.0kV Puls

Ferroan dolomite – major Ca, Mg; minor Fe

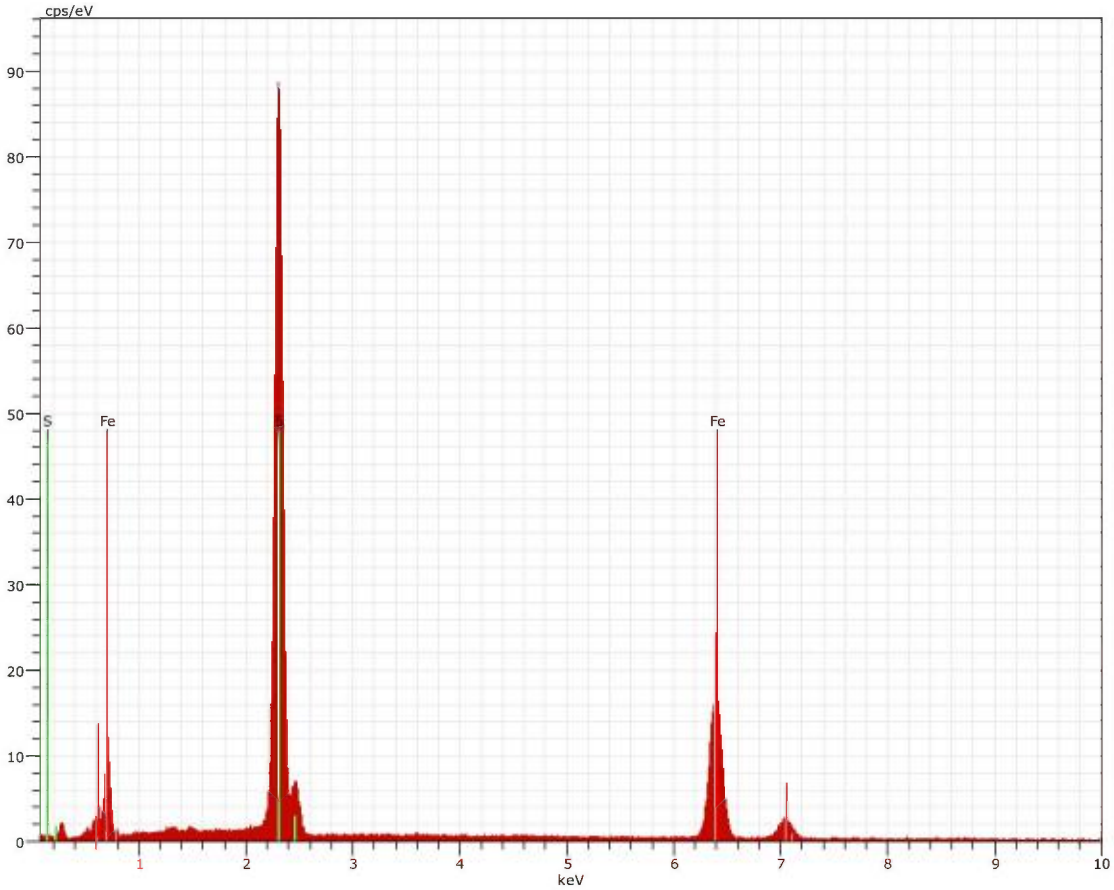


carbonatite_ 18 Date:7/20/2010 9:34:44 AM HV:20.0kV Puls

Parisite – major Ca, La, Ce

Point of Interest 4:

Pyrite. EDS spectrum shows major S, Fe.



carbonatite_ 21 Date:7/20/2010 9:43:45 AM HV:20.0kV Puls

Point of Interest 5:

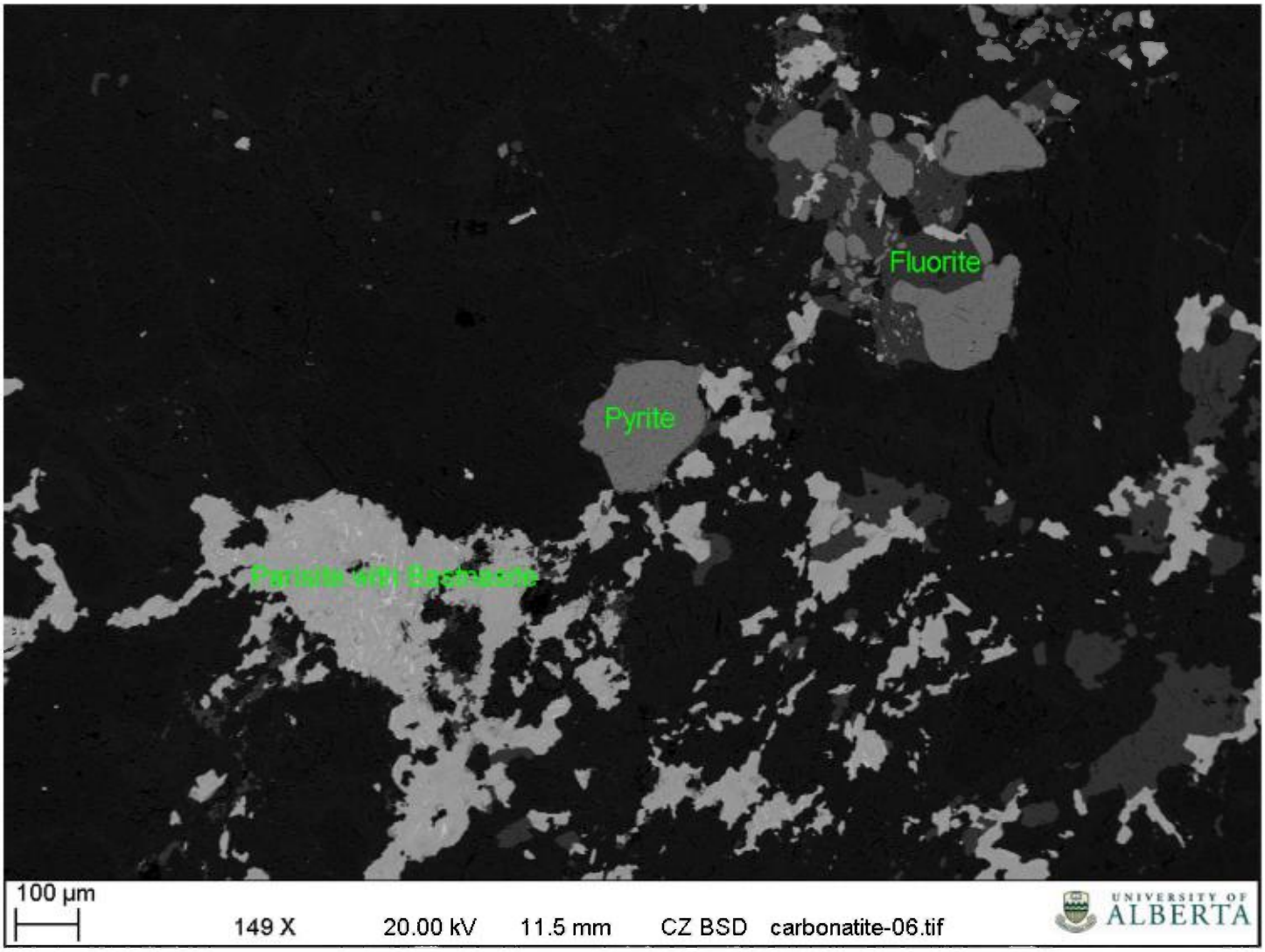
Microphotograph shows two greenish gray triangular groupings, immediately north of black felt dot.

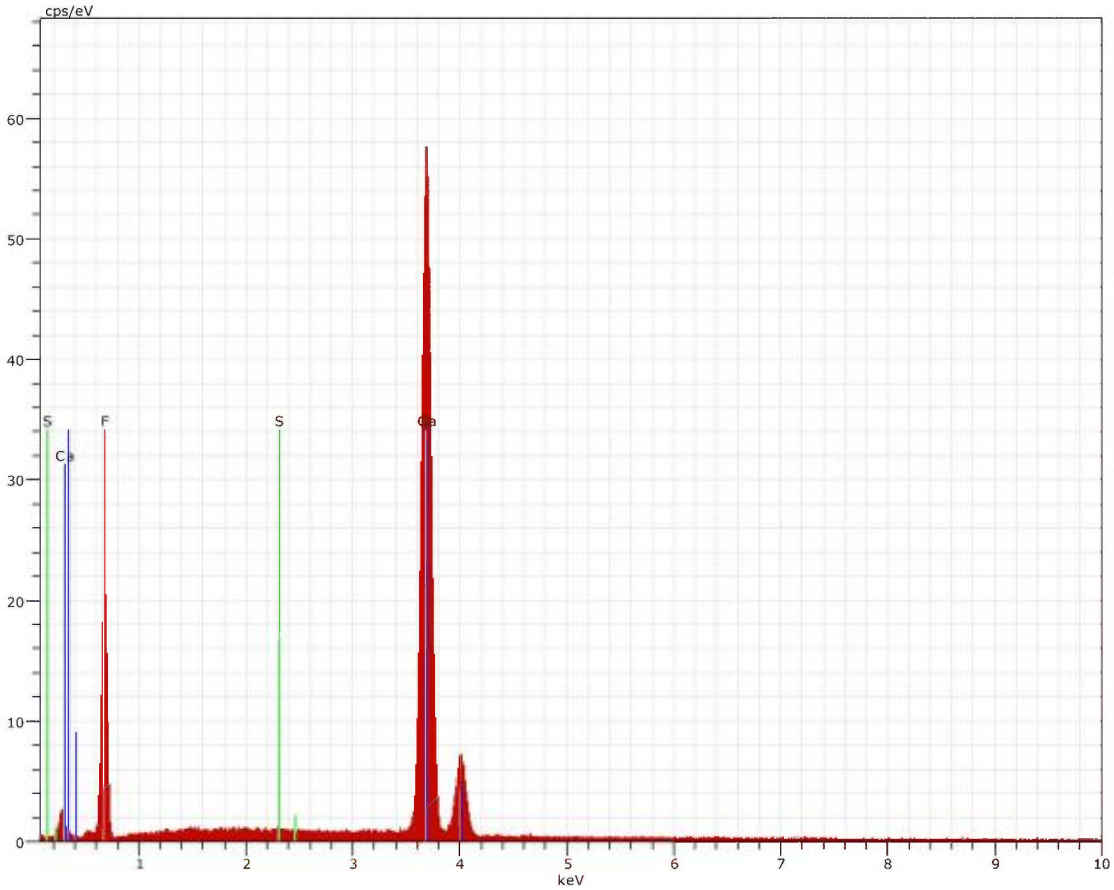
EDS spectrum, not shown here, gave major Mg, Al, Si with minor Fe. Interpretation: chlorite, which is consistent with poor polish of these materials.

Point of Interest 10:

Microphotograph shows brassy material intergrown with purple and red minerals, all in dolomite matrix.

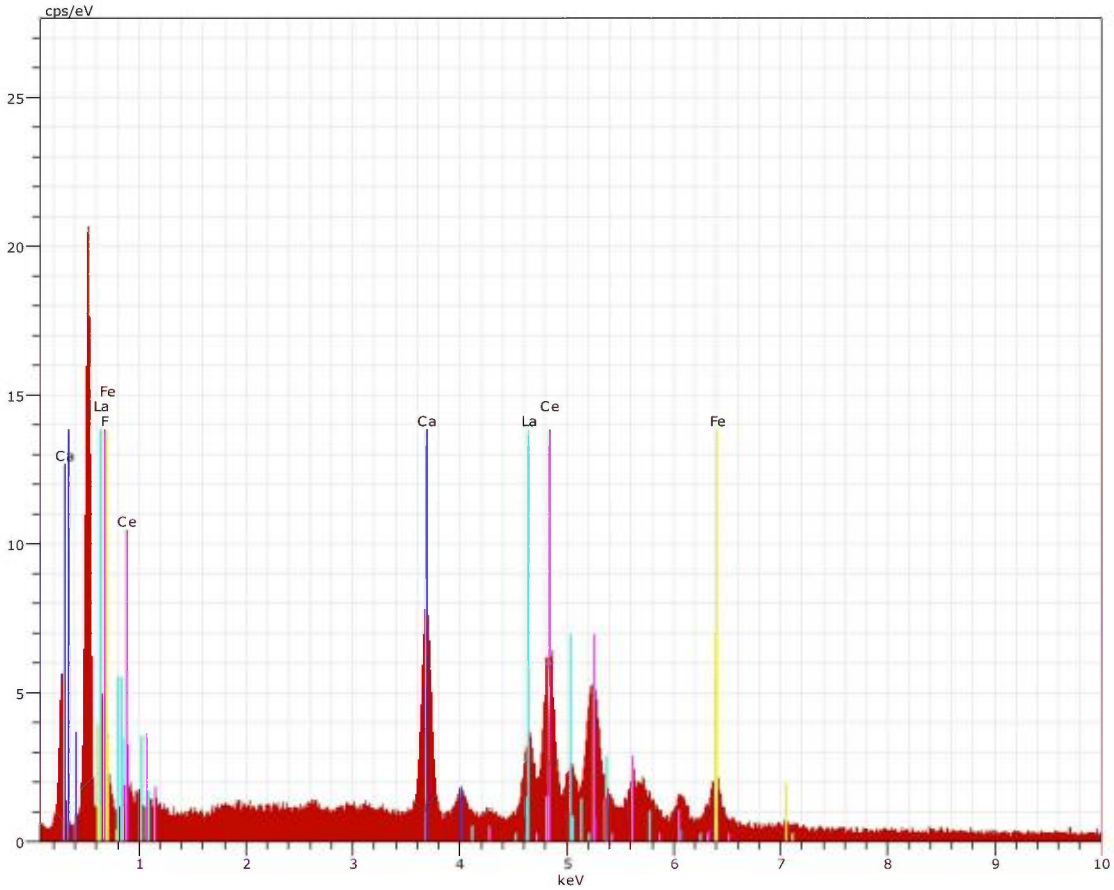
Brassy material is pyrite. Purple mineral is fluorite. Red material is parisite with bastnasite. BSE image is below and selected EDS spectra follow.





carbonatite_ 22 Date:7/20/2010 9:44:21 AM HV:20.0kV Puls

Fluorite – major Ca, F



carbonatite_ 23 Date:7/20/2010 9:45:04 AM HV:20.0kV Puls

Parisite – major Ca, Ce, La