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POTENTIAL OF THE WAKEHAM TERRANE FOR OLYMPIC DAM-TYPE CU-U-AU-AG DEPOSITS AND SANDSTONE-HOSTED PB-ZN DEPOSITS

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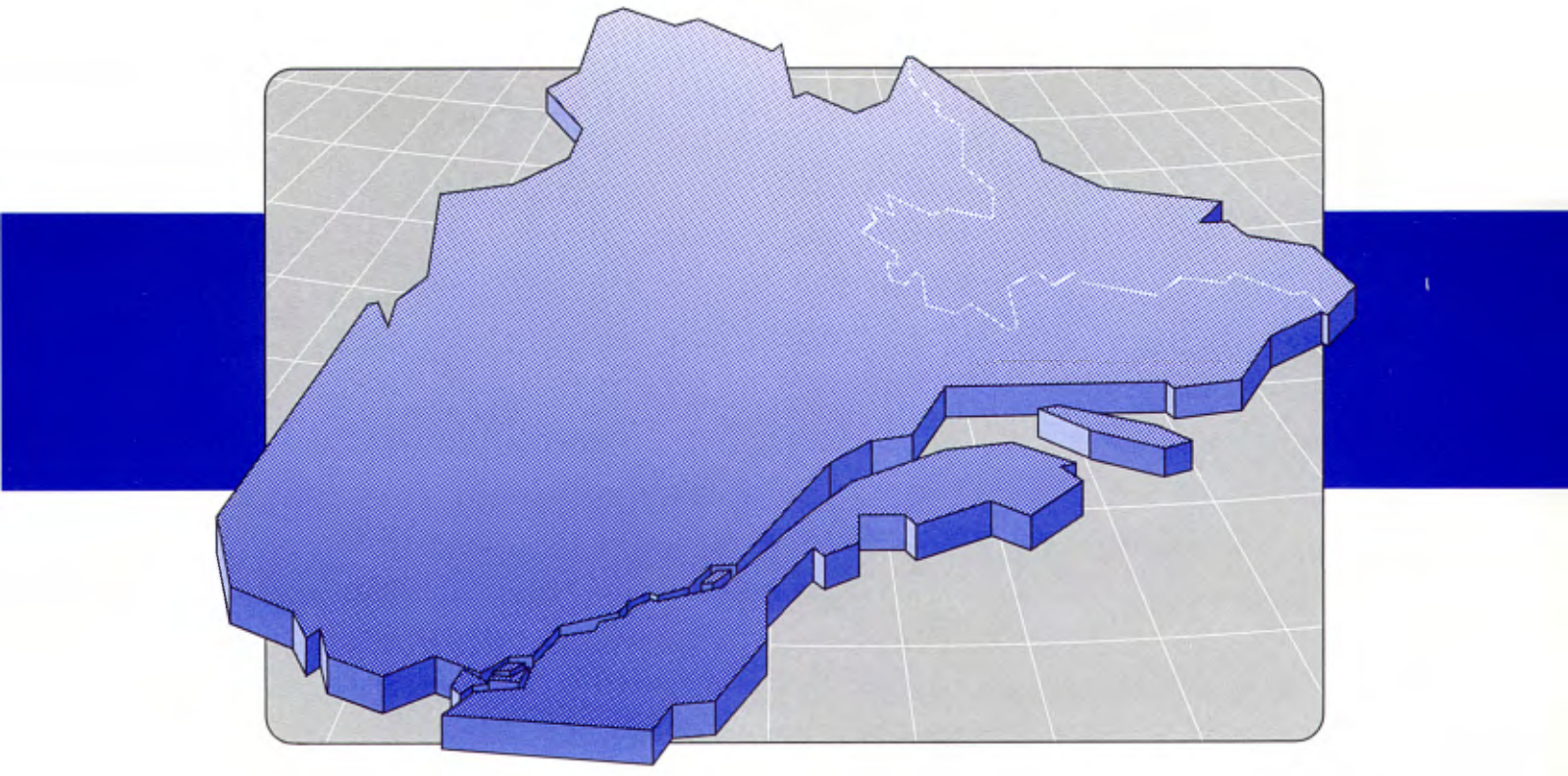
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Potential of the Wakeham Terrane for Olympic Dam-type Cu-U-Au-Ag deposits and sandstone-hosted Pb-Zn deposits

Thomas Clark
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Québec

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Thomas Clark and André Gobeil(1)

INTRODUCTION

Discovered in 1975, the Olympic Dam deposit in South Australia is a major resource containing about 2 billion tonnes averaging 1,6 % Cu, 0,06 % U3O8, 0,6 ppm Au, and 3,5 ppm Ag (Roberts and Hudson, 1983; Oreskes and Einaudi, 1990; Reeve *et al.*, 1990). It also contains significant concentrations of F, Ba, and REE (about 0,5 %).

Stratiform, sandstone-hosted Pb-Zn deposits may contain reserves in excess of 100 million tonnes. Their average Pb content varies between 1 % and 6 %. Zn is much less abundant, although there are exceptions to this. Deposits occur in Sweden, France, Germany, Canada, and elsewhere (Bjørlykke and Sangster, 1981; Mosier, 1986).

The tectonic context, the lithostratigraphy, and the geochemistry of lake-bottom sediments of the Wakeham Terrane suggest that the region has an interesting potential for these types of deposits.

REGIONAL GEOLOGY OF THE WAKEHAM TERRANE

The allochthonous monocyclic belt known as the Wakeham Terrane is located in Québec's Middle North Shore region, about 300 km east of Sept-Îles (figure 1). It consists of Wakeham Supergroup rocks, which include the sedimentary and volcanic rocks of the basal Aguanus Group and the unconformably overlying, mainly sedimentary rocks of the Davy Group (figure 2; Martignole *et al.*, 1987; Avramtchev, 1983). This sequence overlies a gneissic basement of Lower to Middle Proterozoic age.

The lower part of the Aguanus Group is composed of arkose, quartz sandstone, calcareous sandstone, subfeldspathic lithic sandstone, and rare intercalations of pelite and basalt (Martignole *et al.*, 1992; Sharma, 1973). A great thickness of subaerial, porphyritic rhyolite and rhyodacite, including as a few layers of basalt, overlies the sandstones. The volcanic rocks are intruded by porphyritic plutons of granitic, monzonitic, and monzodioritic composition, the hypabyssal equivalents of the felsic volcanics. Trace element study has shown that the felsic volcanic rocks are similar in composition to peralcaline, anorogenic volcanics (Bourne, 1986). The age of the volcanic rocks is 1271 Ma (Loveridge, 1986), although one quartz monzonite pluton has been found to be older, at 1322 Ma (Martignole *et al.*, 1992; age cited in Martignole *et al.*, 1987).

An erosional unconformity separates the Aguanus and Davy groups. The base of the Davy is lithologically varied, and includes, depending on the location, sericite schist, quartz sandstone, black schist, conglomerate, and felsic volcanic rocks. The upper part of the Davy consists mainly of quartz sandstone and sandstone. In places, the sediments contain pebbles of Aguanus Group rocks.

The distribution of the arkosic and pelitic sediments suggests a crude basin polarity in which the sedimentation was relatively immature in the east and distal in the west.

Generally concordant gabbro sills intrude the Aguanus and Davy groups. Several discordant, subcircular, late- to post-tectonic biotite granite to quartz monzonite plutons (one was dated at 993 Ma) are scattered about the region.

The Wakeham Supergroup probably originated in a continental rift zone by erosion of the basement gneisses. The source of part of the detritus in Davy Group rocks was the underlying Aguanus Group. Sedimentation may have occurred in a high energy, fluvio-deltaic environment.

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1 – Service géologique de Québec

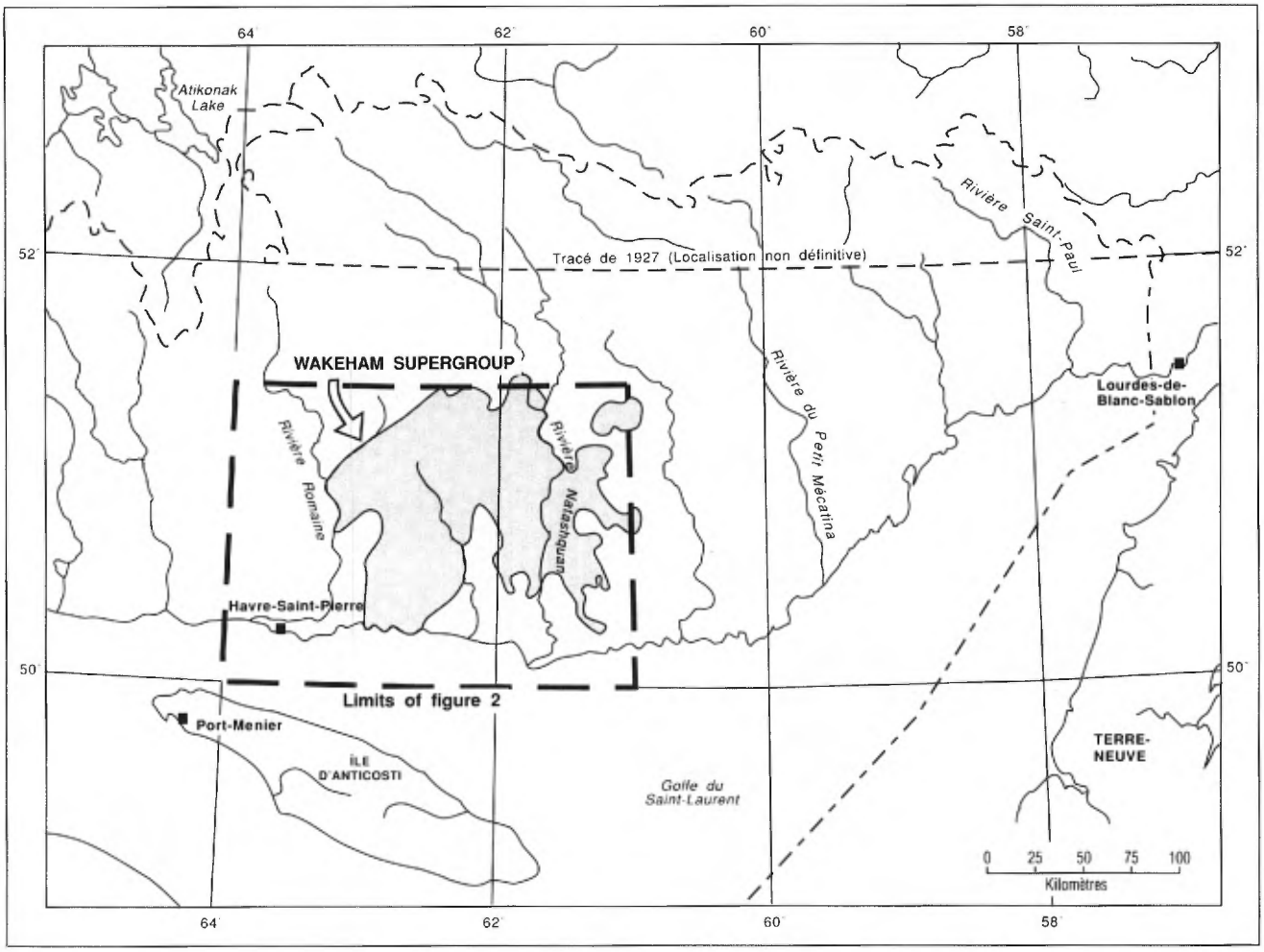


FIGURE 1 – Location map for figure 2 showing the limits of the Wakeham Supergroup.

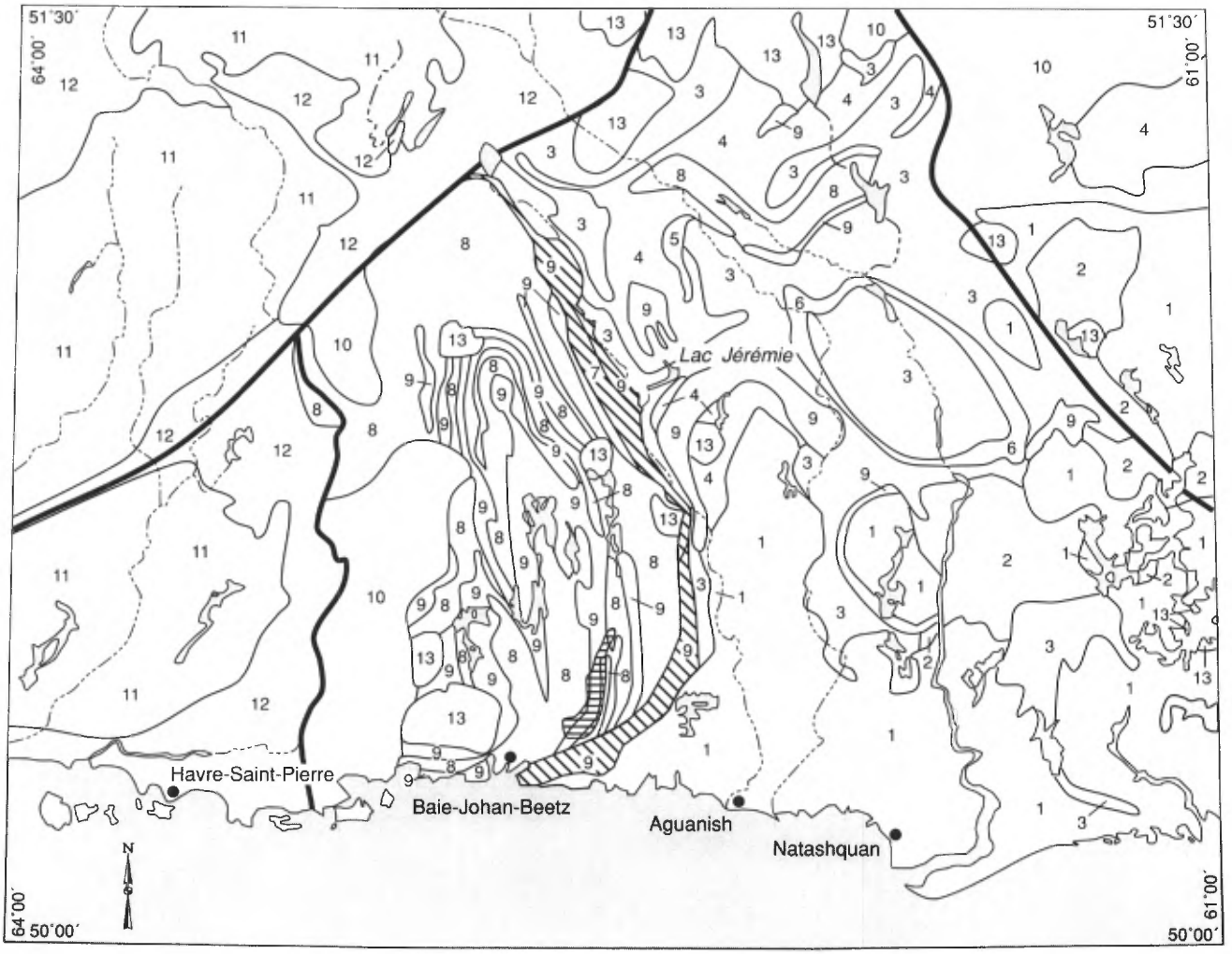
The allochthonous, polycyclic basement of the Wakeham Terrane was affected by Grenvillian and older deformations. By contrast, the Wakeham was deformed only during the Grenville orogenic cycle (1,16 - 0,97 Ga, Rivers *et al.*, 1989). The basal Aguanus Group records two phases of deformation, while the younger Davy Group was affected by just one. A major deformation zone, the Caron Lake Zone, forms the eastern limit of Davy Group rocks (Gobeil and Clark, 1992; figure 2). Greenschist facies metamorphism dominates in the Wakeham Terrane, except along a part of its southern border where amphibolite facies is reached.

POTENTIAL FOR NEW TYPES OF DEPOSITS

More than forty metallic mineral occurrences have been found in the Wakeham Terrane. Most are Cu, Cu-Au, and Cu-Au-Ag mineralizations associated with quartz veins; these have an interesting economic potential (Gobeil and Clark, 1992). Several uranium showings have also been discovered, especially in the Turgeon Lake granite.

Olympic Dam-type Cu-U-Au-Ag deposits

Analysis of the tectonic context, the nature of the magmatism, and the surficial geochemical data suggests that the Wakeham Terrane could have a potential for deposits like that at Olympic Dam. This Middle Proterozoic deposit is of epigenetic-hydrothermal origin (Oreskes and Einaudi, 1990). It formed in a continental rift setting, and is hosted by a type A syenogranite, part of a suite of alcalic to subalcalic granitic plutons and felsic volcanics. The mineralization occurs in granitic breccias rich in hematite. It is characterized by enrichments in Fe, Cu, U, Au, Ag, REE, Ba, F, Cl, S, and CO_2. The central part of the deposit is enriched in REE and copper sulfides. The sulfides become



MIDDLE PROTEROZOIC

13	Late granite
12	Monzonite
11	Anorthosite
10	Foliated granite (may include some late granite)
9	Gabbro

Davy Group

8	Quartz sandstone, minor conglomerate
7	Sericite and/or chlorite schist

Aguanus Group

6	Black schist, crystalline limestone
5	Hypabyssal monzonite
4	Rhyolite, rhyodacite, minor basalt
3	Quartz sandstone, sandstone, pelite, quartzite
2	Arkose

MIDDLE / LOWER PROTEROZOIC

1	Granite gneiss (basement)

Caron Lake deformation zone

Pb anomaly (lake sediments)

Geological contact

Lineament

River

FIGURE 2 – Simplified geology of the Wakeham Terrane and adjacent areas (adapted from Indarès and Martignole, 1992). The Wakeham Terrane includes units 2 to 9, which are intruded by unit 13.

more iron-rich towards the margin of the deposit. The U, Au, Ag, and REE are associated with the sulfides. The mineralizing event was contemporaneous with the local deposition of laminated, hematite-barite-rich sediments.

The following elements appear to be important for the origin of the Olympic Dam deposit:

- extension of the continental crust (rift);
- anorogenic plutonism and volcanism;
- alcalic to subalcalic magmatism;
- epizonal to superficial emplacement of the mineralization;
- strong hydrothermal alterations, especially hematitization;
- linear tectonic structures.

Several of these elements pertain to the Wakeham Terrane. Although no widespread hematite enrichment is known, quartz-hematite veins are locally quite common (Indarès and Martignole, 1992). At Noel Lake, about 15 km NE of Jérémie Lake (figure 2), a chalcopyrite-chalcocite-hematite mineralization occurs in a brecciated basalt-rhyolite sequence cut by quartz-calcite veins (Carrier, 1974). Also, fluorite-bearing veins are present locally in the subvolcanic granites. Lake-bottom geochemical surveys (Pelletier, 1986; Beaumier, 1989a, 1989b) show that the area to the north of Jérémie Lake underlain by Aguanus Group rhyolite and quartzite contains several anomalies characteristic of Olympic Dam, such as Ba, REE, F, Mo, Pb, Sr, Th, U, Y, and Zn. This area therefore seems to be the most promising.

Stratiform, sandstone-hosted Pb-Zn deposits

The Wakeham Terrane may also have a potential for sandstone-hosted Pb-Zn deposits. Such deposits vary in age from Lower Proterozoic to Mesozoic. They are generally composed of disseminated sulfides, which occur in quartz sandstones in a transgressive sequence deposited in either a fluvio-continental or a shallow water marine environment. Marine sediments are usually present in the upper parts of the sequences, but examples exist where such sediments are absent (e.g. Yava deposit, Nova Scotia). The mineralized sediments are typically grey to white in colour, indicating relatively reducing conditions.

In one model, the mineralizing solutions are brines expelled from the sedimentary sequence during compaction. They migrate along permeable strata (such as sandstone beds) towards the edge of the basin. Another model (preferred by Bjørlykke and Sangster, 1981) proposes the weathering of the source rocks and the transport of the metals by meteoric water circulating in aquifers towards the sedimentary basin. In both models, metal deposition occurs in porous strata when the physico-chemical conditions become reducing, due for example to the presence of reduced sulfur. A possible source for the lead is the potassic feldspar in the granitic basement, especially if these rocks are relatively enriched in Pb. Another possible source would be potassic volcanic rocks or arkoses if these are present in the supracrustal sequence and available for weathering.

The Wakeham Terrane displays several of the characteristics favorable for sandstone-hosted Pb-Zn deposits, for example, a continental rift context, suitable sources for Pb (granitic basement, arkoses, and potassic volcanic rocks), and aquifers. However, the Wakeham Terrane contains few carbonate rocks, suggesting that a generalized marine invasion was unlikely. Nevertheless, there are sporadic horizons of calcareous sandstone, local inclusions of crystalline limestone in gabbro (Claveau, 1949), and a marker unit of black to dark grey schist and pink crystalline limestone in the eastern sector of the Wakeham Terrane (Sharma, 1973). These occurrences suggest that marine conditions may have existed in places. Horizons of dark grey to black schist near the base of the Davy Group and intercalated with the sandstones elsewhere in the sequence indicate that reducing conditions favorable for sulfide deposition were locally present.

From an exploration point of view, it is interesting to note that a lake bottom geochemical survey (Pelletier, 1986) has revealed, in the southern part of the area, a 20 km-long Pb anomaly parallel to the stratification in the Davy Group (figure 2). The cause of this anomaly is not known. Because of its large size and its stratiform shape, this anomaly warrants further study in the field.

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