

GM 28448

A REVIEW AND DRILLING PROPOSAL, MAGDALEN ISLANDS SALT PROJECT

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MAGDALEN ISLANDS SALT PROJECT

- A Review and Drilling Proposal -

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George V. Mueller, Ph.D.,
Consulting Geologist

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LOCATION MAP

MAGDALEN ISLANDS SALT PROJECT

- A Review and Drilling Proposal -

SUMMARY

Suspected salt deposits under the Magdalen Islands in the Gulf of St. Lawrence, Quebec (Index Map facing this page and Fig.1, Page 2), were investigated during 1971 by a private Quebec group. As a result of this investigation the group staked and owns outright a block of 91 contiguous claims, with an area of approximately 3,640 acres, on the southern Magdalen Island of Hâvre Aubert (Amherst), and a block of 144 contiguous claims, with an area of approximately 5,760 acres, on the central islands of Grindstone and Alright. The claim blocks cover pronounced low gravimetric anomalies. The character of these anomalies, and regional and local considerations, indicate they are caused by true salt domes underlying the islands at non-uniform depths but rising closest to the surface under the claim groups. These domes appear to be within a potential but still largely unexplored so-called "salt dome basin", extending under the Gulf of St. Lawrence eastwards from the Magdalen Islands towards Newfoundland. They are probably the only true salt domes in North America, outside of Louisiana and Texas in the Gulf Coast region salt basin, which are accessible from land for mining purposes.

The gravity-indicated high points of both salt domes happen to be situated within one mile of harbour facilities. The Hâvre Aubert anomaly is the most pronounced and has a magnitude (amplitude) of about 14 to 15 milligals measured

.../...



Figure 1

against local background and a magnitude of approximately 7 milligals measured over a distance of 1.5 miles from the lowest value. The latter gives a gradient of 4.7 milligals per mile. The steepest gradient at Hâvre Aubert - measured over a distance of $\frac{1}{2}$ mile - is 8 milligals per mile. The dimensions of the inner core of the anomaly as measured on land are approximately 3 miles by 1 mile with the latter dimension still open. The Grindstone/Alright anomaly has a magnitude of 13 to 14 milligals measured against local background and a magnitude of 5.5 milligals measured over a distance of 1.5 miles from the lowest value. The latter gives a gradient of 3.6 milligals per mile. The steepest gradient on the Grindstone/Alright anomaly is 6 milligals per mile. The dimensions of the inner core of the anomaly are approximately 5 miles by 1 to 2 miles with the former dimension still open.

Computations based on field data, details of which are presented in the accompanying gravity survey reports prepared by the Nova Scotia Research Foundation (Enclosures 1 and 2), and other considerations, suggest that the high point on top of the salt dome under the Hâvre Aubert claim group is probably between 500' and 2,000' below the surface; the high point on top of the Grindstone/Alright salt dome is probably between 700' and 2,000' below the surface. Although the depth at which mining of salt becomes uneconomic will depend upon many factors, it is tentatively assumed here that 200 to 300 feet of the dome will have to have been penetrated before the 2,000' level is reached. The high points of the observed anomalies represent upward projections or protrusions of salt which have developed out of immense salt domes of great thickness (5 miles) and areal extent rising

under and beyond the shores of all three islands. Because of the size of the upward projections, not to mention the main domal structure, it is clear that once diamond drilling has established that salt of adequate purity occurs within a mineable depth, there will be no question of the adequacy of reserves. Five targets have been designated by the Nova Scotia Research Foundation where drilling may intersect a substantial thickness of salt before 2,000'.

The promoters of the Magdalen Islands salt project invite participation by interested companies in a core-drilling project to confirm the presence of salt at a mineable depth under either Hâvre Aubert or Grindstone/Alright Islands and to establish its purity. The terms of participation and the level of interest which could be earned are open to discussion. Procedural instructions for the proposed drilling program are attached (Enclosure 3).

SALT BASINS AND THE
REGIONAL GEOLOGICAL SETTING OF THE MAGDALEN ISLANDS

The Magdalen Islands lie within a former sedimentary basin - the Fundy Epieugeosyncline - in which terrestrial and marine sedimentation took place in Carboniferous time. Fundy Basin rocks are now exposed in all of the Maritime Provinces, Newfoundland and the Magdalen Islands. The boundaries of the Fundy Basin are shown in Enclosure 4.

The rocks of marine origin are at the bottom of the Carboniferous section; they make up the so-called Windsor Group of Upper Mississippian age. The group consists of various clastics and limestone and of the evaporites -

.../...

gypsum, anhydrites and rock salt. Evaporites make up as much as 20 to 30% of the Windsor Group. The salt is sufficiently important volumetrically that the entire Fundy Basin is classed as one of the major salt basins of the Western Hemisphere (1). Outcrops of Windsor Group rocks, including gypsum, are, of course, well-known in Nova Scotia, New Brunswick, Newfoundland and the Magdalen Islands. Salt deposits of Windsor age have also been known for many years in Nova Scotia and New Brunswick, particularly the former. Much more recently, limited drilling for oil and regional gravity and seismic work indicate that the Carboniferous rocks deposited in that portion of the Fundy sedimentary basin now under the Gulf of St. Lawrence are probably largely Windsor in age and contain thick sections of salt of quite different structural character from that previously known in Nova Scotia.

Occurrence and Distribution of True Salt Domes
in the Gulf of St. Lawrence Area

True salt dome structures, in the sense of those found in the region of the Gulf of Mexico, have not, until recently, been suspected in eastern North America. Off-shore oil drilling over the past two years, however, and the regional marine seismic and gravity work referred to above, now point to their presence under the Gulf of St. Lawrence in certain parts of the Fundy Salt Basin. The detailed gravity work recently completed on the Magdalen Islands suggests the islands themselves reflect underlying rising salt domes.

More specifically, regional seismic evidence has demonstrated that Windsor Group rocks under the Gulf achieve their maximum thickness in a so-called depositional centre

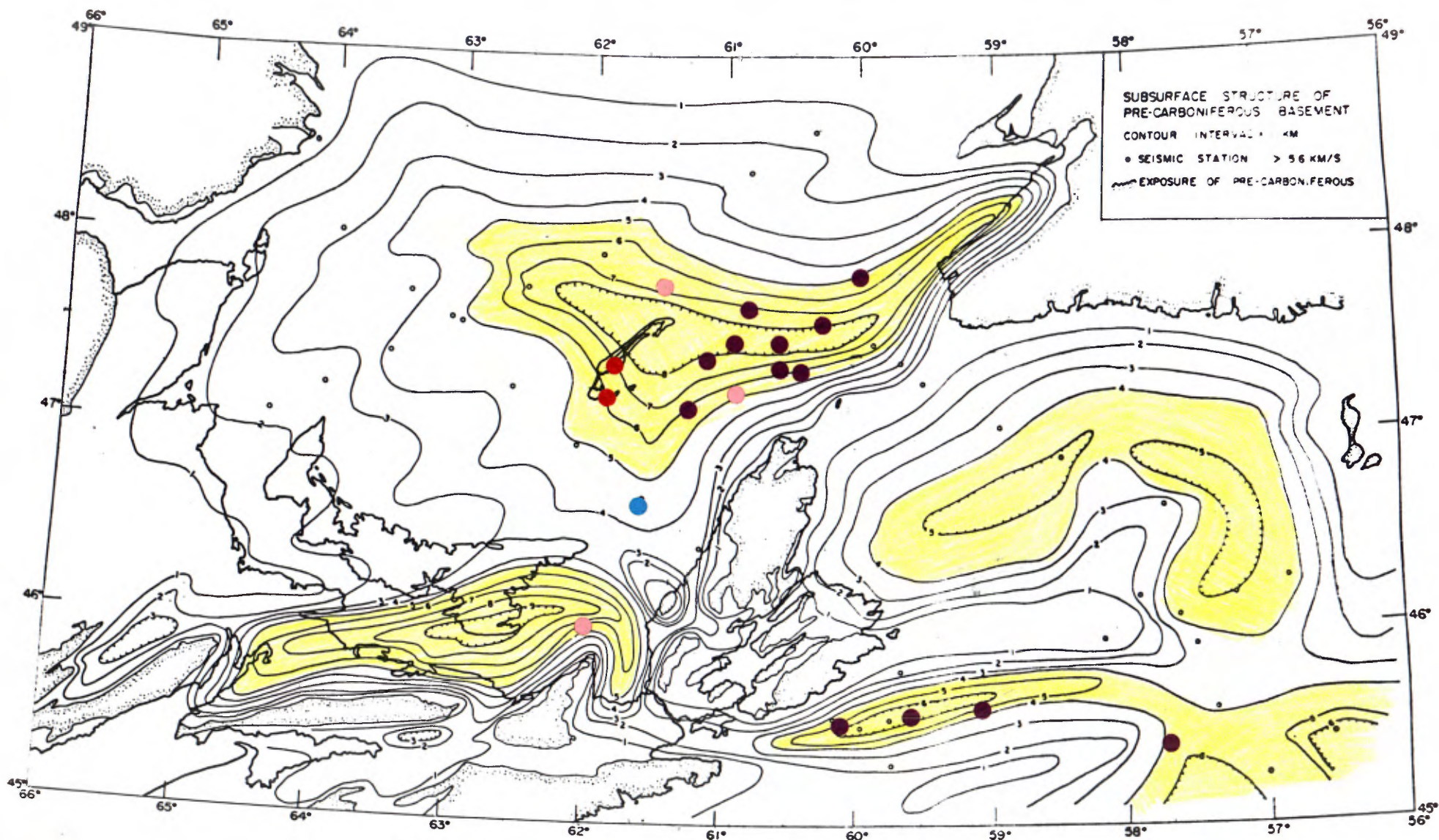
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(depocentre), or sub-basin, within the larger Fundy Basin, in the immediate vicinity and east of the Magdalen Islands. Figure 2, Page 7 after Sheridan & Drake (2), shows a maximum thickness of 20,000 to 26,000 feet of Carboniferous rocks in this depocentre. It is also evident from Figure 2 that other depocentres existed within the Fundy Epi-geosyncline and, in fact, beyond this major feature as well in the general Gulf area. Such depocentres within a larger salt basin are important features that appear to control the probable location of true salt domes. In the important salt basin embracing the Gulf of Mexico and adjacent coastal regions, for example, a great deal of oil drilling has revealed the presence of five separate depositional centres within the main basin with exceptionally thick sedimentary sections. Halokinetic salt structures, that is, true salt domes which have developed through the isostatic movement of salt from a mother bed, are invariably confined, in the Gulf of Mexico region, to these depocentres - called "salt dome basins" - within the larger basin. Over 400 domes have been discovered in the salt dome basins in question. Beyond them the salt is either bedded and flat-lying or tectonically deformed into so-called halotectonic structures which are sometimes dome-like in form but without deep roots. Adequate continuous thicknesses of sufficiently pure salt are considerably more difficult to develop in halotectonic structures than in true salt domes. Figure 3, Page 8 illustrates the distinction between halokinetic and halotectonic salt structures.

The numerous salt structures shown within the Fundy Basin in Nova Scotia in Encl.4 are, by and large, at the edge of

Figure 2

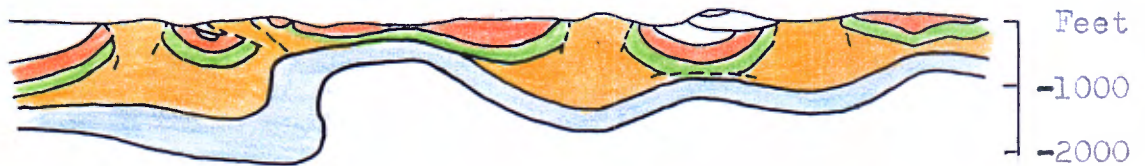
SUBSURFACE STRUCTURE OF PRE-CARBONIFEROUS BASEMENT - AFTER SHERIDAN & DRAKE



Certain Off-shore Wells and Potential Salt Domes

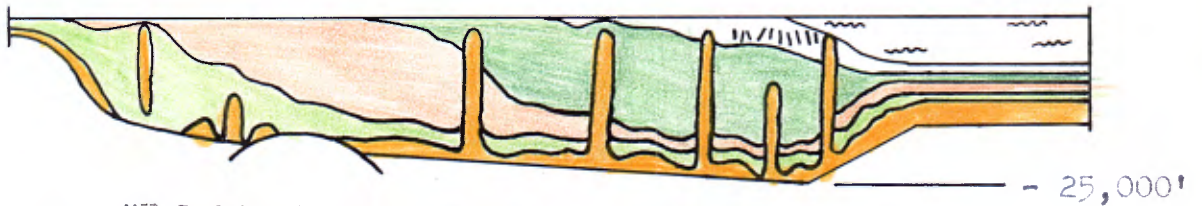
- Salt Intersection - in deep or shallow well
- Deep Hole - no salt
- Gravity-indicated salt domes - Magdalen Islands
- Other gravity-indicated salt domes
- Depositional Center

- a -



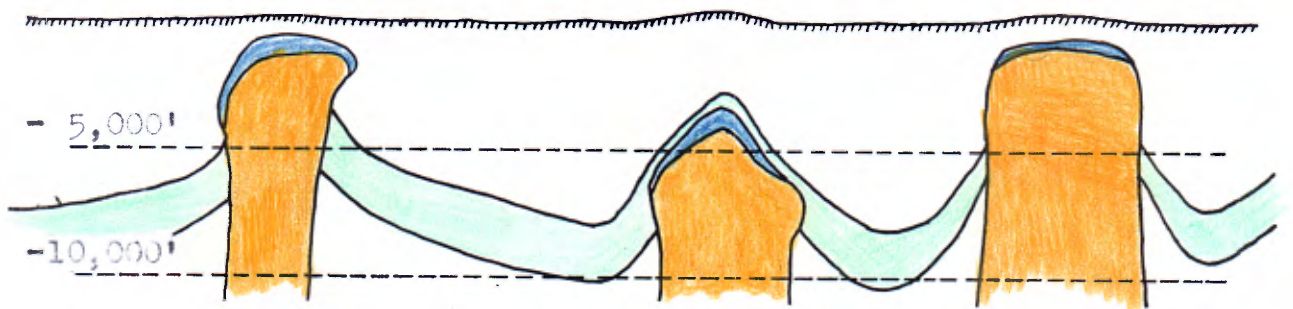
"Halotectonic" salt structures developed through tectonic compression of mother salt bed and enclosing rocks - Iran.

- b -



"Halokinetic" salt structures or true salt domes isostatically rising from mother salt bed in Gulf Coast depocentre.

- c -



Section across three adjacent salt domes, Chamber and Liberty Counties, Texas, illustrating common shapes and sizes of Gulf Coast domes in relation to halotectonic structures of "a".

Figure 3

or beyond a depocentre and appear to be largely halotectonic in character. In the Gulf of St. Lawrence itself, drilling has been limited, either in the depocentres or between them. What drilling has been done, however, coupled with fairly extensive marine gravity work in the Gulf area, has revealed the presence of numerous true salt domes within the depocentres. Enclosures 5 and 6 show the results of recently completed marine gravity surveys in the St. Lawrence Gulf area and beyond. The so-called Magdalen Islands Gravity Low, whose outline is apparent in the smaller-scale Earth Physics Branch map (Encl.6), was studied in more detail by the Bedford Institute, Halifax, whose still unpublished results are shown in Encl.5; the low in question is shown in colour. This low coincides well with one of the main depocentres shown in Figure 2. Broadly, it reflects thick salt accumulations in Windsor rocks while its detail suggests numerous halokinetic structures approaching the surface. These structures are also shown in Fig.2 along with others beyond the Magdalen Islands Low.

Certain off-shore drilling operations have substantiated the gravity-inferred presence of salt domes. The salt structure indicated in Northumberland Straits in Enclosure 4 and Fig.2, for example, was intersected during a 9876' test drilled by Fina - H.B.O.G. in 1969/70 (6). Figure 2 shows the hole was put down in one of the Fundy Basin depocentres. Salt was first encountered here at 2,500 feet and continued irregularly to 4,500 feet where massive salt was entered and finally bottomed at 6,170 feet (personal communication), suggesting a true salt dome structure. In addition, the salt structure indicated between Cape Breton Island and the Magdalen Islands in Enclosure 4 and Fig.2 was intersected during a shallow

.../...

(661') test drilled by Pan American in 1965 (7). As in the previous example, the hole was put down within a depocentre and, although the salt was not penetrated for more than 10 feet, its shallow depth coupled with gravity data suggests it represents the top of another true salt dome. Interestingly enough, an 11,569 foot test also drilled by Fina - H.B.O.G. in 1970 (6) and situated between the Northumberland Straits well and the Pan-American well, but lying on a relative high between two depocentres, did not intersect any salt whatsoever. The most recent important well drilled within the off-shore portion of the Fundy Basin was on Brion Island, the most northerly of the Magdalen group. It was drilled to 10,519' by Texaco and Hydro Quebec in 1970 (6). The well is within the most important depocentre in the Fundy Basin and intersected a salt structure at 8,300' in which it remained to total depth. Apparent salt thickness here and the structural location suggest a halokinetic salt structure but what regional gravity work is available does not suggest a close approach to surface in this vicinity. The Prince Edward Island salt structures indicated in Enclosure 4 were intersected by Imperial Oil during drilling operations in the late fifties (8) and were at depths greater than 10,000'. They appear to be halotectonic or possibly flat-lying.

Significance of Magdalen Islands Domes

While it is clear from the foregoing review of gravity and drilling evidence that true salt dome structures are probably numerous within the depocentre extending from the Magdalen Islands eastward towards Newfoundland, those actually under the Gulf waters are, for obvious reasons, of no interest as potential sources of salt but only as sites

.../...

of possible hydrocarbon accumulations. Since most if not all presently known on-shore salt structures in the Maritime Provinces are halotectonic in origin and provide less scope for developing adequate reserves of acceptably pure salt, the Magdalen Islands emerge as the only on-shore area in North America, outside of the Gulf Coast region, which provide access to the kind of large reserves of pure salt found in true domes.

EVIDENCE OF SHALLOW SALT
UNDERLYING THE MAGDALEN ISLANDS

Geological Indications

Quite apart from the evidence provided by a recently completed detailed gravity survey, results of which are reviewed below, the presence of salt domes under the Magdalen Islands could have been inferred from a consideration of such regional factors as discussed in the foregoing. In addition, a close scrutiny of the geology of the islands (3,4) and of the logs from shallow holes drilled primarily for hydrographic purposes (5) reveal considerable evidence that salt underlies the principal islands at not too great a depth. For example, while a broad and gentle tectonic deformation of the Mississippian and Permo-carboniferous rocks underlying the islands might be expected in this part of the Fundy Basin, the anticlinal structures striking through Grindstone/Alright Islands (Figures 4 & 5, Pages 12 & 13) and Hâvre Aubert Island have features which indicate

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a more localized deformational force with considerable disruptive character - as might be expected, for example, from an isostatically rising salt dome. Windsor beds involved in the folding are frequently steeply dipping and sometimes overturned and have somewhat erratic strike directions. Moreover, blocky, fractured and brecciated rocks in the central parts of the anticlines are not uncommon, both in outcrop and in drill holes. Relatively shallow drilling (about 500 feet), on Grindstone Island has revealed open cavities at least several feet in diameter; blocks of gypsum without orientation, rocks laced with gypsum-filled fractures and unconsolidated clay-like material at depths as great as 500 feet have also been noted. All these features are characteristically found in the so-called cap rock zone which develops over rising salt dome and may be up to 1,000' thick.

Gravity Results

Introductory Remarks: Gravimetric surveying is the most commonly employed geophysical tool in the search for and in the delineation of salt structures for mining purposes. The gravity method is particularly useful in revealing the point or points at which large salt structures make their closest approach to the surface. It was for this purpose that a detailed gravity survey was undertaken on the Magdalen Islands. The results of the survey are presented in Enclosures 1 (Hâvre Aubert) and 2 (Grindstone/Alright).

The gravity method's effectiveness is based on a quite pronounced difference in density between rock salt and the rocks which normally enclose it. This density contrast results in a measurable difference in gravitational attraction over the different rock types. Gravitational

.../...

values obtained in the field are expressed in milligals and may be tied to an arbitrarily selected datum.

Non-bedded salt structures are identified by anomalous low gravity readings. The magnitude or amplitude of a salt-induced gravity anomaly is measured against a regional background value and will be influenced by the size of the salt body, its closeness to the surface and the density contrast assumed. The outline of an anomaly will, by and large, reflect the outline of the buried salt body but complex local geology involving several rock types of different densities can alter this simple relationship.

Gravity anomalies lend themselves to a theoretical analysis of the depth and size of the body causing them. The depth estimate is made through the use of idealized models (cylinders, vertical or horizontal, spheres, polygonal shapes, etc.) that approximate possible salt structures in shape and gravitational effect. An attempt is made to "fit" such models or, more correctly, the gravity profiles that can be computed for the models, to actual gravity profiles derived from field studies. Once an appropriate model is selected and a good "fit" obtained, the application of a standard formula which gives account to the observed "half width" of the anomaly and to the assumed density contrast, will give the depth to the top of the model and hopefully to the top of the salt structure. The model most frequently employed by the Nova Scotia Research Foundation in the analysis of the Magdalen Islands anomalies is a horizontal cylinder of infinite length. This model was used because of the presumed elongate character of the salt structures. The formula for determining depth to top with such a model is given in the accompanying N.S.R.F. reports.

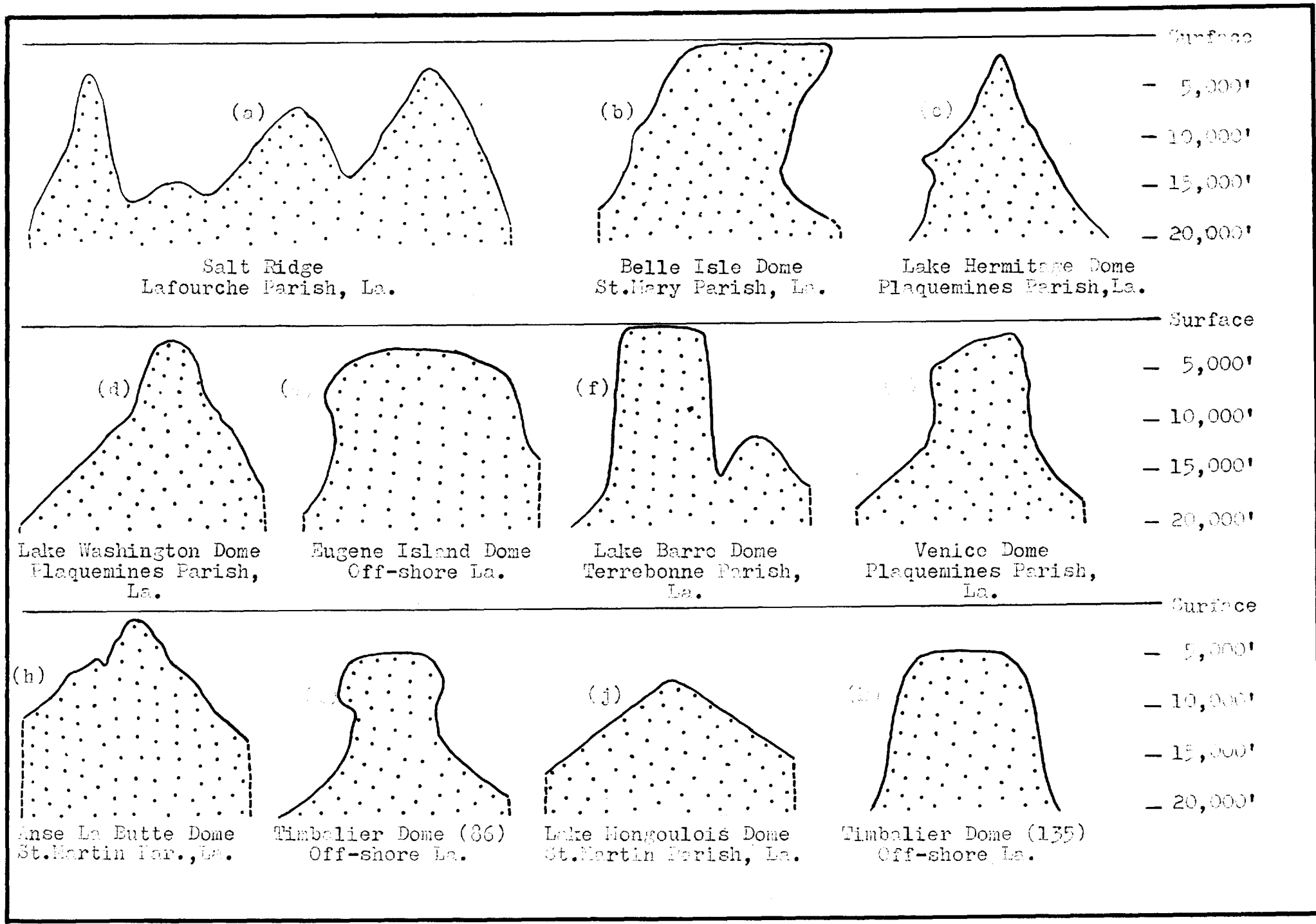
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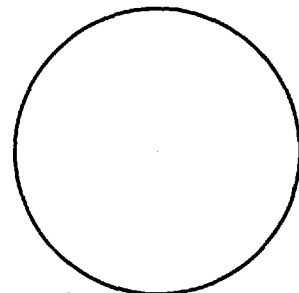
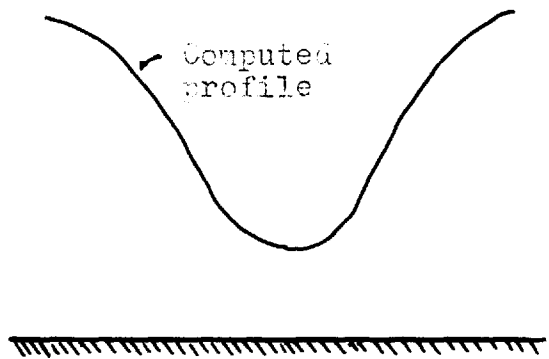
Needless to say, gravity profiles of actual salt structures frequently depart markedly from model profiles. One of a number of reasons for this might be the close approach to the surface of a portion of a salt body as the example in Figure 6(h) for instance. Such a close approach would alter what might otherwise have been a more model-like profile. The net result is to superimpose the gravitational effect of the irregularity or close approach over the gravitational effect produced by the deeper, larger body, making any attempt to fit a simple model to the whole profile more difficult. This is illustrated in Figures 7(a) and (b); it is obvious that no simple model could produce a profile approaching in shape the hypothetical profile (b). In order to determine depth in such an event an attempt is made to fit a simple model of the right proportions to that part of the profile presumed to be caused by the larger body, and thereby derive a depth estimate to the larger body, and then to attempt to fit another simple model of appropriate size on top of the larger, in order to "fit" the residual part of the curve, as shown in Figs. 7(c) and (d). This procedure should yield an approximation of the depth to the top of any protrusion making a closer approach to the surface.

Discussion and Interpretation of Magdalen Anomalies: The gravity survey conducted over the Magdalen Islands suffered from the inconvenience of working in an island environment; this did not permit as complete a coverage of anomalous areas as might sometime have been desired. Nevertheless, the work revealed the presence of two pronounced anomalies, one elongate anomaly embracing the Islands of Grindstone and Alright and one oval-shaped anomaly centered on the southeast coast of the Island of Hâvre Aubert. While the

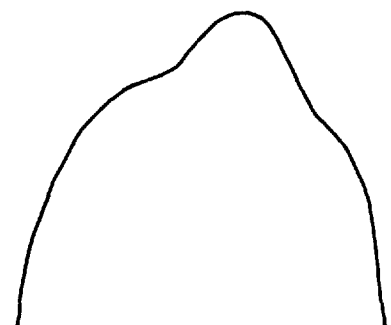
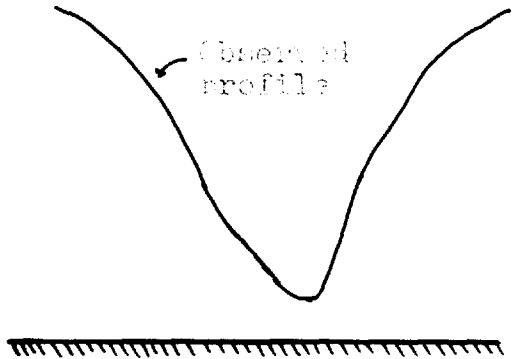
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TYPICAL SALT DOME CROSS-SECTIONS - LOUISIANA

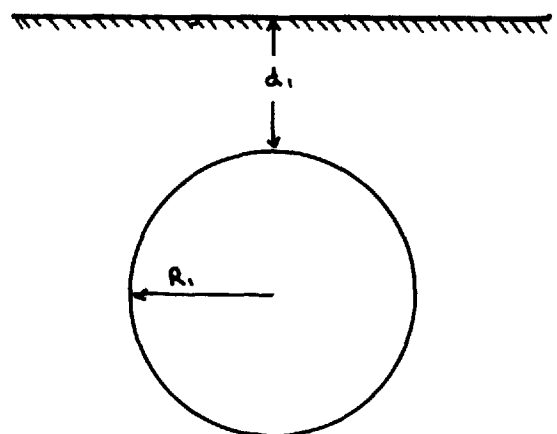
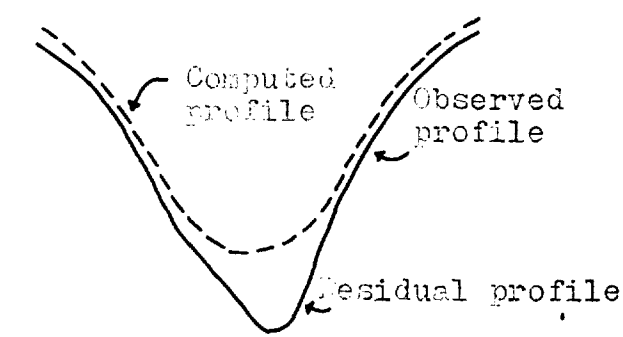




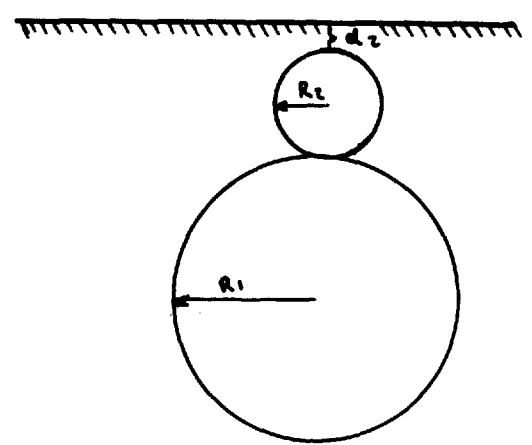
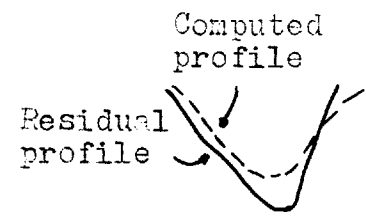
Horizontal cylinder and
computed gravity profile
(a)



Hypothetical dome and
possible gravity profile
(b)



Cylinder with radius R_1 and
depth d_1 and fitted computed
profile
(c)



Cylinder with radius R_2 and
depth d_2 and computed pro-
file fitted to residual
(d)

detailed features of both anomalies are presented in the maps accompanying Enclosures 1 and 2, their cores are shown in relation to the geology of the islands in Figures 4 and 5.

- Hâvre Aubert Anomaly -

The gravity contours on the Island of Hâvre Aubert suggest an underlying salt structure whose top rises towards the surface eastward and culminates at a point or points closest to the surface at the east end of the island, most notably on the southeast coast (Anomaly Y). Hence the dome shape might approximate Figures 6(d), (g) or (h), Page 17. Figure 6 illustrates the great variety of dome configurations possible.

An attempt has been made in Enclosure 6 to extrapolate the gravity findings on Hâvre Aubert beyond the shores of the island into the region to the east surveyed by the Bedford Institute. It appears not unlikely, from this extrapolation, that the dome culmination under the east end of the island represents the top of one of the many domes which have developed under the regionally significant Magdalen Island Low extending eastwards from the Magdalens.

It is clear from the introductory comments that a proper approximation of the depth to the top of a dome requires a complete profile - ideally from background level down to a low value and back. Unfortunately, the main anomaly on Hâvre Aubert, Anomaly Y, is bisected by the coastline across what appears to be its centre and we are left with only one half the profile with no idea of the configuration of the missing portion. Only the roughest depth approximation can therefore be made. This may be done by

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assuming a symmetrical profile and attempting to fit several models to the whole profile without the refinement of a residual profile analysis. Following this procedure, the Nova Scotia Research Foundation estimated the depth to the top of the salt body causing the main anomaly at between 2,400 and 3,000 feet. As may be seen in Figure 7 of the Foundation's report, the fit obtained using three different models was not good and the Foundation states that in actual fact, the depth to top is probably substantially less than estimated. This judgement is based not only on the poor fit obtained but on several depth estimates made to the west of the main anomaly where, among other things, a westward, tongue-like extension of the gravity contours enables more complete profiles to be drawn (Gravity map Enclosure 1). Beginning at the extreme west of the island and moving east, a series of largely N-S gravity profiles gives increasingly shallower depth-to-top values. These values reach 1,960 feet along a N-S section (00') crossing the tongue referred to above. This latter value is obtained when a model fit to the whole gravity profile is attempted, that is, without a residual profile analysis. When the latter analysis is made, Profile 00' gives a depth-to-top of as little as 500 feet. Other residual profiles across the tongue give depths of under 1,000'.

Considering the rising top of the larger salt dome as we move eastward, the possibility of an upward projection of salt along the "tongue" where residual analysis shows shallow depths, and, in particular, the fact that actual gravity readings in the centre of Anomaly Y are more than five milligals less than in the tongue area, it is not unreasonable to postulate that the depth-to-top on Anomaly Y is substantially less than that tentatively estimated by N.S.R.F. Moreover, the particularly steep gravity gradients

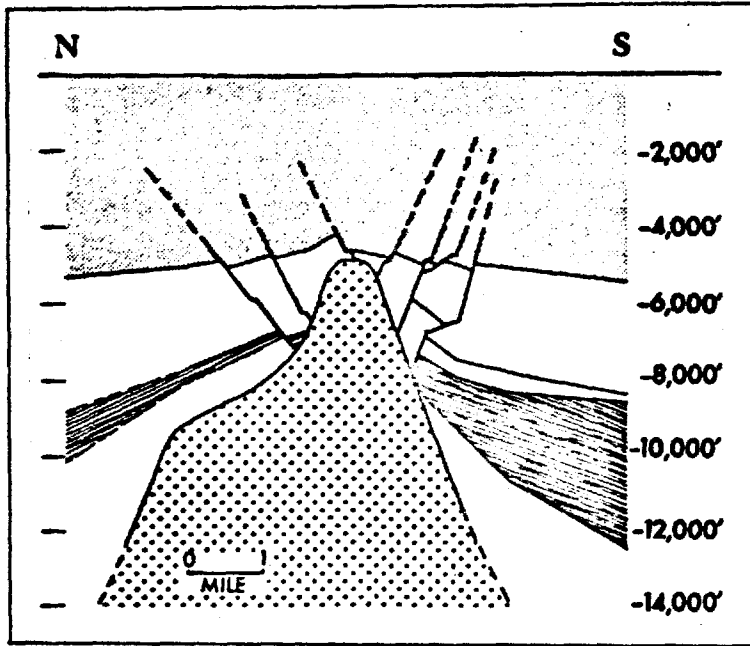
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on both the east and west sides of Anomaly Y strongly suggest faults and it is not unlikely that the anomaly is a horst-like structure which has brought salt closer to the surface. Shear faulting around the margins of a rising salt mass to produce horst-like structures is not an uncommon phenomenon as the central core of salt breaks away from the marginal salt which is encountering more friction at the salt - host-rock interface. The fault shown on the southwest side of the Bayou Blue salt dome in Louisiana, illustrated in Figure 8, is of this type. There is also evidence of additional faulting associated with Anomaly Y. Some of these faults are shown in Figure 5. This is not unexpected, of course, as complex fault patterns frequently develop above rising domes as other illustrations in Fig.8 demonstrate.

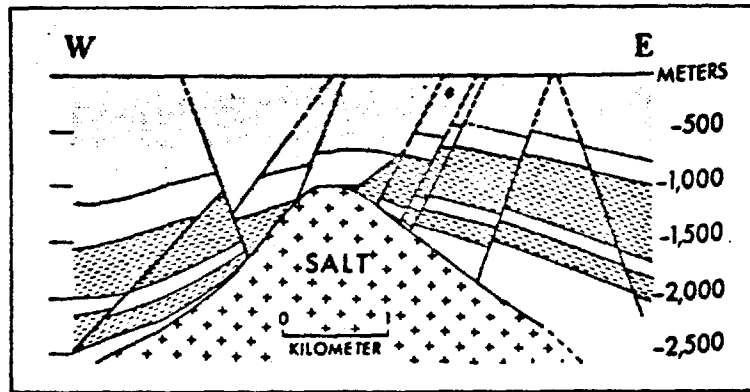
- Grindstone/Alright Anomaly -

An analysis of the gravity contours on the Islands of Grindstone and Alright suggests an underlying salt structure whose top rises from west to east making its closest approach to the surface on the east side of Grindstone Island (local Anomaly B - Enclosure 2) and along the south side of Alright Island (local Anomalies C and D). The apparent correlation between the gravity contours and the anticlinal structure striking across both islands (Figure 4), suggests this structure is salt-controlled. Salt-controlled anticlines are not an uncommon feature in the Gulf Coast region (particularly in East Texas) and elsewhere. The salt under the Grindstone/Alright anticline

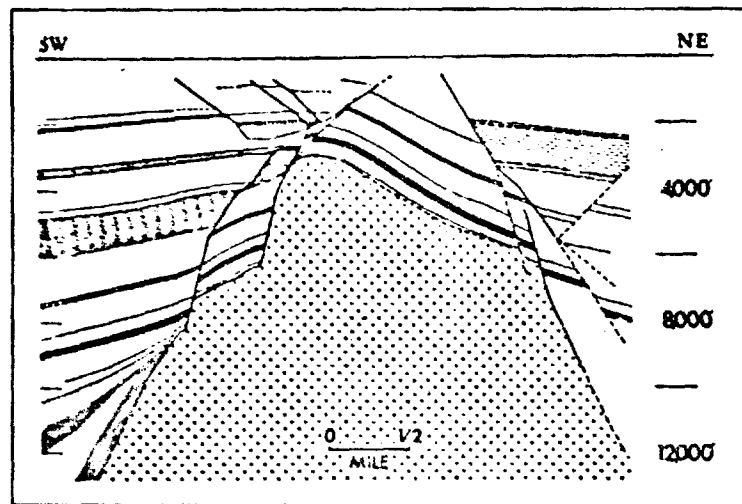
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Cameron Meadows Dome
Cameron Parish, La.



El Plan Dome
Veracruz, Mexico



Bayou Blue Dome
Iberville Parish, La.

would have an elongate or ridge-like configuration whose crest could be smooth, or irregular as in the ridge illustrated in Fig.6(a). The mere presence of a gravity low over an anticlinal structure points to salt control inasmuch as whenever gravity anomalies are associated with fold-structure outside of salt basins, anticlines are usually centres of gravity maxima and synclines of gravity minima.

Faulting, as we have seen, is commonly associated with salt domes of the piercement type, with which we are dealing in the Magdalens. Halbouty (1) lists seven types of faults found over and adjacent to salt domes and two types associated with, but away from the domes. As at Hâvre Aubert, local gravity contour irregularities and steep gradients are observed around the Grindstone/Alright salt dome suggesting fairly complex faulting. For example, the prominent bending of the gravity contours between local Anomalies B and C may reasonably be ascribed to a fairly strong NW-SE striking fault, while a more minor fault may account for the strike change in the larger anomalous trend between local Anomalies C and D. There is, in addition, some surfacial evidence that a prominent fault runs parallel to the axes of the Grindstone/Alright anticline and the gravity anomaly. This evidence is mainly in the form of a series of remarkably well-aligned sink holes and cliff breaches on Grindstone Island. A line joining these features and projected to the margins of the islands, is shown in Figure 4 along with the other presumed faults.

The Grindstone/Alright gravity anomaly provides more opportunities than the Hâvre Aubert anomaly to construct complete gravity profiles for depth determinations. The situation is still far from ideal, however, since one of the

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most interesting portions of the Grindstone/Alright anomaly lies in the bay between local Anomalies B and C and a suitable profile cannot be constructed here. Nevertheless, a number of profiles have been constructed and depth analyses made using an infinite horizontal cylinder as a model and selected residual profile analyses. This analytical work has highlighted the three local anomalous areas (B, C and D) where salt is judged to rise to within 700 & 1,000' (B and D) and 1400 feet (C) of the surface. The residual profile analyses to establish these depths yielded a model configuration consisting of a smaller upper cylinder separated from a lower larger cylinder. N.S.R.F. has pointed out that while separated salt masses are now unknown in nature, it was an unlikely situation. If this view is accepted, then the computed minimum depths should be increased somewhat. However, a true dome or ridge approximating Figure 6(i) in shape - with perhaps an even narrower neck below the top-side bulge - could yield the model configuration derived by N.S.R.F., in which case the shallow depth estimates would hold.

RECOMMENDATIONS

The Nova Scotia Research Foundation has recommended two drill sites to test the anomalous areas at the east end of Hâvre Aubert; these are shown on the gravity map accompanying Enclosure 1. The site DDH-A2 on the tongue where residual profile analysis shows depths of as little as 500 feet, would seem an obvious first choice over the site DDH-A1 centered on Anomaly Y. However, the possibility is raised that the tongue-like extension on which Hole A2 is recommended, may not, in fact, represent an upward protrusion of salt but may simply reflect density differences between sediments and volcanics in some appropriate configuration or even some non-salt structural feature. In the final analysis, both sites will have to be drilled during the initial exploratory phase. A 2,000-foot (true depth) hole should be programmed for Site A1, inclined 60° to the South, and a vertical hole of 1500 feet for Site A2.

The Research Foundation has recommended three drill sites to test the Grindstone/Alright anomalous area; these are shown on the gravity map accompanying Enclosure 2. Site DDH-G1 on local Anomaly B and Site DDH-G2 on local Anomaly D have the shallowest depth estimates and are obvious first choices with DDH-G1 having first priority. Site DDH-G3 (Anomaly C) is not recommended. 2,000-foot vertical holes should be programmed for both the recommended sites for the initial exploratory phase.

In the light of the foregoing, a total of up to 7,500' of drilling should be budgeted for to properly test the Hâvre Aubert and the Grindstone/Alright anomalies. In summary, the sequence of drilling should be as follows:

.../...

Hâvre Aubert -	Site DDH-A1	2000' at 60° inclination due South
	" " A2	1500' vertical
Grindstone/Alright -	Site DDH-G1	2000' vertical
	" " G2	2000' vertical

The merit of proceeding to the end of the foregoing program would have to be re-assessed if early success was experienced at Hâvre Aubert, that is, if a significant salt thickness (300' or more) was intersected before 1500'. In the latter case, priorities would probably best be re-arranged to allow more drilling on the Hâvre Aubert structure during this initial phase. Special problems encountered in salt drilling and the drilling procedure to be followed are reviewed in Enclosure 3. Estimated cost of the full drilling program, excluding operator's supervision, travelling and administrative costs is \$100,000.

BIBLIOGRAPHY

- (1) Halbouty, M.T. 1967. Salt Domes, Gulf Region, United States and Mexico. Gulf Publishing Co. 425 p.
- (2) Sheridan, R.E. and Drake, C.L. 1968. Seaward extension of the Canadian Appalachians. Cdn.Jour. Sci., Vol.5, No.3, Pt.2
- (3) Sanschagrín, R. 1964. Geol.Rept.106 - Magdalen Islands. Dept.Nat.Res. Quebec, 58 p.
- (4) Tephane, M. 1970. Gypsum Deposits of the Magdalen Islands. Dept. of Nat. Res. Quebec. Special Paper No.7. 27 p.
- (5) Dessurrault, R. and Simard, G. 1970. Hydrogeology of the Magdalen Islands. Dept.Nat.Res., Mines Branch, Hydrographic Service, Quebec. Rept. No. N.G.1, 95 p.
- (6) Howie, R.D. and Hill, J.V. 1971. Developments in Eastern Canada in 1970. Bull.Am.Assoc. Petrol.Geologists. July 1971.
- (7) Howie, R.D. 1970. Oil and Gas exploration - Atlantic Coast of Canada. Bull. Am.Assoc.Petrol.Geologists. Nov.1970.
- (8) Roliff, W.A. 1962. The Maritime Carboniferous Basin of Eastern Canada. Proc.Geol. Assoc.Can., Vol.14.