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PETROLEUM POTENTIAL OF THE CAMBRIAN MOUNT CLARK FORMATION (TEDJI LAKE PLAY), COLVILLE HILLS AREA, N.W.T.

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ABSTRACT

Recent activity and discoveries of gas in Cambrian reservoirs at shallow depths in the Colville Hills area have generated new interest in the "Tedji Lake play" (original discovery in 1974). Lower Cambrian Mount Clark Formation sandstone and siltstone (potential reservoir rock) unconformably overlie Precambrian basement. They are in turn overlain by Lower to Middle Cambrian Mount Cap Formation shales, siltstones and carbonates (potential source rock) and Middle to Upper Cambrian Saline River Formation evaporites (potential seal rock). Deposition occurred in a slowly-subsiding intracratonic basin behind the craton rim uplifts after Late Precambrian rifting.

Potential reservoir rock facies are fine- to medium-grained clean sandstone with good porosity and permeability, or fine- to coarse-grained argillaceous burrowed sandstone with fair porosity and permeability. These occur in aggregate thicknesses up to 65 m in the Mount Clark interval. The sandstones have undergone complex diagenetic histories involving several phases of cementation (which occluded primary porosity) and dissolution (which produced secondary porosity). Thin potential source rock horizons occur in bioturbated, greenish, carbonaceous sandy siltstone and shale of the Mount Cap interval. There are indications of hydrocarbon generating capability in at least one well.

Discoveries to date, and most potential, likely involve structural traps. Synthesis of published descriptions indicates the structural geology of the area involves complex superimposition of several scales of features. These include: a) the regional Keele Arch, oriented north-south, which affects all Paleozoic rocks and can be identified by surface mapping; b) large Laramide domal and

linear faulted folds identified by remote sensing and seismic or surface mapping; and c) small horst blocks, involving Precambrian basement, which represent Laramide reactivation of older fault trends and are identified using seismic and well data.

Several play possibilities in the Mount Clark sandstones are apparent. These include: 1) structural traps where small fault-bound folded structures are superimposed on large domal features; 2) stratigraphic/structural traps where reservoir sandstones pinch out against syndepositional horst blocks if this actually occurs; and 3) pure stratigraphic traps where Mount Clark sandstone passes laterally or vertically into Mount Cap shale. The best combination of structural and stratigraphic factors for future exploration comes together in an area defined by latitude 66° to 68°N and longitude 124° to 127°W. Within this area there is greater than 10 m of clean sandstone at less than -1000 m structural elevation located updip from thick potential source rock depocentres, and many prospective structures. All shows and discoveries to date are within this area.

INTRODUCTION

The Mount Clark Formation (Williams, 1922) sandstone is distributed in the subsurface over an area of the Interior Plains of Northwest Territories from at least 65° to 69°N and 122° to 129°W, from the edge of Precambrian outcrop to the Mackenzie River. The oil and gas potential of this area, centred on Colville Hills (Fig. 1), is of interest to the petroleum industry because there are shallow drilling depths to basement in a location near Norman Wells and Mackenzie Delta, where significant reserves of oil and gas are known and a pipeline connection may be possible in future.

A number of workers have dealt with the regional stratigraphic and structural geology relevant to this topic in the past. Haimila (1975), AGAT and Geochem joint project (1977), Davis and Willott (1978), Cook (1983), Aitken and Pugh (1984), Cecile (1986) and Williams (1987) have all investigated the structural and tectonic setting of the Late Precambrian/Cambrian of the area. Tassonyi (1969), Aitken et al. (1973), AGAT and Geochem joint project (1977), Gilbert (1973), Pugh (1983) and Williams (1987) all considered the stratigraphy and deposition. Factors in the petroleum geology of the Tedji Lake play were summarized briefly by Dixon and Macdonald (1978) and Wilson et al. (1979) of Petro-Canada using the data base up to that time. Since then there has been an active and successful exploration effort. Snowdon and Williams (1986) discussed the petroleum source rock potential of Cambrian and Proterozoic rocks in the area, while Wielens et al (in press) focussed on the source rock potential of the Mount Cap Formation.

The Ashland et al. Tedji Lake K-24 well was the only hydrocarbon discovery in the Cambrian of Western Canada up to 1985 but several other shows, recent drilling and seismic, and further discoveries at Tweed Lake (75 km to the southeast) have rekindled interest in the play. There are currently three gas and one gas-condensate discoveries recognized in the Mount Clark. Known basement structures, close association of reservoir and source/seal facies, and a chance for liquid hydrocarbons are all encouraging factors. My purpose is to briefly synthesize the diverse sources of information in order to focus attention on the exploration opportunities of this play and introduce some basic play concepts and a framework for more detailed study to those unfamiliar with the area. I have included my own subsurface mapping and core description material to supplement published data.

REGIONAL GEOLOGY

General Tectonic and Structural Setting

During the early Paleozoic the Colville Hills area was a broad platform between the Franklinian geosyncline to the northeast and the Cordilleran geosyncline to the southwest (Gabrielse, 1967). Late Precambrian rifting along these craton margins resulted in an extensional tectonic regime and crustal attenuation during the Cambrian (Williams 1987). A complex trough/arch system near the craton margins and more subtle basement features toward the interior apparently developed at this time (AGAT and Geochem joint project, 1977; Cecile, 1982).

Important positive tectonic features during Cambrian deposition were ancestral Aklavik Arch and Mackenzie Arch, which formed the craton rim uplifts to the northwest and southwest respectively, after Late Precambrian rifting (Fig. 1). These features flanked and defined the main Cambrian depositional trough (AGAT and Geochem joint project, 1977) which remained as a slowly subsiding intracratonic basin until middle Paleozoic time. In addition, the Bulmer Lake/Mahoney Lake Arch existed in the southern portion of the area where Early to Middle Cambrian sediments were not deposited/preserved (AGAT and Geochem joint project, 1977; Williams, 1987). A Late Silurian/Devonian compressional regime caused the emergence of Keele Arch as a regional positive feature in the same area (Cook, 1975, Williams, 1987). Later Laramide-related compression, directed from southwest to northeast, created a complex network of deformation structures involving Precambrian basement and Paleozoic cover (including near-vertical faults and large anticlines as illustrated by Davies and Willott, 1978). Major structural features within the Precambrian trend northerly (Aitken and Pugh, 1983) and likely extend under the Paleozoic cover of this area. Reactivation along such zones of weakness may have affected sedimentation patterns during the Cambrian, and influenced present structural patterns throughout the Colville Hills area (Davis and Willott, 1978; Williams, 1987).

General Depositional Setting

The Cambrian of the northern Northwest Territories comprises a thick succession of mixed carbonate/clastic sediments preserved over large area of about 200 000 square kilometres. Deposition occurred on the western stable craton margin during post-rift subsidence with most sediment derived from the

Shield to the east. The Sauk transgression (Sloss, 1963) proceeded onto the continent with platformal deposition beginning in Late Proterozoic at the craton edge, early Cambrian in the Interior Plains and as late as early Ordovician near the craton centre.

The diachronous basal Cambrian sandstone was deposited on the Precambrian regional erosional surface (Gilbert, 1973; Williams 1987) behind the positive rim uplift located in the Mackenzie Mountain area (Fig. 2). In Grand Cycle terminology it represents the inner detrital coarse-grained facies, while the overlying Mount Cap shale represents the inner detrital fine-grained facies (Aitken et al., 1973). The overlying Saline River evaporites filled the depression behind the Arch, and as slow subsidence drowned this platformal basin, subsequent Franklin Mountain carbonates blanketed the whole area (Pugh, 1983). All Cambrian units thin toward the craton centre, and thin onto the Mackenzie Arch which was not submerged until latest Cambrian time (Gilbert, 1973).

Local Stratigraphy (Fig. 3)

In the Colville Hills the Early Cambrian Mount Clark Formation is a clastic unit of variable lithology and thickness up to 65 m. It generally consists of interbedded reddish sandstone and siltstone. Sandstones are commonly coarsest toward the Mackenzie Arch and craton, porous, and represent the main reservoir rock. The overlying Mount Cap Formation, up to 270 m of shale, siltstone and carbonate, is in facies contact with the sandy unit and is of Early to Middle Cambrian age. It is thicker, blacker and more bioturbated toward the west (Aitken et al., 1973) and represents the most significant potential source rock in the Cambrian sequence.

The presence of a regional disconformity at the Mount Cap - Saline River contact has been postulated from outcrop data on the east side of Mackenzie Arch 200 km west of Colville Hills (Aitken et al., 1973). This contact is more likely a conformable facies change in the Interior Plains subsurface (Davis and Willott, 1978; Williams, 1987). The overlying Middle to Late Cambrian Saline River Formation comprises up to 200 m of carbonates and evaporites, and provides an excellent potential seal rock, distributed over a very wide area (Pugh, 1983)

PETROLEUM GEOLOGY

Activity and Hydrocarbon Indicators

To date twenty-five wells penetrate the Mount Clark Formation in the northern Northwest Territories Interior Plains (dating from 1969 to present; Fig. 4). Most are in the Colville Hills area. Ten have cores; ten have hydrocarbon shows on DST; several show live oil staining in cuttings; a total of four are classified as gaswells. The total drilling density is 1 well/2700 km^2 and even in the densest area is only 1 well/1400 km^2 (Williams, 1987). Several known surface oil seeps occur in the Colville Hills area near Tedji Lake, Rond Lake, and Lac Belot. Drilling depth to Precambrian basement is variable but ranges 300-1400 m.

The initial gas discovery well, Ashland et al. Tedji Lake K-24 (land later leased to Petro-Canada) was drilled to basement in 1974 on a seismic anomaly. A thin Mount Clark sandstone section overlies an interpreted fault-bounded block of Precambrian strata. A DST recovered gas to surface at a rate of 124 000 m^3/d from about 3.5 m of oil-stained sandstone net pay with an average porosity of

13% and an average water saturation of 30%. The potential area of closure is about 2000 ha.

Exploration agreements were held by Petro-Canada, Esso, Chevron and Dome, and activity in the mid-eighties was very brisk. In fact, half the wells now in the data base were completed between 1983 and 1986. Foreward Resources (Exco Energy Ltd.) and Petro-Canada Inc. have been the most active operators and their efforts have been concentrated in the Colville Hills area north of Great Bear Lake.

In 1985/86 Petro-Canada and Petro-Canada/Canterra drilled seven wells in the study area with the Mount Clark Formation as the prime target (Fig. 4). Significant discoveries included M-47 (gas-condensate), A-67 (gas) and 0-35 (gas with minor condensate), all located on, or adjacent to, a major structural feature in the Tweed Lake area. Discovered reserves are on the order of 7 x $10^9 m^3$ gas total for the three discoveries with average porosity of 12% and water saturation of 30% over average net pays of 6m (Tim Bird, C.O.G.L.A., pers. comm.). In these three wells the Mount Clark consists of:

a) a lower sandstone up to 20 m thick with average porosity of 11% and permeability up to 23 md (gas flows up to 156 000 m^3/d and condensate), and,

b) an upper sandstone up to 10m thick with average porosity of 10% and permeability up to 5 md (gas flows up to 254 000 m^3/d).

Mount Clark Reservoirs

The Lower Cambrian Mount Clark sediments in subsurface are heterogenous very fine- to coarse-grained porous sandstones with some red, green and grey shaley interbeds. They are of variable thickness up to 65 m (generally 25-50 m) (Fig. 5). Pugh (1983) and Williams (1987) suggested that these sandstones are relatively discontinuous in distribution, filling depressions in the underlying Proterozoic surface. In the Colville Hills area up to 65 m of clean sandstone can be mapped in the interval (Fig. 6). Subsurface mapping indicates gradual east-to-west thinning of the Mount Clark to an approximate depositional limit (Figs. 5,6). With the current sparse date base there is no evidence of discontinuity in the formation, although individual sandstone beds have unknown lateral extent. Known fossils include Lingula, Olenellus, Skolithos and Teichichnus and the unit can be interpreted as a predominantly shallow marine deposit in this area, a conclusion which generally coincides with the paleogeography outlined by Williams (1987). The AGAT and Geochem joint project (1977) provided many details of the lithologic and diagenetic characteristics of Mount Clark sandstones.

My preliminary study of the all ten cores available revealed several lithofacies with differing reservoir characteristics. Two example cores are described in Figures 7 and 8.

1. Fine- to medium-grained sandstone. White to reddish to grey, clean, well sorted quartz arenite with well defined stratification occurs in units 5 to 20 m thick. Beds are generally low-angle laminated with some ripples and minor (Skolithos) burrows especially at the bed tops. Units appear very uniform, have sharp bases and tops and are most common in the lower Mount Clark. Silica cement is prevalent, occluding primary porosity, but variable amounts of secondary

porosity and oil staining are common (Dixon and Macdonald, 1978). Porosity ranges 4-21%, generally 10-15%, and averages 12%. Permeability ranges 0-500 md., generally 10-50 md., and averages 25 md. This facies represents the best reservoir rock.

2. Fine- to coarse-grained silty sandstone. Thoroughly bioturbated, calcareous, argillaceous sandstones alternate in thick units with lithofacies 1. These sediments tend to be reddish or greenish, carbonaceous and glauconitic. and have grain sizes which vary bed-to-bed. Large horizontal burrows (Paleophycus?; Teichichnus?) are common, and consequently there is only minor preservation of parallel lamination. The facies typically displays a coarsening-upward aspect and likely represents deposits which were originally interbedded sandstone and siltstone, now thoroughly burrow-homogenized. Porosity averages 10% and permeability averages 1 md.

3. Sandy siltstone. Thoroughly bioturbated dark grey-green or reddish siltstone, much like overlying Mount Cap sediments, is less common. These sediments are carbonaceous and glauconitic, have horizontal sandstone-filled burrows (Chondrites?,Teichichnus?) and a few thin discontinuous burrowed very fine sandstone beds (sandstone:siltstone ratio, 1:4). This lithofacies has no reservoir potential.

In summary Mount Clark sandstones have good reservoir characteristics. Grain size ranges from very fine sandstone to conglomerate, sorting ranges from fair to good, and the grains are subround to round. Porosity is generally in the 8-18% range while permeability is several to several tens of millidarcys. Most primary porosity is occluded by ubiquitous silica overgrowths and minor clay (illite) and carbonate cements (AGAT and Geochem joint project, 1977), but the present porosity is moldic secondary in origin after dissolution of calcite, feldspar and some accessory minerals (Dixon and Macdonald, 1978). A complex diagenetic history involving several phases of cementation, dissolution and hydrocarbon migration is outlined by Dixon and Macdonald (1978) and Wilson et al. (1979).

Mount Cap Deposition and Source Rock

The overlying Mount Cap Formation is in facies contact with the Mount Clark and represents continued transgression and deepening of the Cambrian shallow marine sea (Williams, 1987). It comprises up to ?920 m (Fig. 9) of Lower/Middle Cambrian glauconitic shale with some limestone and sandstone interbeds. Olenellus and Lingula are known from the unit (Tassyoni, 1968) and it too is probably diachronous across the depositional basin.

The Mount Cap is postulated as a possible source rock for the discoveries, shows and seeps in the area. The AGAT and Geochem joint project (1977) found that, in general, the Mount Cap has poor to fair source rock potential but that thin rich zones exist. It was suggested that gas was derived from the deeply buried trough to the west of Colville Hills and that traces of oil were derived from the shallower trough east of the Keele Arch. Wilson et al. (1979) suggested "levels of organic maturation within the Cambrian basin are ideal for oil generation". A recent geochemical study (Wielens et al, in press) indicated that thin (10 cm.) organic-rich intervals in the Mount Cap are indeed potential source rocks with the capacity to generate large volumes of petroleum. These authors suggested that mature Mount Cap source rocks might be present in the thick depocentres to the south and southeast of the Tweed Lake discoveries.

Preliminary description of four cores outlined several common lithofacies.

1. Green-grey siltstone and shale. Well bioturbated, carbonaceous, sandy siltstone and shale are the most common lithologies making up about 75% of the Mount Cap. Beds generally have gradational boundaries and irregular lamination disrupted by small, horizontal, sandstone-filled burrows (Chondrites?). A few thin, very fine-grained sandstone beds are scattered throughout. This facies contains thin, laminated, organic-rich potential source rock horizons.

2. Very fine- to fine-grained sandstone. Grey, calcareous, glauconitic, argillaceous sandstone units a few metres thick may alternate with facies 1. These sediments are thoroughly bioturbated with silt-lined, sub-horizontal (Planolites?) and sub-vertical burrows. They are commonly tight but locally have some porosity and may be oil-stained. This lithofacies has minor reservoir potential.

3. Dark-grey dolostone. Thin, massive beds of argillaceous or sandy, medium-crystalline dolostone are common throughout the Mount Cap. This facies is typically thoroughly bioturbated with horizontal burrows (Paleophycus?) and bed boundaries are gradational. Porosity and permeability are low. In at least one well to the west (D-40), thick units of oolitic dolostone occur which could provide additional reservoir rock, if porous and more widespread (AGAT and Geochem joint project, 1977).

Local Structural Features and Trap Potential

Although northern Northwest Territories Interior Plains had several broad uplifts and depositional basins in Cambrian time there appear to be more subtle features of various scales within that framework, which are important as exploration targets. This complex superimposition of multiple scales of structures is the result of several phases of regional tensional and compressional forces affecting the area through its geological history. In fact, three general scales of structures can be identified: a) the regional-scale Keele Arch, an uplift which affects all Devonian and older rocks; b) large Laramide-age(?) domal and linear folds with faults which affect the whole pre-Cretaceous sequence; and c) small horst blocks of Proterozoic basement which may represent Laramide reactivation of older fault trends.

The Keele Arch is a sub-Mesozoic regional-scale structure oriented north-south from Colville Hills to the Keele River (300 km long by 125 km wide). It is defined by outcrops of Ordovician-Silurian rocks along its crest (Cook, 1975) and had developed as a positive feature by early Devonian time (Williams, 1987). Pre-Devonian and pre-Cretaceous erosion has downcut through the stratigraphy, more so in the south than in the north (Cook, 1975) and a thick Lower Paleozoic section is present beneath parts of Colville Hills. The presence of this regional positive feature results in the entire Colville Hills area being structurally high.

Superimposed on this feature are a variety of domal and linear faulted folds which have been described by Cook (1975), Haimila (1975), and Davis and Willott (1978). Although the geometric descriptions differ, all these studies interpret these as penetrating the entire stratigraphy, including Proterozoic basement, and related to fault reactivation during Laramide compressional stress against the buttress of the Canadian Shield.

Through remote sensing techniques (Haimila, 1975) and more conventional seismic and surface mapping (Cook, 1975; Davis and Willott, 1978) the existence of very large, high relief, elongate complex anticlines aligned along the Keele Arch axis can be interpreted (Fig. 10). These are generally associated with large, high gravity anomalies, surrounded by low gravity values, and their geometry is apparently controlled by basement fault trends (Davis and Willott, 1978). These anticlines may be tens of kilometres across with vertical relief of hundreds of metres, and some lie along the structurally highest trend within the mappable limits of Mount Clark reservoir facies (Fig. 10).

Throughout the Colville Hills area there are many small fault-bounded blocks of uplifted Proterozoic basement which can be identified from seismic (Fig. 11) and well data. These are an order of magnitude smaller than the folds described above but in fact represent most of the anomalies tested to date. These structures are on the scale of individual drillable prospects (up to 5 km by 5 km or 2000 ha in area, with up to 100 m of vertical closure) (Fig. 12). Published seismic (Davis and Willott, 1978) indicates that many are broadly folded and bounded by high angle faults. Because these involve Proterozoic basement they may represent reactivation of older faults. In outcrops 200 km to the east, Mount Clark/Old Fort Island sandstone pinches out over basement structures (Cook and Aitken, 1970) suggesting that some positive basement features were present during early Cambrian deposition.

SUMMARY OF PLAY POSSIBILITIES

Structural

The regional culmination known as Keele Arch makes the entire Colville Hills structurally high and the large linear and domal folds superimposed on top of it can be identified. With up to 40 000 ha of areal extent and up to several hundred metres of vertical closure these anticlines could enclose very large hydrocarbon accumulations, or control migration paths to localize filling of smaller traps. Few of these major elements have been adequately tested.

The presence of smaller fault-bounded folded structures with up to 2000 ha area and 100 m of closure superimposed on the large structures represents the most obvious play possibility and has been the focus of exploration efforts to date. All discoveries fall in this category. In addition, complex faulting of these structures may allow truncation and trapping updip against high angle bounding faults (Fig. 13).

Structural/Stratigraphic

Since many of the above-mentioned structures may represent reactivation of older features, some might have been present as syndepositional positive elements during sedimentation of the Mount Clark sandstone (Fig. 13). On a local scale sandstone facies distribution may be controlled by the paleogeography of these ancient horsts. Drilling the highest points of these structures could encounter thinner or poorer quality reservoirs, while a greater sandstone thickness might be present around the flanks. However, these is currently no evidence to confirm or deny this conceptual possibility in the Colville Hills area.

Stratigraphic

Since the Mount Clark Formation passes laterally and vertically through a major facies change into Mount Cap shales, and individual sandstones have lateral limits, there is some stratigraphic trap potential (Fig. 13). However, with current sparse well control and rudimentary understanding, these subtle trap situations may not be predictable.

Prime Play Area

Combining information from Figures 6, 9 and 10 allows the definition of a prime area for further exploration. The best combination of elements would involve the presence of many structural trap possibilities on a regional high within the limits of Mount Clark deposition where a reasonable thickness of reservoir facies could be expected. It would also be important to have thick potential source rock in a structurally low area downdip.

These factors appear to be fulfilled by that part of Colville Hills along the Keele Arch axis between about 66° to 68°N latitude and 124° to 127°W longitude, an area of about 10 000 square kilometres (Fig. 14). Abundant small structural blocks are superimposed on larger domal structures where there is generally 10 to 40 m of Mount Clark clean sandstone as potential reservoir. To the southwest and southeast of this defined area are thick accumulations of Mount Cap shale structurally downdip relative to the Keele Arch axis. This play area could extend to the northeast depending on the orientation of the Keele Arch axis and the distribution of Mount Clark reservoir rock, but there is no well data in this area.

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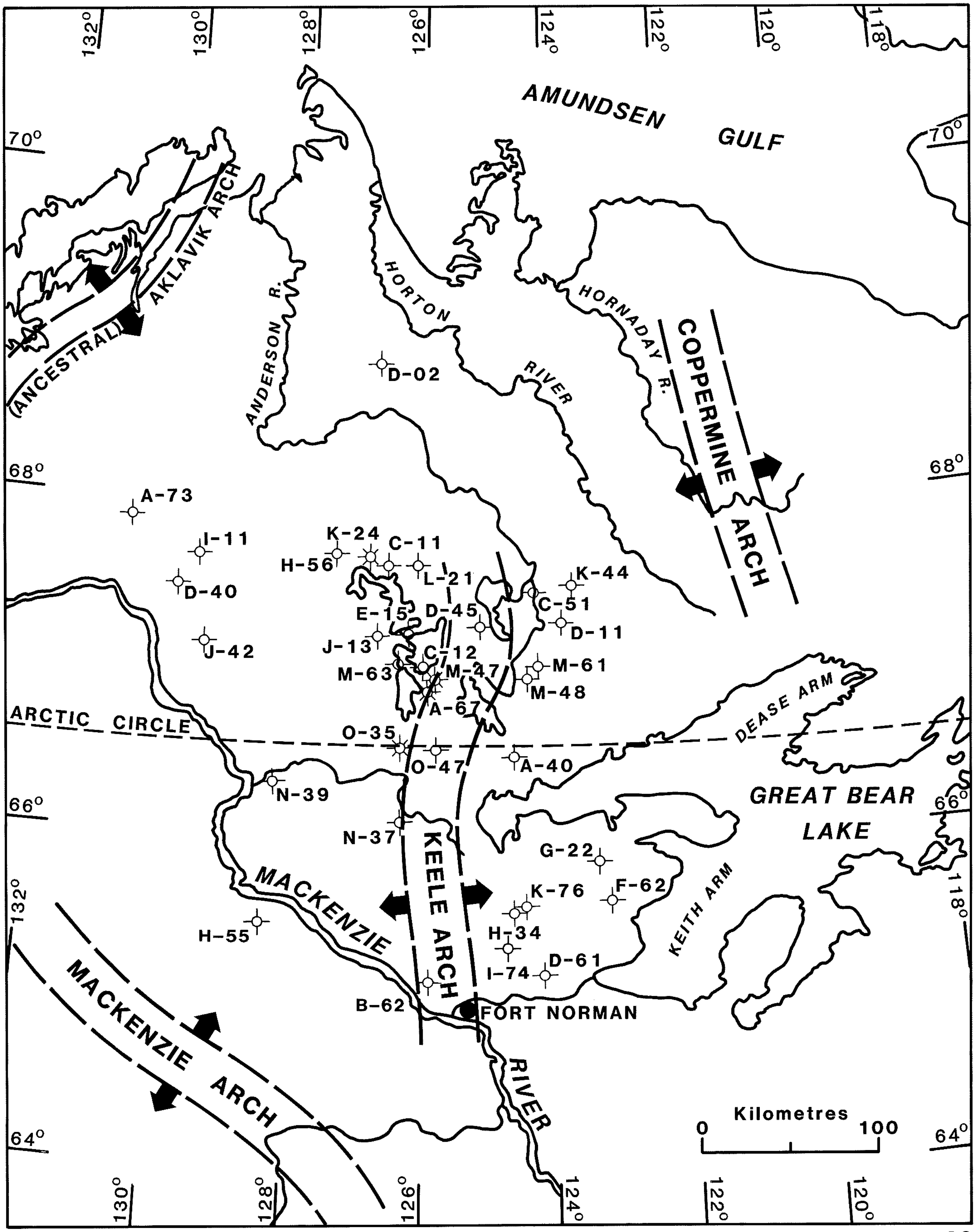
LIST OF FIGURES

Figure 1.



AMUNDSEN GULF
AKLAVIK ARCH
(ANCESTRAL)
ANDERSON R.
HORTON
RIVER
HORNADAY R.
COPPERMINE ARCH
D-02
A-73
I-11
D-40
J-42
K-24
C-11
H-56
L-21
K-44
E-15
D-45
C-51
D-11
J-13
C-12
M-61
M-63
M-47
M-48
A-67
ARCTIC CIRCLE
DEASE ARM
O-35
O-47
A-40
N-39
GREAT BEAR LAKE
N-37
KEELE ARCH
G-22
MACKENZIE
K-76
F-62
KEITH ARM
H-55
H-34
D-61
I-74
B-62
FORT NORMAN
MACKENZIE ARCH
RIVER
Kilometres
0
100
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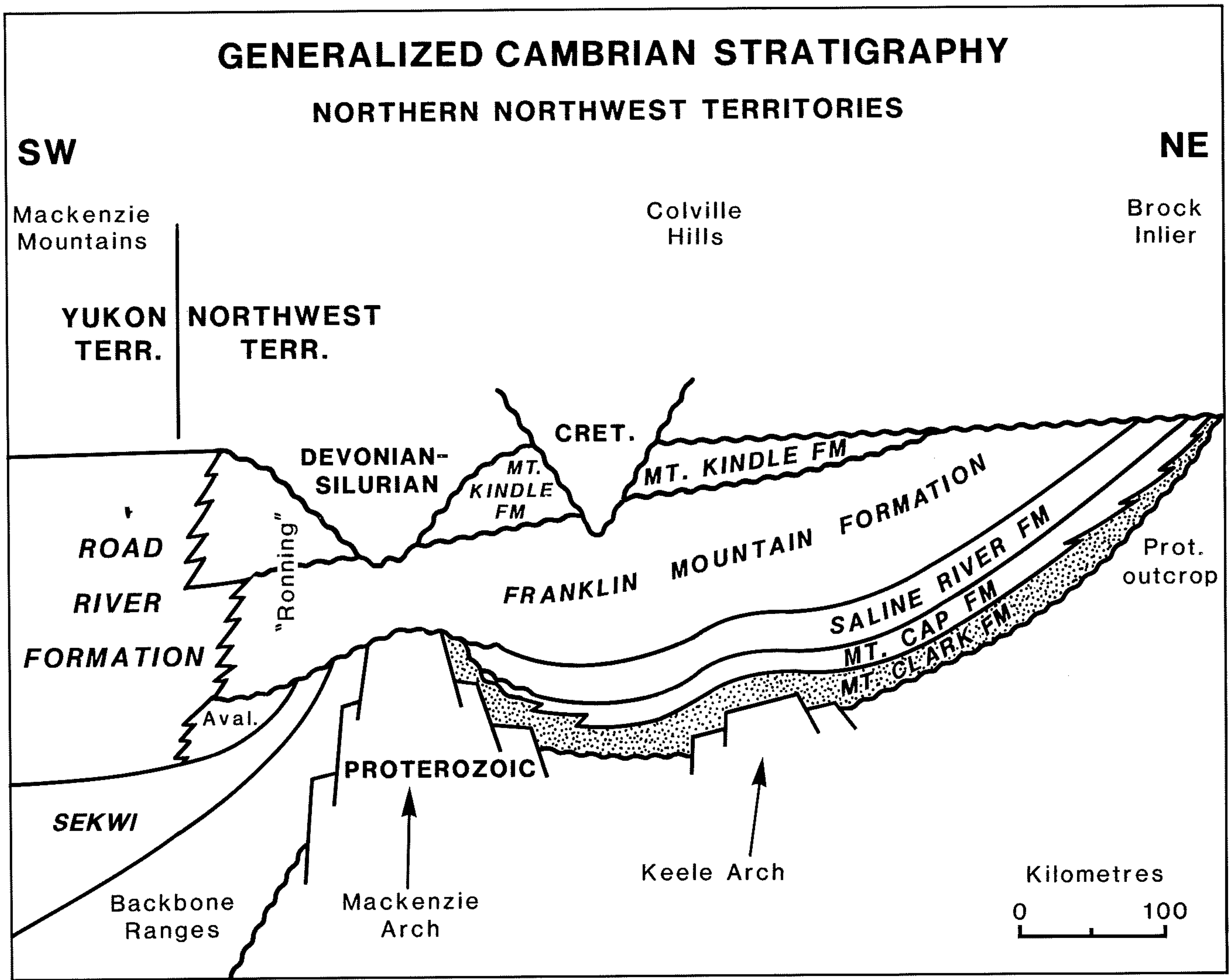
66°
64°

GSC

Figure 2.


GENERALIZED CAMBRIAN STRATIGRAPHY
NORTHERN NORTHWEST TERRITORIES
SW
NE
Mackenzie Mountains
Colville Hills
Brock Inlier
YUKON TERR.
NORTHWEST TERR.
CRET.
DEVONIAN-SILURIAN
MT. KINDLE FM
MT. KINDLE FM
ROAD RIVER FORMATION
"Ronning"
FRANKLIN MOUNTAIN FORMATION
SALINE RIVER FM
MT. CAP FM
MT. CLARK FM
Prot. outcrop
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PROTEROZOIC
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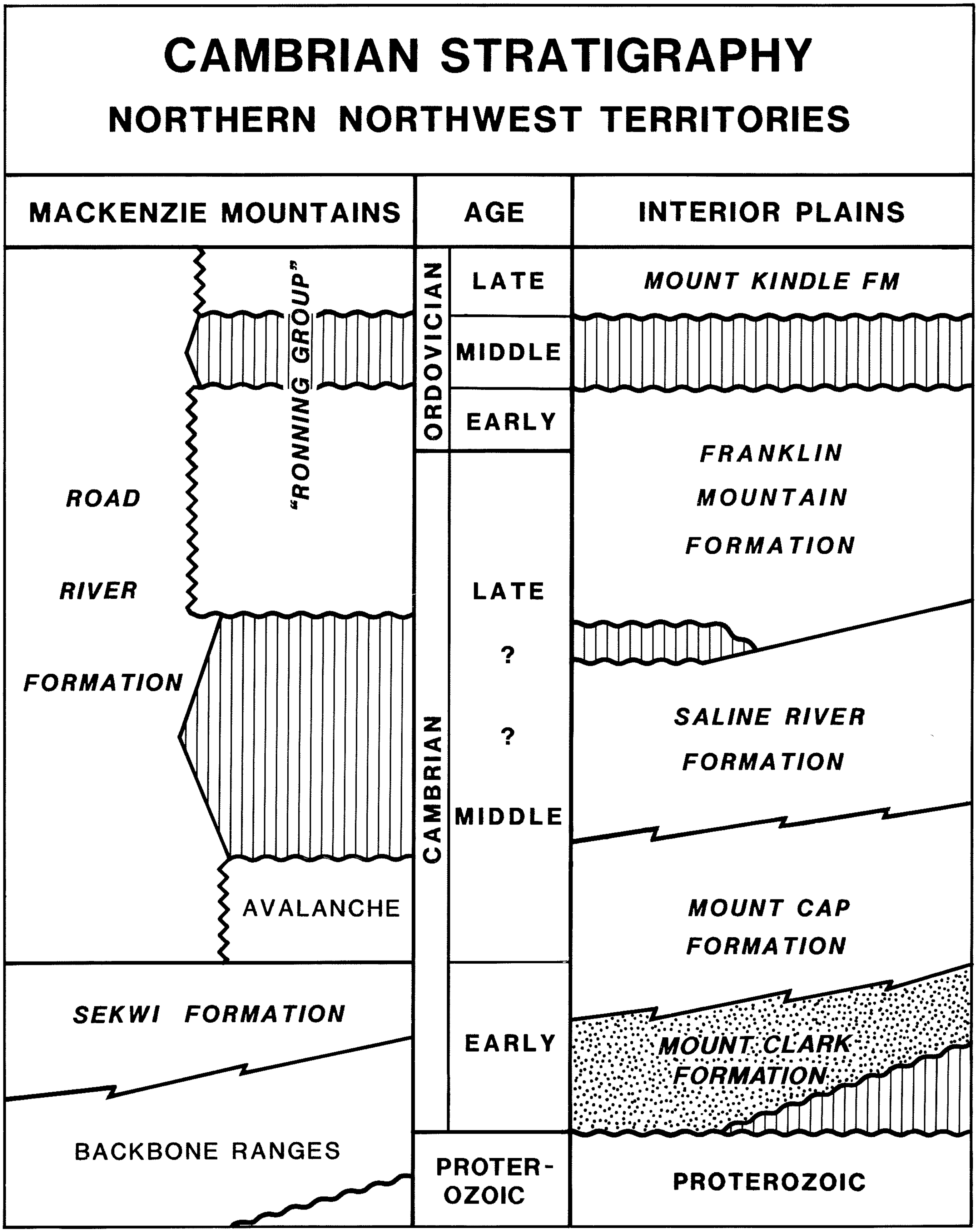
Backbone Ranges
Mackenzie Arch
Keele Arch
Kilometres
0
100

GSC

Figure 3.


CAMBRIAN STRATIGRAPHY
NORTHERN NORTHWEST TERRITORIES
MACKENZIE MOUNTAINS
AGE
INTERIOR PLAINS
"RONNING GROUP"
ORDOVICIAN
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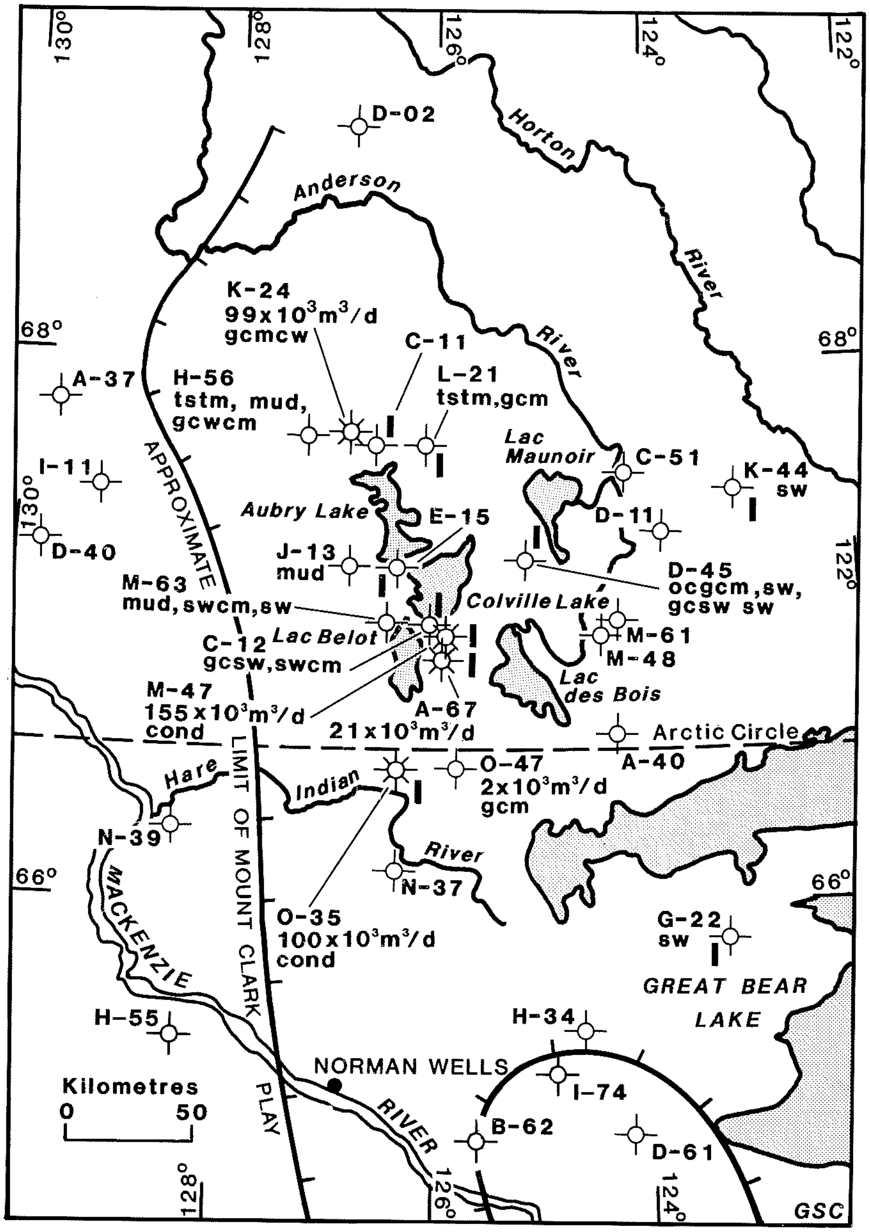
MIDDLE
EARLY
MOUNT KINDLE FM
ROAD RIVER FORMATION
CAMBRIAN
LATE
?
?
MIDDLE
FRANKLIN MOUNTAIN FORMATION
SALINE RIVER FORMATION
AVALANCHE
MOUNT CAP FORMATION
SEKWI FORMATION
EARLY
MOUNT CLARK FORMATION
BACKBONE RANGES
PROTER-OZOIC
PROTEROZOIC

GSC

Figure 4.



OPERATORS

1969 D-61 SINCLAIR
1969 I-74 SINCLAIR
1970 E-15 MOBIL
1972 M-63 MOBIL
1972 H-34 ARCO
1973 D-45 MOBIL
1974 M-48 UNION
1974 K-24 ASHLAND
1975 K-44 UNION/IMPERIAL
1975 G-22 BP
1975 A-40 UNION/DECALTA
1977 D-02 MOBIL/GULF
1978 L-21 PETROCAN
1983 C-51 FOREWARD
1983 D-11 FOREWARD
1984 M-61 FOREWARD
1984 J-13 FOREWARD
1984 C-11 FOREWARD
1984 H-55 PETROCAN
1985 M-47 PETROCAN
1985 N-37 EXCO
1985 H-56 PETROCAN
1985 A-67 PETROCAN/CANTERRA
1986 C-12 PETROCAN
1986 B-62 PETROCAN
1986 O-47 PETROCAN/CANTERRA
1986 O-35 PETROCAN/CANTERRA

▌ CORE

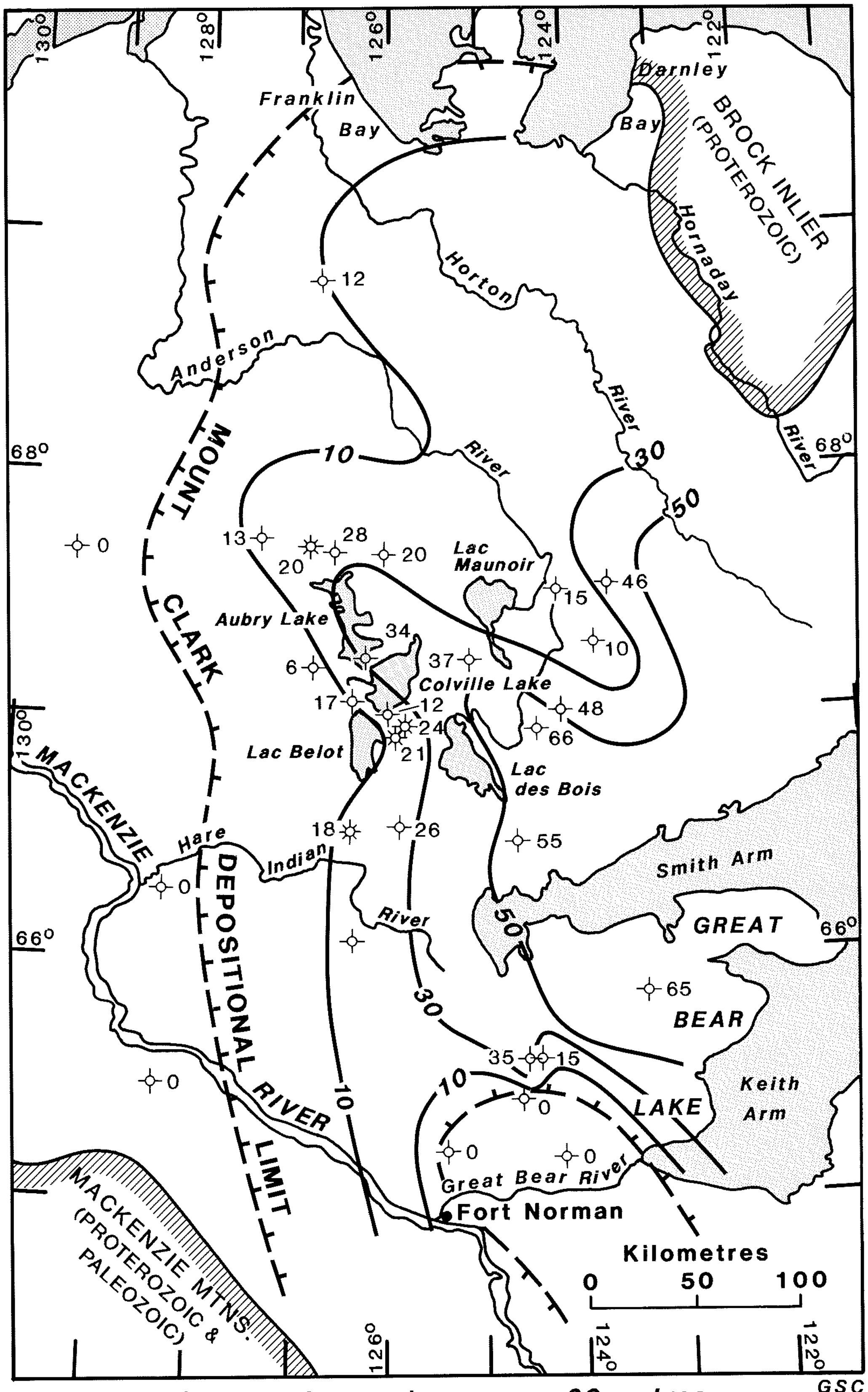
$2x10^3m^3/d$ = DST GAS FLOW

gcsw = DST RECOVERY

MOUNT CLARK FORMATION

NORTHWEST TERRITORIES WELL PENETRATION AND TESTS

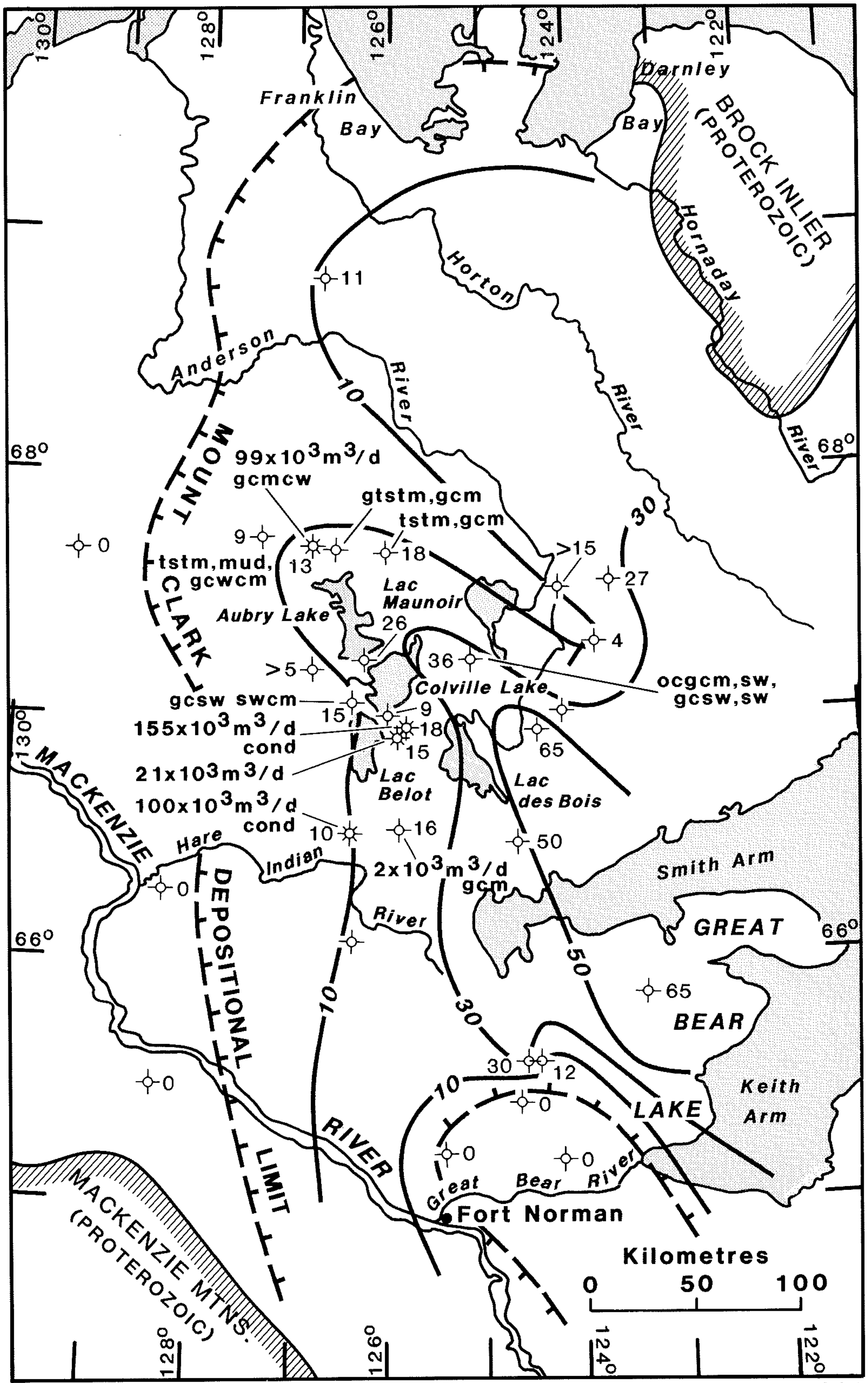
Figure 5.



Contour interval............. 20 metres

MOUNT CLARK FORMATION GROSS ISOPACH MAP

Figure 6.



Contour interval............20 metres

GSC

MOUNT CLARK FORMATION
CLEAN SANDSTONE ISOPACH

Figure 7.

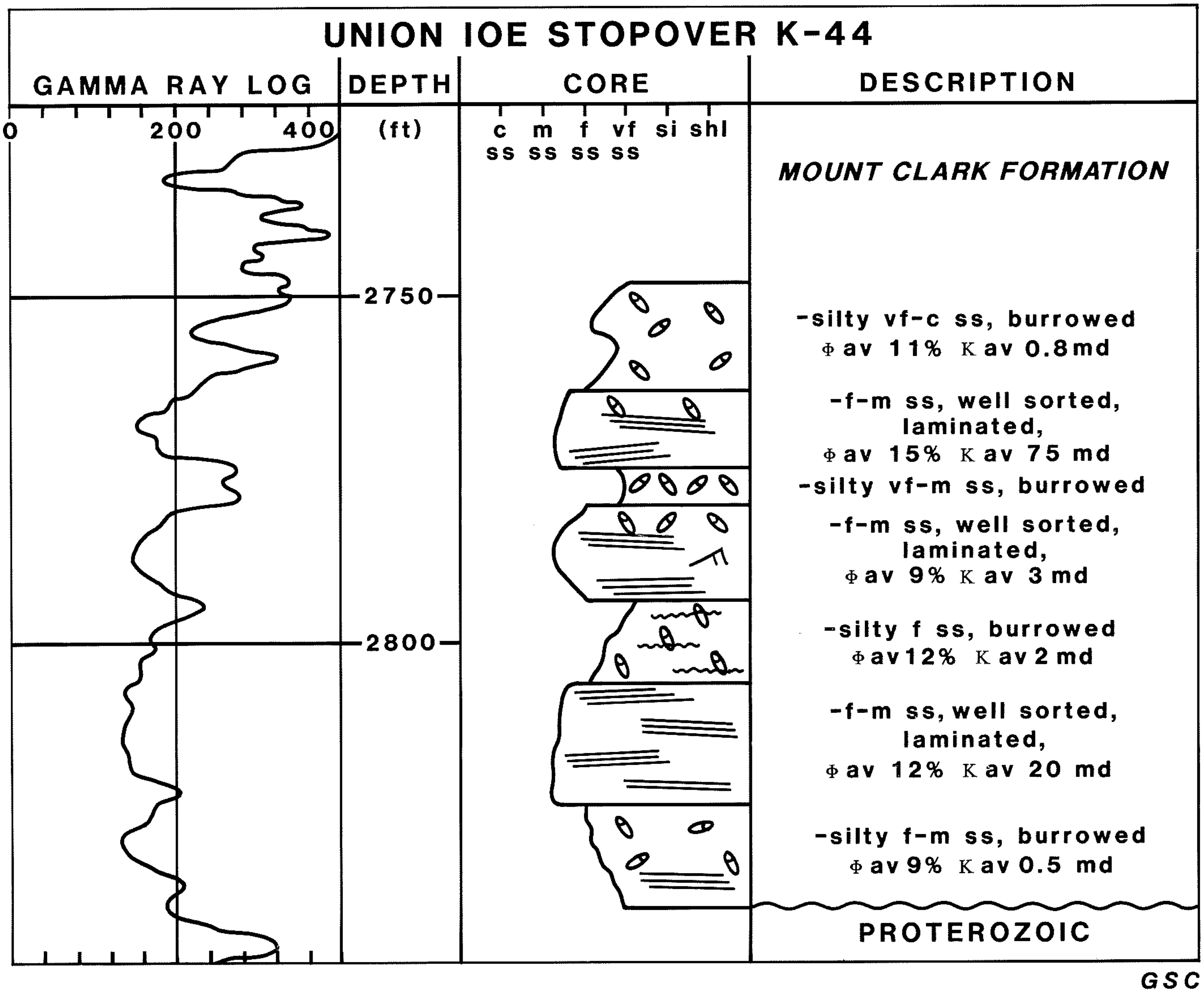
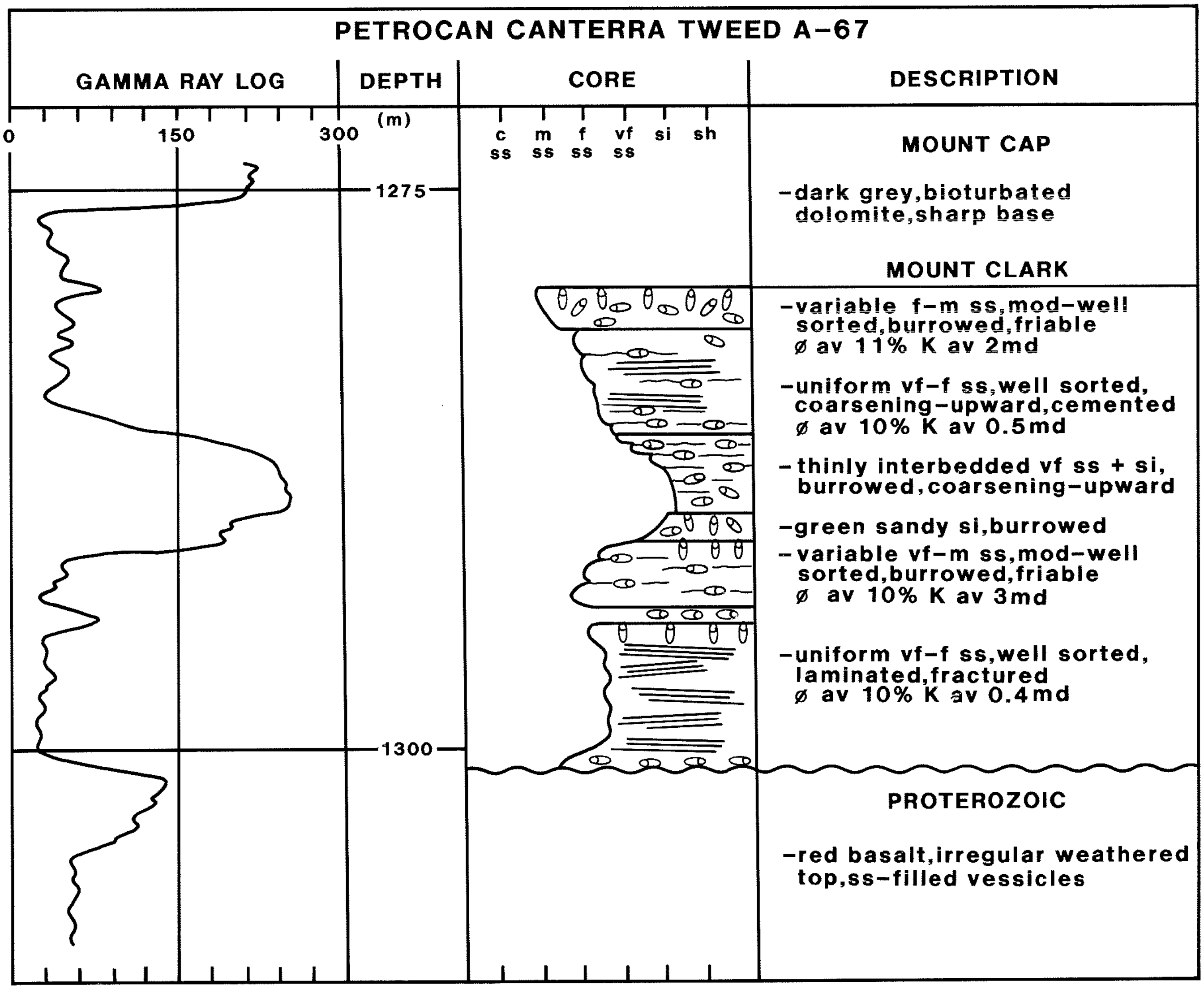
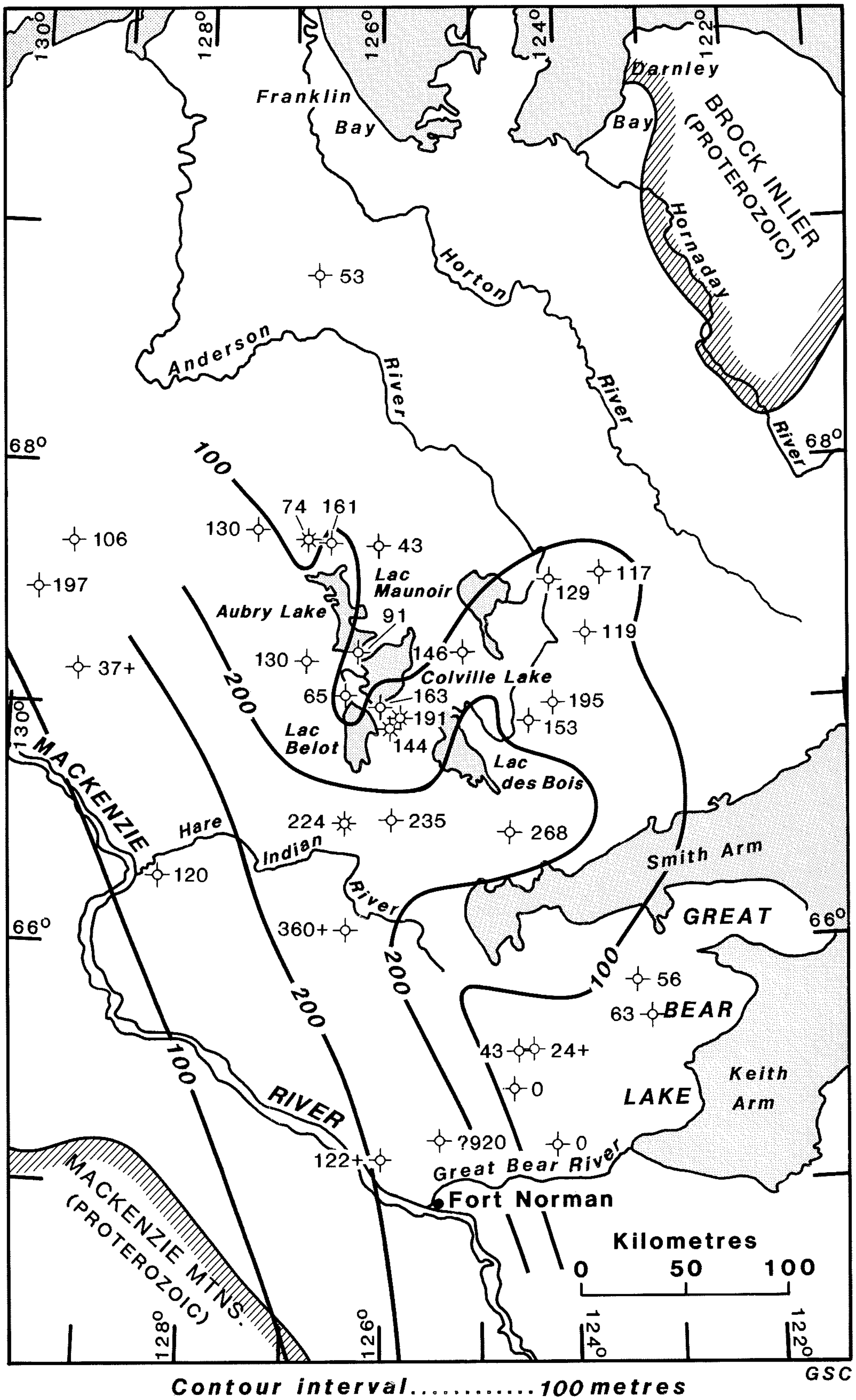

UNION IOE STOPOVER K-44
GAMMA RAY LOG
DEPTH
CORE
DESCRIPTION
0
200
400
(ft)
c ss
m ss
f ss
vf ss
si
shl
MOUNT CLARK FORMATION
2750
2800
-silty vf-c ss, burrowed
Φ av 11% K av 0.8md
-f-m ss, well sorted, laminated,
Φ av 15% K av 75 md
-silty vf-m ss, burrowed
-f-m ss, well sorted, laminated,
Φ av 9% K av 3 md
-silty f ss, burrowed
Φ av12% K av 2 md
-f-m ss, well sorted, laminated,
Φ av 12% K av 20 md
-silty f-m ss, burrowed
Φ av 9% K av 0.5 md
PROTEROZOIC
GSC

Figure 8.



PETROCAN CANTERRA TWEED A-67
GAMMA RAY LOG
DEPTH
CORE
DESCRIPTION
0
150
300
(m)
c ss
m ss
f ss
vf ss
si
sh
1275
1300
MOUNT CAP
-dark grey,bioturbated dolomite,sharp base
MOUNT CLARK
-variable f-m ss,mod-well sorted,burrowed,friable
ø av 11% K av 2md
-uniform vf-f ss,well sorted, coarsening-upward,cemented
ø av 10% K av 0.5md
-thinly interbedded vf ss + si, burrowed,coarsening-upward
-green sandy si,burrowed
-variable vf-m ss,mod-well sorted,burrowed,friable
ø av 10% K av 3md
-uniform vf-f ss,well sorted, laminated,fractured
ø av 10% K av 0.4md
PROTEROZOIC
-red basalt,irregular weathered top,ss-filled vessicles

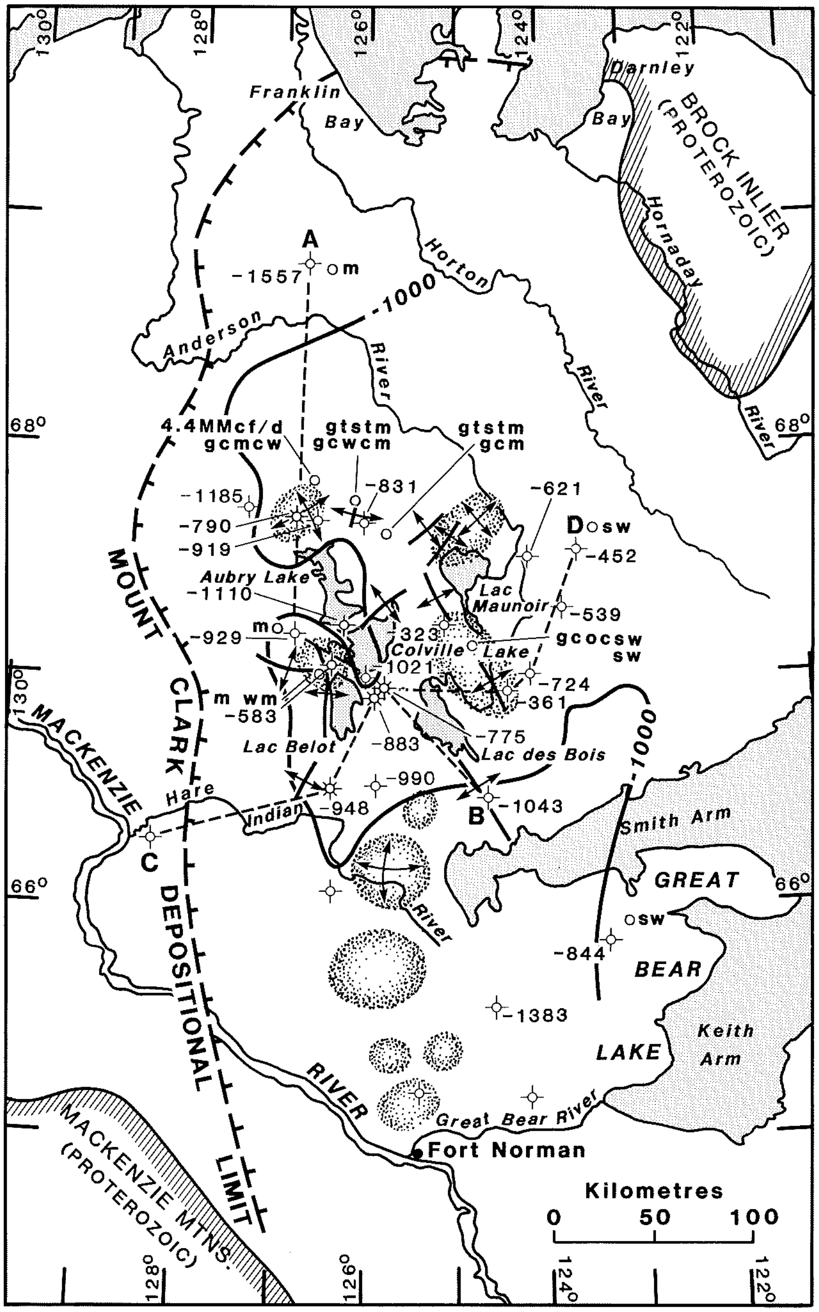
Figure 9.



Contour interval............100 metres

MT. CAP GROSS ISOPACH

Figure 10.



Mapped domal culminations

Identified or interpreted domal structure

Mapped linear folds

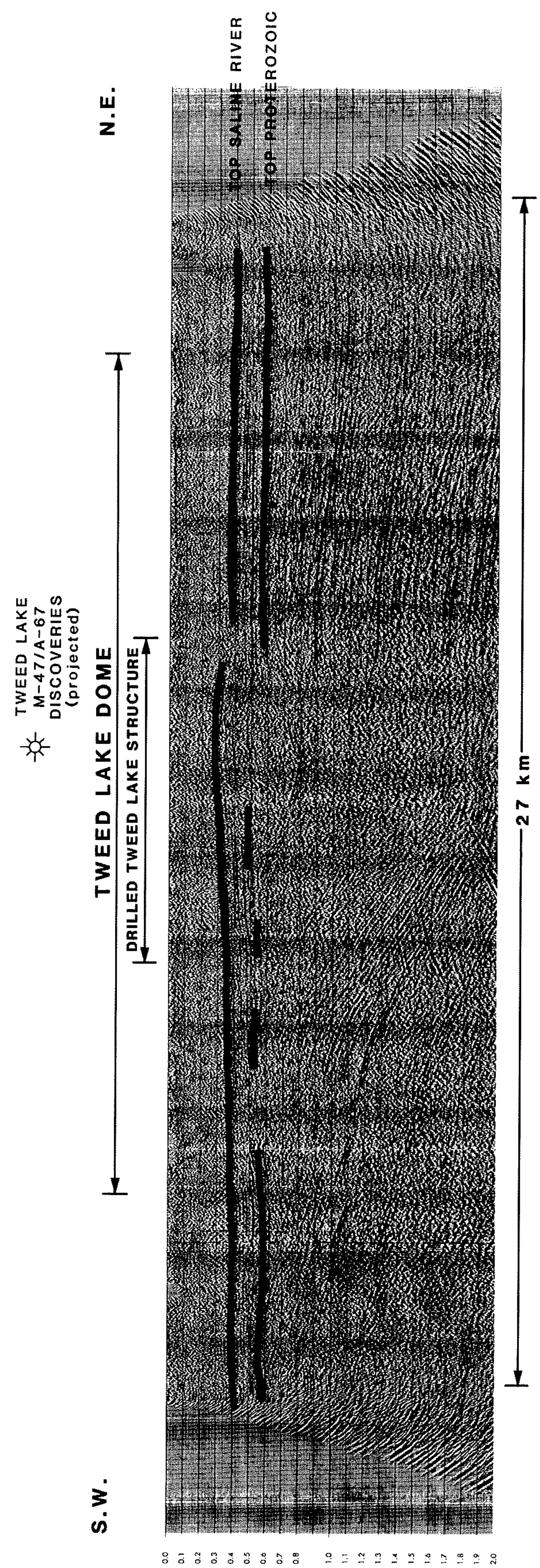
Contour interval .... -1000 metres

Control point .... -724

Well data plus info from Cook(1975), Haimila(1975), Davis & Willot (1978).

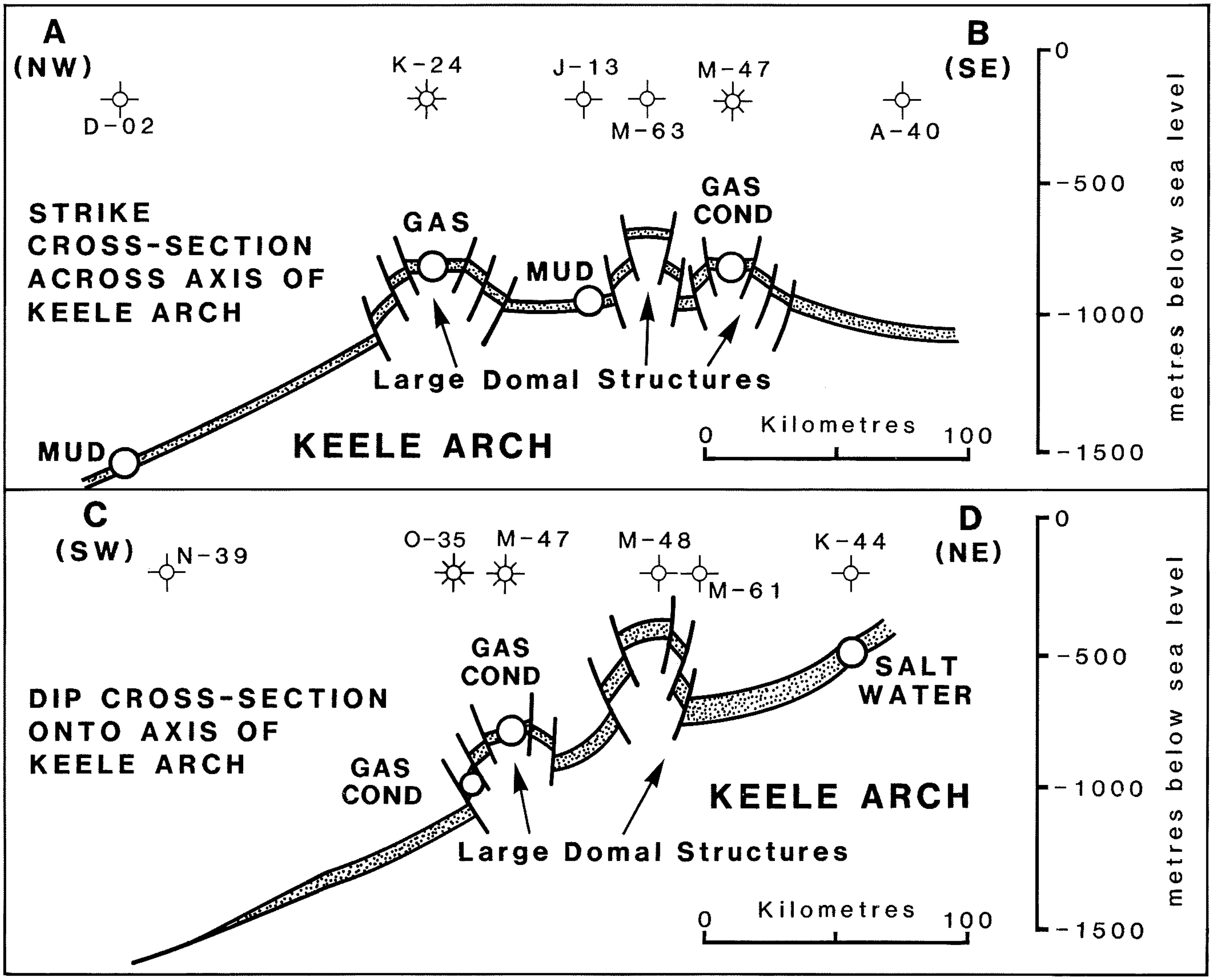
TOP OF MOUNT CLARK STRUCTURE CONTOUR MAP

Figure 11.



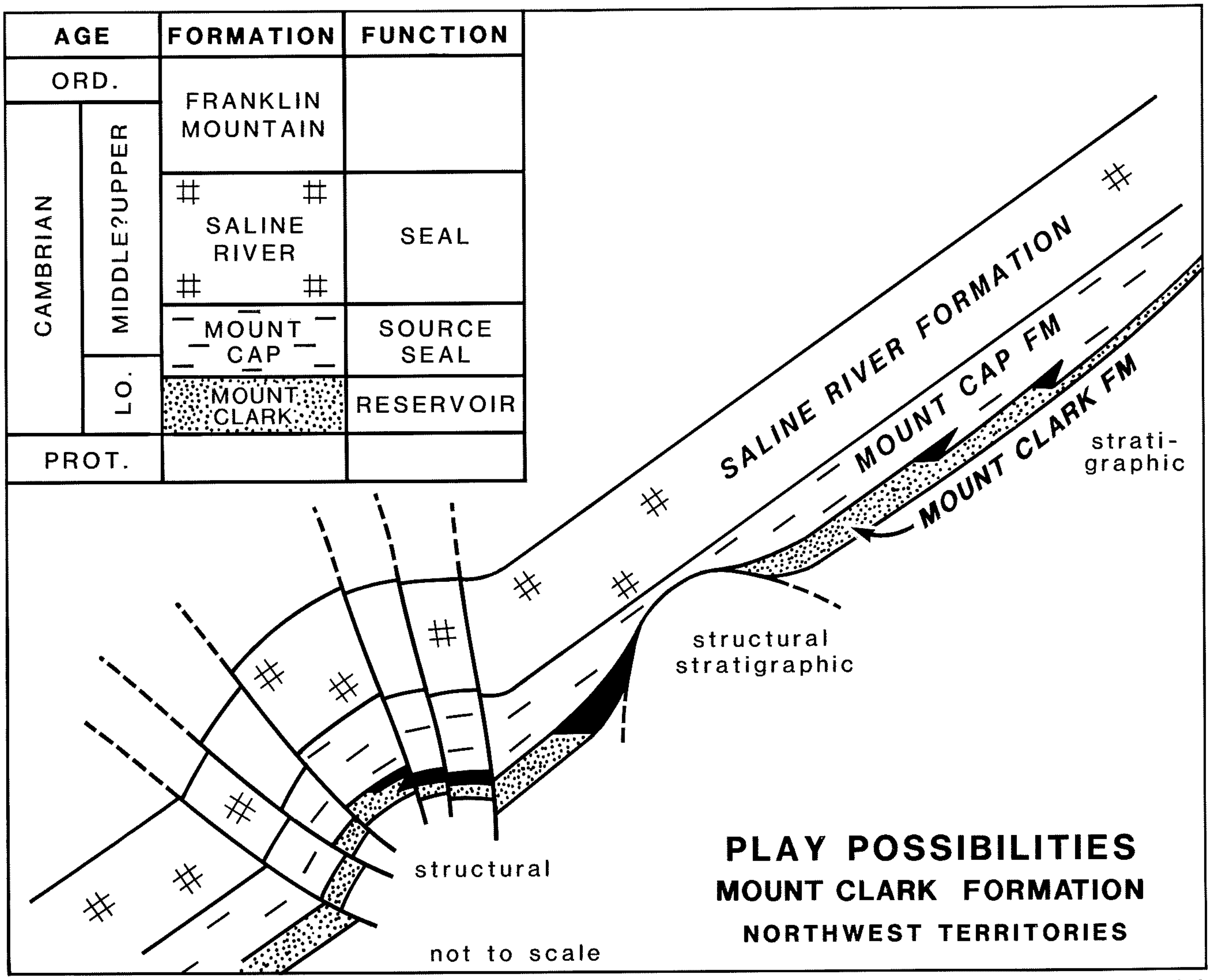
S.W.
N.E.
TOP SALINE RIVER
TOP PROTEROZOIC
TWEED LAKE
M-47/A-67
DISCOVERIES
(projected)
TWEED LAKE DOME
DRILLED TWEED LAKE STRUCTURE
27 km
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0

Figure 12.



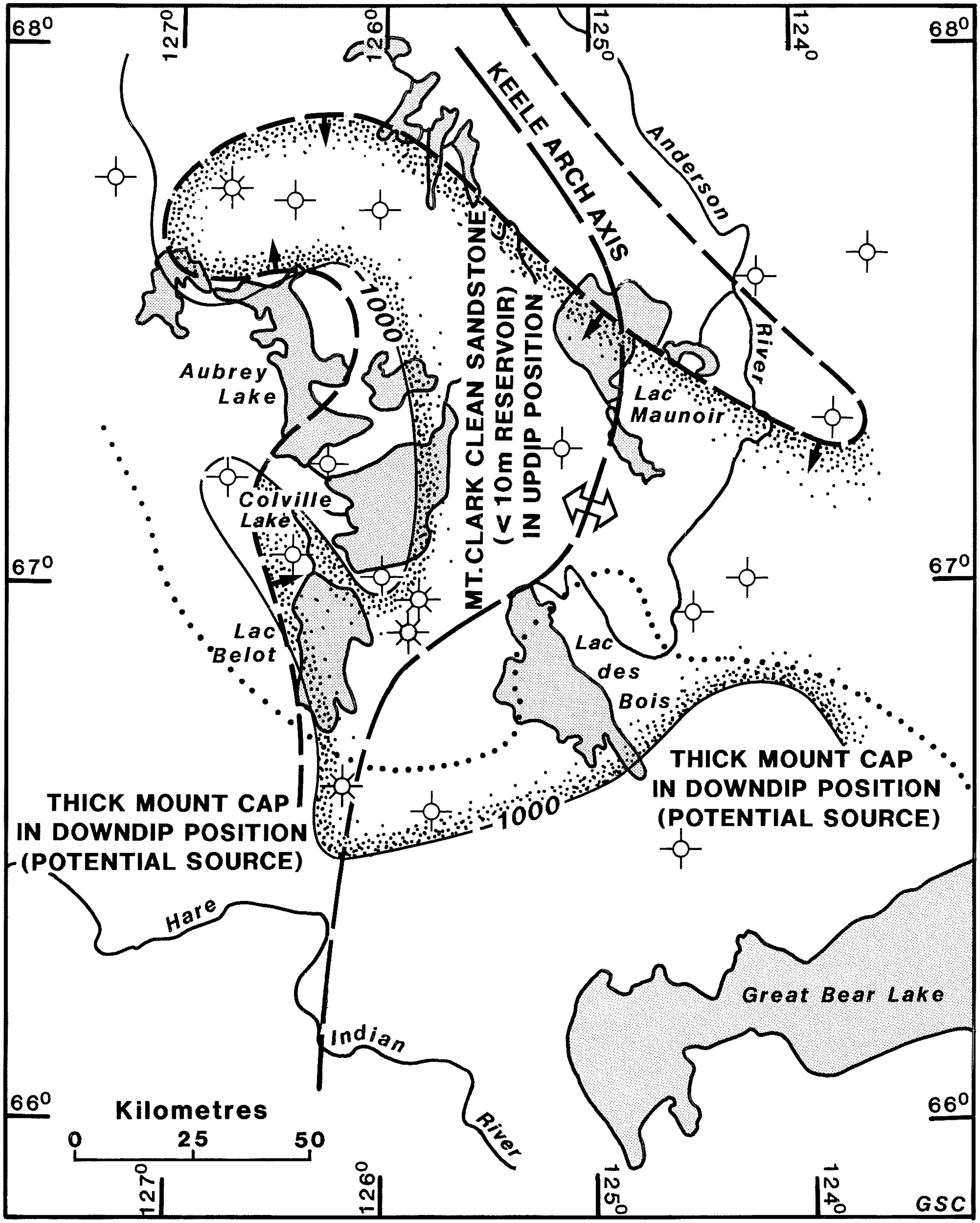
GSC

Figure 13.



GSC

Figure 14.



68°
127°
126°
125°
124°
68°
KEELE ARCH AXIS
Anderson
River
MT.CLARK CLEAN SANDSTONE
(< 10m RESERVOIR)
IN UPDIP POSITION
1000
Aubrey
Lake
Lac
Maunoir
Colville
Lake
67°
67°
Lac
Belot
Lac
des
Bois
THICK MOUNT CAP
IN DOWNDIP POSITION
(POTENTIAL SOURCE)
THICK MOUNT CAP
IN DOWNDIP POSITION
(POTENTIAL SOURCE)
1000
Hare
Indian
River
Great Bear Lake
66°
66°
Kilometres
0
25
50
127°
126°
125°
124°
GSC