GEOLOGY OF PORTIONS OF THE CARBONIFEROUS DEER LAKE BASIN, WESTERN NEWFOUNDLAND

by R.S. Hyde

INTRODUCTION

During 1978, mapping of Carboniferous strata and underlying basement rocks was conducted in the following map areas: 1) Hampden (12H/10), 2)Sheffield Lake (12H/7), 3) The Topsails (12H/2), 4)Pasadena (12H/4), and 5)Corner Brook (12A/13). Reconnaissance work was also done along Junction Brook and Lane's Brook (Deer Lake area, 12H/3),on portions of the Silver Mountain area (12H/11), on outliers of Carboniferous strata along Shanadithit Brook (Star Lake area, 12A/11), and in the vicinity of Conche (Groais Island area, 2L/13).

Important results include:

1)Recognition of probable pre-Carboniferous igneous and metasedimentary rocks on the west shore of White Bay. These do not appear on any previously published maps.

2)Repositioning of the following geologic boundaries: a) the fault contact between the Mississippian Anguille Group and Silurian sedimentary and volcanic rocks in the Hampden area; b) the unconformable contact between the Mississippian North Brook Formation and Cambrian quartzites and schists northwest of Deer Lake in the Pasadena area; and c) the conformable contact between the North Brook Formation and Rocky Brook Formation on North Brook in the Pasadena area.

3)Discovery, mostly by Westfield Minerals, of uraniferous zones within the Rocky Brook Formation. On North Brook, uraniferous zones are associated with the sequence limestone-gray mudstone.

Carboniferous strata of the Deer Lake Basin unconformably overlie Precambrian to Devonian igneous, metamorphic, and sedimentary rocks, and consist of two groups of rocks: 1) the Anguille Group of early Mississippian age, and 2) the Deer Lake Group of late Mississippian to early Pennsylvanian age.

GENERAL GEOLOGY

Probable pre-Carboniferous basement rocks -- White Bay

Three varieties of pre-Carboniferous rocks occur along the west side of White Bay. The first consists of foliated fine grained metagabbros which are commonly altered to a greenish gray calc-silicate rock. Other greenish gray calc-silicates are distinctly banded, and may have had a tuffaceous or sedimentary parentage. Locally, the calc-silicates weather to an orange color. The metagabbros and their alteration products are laced with calcite veins up to 4 cm in width, in contrast to nearby Carboniferous sedimentary rocks, which contain predominantly quartz veins.

The second variety consists of feldspar phyric and aphyric mafic-intermediate dikes or flows. At one place these rocks are in gradational contact with orange weathering calc-silicates, although the contact is sheared. Some of the dikes and/or flows, however, appear to post date the deformation. These igneous rocks should not be confused with previously reported dikes that cut Carboniferous strata (Hyde, 1978).

The third variety consists of mélange-type rocks containing clasts of serpentinite, mafic-intermediate lavas or intrusive rocks, and orange weathering calc-silicates set in a sheared, shaly matrix. These are areally associated with the second variety of rocks.

The age of these rocks is unknown, but a pre-Carboniferous age is suggested for several reasons. First, the metagabbros have undergone a much more severe and complex deformation and metamorphism than known Carboniferous rocks in the immediate area. Second, the mélange-type rocks are totally out of character with the style of Carboniferous sedimentation in the Deer Lake Basin, or for that matter Carboniferous basins of the entire Appalachian orogen, and are therefore considered to be pre-Carboniferous in age. Clasts of rocks belonging to the second variety occur within the mélange-type rocks, which suggests that the second variety is also pre-Carboniferous.

Anguille Group

Hyde (1978) subdivided the Anguille Group into five mappable units as follows: **Unit 1**-- Red and gray sandstones, red and gray conglomerates, red and gray siltstones; **Unit 2**-- Interbedded tan dolomites and reddish brown siltstones; **Unit 3**-- Dark gray, fine grained sandstones, siltstones, and mudstones interbedded with light gray, medium to coarse grained sandstones; **Unit 4**-- Carbonate pebble conglomerate, minor quartz pebble conglomerate, gray sandstone, siltstone, and limestone; and **Unit 5**-- Interbedded gray sandstone and red siltstone arranged in fining upwards sequences. The numbering of these units is basically north to south, and does not imply any temporal sequence.

On the basis of work in 1978, however, it is suggested that Unit 5 should be included in the North Brook Formation of the overlying Deer Lake Group. This is because the North Brook Formation exposed on Junction Brook, 10 km along strike to the southwest, contains similar lithologies arranged in fining upwards sequences.

Figure 1 is a highly idealized section (after removal of faulting and folding) showing the relationships between the four lithologic units in the Anguille Group. This sketch highlights the fact that these units are lensoidal in geometry with extensive interfingering.

Not shown on the accompanying map because of the scale is extensive intertonguing of Units 2 and 3 along the southeast shore of Saltwater Cove. Unit 2 in the vicinity of Saltwater Cove and Spear Point is lithologically very similar to the Cape Rouge Formation defined by Baird (1966) for the Conche area 150 km to the northeast. Although Belt (1969, p. 737) correctly states that it is uncertain that these two groups of rocks are time equivalents, the fact that they occur along strike from each other, have a Tournasian age, and are nearly identical in all aspects makes their time equivalency likely.

Deer Lake Group

The Deer Lake Group has been subdivided into the following units (ascending order): 1) North Brook Formation, 2) Rocky Brook Formation, and 3) Humber Falls Formation (Belt, 1969). In the eastern part of the basin, the Deer Lake Group is represented by the Howley Formation or Howley "Beds" (Hacquebard *et al.*, 1960). These are partly equivalent and probably slightly younger than the Humber Falls Formation (Belt, 1969, p. 74). The Deer Lake Group overlies the Anguille Group with an angular unconformity, but in many areas (*e.g.*, northwest of Deer Lake) the Deer Lake Group rests unconformably on pre-Carboniferous basement.

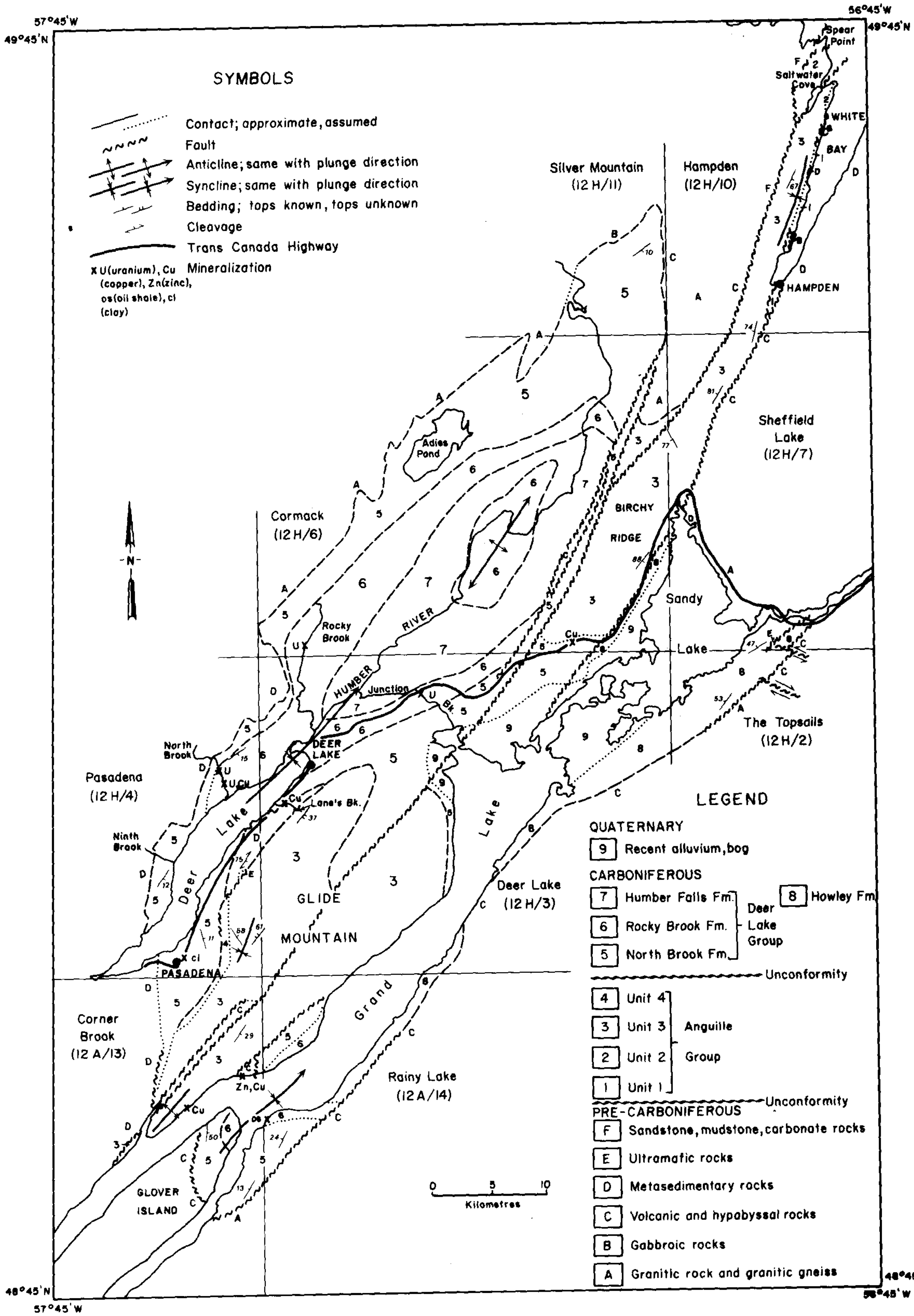
North Brook Formation

The North Brook Formation consists of gray and red, pebble to boulder conglomerates, gray, orange, and red sandstones, red siltstones, thin limestone beds, and an amygdaloidal basalt flow. On a basinwide scale the North Brook Formation is heterogeneous, so subdivision into members may not be possible. Gray pebble to boulder conglomerates and intercalated gray sandstones tend to occur in the lower part of the formation, with red arkosic sandstones overlying them. The thickness of the formation varies from 70 m at the type section to over 1200 m on Glover Island. This rapid thickening to the southeast was also observed by Belt (1969).

In the vicinity of Grand Lake the North Brook Formation consists mostly of medium to coarse grained red arkosic sandstone and reddish gray pebble-cobble conglomerate. In places, the sandstones contain greenish gray reduction splotches and tan calcareous nodules, and are extensively cross-stratified and scoured. The conglomerates contain rounded clasts up to 35 cm in apparent long dimension. Clast types include a distinctive brick-red porphyry, mafic to felsic volcanics, quartz, and pink and orange granite.

In contrast, north of Deer Lake the formation contains clasts derived mainly from a quartzite, quartz-mica schist, and carbonate terrain. This is also the case at Lane's Brook in the Deer Lake area. In the Silver Mountain area, at the northern margin of the basin, there is a remarkable diversity of plutonic debris, almost to the exclusion of other rock types. There, clast types include gabbro, diorite, syenodiorite, and granite.

Based on clast composition and paleocurrent data, it is evident that a northeast-southwest trending basin was being filled from both sides, a conclusion reached earlier by Werner (1955) and Belt (1969). Easterly transport of material took place northwest of Deer Lake, whereas



57°45'W
49°45'N
56°45'W
49°45'N
SYMBOLS
Contact; approximate, assumed
Fault
Anticline; same with plunge direction
Syncline; same with plunge direction
Bedding; tops known, tops unknown
Cleavage
Trans Canada Highway
X U(uranium), Cu (copper), Zn(zinc), os(oil shale), cl (clay)
Mineralization
Silver Mountain (12 H/11)
Hampden (12H/10)
Spear Point
Saltwater Cove
WHITE BAY
HAMPDEN
Sheffield Lake (12H/7)
Adies Pond
BIRCHY RIDGE
Sandy Lake
Cormack (12H/6)
Rocky Brook
RIVER
HUMBER
Junction
DEER LAKE
North Brook
Pasadena (12 H/4)
Ninth Brook
Deer Lake
Lane's Bk.
GLIDE MOUNTAIN
PASADENA
Corner Brook (12 A/13)
Grand Lake
Zn,Cu
Rainy Lake (12A/14)
GLOVER ISLAND
Deer Lake (12 H/3)
The Topsails (12H/2)
0 5 10
Kilometres
LEGEND
QUATERNARY
9 Recent alluvium, bog
CARBONIFEROUS
7 Humber Falls Fm.
6 Rocky Brook Fm.
5 North Brook Fm.
Deer Lake Group
8 Howley Fm
Unconformity
4 Unit 4
3 Unit 3
2 Unit 2
1 Unit 1
Anguille Group
Unconformity
PRE-CARBONIFEROUS
F Sandstone, mudstone, carbonate rocks
E Ultramafic rocks
D Metasedimentary rocks
C Volcanic and hypabyssal rocks
B Gabbroic rocks
A Granitic rock and granitic gneiss
48°45'N
57°45'W
48°45'N
56°45'W

westerly transport of material occurred on the east side of Grand Lake and near Junction Brook in the Deer Lake area.

It is also clear that there was a fair amount of topographic relief (up to 15 m) on the northwestern basin margin (Werner, 1955). There, numerous windows of Cambrian quartzites and schists occur near the Cambrian-Carboniferous contact northwest of Deer Lake. Locally, topographic gradients must have been steep, as evidenced by marble boulders over 1 m in diameter on Ninth Brook in the Pasadena area.

Locally, thin, fine grained limestone beds occur interbedded with red arkosic sandstone and pebble conglomerate northwest of Deer Lake in the Pasadena area. On Lane's Brook, thin stromatolite beds occur interbedded with pebble-cobble conglomerates (Fong, 1976). Also on Lane's Brook there is a 2 m thick amygdaloidal basalt, with pillowlike features, associated with medium to coarse grained gray sandstone. The basalt was first reported by Baird (1950).

Belt (1968) has interpreted the North Brook Formation as representing deposition on alluvial fans. This is true for the base of the unit, but the alluvial fan deposits grade upwards into cross-stratified sandstones and pebble conglomerates which were probably deposited in low sinuosity braided rivers. Along Junction Brook and the Trans Canada Highway in the Deer Lake and Cormack areas, respectively, the presence of classic fining upwards alluvial sequences reflects deposition in meandering rivers. Stromatolites occurring on Lane's Brook probably formed in gravel floored ponds on an alluvial fan surface.

Rocky Brook Formation

The Rocky Brook Formation consists of the following lithologies: red siltstone and mudstone, red very fine grained to fine grained sandstone, gray siltstone and mudstone, gray calcilutite and calcarenite (in places oolitic and stromatolitic), and dark brown oil shale.

The contact between the Rocky Brook Formation and underlying North Brook Formation is gradational in that coarse grained red sandstone and conglomerate (typical North Brook Formation lithologies) are separated stratigraphically from red and gray siltstones and mudstones (typical Rocky Brook Formation lithologies) by very fine to medium grained red sandstones. Werner (1955) defined the top of the North Brook Formation as the last appearance of conglomerate, but conglomerates in the upper part of the North Brook Formation are thin and lensoidal, and are easily missed. It is tentatively proposed to define this boundary as the last appearance of thick (>1 m) medium to coarse grained red sandstone. Thus, on North Brook, the contact between the North Brook Formation and Rocky Brook Formatin is placed further north than is shown on maps by Baird (1959) and Fong (1976).

On Junction Brook, the Rocky Brook Formation can be subdivided into a lower member containing red and gray siltstones and mudstones, with thin interbeds of limestone, and an upper member lacking red strata. The thickness of the lower member is estimated to be 640 m. A detailed measured section on North Brook showed 130 m of the lower part of the Rocky Brook Formation to consist of red sandstone, interbedded red and gray siltstone, and mudstone, with thin beds of limestone and gray sandstone. In the 130 m section, the ratio between red siltstone-mudstone: gray siltstone-mudstone: carbonate rock is 12.3:6.4:1. There also appears to be a preferred vertical sequence of beds starting with each bed of limestone. The vertical sequence limestone-gray siltstone/mudstone-red siltstone/mudstone occurs in nine out of thirteen cases involving limestones. The contact between gray and red beds is usually sharp.

The lower part of the Rocky Brook Formation tends to be calcareous with calcite cements and nodules. On Grand Lake the lower part of the formation consists of reddish brown calcareous siltstones. This subdivision into dominantly red beds in the lower part and fewer or no red beds in the upper part was made by Landell-Mills (1922), but was not discussed by subsequent workers.

Belt (1968) has summarized the evidence for lacustrine and mixed lacustrine-fluvial sedimentation in the Rocky Brook Formation. In all probability fluvial deposition is restricted to near the base of the Rocky Brook, and it would appear that conditions became more reducing with time, as evidenced by the paucity of red beds and the presence of dark gray marcasitic mudstones near the top of the unit. The cyclic deposition outlined above may have been caused by fluctuations in water depth, leading to changes in Eh-Ph conditions.

Humber Falls Formation

The Humber Falls Formation sharply overlies the Rocky Brook Formation, and consists of red and gray coarse grained arkoses and arkosic conglomerates. It does not outcrop in the area mapped, and is not discussed further.

Howley Formation

The Howley Formation consists of red and gray arkosic sandstones and conglomerates, dark gray and red siltstones and mudstones, and thin seams of coal.

The Howley Formation is poorly exposed in the south end of 12H/7 and the north end of 12H/2. Tentatively, two units are distinguished. A lower member consists largely of cross stratified, red, coarse grained arkose, with gray reduction spots and streaks, and to a lesser extent red and gray conglomerate. Clasts in the conglomerate are subrounded, and include quartz, orange feldspar, fine grained muscovite granite, gabbro, mafic and intermediate volcanics, phyllite, and red sandstone, siltstone, and mudstone. It is estimated that this lower unit is at least 1800 m thick, of which approximately 75 percent is sandstone.

The lower member intertongues with the upper member, which consists mainly of friable, coarse to very coarse, gray and brown arkose, and associated conglomerates and siltstones. In the sandstones, orange feldspar grains are prominent, and channelling and cross-stratification are abundant. The siltstones and mudstones contain abundant plant debris and organic matter. Gray conglomerate contains clasts up to 8 cm in size, and include quartz, orange feldspar, muscovite granite, flow banded rhyolite, phyllite, and reddish brown siltstones. This upper unit is at least 1300 m thick.

Sedimentary structures and textures indicate a predominantly fluvial origin for the Howley Formation.

STRUCTURAL GEOLOGY

Rocks in the Anguille Group are tightly folded with fold limbs usually exceeding 45° in dip. Following this folding of the Anguille Group, the Deer Lake Group was deposited and deformed, but much less than the Anguille deformation such that in most areas dips are less than 45°.

There is a complex relationship between folding and faulting in that most of the folding is caused by faulting. For example, the generally shallowly dipping Deer Lake Group assumes steep dips (>50°), and even overturning, only in the vicinity of faults. This fault-induced folding appears to have generated a later period of faulting, because many fold limbs are faulted off. In the Spear Point area some faults are folded. Folding and faulting appear to be the product of the same stress field.

Folds in the Carboniferous strata are dominantly flexural slip in style and only a few examples of axial plane cleavage were observed. Folds range from a broad open state to nearly isoclinal. In the western half of the basin, axial planes dip eastwards, but in the eastern half of the basin, axial planes dip westwards. Plunge directions are generally equally distributed to the northeast and southwest, and plunge angles are usually less than 50°. Three major synclines occur in the area studied. The first is in the Hampden area, west of White Bay, and is delineated on the basis of reversals in facing directions. Numerous second order folds are present on the limbs. Unit 1 of the Anguille Group on the eastern limb is not exposed on the western limb, presumably due to faulting. The second syncline in the Deer Lake Group near the lower Humber River is asymmetric, with the southeast limb being steeper. Again, subsidiary warpings occur on the limbs, and an anticline is superimposed on the axial plane trace, bringing the Rocky Brook Formation to the present erosional level. South of the pre-Carboniferous basement rocks east of Deer Lake, the syncline loses its identity, such that facing and dip direction are eastwards. In the Grand Lake area a regional syncline exists with the Rocky Brook Formation at the north end of Glover Island defining a fold nose. Dips on the eastern limb are shallower than those on the western limb.

Large strike faults in the Deer Lake Basin have been interpreted either as easterly dipping thrusts (Heyl, 1937; Betz, 1943) or as strike-slip faults of either dextral (Belt, 1969; Webb, 1969; and Locke, 1969) or sinistral (Popper, 1970) displacement. Fault planes of these major faults are not exposed, but exposed subsidiary faults adjacent to the major faults passing through Hampden show no evidence for horizontal motion. For other faults in the White Bay and Grand Lake areas where the sense of movement could be detected, nine out of nineteen faults were high angle reverse faults, and the remaining ten were high angle normal faults. For the White Bay area, reverse faults tend to dip eastwards whereas normal faults tend to dip westwards. On Lane's Brook, well exposed small easterly directed thrust faults occur within the North Brook Formation adjacent to the border fault with the pre-Carboniferous rocks east of Deer Lake.

Deformed Carboniferous strata generally contain a single cleavage that is parallel or subparallel to bedding. Where two cleavages are present, they are usually fracture cleavages in which the planes are nearly orthogonal to each other. In areas adjacent to faults the cleavage may be folded. Cleavages and mineral foliations in the basement rocks exposed along the west side of White Bay show two easterly dipping sets, one oriented northwesterly and another trending northeasterly.

ECONOMIC GEOLOGY

Six distinct radioactive zones are present in the lower part of the Rocky Brook Formation on North Brook. These zones have an aggregate thickness of 3.4 m and occur over a stratigraphic distance of 58 m. The four upper radioactive zones are known to contain uranium; the thickest zone is 1.3 m. Uraniferous zones are associated with the sequence limestone/calcareous gray mudstone and to a lesser extent with red siltstone. Highest values were recorded from a gray mudstone containing nodules and veins of a solid hydrocarbon material. Uranium is apparently concentrated in the nodules. Veins of this solid hydrocarbon also contain disseminated pyrite. In all cases but one, radioactive zones are contained in sequences in which gray mudstone overlies limestone. Two assays of limestone yielded 105 and 109 ppm U. The uranium anomaly on Junction Brook is associated with gray mudstone and is near the base of the upper member; it is much higher stratigraphically than the anomalies on North Brook. The anomaly on Rocky Brook is also associated with gray mudstone, and appears to be in the upper part of the Rocky Brook Formation. These latter two anomalies are not as strong as on North Brook.

Zinc-copper mineralization occurs in a gossan zone in intermediate volcanic rocks in an upfaulted slice of basement rock (probably the Ordovician Glover formation) on Grand Lake. One assay showed 0.6 percent Zn and seven other assays averaged 81 ppm Zn and 115 ppm Cu. Blue coatings on a bedding plane surface within Unit 3 of the Anguille Group may be evidence of copper mineralization. This occurs on the west shore of Grand Lake in the Corner Brook area north of the powerline. Bornite was observed near the top of the basalt on Lane's Brook in the North Brook Formation. Malachite was observed in the North Brook Formation exposed along the Trans Canada Highway in the Cormack area. Malachite staining was also seen in a pink finegrained sandstone and siltstone unit 13 m above the base of the Rocky Brook Formation on North Brook. Copper in the form of chalcopyrite occurs with one of the uranium anomalies on North Brook.

Some beds of possible oil shale were observed on the east shoreline of Grand Lake in the westernmost part of the Rainey Lake area (12A/14). Float cobbles of oil shale occur at the mouth of North Brook, but none was identified *in situ*.

Red mudstone belonging to the North Brook Formation has weathered to a residual clay along an unnamed brook immediately north of Bill's Tourist Lodge in the Pasadena area.

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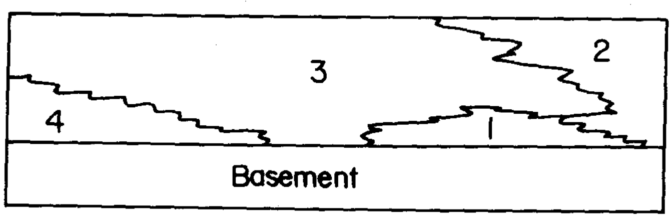

Figure 1. Idealized stratigraphic relationships between Units 1-4 of the Anguille Group.