THE GEOLOGY OF THE WALKER LAKE-MACLEAN LAKE AREA (13K/9, 13J/12), CENTRAL MINERAL BELT, LABRADOR

by D. G. Bailey

INTRODUCTION

The Walker Lake - Maclean Lake area is underlain mainly by rocks of the Aillik Group (King, 1963; Stevenson, 1970) and associated granitic intrusions. Work carried out in this area during the summer of 1977 consisted mainly of mapping at a scale of 1:50,000 in order to define and delimit the various lithologies and structures of the area. However, some detailed work was started on two uranium deposits in the area, those of Burnt Lake (Kontak, this volume) and Michelin, the largest uranium deposit discovered so far in the Central Mineral Belt.

PREVIOUS WORK AND REGIONAL GEOLOGY

The coastal areas of the Central Mineral Belt were first described by Daly (1902), and later by Douglas (1953) and Kranck (1953). Both these latter authors recognized the supracrustal nature of the rocks of the Makkovik - Aillik area, and Kranck (1953) proposed the name Aillik series for them. Stevenson (1970) changed the Aillik series to group status, and most workers have since referred to these rocks as the Aillik Group. Gandhi *et al.* (1969) and Sutton *et al.* (1972), however, retained the term "series".

Marten (personal communication, 1977) on the basis of lithologies, has suggested that the Aillik Group be subdivided into upper and lower units, with the "lower" Aillik Group comprising all basic volcanic and associated rocks in the Kaipokok Bay area. These rocks are lithologically correlated with the Aphebian Moran Group to the west (Smyth *et al.*, 1975). It has also been suggested that the "upper" Aillik Group, or the thick sequence of mainly felsic volcanic rocks south of the Kaipokok Bay area, may be correlated with the Paleohelikian Bruce River Group (Beavan, 1958; Sutton *et al.*, 1972; Smyth *et al.*, 1974). Radiometric dating, however, has indicated that such correlation is probably untenable (Gandhi *et al.*, 1969; Fahrig and Larochelle, 1972; Wanless *et al.*, 1974; Watson - White, 1976), and that the whole of the Aillik Group is of Aphebian age.

The work described in this report is that of the first year of a program of remapping and reinterpreting the geology of the Aillik Group at a scale of 1:50,000.

The regional geological framework of the Central Mineral Belt is outlined in separate 1:250,000 map sheets by Stevenson (1970), Fahrig (1959) and Williams (1970) and others, and is summarized by Kontak in this volume. The southern boundary of the Central Mineral Belt is defined by the disappearance of supracrustal rocks and the appearance of rocks of dominantly Grenville age. The northern boundary is the contact between Archean and Proterozoic rocks. Structural trends in the Central Mineral Belt are generally northeasterly, similar in direction to those of the Grenville Province to the south, but discordant to the dominantly northerly structural trends of the Archean Nain Province to the north. This observation led Taylor (1971) to name the Central Mineral Belt, the Makkovik Subprovince, a name with which it is essentially synonomous.

STRATIGRAPHY

The stratigraphy of the Walker Lake - Maclean Lake area comprises two main groups of rocks: **1)** those rocks which have undergone polyphase deformation and which have been metamorphosed to at least amphibolite grade, and **2)** those rocks which were deformed initially during the Hudsonian Orogeny, and which are generally metamorphosed only to upper greenschist or lower grades of metamorphism.

Archean Rocks

Rocks considered to be of Archean age occur in the western and northwestern parts of the map area (Units 1 and 2). Unit 1a comprises mainly banded amphibolite with foliations generally striking northwest. Zones of migmatization occur at contacts with enclosing granitic rocks. South of Anna Lake the amphibolite contains banded gneiss exhibiting polyphase deformation. Unit 1a also characteristically contains boudins of quartz and well defined pyritic bands continuous over considerable distances.

Unit 1b, outcropping to the northwest of Walker Lake, comprises polyphase deformed migmatite in which recognizable metasedimentary and metavolcanic components are present. Generally, these migmatites are leucocratic.

Unit 2 has been subdivided on the basis of color and grain size into a medium gray, coarse grained gneissic granodiorite with dioritic zones (unit 2a) and a generally fine grained, leucocratic granite (unit 2b). The banded amphibolite unit (1) south of Anna Lake is partly to completely enclosed by granitic rocks of unit 2. The foliation of unit 2 is concordant with the dominant foliation direction of the enclosed amphibolite.

Because of the marked discordance of structural trends of units 1 and 2 with rocks to the south, the well developed foliation, the indications of polyphase deformation, and the much higher metamorphic grade of unit 1 than rocks to the south, it is considered that units 1 and 2 are of Archean age and may represent basement on which the Aillik Group was deposited.

Aphebian-Aillik Group

The Aillik Group in the map area is represented by volcaniclastic and epiclastic sedimentary rocks (unit 3) and by the primary eruptive products of rhyolitic volcanism (unit 4). These rocks occupy a northeasterly trending belt stretching from Walker Lake in the west to the northeastern margin of the map sheet. On a gross scale, the rhyolites (unit 4) are flanked to the north and southeast by sedimentary rocks. Contacts between sedimentary rocks and rhyolites are almost invariably faulted.

The oldest rocks of the Aillik Group represented in the map area are tuffaceous, arkosic sandstone and siltstone (3a) overlain in places by quartzitic sandstone (3b). The tuffaceous sedimentary rocks of unit 3a are generally thinly bedded and comprise alternating arkosic and chlorite-rich beds, in places interlayered with dark gray, fissile, argillaceous sandstone and more massive quartzitic horizons. These rocks are generally magnetite rich.

South of Maclean Lake and adjacent to Otter Pond sandstones and siltstones of unit 3a are maroon and red, suggesting deposition in shallow water under oxidizing conditions. These rocks always occur stratigraphically above green and gray banded sandstones and siltstones, and indicate a shallowing of the basin of deposition with time.

Massive, pink, gray and white arkosic and quartzitic sandstone overlies banded green and gray tuffaceous sandstone east of Walker Lake, and east of Steven and Burnt Lakes. It is probable that the quartzitic and arkosic sandstones of unit 3b are also, in part, time stratigraphic equivalents of unit 3a. Although generally massive and featureless, heavy mineral laminations (mostly magnetite) in places define trough cross-bedding and other bedding features. East of Steven Lake, the sandstones are almost pure orthoquartzites, but east of Walker Lake pyroclastic beds and silty layers are common and the sandstones tend to be more arkosic than those in the southeastern part of the map area.

Near the contact of 3a and 3b about two miles east of Walker Lake, a polylithologic breccia horizon is exposed. Comprising poorly sorted, subangular to subrounded fragments of underlying sedimentary rocks and some rhyolitic debris in a chloritic muddy matrix, this breccia unit was probably formed as the result of slumping in a submarine environment. The horizon is narrow and lenticular and passes into sandstone at both ends. Contacts with the underlying and overlying rocks, where exposed, are generally sharp.

Unit 4 mainly comprises the direct products of felsic volcanism and forms the prominent outcrops of Michelin ridge and the hills between Mustang and Maclean Lakes. It is generally in fault contact with the rocks of unit 3 except near Maclean Lake, where the contacts are probably conformable. Numerous dikes of the same composition and texture as the rhyolitic rocks intrude unit 3; these dikes are considered to have been feeders for the volcanic rocks of unit 4. A high level intrusion of feldspar porphyry (4a) intrudes rocks of unit 3 just to the east of Walker Lake; this intrusion is a hypabyssal equivalent of the volcanic rocks of 4b.

Unit 4b is a thick, rather homogeneous unit on a macroscopic scale and is dominantly rhyolitic in composition. The large areal extent, the local abundance of lithic fragments, the presence of both rounded and euhedral phenocrysts of feldspar and quartz, primary flattening of what was probably vitric material, and the development of eutaxitic structures and gradations from nonwelded to welded textures over short vertical distances, indicate that most of these rocks are similar to the pyroclastic flow tuffs described by Williams (1941), or the ash-flow tuffs of Ross and Smith (1961). Because a considerable amount of the rocks of 4b is nonwelded, the term "ignimbrite" (Marshall, 1935) is not used in this report. Instead, the term "ash-flow tuff" (Smith, 1960) is preferred to describe the rocks of this unit.

Although the ash-flow tuffs show considerable compositional and textural variation, in gross aspect the southern parts of 4b contain only very few quartz phenocrysts, while the northern parts contain both quartz and feldspar as phenocrysts. However, mesoscopically, both quartz and feldspar ash-flow tuffs and feldspar ash-flow tuffs are represented throughout the sequence. In addition to porphyritic varieties of tuff, nonporphyritic ash-flow tuffs are also common. In places, these rocks appear to grade into bedded ash-fall tuffs.

Subaqueous tuffaceous deposits locally exhibiting cross bedding are also present in unit 4b. Such deposits are limited in extent, however, indicating that probably only small bodies of water were present during the deposition of unit 4b; most of the rocks of the unit are subaerial in origin.

Fragmental rhyolitic horizons are present throughout unit 4b, for example, north of Mustang Lake and on Michelin ridge. Most of these are poorly sorted, polylithologic breccias with characteristics similar to laharic breccias described by Fisher (1960), and to "unsorted heterolithologic breccias" associated with laharic breccias described by Parsons (1960). Some fragmental units, however, because of their monolithologic character with little variation in clast size, are probably true pyroclastic breccias formed by explosive volcanism. Such breccias are not common within 4b.

Immediately to the south of Maclean Lake a thick breccia unit is extensive enough to be mapped as a separate unit. Unlike any of the fragmental rocks within 4b, this unit (4c) grades vertically from a monolithologic to a polylithologic breccia. A group of outcrops in the southern part of the unit comprise a uniformly monolithologic rhyolite breccia with a high clast to matrix ratio and a well developed unidirectional flow texture in the matrix. The matrix is also pervasively altered to chlorite and epidote; some epidote alteration of clasts has also occurred. To the northwest, the breccia becomes polylithologic, with fragments of sedimentary rock and rhyolite of differing textures becoming common. Clast to matrix ratio is not as high as in the monolithologic breccia and alteration of the matrix is not as pervasive. Monolithologic breccias of 4c are probably the result of phreatic eruption, and formed within the volcanic pile by sudden increase of vapour pressure. Hot solutions passing through the resultant breccia probably caused alteration of the matrix and some of the clasts to chlorite and epidote. Polylithologic breccias, on the other hand, were probably deposited externally allowing fragments of other rock types to be included. Here the water-rich transporting medium would have been too cold to cause any appreciable metasomatism of the matrix or clasts. Parsons (1967) has described similar breccias in the Absaroka volcanic field, and has attributed their origin in part to underground brecciation of previously consolidated material by phreatic eruption.

In addition to the felsic volcanic rocks of unit 4, minor amounts of mafic flow material and tuffaceous sedimentary rocks are present within the felsic sequence. These rocks, now altered to chlorite in most cases, were probably andesitic in composition.

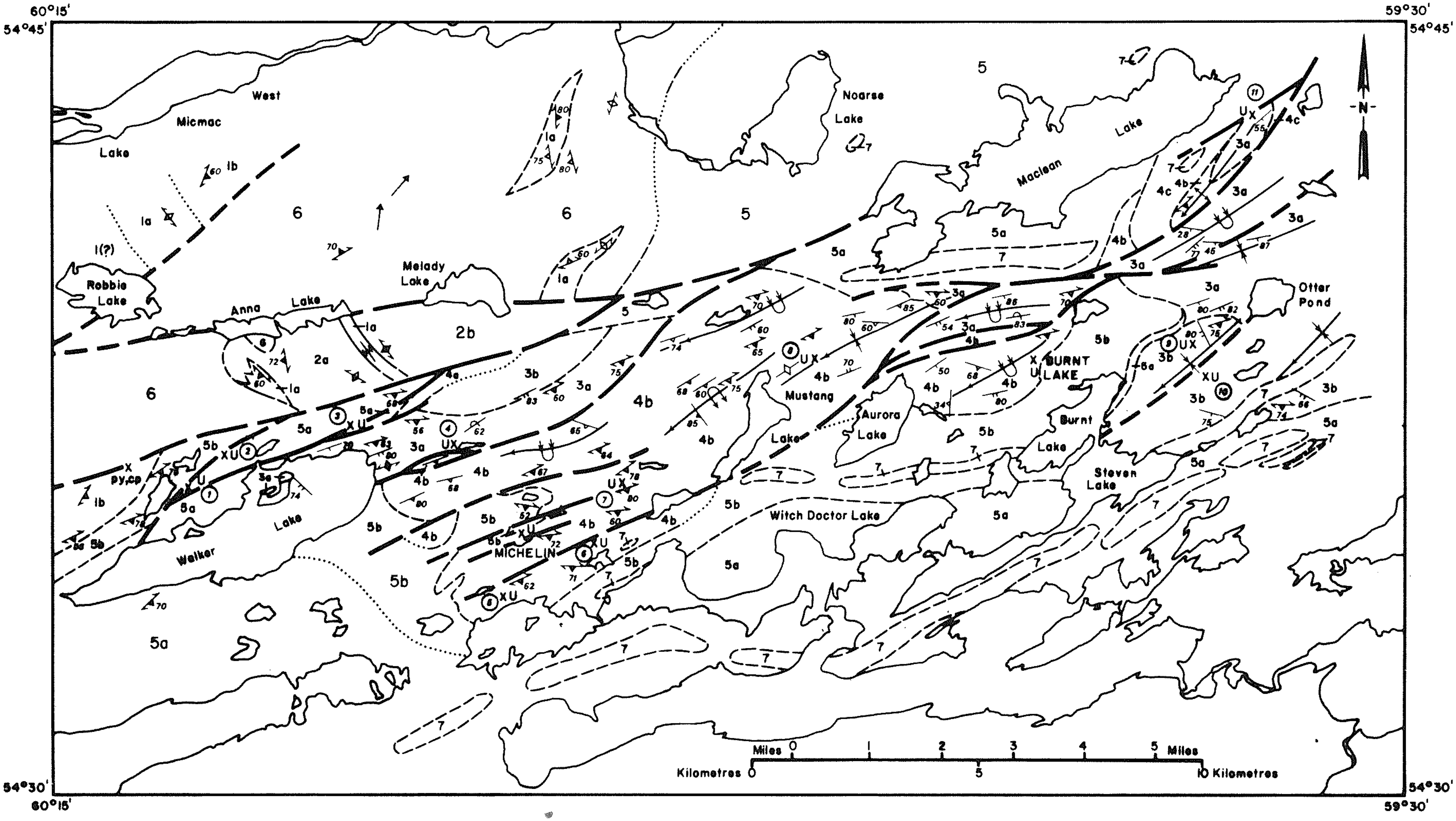
INTRUSIVE ROCKS

Intruding the Aillik Group and older rocks are several types of felsic intrusions which were later intruded by gabbroic dikes and plugs.

The Walker Lake granite (an informal name used by Brinex geologists) (Smyth, 1977), almost completely encloses the rocks of the Aillik Group in the map area. Two major phases of this intrusion were recognized at the scale of mapping. The most extensive type is granodioritic in composition (5a) often with older dioritic phases. The rock is coarse grained, generally gray to pinkish in color, and usually massive, although later shearing has imparted a local foliation. Similar granodiorite and granite extend for a considerable distance southwards and southwestwards. For example, granodiorite and granite of the Nipishish Lake area, about 100 km to the southwest, is very much like that at Walker Lake (Ryan, this volume); however, relative ages between these two areas are not known.

Unit 5a commonly contains bluish quartz (similar in color to some quartz phenocrysts in the rhyolites of 4b) and variable amounts of plagioclase and potassium feldspar. Hornblende is the main mafic mineral phase, although some areas have abundant biotite as well as hornblende. To the north of Walker Lake, a small plug of rhyolite has been intruded by granodiorite of 5a.

Unit 5b, in contrast to unit 5a, is generally much finer grained and contains very little mafic component. Forming a northern fringe to 5a, 5b intrudes the rhyolites of 4b at Aurora Lake, Burnt Lake and Michelin. At Burnt Lake, there is very little compositional and textural difference between the rocks of 5b and the rhyolites which they intrude. Generally, the composition of 5b is that of quartz monzonite locally grading into monzonite. The age relationship of 5b to 5a is unclear. Some dikes of leucocratic granite cut the granodiorite of



60°15'
54°45'
59°30'
54°45'
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N
West Micmac Lake
Robbie Lake
Anna Lake
Melady Lake
Noarse Lake
Maclean Lake
Otter Pond
Mustang Lake
Aurora Lake
BURNT LAKE
Burnt Lake
Steven Lake
Witch Doctor Lake
Walker Lake
MICHELIN
py,cp
Miles 0 1 2 3 4 5 Miles
Kilometres 0 5 10 Kilometres

LEGEND

NEOHELIKIAN

7 *Massive to weakly foliated pyroxene gabbro, diorite and granodiorote.*

APHEBIAN-PALEOHELIKIAN(?)

6 *Coarse grained porphyritic and nonporphyritic hornblende granite and pink megacrystic leucogranite, occasionally lineated.*

5 **5a,** *Medium coarse-grained, gray and pink, biotite granite and biotite-hornblende granite and granodiorite; minor diorite; lineated in places;* **5b,** *fine-medium grained, gray and pink leucogranite and quartz monzonite; minor monzonite.*

APHEBIAN

AILLIK GROUP

4 **4a,** *Massive feldspar porphyritic rhyolite (probably intrusive);* **4b,** *feldspar and quartz-feldspar porphyritic rhyolite ash-flow tuff, welded and non-welded; minor nonporphyritic rhyolite ash-flow tuff and tuffaceous sandstone and siltstone; minor basic flows and tuffs;* **4c,** *polylithologic and monolithologic rhyolitic breccia.*

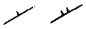
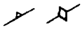
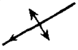
3 **3a,** *Maroon, gray and green, banded tuffaceous siltstone and sandstone;* **3b,** *pink and gray arkosic and quartzitic sandstone.*

ARCHEAN (?)

2 **2a,** *Coarse grained, well foliated granite and granodiorite; minor diorite;* **2b,** *fine to medium grained, well foliated granite.*

1 **1a,** *Amphibolite, minor migmatite and banded gneiss;* **1b,** *migmatite, banded gneiss.*

SYMBOLS

Geological contact (known, approximate, assumed)	
Fault or shear (known, approximate, assumed)	
Bedding attitude (tops known, tops unknown)	
Primary igneous layering: Flow banding, eutaxitic structure (inclined, vertical)	
Schistosity, cleavage, foliation (age unknown)	
Gneissic foliation	
Gneissic banding	
Mineral lineation and plunge direction	
Syncline (overturned)	
Anticline	
Anticline (overturned)	
Mineral occurrence	x
Uranium	U
Pyrite	py
Chalcopyrite	cp
Syncline	

5a, but whether these dikes are related to 5b or not is uncertain. In drill core from west of the Michelin uranium deposit, granodiorite similar to that of 5a grades into quartz monzonite of 5b, suggesting that the two rock types may be of similar age. Likewise, south of Aurora Lake, quartz monzonite grades southwards into a pink, coarse grained, slightly more mesocratic quartz monzonite that is similar in appearance to 5a.

A large poorly exposed area of granodiorite north of Maclean Lake is included here with the "Walker Lake Granite" of 5a on the basis of composition. However, contact relations are not seen and its relations to adjoining rocks are unknown. Unlike most of 5a, this undifferentiated granodiorite is generally very pink in color and, colorwise, more like rocks of unit 6 than the granodiorite of 5a.

Unit 6 is a pink, usually leucocratic, massive granite, which in places has megacrysts of feldspar up to 3 cm long. It is composed mainly of intergrown quartz and feldspar, with hornblende being present in some areas. Unit 6 intrudes unit 5 north of Walker Lake, but has been affected by shearing along tbe Walker Lake - Maclean Lake fault, and locally a mineral lineation is developed.

Unit 7 comprises pyroxenite, gabbro, biotite gabbro, diorite and minor granodiorite dikes and plugs that intrude the granitic terrain. The larger dikes are zoned with granodiorite margins passing into diorite, which in turn passes into coarse grained gabbro and pyroxenite cores. The close association of gabbros with the granites of unit 5 suggests either that they were part of the same magmatic system as the granites or that the same structures which controlled the sites of granite intrusion also controlled the sites of gabbroic intrusion. The linear arrangement of gabbro dikes along the southern margin of the Central Mineral Belt (Greene, 1970) strongly suggests that intrusion was structurally controlled.

Unit 7 is part of the suite of gabbroic rocks known as the Michael gabbro (Fahrig and Larochelle, 1972). Although the centres of the dikes are undeformed, in places the margins are strongly foliated. In most cases the gabbro has been metamorphosed to greenschist facies.

Numerous diabasic and basaltic dikes are distributed throughout the map area and are not shown on the map. These dikes are commonly foliated, and all strike northeast, parallel to the regional structural trends of the Aillik Group. The dikes have been metamorphosed to greenschist facies; in some cases, the presence of hornblende indicates that amphibolite facies was reached.

STRUCTURE

The dominant structural style in the map area is that of tight isoclinal folding and reverse faulting. Folds are best developed in anisotropic rocks such as those of unit 3, although detailed mapping has disclosed tight folding in some areas of rhyolitic rocks (Kontak, this volume). Axial planes of folds south of the Walker Lake - Maclean Lake fault strike to the northeast, and have an accompanying axial planar fabric. Synclines mapped at 1:50,000 scale are seen on a large scale to be actually part of a large synclinorium. Wavelengths of the larger folds are in the order of 1 km, while the smaller folds within these large structures have wavelengths of about 100 m. Axial planes of the large folds are vertical or dip steeply to the south, with some overturning of these folds towards the north.

Anticlines are almost invariably sheared along their axial zones, probably as a result of extreme tightening. Within the rhyolites, this shearing has caused the development of schistose textures, with recrystallization of quartz and feldspar, and the formation of biotite. These metarhyolites correspond to the "banded rhyolites" of Watson-White (1976) and the "Long Island Gneiss" of Gandhi (1976) which occurs adjacent to the Michelin uranium deposit.

Major faults in the map area are sinuous, with smaller faults branching off bends in the major faults. All are compressional features with shear planes dipping steeply to the south. Although fault zones are characterized by well developed S-fabrics, an L-fabric is developed in faulted granite, such as on subsidiary faults associated with the Walker Lake - Maclean Lake fault. Here, mineral lineation is normal to the strike of shear planes and plunges steeply, indicating vertical movement along these shear planes. In some cases, vertical slickensides are also present. Such faults must be reverse faults, downthrown on their northern sides. Mylonite zones up to 20 m wide are commonly developed with the major faults.

Throughout the Proterozoic rocks of the map area, there is one dominant cleavage (S_1). However, S_1 is locally folded and a crenulation cleavage is developed in mafic dikes near Burnt Lake (Kontak, this volume). Thus, a D_2 event is recognizable in places, although there is no widespread record of a second deformation such as to the northeast in the Kaipokok Bay area (Sutton *et al.*, 1972).

Within the Archean terrain, amphibolite and banded gneiss exhibit, in some places, nonsystematic polyphase deformation, but for the most part, a single strong foliation in these rocks strikes to the north or northwest.

MINERALIZATION

The map area is economically important, as is the whole of the Aillik Group, in that it contains anomalous amounts of uranium, and at least one possibly economic ore deposit (Michelin).

Within the area, uranium occurs associated with three rock types: **1)** granitic rocks of unit 5; **2)** sedimentary rocks of unit 3; and **3)** rhyolitic ash-flow tuffs of unit 4b. Most of the uranium occurrencs show a strong relationship between mineralization and shearing. The occurrences north and northeast of Walker Lake are all arranged along well defined shear zones (Smyth, 1977). This leads to the conclusion that remobilization of uranium along faults has occurred, either during or after shearing, giving rise to narrow zones of uranium concentrations. This is exemplified by the uranium showings of Brinex's Walker Lake East prospect (3 on accompanying map) (Krajewski, 1975) where a shear in granite is mineralized in places over a strike length of 200 m. Other deposits in the Walker Lake area are also localized along shears in granite (*e.g.* at Active Pond (1) and Elbow Pond (2)), suggesting that the granite was the initial source of the uranium in this area.

Uranium showings in sedimentary rocks are located two miles east of Walker Lake (Ribs Lake showing (4)) and between Burnt Lake and Otter Pond in the eastern part of the map sheet (M. Ben showings (9 and 10)). The deposit at Ribs Lake was not examined by the writer owing to sparse outcrop in the area. At the M. Ben showings uranium occurs in reddish rhyolitic tuffaceous sandstone which has a well developed schistosity, unlike the sandstone away from the deposits. This also suggests an association of uranium with shearing.

One kilometre east of the northeastern end of Maclean Lake, a zone of anomalous radioactivity occurs in sheared and altered sedimentary rocks of unit 3a.

Within the volcanic rocks of unit 4b, there are a number of significant uranium occurrences. There is a concentration of uranium occurrences in the area of the Michelin deposit. Most of these occurrences are within schistose rhyolitic rocks which can be traced northwards into less deformed rhyolitic ash-flow tuffs. The strong schistosity and recrystallization of the rhyolites in the Michelin area indicate the presence of shear zones. One kilometre east of the Michelin deposit a narrow zone of mylonitization can be traced across strike into less deformed cataclastic rocks, while at the Michelin portal itself, strongly foliated metarhyolites become less deformed away from the deposit, again indicating that the uranium mineralization is associated with zones of "tectonic schist". Similar observations were made at the Chitra (6) and Rainbow (5) uranium occurrences.

The Michelin deposit occurs in rhyolitic ash-flow tuffs which have a complex stratigraphy. These tuffs are variably porphyritic, ranging from feldspar porphyritic rhyolite with large subhedral phenocrysts, to nonporphyritic and slightly porphyritic rhyolitic ash-flow tuffs. Coarse porphyritic ash-flow tuffs are commonly welded; the lack of eutaxitic structures in nonporphyritic rhyolitic rocks suggests that they are nonwelded.

The uranium mineralization occurs in a sequence of coarse porphyritic and slightly porphyritic tuffs with individual tuff horizons ranging up to three metres thick. Adjacent to the mineralized zone, porphyritic tuff with large feldspar phenocrysts occurs. The rocks of the Michelin deposit have been metasomatized to varying degrees. A preliminary study by this writer of drill core and surface exposures suggests that two rather diffuse zones of hydrothermal alteration are present. Away from the ore zone, the assemblage chlorite - epidote - pyrite is present. Approaching the ore zones, calcite becomes common and epidote less common or absent.

Wall rock alteration occurs along discrete fractures that form veinlets generally parallel or subparallel to the foliation, although crosscutting relations are noted. Density of veinlets is generally low. Chlorite along closely spaced foliation planes is probably not related to wall rock alteration by hydrothermal activity, but rather to Grenville deformation and metamorphism.

West of the Michelin deposit, in diamond drill core that intersects granitic rocks, granodiorite of unit 5a has been considerably altered in places to chlorite, epidote and pyrite. If the uranium mineralization is related to wall rock metasomatism, then intrusion of granitic rocks predated, or was synchronous with, the formation of the ore deposit. It is possible that granitic intrusion initiated hydrothermal activity which mobilized the uranium contained in anomalous amounts within both granitic and rhyolitic rocks.

The close association of uranium deposits in the Michelin area with shearing suggests that deformation may have had some later concentrating effects. On the other hand, there is no concrete evidence that shearing controlled the formation of the ore deposits, and may have only caused the "resetting" of the radiometric ages of the deposits.

At Burnt Lake, about 20 km east of Michelin, Kontak (this volume) considers that uranium mineralization may be related to devitrification of volcanic glass, and that the uranium may have moved into structurally favorable horizons by fumarolic solutions associated with the last volcanic stages. Strong shearing has not been recognized at Burnt Lake, although a pyritic shear zone is present just south of the main showing.

The presence of both disseminated and banded uraninite at Michelin (Piloski, 1976) indicates that uranium was probably introduced into the rock before compaction of the rhyolitic ash, and so the hydrothermal solutions which introduced the uranium into the rock may have been synchronous with volcanism. It follows that as the granodiorite near the deposit is also hydrothermally altered, then this rock may also have been intruded at about the same time as the volcanic rocks were being deposited. This raises the possibility that the Walker Lake granite (units 5a and 5b) may have been formed at the same time as the volcanic rocks and may, in part, be comagmatic with the rhyolitic rocks.

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