DESCRIPTIVE NOTES

Bedrock mapping at 1:50 000 scale in the Archean Kaminak greenstone belt, eastern District of Keewatin, was undertaken by the GSC in 1996. The area (parts of 55 F/12 and 13, 55 E/9 and 16) was previously mapped at 1 : 250 000 by Davidson (1970), and adjoins the south edge of an area mapped at 1:50 000 by Park and Ralser (1992). Additional observations made in 55 K/4, 55 K/5, and 55 K/6, which lie within the area mapped by Park and Ralser, were useful in constraining the stratigraphic and deformational interpretations depicted in this map (Peterson, 1997).

No U-Pb ages are yet available in the map area, but the ages of most rocks and deformation events are likely to be similar to those in other parts of the belt (Cavell et al., 1992, and references therein). Mafic to felsic volcanic rocks probably erupted in the period 2.70-2.68 Ga, with deformation events constrained by intrusion of post-tectonic granitic plutons near 2.65 Ga, and by the age of the substantially younger Snow Island intrusive suite (Peterson and Lee, 1995), dated throughout the western Churchill Province at about 2.60 Ga (LeCheminant and Roddick, 1991). Additional U-Pb dating of volcanic and intrusive rocks is in progress.

KAMINAK GROUP: LITHOLOGIES AND STRATIGRAPHY

Davidson (1970) referred to the Archean supracrustal rocks of the Kaminak Lake area as the Kaminak Group. This term was not used by Park and Ralser (1992), since they interpreted one of their map units (the Tagiuluk Formation) as allochthonous, requiring a separate group name. However, in this study a basal sedimentary unit conformably overlain by volcanic rocks (unit Āκs1) was tentatively correlated with the Tagiuluk Formation; hence, the term Kaminak Group is re-introduced here.

The Archean supracrustal rocks consist of two sequences of tuff, volcanic epiclastic rock and quartzofeldspathic arenite, and iron formation (units **Āκs1** and **Āκs2**), separated by a thick sequence of mainly pillowed basalt and basaltic andesite (units **Āκb** and **Āκba**), plagioclase-rich andesite (unit **Āκa**), and minor basalt + rhyolite (unit **Āκbr**). Clastic sedimentary rocks are rare within the volcanic sequences. The terms "basalt", "basaltic andesite", and "andesite" were used in the field to designate distinctive, mappable volcanic lithologies. These terms may be revised when geochemical data become available.

The oldest rocks identified in the map area consist predominantly of mafic volcanogenic arenite with lean sulphide-facies iron formation, and minor greywacke and arkose (unit **Āκs1**). Silty, pale apple-green beds with no current indicators, but excellent size grading, were observed in the central part of the map area. The sediments are interbedded with and overlain by basalt flows, and intruded by numerous mafic sills and dykes. Very similar lithologies, though in different proportions, are present in the Tagiuluk Formation of Park and Ralser (1992) (see Peterson, 1997 for a detailed description).

The top of unit **Āκs1** is defined where volcanogenic arenite is no longer present. Basalt (unit **Āκb**) occurs as massive, featureless flows, or as highly irregular pillows (< 50 cm), with thick chilled margins and abundant interpillow volcaniclastic sediment. Outcrops are invariably dark-weathering in shades of black or green, grey, and red-brown. Vesicles are uncommon but where present are the only dependable way to determine younging direction. Pillow cores are commonly metamorphosed to black-weathering amphibolite, with grain size of about 1 mm. Thin beds of chert and oxide-facies iron formation are dispersed throughout this unit.

The pillowed basaltic flows grade upwards into green-black to dark green, flinty pillows with pronounced smooth, elliptical morphology, thin chilled zones, and negligible selvage material (unit **Āκba**). These usually yield clear younging directions from pillow morphology alone. Pillows are invariably larger than in the underlying **Āκb** unit. A "megapillow" facies with rounded pillows up to 5 m wide, or tabular flows 1 m thick, occurs near the base of the unit. Iron formation and chert were rarely observed in this unit; however, interpillow carbonate is very abundant. Vesicular, "clinkery" flows with numerous small pillow buds and a high content of carbonate form impersistent but mappable units which aided in delineating folds in some areas.

With increasing lightening of color and the appearance of plagioclase phenocrysts, the basaltic andesite (unit **Āκba**) grades into medium to pale green-weathering, highly rounded pillowed flows, termed "andesite". Chert and iron formation are not present in this unit. A plagioclase-porphyritic variant of the andesite (unit **Āκa**) occurs within the basaltic andesite flows. This rock type is widely distributed in the eastern Kaminak belt, forming discontinuous but mappable horizons within the **Āκba** unit. Euhedral plagioclase crystals up to 7 cm, and anhedral ones up to 20 cm, occur in sills 2-5 m thick that intrude pillowed flows with somewhat smaller (~ 5 cm) crystals.

A mixed mafic/felsic volcanic unit occurs at the northern limit of the map area. It consists of rare pillowed mafic flows strongly resembling those of the **Āκba** unit, orange-white weathering rhyolite autobreccia and flows, and tuffs. The tuffs are mm to cm-scale banded mafic/felsic rocks containing locally thick (1 m) beds of white to pale grey or orange weathering rhyolite ash. This unit is intruded and migmatized by megacrystic granite, granodiorite, and diorite assigned to the Snow Island suite. East of the migmatite zone, the mixed volcanic rocks are overlain by the **Āκa** pillowed flow unit which clearly youngs to the south. West of the migmatite, the unit is bounded to the south by a fault and additional Snow Island intrusive bodies in an area poor in outcrop. The **Āκbr** unit appears to be stratigraphically equivalent to the lowermost **Āκba** (below unit **Āκa**).

The youngest stratigraphic unit is dominantly volcaniclastic or epiclastic and is rich in iron formation. It is exposed only at its eastern edge, and probably corresponds to a magnetic anomaly delineated by the 3500 gamma contour on GSC aeromagnetic map 3473G (1965). The anomaly parallels the mapped eastern margin of the unit. The outcrops of unit **Āκs2** closest to the contact with **Āκba** are of strongly reduced shale and cherty, sulphide-rich iron formation, exposed for about 2 m across strike. They comprise porous, granular quartz layers, as well as pyrite, massive iron oxides, chloritoid, and massive and disseminated graphite. Chloritoid and graphite-rich layers have a folded schistosity. Marcasite rosettes occur with euhedral quartz in open vugs, and iron-rich silty layers display intense spheroidal weathering of unknown age (possibly Proterozoic).

Immediately overlying the iron formation are lithic and feldspar arenite and siltstones. The arenite is medium-grey weathering and very rich in plagioclase, with little or no quartz. The sequence dips steeply southeastward but fines towards the northwest, younging away from the reduced iron formation and the **Āκba** volcanic unit. In the interior of the unit, feldspathic clastic rocks are interbedded with chert and magnetite-facies iron formation beds, usually about 1 m thick, and minor pillowed flows. The clastic rocks may be tuff or arenite, and consist mainly of sandy beds containing about 50% plagioclase, plus a mafic or lithic component. Thin (~ 1 cm) ferruginous bands, represented by layers of massive chloritoid, dark green amphibole, and locally almandine garnet, are common within the clastic rocks and the cherts.

DEFORMATION, INTRUSION, AND METAMORPHISM

Two major phases of deformation were recognized. A spaced to penetrative cleavage (S_2), developed at greenschist facies, is commonly observed in rocks previously ductilely deformed at greenschist to amphibolite facies (S_1). Locally, S_2 was folded and sheared at sub-greenschist facies conditions (S_3). No Proterozoic rocks were identified in the map area and hence, no post-Archean deformation could be demonstrated. However, an impersistent, low-grade, anastamosing cleavage in the **Āκba** and **Āκa** units was observed in the northeast corner; this closely resembles the cleavage observed in Archean volcanic rocks affected by Proterozoic shear zones adjacent to Hurwitz Group basins farther north. Disruption of the graphitic schistosity observed in unit **Āκs2**, and secondary mineralization (quartz-marcasite), may also be Proterozoic in age.

Two styles of deformation were associated with S_1: (1) strong flattening at greenschist to amphibolite facies, with production of small-scale intrafolial folds, and (2) moderate to strong flattening at amphibolite grade, locally with development of injection migmatite with production of chaotic, ductile folds. The first style was readily observed in the sediment-dominated units, where S_o is tightly folded into cm- to m-scale, intrafolial folds, and a true mineral foliation is developed. South of the Tavani shear zone, mafic volcanic rocks are extensively intruded by small bodies of Wallace River Diorite and commonly display a migmatitic layering formed by injected leucosomes, recrystallized amphibolite, and transposed folds.

Numerous reversals of facing direction over short distances, particularly near the south end of the Tavani shear zone, are consistent with tight F_1 or F_2 folds. Most younging directions obtained in the northwest-trending belt of **Āκb** and **Āκs1** units in the central part of the map area are apparently inconsistent with the interpreted stratigraphic succession (they indicate that unit **Āκs1** overlies unit **Āκb**), but numerous repetitions of basalt/sediment along the contact indicate that these units are also tightly folded there.

Metamorphic grade was most easily discerned in carbonate-rich mafic volcanic flows, and in Fe, Al-rich sediments associated with iron formation. Chloritoid-amphibole-almandine is a common assemblage in tuff or arenite associated with iron formation, particularly in unit **Āκs2**. Amphibolite grade mineral assemblages in calcsilicate pods contain grossular, diopside, and tremolite (mainly in unit **Āκba**). It is considered that the graphite in folded layers at the base of the **Āκs2** unit may have been precipitated from CO_2 released from underlying carbonate-rich volcanic units during S_1 metamorphism.

The younger deformation event affecting S_1 structures is very evident in the central part of the map area, where the Tavani shear zone cut across flattened, migmatized volcanic rocks and juxtaposed them against volcanic flows and sills containing a very strong, penetrative cleavage developed at chlorite grade. Thin dykes of a syn-S_2 tonalite-granite suite appear in profusion on both sides of the shear zone, and were variably deformed within it. This is the SW extension of a shear zone that affected syn-S_2 granites of the Tavani igneous complex to the NE (Park and Ralser, 1992). Outside the shear zone, the S_2 cleavage is of variable intensity. It was commonly observed as a weak schistosity developed thin pillow margins, and as a set of spaced, conjugate fractures in the pillow centres. A moderately NE-plunging stretching lineation was observed locally in the shear zone, but mineral lineations are otherwise weakly developed in the map area.

Several map-scale folds were identified north of the Tavani shear zone, having axial plane traces parallel to S_2. These were delineated mainly by reversals in facing direction, and by repetitions of unit **Āκa** and of carbonate-rich layers in the **Āκba** unit. Fold hinges were directly observed for the closely spaced anticline/syncline pair immediately east of unit **Āκs2**. The folds are upright and shallowly plunging. The relatively open style of folding, and its association with a low-grade cleavage, are consistent with these being F_2 folds.

The S_2 cleavage was observed to be locally intersected by a spaced cleavage axial planar to broad, low-amplitude folds with shallowly-plunging axes (generally eastward). Rarely, this third cleavage (S_3) intensifies in narrow zones with minor dextral shear of S_2 observed. The S_3 cleavage developed at very low metamorphic grade and was probably associated with limited strain, as it rarely becomes penetrative on an outcrop scale. It was observed on both sides of the Tavani shear zone, but was most intense along the exposed eastern edge of unit **Āκs2**. East-pointing protrusions of the 3500 gamma magnetic anomaly are suggestive of southeast-plunging F_3 folds in the **Āκs2** unit. This interpretation was supported by the observation of a high concentration of S_3 features near the interpreted traces of their axial planes. An offset in the axial traces of the anticline/syncline pair of S_2 folds east of the **Āκs2** unit occurs in an area laced with folded quartz veins. This is interpreted as part of a S_3 shear zone, and is linked on the map with a gap in the 3500 gamma anomaly to the northwest.

A NNW-trending fault in the north part of the map area cuts across one limb of a large-scale fold of S_o and S_1 in the **Āκs1** and **Āκb** map units. Development of this fault began with emplacement of a large volume of vein quartz, in sheets now strongly flattened parallel to the fault plane, which dips 50° to the northeast. The S_2 fabric is folded near this fault. No syndeformational igneous activity could be discerned. This large fault is in turn intersected to the north by a fault which demarcates the edge of the **Āsg** migmatite aureole. The fault zone is intruded by dykes of pale pink leucogranite showing minor brittle offsets. Both of these faults are tentatively interpreted as a late Archean structure, synmagmatic with respect to the **Āsg** plutons.

In the central part of the map area, unit **Āκs1** was intruded by a small stock of homogeneous, grey-weathering, equigranular diorite with sharp, chilled contacts. The diorite postdates major folding events in **Āκs1**. Further north, the diorite is heterogeneously mixed with a K-feldspar megacrystic granite to monzonite, and adjacent outcrops of the **Āκs1** unit are extensively migmatized (including both injection migmatite and diatexite) and laced with granite dykes. This is the south edge of a small pluton of heterogeneous megacrystic granite (unit **Āsg**) which is surrounded by a migmatite aureole. Identical migmatite and granite in the southwest corner of the map area clearly postdate syn-S_2 tonalite dykes, which were strongly deformed in the migmatite aureole there. A relict foliation, acquired from partially digested xenoliths, is widespread within the megacrystic granite, but dykes and veins of granite beyond the migmatite aureole were not deformed. Hence the diorite-granite suite is considered post-tectonic, and from its petrographic characteristics is tentatively correlated with the Snow Island suite (ca. 2.60 Ga), which is very commonly megacrystic.

Diabase dykes of the Kaminak swarm (2.45 Ga: Heaman, 1994) are present in profusion north of the map area. Davidson (1970) reported finding short segments of four Kaminak dykes in the map area; these were not identified in 1996.

MINERAL SHOWINGS

Significant mineral showings in the map area are restricted to exhalative sulfides (only pyrite recognized) in dismembered iron formation, hosted almost entirely by the sediment-dominated units **Āκs1** and **Āκs2**. The northernmost exposure of **Āκs1** is much poorer in sulfides than the southernmost one. Detrital magnetite in graded, sandy beds within **Āκs1** may indicate that oxide-facies iron formation was locally present, but no in situ beds of this were observed. However, oxide-facies iron formation beds are prominent within the Tagiuluk Formation to the northwest (Peterson, 1997), which is tentatively correlated with unit **Āκs1**.

Immediately north of the map area, Proterozoic quartz-carbonate-sericite veins commonly occur as *en echelon* tension gashes and as fractures axial planar to folds. Some of these have been shown to contain significant gold, as at Fat Lake, in sheet 55 K/4. Undeformed, rusty quartz veins were infrequently observed in the map area, which is consistent with the absence of unambiguous Proterozoic rock fabrics and lamprophyre dykes in the area.

INTERPRETED SEQUENCE OF EVENTS

1. Deposition of conglomerate, sandstone, siltstone, iron formation, rhyolite ash, and thinly bedded (biogenic?) carbonate on an unrecognized basement. The clastic rocks had mixed mafic volcanic and quartzofeldspathic sources, and there is evidence for unroofed mafic and felsic plutons, indicating the basement may have been an older volcanic/plutonic complex. Shallow water to subaerial deposition is indicated; no true turbidites are present.

2. Eruption of a submarine basalt pillow lava sequence (unit **Āκb**).

3. Gradual progression to more silicic and phenocryst-bearing (basaltic andesite and andesite) lavas, with changes in pillow morphology corresponding to increasing magma viscosity (units **Āκba**, **Āκa**).

4. Deposition of a second sedimentary unit, dominated by plagioclase-rich tuff or greywacke (unit **Āκs2**) and iron formation.

5. Emplacement of small diorite plutons (Wallace River Diorite) during a deformation event (S_1). Near the diorite, volcanic rocks were locally migmatized, and amphibolite-facies mineral assemblages developed sporadically. Regional metamorphism during S_1 was at greenschist facies.

6. Widespread intrusion of tonalite to granite dykes within all volcanic units during a second phase of deformation (S_2). A spaced to penetrative cleavage developed at greenschist facies.

7. A minor folding event (S_3), during a phase of low grade regional metamorphism, may have preceded or accompanied intrusion of diorite and megacrystic granite. Granite-dominated, post-tectonic plutons are surrounded by a migmatite aureole and contain many partly digested xenoliths of the supracrustal rocks.