DYKE DISTRIBUTION

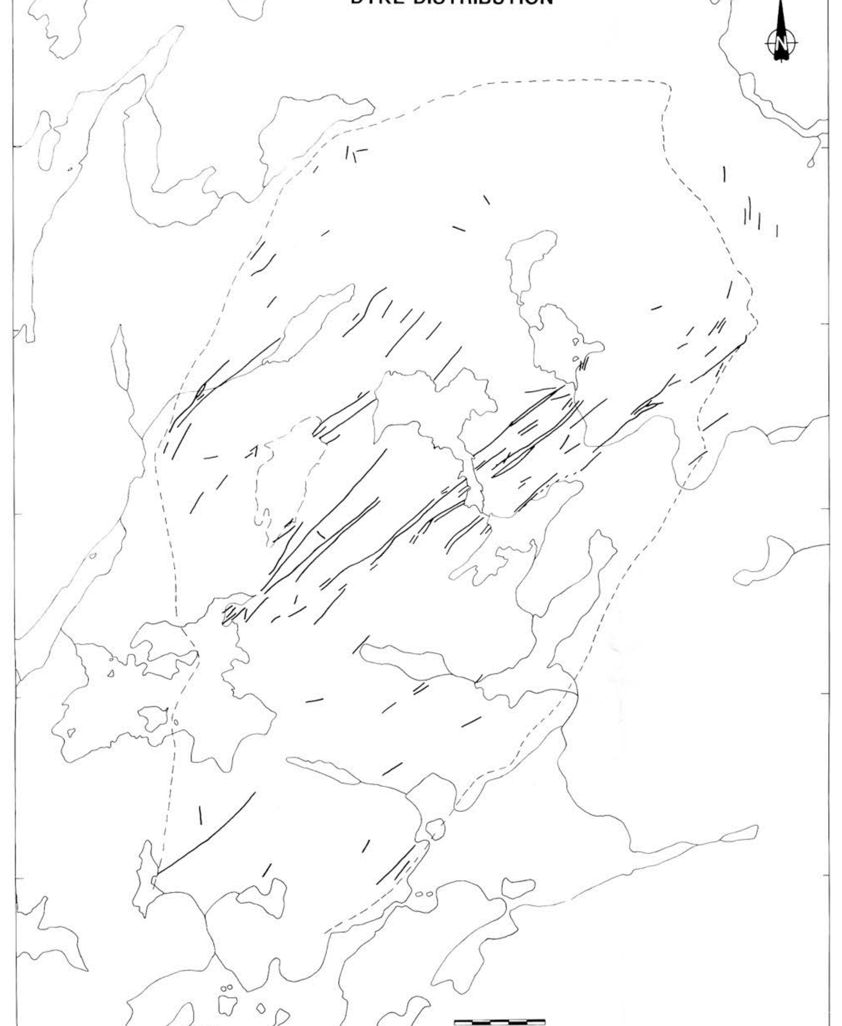

FIGURE A

FOLIATION TRAJECTORIES

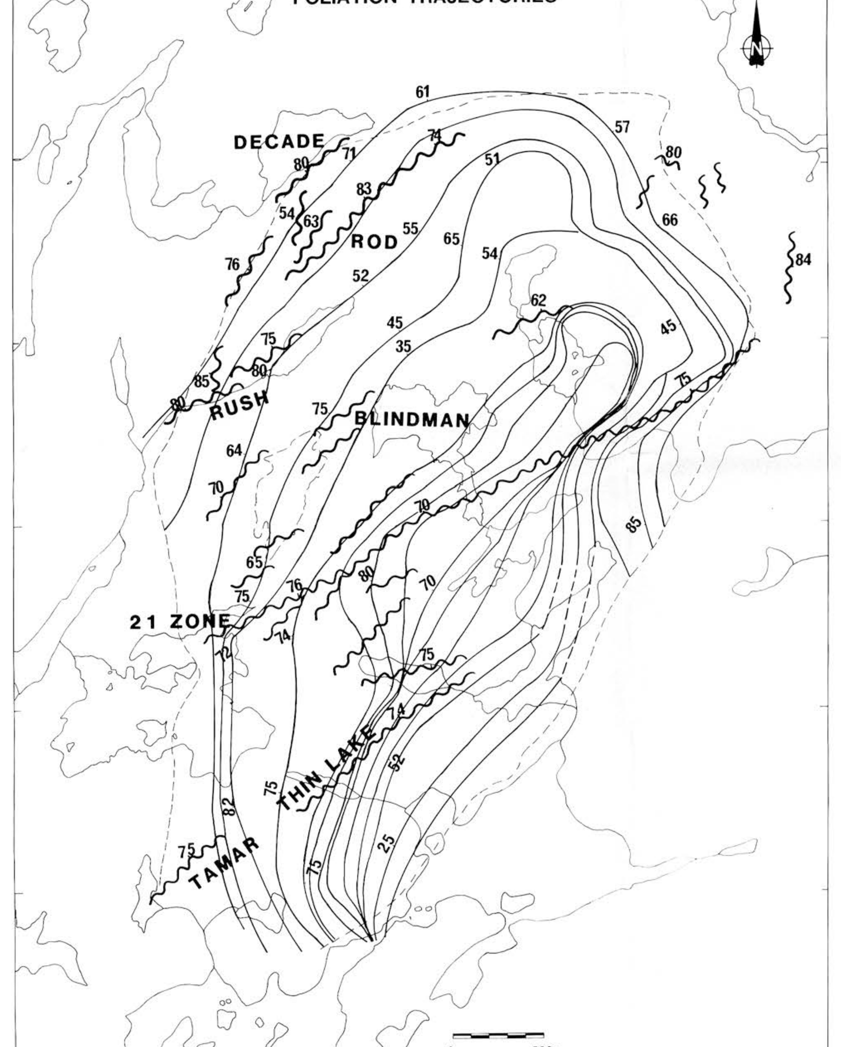

FIGURE B

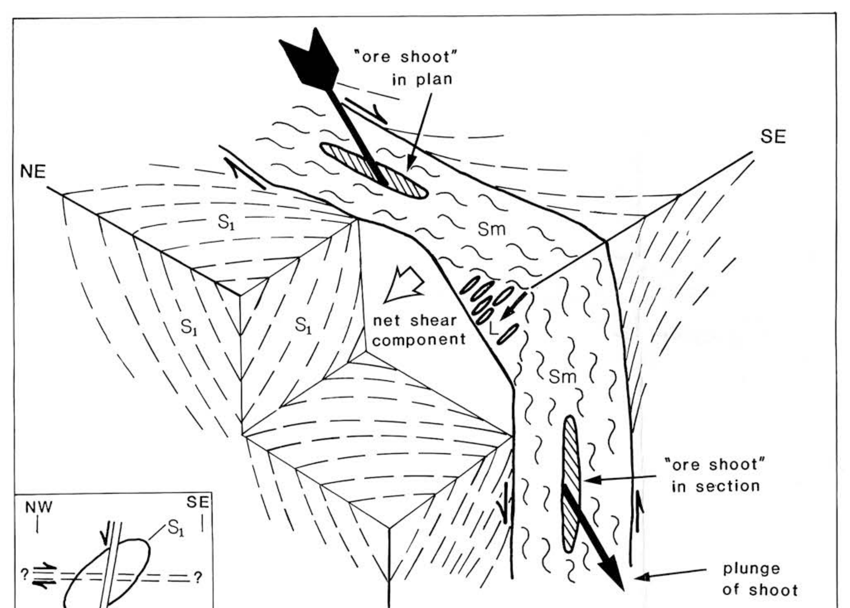

FIGURE C

DESCRIPTIVE NOTES

Introduction

The Star Lake syn – to late-tectonic pluton, located 150 km northeast of LaRonge Saskatchewan, intrudes metavolcanic and metasedimentary rocks of the Aphebian LaRonge granite-greenstone domain (Thomas, 1984). Gold was discovered in the intrusion in 1944 (Coombe, 1984) and subsequent exploration resulted in the discovery of the 21 Zone deposit in 1983. This small deposit, having drill indicated reserves of 230,000 tons grading 0.5 oz Au per ton (Murphy, 1986), is scheduled for production at the rate of 220 tons per day (Northern Miner, Aug. 1, 1985, p. 1). The Geological Survey of Canada initiated a study of gold mineralization in the Star Lake pluton in 1984 under the Canada-Saskatchewan Mineral Development Agreement.

General Geology

The Star Lake pluton is crudely elliptical in plan, approximately 6 km by 3 km, with its long axis oriented north-northeast. The intrusion is zoned, consisting of a dioritic margin, an interior annular zone of quartz monzonite and a core of porphyritic granite. The internal contacts between the various plutonic phases range from sharp to gradational. The plutonic rocks locally display faint igneous layering and commonly contain abundant subrounded cognate xenoliths as well as angular to subrounded xenoliths of metamorphosed volcanic and sedimentary country rocks. A small, probably related intrusion, composed of gabbro, lies to the north of the pluton.

The pluton is cut by a swarm of dykes which typically strike N50°E (Figure A). Individual dykes vary in width from a few centimetres to a few metres and most commonly have sharp planar walls. Locally, amoeboid intrusive masses coalesce into a single dyke with straight walls suggesting that, in some cases, the dykes were injected into a plutonic host which was only partially crystallized. Dykes have the same range of compositions as their coarser plutonic hosts and vary from diabase, through diorite and quartz monzonite to aplitic granite. Cross-cutting relationships suggest that this compositional order is also the order of emplacement. Of particular note are the tourmaline-bearing aplites which occur in the vicinity of the Rod Zone.

Structural Geology

Metamorphic Foliation

The rocks of the Star Lake pluton have been metamorphosed and variably deformed. Biotite is a ubiquitous phase within the intrusion and, along with epidote, it replaces primary hornblende. Most of the rocks within the pluton have a weak to moderate metamorphic foliation (S_1) which is defined by the planar alignment of grains and aggregates of biotite and locally tabular grains of feldspar. Deformed xenoliths have long axes which typically lie within this foliation and their aspect ratios are nearly equal in all directions within the foliation. The orientation of S_1 varies from place to place (Figure B) but on average strikes N15°E, subparallel to the long axis of the intrusion, and dips 60° west-northwest. The attitude of foliation mimics the attitude of the pluton margins and, even though there is no other direct evidence of the 3-dimensional shape of the pluton, this observed foliation-contact relationship suggests the possibility of a moderate west-northwesterly plunge for the intrusion as a whole.

Mylonitic Shear Zones

An intense protomylonitic to locally mylonitic foliation (Sibson, 1977) is superimposed on the weaker metamorphic foliation within narrow shear zones (Figure B). The protomylonitic rocks have a strong undulose foliation (S_m) defined by ribbons of quartz, by flat elongate aggregates of mafic minerals, and by tabular to rod-shaped feldspar porphyroclasts (Poulsen, 1986; Poulsen et al., 1986). The original igneous constitutents, quartz, microcline and plagioclase have been substantially reduced in grain size. The shear zones are up to 30 metres wide and typically strike N60°E and dip steeply northwestward. In the northern part of the intrusion, the shear zones and their internal mylonitic foliation are sub-parallel to the external metamorphic foliation but in the southern and central part a high angle exists between S_1 and S_m (Figure B).

The location of the shear zones was established primarily on the basis of the presence of a mylonitic foliation in the coarse plutonic rocks. The shear zones also cut, and in some cases are localized by, dykes. This results in some dykes being intensely foliated whereas adjacent ones are not.

The shear zones within the Star Lake pluton are typically 400-500 metres apart and form an array of sub-parallel structures (Figure B); some extend beyond the pluton margins where their orientation and spacing is much more irregular. At least seven shear zones, although commonly composed of more than one branch, have significant strike length. From north to south, these are:

i) the Decade shear which occupies the northwest margin of the pluton and hosts the Decade deposit, a past-producer.
ii) the Rod shear, which has a strike length of at least 1.4 km, cuts diorite, quartz monzonite and granite and hosts several gold bearing zones.
iii) the Rush Lake shear, which extends for at least 2 km through diorite and quartz monzonite, contains some gold mineralization.
iv) the Blindman shear, which has not yet been shown to contain significant gold concentrations.
v) the B shear, which strikes NE and contains very little protomylonitic material, has substantial quartz veins without significant gold.
vi) the Star Lake shear, transects the entire pluton and is most prominent in that significant deflections of S_1 and of the pluton contact are coincident with it; this shear hosts the 21 Zone gold deposit.
vii) the Thin Lake-Tamar shear, which extends at least 0.7 km at the eastern end of Thin Lake; its position and orientation suggest that it is likely an extension of the shear zone hosting the Tamar gold occurrence to the southwest; this shear is coincident with significant deflections of S_1 (Figure B) and with several adjacent occurrences of hematite-filled brittle fractures (see below) suggesting that it may have a strike extent of as much as 3.7 km.

In addition, several shorter segments of shear zones are shown on the map, notably at the western end of Thin Lake; at the southwest end of Nameless Lake and along the northwest shore of Fork Lake. These may be parts of more extensive structures but they have not been fully traced along strike.

All of the shear zones have recurring geometric features which suggest a common sense of displacement:

i) the mylonitic foliation S_m contains a prominent mineral lineation (L, Figure C) formed by extended, rod-shaped porphyroclasts; this lineation typically pitches 75-85° from the northeast in the foliation plane.
ii) the mylonitic foliation is oblique to the boundaries of the shear zones; its strike is more northerly and its dip is shallower than that of the shear zone boundaries (Figure C).
iii) in plan view, shear zones tend to deflect S_1 (Figure B) and create dextral offsets where they cut across dykes.
iv) a secondary foliation (not shown on the map) is visible locally on surfaces normal to S_m and parallel to the mineral lineation (Poulsen et al., 1986). This shear band or extensional crenulation cleavage is probably a reliable kinematic indicator (White et al., 1980).

All of the above observations show that the principal component of shear displacement is roughly down dip of the shear zones with the northwest side down. Transcurrent components are smaller and most commonly dextral, to yield an oblique "net" shear sense. This results essentially in a "normal fault" geometry which may be related to extension accompanying the flattening indicated by S_1 (Figure C). This implies that relatively deeper levels of the intrusion are exposed in successive shear bounded blocks from north to south; no magnitudes of displacement have been established.

Mineralization

Gold occurs in quartz veins and breccia zones within the ductile shear zones. Extensional quartz veins are present at a high angle to the dip of the shear zones. Diamond drill data show that these veins form ore shoots plunging moderately to shallowly to the southwest (Figure C). This plunge coincides roughly with the line of intersection of S_1 and S_m and likely also represents the intersection of individual branches within the shear zones.

Individual veins may be long and continuous with common ribbon structure, or short and lenticular quartz masses containing wallrock inclusions. Gold occurs with iron sulphides within the veins. At the 21 Zone deposit, which is in quartz monzonite, the principal sulphide is coarse pyrite and its abundance is directly proportional to that of gold. However, pyrrhotite with lesser pyrite are typical in the northern parts of the intrusion where shear zones cut dioritic rocks. Visible gold is rare, particularly at 21 Zone, and calcite, scheelite, tourmaline, molybdenite and chalcopyrite occur in variable amounts from vein to vein.

Ore specimens from the 21 Zone contain large pyrite crystals (1 to 2 cm) which poikilitically enclose small composite inclusions of calaverite ($AuTe_2$), tellurobismuthite (Bi_2Te_3), hessite (Ag_2Te), rare chalcopyrite and native gold (D.C. Harris, GSC Mineralogy Report M84-145). Aside from this common site within pyrite crystals, native gold also occurs locally in fractures in pyrite or rarely with tellurides in the gauge. Chalcopyrite, commonly intergrown with bornite, covellite and wittichenite (Cu_3BiS_3), occurs mainly in gangue minerals or in fractures in pyrite. Magnetite, marcasite and most of the pyrrhotite occur adjacent to pyrite in the gangue. Melonite ($NiTe_2$) was identified in a single euhedral crystal in pyrite.

Ore specimens from the Rod Zone contain, in addition to pyrrhotite, chalcopyrite and pyrite, traces of tsumoite (a bismuth telluride), cobaltite and sphalerite (GSC Mineralogy Report M85-156 D.C. Harris).

Alteration

A notable feature of the deposits in the Star Lake pluton is the lack of extensive hydrothermal alteration in wallrocks adjacent to veins. For example, the mylonitic and protomylonitic rocks within the 21 Zone shear are compositionally indistinguishable from the adjacent, less deformed quartz monzonites (Poulsen et al., 1986). The only recognized alteration is a pale green colouration of otherwise grey to pink mylonitic rocks as a result of the sericite formed by hydration of microcline. Mafic dykes within the shear zones have some visible effects of alteration, characterized by the development of calcite and actinolite patches and veins. Considerable biotite occurs adjacent to veins in shear zones in rocks of dioritic composition.

Late brittle fractures containing hematite and clay minerals are present in outcrops adjacent to mineralized segments of the Rod and 21 Zone shears. The iron sulphides at depth within both deposits are also locally hematized both at grain boundaries and in cross-cutting fractures. Thus, hematite in the more extensive wallrock fractures may have its source in the oxidized sulphide ores. The presence of hematitic fractures in wallrocks may be a guide to mineralized portions of shear zones.

Conclusions

The Star Lake pluton is a zoned intrusion, which was cut by a swarm of dykes, metamorphosed and penetratively deformed, and then further cut by mylonitic shear zones. The irregularity of some dykes, the relatively high-temperature metamorphic mineral assemblages containing epidote-biotite-calcite and the ductile nature of the shear zones suggest that intrusion, metamorphism, dyke emplacement and shear zone development may have occurred over a very short time interval or, alternatively, that a very hot environment was maintained for a longer period. Gold is not localized in any particular phase of the intrusion nor in any specific association with dykes but rather is controlled by the mylonitic shear zones. Late brittle fractures adjacent to shear zones may prove to be a useful guide to those parts of shear zones which contain significant sulphide mineralization. Future exploration may be directed to the mapping of shear zones, which are as yet poorly defined. The empirical observation that known gold mineralization is confined to the western margin of the Star Lake pluton (Murphy, pers. comm.) may be related to the fact that this margin may be the expression of the upper surface of the northwesterly plunging pluton.

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Saskatchewan Energy and Mines

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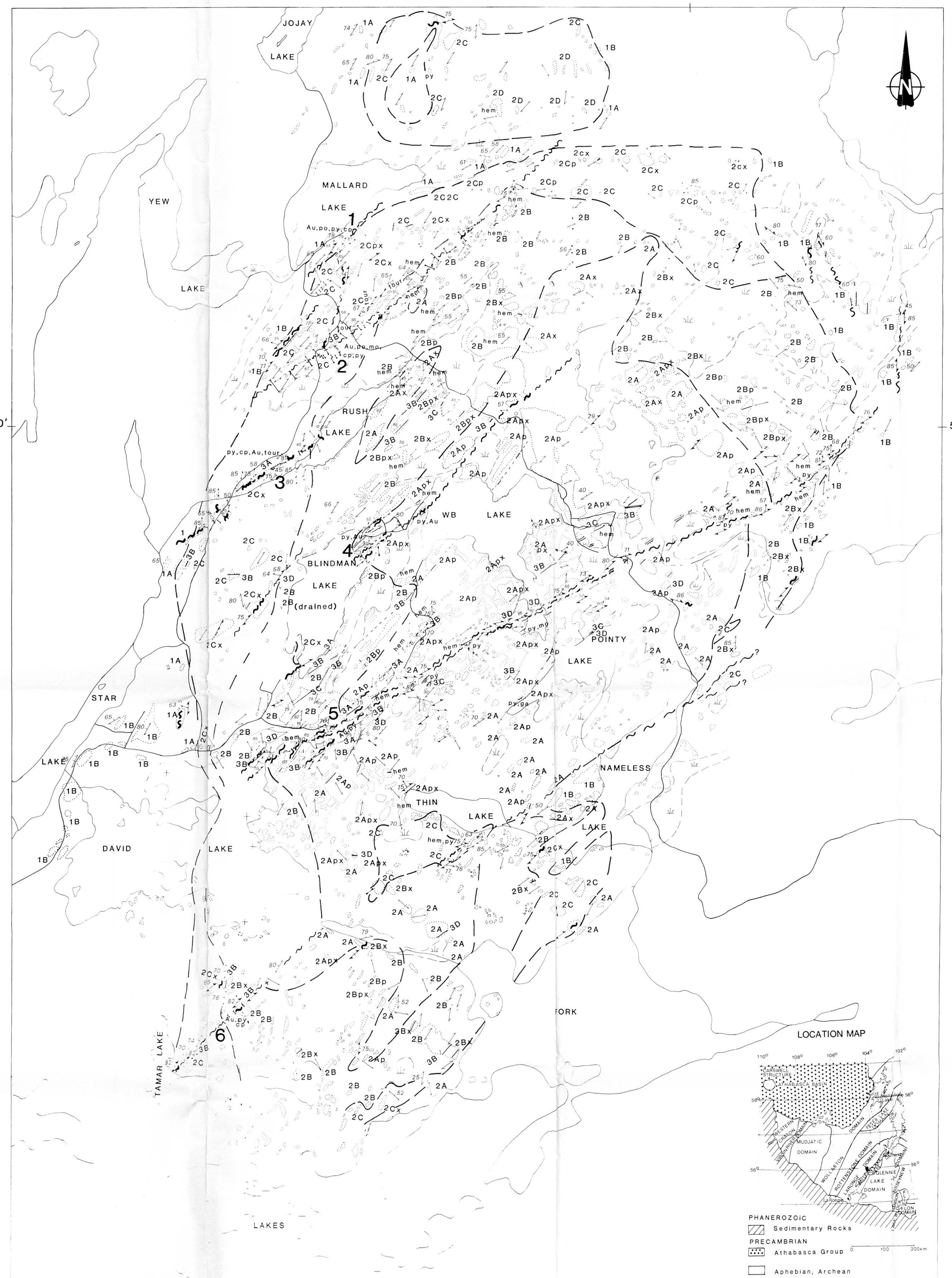

LEGEND

DYKES

3D	APLITE
3C	QUARTZ MONZODIORITE
3B	DIORITE
3A	DIABASE

PLUTONS

2D	GABBRO
2C	DIORITE
2B	QUARTZ MONZONITE
2A	GRANITE

METAMORPHOSED SUPRACRUSTAL ROCKS

1B	METAVOLCANIC
1A	METASEDIMENT

SYMBOLS

Metamorphic Foliation (S)
Mylonitic Foliation, with lineation (Sm)
Shear Zone (known, inferred)
Quartz Vein
hem Hematite
tour Tourmaline
py Pyrite
cp Chalcopyrite
Swamp
Outcrop
Igneous Layering
x Xenolith
p Porphyritic
po Pyrrhotite
mo Molybdenite
ga Galena
Road
Contact

GOLD OCCURRENCES

1 Decade 2 Rod 3 Rush/Pie 4 Blindman 5 21 Zone 6 Tamar

GEOLOGICAL SURVEY OF CANADA COMMISSION GÉOLOGIQUE DU CANADA
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GEOLOGY AND GOLD DEPOSITS, STAR LAKE PLUTON, LARONGE DOMAIN, SASKATCHEWAN

MAPPING BY: D.E. AMES, A.G. GALLEY, K.H. POULSEN
AND ASSISTANTS

Scale 1:10 000

Metres 0 200 400 600 800 1000 Metres

Universal Transverse Mercator Projection

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