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DEPARTMENT OF ENERGY AND MINES

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ECONOMIC GEOLOGY REPORT

ER79-5

DISSEMINATED STRATIFORM BASE METAL MINERALIZATION ALONG THE CONTACT ZONE OF THE BURNTWOOD RIVER METAMORPHIC SUITE AND THE SICKLE GROUP

by

D.A. Baldwin

1980

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ABSTRACT

Disseminated stratiform sulphide mineralization has been recognized at or close to the contact of two major litho-stratigraphic rock units in the northern part of the Kisseynew sedimentary gneiss belt. All of the rocks in the gneiss belt have been regionally metamorphosed to the amphibolite facies during the Hudsonian orogeny and are thought to be of Aphebian age.

The older and stratigraphically lower of the two major litho-stratigraphic units, the Burntwood River Metamorphic Suite, contains the metamorphosed derivatives of mudstones, greywackes and psammites that are interpreted to have been turbidite deposits. The Sickle Group, which stratigraphically overlies the Burntwood River Metamorphic Suite, consists of metamorphosed arkose and greywacke with a locally developed basal metamorphosed conglomerate. A transition zone between the two major litho-stratigraphic units, but which is here included in the Burntwood River Metamorphic Suite, is characterized by a layered sequence of amphibolite, and metamorphosed carbonate rocks and quartzite.

The lithological variations and primary sedimentary structures in the rocks in the stratigraphic succession suggest that; the turbidites in the Burntwood River Metamorphic Suite were deposited in deep water during a transgressive cycle; the rocks in the transition zone were deposited during a period of stagnation in which there was little sediment supply; the arkoses and greywackes of the Sickle Group were shallow water deposits of which the basal beds were probably deposited during a regressive cycle. A calcareous, scapolite-bearing layer near the base of the Sickle Group at Kadeniuk Lake may represent a fossil evaporite deposit.

Disseminated stratiform sulphide mineralization and sulphide iron formation occur in the rocks of the transition zone and lower part of the Sickle Group. Graphite increases toward the stratigraphic top of the Burntwood River Metamorphic Suite and decreases abruptly within the transition zone.

Where more than one sulphide mineral is present the mineralized zone exhibits a crude sulphide zoning (pyrrhotite $\rightarrow$ pyrite $\rightarrow$ copper sulphide $\rightarrow$ pyrite) toward the stratigraphic top.

In the southern part of the Kisseynew sedimentary gneiss belt, many occurrences of disseminated sulphide are present at or close to the contact of the Burntwood River Metamorphic Suite and the overlying metamorphosed arkosic rocks of the Sherridon Group.

Copper, lead and zinc sulphides have been found in the Wollaston Lake fold belt in Saskatchewan, and in the Hurwitz Group in the Northwest Territories. In northwestern Manitoba, rocks correlative with those in the Wollaston fold belt and Hurwitz group contain minor occurrences of base metal sulphides. These rocks are similar in age and lithology to the rocks in the Burntwood River Metamorphic Suite and the Sickle Group. To date, major deposits of disseminated stratiform sulphide have not been found in Manitoba. However, based on the example provided by the northern part of the Kisseynew sedimentary gneiss belt it appears that, geological environments potentially favourable for this type of deposit may be present elsewhere in the Churchill Structural Province.

INTRODUCTION

The disseminated base metals project was initiated in 1975 as part of the Canada/Manitoba Non-Renewable Resources Evaluation Program (NREP). As a part of this project a study was begun in 1976 to investigate the potential for disseminated stratiform base metal deposits along the contact zone of the Burntwood River Metamorphic Suite and the Sickle Group following an earlier discovery of a copper occurrence at Kadeniuk Lake in 1974 (Baldwin, 1976). Data from all available sources, including cancelled assessment reports, mineral inventory cards, published geological maps and reports, geological data on known mineral occurrences and showings and field work by the author were compiled and analysed.

This report is designed to serve as:

1) A presentation of the data base.
2) A documentation of the mineralization, and where possible, the controls of mineralization.
3) An interpretation of the geological environment in which the mineralization occurs.
4) A general and qualitative statement of the potential for disseminated stratiform base metal deposits to occur along the contact zone of the Burntwood River Metamorphic Suite and the Sickle Group, and to suggest other areas in the Churchill Province in Manitoba where similar mineralization may be encountered.

Because of the limited data base and short duration of the project, it was not possible to develop a deposit model to explain the observed mineralization, other previously reported occurrences that were not observed by the author during this study, and other types of mineralization that may be expected to occur in the area.

In this report, the name Sickle Group is used as defined by Campbell (1969). The former Burntwood River Supergroup (McRitchie, 1974) and Amphibolite Sequence (Baldwin, 1974) together comprise the Burntwood River Metamorphic Suite (P.G. Lenton, in prep.).

A brief description and review of exploration work done on mineral properties shown on the accompanying maps (Map ER 79-5-1 and Map ER 79-5-2) is included as an Appendix.

ACKNOWLEDGEMENTS

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GENERAL GEOLOGY

Details of the geology of the Granville Lake area (NTS 64C) and the Uhlman Lake area (NTS 64B) have been published by Milligan (1960), Burwash (1962), Pearce (1964), Godard (1966), Pollock (1966), Cranstone (1968), Campbell (1972a, 1972b), Cranstone (1972), Elphick (1972), Frohlinger (1972), Hinds (1972), Kendrick (1972), Schledewitz (1972), Steeves and Lamb (1972), Thomas (1972), Baldwin (1974, 1976), Lenton (1975), Zwanzig and Wielezynski (1975), Gilbert (1976, 1977), Syme (1976, 1977) and Zwanzig (1976, 1977).

The two major litho-stratigraphic rock units under consideration in this report, are referred to as the Burntwood River Metamorphic Suite and the Sickle Group. They can be traced laterally along strike throughout the northern half of the Kisseynew sedimentary gneiss belt. The Burntwood River Metamorphic Suite comprises greywacke and mudstone-derived gneisses and migmatites that underlie a major part of the Kisseynew sedimentary gneiss belt between the Flin Flon and Lynn Lake greenstone belts. At the interpreted stratigraphic top of the Burntwood River Metamorphic Suite, a layered sequence of amphibolite and minor metamorphosed carbonate rocks and quartzites, referred to as the transition zone, conformably overlies the gneisses and migmatites. Sickle Group meta-arkose, arkosic gneisses and arkose-derived migmatites stratigraphically overlie the rocks of the Burntwood Metamorphic Suite along a broad Z-shaped fold belt and in structurally controlled outliers at and close to the northern boundary of the Kisseynew sedimentary gneiss belt (Fig. 1).

The rocks in the gneiss belt are metamorphosed to upper amphibolite facies mineral assemblages, except along the northwest margin of the gneiss belt where lowermost amphibolite facies mineral assemblages are present.

REGIONAL SETTING, STRUCTURE AND METAMORPHISM

The Kisseynew sedimentary gneiss belt is 140 km wide and 240 km long and occupies the southeastern corner of the Churchill Structural Province in Manitoba. Its east trend is truncated by the Hudsonian northeast-trending Thompson and Wollaston fold belts. To the north and south the belt is flanked by the granite diapir and greenstone terranes of the Lynn Lake and Flin Flon areas respectively.

The belt is characterized by a bilateral symmetry in the distribution of rock types and metamorphic grade. The centre of the belt is occupied by greywacke and mudstone-derived gneisses and migmatites with flanking belts of arkose-derived gneisses and migmatites grading out into generally low metamorphic grade metavolcanic domains. A detailed account of the transition from low to high grade metamorphism in the Kisseynew sedimentary gneiss belt has been given by Bailes and McRitchie (1978).

The Kisseynew sedimentary gneiss belt is thought to represent a sedimentary basin developed contemporaneously with volcanism in the adjaceant Flin Flon and Lynn Lake greenstone belts (Bailes and McRitchie, 1978). Turbidite-like sedimentation of volcanic-derived greywacke and mudstone took place within the basin. A brief period of stagnation followed and mafic tuff (?), chert (?), calcareous mudstone, iron formation and locally limestone and red beds were deposited. The region was then subjected to a second cycle of clastic sedimentation represented by an influx of arkosic sediments.

A minimum of five deformational events resulted in the upthrusting of the entire sedimentary pile, the formation of nappe-like structures and development of a thermal high along the axis of the sedimentary belt (McRitchie et al., 1979).

REGIONAL STRATIGRAPHY

The stratigraphic succession in the Granville Lake (NTS 64C) and Uhlman Lake (NTS 64B) areas is consistent and uniform, although on a local scale variations are present. Details of local stratigraphy have been given by Milligan (1960), Campbell (1972a), Baldwin (1974, 1976), McRitchie (1974), Lenton (1975), Lenton and Cameron (1976), Zwanzig and Wielezynski (1975), Zwanzig (1976), Gilbert (1977) and Syme (1977).

The Burntwood River Metamorphic Suite represents the lowest part of the succession and is correlated with part of the Wasekwan Group, which is comprised of metavolcanic and metasedimentary rocks of the Lynn Lake greenstone belt (H.V. Zwanzig, in prep.). The upper part of the succession is represented by the Sickle Group.

The changes that occur across the contact of the Burntwood River Metamorphic Suite and the Sickle Group can be summarized as follows:

- Toward the stratigraphic top of the Burntwood River Metamorphic Suite the metagreywackes become gritty and richer in quartz, shaley and graphitic, and sporadic beds of amphibolite of variable thickness are common.
- At the top of the Burntwood River Metamorphic Suite the dominant metagreywacke lithology gives way to amphibolite, calc-silicate and quartzite lithologies (transition zone).
- Metaconglomerates of variable thickness locally mark the base of the overlying Sickle Group.
- Metasandstone (subgreywacke, greywacke, arkose) comprise the dominant rock type in the Sickle Group.

Locally, either the transition zone at the stratigraphic top of the Burntwood River Metamorphic Suite or the Sickle Group metaconglomerate may be absent, but in general, the rocks occur in a continuous conformable sedimentary succession.

Representative stratigraphic sections showing regional stratigraphy, stratigraphic changes across the transition of the Burntwood River Metamorphic Suite and Sickle Group and stratigraphic distribution of sulphide mineralization for four localities in the northern part of the Kisseynew sedimentary gneiss belt are presented diagramatically in Figure 2. The locations of these stratigraphic sections are shown in Figure 1.

Numerous occurrences of minor disseminated copper sulphides have been identified in the lower 200 m of the Sickle Group. The most prominent of these, at Kadeniuk Lake (Baldwin, 1974, 1976), is probably a metasedimentary stratiform base metal type of deposit.

DISTRIBUTION OF SICKLE GROUP ROCKS

The main belt of Sickle Group rocks is exposed continuously in a long and broad Z-shaped belt that extends from Laurie Lake east to Harding Lake (Map ER 79-5-1 and Map ER 79-5-2). South of this main belt, numerous structurally controlled outliers of Sickle Group rocks occur from Kamuchawie Lake east to Nelson House (Map ER 79-5-1, Map ER 79-5-2, and Fig. 1).

Discontinuous northeast-trending belts of Sickle Group rocks crop out north of Lynn Lake at Zed Lake and Goldsand Lake and in structurally controlled outliers at Hughes Lake, Opachuanau Lake, Issett Lake and Southern Indian Lake (Map ER 79-5-1 and Map ER 79-5-2).

McRitchie (1976, 1977, 1978), in conducting a regional reconnaissance program, recognized meta-arkosic rocks to the east of the main Sickle Group outcrop belt in the Macheewin-Waskaiowaka region and north of the Lynn Lake greenstone belt in the Paskwachi Bay-Melvin Lake and Partridge Breast-Northern Indian Lake regions. These meta-arkosic rocks resemble the lithologies of and have a stratigraphic position similar to the Sickle Group.

Sickle Group rocks have been traced from the Manitoba-Saskatchewan border east to the Thompson Nickle Belt, then northeast to Gillam (T. Corkery, pers. comm., 1979), a distance of approximately 450 km.

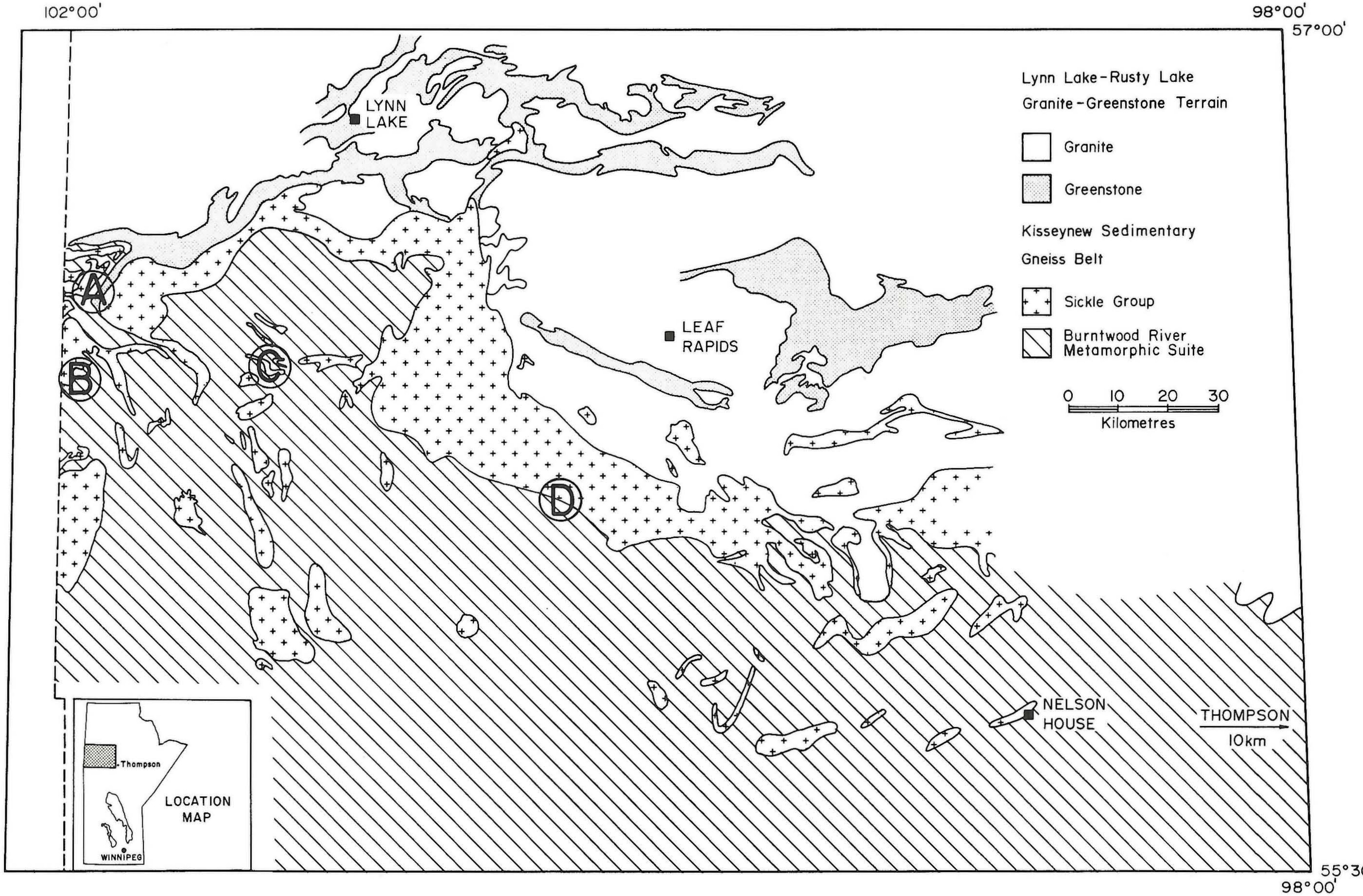

FIGURE 1: *Generalized geology of the Lynn Lake-Rusty Lake granite-greenstone terrane and the northern half of the Kisseynew sedimentary gneiss belt, (modified after McRitchie, 1974; Baldwin, 1976). A, B, C and D indicate the location of the stratigraphic columns in Figure 2.*

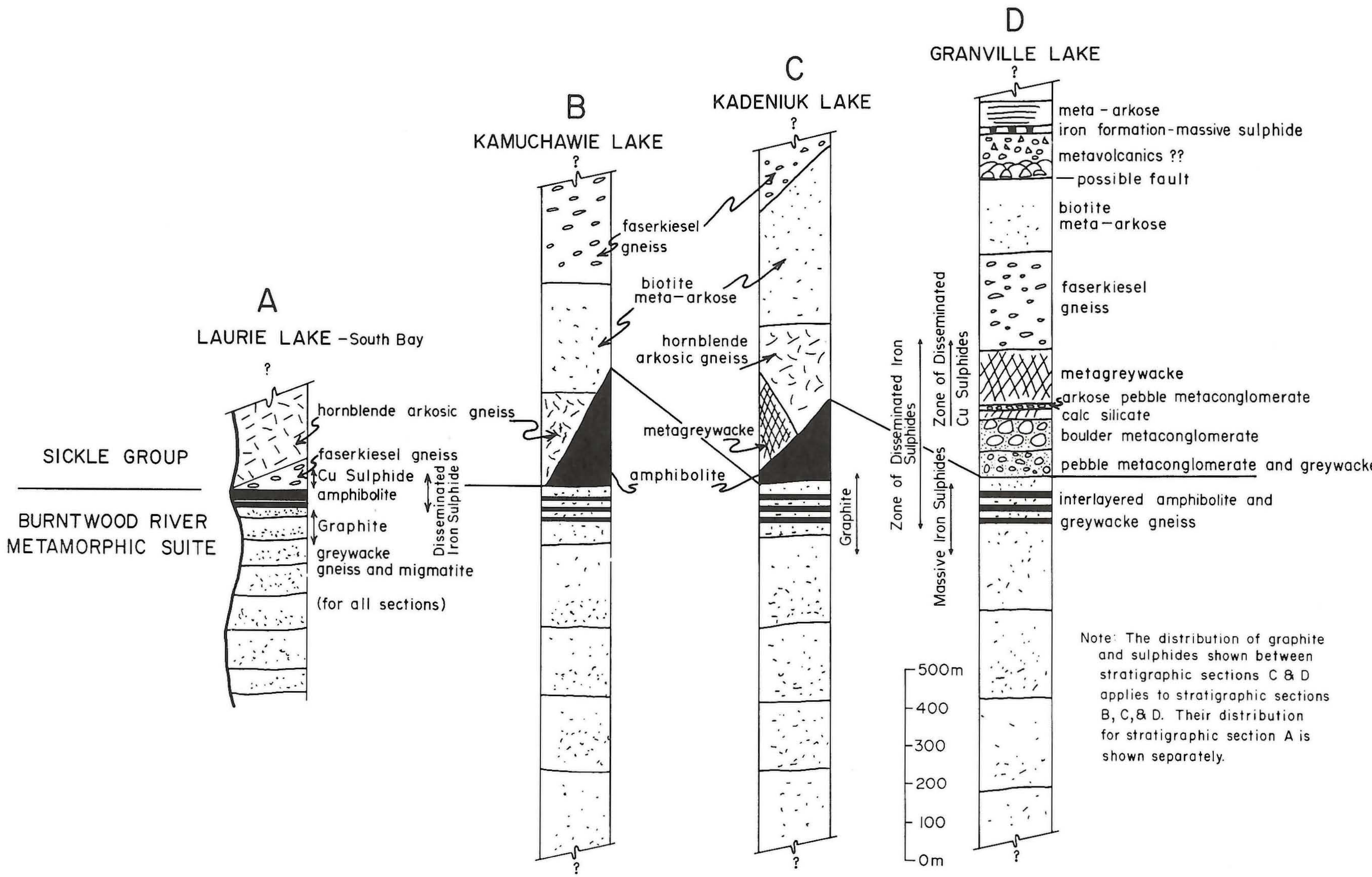

FIGURE 2: Regional stratigraphy and stratigraphic distribution of sulphides. Modified after Zwanzig, 1976).

CONTACT RELATIONSHIPS

Contact relationships between the Sickle Group, Wasekwan Group, Burntwood River Metamorphic Suite and intrusive rocks vary from locality to locality along the entire Sickle Group outcrop belt.

In the Laurie Lake area, (Map ER 79-5-1) Sickle Group rocks conformably overlie the Wasekwan Group volcanic rocks to the north and have a conformable transitional contact with the Burntwood River Metamorphic Suite to the south (Zwanzig, 1976).

Throughout the Kamuchawie, Russell and McKnight Lakes areas (Map ER 79-5-1) the Sickle Group conformably overlies the Burntwood River Metamorphic Suite (Baldwin, 1974; McRitchie, 1975; Lenton, 1975; Zwanzig and Wielezynski, 1975).

Between Story Lake and Finch Lake (Map ER 79-5-1) post-Sickle Group granitic rocks intrude the northern contact between the Sickle Group and Wasekwan Group and the southern contact between the Sickle Group and the Burntwood River Metamorphic Suite.

In the Lasthope Lake, Amy Lake and Sickle Lake areas (Map ER 79-5-1) granitic rocks cut the Sickle Group metasedimentary rocks (Fawley, 1952) whereas on Sickle Lake there is an unconformity between the Sickle Group, Waskewan Group and intrusive rocks (Milligan, 1960; Campbell, 1972a). Two ages of granite intrusions, pre- and post-Sickle Group, are therefore present in the area.

South of Sickle Lake at Beaucage Lake and east to the Mynarski Lakes, (Map ER 79-5-2) the northern contact of the Sickle Group outcrop belt is cut by a post-Sickle Group granitic batholith (Campbell, 1972b; Schledewitz, 1972; Elphick, 1972). Sickle Group rocks conformably overlie rocks of the Burntwood River Metamorphic Suite along the southern contact of the outcrop belt from Metcalf Bay east to the Mynarski Lakes (Campbell, 1972a; Schledewitz, 1972; Elphick, 1972).

The contact relationships between the Sickle Group and the Wasekwan Group in the Zed Lake and Goldsand Lake area (Map ER 79-5-1) are little known. At Hughes Lake the basal Sickle Group metaconglomerate lies with angular unconformity on tightly folded Wasekwan Group strata and on pre-Sickle Group intrusive rocks.

On the Churchill River approximately 5 km west from Opachuanau Lake (Map ER 79-5-2), Sickle Group metaconglomerate rests unconformably on Wasekwan Group metavolcanic rocks and on pre-Sickle Group gneissic intrusive rocks (Opachuanau Gneiss) (Zwanzig, 1974). It is likely, therefore, that this same relationship exists for the northern contact of the narrow belt of Sickle Group rocks that trends east-west from Opachuanau Lake through Issett Lake (Map ER 79-5-2). The southern contact of this belt of Sickle Group rocks is an intrusive contact with post-Sickle Group granitic rocks (Steeves and Lamb, 1972).

The outlier of Sickle Group rocks at Southern Indian Lake (Map ER 79-5-2) is entirely surrounded by post-Sickle Group intrusive rocks.

In summary, it may be stated that the northern contact of the main Sickle Group outcrop belt has been cut by post-Sickle Group intrusive rocks, except for the area from Tod Lake to Pool Lake and the northern and eastern shores of Sickle Lake where Sickle Group rocks unconformably overlie Wasekwan Group rocks. The southern contact of the main Sickle Group outcrop belt and the contacts around the Sickle Group outliers in the Kamuchawie Lake, Russell Lake and Nelson House areas are continuous, conformable and transitional with the rocks of the underlying Burntwood River Metamorphic Suite.

MINERALIZATION

Sulphide mineralization in the stratigraphic succession occurs in the gritty, shaley and graphitic metagreywackes and the amphibolites near the stratigraphic top of the Burntwood River Metamorphic Suite, in the rocks of the transition zone and in the lower 200 m of the Sickle Group (Fig. 2).

In the Burntwood River Metamorphic Suite the mineralization is in the form of disseminated pyrrhotite (po) and pyrite (py) in the graphitic metagreywacke and as either thin (10cm) bands of massive sulphide (po, py) or disseminated sulphide (po, py) in the amphibolites. Minor chalcopyrite and arsenopyrite are present. The mineralization is conformable with metamorphic layering which is in turn parallel to unit contacts and probably closely reflects bedding attitudes. Mineralization at localities 3, 5, 6, 7 on Map ER 79-5-1 and locality 2 on Map ER 79-5-2 is of this type.

In the transition zone, disseminated iron sulphide (po, py) with minor chalcopyrite and sphalerite is ubiquitous in the amphibolites and the metamorphosed carbonate rocks and quartzite. Massive iron sulphide (po, py) layers, 10 cm - 50 cm thick, with minor chalcopyrite and sphalerite occur only in association with calc-silicate rocks in the amphibolite layers, and probably represent metamorphosed sulphide-silicate facies iron formation. Sulphide mineralization in these rocks has been recorded throughout the Granville Lake and Uhlman Lake areas. At a locality on Russell Lake (UTM 6245000N, 346000E) (Map ER 79-5-1) minor finely disseminated bornite occurs in quartzite. Graphite has been observed in the metamorphosed carbonate rocks interlayered with amphibolites in the Russell Lake area (Baldwin, 1974) and the Kamuchawie Lake area (Zwanzig and Wielezynski, 1975).

Baldwin (1976) described in detail the geology of the Kadeniuk Lake copper occurrence (Locality 8, Map ER 79-5-1) in Sickle Group rocks. Although most of the copper showings in the Sickle Group contain chalcopyrite, some consist of chalcopyrite and bornite with or without pyrite. At Kadeniuk Lake the sulphide mineralogy consists of chalcopyrite, bornite, native copper and pyrite. Rare chalcocite is present in the copper showings. Where more than one sulphide mineral species is present, the mineralization is zonally arranged. At Kadeniuk Lake the zonation of sulphide minerals from the base to the top of the horizon is native copper; bornite and chalcopyrite; chalcopyrite and pyrite; pyrite. The observations made and documented on the mineralization at Kadeniuk Lake (Baldwin, 1976) appear to hold true for disseminated copper mineralization throughout Sickle Group meta-arkosic rocks. Mineralization at localities 2, 4, 9 and 10 on Map ER 79-5-1 is similar to the occurrence at Kadeniuk Lake.

Grains of galena, chalcopyrite and native copper are present in Sickle Group metaconglomerate on the Churchill River, west of Opachuanau Lake (Map ER 79-5-2). The metaconglomerate lies unconformably on pre-Sickle Group intrusive tonalitic rocks and Wasekwan Group metavolcanic rocks (Zwanzig, 1974). A large body of post-Sickle Group pink quartz-eye granite and quartz monzonite intrudes the older tonalite immediately to the north of the metaconglomerate. The galena and chalcopyrite are contained in quartz veins within the metaconglomerate (Steeves and Lamb, 1972). The sulphides were probably remobilized into the quartz veins as a result of the intrusion of the post-Sickle Group granite. The native copper is disseminated in the matrix of the metaconglomerate (D. Robertson, pers. comm., 1977). Another occurrence of copper in Sickle Group metaconglomerate is recorded from the north side of Conglomerate Lake (Milligan, 1960) (Map ER 79-5-1). At this locality a few grains of chalcopyrite occur in the matrix of the metaconglomerate within the Sickle Group. A few grains of bornite occur near the base of the Sickle Group southeast of Laurie Lake (H.V. Zwanzig, pers. comm., 1976).

A unit of amphibolite and associated metasedimentary rocks in the Sickle Group outcrops along the south shore of Granville Lake from Metcalf Bay east to Suwannee Lake (Map ER 79-5-1). Conformable, stratiform disseminated and massive pyrrhotite and pyrite with minor chalcopyrite have been observed locally along the length of the unit. The disseminated sulphides (po, py) occur as discrete grains and streaks on foliation planes. The massive sulphide is confined to amphibolitic rocks of possible volcanic origin. Good exposures between Pickerel Narrows and the Churchill River reveal massive pyrrhotite and pyrite with minor chalcopyrite underlain by massive, layered and possible fragmental rocks that are volcanic in appearance. A one metre thick bed of quartzite, interpreted to be a metamorphosed chert, directly overlies the massive sulphide mineralization which probably represents a sulphide facies iron formation.

In summary, the nature and form of the mineralization at or close to the Sickle Group-Burntwood River Metamorphic Suite contact are:

(1) Disseminated and minor massive sulphide mineralization associated with graphite bearing metagreywacke interlayered with amphibolite near the stratigraphic top of the Burntwood River Metamorphic Suite. Minor copper mineralization is present locally.

(2) Disseminated and massive iron sulphides with minor chalcopyrite and sphalerite in amphibolite and metamorphosed carbonate rocks and quartzite in the transition zone at the stratigraphic top of the Burntwood River Metamorphic Suite.

(3) Copper and lead sulphides plus native copper in Sickle Group metaconglomerate.

(4) Disseminated copper sulphides and native copper with or without iron sulphides, zonally arranged, conformable, and stratabound in meta-arkosic rocks at or close to (within 200 m) the base of the Sickle Group.

(5) Disseminated and massive iron sulphides with minor copper in metasedimentary and amphibolite rocks of possible volcanic origin within the Sickle Group.

DISTRIBUTION OF THE SULPHIDES

The most common site of deposition of disseminated sulphides in the region is in the amphibolites of the transition zone and in the interlayered graphitic metagreywackes and amphibolites of the Burntwood River Metamorphic Suite. Sulphide occurrences in these rocks with fifteen to twenty per cent pyrrhotite, pyrite and minor chalcopyrite are not uncommon throughout the metasedimentary gneiss belt (McRitchie et al., 1979).

In Sickle Group rocks sulphide mineralization appears to be confined to the lower 200 m of the group (Fig. 2).

It can be seen from Map ER 79-5-1 that the main concentration of sulphide occurrences appear to lie in the area west of longitude 101°00′. However, this apparent localization of sulphide occurrences is probably erroneous and results from a concerted search and delineation of such occurrences in the area following the initial discovery of the Kadeniuk Lake copper mineralization (Baldwin, 1974).

The relationships between the Burntwood River Metamorphic Suite and the Sickle Group are very similar throughout the region. Accordingly a re-examination of the lower part of the Sickle Group from Granville Lake east to Mynarski Lake could well result in the identification of an equivalent number of copper showings to those in the Russell Lake, Kamuchawie Lake and Laurie Lake areas.

METAL CONTENT

During the course of the field work, samples were collected for a pilot geochemical study. Samples were collected from units in areas where the stratigraphic position of the unit is known or interpreted from stratigraphic documentation elsewhere in the Kisseynew sedimentary gneiss belt. The results of this pilot study from single grab samples are summarized below (Table 1) and arranged in relative stratigraphic position from oldest unit at the bottom of the table to youngest at the top of the table. Although the metal contents are low, the results of the pilot study indicate that:

(1) mineralization is widespread
(2) there appears to be a general increase in copper toward the top of the Burntwood River Metamorphic Suite and into the lower part of the Sickle Group
(3) zinc and nickel appear to be concentrated in rocks that may be volcanic in origin.

TABLE 1

Analyses of Burntwood River Metamorphic Suite (B.R.M.S.) and Sickle Group Rocks

Rock Type	Group	Locality	Cu%	Zn%	Ni%
greywacke-migmatite	B.R.M.S.	Russell Lake	Tr	Tr	N.D.
greywacke	B.R.M.S.	Wheatcroft Lake	Tr	Tr	N.D.
amphibolite-greywacke	B.R.M.S.	Wheatcroft Lake	0.02	Tr	N.D.
amphibolite-greywacke	B.R.M.S.	Laurie River	0.02	Tr	N.D.
amphibolite-quartzite	B.R.M.S. (transition zone)	Russell Lake	0.07	Tr	0.06
amphibolite-carbonate	B.R.M.S. (transition zone)	Russell Lake	0.07	0.03	N.D.
amphibolite-quartzite	B.R.M.S. (transition zone)	Russell Lake	0.14	0.04	0.06
arkose	Sickle	Kadeniuk Lake	0.06 to 3.7	N.D.	N.D.
amphibolite (metavolcanic)	Sickle	Granville Lake	0.11	0.04	0.04
amphibolite (metavolcanic)	Sickle	Granville Lake	0.11	0.05	0.08
amphibolite (metavolcanic)	Sickle	Granville Lake	0.20	0.06	0.06
amphibolite (metavolcanic)	Sickle	Granville Lake	0.11	0.10	0.03

Analyses by: Staff of the Analytical Lab, Manitoba Mineral Resources Division

Method: Atomic Absorption.

N.D. = Not detected.

SIGNIFICANCE OF THE STRATIGRAPHIC SUCCESSION

The rock types, the occurrence of graphite and sulphides and primary sedimentary structures in the continuous and conformable stratigraphic succession indicate the chronologic changes in the environment of sediment deposition and sediment supply.

The thick sequence of metagreywacke in the Burntwood River Metamorphic Suite has been interpreted to have been turbidite deposits (McRitchie, et al., 1979; Bailes and McRitchie, 1978). They were deposited below wave base in a deep water basin marginal to a volcanic belt. Thin units of amphibolite that occur toward the top of the Burntwood River Metamorphic Suite can be traced along strike into volcanic rocks of the Wasekwan Group (Zwanzig, 1976). They provide evidence for sporadic volcanic activity late in the depositional history of the Burntwood River Metamorphic Suite. The marked increase of graphite in the metagreywackes interlayered with amphibolites, suggests anoxic conditions, favourable to some forms of life, were present during this time in the evolution of the basin.

Finely laminated to massive amphibolite, calc-silicate rock, iron formation and quartzite with minor amounts of carbonate, comprising the transition zone at the very top of the Burntwood River Metamorphic Suite strongly suggest a period of sediment starvation in a low energy environment, and the disseminated iron sulphides and sulphide facies iron formation in these rocks indicate the presence of sulphur in the environment.

Deposition of the Sickle Group at the basin margin, followed this period of stagnation in the basin. Rapid erosion of the uplifting Lynn Lake volcanic belt to the north and east, and the unroofing of granitic plutons in the volcanic belt is evidenced by the polymictic character of the Sickle Group metaconglomerates and the general tonalitic to quartz monzonitic composition of the Sickle Group meta-arkosic rocks. Primary structures in Sickle Group rocks (Milligan, 1960; Campbell, 1972a; Zwanzig and Wielezynski, 1975; Zwanzig, 1976) indicate that they were deposited in a high energy shallow marine environment. Disseminated sulphides of iron and copper at or close to the base of the Sickle Group (Milligan, 1960; Baldwin, 1974; McRitchie, 1975; Zwanzig and Wielezynski, 1975; Zwanzig, 1976) are evidence for sulphur being present in the environment during the early depositional history of the Sickle Group.

The Unit of amphibolitic rocks within the Sickle Group at Granville Lake (Map ER 79-5-1) comprises amphibolite, quartzite and metagreywacke. The amphibolites have been interpreted to be volcanic in origin (Barry, 1976; Barry and Gait, 1966; Godard, 1966; Cranstone, 1968; Campbell, 1972a). The author visited localities described by Campbell (1972a) and investigated the unit along its entire strike length; structures that could be interpreted as pillows and pillow breccia were observed and the quartzites are possibly recrystallized chert. Deformation and shearing superimposed upon the rocks render the structures difficult to interpret. Although the evidence for a volcanic origin is not conclusive, there is as yet no evidence to the contrary. It is therefore possible that short periods of volcanic activity occurred during the deposition of the lower part of the Sickle Group. If this is so, then the volcanic activity could have been a source of sulphur and possibly the metals.

The Burntwood River Metamorphic Suite turbidite deposits are considered to be a time transgressive sequence. Toward the end of this sedimentary episode static conditions existed and the environment was anoxic and as a result of organic activity may have been acidic ($SO_4^{=}$?). The static conditions of the environment prevailed until deposition of the Sickle Group which, in its early stages, may have been time regressive. The anoxic and acidic (?) conditions of the environment existed during the deposition of the lower part of the Sickle Group and it was in this environment that the disseminated sulphides were deposited (Fig. 3).

At Kadeniuk Lake, the highest Cu values (3.7%) were recorded from a scapolite, diopside, sphene-bearing calc-silicate rock near the base of the Sickle Group. The presence of scapolite in these rocks may suggest a fossil evaporite (Serdyuchenko, 1975; Kwak, 1977).

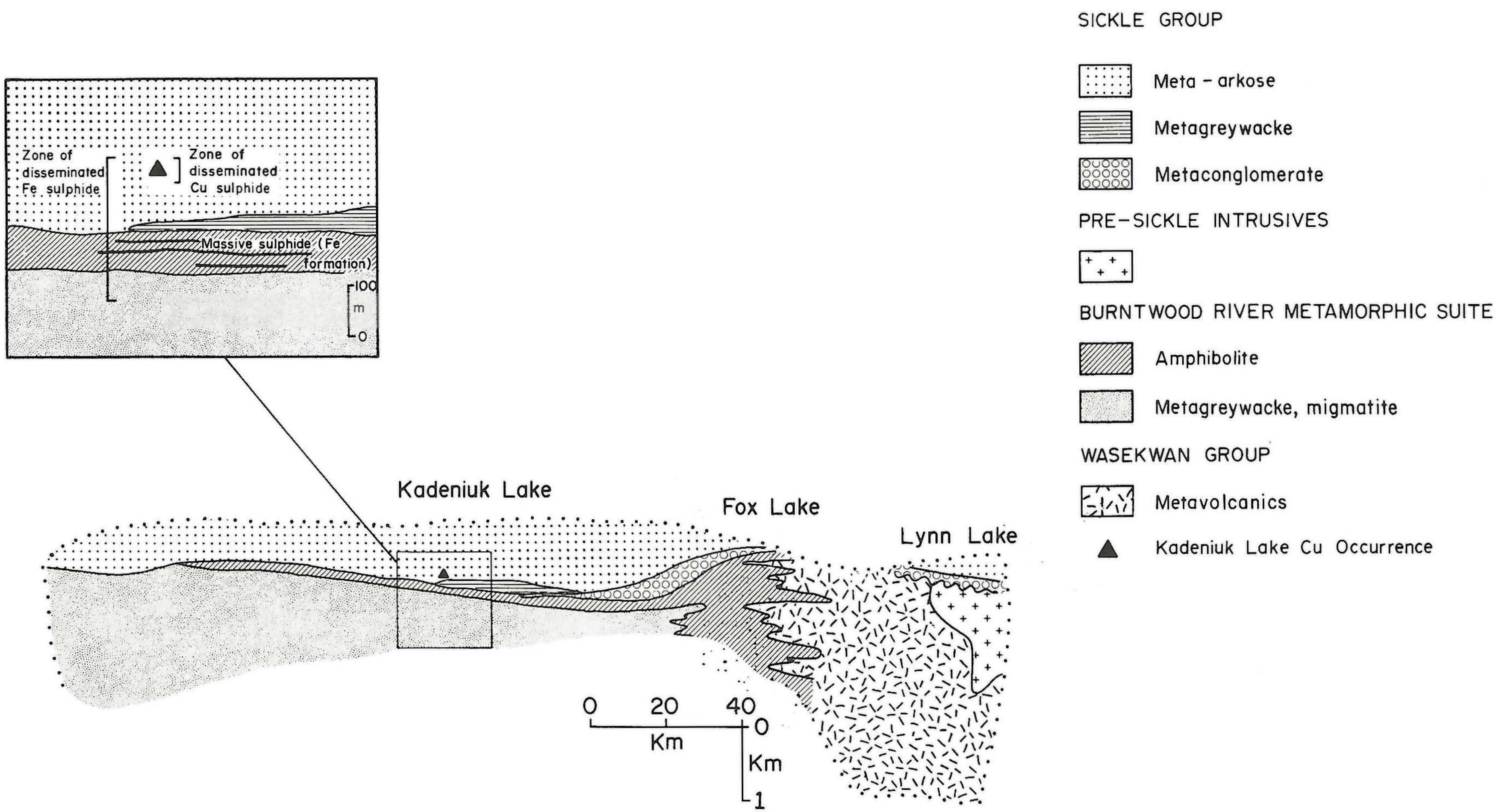

FIGURE 3: Diagramatic reconstruction of a north-south cross-section of part of the Kisseynew sedimentary gneiss belt showing stratigraphic relationships and the stratigraphic spatial position of disseminated, conformable and stratiform mineralization, (modified after Zwanzig, 1976, unpubl. diagram).

DISCUSSION

Disseminated, conformable, stratiform sulphide mineralization occurs at or close to the Sickle Group-Burntwood River Metamorphic Suite contact in Manitoba from the Manitoba-Saskatchewan border eastward to the Mynarski Lakes. Reconnaissance mapping in the Macheewin-Waskaiowaka, Partridge Breast — Northern Indian Lake regions (McRitchie, 1976, 1977, 1978) indicates that Sickle Group — Burntwood River Metamorphic Suite lithologies continue eastward from the Mynarski Lakes to the Thompson Nickle Belt and therefore extends the potential environment for sulphide mineralization to a total strike length of 270 km, and to 450 km if the meta-arkosic rocks in the Long Spruce area are correlated with the Sickle Group.

The sulphide minerals are zonally arranged from iron rich to copper rich to iron rich within the mineralized zone. The copper zone is itself zoned being copper rich at its base, increasing in iron content toward its top, similar to the mineral zoning found in the Rhodesian Copperbelt which is thought to be transgressive. The highest copper values (3.7%) found to date are from Sickle Group meta-arkosic rocks at the Kadeniuk Lake occurrence (Baldwin, 1976). Although the host rock lithologies are laterally continuous without change, the mineralization cannot be traced for more than 600 metres along strike, and the down-tip extension for more than 60 metres. This same characteristic has been noted in many sulphide occurrences in the Wollaston Lake Fold Belt in Saskatchewan for which Sangster and Kirkham (1974) suggest that the original control for mineralization may have been related to permeability channels and/or "pinch-out" traps.

The Anglo-Rouyn Mine near La Ronge, Saskatchewan, occurs in Archean (?) highly metamorphosed argillaceous sandstone and arkose (Forsythe, 1972). Two million tons of ore grading 2.4 per cent copper and about 0.03 to 0.05 ounces per ton gold occurred in boudinaged, concordant zones of disseminated chalcopyrite, pyrite and pyrrhotite. Forsythe (1972) suggested an epigenetic, fault controlled origin for the deposit. Kirkham (1974) suggested that the deposit was initially a disseminated stratiform deposit that has been subjected to intense deformation and metamorphism resulting in local redistribution and recrystallization of the sulphides, even though the gold content of the ore is not typical of stratiform copper deposits in sedimentary sequences.

Although metamorphosed to granulite facies of regional metamorphism, the succession of Precambrian rocks at the Kilembe Mine, Uganda (Barnes et al., 1959), resembles the Burntwood River Metamorphic Suite — Sickle Group succession. The ore deposit is conformable, stratiform and hosted in amphibolitic rocks that are interpreted to have formed from calcareous sediments. The rocks underlying the amphibolites are plagioclase-biotite granulites with intercalated biotite-garnet and sillimanite-garnet gneisses. These rocks probably represent a metamorphosed pelitic sediment. The rocks overlying the ore bearing amphibolites vary from arkosic grits to a fine grained quartzite and grade upwards into potassic gneisses that are recrystallized to a state where a para- or ortho-gneiss origin cannot be distinguished; however, it is conceivable that they may have been derived from arkosic sediments.

The Mokoman Lake Prospect in Saskatchewan is located 60 km southwest of Kamuchawie Lake, Manitoba. Here, the rocks are migmatized pelitic gneisses with interlayered amphibolite, amphibole-bearing gneisses with quartz-diopside rich layers and psammites (feldspathic sandstone) (Pearson, 1973). The copper mineralization appears to be related to quartz rich rocks associated with amphibole bearing gneisses.

The most abundant continuous and consistent mineralization associated with the Burntwood River Metamorphic Suite — Sickle Group contact zone is found in the amphibolite-quartzite-metacarbonate succession at the stratigraphic top of the Burntwood River Metamorphic Suite. It is these rocks that have received the attention of the private mining sector to date (Appendix).

Stratiform copper deposits in sedimentary sequences characteristically have been deposited in low latitude, arid and/or semi-arid, continental or marginal marine areas and commonly have associated evaporite deposits (Strakhov, 1962; Lombard and Nicolini, 1962; Kirkham, 1973; Renfro, 1974). Irving and Lapointe (1975) suggest that 1850 Ma ago the north magnetic pole was positioned in northern South America approximately at the latitude of the present day equator. A Rb-Sr whole rock isochron age of the greywacke-derived gneisses of the Burntwood River Metamorphic Suite is 1850 + 80 Ma. (Clark, et al., 1974). Deposition of the rocks in the Burntwood River Metamorphic Suite and the Sickle Group would have taken place between latitude 34° N and 35° N. This position would be low latitude but only marginal to the latitudinal limits within which present day arid desert conditions are found.

Calc-silicate rocks, marbles and scapolite-diopside rich rocks occur in a zone at the stratigraphic top of the Burntwood River Metamorphic Suite and base of the Sickle Group. Although these lithologies do not conclusively represent evaporite deposits they indicate conditions of stagnation and sediment starvation, a favourable environment for the deposition of evaporites, carbonates and coastal sabkhas.

It is important to note that the rocks and the geological environments present in the Granville Lake-Uhlman Lake area and in the Kasmere Project area (Weber et al., 1975) have broad similarities to those of the Rhodesian Copperbelt and to the Permian Basins of Central Europe and South-Central U.S.A. Also, the history of exploration and mining development in these areas should be considered in relation to the history of exploration in the sedimentary gneiss terranes of Manitoba.

The "ancients" mined several deposits in the Rhodesian Copperbelt, down to the water table using primative methods (Fleischer et al., 1976) but those deposits, covered by thick overburden, were not re-discovered until the late 1920's. In the Permian Basin of Central Europe, base metal mineralization has been known and exploited since the 13th century; geological investigations date back to early 1800's, however, systematic exploration and detailed studies have only been carried out over the past 40 years. It is noteworthy that the largest polymetallic stratiform ore deposit in this area, the Lubin deposit, was not discovered until 1957. Red-bed copper mineralization has been known in the Permian Basin of South-Central U.S.A. since the middle of the 19th century (Dingess, 1976) but active mining did not begin until the early 1920's.

In northern Manitoba exploration for polymetallic massive sulphide deposits in the sedimentary gneiss belts has been intermittent since the 1930's. Disseminated, conformable, stratiform copper mineralization, although widespread (Map ER 79-5-1 and ER 79-5-2) was not recognized and documented until 1974 (Baldwin, 1976). The level of exploration activity and the paucity of geological mapping in the sedimentary gneiss belts of northern Manitoba in comparison with that in the Rhodesian Copperbelt and the Permian basins of Central Europe and South-Central U.S.A. indicate that the exploration for disseminated, conformable, stratiform copper deposits in northern Manitoba is in its infancy.

The absence of known mineable deposits in the sedimentary gneiss belts of northern Manitoba should not therefore be taken as an indication of "barren ground" in view of the time difference between discovery of mineralization and the finding of mineable deposits as is indicated in the preceding paragraph.

OTHER AREAS IN MANITOBA WITH A POTENTIAL FOR DISSEMINATED STRATIFORM BASE METAL DEPOSITS

Numerous occurrences of disseminated copper, lead and zinc minerals have been found in the highly deformed and metamorphosed Aphebian rocks of the Wollaston Lake fold belt in Saskatchewan (Rath and Morton, 1969; Sangster and Kirkham, 1974). Similar mineralization is reported to occur in rocks of the Hurwitz Group in the Northwest Territories (Kirkham, 1974).

Pyrite, sphalerite, galena, chalcopyrite, bornite, chalcocite and native copper have all been found in highly metamorphosed arkosic sandstones and conglomerates. The sulphides appear to be most abundant in metasandstones that contain a minimum of pelitic material (Sangster and Kirkham, 1974). The disseminated nature of the sulphides and the lack of epigenetic characteristics (veining, faulting, etc.) suggest that the sulphides were emplaced before the rocks lost their primary porosity (Sangster and Kirkham, 1974). Characteristically, the mineralized zones cannot be traced for any significant distance along strike even though the host rocks are laterally continuous without marked change beyond the mineralized zones.

In the Kasmere Project area in northwestern Manitoba, rocks correlative to the Wollaston Lake fold belt and the Hurwitz Group are reported to contain sulphide occurrences (Weber et al., 1975). The bulk of the base metal mineralization occurs in calc-silicate and quartz rich units within a pelitic sequence. The rocks are interpreted to be metamorphosed mudstones (graphitic aluminous shales) with subordinate sandy and calcareous shales that were deposited in a deep water environment during the geosynclinal phase of the facies evolution in the Kasmere Lake — Thanout Lake area.

The presence of graphite in the pelitic metasediments suggests that an anoxic environment existed on the sea floor during the geosynclinal phase of sedimentation. Because of pore spaces, the arenaceous and calcareous rocks provided a suitable host for sulphide precipitation.

According to Weber et al. (1975) the copper sulphides in calc-silicate rocks which overlie the pelitic gneisses were probably formed under arid conditions during which metal and sulphide concentrations in sea water increased and led to sulphide precipitation. A mechanism similar to the "sabkha" process (Renfro, 1974) possibly caused this metal concentration.

Geochemical data (Weber et al., 1975) from the Kasmere Lake area suggest that foliated quartz monzonite has an above average lead content and foliated alaskite an above average zinc content. These rocks could have been the source for the lead and zinc that occurs in the unconformably overlying metasedimentary rocks.

The source of the copper is unknown. In the Rhodesian Copperbelt, the granitic basement is thought to be the source of copper, cobalt and uranium. In the Kasmere Lake area, anoxic conditions prevailed during early aphebian time and may have prevented the complete dissolution of the accessory oxides in the eroded granitic rocks, and much of the copper may have been derived from sulphides from greenstone belts as suggested by Eade (1971) and Davidson (1972).

On the southern flank of the Kisseynew sedimentary gneiss belt, rocks of the Burntwood River Metamorphic Suite are in conformable contact with rocks of the Sherridon Group, and the gross stratigraphy (Robertson, 1953; Pollock, 1961, 1963; Bailes, 1971, 1975) appears to be similar to that encountered on the north flank of the gneiss belt.

In the Russick Lake and Duval Lake area Pollock (1961, 1963) reported several occurrences of disseminated pyrrhotite and pyrite with minor chalcopyrite in greywacke migmatite and amphibolite adjacent to and at the top of the metagreywacke succession as well as disseminated pyrite near the base of the meta-arkose (Sherridon Group) succession. Disseminated pyrite, pyrrhotite, chalcopyrite, bornite, molybdenite and graphite in amphibolite at the contact between metagreywacke and meta-arkosic rocks in the Takipy Lake area has been reported by McRitchie et al. (1972). Robertson (1953) reports that in the Batty Lake area disseminated sulphides occur in similar lithologies and at what would appear to be the same stratigraphic position as the occurrences encountered by Pollock (1961, 1963) and McRitchie et al. (1972).

If the meta-arkosic rocks of the Sherridon Group flanking the southern margin of the Kisseynew sedimentary gneiss belt can be correlated with the Sickle Group, the disseminated sulphides in the meta-arkosic rocks in both the Sherridon Group and Sickle Group may be similar in age, origin and stratigraphic position.

CONCLUSIONS

The sulphide mineralization at or close to the Sickle Group — Burntwood River Metamorphic Suite contact is conformable, stratiform and probably sedimentary in origin.

The mineralization is widespread indicating that conditions were favourable and a mechanism conducive for deposition of sulphides operated intermittently over a very large area.

The sulphide deposition was greatest during a period when clastic sediment supply was restricted and euxinic conditions were able to develop in the sedimentary basin.

The source of the metals is still unknown, but it seems probable that they originated from the same terrain that supplied the sediment to the basin: i.e. the Lynn Lake volcanic belt.

The zone most favourable for the occurrence of disseminated copper mineralization is that containing amphibolite, quartzite and carbonate rocks at the top of the Burntwood River Metamorphic Suite and including meta-arkosic rocks in the lower (200 m) part of the Sickle Group.

Types of disseminated stratiform base metal mineralization that might be expected to occur in the area are:

1) Meta-arkose hosted disseminated, conformable and strata-bound copper.
2) Meta-arkose hosted, copper and uranium deposits.
3) Metaconglomerate and/or meta-arkose hosted lead deposits close to pre-Sickle intrusions that occupied paleotopographic highs.

Currently, there are no producing deposits and only a few interesting prospects of Copperbelt or Kufferschiefer type in Manitoba. The present level of information on this type of mineralization in Manitoba is insufficient for a sophisticated treatment of the undiscovered mineral potential in Manitoba. The known occurrences are of limited extent and have low metal values. Nevertheless, the available data suggest that the rocks, and the geological environment in which the rocks were deposited in the Granville, Lake-Uhlman Lake area, the Kasmere Project area, and the Sherridon region are favourable to host disseminated stratiform base metal deposits.

Considering that stratiform copper deposits contain about 20 per cent of the world's copper resources (R.V. Kirkham, pers. comm., 1980) and that future work will yield more complete geological data on the gneiss belts of northern Manitoba this important class of ore deposits should not be overlooked as a potential source of recoverable base metals in the Churchill Structural Province in Manitoba.

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APPENDIX

MINERAL OCCURRENCES: A BRIEF DESCRIPTION AND EXPLORATION REVIEW: (NTS 64C and NTS 64B)

Although the Lynn Lake Greenstone Belt has been the main areal target for base metal exploration, the Sickle Group-Wasekwan Group and the Sickle Group-Burntwood River Metamorphic Suite contact zones have received some attention from exploration companies.

This part of the report is meant to serve as a compilation and brief description of disseminated mineralization encountered by the exploration companies. The original data are contained in the cancelled assessment files and Mineral Inventory cards of the Mineral Resources Division, 993 Century Street, Winnipeg, Manitoba. The locations of the occurrences are identified on Map ER 79-5-1 and Map ER 79-5-2. The claim name or property name (e.g. Rock #8) and the Mineral Resources Division cancelled assessment file number (MRD-CAF) are given for each mineral locality in this appendix.

NTS 64C MAP ER 79-5-1

LOCALITY #1, Rock #8, MRD-CAF #90989

1957: Pre-Cam Exploration and Development Ltd. 2 D.D.H.
1961: Trenching
1966-1969: Trenching

The area of the Rock claims is underlain by the post-Sickle Granville Lake gabbro and Sickle Group arenites (Godard, 1966; Cranstone, 1968). The gabbro body is a tabular differentiated intrusion, that consists of a thick basal gabbro zone, overlain by a transition zone of diorite to quartz diorite and an granitic zone of granodiorite to granite. The intrusion and the Sickle Group metasediments are cut by pegmatite dykes.

In the subsurface, exploration diamond drilling intersected a thick sequence of Sickle Group metasediments, the Sickle metaconglomerate and quartz diorite. Mineralization appears to be confined to the quartz diorite. The sulphides occur as sparse disseminated specks of chalcocite and chalcopyrite and as stringers of chalcopyrite.

The differentiation of the rock types in the intrusion indicates that the stratigraphic top of the gabbro body is to the west. If this is so, then the disseminated mineralization occurs closer to the top of the intrusion than the stringer sulphide mineralization.

LOCALITY #2, Lar #5-317, MRD-CAF #91371, #91372

1963: Hudson Bay Exploration and Development Company Ltd. E.M. Survey
1965: Hudson Bay Exploration and Development Company Ltd. E.M. Survey. Diamond Drilling (5,640 feet).

Surface exposures in the area are metagreywackes of the Burntwood River Metamorphic Suite. On Trophy Lake, rocks previously mapped as greywacke-derived paragneisses of the Burntwood River Metamorphic Suite have been re-interpreted as Sickle-type arkosic rocks (Lenton, 1976). Aeromagnetic maps of the area indicate that these Sickle-type arkosic rocks may continue in the subsurface, eastward from Trophy Lake. Sickle-type arkosic gneisses and amphibolite have been encountered in the diamond drill holes on the property. "Nodules" in quartz-biotite-hornblende gneisses, recorded in the drill logs could possibly be quartz-sillimanite-muscovite knots that are common in Sickle Group rocks.

The stratigraphic succession in the area would appear to be overturned. In drill core from top to bottom of the drill holes, the rocks encountered are as follows:

(1) Metasedimentary greywacke gneisses with some graphitic zones. (Burntwood River Metamorphic Suite).
(2) Amphibolites
(3) Quartz-biotite-hornblende gneisses, quartz-plagioclase-biotite gneisses, quartz-plagioclase-biotite-hornblende gneisses (Sickle Group).

Sulphide mineralization occurs in the amphibolite rocks and the Sickle Group rocks. Massive barren pyrrhotite and pyrite + quartz (sulphide facies iron formation?) zones are present as thin bands throughout the amphibolite. In the Sickle Group gneisses, zones of up to 350 feet in thickness containing disseminated to semi-massive pyrrhotite, pyrite and minor (a few specks) chalcopyrite have been recorded in the diamond drill logs. Assays of the mineralized intersections are not available.

LOCALITY #3, Vil #1-39, MRD-CAF #90980, #90982, #91396

1965: Kerr Addison Mines Ltd. Ground E.M. Survey, 27 conductors
1965-1966: Kerr Addison Mines Ltd. Diamond drilling. 10 D.D.H. totalling 2298 feet.

The area of the claim group is underlain by fine grained, granoblastic biotite and biotite-muscovite bearing, regularly bedded greywacke, schist and siltstone plus well banded, evenly layered and coarse grained amphibolites (Barry, 1965; Campbell, 1972; McRitchie, 1974). Small intrusions of gabbro and pegmatite are present locally.

The sulphide mineralization is confined to the amphibolite. Four zones of disseminated pyrite and pyrrhotite with scattered specks of chalcopyrite and sphalerite are associated with the more siliceous bands in the amphibolite. Reported assay values for mineralized zones in one of the drill holes are summarized below.

Sample Length	% Cu
1.2′	0.01
.6′	0.02
5.6′	0.02
1.5′	0.03
1.0′	0.05

LOCALITY #4, Gran #9-35 (formerly Moss 7, 8 and Wax 1-43); MRD-CAF #90981, #91364, #91859

1952: Hudson Bay Exploration and Development Co. 12 D.D.H. totalling 4361 feet.
1963: Prospectors Airways Co. Ltd. Ground E.M. Survey.
1964-1970: Trenching

Metasedimentary, fine grained, granoblastic, mica-poor quartzo-feldspathic rocks that are massive to coarsely layered and amphibolite rocks (Burntwood River Metamorphic Suite) underlie the area of the claim group. Well bedded Sickle Group arkose and conglomerate crop out on the south shore of Granville Lake less than one mile to the north of the property. The rocks in the area strike east-west and dip moderately (40° to 60°) to the south.

In diamond drill core rocks of the Sickle Group have been intersected below the amphibolitic rocks. The stratigraphic succession would therefore appear to be overturned. In order for Sickle Group rocks to be present in the subsurface about one mile away from their nearest outcrops which show dips of bedding to be 40° to 45°, the rocks must be tightly folded and the enveloping surface of the units must be very flat lying.

Sulphide mineralization is present in both the Burntwood River Metamorphic Suite and the Sickle Group rocks. In the Burntwood River Metamorphic Suite massive sphalerite, pyrite, chalcopyrite and minor galena occur in a shear that is parallel to the bedding. In the shear, the sulphides occur in lenses that are 7 to 25 cm in width. Parts of the shear contain stringers of quartz and minor carbonate with disseminated sulphides. The zone is exposed intermittently for about 100 m along strike (Barry, 1965). A channel sample collected across 25 cm of the best exposed massive sulphide lens assayed: 22% Zn, 1.03% Cu, 0.94% Pb, 2.6 oz/ton Ag and trace Au. Diamond drilling failed to prove continuity of the zone at depth. The amphibolites intersected are heavily mineralized with disseminated pyrrhotite, pyrite and very minor chalcopyrite. In the Sickle Group rocks the drill logs contain reports of disseminated pyrrhotite, pyrite plus minor disseminated chalcopyrite and sooty chalcocite. The copper and iron sulphides occur separately from each other. This may be a manifestation of primary zoning similar to that at Kadeniuk Lake (Baldwin, 1976). Assays for the mineralization encountered in the diamond drilling are not reported.

LOCALITY #5, Jim Claim Group, MRD-CAF #90979, #91370

1960: Prospectors Airways Co. Ltd. Ground E.M. Survey
1961: Prospectors Airways Co. Ltd. Diamond drilling totalling 508 feet in six holes.
1962: Prospectors Airways Co. Ltd. Diamond drilling of two shallow holes.

The claim group is underlain by metasedimentary rocks and amphibolites of the Burntwood River Metamorphic Suite. Basal Sickle Group conglomerate and meta-arkosic rocks crop out within about 60 to 100 metres of the sulphide showing that prompted the staking and exploration work on the claim group. Small irregular masses of gabbro, diorite and pegmatite intrude the Burntwood River Metamorphic Suite rocks but it is not known whether they intrude into the Sickle Group rocks. Structurally, the rocks have been folded into an antiform, the east limb of which is overturned as evidenced by top directions facing east and bedding dipping west (Barry and Gait, 1966).

The geophysical survey and subsequent diamond drilling were prompted by a base metal prospect in Burntwood River Metamorphic Suite rocks approximately 15 m away from a gabbro-metasediment contact. The best reported assays from this prospect were 7.0% Zn and 1.5% Cu across seven feet. In the diamond drilling, 1.5 to 6 m intersections contained up to 30% disseminated pyrrhotite with some pyrite and visible chalcopyrite. The best assays obtained from these intersections were 1.02% Cu and 0.6% Zn over 1.5 m. The irregular gabbroic and pegmatitic masses are not mineralized.

LOCALITY #6, Jet #745-766; MRD-CAF #90984, #91360, #91368

1962: Hudson Bay Exploration & Development Co. Ltd. E.M. Survey.
1963: Hudson Bay Exploration & Development Co. Ltd. Diamond drilling totalling 846 feet in four holes.

The bedrock geology in the area is dominantly Burntwood River Metamorphic Suite greywacke-derived migmatite (Lenton, 1975). A large north-northwest trending outlier of Sickle Group rock is exposed just to the east of the property. The Sickle Group rocks occupy the core of a large synclinal structure.

The EM conductor tested, is parallel to a long linear zone that is readily discernable on air photos of the area. These linear structures have been interpreted as fault zones (Baldwin, 1974; McRitchie, 1975; Lenton, 1975).

The mineralization encountered in the diamond drill holes is contained in the greywacke metatexite. Graphite with 2 to 3 cm bands of massive pyrrhotite and pyrite are common. Very minor chalcopyrite and molybdenite were recorded in the drill logs. No assays have been recorded. The mineralization is parallel to and appears to be contained in the fault zone.

LOCALITY #7, Mat Group; MRD-CAF #91362

1962: Hudson Bay Exploration & Development Co. Ltd. E.M. survey located one hundred and four conductors ranging from poor to very good in strength and conductivity.
1963: Hudson Bay Exploration & Development Co. Ltd. Diamond drilling of 6 holes totalling 831 feet.

The area of the claim group is underlain by greywacke metatexite and amphibolite of the Burntwood River Metamorphic Suite (Baldwin, 1974). There are no Sickle Group rocks exposed in the immediate vicinity of the property nor were they encountered in the diamond drill holes.

Graphite, with pyrrhotite and pyrite are present in the greywacke metatexites. Disseminated pyrrhotite and pyrite were encountered in the amphibolites. Base metal sulphides do not appear to be present.

The numerous EM anomalies are probably due to the abundance of graphite in the greywacke metatexites.

LOCALITY #8, CB6684, CB6685; MRD-CAF #92026

This occurrence has been described in detail elsewhere (Baldwin, 1976) and only a brief summary will be presented here.

The area is underlain by Precambrian migmatites derived from greywacke and arkosic sedimentary rocks. The greywacke-derived migmatites of the Burntwood River Metamorphic Suite are the most abundant of the supracrustal rocks in the Kadeniuk Lake area. Sickle group migmatites, derived from arkoses and lithic arenites, lie in fold controlled outliers. Thinly layered amphibolite, calc-silicate rock, quartzite, marble and garnet amphibolite are conformable with and mark the top of the Burntwood River Metamorphic Suite and are conformably overlain by the Sickle Group.

Polyphase deformation, and metamorphism to upper amphibolite facies, have obscured primary features and resulted in a complex geological history that is extremely difficult to unravel. Intense polyphase deformation and high grade metamorphism have obscured stratigraphic detail. Nevertheless, from the examination of diamond drill core it appears that there is continuity of layers (beds) down dip toward the north and that the layers (beds) thicken in that direction.

Disseminated copper minerals occur in the basal part of the Sickle Group. The mineralization is conformable with the local layering and stratigraphic contacts. On surface the copper mineralization is traceable for 600 m along strike, and from a few centimetres to three metres across the strike. Chalcopyrite, bornite, native copper and chalcocite have all been observed but chalcopyrite predominates. Individual mineralized units are copper rich at the base, and Cu:Fe ratios decrease gradually upwards with decreasing copper and increasing iron in the sulphides.

Stratigraphic Column of the Kadeniuk-Kamuchawie Lake Areas

Sickle Group	TOP	Ore Mineralogy
up to 300 m	top not exposed knotted arkose (sillimanite faserkiesel)	
	gradational	
300 to 500 m	biotite meta-arkose	
	gradational	

Sickle Group	TOP	Ore Mineralogy	
0 to 250 m	hornblende meta-arkose, minor biotite meta-arkose	Cp, Bn, native Cu, chalcocite	Up to 3.7% Cu
	gradational		
0 to 350 m	metagreywacke		
	conformable sharp		
Burntwood River Metamorphic Suite			
0 to 250 m	thinly interlayered amphibolite, quartzite, marble, and garnet amphibolite	Py, Po, minor Cp	
	conformable — sharp		
100 + m	greywacke migmatite	minor Py, Po	
	BASE unknown		

ORE MINERALOGY

Primary ore minerals are pyrite, pyrrhotite, chalcopyrite, bornite, native copper, molybdenite and magnetite. Malachite, chalcocite, native copper, marcasite and hematite are secondary ore minerals near the surface and along fractures but are generally present in only minor amounts.

Except for molybdenite and native copper, the primary minerals occur as disseminated equidimensional grains uniformly distributed throughout the mineralized rocks, generally having the same size as the silicate crystals (grains). Iron sulphides are most abundant with lesser chalcopyrite and minor bornite in some localities. The copper and iron sulphides are zonally distributed. The zonation in the mineralized rocks is from a copper sulphide rich base passing stratigraphically upwards into more iron rich sulphide minerals.

Native copper occurs as thin foils which are interstitial coatings on and in quartz and feldspar grains. Fine native copper dust occurs included in feldspar grains giving them a copper red colour.

Molybdenite is concentrated in anatectically derived mobilizate in migmatites. It forms disseminated blebs which are unequally distributed in the mobilizate.

The secondary minerals form coatings on fractures and shear planes.

Malachite encrusts silicate grains and, rarely, occurs as pseudomorphs after native copper. Dendritic chalcocite and marcasite coat quartz and feldspar grains. Native copper also occurs as thin smears and foils on shear planes and in fractures. Hematite occurs as pseudomorphs after iron sulphides, particularly pyrite, and locally replaces magnetite.

ORE MINERAL RELATIONSHIPS

Iron sulphides (pyrite, pyrrhotite) and magnetite occur in two modes, by themselves, and with chalcopyrite.

Where chalcopyrite and iron sulphide co-exist, the chalcopyrite is either included within the iron sulphide or is interstitial between the iron sulphide and silicate minerals. In some zones chalcopyrite is present as the only ore mineral.

Bornite occurs with chalcopyrite and by itself. Where it is present with chalcopyrite it can be included in chalcopyrite, interstitial between chalcopyrite and silicate minerals or enclosing the chalcopyrite. Bornite has not been observed in association with the iron sulphides.

Where native copper is present it occurs as the only ore mineral in the rock.

Magnetite often occurs in association with iron sulphides but not in direct contact with them. Where magnetite and chalcopyrite co-exist, the latter is a very minor constituent; the two minerals have not been seen in contact. Bornite and magnetite have not been found in the same rock.

HOST ROCK — ORE MINERAL RELATIONSHIPS

Iron sulphides and, less so, chalcopyrite have been found in all of the rocks present. Bornite, native copper, magnetite and ilmenite are confined to Sickle Group rocks. Iron sulphides (po, py) are dominant in the Burntwood River Metamorphic Suite and chalcopyrite is subordinate. Iron sulphides, chalcopyrite and bornite occur in all rock types of the Sickle Group. Native copper observed in drill core and hand sample is confined to the biotite meta-arkose. Magnetite and ilmenite are more prevalent in the hornblende meta-arkose and though present in minor amounts in the biotite meta-arkose, are never seen in association with copper sulphides.

MINERAL ZONING

Although the rocks are highly deformed and recrystallized, primary mineral zoning is preserved.

In diamond drill hole S-3-75 an intersection of sulphide mineralization is as follows:

23'0" - 25'8"	Fe sulphide
25'8" - 30'0"	Fe sulphide plus chalcopyrite
30'0" - 30'6"	Barren
30'6" - 32'0"	Chalcopyrite
32'0" - 35'4"	Barren
35'4" - 37'0"	Bornite plus chalcopyrite
37'0" - 38'0"	Native copper

Similar zoning is present in a mineralized intersection from diamond drill hole S-2-75.

2'6" - 3'0"	Fe sulphide
3'0" - 4'6"	Barren
4'6" - 20'8"	Fe sulphide plus chalcopyrite with amount of chalcopyrite increasing with depth in hole
20'8" - 23'6"	Bornite plus chalcopyrite
24'6" - 25'8"	Barren
25'8" - 26'1"	Native copper
26'1" - 26'9"	Barren
26'9" - 27'6"	Bornite plus chalcopyrite

Zoning in diamond drill hole S-1-75 is not as well defined in holes S-2-75 and S-3-75. But in general, intersections mineralized with sulphide show a copper-rich to iron-rich zonation.

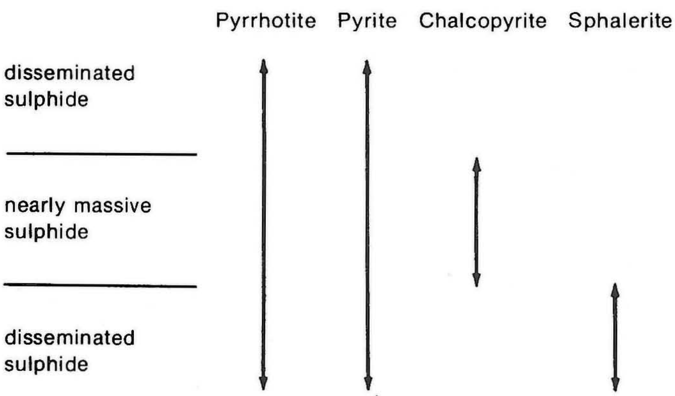
LOCALITY #9, CB2795; MRD-CAF #91640

1973: Hudson Bay Exploration & Development Co. Ltd. E.M. Survey

1973: Hudson Bay Exploration & Development Co. Ltd. Diamond Drilling of four holes totalling 1138 feet.

The rocks in this area and the rocks described in the drill logs are Sickle Group meta-arkosic gneisses.

Sulphide mineralogy is dominantly pyrrhotite and pyrite with trace to 3 per cent chalcopyrite. The 3 per cent chalcopyrite occurs in a zone of massive sulphide. Disseminated chalcopyrite forms a haloe above and below the massive zone. Specks and traces of sphalerite occur with disseminated pyrrhotite and pyrite but separate from the chalcopyrite. The mineral zoning is presented diagramatically below.



LOCALITY #10, CB2966; MRD-CAF #91603

1974: Hudson Bay Exploration & Development Co. Ltd. E.M. Survey

1974: Hudson Bay Exploration & Development Co. Ltd. 7 diamond drill holes totalling 2317 feet.

The occurrence area is underlain by Sickle Group quartzofeldspathic arkosic metasedimentary rocks and hornblende-plagioclase schists and massive rocks (amphibolites) that possibly have a volcanic origin. These rocks strike east, dip moderately to the south and possibly young toward the north (Barry, 1965). The succession would therefore be overturned toward the north.

With the exception of a few intersections of disseminated pyrrhotite and pyrite in the hornblende-plagioclase schists and massive rocks, most of the sulphide mineralization is in Sickle Group rocks. This mineralization is finely disseminated pyrrhotite and pyrite with traces of chalcopyrite and sphalerite. The sphalerite occurs separate from the chalcopyrite. Assay values are not available for mineralized intersections.

NTS 64B MAP 79-5-2

LOCALITY #1, Tel Group; MRD-CAF #90722

1966: Hudson Bay Exploration & Development Co. Ltd. Ground E.M. Survey

1966: Hudson Bay Exploration & Development Co. Ltd. Diamond drilling, 6 D.D.H.

The rocks in the occurence area are quartzofeldspathic biotite schists and gneisses of the Burntwood River Metamorphic Suite. These rocks are cut by narrow pegmatite stringers and are intruded by bodies of biotite granodiorite.

The sulphide mineralization is contained in the schists and gneisses. Pyrite and pyrrhotite occur as disseminations (5 to 15%) and as narrow massive (75%) sections. Sparse specks of chalcopyrite are present in both the disseminated and massive sulphide sections.

LOCALITY #2, Peg; MRD-CAF #90941

1963: Canadian Nickel Co. Four D.D.H. totalling 1386 feet

The area is underlain by pelitic gneiss and amphibolite (Elphick, 1972) of the Burntwood River Metamorphic Suite.

In the diamond drill records, the rocks encountered are described as hornblende-quartz gneiss, biotite-quartz schist and biotite-garnet gneiss.

The sulphides occur as streaks in the biotite schist. The sulphide mineralogy and the width of the intersections are not stated in the drill logs.