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Structural and Metallogenetic Studies in the Flint-Cameron Lakes Area, District of Kenora

by

Shane Buck

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FOREWORD

The Pipestone-Cameron Deformation Zone in the Flint-Cameron Lakes area is a zone of strongly strained and carbonatized rocks. Several gold occurrences are associated with it. The results of the investigations on this zone reported here will help to better understand the origin of gold occurrences in the Flint-Cameron Lakes area and,in general, will provide insight into Archean gold mineralization environments in the Precambrian of Ontario.

The detailed project described in this report is one component of the Canada-Ontario Mineral Development Agreement (COMDA), which is a subsidiary agreement to the Economic Development Agreement (ERDA) signed by the governments of Canada and Ontario. Within this COMDA agreement several projects including the investigations of structure and metallogeny of the Flint-Cameron Lakes area, have been targetted on the Lake of the Woods - Rowan-Kakagi Lakes - Kenora area. This area has an excellent potential for discoveries of economic gold deposits.

V.G.Milne
Director
Ontario Geological Survey

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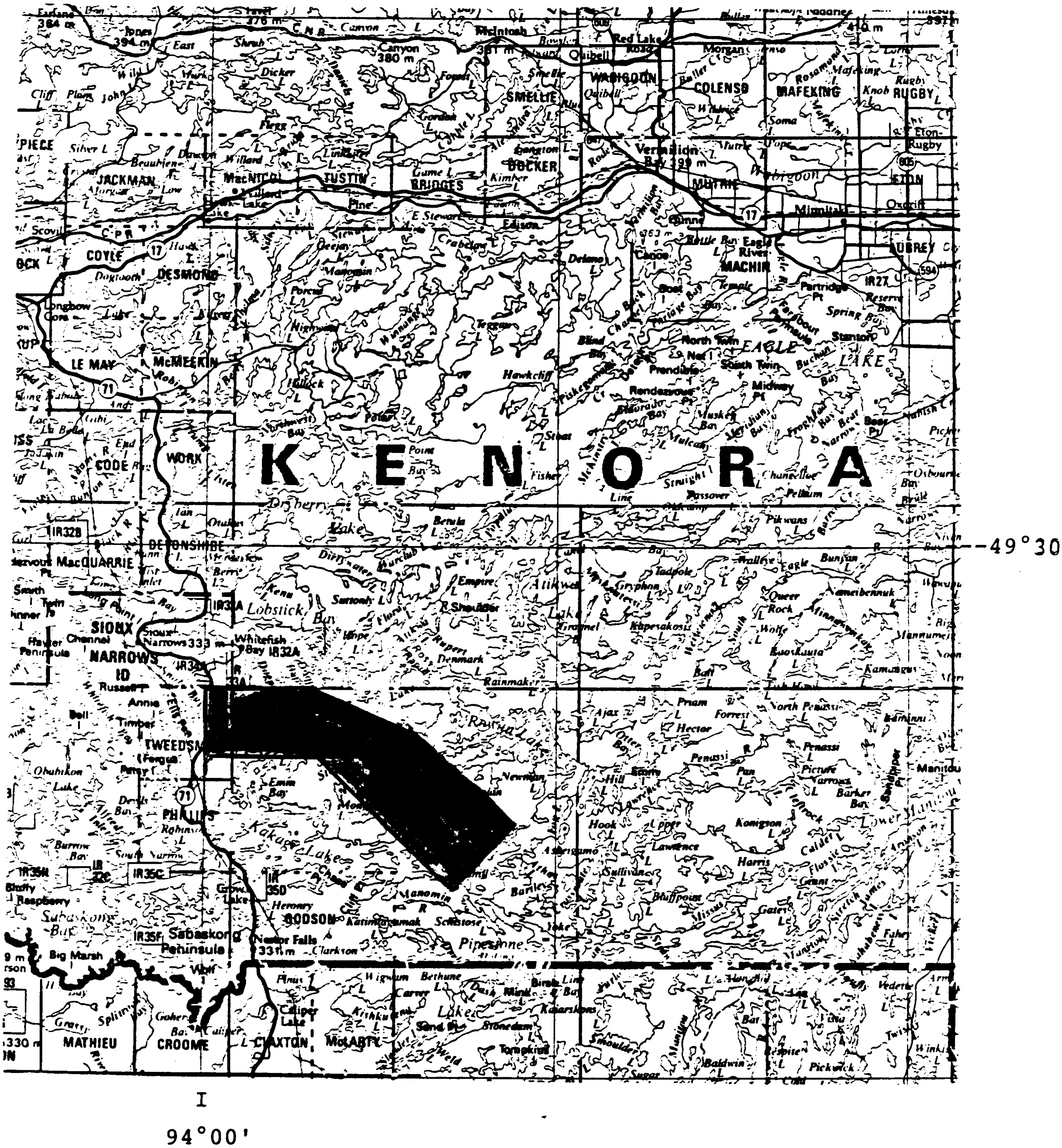

FIGURE 1. Location of Flint-Cameron Lakes
Area in northwestern Ontario.
Scale 1:600 000.

ABSTRACT

Gold occurrences in the Flint-Cameron Lakes area are localized within the Pipestone-Cameron Deformation Zone (PCDZ), a wide zone of highly strained and carbonatized rocks. Locally stratigraphy and regional foliation trends are displaced by the PCDZ and cannot be correlated across the zone. Within the Flint-Cameron Lakes area the PCDZ is up to 3000 m in width and is made up of subparallel and anastomosing, steeply dipping, northwest trending discrete high strain zones. The high strain zones are defined by chlorite +/- carbonate and/or sericite +/- carbonate schists. Within these highly strained rocks stretching lineations and kinematic indicators such as shear fabrics, extensional crenulation cleavage and rotated phenocrysts indicate that both vertical, northeast side up and dextral horizontal displacements have occurred within the PCDZ. U-Pb radiometric ages from the area indicate that the deformation responsible for these displacements occurred during a 12 ma period between 2711.1 and 2699.2 Ma.

Gold mineralization within the PCDZ is associated with ferroan carbonatized high strain zones where gold occurs with sulfides along schistosity planes and in foliation parallel quartz + ankerite veins. Gold occurrences are less common outside of the PCDZ where gold is associated with sulfides in minor ferroan carbonatized high strain zones localized at the contacts of felsic dikes.

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STRUCTURAL AND METALLOGENETIC STUDIES

IN THE FLINT-CAMERON LAKES AREA

DISTRICT OF KENORA

by

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INTRODUCTION

Recent investigations into the environment of Archean lode gold deposits, both throughout Ontario (Colvine et al. 1984) and world wide (Macdonald 1986), have emphasized the important role regional and local deformation play in the mineralization of gold. Evidence from widespread gold camps suggest that while gold deposits occur in a diverse range of lithologies, localization of gold mineralization is dependent on structurally generated sites of permeability. It is generally recognized that deformation zones produced during regional tectonism provide conduits for the transportation of gold bearing hydrothermal fluids to these sites of permeability. The recognition of deformation zones and areas of alteration, indicating hydrothermal fluid flow, provides a useful aid in narrowing the focus of gold exploration.

The Flint-Cameron Lakes area, one part of the larger Rowan-Kakagi Lakes area (Johns in prep), is located in Northwestern Ontario 58 km southeast of the Town of Kenora (Fig. 1). Exploration for gold in northwestern Ontario started as early as 1872 when gold was first discovered near Kenora on the Lake of the Woods. The greatest amount of exploration occurred during the period between 1892 and 1906 when most of the gold occurrences in the Flint-Cameron Lakes area were discovered (Clark 1984). Sporadic exploration continued up until the 1970-1980's when higher gold prices and the discovery of gold at Hemlo spurred renewed interest in gold exploration throughout northwestern Ontario. Continued interest in gold in the Rowan-Kakagi Lakes area has been fueled by the initiation of underground exploration at the Cameron Lake deposit in 1986.

The Flint-Cameron Lakes area is easily accessible by water from the Whitefish Bay Indian Reserve near Sioux Narrows through Dogpaw Lake or from Nestor Falls through Kakagi Lake with only short portages separating the major lakes. An all weather road recently constructed by Nuinsco Resources Limited provides access from Highway 71 south of Sioux Narrows to Cameron Lake. Presently the use of this road is subject to agreement with the operators of the Cameron Lake deposit, Echo Bay Mines Limited. Most lakes in this area are accessible by float equipped planes which are available in Nestor Falls and Kenora.

The Rowan-Kakagi Lakes area is subdivided by the Pipestone-Cameron Deformation Zone (PCDZ), a regional scale zone of intensely deformed and altered rocks, which are geographically associated with many minor gold occurrences. This deformation zone was studied in the Flint-Cameron Lakes area (Fig. 1) as part of a one year reconnaissance project initiated to investigate the regional setting of gold mineralization in the Rowan-Kakagi Lakes area.

REGIONAL GEOLOGY

The rocks of the study area make up a part of the western part of the Wabigoon Subprovince, a major subdivision of the Superior Province. The Wabigoon Subprovince is a granite-greenstone terrane separating the gneissic terranes of the Quetico Subprovince to the south and the English River Subprovince to the north (Fig. 2).

The geology of the western Wabigoon Subprovince including the Rowan-Kakagi Lakes area has been described in detail by several workers (Goodwin 1970, Blackburn et al. 1985, Trowell et al. 1980, Johns 1985, Johns 1986a) and has been mapped in detail (Fig. 3) by Kaye (1976), Davis and Morin (1976), Edwards (1980) and Johns (1984, 1985, 1986a,1986b). For this reason only a brief description of the general geology of the Rowan-Kakagi Lakes area is provided in this report.

Metavolcanic Rocks

In general the volcanic stratigraphy of the western Wabigoon Subprovince consists of a lower mafic tholeiite sequence, overlain by a middle mixed mafic to felsic, calc-alkaline and tholeiitic sequence and in some places capped by an an upper mafic tholeiitic sequence (Blackburn et al. 1985). Only the lower and middle sequence have been recognized in the Rowan-Kakagi Lakes area.

The lower sequence is represented in the Rowan-Kakagi Lakes area by the Populus Lake and Rowan Lake volcanics to the north and east and the Snake Bay formation to the west and south (Fig. 4). These mafic volcanic groups have not been correlated across the

Pipestone-Cameron Deformation Zone (Blackburn et al. 1985). The Populus Lake volcanics occur in the study area at the northern part of Flint Lake and the southern part of Dogpaw Lake (Fig. 4), where they consist of tholeiitic (Johns 1986b) massive and pillowed mafic flows. The Rowan Lake volcanics consist of pillowed and massive mafic flows intruded by synvolcanic gabbroic sills and dikes and are exposed in the study area north of Cameron Lake and at the northeast end of Stephen Lake (Fig. 4). The Snake Bay formation is best exposed west of Cedartree Lake and consists of massive, pillowed and plagioclase phyric flows intruded by synvolcanic gabbro sills. Chemical analysis of the Snake Bay formation (Johns 1986b) indicates that the mafic volcanics can be divided into a lower magnesium tholeiite group and an upper iron tholeiite group. Johns (1986b) points out that although the Populus Lake volcanics and the Snake Bay formation are similar chemically, correlation between the two is unreliable due to their separation by the Pipestone-Cameron Deformation Zone.

Within the Flint-Cameron lakes area, the middle sequence of the volcanic stratigraphy is represented by the Dogpaw Lake volcanics, the Cameron Lake volcanics and the Kakagi Lake group (Fig. 4). The Dogpaw Lake volcanics are exposed at the southern end of Dogpaw Lake where they consist of calc-alkaline, (Johns 1986b) mafic tuff and tuff breccia. Overlying the Rowan Lake volcanics at the northern part of Cameron Lake are the Cameron Lake volcanics (Blackburn and Hailstone 1983), a mixed sequence of mafic flows, mafic intrusive rocks and intermediate to felsic pyroclastic rocks. The Cameron Lake volcanics, the Dogpaw lake volcanics and the Hill Lake volcanics (Chivers 1986), to the east, are the only rock units of the middle sequence of volcanic stratigraphy recognized north of the Pipestone-Cameron Deformation Zone in the Rowan-Kakagi Lakes area.

Within the study area, mafic rocks of the Cameron Lake volcanics consist of massive and pillowed flows, and synvolcanic gabbro sills. Intermediate to felsic rocks include a distinctively coarse-grained crystal tuff and a quartz-sericite-carbonate schist, both of which are exposed on islands in the northern part of Cameron Lake. This latter unit may represent a sheared and altered synvolcanic sill or a quartz-plagioclase porphyry intrusion.

West of the Pipestone-Cameron Deformation Zone, the middle stratigraphic sequence is represented by the Kakagi Lake group. This group of calc-alkaline intermediate to felsic pyroclastics (Edwards 1980), unconformably overlies the Snake Bay formation and has been divided into five formations (Johns,1985); the South Kakagi Lake, East Kakagi Lake, Emm Bay, Cedartree Lake and the Stephen Lake formations. Only the three upper formations are observed in the present study area (Fig. 4).

The lowest unit of the Kakagi Lake group present in the study area is the Emm Bay formation. Good exposures of this formation are observed at the north end of

Cedartree Lake and in the Flint Lake area. At these locations the Emm Bay formation consists predominantly of intermediate, heterolithic tuff breccia with minor interbeds of tuff and lapilli tuff. The tuff breccia units are dacitic in composition (Davies and Morin 1976) and consist of light grey-green fragments in a darker green, fine-grained tuffaceous matrix. In most parts of this area the tuff breccia has been deformed by the Emm Bay-Peninsula Bay syncline and the Pipestone Cameron Deformation Zone (PCDZ) and is moderately to strongly foliated. At many locations, especially in the Flint Lake area, deformation has produced very elongate breccia fragments in a schistose matrix.

The Emm Bay formation is also exposed within the study area along the western shore of Cameron Lake where it consists of mafic tuff and intermediate to felsic tuff and tuff breccia. In most places these rocks have been subjected to deformation related to the Pipestone-Cameron Deformation Zone and are represented by chlorite and sericite schists.

The Kakagi Lake group has been investigated by Johns (1985) who classified the group according to volcanic facies. The Emm Bay formation in the north Cedartree Lake area and the west Cameron Lake area are interpreted by Johns (1985) as debris flows in both proximal and distal volcanic enviroments.

The Emm Bay formation is conformably overlain by the Cedartree Lake formation which consists dominantly of intermediate tuff with minor units of tuff breccia, cherty tuff, chert and rare thinly bedded wacke. The Cedartree Lake formation is exposed at the northeast end of Cedartree Lake, the south end of Flint Lake and at the southeast end of Stephen Lake. At these locations the Cedartree Lake formation consists of relatively homogeneous fine-grained tuff with rare minor chert units. In most areas these units are moderately to highly foliated and in the Flint Lake area commonly altered, making it difficult to recognize bedding. However, well developed bedding is observed in chert layers exposed on the east shore of Cedartree Lake where primary sedimentary structures provide stratigraphic facing direction. The tuff is dacitic in composition (Davies and Morin 1976) and is considered to represent both distal and epiclastic volcanic facies (Johns 1985).

The uppermost unit of the Kakagi Lake group is the Stephen Lake formation. This formation is present within the study area on and north of Stephen Lake, where it consists of well bedded fine-grained tuff, siltstone sandstone and chert. Graded bedding and other sedimentary structures are common and easily recognized as this formation is strongly foliated only at the boundaries of the Pipestone-Cameron Deformation Zone north of Stephen Lake. The tuff is dacitic (Davies and Morin 1976) and represents both a distal and epiclastic volcanic facies (Johns 1985). A sample of this tuff was dated using U/Pb zircon methods by Davis and Edwards (1982) providing an age of 2711.1 + 1.3, - 1.2 Ma.

Metamorphosed Mafic Intrusives

The Emm Bay and Cedartree Lake formations are intruded by the Kakagi Lake Sills (Davies and Morin 1976). Although these differentiated, peridotitic to gabbroic sills are conformable to the volcanic units within the study area they have been observed to cross-cut the volcanic stratigraphy south of the study area (Johns 1985) and therefore appear to have been emplaced after deposition of the Emm Bay and Cedartree Lake formations. Within the study area these sills are best exposed in the Flint Lake area where they are commonly strongly schistose due to deformation associated with the PCDZ. A U-Pb zircon age of 2724 + 2.5, - 2.3 Ma has been determined from one of these sills (Davis and Edwards 1982).

During the present mapping a number of thin (less than 1 m) mafic dikes were observed intruding the volcanic units of the Emm Bay formation in the Flint and Dogpaw Lake areas. These dikes have intruded in an irregular fashion but clearly cross-cut the pyroclastic units (Photo 1). The dikes were most commonly observed in the Flint Lake area where deformation associated with the PCDZ has transformed the dikes into boudinaged "pods" of chlorite schist within a matrix of intermediate volcanics transformed into sericite + chlorite schists (Photo 1).

Felsic Intrusive Rocks

The Flint-Cameron Lakes area is surrounded by several massive, granitic batholithic complexes (Fig. 2). These include the Aulneau and Sabaskong Batholiths to the west, the Dryberry and Atikwa Batholiths to the north, the Lawrence Lake Batholith to the east and the Rainy Lake and Irene-Eltrut Batholiths to the south. U-Pb zircon age dating by Davis and Edwards (1986) have provided a single age of 2723.2 +/- 1.8 Ma for the Sabaskong Batholith and two ages of 2716.8 + 4.9, - 2.8 Ma and 2709.6 + 3.9, - 1.5 Ma for separate phases of the Aulneau Batholith.

Early felsic intrusive rocks ranging from granodiorite to quartz, plagioclase and quartz+plagioclase porphyries are found as sills and dikes throughout the study area and are especially common in the area west of Cedartree and Flint Lakes (Fig. 3). These intrusions range in thickness from less than 1 m to 10 m and generally are less than 100 m in length. These early felsic intrusions are moderately to strongly foliated and are often altered by calcium and/or ferroan carbonate.

The Stephen Lake Stock (Fig. 3) is a massive, medium-to coarse-grained granodiorite intrusion which intrudes the Cedartree Lake formation. Where it was observed in the study area, the stock is unfoliated and with the exception of a narrow hornfels contact metamorphic aureole, has had little effect on the surrounding volcanic units. The Stephen Lake Stock has been interpreted as a late to post tectonic intrusion and has been U-Pb zircon age dated by Davis and Edwards (1982) at 2699.2 +/- 1.9 Ma.

METAMORPHISM

With the exception of the hornfels aureole around the Stephen Lake Stock, all of the rock units in the study area have been metamorphosed to lower greenschist facies rank.

STRUCTURAL GEOLOGY

Two areas of distinctly different structural character were outlined in the Flint-Cameron Lakes area (Fig. 5). The dominant structural style in this area is characterized by high strain zones associated with the Pipestone Cameron Deformation Zone. However in the Cedartree Lake area, structures representative of a more regional deformation style were observed.

Cedartree Lake Area

The Cedartree Lake area is outlined as that part of the study area which includes the northern limb of the Emm Bay -Peninsula Bay Synform (Figs. 3 and 5).

The Emm Bay-Peninsula Bay synform is outlined by stratigraphic younging directions found in the volcanics and by differentiation trends in the Kakagi Lake Sills (Davies and Morin 1976) and is clearly defined by the map pattern south of Cedartree Lake (Fig. 3). This structure is subvertically plunging with a northeast trending, steeply dipping axial surface and refolds an earlier, shallow plunging regional syncline (Osadetz 1979). Evidence supporting Osadetz's interpretation of an earliar folding event was observed during the present study on the north shore of Stephen Lake where reversals in younging direction in fine-grained tuffs and chert outline a shallow plunging syncline. The position and trend of this structure corellates with the syncline outlined by Osadetz (1979).

Small scale folds associated with the Emm Bay-Peninsula Bay synform have been observed in the area immediately west of the Stephen Lake Stock (Osadetz 1979). In the present study area small scale folding was observed in thinly laminated tuff units between Flint and Cedartree Lakes (Photo 2). At this location the folds are northeast trending, plunge to the northeast (078/50) and are cut by a well developed spaced cleavage axial planar to the folding, suggesting that these small scale folds may be parasitic to the larger scale Emm Bay-Peninsula Bay synform. In several places folded layering has been displaced along the cleavage (Photo 2), and therefore these folds may be slip folds produced due to movement along the cleavage and may post date the larger Emm Bay-Peninsula Bay structure.

The dominant foliation in the Cedartree Lake area is an axial planar cleavage associated with the Emm Bay-Peninsula Bay Synform. As this fabric is cut and/or displaced by shear fabrics within the PCDZ it is referred to as S1. S1 is defined by a wide spaced cleavage, weak alignment of breccia fragments and a weak schistosity in the finer-grained matrix of the breccia units. The general trend of this foliation away from the margins of the PCDZ is 242/90 (Fig. 6). In the northern part of Cedartree Lake the foliation becomes progressively rotated by the PCDZ to an average trend of 260/88 (Fig. 6).

In several places minor zones of high strain were observed parallel to the axial planar cleavage. These zones were most common in the northern part of the area closer to the margins of the PCDZ. Although rotational structures were rarely observed in these zones, subhorizontal elongation and mineral lineations suggest that there has been extension parallel to the foliation. Other small scale structures which also indicate extension include breccia fragments which are fractured and separated along the foliation and also arrays of tensional fractures parallel to the foliation (Photo 3). Conjugate shear fractures were observed in several of these high strain zones (Berger and Summers 1987). These fractures form with the acute angle of intersection bisected by the foliation (Photo 4) and may indicate that these high strain zones were in part the result of pure shear. In many places the axial planar cleavage is displaced dextrally by steep dipping to vertical, east striking shear zones which may be related to the PCDZ.

The axial planar foliation associated with the Emm Bay-Peninsula Bay synform was observed up to 2 km west of Cedartree Lake. West of this the mafic basalts of the

Snake Bay formation are generally massive and unfoliated. South and east of the Cedartree Lake area several folds related to the Emm Bay-Peninsula Bay synform have been outlined by the mapping of Kaye (1981) and Davies and Morin (1976). Like the Emm Bay-Peninsula Bay syncline these folds have steeply dipping axial surfaces and plunge steeply. Foliations observed by these mappers and by Edwards (1980) further to the east are northeast to east trending and presumably represent S1 in these areas. Although S1 rotates into the PCDZ (Fig. 7) it was observed at several locations within the PCDZ where lithons of relatively undeformed rocks exist.

The area west of Cedartree Lake does not show any evidence of the high strain associated with the PCDZ and therefore was included as part of the Cedartree Lake Area. The S1 foliation characteristic of the Cedartree Lake Area can only be traced up to 2 km west of Cedartree Lake. Further west in the study area the rocks are either undeformed or irregularly foliated. Felsic dikes common throughout the area west of Cedartree Lake have contacts which are commonly higly strained and in some cases carbonatized. Stretching lineations are rare in these high strain zones but those observed suggest that displacement within these discrete high strain zone was dominantly subhorizontal.

The Pipestone-Cameron Deformation Zone

The Pipestone Cameron Deformation Zone (PCDZ) is defined by a wide zone of highly strained and carbonate altered rock which has been traced from the Chisholm Island area (Buck and Ayer 1987) in Lake of the Woods in the north, to the Pipestone Lake area in the south (Edwards 1980).

Within the study area the PCDZ was traced from Otterskin Lake in the south, to the southern part of Dogpaw Lake in the north (Fig. 5). The PCDZ is outlined in this area as a northwest trending zone of strongly foliated and/or lineated rocks varying in width from 500 m to 3000 m. Within these boundaries the PCDZ is made up of subparallel, discrete high strain zones 1 m to 400 m in width, alternating with lithons of less deformed rock. These high strain zones are represented in mafic lithologies by chlorite schists and in felsic rocks by sericite +/- quartz schists. In some cases, due to intense shearing and alteration, a compositional layering is developed parallel to the deformation zone boundaries and the original rock type is difficult to determine.

Regional geological maps (Fig. 3) and foliation trajectory maps (Fig. 7), reveal that stratigraphy and foliation are rotated dextrally into the PCDZ. Within the PCDZ both stratigraphy and foliation are subparallel to the deformation zone.

Based on foliation and lineation trends, the PCDZ was subdivided into three separate structural domains;the Cameron Lake, Flint Lake and Dogpaw Lake domains (Fig. 5).

The Cameron Lake Domain

The Cameron Lake domain includes that part of the study area from the southern end of Otterskin Lake to the northern end of Stephen Lake. Based on the consistent northwest foliation trend and the presence of, with one exception, easterly plunging mineral and elongation lineations, this area has been designated as a separate domain within the PCDZ.

The dominant foliation in this domain is parallel to and associated with the high strain zones defining the PCDZ and therefore is referred to as S2. Within the high strain zones S2 is defined by an intense schistosity. One of the best exposures of a high strain zone was observed in the southeast part of Cameron Lake (Fig. 8), where the high strain zone is defined by up to 400 metres of sericite +/- carbonate schist. This zone separates units of relatively undeformed massive mafic flows to the north and intermediate tuff to the south. Within the high strain zone it was impossible to identify a protolith. Thin section analysis of samples from this high strain zone reveals that the rock is finely laminated and consists of alternating bands of recrystallized sericite and plagioclase (Photo 5). This is interpreted as mylonitic layering (Buck 1986) which has developed parallel to the margins of a simple shear zone. The S2 foliation within this shear zone was asymmetrically crenulated both on the vertical and horizontal planes producing both a subhorizontal extensional crenulation cleavage and also a vertical extensional crenulation cleavage (Photo 6). The geometry of these fabrics at this location indicated a vertical movement with a north side up sense of displacement and a horizontal movement with a dextral sense of displacement.

The shear fabric S2 generally becomes less intensely developed away from the discrete shear zones where it is more commonly observed as a widely spaced schistosity which displaces or cuts the earlier S1 foliation which is preserved in these less deformed areas. The average orientation of this earlier (S1) foliation in the Cameron Lake domain is 282/72 (Fig. 9), similar to the trend of the regional foliation outside of the PCDZ. S2 dips steeply to the northeast and has an undulating strike locally. However the domanial trend is relatively consistent with a stereographic maximum of 302/75 (Fig.15).

At several locations in the Cameron Lake domain S-C shear fabrics were observed. These fabrics are best defined in coarse-grained lithologies such as coarse mafic flows, gabbros and quartz +/- plagioclase porphyries (Photo 7). The relative geometry of these shear fabrics can be used to indicate the sense of displacement within a shear zone (Berthe et al. 1979, Simpson 1986). Examples of shear zones with S-C fabrics indicating horizontal displacement and others showing vertical displacement were observed in the Cameron Lake domain.

Lineations were measured on foliation planes and included mineral lineations and elongation lineations defined by the long axes of lapilli and block fragments and in some cases recrystallized mineral aggregates. These lineations are most commonly recognized in high strain zones where they can be used to indicate the relative direction of movement within the shear zone. Two discrete sets of stretching lineations, one steeply east plunging and another shallow east plunging were observed in the Cameron Lake domain. A stereonet plot of these lineations (Fig. 9) shows the steeply east plunging set at 072/58 and the shallow east plunging to horizontal set with variable attitude (Fig. 9). The third set shown in Figure 9 is northwest plunging but is based on only a small number of lineations observed in several outcrops at the northeast side of Stephen Lake. An extensional crenulation cleavage observed at this location plunges to the northeast, perpendicular to the lineation supporting the evidence of local northwest side up movement indicated by this isolated lineation trend.

An exception to the general northwest trend of foliation in the Cameron Lake domain was observed in the north part of Cameron Lake where a large high strain zone is outlined by up to 100 m of quartz + plagioclase + sericite schist (Fig. 8). At the eastern side of the lake this zone has an easterly trend, oblique to the PCDZ. Further west this zone rotates to a northeast trend. S-C fabrics observed within this zone (Photo 7) suggest a dextral, subhorizontal displacement. At several other locations within the same zone rotated phenocrysts seen both in outcrop and in thin section

(Photo 8) suggest that vertical, south side up sense of displacement has occurred. This shear zone may represent a splay off of a larger shear zone within the PCDZ or it may represent an extension of the Monte Cristo Shear Zone to the north, where a similar style of deformation has been reported by Melling et al. (1986).

Flint Lake Domain

The Flint Lake domain includes that part of the PCDZ from the south end of Dogpaw Lake to the northeast end of Stephen Lake (Fig. 5). This domain is defined by a well developed foliation with an average trend of 282/74 (Fig. 10). This foliation is generally parallel to the numerous high strain zones observed in this domain and is interpreted as S2. S1 is present in less deformed parts of the domain where its trend averages 264/70 (Fig. 10). Subhorizontal mineral and elongation lineations (Fig. 10), indicate that the dominant direction of motion within the high strain zones of this domain was horizontal. However, rare steep plunging lineations were observed in the high strain zones of this domain and show up weakly in Figure 10. Although kinematic indicators are poorly developed in this area, S-C fabrics, shear bands or extensional crenulation cleavage, pyrite pressure shadows (Photo 9), and in one location Z folded foliation indicate that the sense of horizontal displacement within the high strain zones was dextral.

The degree of deformation which develops in the high strain zones is best observed by tracing one of the pyroclastic breccia units from outside of the PCDZ where it is relatively undeformed (Photo 3), into the Flint Lake domain where it becomes progressively more deformed (Photo 10). In several cases shearing of the breccia has produced a mylonitic layering (Fig. 10) which has subsequently or syn-deformationally undergone Fe - carbonatization.

In the south and west parts of Flint Lake and south part of Dogpaw Lake the high strain zones can be traced southwestwards (Fig. 11) where they become progressively less foliated with trends similar to the foliation in the Cedartree Lake domain. Within these southwesterly trending high strain zones conjugate shear fractures are observed and are similar to those seen in high strain zones in the Cedartree Lake area.

At the eastern extension of the Flint Lake domain an extensive zone of sericite schist, similar to the zone described at the south end of Cameron Lake in the Cameron Lake domain, was outlined in which extensional crenulation cleavages indicating opposing directions of displacement were observed. At this location the schist is deformed by a subhorizontal extensional crenulation cleavage produced during vertical displacement and also by a subvertical extensional crenulation cleavage produced during horizontal displacement. Lineations parallel to the hinge lines of these crenulations are approximately perpendicular at this location.

Dogpaw Lake Domain

The Dogpaw Lake domain includes only that small area of the PCDZ mapped at the south ends of Dogpaw Lake and Caviar Lake. This domain is defined by a strongly developed S2 foliation with a northwest trend (294/68) similar to that of the Cameron Lake domain but distinct from that of the Flint Lake Domain (Fig. 12). S-C shear fabrics, extensional crenulation cleavage (Photo 11) and subhorizontal elongation lineations (Fig. 12) indicate that movement within this domain was dominantly horizontal with a dextral sense of displacement. In several places stretching lineations and extensional crenulation cleavage suggested oblique motion within this zone with both north side up and north side down senses of displacement being observed.

Minor Shears

The sense of displacement observed in the high strain zones was in almost all cases interpreted from the presence of shear fabrics, extensional crenulation cleavage and/or rotated phenocrysts. However in many areas both within and adjacent to the PCDZ the rotation of markers by small (<1 m wide) discrete shears is observed (Photo 12). In almost all cases the smaller shears are parallel to the PCDZ boundaries and examples of both horizontal and vertical displacement can be observed. In some cases these smaller shears are represented only by thin zones of intense schistosity and simple shear related structures are not observed. These high strain zones may represent planes of flattening or pure shear, but as many were observed in flat lying outcrops they may simply represent vertical shear zones in which the plane of displacement is impossible to observe.

In most cases those smaller shears which show horizontal displacement indicate a dextral sense of displacement. A small number of sinistral shear zones were observed which have a generally north-south attitude and may represent a weakly developed conjugate set of shears. Evidence of vertical displacements was observed in many minor shears within the PCDZ. The dominant sense of displacement indicated by these vertical shears is north side up. However, several vertical shears observed on the northeast shore of Cameron Lake indicate a north side down sense of displacement.

Structural Summary

Based on the styles of deformation present, the Flint-Cameron Lakes area can be subdivided into the Cedartree Lake area and the PCDZ. The following observations summarize the structural character of each area.

Cedartree Lake Area

1. The dominant style of deformation in this area is related to the Emm Bay-Peninsula Bay Synform, a steeply plunging, northeast trending structure which folds an earlier shallow plunging, north trending syncline.

2. A penetrative foliation, S1, is developed axial planar to the Emm Bay-Peninsula Bay Synform. This foliation can be traced regionally and is displaced dextrally by the PCDZ.

3. High strain zones are developed parallel to the S1 foliation in the north part of the area, adjacent to the PCDZ. Conjugate shear fractures were observed within these high strain zones and stretching lineations within the zones indicate subhorizontal displacement along the foliation planes.

The Pipestone-Cameron Deformation Zone

1. The PCDZ is defined by a regional zone of highly strained, schistose and variably carbonate altered rocks up to 3000 m in width. Within the study area the PCDZ can be subdivided into three domains based on foliation and lineation trends.

2. While the Cameron Lake and Dogpaw Lake domains display similar southeast high strain zone and foliation trends, the Flint Lake domain is characterized by easterly trending high strain zones and foliations.

3. Locally, stratigraphy can not be correlated across the PCDZ.

4. Regional geological mapping patterns suggest that stratigraphy north of the PCDZ has been uplifted relative to that on the south side of the PCDZ. Mapping patterns and foliation trajectories also indicate that stratigraphy has been displaced by dextral transcurrent motion along the PCDZ.

5. Kinematic indicators and stretching lineations in the PCDZ indicate that both vertical north side up and dextral horizontal displacements have occurred.

The actual transition from east trending foliation and high strain zones of the Flint Lake domains and the southeast trending foliation and high strain zones of the Dogpaw Lake and Cameron Lake domains can not be clearly defined in the field. The western boundary of the Flint Lake domain is irregular and may be modified by brittle faulting between Caviar and Flint Lakes (Davies and Morin 1976). A distinct change in the strike of foliation and high strain zones was not observed between the Cameron Lake and Flint Lake domains and it may be possible that this boundary is defined by a gradual rotation of foliation into the Cameron Lake domain. However most of the area north of Stephen Lake is low lying or swampy and it is possible that the Cameron Lake domain extends into this area, cutting off the easterly trends of the Flint lake domain.

With the exception of minor discrete shear zones, the area north and east of Flint Lake appears to be relatively undeformed. Wide zones of highly strained rock such as those exposed on the east side of Caviar

Lake (Fig. 11) and north of Stephen Lake (Fig. 8) were not observed north of Flint Lake. Therefore it does not appear that the Dogpaw Lake and the Cameron Lake domains can be extended through this area. A similar situation has been described by Edwards (1980) in the Schistose Lake area, immediately south of the study area, where the southeast trend of the PCDZ gradually changes to an east-west trend in the area south of Otterskin Lake. The trace of the PCDZ has been extended through to the Flint-Cameron Lakes area by Edwards (1980) through air photo linement interpretation.

ALTERATION

Alteration in the Flint-Cameron Lakes area is characteristically confined to the high strain zones associated with the PCDZ. Undeformed rocks are generally represented by pristine textures and typical lower greenschist facies mineral assemblages. Apart from the distinctive carbonate alteration present in many of the high strain zones of the area, the most apparent effect of alteration is the production of chlorite and sericite schists.

In mafic lithologies, ferromagnesian minerals are partially to totally replaced by chlorite with albite generally overgrown by fine-grained epidote and sericite. In intermediate and felsic lithologies, sericite alteration ranges from secondary replacement of albite at grain boundaries and in pressure shadows, to total replacement of albite grains.

The presence of a wide zone of carbonatization, spatially associated with the PCDZ has been reported in past geological investigations in the Rowan-Kakagi Lakes area (Kaye 1976, Edwards 1980, Davies and Morin 1976 and Johns 1984). During the present project two distinctive styles of carbonate alteration were recognized. A weak carbonatization represented by calcite in the least deformed rocks and a more intense ankerite and Fe-calcite carbonatization in the more highly strained rocks. The carbonate minerals were identified with the aid of petrography, X-ray diffraction and staining techniques.

Calcite Alteration

Although carbonate alteration is most obvious within the high strain zones defining the PCDZ, carbonatization in the form of calcite is also common in the less deformed rocks within and adjacent to the PCDZ. Calcite occurs within and adjacent to voids and brittle fractures, which tend to be concentrated in the less deformed rocks adjacent to the discrete high strain zones defining the PCDZ. Outside of the PCDZ calcite is generally observed within late fractures and in some locations as amygdules in mafic flows. Calcite is less common in highly strained rocks, but is observed with quartz, as foliation parallel veins in the Otterskin Lake area.

Moderate to Intense Carbonatization

In almost all cases, high strain zones defining the PCDZ in the Flint-Cameron Lakes area, are accompanied by moderate to intense carbonatization in the form of ankerite and/or Fe-calcite. Alteration within these zones varies from minor fracture filling and carbonate + quartz veining to total replacement of the original mineralogy.

Ankerite +/- Fe-calcite + quartz veining occurs both as thin (less than 1 cm) veinlets and also larger (1-10 cm) veins. The smaller veinlets cross-cut the foliation but are subsequently deformed by continuing strain within the high strain zones (Photo 13). The larger veins are dominantly at a low angle or parallel to the foliation. The presence of quartz filled extension fractures within the veins and pinch and swell structures (Photo 14) indicate that these veins have been deformed in a brittle - ductile fashion by continuing strain.

In several high strain zones, C' structures which crenulate the shear foliation, are infilled by coarse grained ankerite and/or Fe-calcite. Extension within the shear zone causes dilatancy within the C' structure which is subsequently infilled by carbonate (Reilly 1988). Similar examples of this alteration style have been reported in other gold areas of Ontario (Reilly 1988). Examples of this alteration style were observed at an exposure of chlorite schist at the northeast end of Stephen Lake. At this location the C' structures have been infilled by a central core of Fe-calcite bordered on the outside by a rim of ankerite (Photo 15a) suggesting that more than one phase of extension has occurred. At the same location, the carbonate infilled C' structures have been disrupted by continuous strain (Photo 15b).

In more intensely carbonatized rocks ankerite and /or Fe-calcite are present at grain boundaries and also overgrow sericitized plagioclase. For instance, in the highly strained quartz + plagioclase porphyry unit exposed on Cameron Lake, recrystallized tails of quartz and plagioclase phenocrysts have been sericitized and subsequently overgrown by coarse-grained ankerite (Photo 8). Ankerite is also present throughout the fine-grained quartz and plagioclase matrix.

Carbonate alteration was also observed in many small, discrete shear zones outside of the PCDZ. The degree of alteration varies from minor ankerite + quartz veining to complete replacement of the host rock. In the western part of the Cedartree Lake Area, carbonate alteration is isolated in small high strains zones associated with numerous felsic dikes. Both the dikes and the mafic country rock are moderately deformed with carbonate present both in ankerite + quartz veins and as replacement in both rock types.

In moderately to intensely carbonatized mafic lithologies where high strain zones are defined by chlorite schists, typical alteration mineral assemblages consist of chlorite + ankerite + plagioclase +/- epidote +/- sericite +/- Fe-calcite +/- leucoxene +/- pyrite. In more felsic lithologies the high strain zones are represented by sericite schists and typical mineral assemblages are sericite + ankerite + plagioclase +/- quartz +/- chlorite +/- Fe-calcite +/- leucoxene +/- pyrite. In the most intensely deformed and altered rocks where original lithologies are difficult to identify, replacement is close to complete and assemblages consist of sericite + ankerite +/- plagioclase +/- chlorite +/- leucoxene.

Distribution and Timing of Alteration

Carbonate alteration was observed in all rock types in the PCDZ, and showed a general distribution of ankerite +/- Fe-calcite in highly strained rocks and calcite in less deformed rocks. A similar distribution has been reported by Melling et al. (1986) who in describing the Cameron Lake gold deposit reports that calcite is common in the less deformed rocks of the deposit but disappears within the Cameron Lake Shear Zone which is host to the gold deposit. At the same time ankerite is concentrated within the Cameron Lake Shear Zone but is less common outside of the zone.

While calcite is common throughout the PCDZ, ankerite and Fe-calcite appear to be most common north of Otterskin Lake, especially in areas north of Stephen Lake and around Flint Lake. A number of carbonatized high strain zones were outlined in the Otterskin Lake area but alteration consisted of mainly calcite and minor Fe-calcite. This spatial distribution may be significant in that the area most altered by ankerite lies north and west of the Monte Cristo Shear Zone (Fig. 4) and south and east of the east trending shear zones outlined in the Flint Lake area. Hydrothermal fluids may have been concentrated at the intersection of these structures with the main PCDZ resulting in the alteration pattern outlined.

The concentration of carbonate alteration in and adjacent to zones of high strain, and the presence of ankerite overprinting strained and sericitized plagioclase suggests that carbonatization occurred at some time after the initiation of deformation. However the deformation and disruption of ankerite infilled fractures and veins indicates that deformation continued after alteration. The presence of Fe-calcite cores in ankerite infilled C' structures may indicate that more than one period of alteration took place. Melling et al. (1986) proposed a similar sequence of events to explain the formation and subsequent deformation of veins in the Cameron Lake gold deposit.

GOLD OCCURRENCES

The Flint-Cameron Lakes area is host to many small gold occurrences (Fig. 13) and at least one proven deposit, Nuinsco Resources Limited's Cameron Lake Gold Deposit. Many of these occurrences were investigated during the present reconnaissance project in order to determine their place in the regional geological setting. Most of the gold occurrences in the study area were discovered in the early part of this century. Work at that time generally consisted of trenching, channel sampling and some diamond drilling. Typical occurrences which were investigated in some detail during the present project include the Bag Lake, Flint Lake, McLennen and Sewell occurrences and the Caswell-Williams prospect (Fig. 13). The following descriptions of these properties are compiled from recconaissance studies in 1986 and from Assessment Files, Resident Geologist's Office, Ministry of Northern Development and Mines Kenora. For detailed information on these and other gold properties in the Flint-Cameron Lakes area the reader is referred to Davies and Morin (1976), Beard and Garratt (1976) and Assessment files, Resident Geologist's Office, Ministry of Northern Development and Mines Kenora. Several grab samples were taken from gold occurrences and prospective sites during the present project and analysed at the Geoscience Laboratories, Ontario Geological Survey, Toronto. Results of this sampling are shown in Table 1, and the locations where these samples were taken is shown on Figure 14.

The occurrences investigated during this project can be subdivided according to whether they are located within or outside of the PCDZ.

Gold Mineralization within the PCDZ

Gold properties investigated within the PCDZ are all located in the Flint Lake area and include the Flint Lake and Sewell occurrences and the Caswell-Williams prospect.

Table 1   Assay results from samples in the Flint - Cameron Lakes area

Sample Number	SB-01	SB-02	SB-03	SB-04
Au	<2.0	85.0	6.0	2470.0
Ag	<2.0	<2.0	<2.0	<2.0
Cu	26.0	33.0	182.0	51.0
Cr	156.0	72.0	504.0	138.0
Ni	12.0	<5.0	58.0	58.0
Zn	73.0	56.0	55.0	20.0
As	2.0	1.5	1.0	260.0
Pt			<1.0	
Pd			<1.0	

Sample Number	SB-05	SB-06	SB-07	SB-08
Au	4.0	7.0	5.0	21.0
Ag	<2.0	<2.0	<2.0	<2.0
Cu	60.0	97.0	130.0	51.0
Cr	90.0	112.0	64.0	1400.0
Ni	24.0	58.0	36.0	378.0
Zn	35.0	69.0	93.0	72.0
As	48.0	6.0	10.0	38.0
Pt				
Pd				

Sample Number	SB-09	SB-10	SB-11
Au	1400.0	120.75ppm	56.2ppm
Ag	<2.0	<2.0	<2.0
Cu			
Cr			
Ni			
Zn			
As			
Pt			
Pd			

Unless otherwise stated values for Au are in ppb. All other elements are given in ppm. Sample numbers correspond to Location numbers on Figure 14.

The Flint Lake occurrence is located in mafic flows of the Populus Lake volcanics north of Flint Lake (Fig. 13). Gold mineralization occurs within a quartz+ankerite vein in chlorite+/-sericite schists which represent a 3-5 m wide high strain zone striking 110 degrees and dipping steeply to the northeast. The vein is parallel to or at a small angle to the schistosity and consists of coarse-grained white quartz and rusty weathered ankerite, pyrite and fine visible gold. Inclusions of the chlorite schist wall rock are common within the vein and suggest that it formed due to a crack-seal process (Ramsay 1980). Native gold was observed in crushed vein material where it occurs as free gold in quartz, flakes parallel to the schistosity at the margins of the schist inclusions and with coarse pyrite grains within the vein. Samples of the vein material returned assay values ranging from less than 2.0 ppb to 120.75 ppm (Table 1).

The Caswell-Williams prospect is located on the south shore of Flint Lake (Fig. 13) in an east trending vertical to steeply north dipping high strain zone up to 100 m in width. The local geology of the prospect consists of intermediate tuff and tuff breccia of the Emm Bay formation which are deformed to sericite schist within the high strain zone. Large pods of chlorite schist within the sericite schist represent the deformed mafic dikes described earlier (Photo 1). Ankerite is present throughout the high strain zone as a pervasive replacement and as discontinuous quartz+ankerite veining parallel to the foliation. Gold mineralization is reportedly associated with disseminated pyrite and chalcopyrite within the veins and schist and as plates along the foliation planes within the schist. (Assessment Files Resident Geologist's Office, Ministry of Northern Development and Mines, Kenora).

The Sewell occurrence consists of ten trenches located on the narrow isthmus separating Dogpaw and Flint Lakes (Fig. 13). The surrounding geology includes a gabbroic phase of the westernmost Kakagi Lake sill and mafic flows, possibly of the Populus Lake volcanics. Felsic dikes are common and both they and the mafic rocks are variably deformed by numerous, east trending steeply north dipping high strain zones. The mineralized zone at this occurrence is associated with an east trending steeply dipping quartz+ankerite vein within and parallel to a 5-10 m wide zone of chlorite schist. Coarse euhedral pyrite is common both in the vein and surrounding schist. South of the mineralized zone the chlorite schist is in contact with a quartz+plagioclase porphyry which is also highly strained and altered by ankerite and pyrite. Rare visible gold has been reported but mineralization is dominantly associated with the pyrite (Assessment Files, Resident Geologist's Office, Ministry of Northern Development and Mines, Kenora).

Gold Mineralization Outside of the PCDZ

Two gold occurrences outside of the PCDZ were investigated during the present project. The McLennen and Bag Lake occurrences are both located in the western part of the study area, southwest of Dogpaw Lake (Fig. 13).

The McLennen occurrence is located southwest of Flint Lake at or near the contact of the western most Kakagi Lake sill and the underlying mafic volcanics of the Snake Bay formation. Both rock types are intruded by numerous quartz porphyry dikes. With the exception of several discrete shears zones, most less than 10 cm in width, rocks in the vicinity of the occurrence are relatively undeformed with only the weak northeast trending foliation related to the Emm Bay-Peninsula Bay Synform present. However, approximately 200 m to the northwest, a 50-100 m wide zone of chlorite schist and quartz+sericite schist define a northeast trending, steeply dipping zone of higher strain. Rocks in the area of the occurrence have reacted to strain in a more brittle fashion resulting in irregular quartz veins, quartz+ankerite veins and ankerite altered fracture zones. This zone of fracturing and alteration trends to the northeast across the contact of the mafic volcanics and the gabbro sill. While visible gold has been reported (Assesment Files, Resident Geologist's Office, Ministry of Northern Development and Mines Kenora), mineralization is mainly associated with pyrite and chalcopyrite in the veins and fractures. Grab samples taken from this occurrence during the present project returned the following results; 2470 ppb gold in an east trending quartz+ankerite fracture in mafic volcanics, 1400 ppb gold in a north-northwest trending quartz+/-

ankerite vein in mafic volcanics and 27 ppb gold in a carbonate altered gabbro (Fig. 14 and Table 1)

The Bag Lake occurrence is located 2 km east of Highway 71 at the north end of Bag Lake. The relatively recent discovery of this property in 1980 was in part the result of exploration in the area of the older Jenson-Johnstone occurrence (Fig. 13). The Bag Lake occurrence lies within the Snake Bay formation and is underlain by fine-grained mafic flows, coarse-grained gabbros which may be both intrusive and/or extrusive and numerous quartz and quartz + plagioclase porphyry dikes. Gold mineralization is associated with disseminated pyrite in thin (less than 2 m) high strain zones at the contacts of the felsic dikes and mafic units. The high strain zones are generally northwest trending and steeply dipping parallel to the felsic dikes. Ankerite alteration is present within the high strain zones both as quartz+ankerite veinlets and replacement in both felsic and mafic rock types. With the exception of these local high strain zones and several smaller shear zones of variable attitude the rocks in the area of this occurrence appear to be relatively undeformed and unfoliated.

Characteristics of Gold Mineralization

The following represents a summary of observations made at gold occurrences during this project.

Gold occurrences within the PCDZ

1. Gold mineralization occurs in several different lithologies and in both the lower and middle levels of the volcanic stratigraphy.

2. Gold occurrences are located in wide high strain zones parallel to and associated with the PCDZ.

3. Ankerite alteration in the form of a pervasive replacement and/or with quartz in veins is common at all of the occurrences.

4. Gold is localized with sulphides along the schistosity planes and in veins parallel or at a low angle to the schistosity.

5. With the exception of the Cameron Lake Gold Deposit, late veins and fracture zones cutting the schistosity are rare in the high strain zones hosting the gold mineralization.

Gold occurrences outside of the PCDZ

1. Gold mineralization occurs within the mafic rocks of the Snake Bay formation and gabbros of the Kakagi Lake Sills.

2. In each of the occurrences studied outside of the PCDZ, early felsic dikes are common and in some cases have been mineralized.

3. Deformation at these occurrences consists dominantly of discrete, small scale high strain zones, commonly located at the margins of felsic dikes.

4. Gold mineralization occurs with sulphides in quartz+ankerite veins and fractures and in zones of

pervasive ankerite alteration localized at felsic dike margins.

The observations summarized above suggest that gold occurrences within the Flint-Cameron Lakes area can be subdivided based on location and geological setting. Gold occurrences within the PCDZ are associated with wide, high strain zones which cut rocks of different composition and stratigraphic level. The presence of pervasive carbonate alteration indicates that these zones were a focus for hydrothermal fluids. The lack of cross-cutting veins and fractures, suggest that either strain within these zones was dominantly ductile, inhibiting the formation of dilatant zones and restricting mineralization to the planes of the schistosity and foliation parallel veining or that any brittle structures have been rotated parallel to the schistosity by continuing or subsequent deformation.

Gold occurrences outside of the PCDZ are located in mafic rocks of the lower level of the volcanic stratigraphy in less deformed rocks. Gold mineralization occurs in veins occupying fractures formed during brittle strain and in small carbonate altered high strain zones which are restricted to the margins of felsic dikes where locally high strain may have developed due to ductility contrast.

The one known major gold deposit in the Flint-Cameron Lakes area, Nuinsco Resources' Cameron Lake deposit is located within the PCDZ. This deposit has been discussed in detail by Melling et al., (1986) who describes several characteristics similar to other gold occurrences in the PCDZ as well as several major differences. Similarities include the location of the gold mineralization in a wide high strain zone referred to by Melling et al., (1986) as the Cameron Lake Shear Zone, and the presence of pervasive ankerite alteration within the highly strained rocks. Gold mineralization occurs in foliation parallel veins similar to other occurrences in the area but at the Cameron Lake Gold Deposit these veins have been subsequently hydraulically brecciated. Other differences between this deposit and the other occurrences investigated in the area include the presence of up to two separate sets of veins or fractures cross-cutting the foliation and an oblique high strain zone which intersects the main ore bearing Cameron Lake Shear Zone.

A common characteristic of all gold occurrences in the Flint-Cameron Lakes area is the presence of sulphides and ankerite alteration both as a pervasive replacement and infilling dilatant structures. This characteristic is common to many Archean lode gold deposits and indicates that gold mineralization was introduced with hydrothermal fluids into structurally prepared sites (Colvine et al., 1984).

Discussion and Conclusions

The Pipestone-Cameron Deformation Zone defines a major break in the stratigraphy of the Rowan -Kakagi Lakes area. Both Blackburn et al. (1985) and Edwards

(1980) indicate that stratigraphy cannot be correlated across the break and suggest that the northeast side of the deformation zone has been uplifted relative to the southwestern side. In the Flint-Cameron Lakes area, kinematic indicators and steep, northeast plunging stretching lineations support this suggestion and indicate that subvertical movement within the PCDZ was west directed with a northeast side up sense of displacement.

Map patterns and regional foliation trajectory patterns indicate that both stratigraphy and foliation rotate dextrally into the PCDZ. This pattern is supported by observed kinematic indicators and a subhorizontal set of stretching lineations. This evidence of dextral horizontal displacement does not concur with the subvertical displacement which should have produced an apparent sinistral component of horizontal displacement. Therefore the observed dextral displacement must be the result of a separate transcurrent (strike - slip) event.

U-Pb zircon radiometric ages from units in the immediate study area are usefull in providing a general time constraint for regional tectonism. The advent of tectonism clearly post dates the intrusion of the Kakagi Lake Sills (2724.5 Ma) and the deposition of the Stephen Lake formation (2711.1 Ma) as both of these units are deformed by the Emm Bay - Peninsula Bay synform. A minimum date for the cessation of tectonism is provided by the post tectonic Stephen Lake Stock at 2699.2 Ma .

Therefore tectonic activity within the study area is constrained to approximately a 12 Ma period between 2711.1 and 2699.2 Ma.

Determination of the tectonic processes responsible for deformation in the Flint-Cameron Lakes area is somewhat problematical. The presence of several major batholithic complexes in the region surrounding the study area suggest that deformation may in some way be related to diapiric emplacement of these plutons. Schwerdtner et al. (1979) have concluded that diapiric emplacement of the Aulneau and Sabaskong batholiths was responsible for the formation of the Emm Bay-Peninsula Bay syncline. Vertical displacement observed in the PCDZ adjacent to the Aulneau batholith in Lake of the Woods (Buck and Ayer 1987) suggests that diapirism might also be responsible for vertical displacements in the Flint-Cameron Lakes area. However as Davis and Edwards (1986) point out, U-Pb zircon age dating indicates that emplacement of both the Aulneau (2709.6 + 3.9 - 1.5 Ma) and Sabaskong (2723.2 +/- 1.8 Ma) batholiths would have been completed prior to formation of the Emm Bay-Peninsula Bay Syncline and the PCDZ.

Diapiric processes can not be disregarded altogether as west directed displacement within the PCDZ in the Flint-Cameron Lakes area could be related to emplacement of batholithic complexes east and southeast of the area. The timing and period of emplacement of the Lawrence Lake and Irene-Eltrut batholiths are not clearly understood at the present but it is interesting to note that subvertical stretching lineations in the Flint-Cameron Lakes area are best preserved in the eastern part of the area closer to these batholiths. Preliminary U-Pb dating by Davis and Edwards (1985) indicates that the Lawrence Lake batholith has a range in ages similar to batholiths west of the PCDZ. Davis and Edwards (1985) also suggest that regional batholiths may have been diapirically remobilized after initial emplacement, resulting in later local deformation.

The mechanism responsible for transcurrent movement along the PCDZ in the Flint-Cameron Lakes area is somewhat easier to interpret. Stresses responsible for dextral transcurrent displacement along east and northwest trending shear zones would have developed as the result of a northwest directed compressional-transpressional event. Evidence of such an event has been reported by several workers in northwestern Ontario (Schwerdtner et al. 1979, Smith 1986 Sanborn 1986) and indicates that deformation in the Western Wabigoon Subprovince during the Archean was the result of a widespread, regional tectonic event.

The prevalence of carbonate alteration and gold mineralization in high strain zones of the Flint-Cameron Lakes area indicates that the PCDZ must have provided a major conduit for hydrothermal fluid flow. Deformation of foliation parallel ankerite veins and ankerite infilled C' structures indicates that while alteration and gold mineralization clearly post date the formation of the high strain zones, deformation continued after the alteration event. Therefore the timing of alteration and gold mineralization in the Flint-Cameron Lakes area coincides with deformation during the 12 Ma period between 2711.1 +1.3 -1.2 Ma and 2699.2 +/-1.9Ma.

The distribution of gold showings and possibly of carbonate alteration within the PCDZ appears to be related to areas where the PCDZ intersects other regional scale structures. Locations such as the Flint Lake area and the northeast part of Cameron Lake where the PCDZ intersects east trending high strain zones may have provided major zones of dilatancy, focussing gold bearing hydrothermal fluids. It is therefore recommended that locations where regional scale structures intersect the PCDZ should be targeted for further gold exploration. Such locations exist north and south of the Flint-Cameron Lakes area where high strain zones associated with the Wabigoon Fault and the Kakagi Lake Fault, respectively, intersect the PCDZ. The presence of gold occurrences and reported gold assay results (Edwards 1980) in the area where the Kakagi Lake Fault intersects the PCDZ support the above recommendation.

Conclusions

1. In the Flint-Cameron Lakes area, the PCDZ is defined by a zone of highly strained and carbonate altered rocks up to 3000m in width.
2. Both subvertical and subhorizontal displacements have occurred within the PCDZ.

3. Deformation in the Flint-Cameron Lakes area can be constrained to a 13 Ma period between 2711.1 + 1.3, - 1.2 Ma and 2699.2 +/- 1.9 Ma.

4. Gold mineralization is associated with ankerite alteration in high strain zones. Both ankerite and gold were introduced during deformation.

5. Gold showings are concentrated in areas where regional scale structures intersect the PCDZ.

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PHOTOGRAPHS

Photo 1. Mafic dikes intruding into intermediate tuff of the Emm Bay formation. A. On a vertical exposure the dikes appear to be parallel and regularly spaced. B. On a horizontal surface the dikes are revealed to be very irregular. C. Deformation within the PCDZ causes boudinage and total disruption of the mafic dikes observed in A and B.

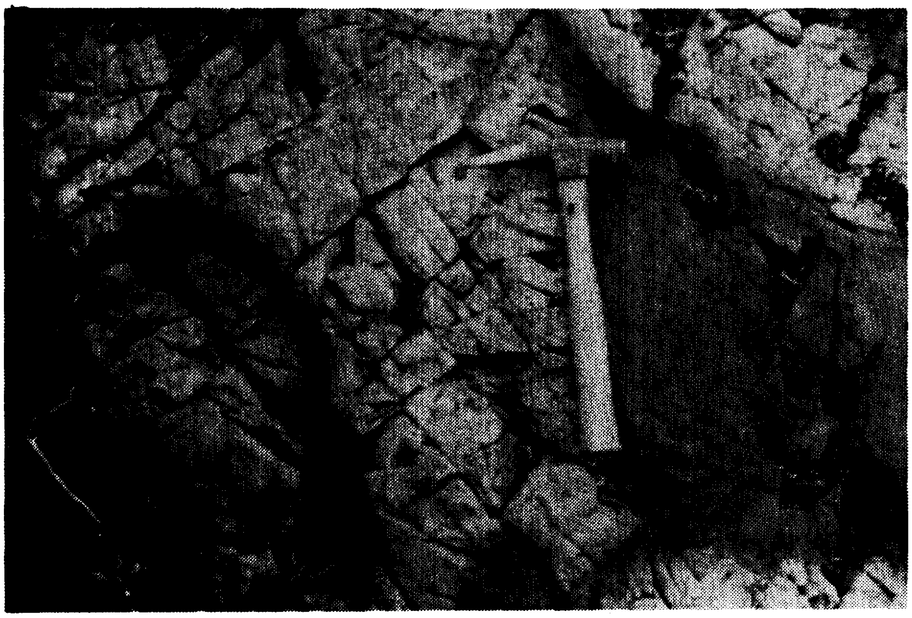
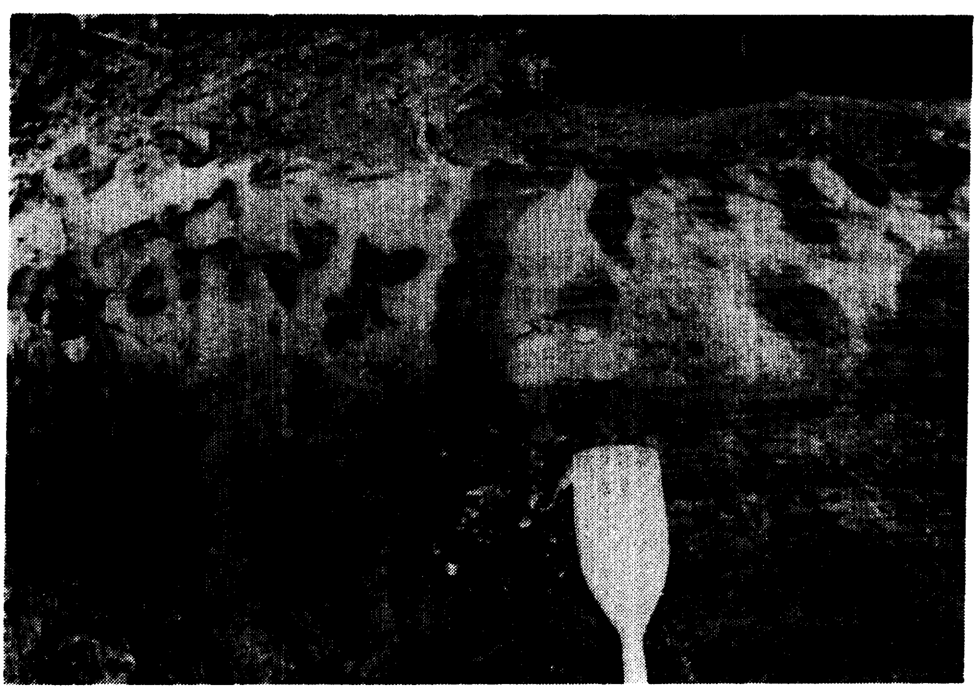


Photo 1b (top)
Photo 1c (bottom)



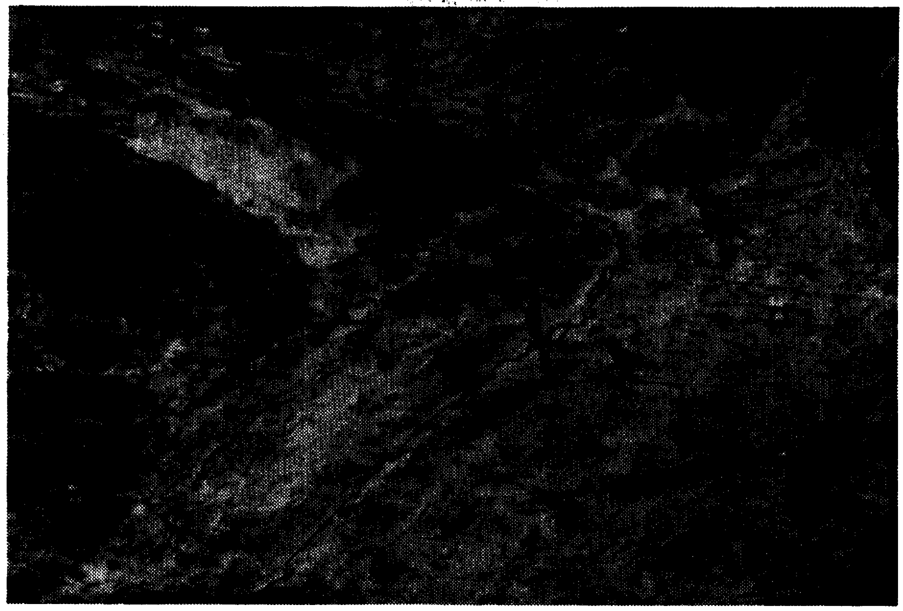


Photo 2. Small scale folds in the Cedartree formation, cut by S1, an axial plan cleavage. Note the displacement al cleavage.

Photo 3. An array of tension gashes in relatively undeformed tuff breccia of the Emm Bay formation.

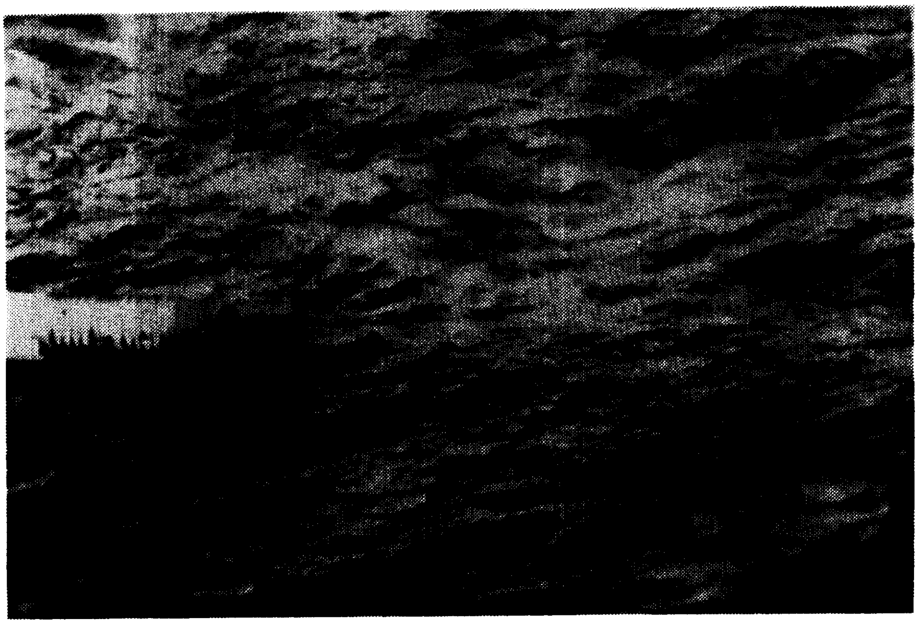


Photo 4. Conjugate shear fractures in intermediate tuff.

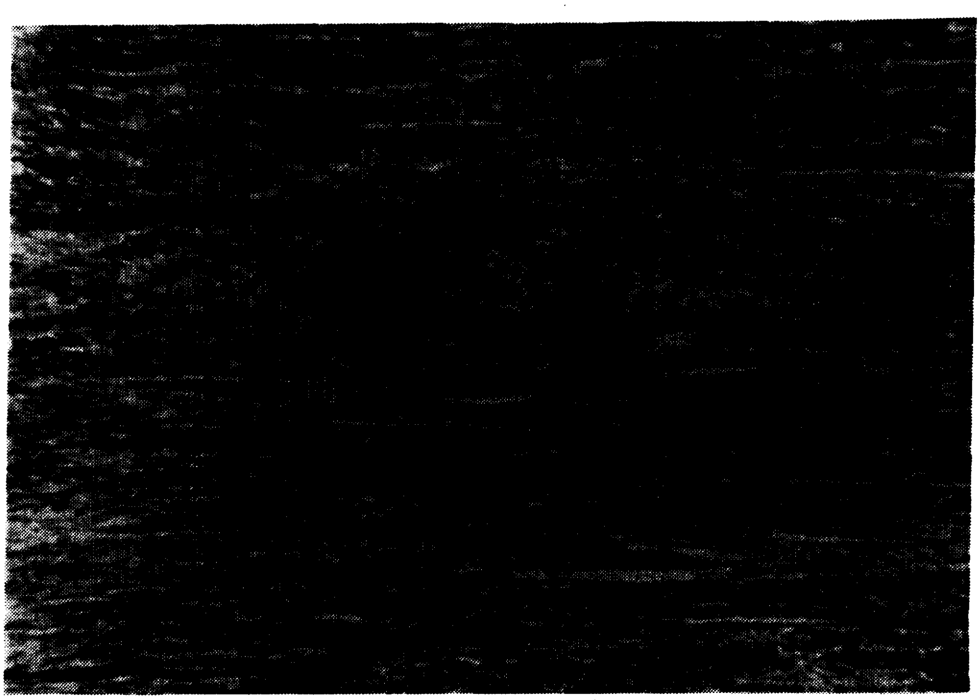


Photo 5. Mylonitic layering developed in a sericite + carbonate schist from the PCDZ. Field of view = 1.8 x 2.7 cm (plane polarized light).

Photo 6. Extensional crenulation in a sericite schist from the PCDZ.

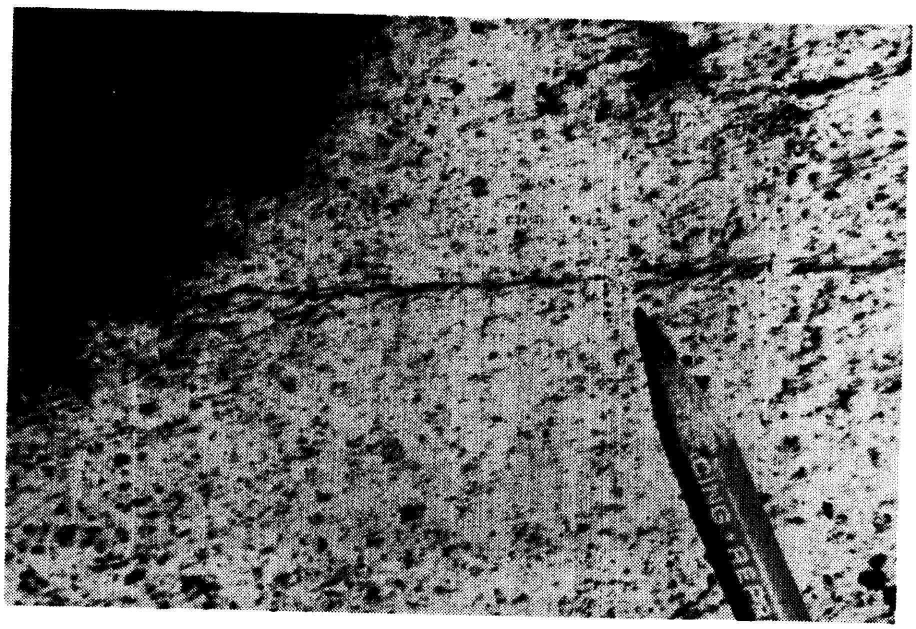


Photo 7. S-C shear fabrics in a quartz + plagioclase porphyry. Note that the geometry of the fabrics indicate a dextral sense of displacement.

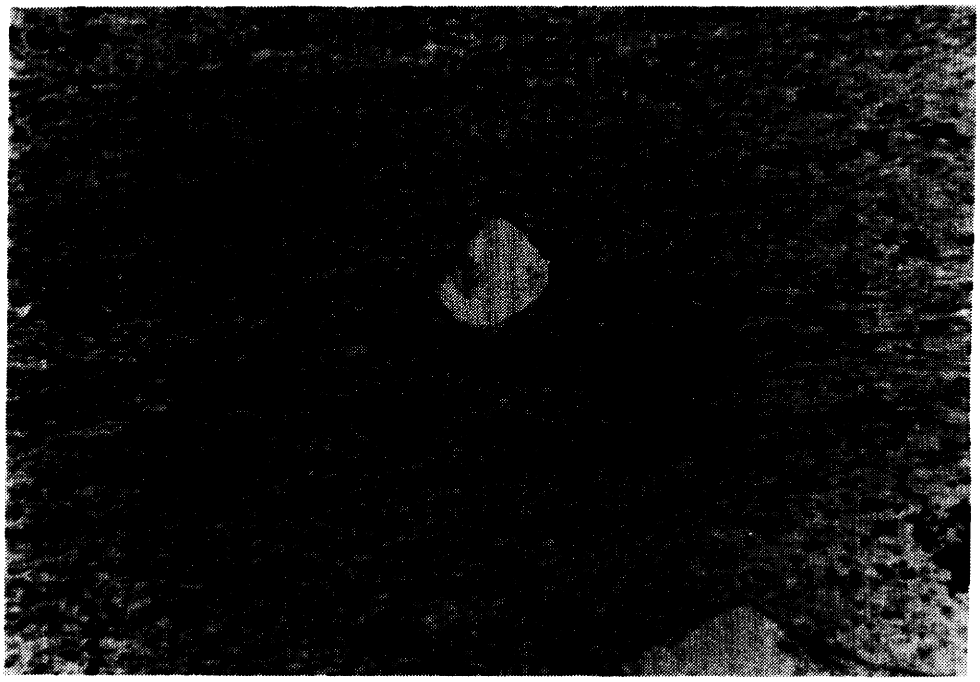
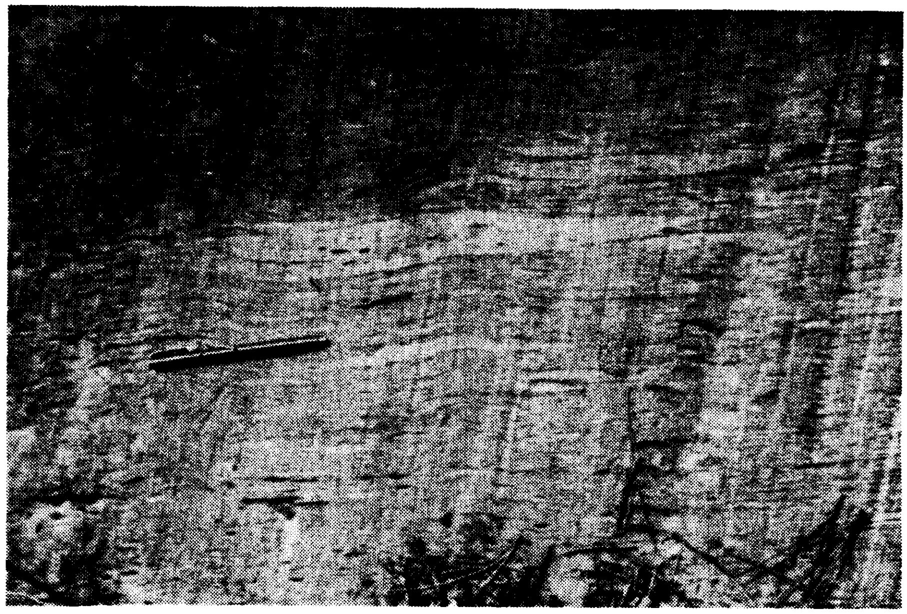


Photo 8. A rotated phenocryst in highly strained quartz + plagioclase porphyry. Note that ankerite has replaced the recrystallized tails of the phenocryst and that the geometry of the tails indicate a dextral sense of rotation (Simpson 1986). Field ofview = 1.8 x 2.7 cm.

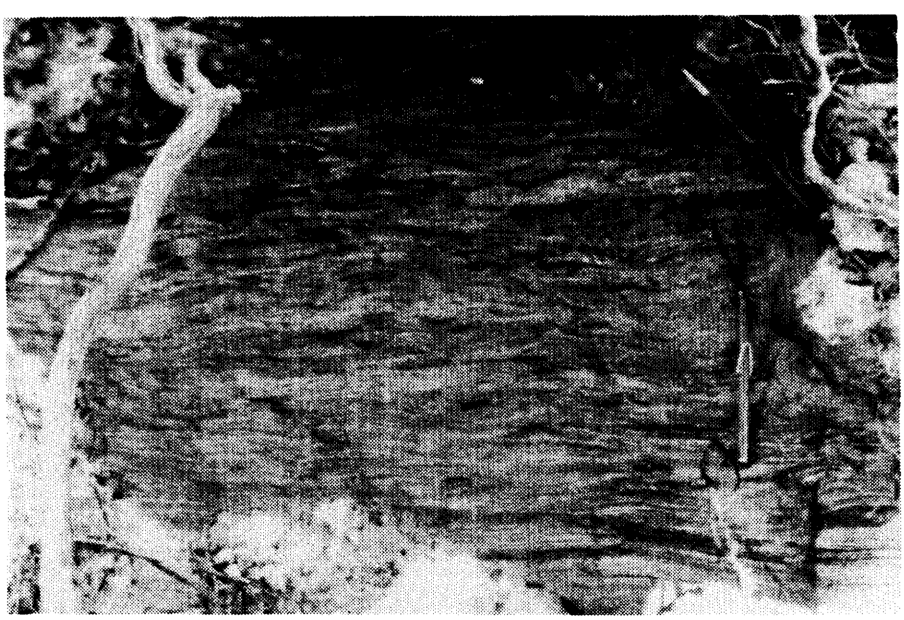
Photo 9. Rotated pyrite crystal in chlorite schist. The shape of quartz fibres in pressure fringes around the pyrite indicate a clockwise or dextral rotation (Ramsay and Huber 1983). Field of view 2.3 x 3.5 cm.



10a

Photo 10. The intensity of strain within the PCDZ is revealed by tracing the relatively undeformed tuff breccia shown in Figure 9 into the PCDZ where fragments become elongated A, and in some cases a mylonitic layering develops B. Note the development of a weak extensional crenulation cleavage.

10b



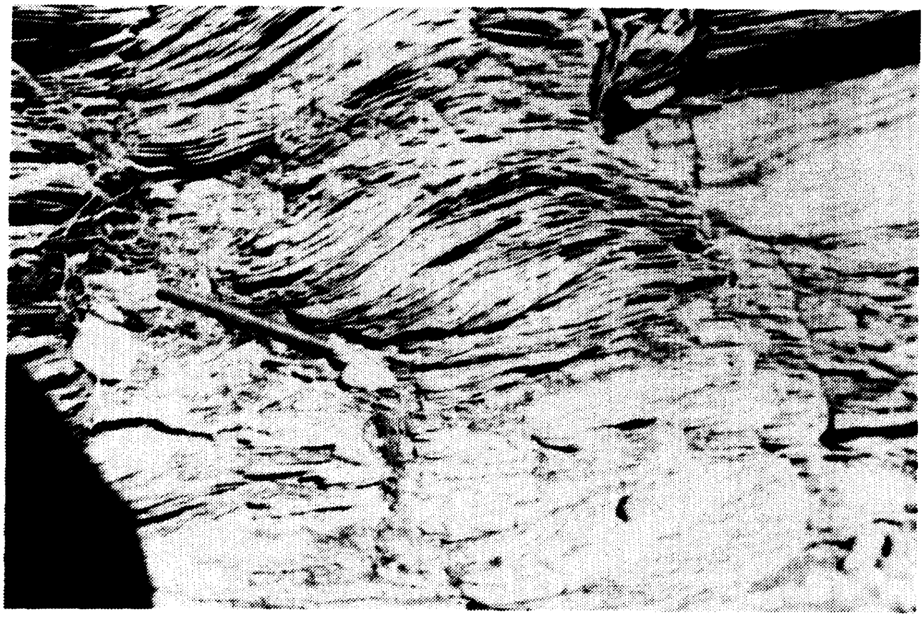
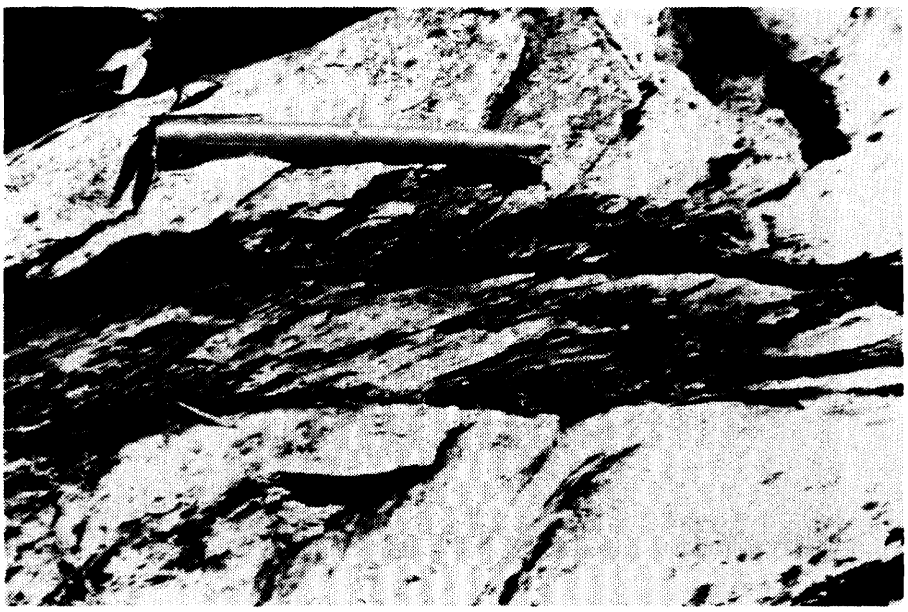


Photo 11. Extensional Crenulation Cleavage - C' structure
in the Dogpaw Lake domain. The asymetry of this crenulation indicates a dextral sense of displacement.

12a

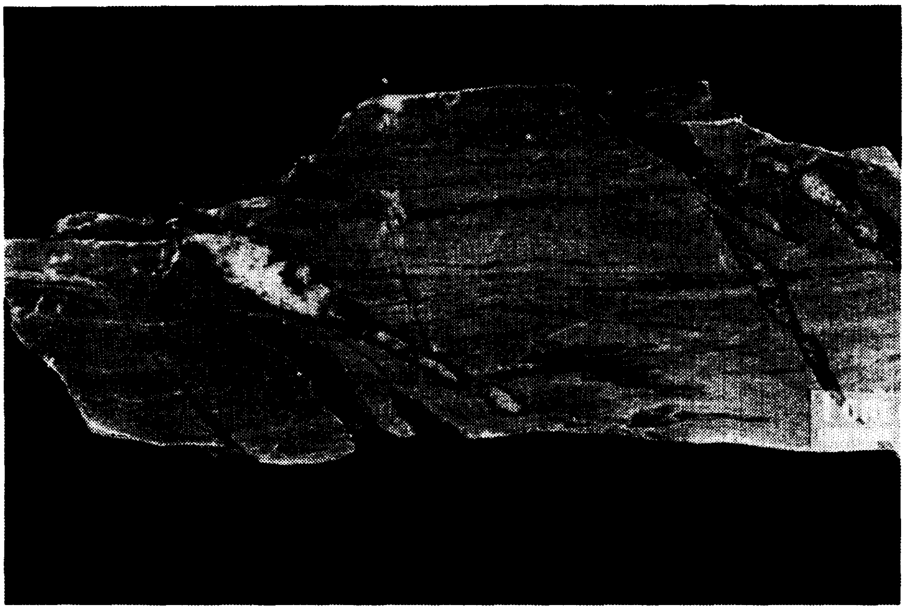
Photo 12. Minor shear zones in the PCDZ. A. Early fractures are rotated parallel to a dextral shear zone in felsic tuff. B. S1 an axial planer cleavage is displaced dextrally by a shear zone 20-30 cm in width.



12b

Photo 13. Early quartz veins are cut and displaced along the foliation in a high strain zone in the Flint Lake domain. Field of view = 2.3 x 3.5 cm (plane polarized light).

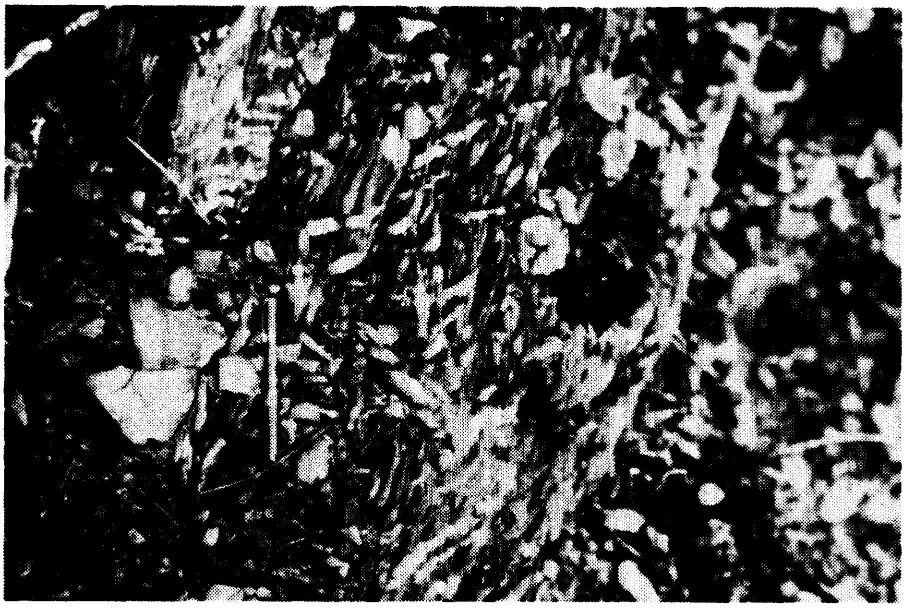
Photo 14. Foliation parallel quartz + ankerite veins. Note the boudinage, pinch and swell of the veins and the presence of quartz infilled tension fractures in the veins.



15a

Photo 15. A. C' structure infilled by an inner core of Fe - calcite (light coloured in photo) with an outer rim of ankerite (dark coloured in photo). B. View of A. in outcrop showing the disruption of the C' structures along the foliation in chlorite schist..

15b



FIGURES

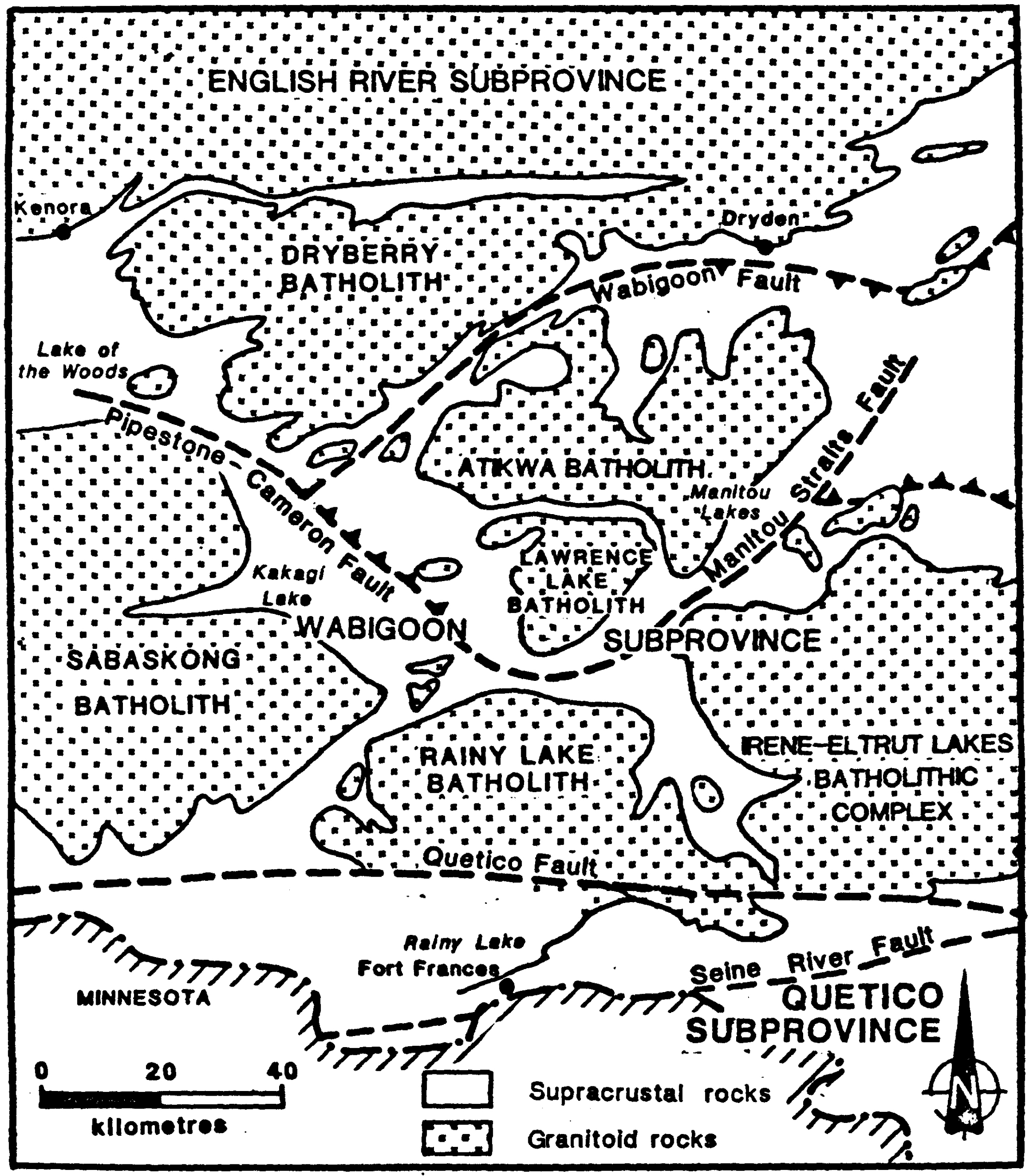


Figure 2. Granite-Greenstone distribution in Northwestern Ontario (Modified after Blackburn 1980).

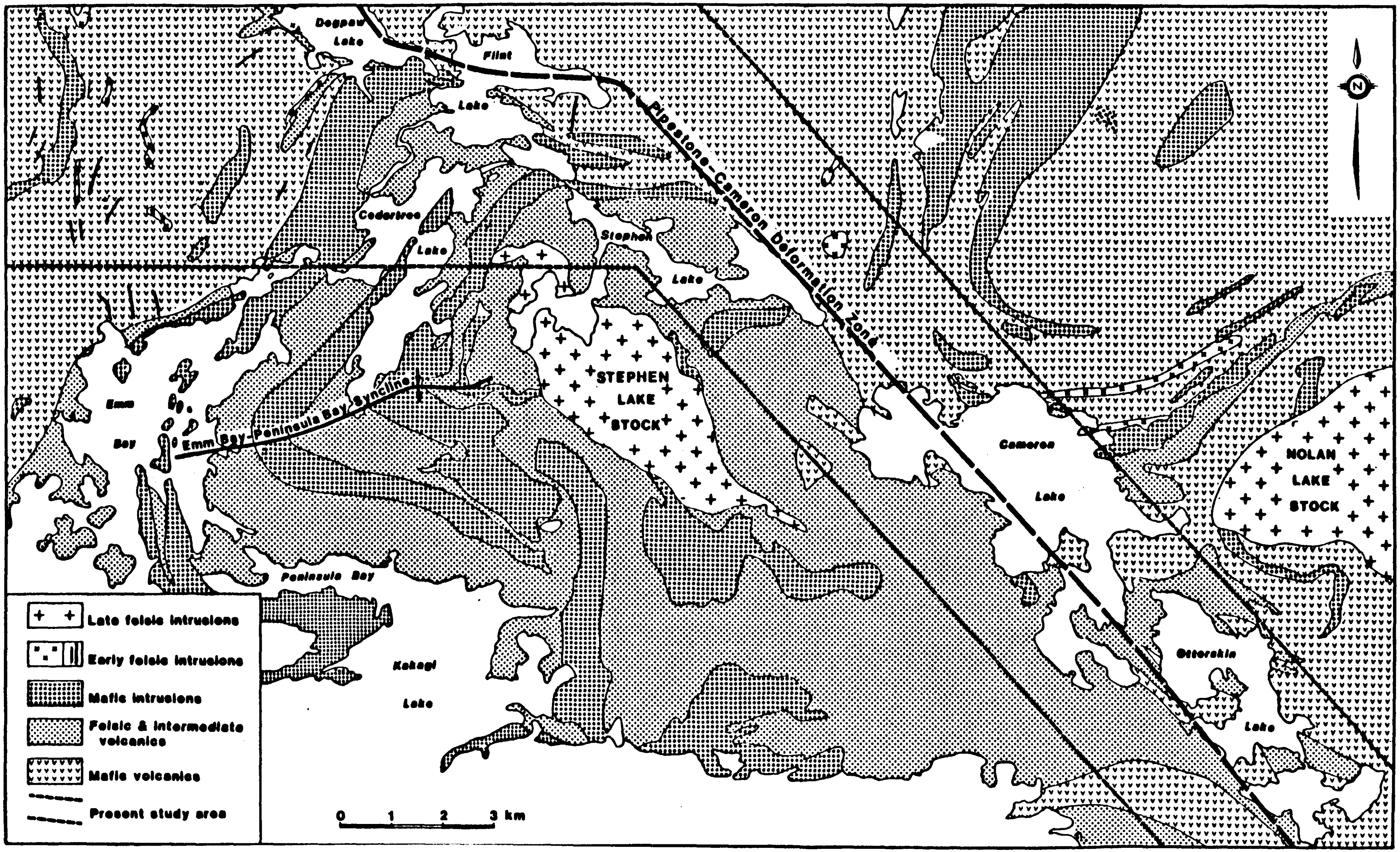
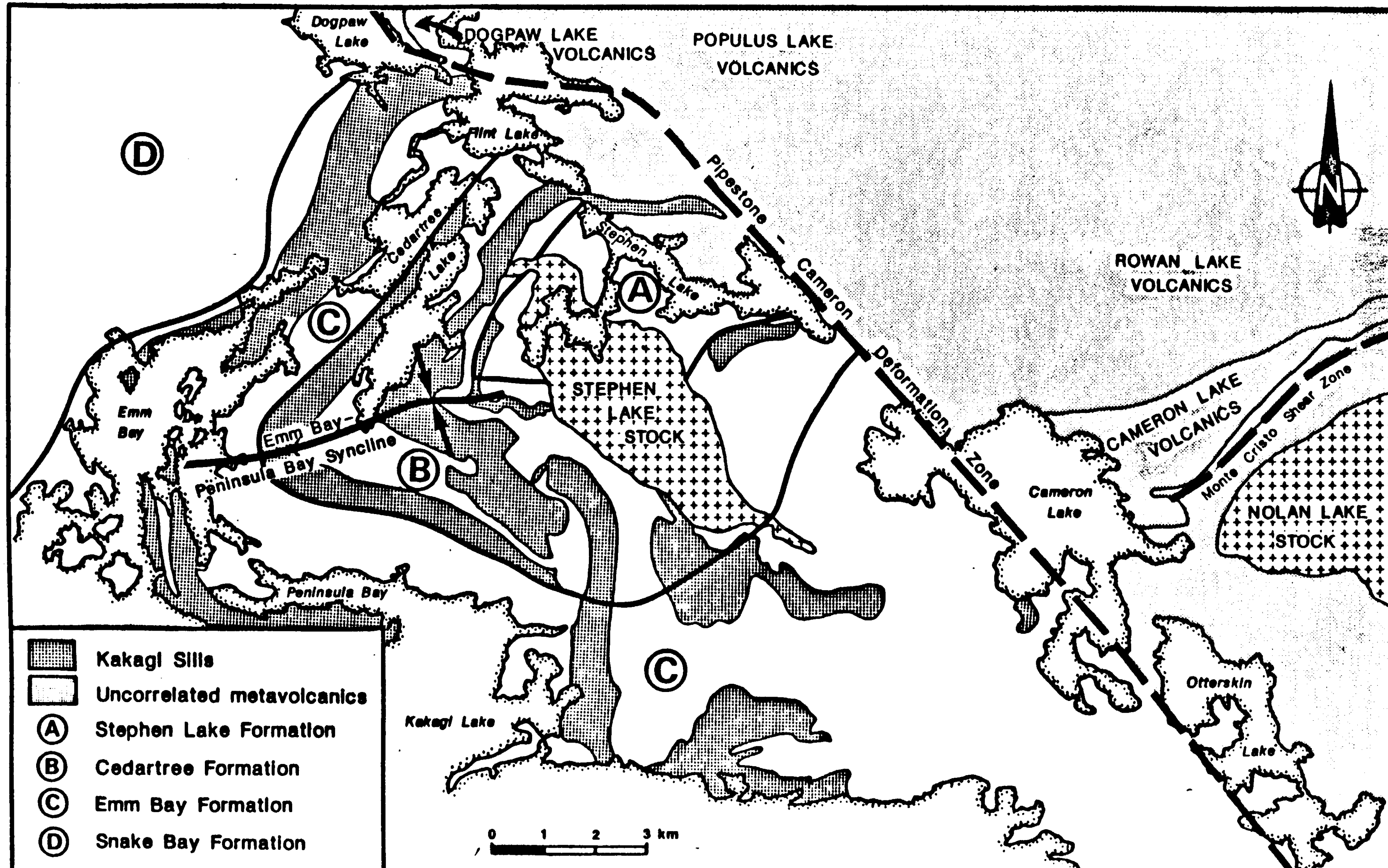


Figure 3. General Geology of the Flint-Cameron lakes Area (After Kaye 1976 and 1981, Davies and Morin 1976, Edwards 1980 and Johns 1986a).

Figure 4. Volcanic stratigraphy in the Flint-Cameron Lakes Area. Note that formations A-C are part of the Kakagi Lake Group (after Johns 1985).



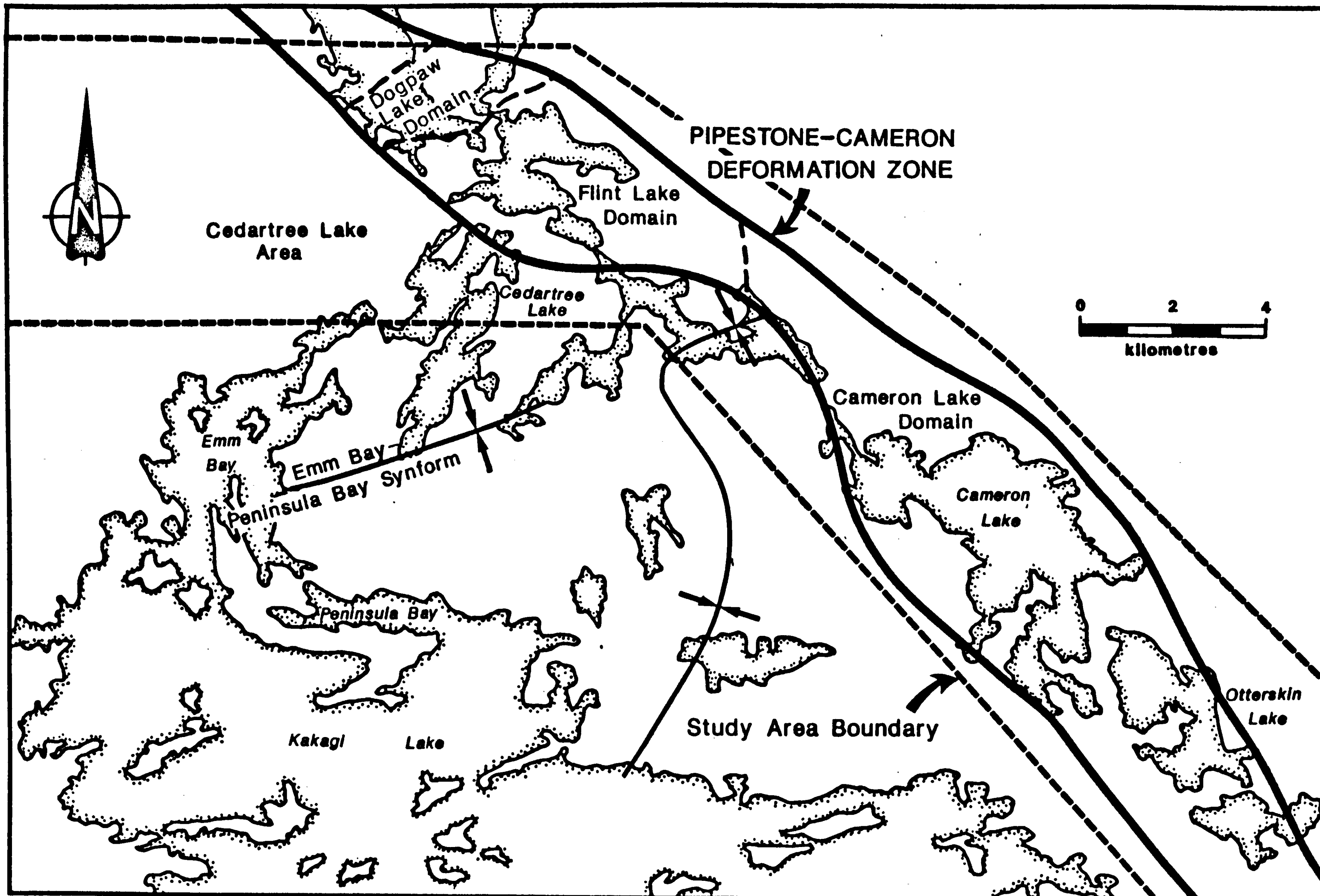


Figure 5. Structural domains in the Flint-Cameron Lakes Area.

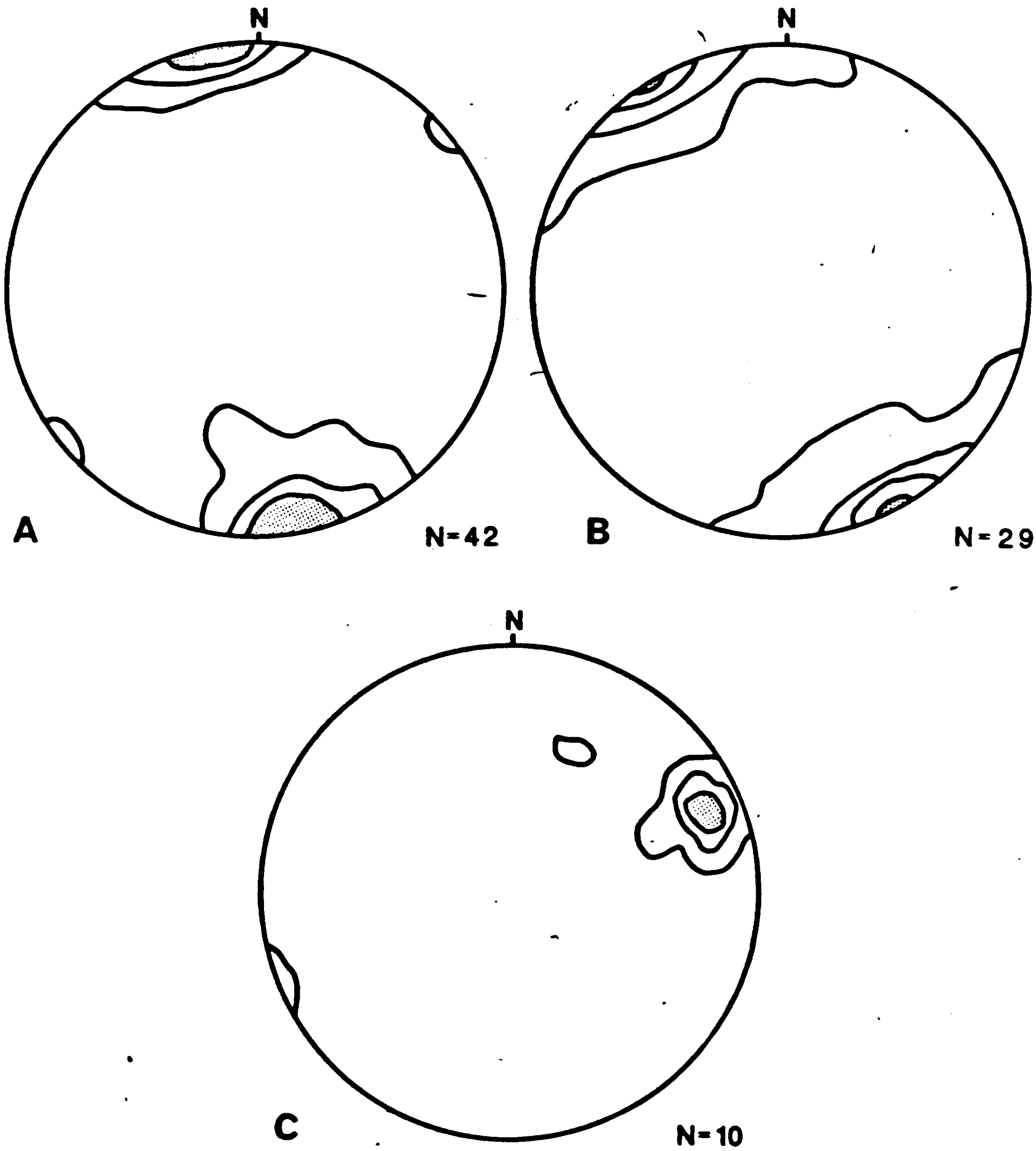


Figure 6. Structural data from the Cedartree Lake Area. A. The S1 foliation in the north part of Cedartree Lake has an average trend of 260/88. B. The S1 foliation in the remainder of the Cedartree Lake area has an average trend of 242/90. C. Stretching lineations in the Cedartree Lake area have an average trend of 060/14. The stereonets above and in following figures were plotted following the procedure outlined by Robin and Jowett (1986). Contour intervals are in standard deviation and vary for each individual plot. (Note that foliations are plotted as poles).

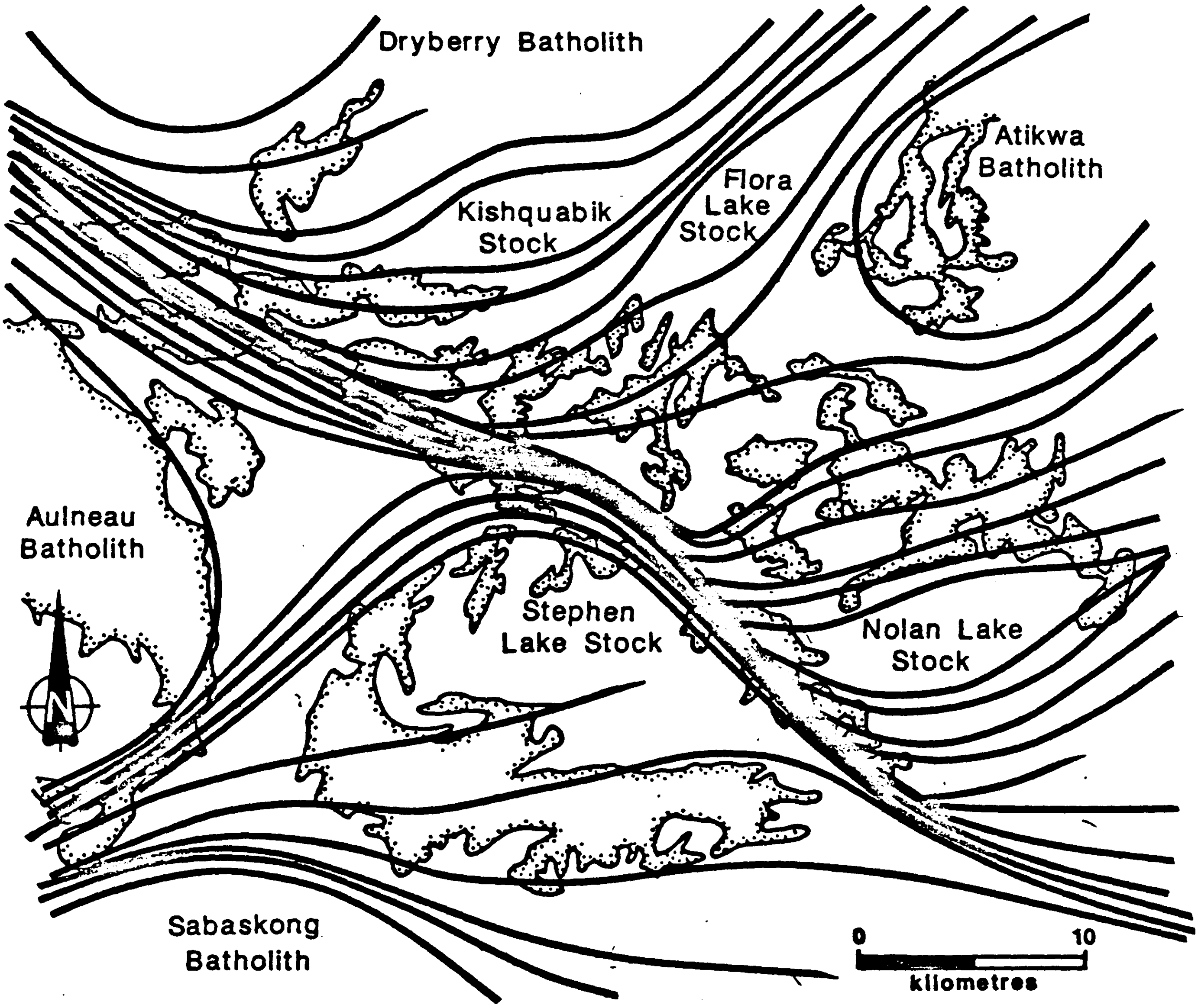


Figure 7. Foliation trajectory map for the Rowan-Kakagi Lakes Area showing rotation of the the regional foliation parallel to the PCDZ. Note that the density of trajectory lines does not reflect the intensity of strain.

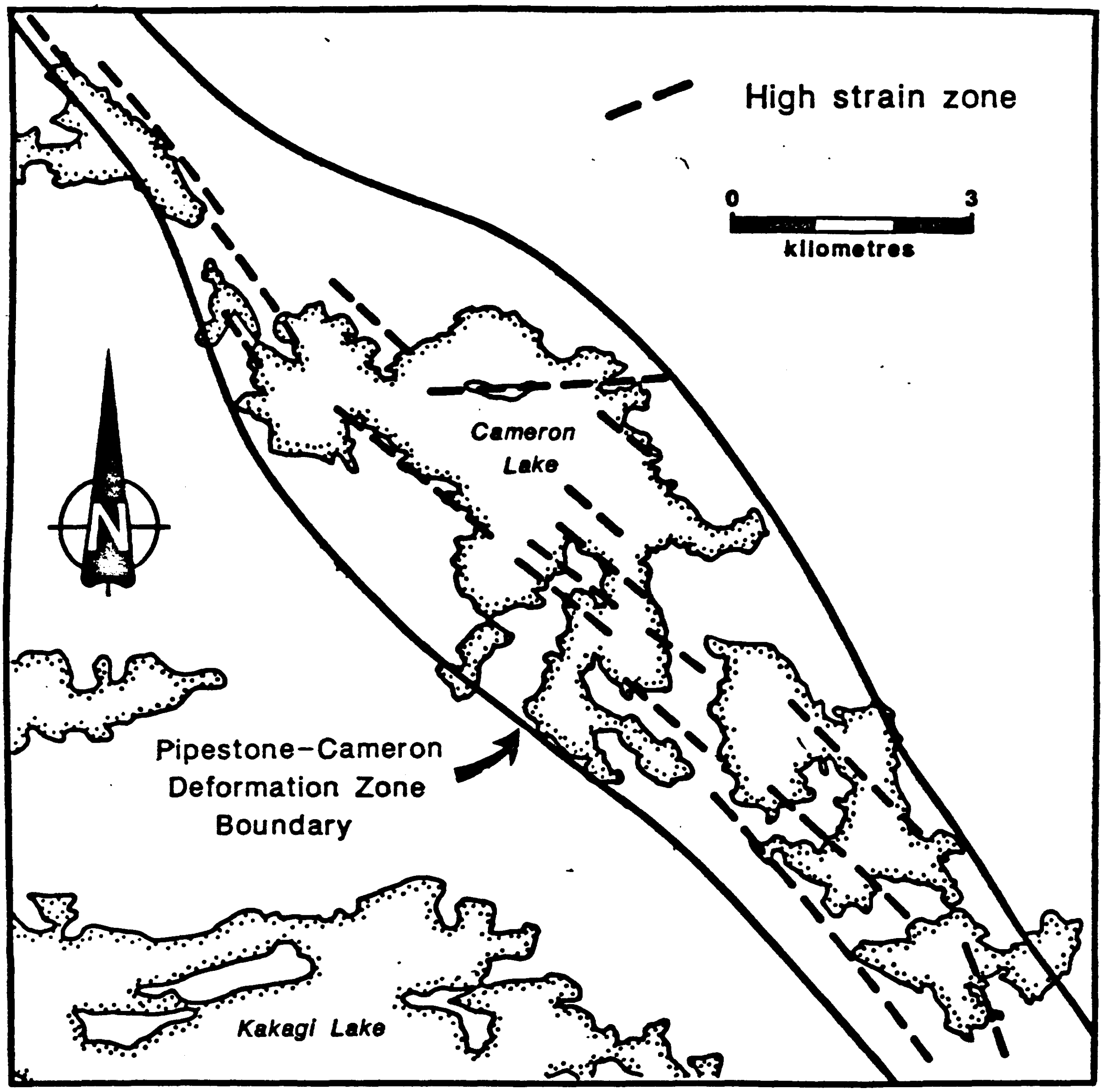


Figure 8. High strain zones in the Cameron Lake domain. Note that the scale of individual high strain zones vary from <1 m in width up to >100 m in width. Note the presence of an oblique high strain zone in the north part of Cameron Lake which may be related to the Monte Cristo Shear Zone east of the PCDZ.

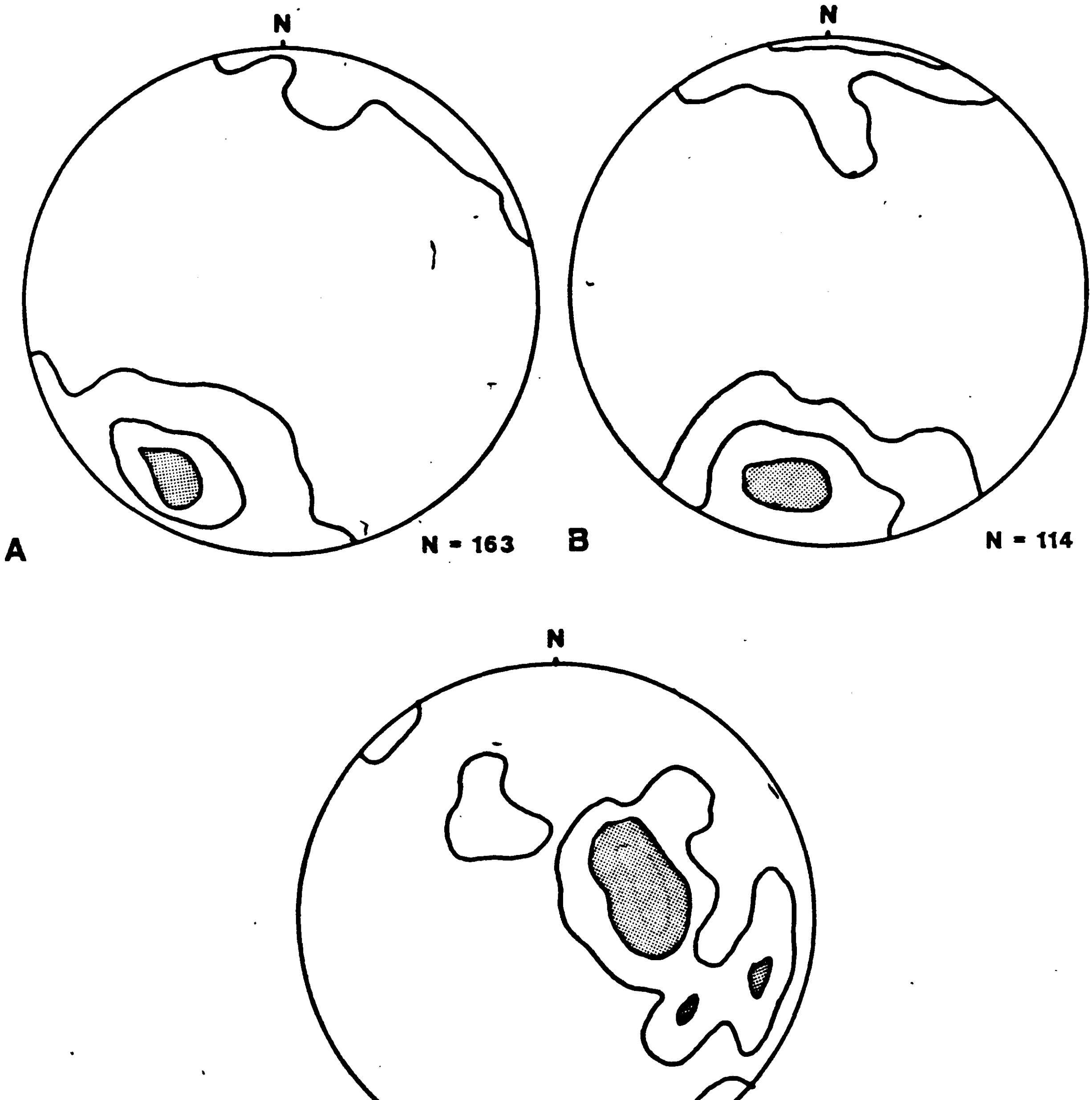


Figure 9. Structural data from the Cameron Lake domain. A. The S2 foliation in the Cameron Lake domain has an average trend of 302/75. B. The S1 foliation in the Cameron Lake domain has an average trend of 282/72. C. Stretching lineations in the Cameron Lake domain define a dominant set which has an average trend of 072/58 and two weaker sets which have average trends of 109/18 and 126/34 (see figure 6 for plotting procedure).

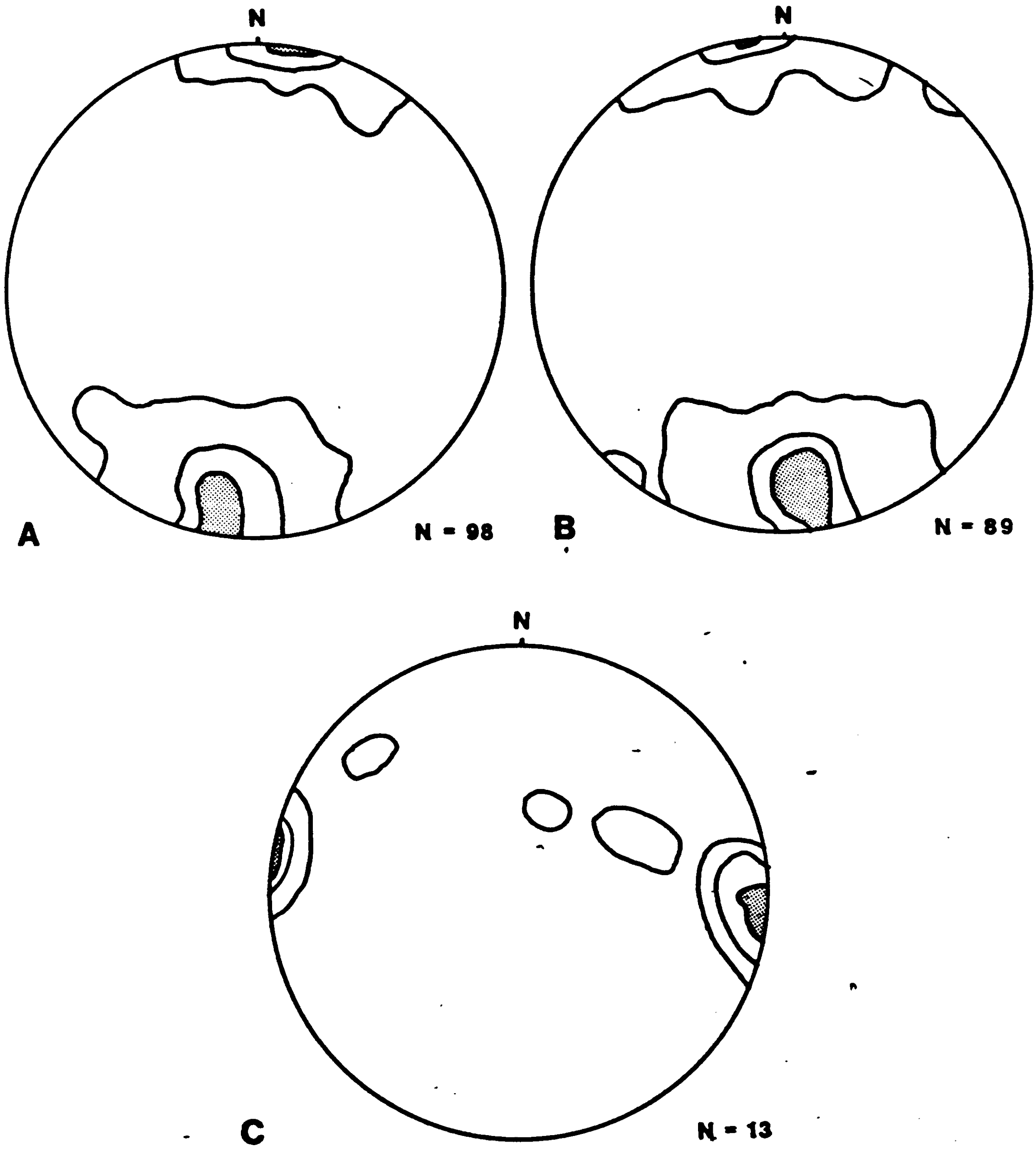


Figure 10. Structural data from the Flint lake domain. A. The S2 foliation in the Flint Lake domain has an average trend of 282/74. B. The S1 foliation in the Flint Lake domain has an average trend of 264/70. C. Stretching lineations in the Flint Lake have an average trend of 096/02 (see figure 6 for plotting procedure).

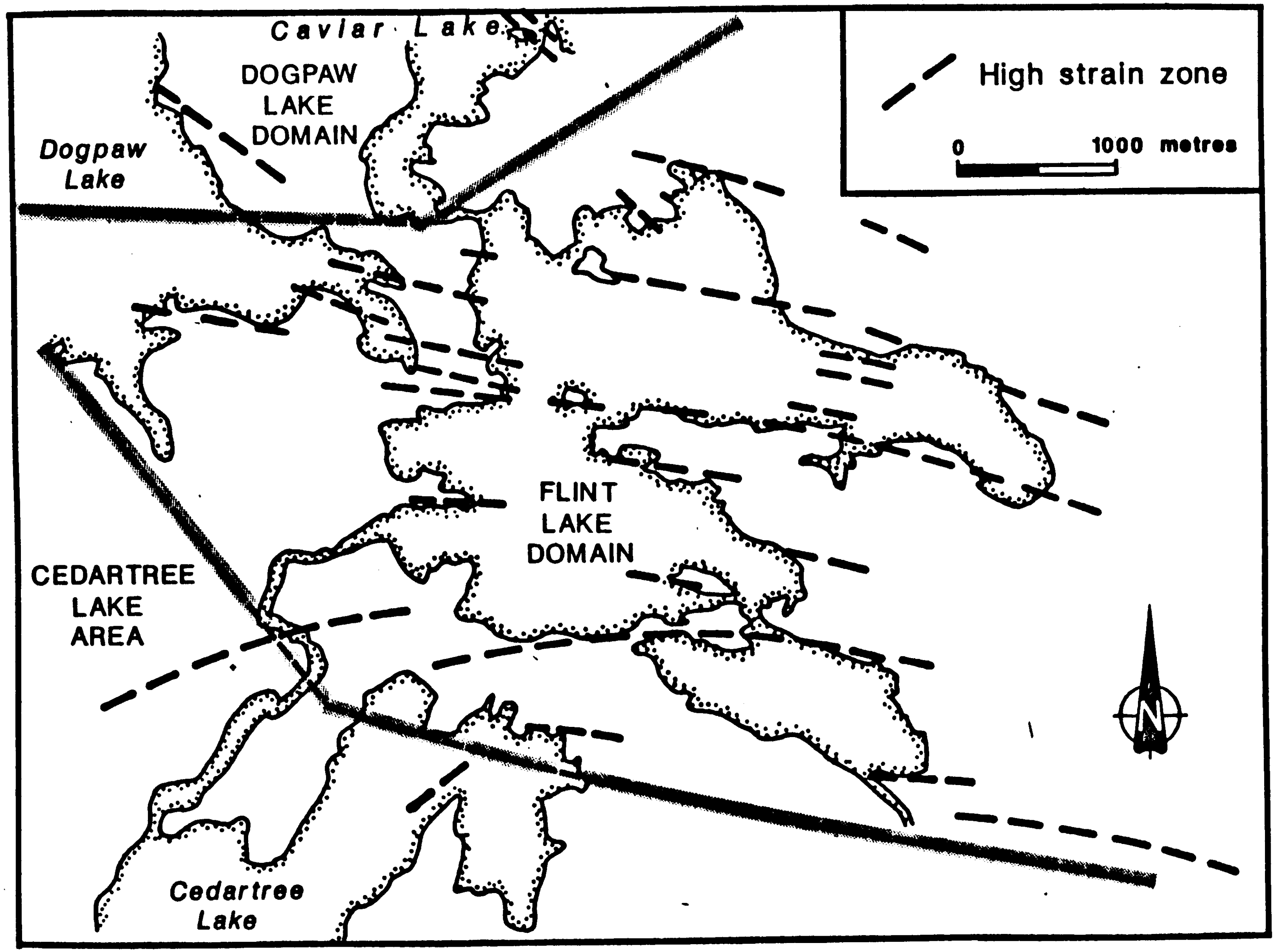


Figure 11. High strain zones in the Flint Lake and Dogpaw Lake domains. Note that scale of individual high strain zones varies from <1 m in width up to >100 m in width.

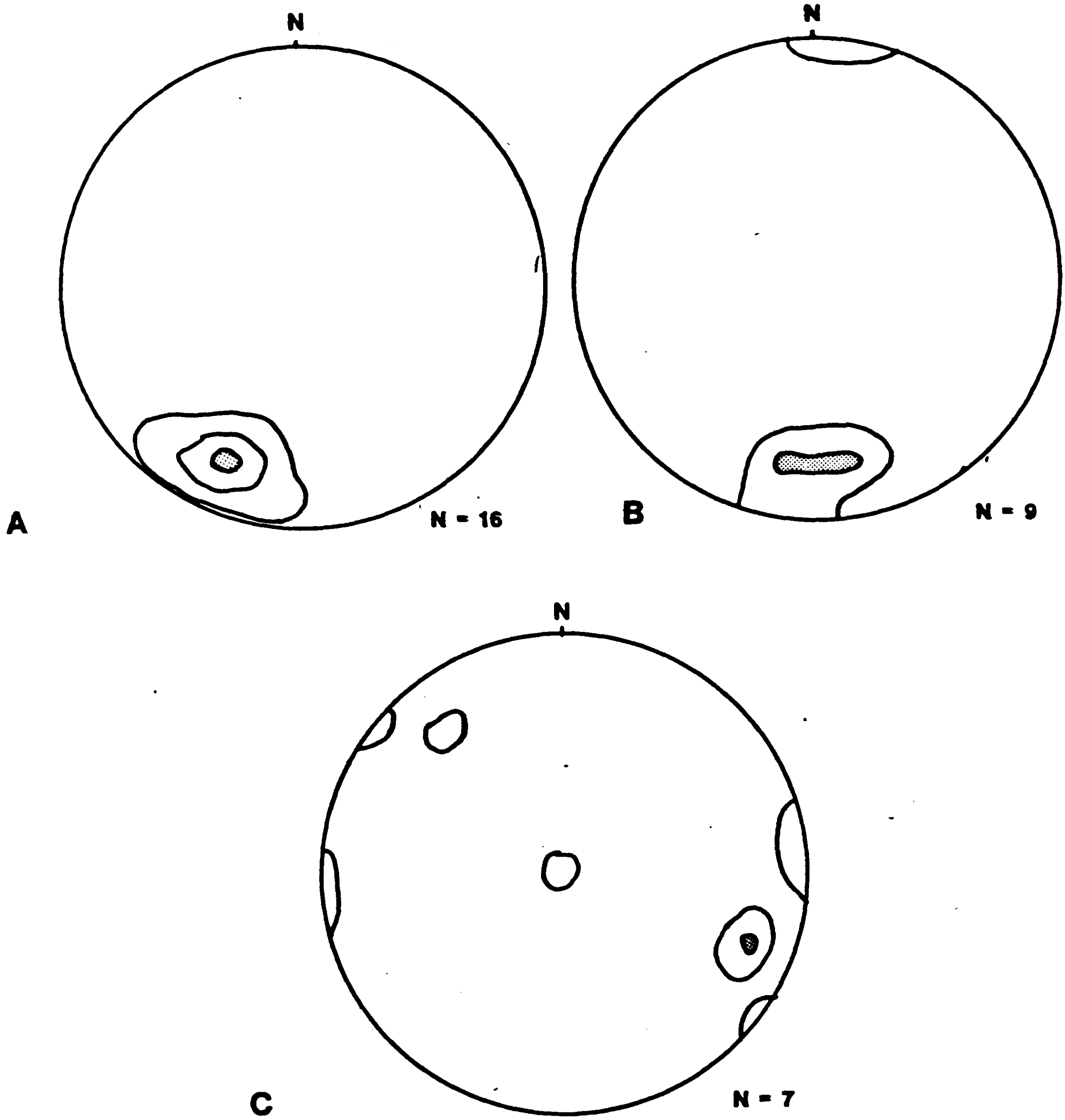


Figure 12. Structural data from the Dogpaw Lake domain. A. The S2 foliation in the Dogpaw Lake domain has an average trend of 294/68. B. The S1 foliation in the Dogpaw Lake domain has an average trend of 269/68. C. Stretching lineations in the Dogpaw lake domain have an average trend of 112/15 (see figure 6 for plotting procedure).

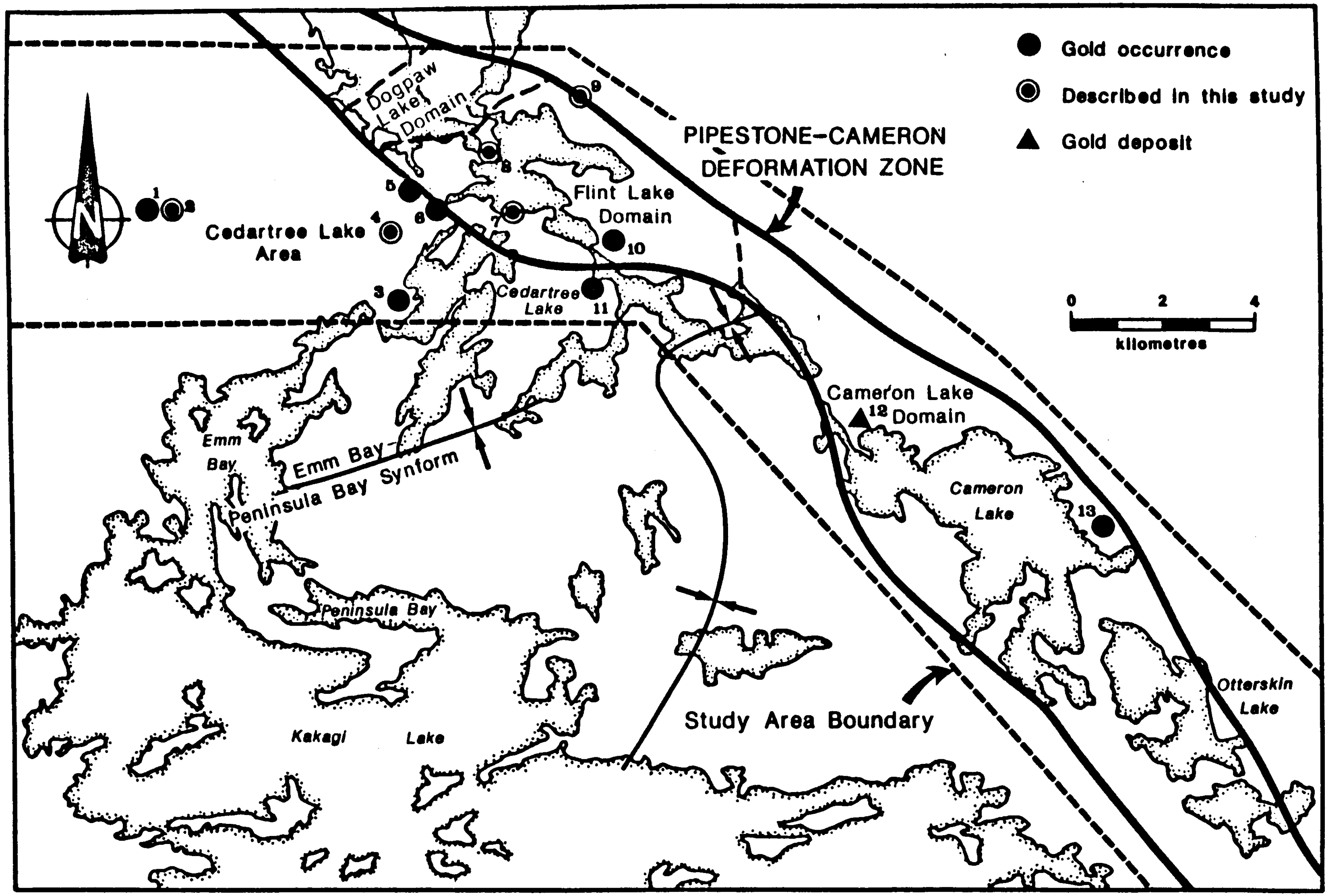


Figure 13. Location of gold occurrences in the Flint - Cameron Lakes Area. 1. Jenson - Johnston 2. Bag Lake 3. Robertson 4. McLennen 5. Martin - Kenty 6. Canadian Arrow 7. Caswell - Williams 8. Sewell 9. Flint Lake 10. Meahan 11. Kenty 12. Cameron Lake Deposit 13. Meston

B

Figure 14. Location of grab samples assayed during this project. Location numbers correspond to the sample numbers (SB1-11) listed in Table 1.