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STRATIGRAPHY, STRUCTURE AND MINERAL OCCURRENCES OF THE APHEBIAN WAUGH LAKE GROUP, NORTHEASTERN ALBERTA

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ABSTRACT

The sedimentary and volcanic rocks of the Waugh Lake Group, contain well preserved primary structures and comprise diverse facies assemblages that can be arranged into a coherent stratigraphic system. The Waugh Lake Group has an estimated measured thickness of 1120 m, and consists of five rock units of formation rank. The Martyn Lake Formation consists of rhythmically bedded, turbiditic sedimentary rocks, that are overlain by strata of the Doze Lake Formation which comprise the lower sedimentary and volcanic assemblage. The rocks of the latter formation are conformably overlain by a distinctive green, brown- to black-grey weathering, mafic sedimentary rock-unit (Sederholm Lake Formation), which is, in turn, succeeded by a second sedimentary and volcanic assemblage (Johnson Lake Formation) and capped by the youngest rock-unit of the Waugh Lake Group (Niggli Lake Formation), which is dominated by mafic volcanic flows and breccia.

The strata of the Waugh Lake Group were deposited in a composite back-arc/strike-slip rift basin that evolved from a marine-dominated tectonically quiescent initial stage (Martyn Lake Formation) into a largely continental depositional regime characterized by syndepositionally active tectonism and related volcanism in the overlying Waugh Lake formations. The rift basin model is supported by the occurrence of bimodal volcanism, latero-vertical facies transitions, significant local thickness variations within members and soft-sediment deformation.

Deeply weathered, mineralized rusty shear zones (gossans) within the Martyn Lake Formation may be related to thrust faulting. These gossan zones contain schists with minor (1-10%) pyrite, trace arsenopyrite and gold contents of up to 3.2 g/t. The preferred location of sulfides in the shear zones indicate that the enrichment is shear-related and that sulfides are remobilized throughout the shearing process. The mineralization (redistribution of sulfides) is syn- to epigenetic in relation to deformation in the shear zones under greenschist facies conditions.

INTRODUCTION

The 1994 geological mapping of the Waugh Lake area resulted in a revision of the work performed in 1993 and in a formal stratigraphic nomenclature for the Waugh Lake Group (Figure 1, in pocket). The metasedimentary and metavolcanic rocks of the Waugh Lake area have previously been assigned only informal nomenclature status (Watanabe, 1961; Godfrey, 1963, Koster, 1971). The more definitive term "Waugh Lake Group" has been used, in an informal sense, in more recent publications (Godfrey, 1986; Salat *et. al.*,1994). The strata of the Waugh Lake Group contain locally well preserved primary sedimentary structures, and comprise distinct lithofacies assemblages that can be arranged into a coherent stratigraphic framework.

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ACCESS

The Waugh Lake area is located approximately 110 km east of Fort Smith, N.W.T. and 140 km NE of Fort Chipewyan on the north shore of Lake Athabasca, Alberta. The best access to the area is by float plane and accommodation is available at Andrew Lake Lodge, 7 km west of the study area. Travel by foot in the area is difficult because of forest fires in the area in 1979 and 1981. Deadfall and new growth make travel difficult. However, removal of moss and lichen by the fires created excellent rock exposures.

PREVIOUS GEOLOGICAL WORK

Watanabe (1961) mapped the geology of the Waugh Lake area at a scale of 1:15,840 as part of a M.Sc. thesis; his work was included in the geological map of the Andrew Lake map sheet, South District by Godfrey (1963). This work focussed on the tectonic characteristics of the different rock units, which were largely interpreted as tectonites rather than as sedimentary and volcanic rocks. Consequently they were mapped as schist, quartzite, phyllonite, etc.

Godfrey (1958) reported specks of galena and pyrrhotite 400 m west of the northwest shore of Waugh Lake (his locality #15) and pyrrhotite(?), pyrite and arsenopyrite on the east side of Waugh Lake (his locality #16). Godfrey (1963) reported tourmaline-quartz-arsenopyrite veins cutting through rusty metasediments on the southeast shore of Waugh Lake, that contain anomalous amounts of gold, silver and nickel (amounts not given). All these occurrences were summarized on the 1:250,000 scale mineral showings map that was compiled by Godfrey (1986).

In 1963, an aeromagnetic survey was flown over the area by Aero Survey Ltd on behalf of the federal government and the map was published in 1964 (Geophysics Paper 2903).

In 1969 and early 1970's, Hudson Bay Oil and Gas Limited carried out an airborne survey over the whole area, conducted limited ground geophysics and completed 4 small trenches over an electromagnetic conductor that was discovered on the northeastern shore of Waugh Lake (Burgan, 1971). No significant mineralization was found in the deeply weathered iron rich metasediments and no further exploration was carried out.

The Andrew Lake area was remapped by the Geological Survey of Canada on a scale of 1:50,000 (McDonough *et al.*, 1994) under the auspices of the Canada-Alberta Partnership Agreement on Mineral Development. The Alberta Geological Survey examined the Waugh Lake area in 1992 and 1993 as part of the same program and found new mineral occurrences (Langenberg *et. al.*, 1993; Salat *et. al.*, 1994). These finds indicated the need for additional geological work on the host rocks. Recognition of primary types of deposition of the rocks will provide the geologist with an understanding of the origin of reported mineral occurrences and where to find mineral deposits.

METHODOLOGY

Four base lines were surveyed and flagged with the help of a compass and hip chain (measuring the length of disposable thread). Other traverses were tied to the base lines using compass, hip chain, aerial photos and a GPS. The field stations were plotted on a 1:10,000 scale base map, which was obtained from enlarged aerial photos and the 1:50,000 scale Andrew Lake (74M/16) map sheet. A database was created in the field with Fieldlog V2.83 (Brodaric, 1992) using a battery powered Laptop computer, where the data was checked by plotting AutoCAD drawing-files on a portable plotter. Stratigraphic sections were measured with hip chain and 30 m steel chain.

In the office the data was transferred into a GSIS (GeoScience Information System) using ArcCAD software for future modelling in the Alberta Geological Survey's Mineral Information System. The final map (Figure 1) was plotted on a Calcomp electrostatic plotter.

GENERAL GEOLOGY

The Waugh Lake Group is defined as an assemblage of lower greenschist facies, late Aphebian metasedimentary and metavolcanic rocks exposed in the vicinity of Waugh, Martyn, Doze and Flagon Lakes adjacent to and straddling the Alberta-Saskatchewan border (Figure 1; Godfrey 1961, 1963). The succession has a maximum measured thickness of at least 1120m (Table 1). The metasedimentary and metavolcanic rocks are preserved in a fault bounded and transected syncline, in northeastern Alberta. The faults and associated shear zones trend generally north-south.

Outcrops of Waugh Lake Group rocks, in the map area, extend south-southwest for 9 km from Doze Lake to West Waugh Lake and are preserved over an area of 32 km^2 (Figure 1). The belt continues southwards for 2 km from

West Waugh Lake to the north shore of Johnson Lake (Godfrey, 1963). The belt continues northeastward, through Doze and Flagon lakes into northwestern Saskatchewan (Godfrey, 1961; Koster, 1961, 1971). Major rock types include felsic to mafic flows and tuffs, subarkose, sublitharenite, pebble to boulder conglomerate, amphibole rich sandstone, quartzitic sandstone and rhythmically interlayered sandstone-siltstone-phyllite (Tables 1 and 2; Figure 1; Plates 1 to 3). McNicoll and McDonough (1995) show that the deposition of Waugh Lake sediments happened between 2.01 and 1.97 Ga ago. This is based on detrital zircons from quartz-feldspar pebbles in a conglomerate with ages between 2.70 and 2.01 Ga, and a 1.97 Ga age for a Colin Lake quartz-diorite, which intrudes the Waugh Lake metasediments.

The Waugh Lake Basin is a small back arc basin, which formed on the Archean to Paleoproterozoic basement of the Taltson Magmatic Zone (McNicoll and McDonough, 1995).

Recent glacial scouring during the Pleistocene has left numerous fresh rounded outcrops in the area. These indicate that the last ice movement was towards the southwest. In low lying areas, extensive sand flats and kames resulted from meltwater of retreating or ablating ice. Large kettles in these sand flats are indications of late ground ice in the area.

STRATIGRAPHY OF THE WAUGH LAKE GROUP

The basal assemblage (the Martyn Lake Formation) is distinctly different from the overlying siliciclastic lithofacies units. The metasedimentary rocks of this formation are much more compositionally mature and generally thinner bedded than those of succeeding formations. The overlying rocks consist of two megacycles of metasediments grading into metavolcanics. The lower megacycle consists of the Doze Lake Formation and the upper megacycle is comprised of the Sederholm Lake and Johnson Lake formations (Figure 1, in pocket).

The metasedimentary and metavolcanic rocks of the Waugh Lake Group contain relict primary sedimentary structures over much of northeast Alberta. Locally, where the rocks are only weakly deformed and sheared, primary sedimentary structures and textures have been well preserved. This is particularly true for outcrops of the Sederholm Lake and Johnson Lake formations where excellent examples of trough cross-beds, graded beds, load structures and scours have been observed (Plate 2-5 and 2-6; Plate 3-1 and 3-2). The description and interpretation of the depositional history of the siliciclastic and volcanic rocks of the Waugh Lake Group are based primarily on the examination of weakly deformed outcrops across the map area. This synthesis includes information derived from analyses of stratigraphic sections, hand specimens and thin sections. The analysis of major relevant stratigraphic and structural features has resulted in the delineation of a regional stratigraphy for the Waugh Lake Group, and the definition of five newly recognized formations (Table 1).

The strata are weakly to strongly sheared and often folded within the map area. The structural and metamorphic effects on these rocks have not been emphasized in the descriptions of the newly defined formations. A preliminary description of structural and metamorphic fabrics in Waugh Lake Group rocks has been presented by Watanabe (1961), Godfrey (1963) and Salat *et. al.* (1994).

The strata also typically contain quartz veins and locally have extensive quartz stockworks. The latter feature is generally associated with fault or shear zones. Tourmaline veins are also present, as are fine- to medium-grained, brown- to grey-green weathered mafic dykes (less commonly sills) and hornblende-biotite diorite dykes. The major sills and dykes have been mapped and are illustrated in the section logs (e.g. Figures 17, 21, 22 and 29) and on the map (Figure 1). The location of outcrops containing extensive tourmaline and quartz veining have been previously outlined in Figure 1 of Salat *et. al.* (1994).

The base of the Waugh Lake Group was not observed within the map area, and consequently its basement is unknown. It is assumed that the Taltson basement is also the basement of the Waugh Lake Group (McNicoll and McDonough, 1995). An unconformity is assumed to exist at the base of the succession because of the prolonged period of uplift and erosion that must have followed basement formation.

MARTYN LAKE FORMATION

The Martyn Lake Formation comprises the basal rhythmically bedded lithofacies assemblage of the Waugh Lake Group (Figures 1 and 2; Table 1). The name is derived from Martyn Lake, adjacent to the Alberta-Saskatchewan border, around which extensive outcrops of the formation occur. The type section is located 500 m west of the central west shoreline of North Waugh Lake (Figure 11). Major reference sections include those measured at stations 4I016 (Figure 5) and 4I050 (Figure 13).

The formation has a maximum measured thickness of 137 m (Figure 11). It is estimated to be at least 200 m thick based on outcrops along the southwest shore of Doze Lake and in the area 1 km west of North Waugh Lake.

The formation consists mainly of interlayered very thin- to medium-bedded, fine- to coarse-grained quartz arenite to quartzitic subarkose, rhythmically layered, thick-laminated to very thin-bedded mudstone - siltstone - quartz arenite and thin horizons of thick-laminated phyllite (Plate 1, Figures 1 and 2). The strata weather generally grey, buff-grey banded dark-grey, black to rust-grey in colour. The original mudstones are now represented by phyllites and schists.

The strata are typically extensively folded and locally contain gossanous sparsely mineralized north-south trending shear zones up to 20 m in outcrop width and several hundred metres in strike length (Figure 1). The rusty shear zones are largely restricted to phyllite and biotite schist bearing horizons.

The rhythmically bedded strata of the Martyn Lake Formation are exposed mainly in the northeast and eastern part of the map area, along the shores of Waugh, Doze and Martyn lakes. The assemblage continues across the border into northwest Saskatchewan (Koster, 1961, 1971). An areally restricted, extensively folded and fault bounded outcrop area is preserved in the northwest portion of the map sheet (Figure 1).

Descriptions of rocks in northeast Alberta equivalent to those of the Martyn Lake Formation occur in Watanabe (1961), Godfrey (1963) and Salat *et. al.* (1994). Martyn Lake Formation strata are included in the "Quartzite" and "Biotite Schist" map units of Watanabe (1961) and Godfrey (1963). The strata have also been described and mapped as the "Rhythmite" (R-unit) by Salat *et. al.* (1994). The MF map unit of Salat et. al (1994), which comprised interlayered mafic and felsic flows and tuffs, was found to consist entirely of folded and rhythmically interlayered sandstone-siltstone-phyllite of the Martyn Lake Formation (Figure 1).

Description

The Martyn Lake Formation comprises alternating sandstone, siltstone and phyllite strata arranged into four major lithofacies associations that occur variably intermixed within successions in the map area (Table 2; Figures 2, 5, 11 and 13).

ML Lithofacies Association 1:
The rocks consist of fine- to medium-grained, less commonly medium- to coarse-grained grey, buff- to green-grey quartz arenite to quartzitic subarkose. The sandstone horizons are thin- to thick-bedded and locally massive; they range in thickness from about 20 cm to over 3 m. The planar to undulatory layered beds contain grading and shallow scours, and locally occur as amalgamated sandstone horizons (Plate 1-2). The graded horizons resemble medial turbidites (thickness range: 5 cm to 15 cm) of A and AB type (Walker, 1984; Stow, 1986). The shallow basal scours, present on some sandstone layers, downcut up to 10 cm into underlying rhythmically bedded sandstone-siltstone-phyllite.

ML Lithofacies Association 2:
The strata of the second association consist of planar- to gently-undulatory, rhythmically bedded, dark-grey to black, thin- to thick-laminated phyllite, which are intermixed with thick-laminated to very thin-bedded grey siltstone to fine-grained and medium-grained quartz arenite to quartzitic subarkose. The strata comprise, in part, distal turbidites (thickness range: 3 cm to 8 cm) of AE, BDE and DE types (Walker, 1984; Stow, 1986). The rhythmically alternating phyllite-siltstone-sandstone layers comprise the dominant sedimentary texture.

ML Lithofacies Association 3:
Phyllite-dominated horizons, less than 0.2 m to more than 1 m thick, comprise the third association. The strata consist of planar layered, thin-laminated to very thin-bedded phyllite, that locally grade into biotite-sericite schist. A few thin laminae of siltstone and fine-grained sandstone may occur within the phyllitic horizons. The rocks weather black, dark-grey to rust-brown. The rust weathered horizons are commonly associated with pyrite (and occasionally arsenopyrite) bearing shear zones.

ML Lithofacies Association 4:
The fourth association consists of very thin- to medium-bedded, light grey fine- to medium-grained quartz arenite to quartzitic subarkose alternating with horizons of intermixed, thin-laminated to very thin-bedded, planar to wavy layered phyllite-siltstone-(fine-to medium-grained) quartz arenite (Plate 1-1). The beds contain lenticular-wavy-flaser bedded horizons (Allen, 1983; Reineck and Singh, 1980), grading, shallow scours, distal to medial turbidites (thickness range: 5 cm to 20 cm; types as noted above), and rare cross-laminations.

Contacts

The strata of the Martyn Lake Formation pass gradationally upwards into massive weathered, poorly stratified polymictic conglomerates of the lower member of the Doze Lake formation in the northeast part of the map sheet (DL.L_{NE}), via a distinctive transitional unit herein defined as the Doze Lake Transitional (DL.TR) member. The transition is characterised by an upward increase in coarse clast content and a corresponding decrease in the argillitic content of the rocks. The DL.TR member is a hybrid unit that contains lithologies typical of both the Martyn Lake Formation and the DL.L_{SW} and DL.L_{NE} members (Plate 1-5). The contact is illustrated in Figures 13 and 23.

The Martyn Lake Formation is conformably overlain by:

(i) Massive pebble to boulder polymictic conglomerate of the DL.L_{NE} member in the northeast part of the map sheet as illustrated in Figures 5 and 12.

(ii) Thick-laminated to very thin-bedded, medium-grained to pebbly subarkose and sublitharenite of the DL.L_{SW} member. This contact relationship occurs in successions in the northeast to east central part of the map sheet and is illustrated in Figure 3.

(iii) Massive fine crystalline, green-grey to brown-grey weathered mafic flows and pyroclastic breccia of the DL.B member in the northeast part of the map sheet east and southeast of Doze Lake (Figures 1 and 2). The volcanic rocks may also be interlayered with the upper part of the Martyn Lake Formation since the complete nature of the contact between the two successions is unknown.

Strata of the Martyn Lake Formation are intruded by the Andrew Lake granite and related Waugh Lake granitoids (Figure 1). This intrusive contact is well exposed at the north end of the map sheet. In this area porphyritic Andrew Lake granite contains pebble to block sized xenoliths of Martyn Lake sandstone at the contact. The Martyn Lake rocks, adjacent to the intrusive contact, have been invaded by veins and narrow dykes of porphyritic Andrew Lake granite.

Depositional History

The occurrence of intermixed rhythmic bedded units, distal and medial turbidites, and horizons of massive and amalgamated sandstone with basal scours indicates deposition of much of the Martyn Lake Formation within a shallow to deep marine setting in mid to outer submarine fan and basin plain environments (Stow, 1986; Walker, 1984; Howell and Normarck, 1982). The alternation of rhythmic layered and more massive sandstone horizons may represent submarine fan deposits with distal channel infill successions.

The presence of minor horizons of lenticular-wavy-flaser bedded, interlayered sandstone-siltstone-phyllite implies that at least some of the succession was deposited on a shallow marine shelf under the influence of tidal currents. This setting may have encompassed offshore shelf to lower shoreface depositional environments (Johnson and Baldwin, 1986; Allen, 1982; Reineck and Singh, 1980).

The deposition of the Martyn Lake Formation may have occurred in a shallow to deep marine continental margin basin. The apparently conformable to gradational nature of the transition to the coarse and immature siliciclastics of the Doze Lake Formation indicates that this major change in sedimentation style occurred in a gradual manner. The transition apparently coincided with a major change in the tectono-sedimentary setting of the Waugh Lake basin as it evolved from a marginal marine basin, in a stable marine setting, to a volcano-sedimentary dominated basin, in a tectonically active terrestrial setting.

DOZE LAKE FORMATION

The Doze Lake Formation comprises the lower sedimentary and volcanic assemblage of the Waugh Lake Group (Table 1; Figure 2). The formation is named after Doze Lake (northeast part of map sheet) along the southern shores of which conglomerates of the DL.L$_{NE}$ member outcrop, forming part of a reference section (Figure 4). The type section is situated along the south shore of West Waugh Lake in the southern part of the map sheet (Figure 17). Strata of the Doze Lake Formation outcrop on both limbs of the syncline in generally north-south trending belts; strata also outcrop in the vicinity and south of Doze Lake in the northeast part of the map sheet (Figure 1). The formation consists of a diverse assemblage of arenaceous, conglomeratic and volcanic rocks which have been subdivided into a lower sedimentary-dominated (i.e. the Lower Doze Lake or DL.L member) and an upper volcanic-dominated member (i.e. the Upper Doze Lake or DL.U member; Table 1, Figure 2). In addition, the DL.L member was found to be comprised of four distinct, laterally equivalent lithofacies assemblages that are herein defined as the Transitional (i.e. DL.TR member), Basal (i.e. DL.B member), Northeast (i.e. DL.L$_{NE}$ member) and Southwest (i.e. DL.L$_{SW}$ member) members of the lower part of the Doze Lake Formation (Table 1, Figure 2).

The Doze Lake Formation ranges from 200 m to 217 m in thickness (Figures 18 and 26) in the southeast part of the map sheet. It is estimated to reach a maximum thickness of 330 m in the southwest part of the map sheet (i.e. in the area of stations 41131 to 41133). The formation appears considerably thicker on the west limb of the syncline (Figure 1). The type section (Figure 17) is representative of the southwest facies assemblage of the formation (i.e. the DL.TR and DL.L$_{SW}$ members). A complete section for the northwest facies assemblage (i.e. the DL.B and DL.L$_{NE}$ members) was not obtained. However, a composite of sections illustrated in Figures 3, 4, 7, 8 and 23 may constitute a reference succession for this assemblage. Major additional reference sections for the formation are illustrated in Figures 18 and 26.

The strata of the Doze Lake Formation gradationally overlie the Martyn Lake Formation. The nature of the contact relationships between the lower members of the Doze Lake Formation and strata of the Martyn Lake Formation have been outlined in the description of the latter succession (see Figures 1, 2, 3, 5 and 12 for reference). The Doze Lake Formation is overlain by strata of the Sederholm Lake Formation or the lower (JL.L) member of the Johnson Lake

Formation (Figure 1). The DL.U member beds are sharply and conformably overlain by green-grey to green-black weathered amphibole-bearing sandstones to pebbly sandstones and (less commonly) intermixed intermediate to mafic tuffs and flows of the Sederholm Lake Formation (Table 1; Figure 2). This contact relationship is present over most of the west limb and about half of the east limb of the syncline. It is illustrated in Figures 17 to 19, 21, 22, and 24 to 29. The strata of the DL.U member are also sharply and apparently conformably overlain by sublitharenite, subarkose and conglomerate beds of the JL.L member in several areas on the east and west limb of the syncline (Figure 1). This relationship occurs where the Sederholm Lake Formation is missing due to erosion or non-deposition. The contact at these sites probably represents an intraformational unconformity.

A gneissic texture is developed in the strata of the DL.L$_{SW}$ member adjacent to the Andrew Lake / Colin Lake granite contact along the west limb of the syncline (Figure 1). The gneissic texture extends up to 100 m into the DL.L member succession away from the intrusive contact. The origin of the gneiss may be related to metamorphism and deformation associated with emplacement of the granitic plutons.

Rocks equivalent to those of the Doze Lake Formation have been mapped as "Biotite Schist" (now the conglomerate dominated DL.L$_{NE}$ member), "Sericitic, Porphyroclastic Phyllonite" (now the DL.L$_{SW}$ member) and "Quartzite" (now the DL.U member) by Watanabe (1961) and Godfrey (1963). Equivalent map units in Salat *et. al.* (1994) consist of the M-unit (=mafic flows and tuffs) for the DL.B member, DC-unit (=diamictite; includes pebble to cobble conglomerate) for the DL.L$_{NE}$ member and F-unit (=felsic to intermediate flows and tuffs) for the undivided DL.L$_{SW}$ member - DL.U member succession.

DL.TR (Transitional) member

Strata of the DL.TR member outcrop only in the east central portion of the map sheet. The successions are thin and beyond current map-unit resolution. The member ranges in thickness from 4 m to 11 m (Figures 13 and 23). This transitional horizon is comprised of a mixture of lithologies found in the Martyn Lake Formation and in the DL.L$_{NE}$ and DL.L$_{SW}$ members of the Doze Lake Formation (Plate 1-5). The type section for the member outcrops 1.2 km west of the southwest shore of North Waugh Lake (Figure 13). A reference section is illustrated in Figure 23.

Description

The strata of the DL.TR member appear to be a hybrid of the Martyn Lake Formation and DL.L member lithologies and represents a gradational assemblage between these two lithologically distinct successions. The sedimentary rocks of the DL.TR member occupy the same stratigraphic position as the volcanic rocks of the DL.B member. They must be laterally equivalent to these rocks and to the basal portion of the DL.L$_{NE}$ member (Table 1). The rocks weather buff- to grey-brown with pink-brown to pink-grey bands. They comprise three major lithofacies associations (Table 2; Figures 13 and 23).

DL.TR Lithofacies Association 1:
The first association consists of planar to wavy layered, thick-laminated to thin-bedded, rhythmic layered, fine-grained quartzitic subarkose and siltstone with quartzitic subarkose lenses and intraclasts.

DL.TR Lithofacies Association 2:
The strata of the second association comprise rhythmically layered, planar thick-laminated phyllite and planar to undulatory layered thin-bedded, fine-grained quartz arenite, which are intermixed with planar to wavy layered, thin-bedded coarse-grained to pebbly subarkose to sublitharenite. The strata contain variably interlayered lenses to intraclasts of fine- to coarse-grained quartzitic subarkose (Plate 1-5). The sandstone intraclasts or lenses are up to 36 cm (long axis) by 12 cm (short axis) in size (Appendix I).

DL.TR Lithofacies Association 3:
The third association consists of planar thin- to thick-laminated phyllite intermixed with thick-laminated to very thin-bedded, lenticular layered fine- to medium-grained quartz arenite to quartzitic subarkose. The sandstone portion of the association ranges from lensed layers to isolated lenses; the latter component may represent sandstone intraclasts.

DL.B (Basal) member

In the northeast part of the map sheet, adjacent to the southeast shore of Doze Lake, outcrop sequences of fragmental volcanic rocks and mafic flows which comprise the DL.B member of the Doze Lake Formation (Figures 1 and 2). The strata represent the oldest volcanic rocks of the Waugh Lake Group. The basal volcanic rocks occur only in this area where they are conformably overlain by pebble to boulder polymictic conglomerates of the $DL.L_{NE}$ member (Figures 7 to 9). The stratigraphic position of these rocks is not completely known; they may also be, in part, interstratified with rhythmically layered strata of the uppermost Martyn Lake Formation (Salat *et. al.*, 1994). The type section outcrops along the east-central shore of Doze Lake (Figure 8). The major reference sections are illustrated in Figures 4, 7 and 9.

<u>Description</u>

The DL.B member consists of intermixed horizons of massive weathered pyroclastic breccia and intermediate to mafic volcanic flows (Figures 4 and 7 to 9). The pyroclastic breccia is comprised of angular felsic to intermediate fragments set in a fine-crystalline intermediate to mafic matrix. The breccia weathers green, green-brown mottled buff- to orange-brown (Plate 1-6). The clast content ranges in amount from less than 20% to more than 70% and the clasts are up to 20 cm in length. The breccia horizons are 1 m to 11 m in thickness and locally they preserve crude layering. A green-brown weathered pyroclastic breccia horizon, 0.3 m to 1 m thick, occurs also in the basal part of the DL.LNE member, 1 m above the contact with the DL.B member, indicating an interfingering contact (Figure 7). Salat *et. al.* (1994) interpreted the pyroclastic breccia horizon, present at the top of the member in Figure 7, as a flow top breccia.

The member also contains subordinate amounts of green-grey to green-brown weathered, fine-crystalline mafic, less commonly intermediate, volcanic flows (i.e. andesitic to basaltic flows). The volcanic rocks occur interlayered with the breccia in horizons 1 m to more than 5 m in thickness.

DL.LNE (Lower, northeast) member

The DL.LNE member consists almost entirely of massive weathering polymictic conglomerates that are comprised of quartz, quartzite, granite, siltstone and sandstone pebbles to boulders set in an argillaceous to arenaceous matrix (Plate 1-3 and 1-4). The strata of this member are the lateral equivalents of the sandstone to pebbly sandstone - dominated successions of the DL.LSW member (Table 1; Figure 2); they grade laterally southwestwards into these beds. The upper contact has not been observed in the map sheet. The conglomerates of the DL.LNE are best exposed along and south of the southern shores of Doze Lake; scattered small outcrops also occur in the area located 1.2 km west of North Waugh Lake (Figure 1). The member measures 119 m in thickness at the type section which is located along the east central shore of Doze Lake (Figure 4). Major reference sections are illustrated in Figures 5, 7, 9, 12, 13 and 23.

<u>Description</u>

The DL.LNE member consists mainly of green-grey, less commonly pink- to red-green weathered, massive non-stratified to poorly stratified pebble to boulder polymictic ortho-conglomerate. The strata are weakly to strongly sheared, the extent of shearing reflected in the amount of flattening of clasts in the beds (e.g. compare Plate 1-3 and 1-4). The conglomerate comprises spheroidal to discoidal, rounded to subangular quartz, quartzite, granite, siltstone and fine-grained to very coarse-grained quartz arenite and subarkose pebble to boulder size clasts. Rare pyroclastic breccia and mafic volcanic clasts occur at the base of the member in the area of Figures 7 to 9. The clasts are set in a matrix ranging from phyllitic subarkose and greywacke to coarse-grained to granular sublitharenite (Plate 1-3 and 1-4; Appendix I). The clast content varies laterally and vertically within successions and ranges from less than 30% to more than 80%. Clast types and maximum dimensions are summarised below (see Appendix I for details):

(i) White quartz; white to buff quartzite: 85 cm (long axis) by 50 cm (short axis).
(ii) Buff, grey-green to grey, fine- to coarse-grained quartzitic sandstone, subarkose and sublitharenite: 140 cm (long axis) by 35 cm (short axis).
(iii) Pink granite: 50 cm (long axis) by 8 cm (short axis).

The predominant clast type observed in all successions consists of grey to grey-green weathered, fine- to coarse-grained quartz arenite to subarkose.

The clasts are massive and thick-laminated to very thin-bedded and rhythmically layered (Plate 1-3 and 1-4); locally cross-laminated to cross-bedded cobbles and boulders also occur. These clasts are similar to sandstone lithologies present in the underlying Martyn Lake Formation. This implies that the source areas of clasts for the DL.LNE member included recently uplifted parts of the craton where Martyn Lake Formation strata were being eroded and reworked into a newly formed basin.

The conglomerate beds sometimes contain minor interbeds and interlenses of buff-pink banded, grey-pink-brown weathered, planar to undulatory layered, fine-grained to pebbly subarkose and sublitharenite. The sandstone horizons are typically thick-laminated to thin-bedded and locally contain small scour structures. These minor lithofacies are more prevalent in the area situated in the east central part of the map sheet, 900 m west of the north end of Waugh Lake (i.e. the area of Figure 23). The sequences in this area represent hybrid successions that probably accumulated in a DL.LNE to DL.LSW member transitional zone (Figures 1 and 2).

DL.LSW (Lower, southwest) member

The sandstone and pebbly sandstone dominated successions of the DL.LSW member comprise the southwest facies assemblage of the lower part of the Doze Lake Formation (Table 1; Figure 2). The successions comprise the major portion of the lower member and outcrop in the east central, southern and western parts of the map sheet (Figure 1). The DL.LSW member varies considerably in thickness. Sections measure from 59 m in the eastern part (Figure 3) to an estimated 220 m in the southwestern part of the map sheet (thickness uncertain because of internal deformation and presence of pegmatites). The sequences of the DL.LSW member appear considerably thicker on the west limb than on the east limb of the syncline (Figure 1). The strata consist mainly of thick-laminated to thin-bedded, medium-grained to pebbly sublitharenite and subarkose, with interlayered minor amounts of polymictic pebble to cobble conglomerate (Figure 2). The type section is situated along the south shore of West Waugh Lake where the member is 99 m thick (Figure 17). Reference sections are illustrated in Figures 3, 18 and 26.

Description

The DL.LSW member consists mainly of sandstone and pebbly sandstone beds arranged into two major lithofacies associations (Plate 2-1 and 2-2; Table 2). The strata are generally buff-grey banded pink-grey weathered and are characterised by the presence of sericitic joint and foliation planes. Minor thin horizons of pebble to cobble polymictic conglomerate occur in most successions. They are most prevalent in sequences in the east part of the map sheet where the transition between the DL.LNE and DL.LSW members occurs. The conglomerates resemble those observed in the DL.LNE member.

DL.LSW Lithofacies Association 1:

The strata of the first association consist of planar to undulatory layered, thick-laminated to thin-bedded, medium-grained to granular subarkose and sublitharenite. The sandstone beds are variably intermixed with layers of thin- to medium-bedded pebbly sublitharenite and lenses to layers of pebble to cobble polymictic conglomerate.

DL.LSW Lithofacies Association 2:
The second association comprises planar to wavy layered, thick-laminated to thin-bedded, fine- to coarse-grained subarkose and sublitharenite with minor thin-laminated phyllitic partings. The sandstone beds alternate with layers of thin- to medium-bedded, granular to pebbly sub-arkose and sublitharenite (Plate 2-1).

The strata generally preserve relict primary bedding. Locally, a variety of additional sedimentary structures are present and well preserved. The sandstones and pebbly sandstones contain small scours, channels, trough crossbeds and load structures (Plate 2-1 and 2-2); possible clast imbrication is also present. The beds are arranged into small scale fining- and thinning-upward couplets or cycles that range from less than 0.2 m to more than 1 m in thickness. They consist of basal layers of conglomeratic to pebbly sublitharenite grading up into thin-bedded to thick-laminated granular to medium-grained sublitharenite and subarkose. Other cycles comprise trough crossbedded pebbly sandstones grading up into planar to undulatory bedded, pebbly to medium-grained sublitharenite and subarkose. The cycles typically contain scoured bases.

The conglomerates of the DL.LSW member are generally clast supported. The pebble to cobble sized clasts are spheroidal to discoidal in shape, subrounded to subangular and are set in a coarse-grained to granular sublitharenite matrix. They include mainly granite, quartz, quartzite and sandstone, with subordinate amounts of phyllite (Appendix I). The sandstone clasts resemble similar lithologies observed in the strata of the underlying Martyn Lake Formation. Clast types and maximum dimensions are summarised below (see Appendix I for details):
(i) Pink granite: 14 cm (long axis) by 4 cm (short axis).
(ii) Green-grey, grey to green fine-grained quartzitic sandstone to greywacke: 44 cm (long axis) by 2 cm (short axis).
(iii) White quartzite: 37 cm (long axis) by 12 cm (short axis).
(iv) Green-grey phyllite: 21 cm (long axis) by 7 cm (short axis).

DL.U (Upper) member

The sedimentary rocks of the lower member are conformably overlain by volcanic and minor volcaniclastic and siliciclastic rocks of the DL.U (upper) member (Table 1; Figure 2). The member outcrops along the west and east limbs of the syncline in generally north-south trending belts (Figure 1). The rocks weather generally green to brown-green, in the basal part, and green- to buff-grey banded pink-grey in the upper part of the member. The strata range from 102 m (Figure 17) to 118 m (Figure 26) in thickness. The type section is situated along the south shore of West Waugh Lake within the same succession designated as the type section for the Doze Lake Formation (Figure 17). Major reference sections are illustrated in Figures 18, 21, 25, 26, 27 and 29.

Description

The DL.U member consists mainly of massive to layered, fine-crystalline felsic (less commonly intermediate) volcanic flows and minor intermixed felsic tuffs (Plate 2-3). The volcanics are rhyolitic to dacitic in composition (Salat *et. al.*, 1994). Where they are massive they are interpreted as flow units and when the volcanic horizons are layered or contain quartz and feldspar crystal fragments they are considered a tuff. Textures in the volcanic beds are not common, but quartz and feldspar phenocyrsts are typically preserved.

The volcanic beds also contain subordinate intermixed horizons of thick-laminated to thin-bedded reworked felsic (less commonly intermediate) tuff to lapilli tuff variably intermixed with layers and lenses of fine-grained to pebbly subarkose and sublitharenite. The volcaniclastic and siliciclastic horizons contain small scours, load casts, lensed to wavy bedding, rare cross-laminations and trough cross-beds (Plate 2-4). The strata comprise a very minor part of the member and occur in horizons less than 0.5 m to 5 m in thickness. They locally occur in lense shaped bodies within felsic flows and tuffs; these may represent broad, shallow channel infill sequences. The basal portion of one such sequence is illustrated in Plate 2-4.

Depositional History

The evolution of the Waugh Lake basin, during Doze Lake depositional time, represents the infill history of a volcano-sedimentary complex in an active, rapidly evolving marginal basin. The lower member of the formation contains a complex lithofacies assemblage characterised by contemporaneous accumulation of volcanic and sedimentary deposits during the initial phase of infill history. The DL.TR member may comprise a marine to continental transitional assemblage influenced by syndepositional tectonism; the member contains elements of both shallow marine to coarse braid plain environments. This interpretation is implied by the presence of component lithofacies of both the Martyn Lake Formation (marine deposits) and the DL.L$_{NE}$ member (continental deposits). The DL.B member comprises subaerially extruded basaltic (to andesitic) flows with intermixed probable vent and flow top breccias. The latter deposits may also include ground and base surge pyroclastic flows (Fisher, 1977; Allen, 1983). The breccia may have accumulated with deposits of a proximal braid plain to alluvial fan complex, as inferred from the occurrence of breccia layers and clasts in the basal part of the DL.L$_{NE}$ member.

Strata of the DL.L$_{NE}$ and DL.L$_{SW}$ members consist or massive, thick pebble to boulder polymictic conglomerate-dominated successions with few sedimentary structures other than primary bedding, and successions comprised of fining- and thinning-upward cycles typical of deposition in broad, shallow channels. These features resemble those found in modern and ancient continental deposits of alluvial fan and gravel- to sand-dominated braid plain systems (Miall, 1977; Rust, 1978; Rust and Koster, 1984; Collinson, 1986). The successions of the DL.LNE and DL.LSW members are interpreted as sand, pebbly sand and gravel to talus sediments that accumulated in mixed alluvial fan and proximal to distal braid plain depositional environments.

The volcanic dominated successions of the DL.U member are interpreted to have accumulated mainly as subaerial flows with associated airfall and water reworked ash deposits (Fisher, 1966, 1977). The presence of volcaniclastic and coarse-grained to pebbly sandstone horizons with scours, cross-laminations, and trough crossbeds, arranged into channel infill sequences up to 5 m thick implies contemporaneous fluvial sedimentation associated with the volcanism. The volcanic deposits were partially reworked during episodes of braid plain construction.

The deposition of the Doze Lake Formation occurred in a marginal continental basin in a tectonically active setting. Doze Lake strata accumulated in a dynamic regime in which sedimentation patterns may have been influenced by syndepositional tectonism. They represent the deposits of the first rift cycle in the Waugh Lake basin. The initial phase consisted of mafic volcanism (DL.B member) associated with marine to continental deposits (DL.TR member). The basal assemblage recorded the transition from stable (Martyn Lake deposition) into active (Doze Lake deposition) stages in basin evolution. The basal volcano-sedimentary succession was succeeded by marginal fan to distal braid plain sediments (DL.LNE and DL.LSW members) that accumulated across the basin during DL.L member deposition. The basin then became the site of mainly felsic volcanism (with minor associated tuff and braid plain deposits) in the upper part of the rift cycle during accumulation of the DL.U member.

SEDERHOLM LAKE FORMATION

The rocks of the Sederholm Lake Formation comprise a distinctive succession situated in the mid-portion of the Waugh Lake Group (Table 1; Figures 1 and 2). The succession is named after Sederholm Lake, located at the west-central edge of the map area. The type section is located 1.5 km south-southeast of this lake (Figures 1 and 22). Major reference sections include those illustrated in Figures 21, 22, 24, 25 and 29. The dark-green, grey- to brown-green weathered, mafic minerals bearing volcaniclastic and quartz-feldspar dominated siliciclastic (including minor volcanic) rocks of the formation range in thickness from 7 m at the south end (Figure 17) to 91 m in the west central part of the map area (Figure 25). The thickness trends outline a basin-like distribution of strata with the thickest sequences located in the west central part of the map area (Figure 1).

This dark weathered and unique lithofacies assemblage acts as an excellent marker horizon in the Waugh Lake Group and comprises the basal volcano-sedimentary assemblage of the upper megacycle. The lithofacies of the Sederholm Lake Formation consist mainly of amphibole-bearing (less commonly biotite-bearing) fine-grained to pebbly arkosic wackes, subarkoses and sublitharenites and variably intermixed minor amounts of polymictic conglomerate layers and lenses, horizons of intermediate to mafic tuff to reworked tuff and very minor fine-crystalline mafic flows. The volcaniclastic and siliciclastic strata contain locally extensive, well preserved trough crossbeds, graded beds, load casts, scour and channel structures, cross-laminations and soft-sediment deformed horizons. Measurement of axial trends of trough crossbeds exposed in three dimensions indicate that paleocurrents were derived from the east-southeast to northeast (i.e. from the direction of Saskatchewan; corrected azimuths = 290°, 223°, 290°, 286°) and from the south and south-southwest (i.e. from the direction of Fort McMurray; corrected azimuths = 005°, 020°, 024°). The formation outcrops on both limbs of the syncline in a discontinuous manner. Locally the succession is absent and intermixed sandstone and conglomerate beds of the lower Johnson Lake (JL.L) member disconformably (?) rest upon felsic flows and tuffs of the DL.U member (Figure 1).

Strata resembling those of the Sederholm Lake Formation were not separately identified during mapping of the Waugh Lake area by Watanabe (1961) and Godfrey (1963). However, some rocks belonging to the Sederholm Lake Formation were mapped as "Biotite Schist". Strata equivalent to the Sederholm Lake Formation were mapped as a distinct horizon by Salat *et al.* (1994) and defined as the ML map unit. This map unit consisted of interlayered mafic lapilli tuff and volcaniclastic sedimentary rocks. The newly defined Sederholm Lake Formation includes the previously defined ML-map unit and expands the definition and outcrop extent of that succession.

Description

The Sederholm Lake Formation comprises intermixed siliciclastic, volcaniclastic and volcanic strata arranged into three major lithofacies associations, which comprise the major part of the formation, and several minor associations (Figure 2; Table 2). The lithofacies associations are arranged into a variety of assemblages across the map area (Figures 21, 22, and 24 to 29).

SL Lithofacies Association 1:
The strata of the first association consist of planar- to crossbedded, thick-laminated to thin-bedded actinolitic (less commonly biotitic) medium-grained to granular arkosic-wacke and sublitharenite intermixed with layers and lenses of pebbly subarkose, sublitharenite and polymictic conglomerate. The conglomerate horizons contain quartz, leucocratic granite, mafic volcanic clasts, and layered mafic sandstone intraclasts that are rounded to subangular and pebble to cobble size; the horizons have undulating, scoured (or channelled) basal contacts (Plate 2-5). The thickest accumulations of this association occurs in sections illustrated in Figures 21 and 25.

SL Lithofacies Association 2:
The rocks of this association comprise planar to trough cross-bedded, thick-laminated to thin bedded actinolitic (less commonly biotitic) fine- to coarse-grained arkose, arkosic wacke to sublitharenite and variably intermixed coarse-

grained to pebbly subarkose and sublitharenite. The alternation of these compositionally distinct sandstone types imparts a striking green-grey to brown-green-grey (from mafic sandstone) banded buff-pink-grey (from quartz-feldspar dominated sandstone) colour to the outcrops of the Sederholm Lake strata (Plate 2-6). This association comprises most of the formation in Figures 18, 19, 24, and 26 to 29.

SL Lithofacies Association 3:
The third major lithofacies association consists of thick-laminated to thin-bedded, fine- to coarse-grained actinolitic subarkose to sublitharenite interlayered with minor amounts of mafic to intermediate tuff. The thickest horizons of these planar to wavy layered strata occur at section 41093 (Figure 21).

The strata of the major lithofacies associations preserve exceptional examples of trough cross-beds, small to large scale scour and channel structures, reactivation surfaces, cross-laminations, load casts and soft-sediment folds (Plate 2-6). Trough cross-beds range in height from about 5 cm to 40 cm and typically contain graded, oversteepened and soft-sediment deformed horizons. Scoured and channelled bases are typical of most trough cross-bedded and conglomeratic horizons. The bases of these layers are downcut up to 0.5 m into the underlying strata. Soft-sediment deformation affects entire horizons within the Sederholm Lake Formation and also individual cross-laminated and cross-bedded layers within a succession. The strata are also commonly arranged into small to moderate scale fining- or thinning-upward cycles. The cycles range from 0.3 m to greater than 1.5 m in thickness. They are comprised of trough cross-bedded, very coarse-grained to pebbly mafic sublitharenite and subarkose (with basal scours, load casts and internal reactivation surfaces), which are overlain by thin-bedded to thick-laminated planar- to wavy-layered, coarse- to fine-grained arkosic-wacke, sublitharenite, subarkose, and minor arkosic siltstone. The cycles resemble channel and bar deposits typical of coarse, proximal braided river systems (Miall, 1977; Rust 1978; Rust and Koster, 1984).

Compositionally the volcaniclastic and siliciclastic strata are close to that of a basalt or dolerite (Salat *et. al.*, 1994). The mafic sandstones, in thin section, contain up to 50% actinolite and up to 20% biotite laths associated with variable amounts of quartz, feldspar and lithic sand to pebble size clastic fragments. The quartz-feldspar dominated sandstones contain mainly quartz, feldspar and lithic clasts in both the matrix and fragments.

The volcaniclastic and siliciclastic strata also contain intermixed thin horizons of dark-green to brown-green, fine-crystalline, massive weathered intermediate to mafic flows (Figure 22) and fine-crystalline, intermediate to mafic tuff (Figures 21, 22 and 24).

Contacts

The Sederholm Lake Formation is gradationally overlain by very thin-bedded to medium-bedded, coarse-grained to pebbly subarkose and sublitharenite of the lower Johnson Lake (JL.L) member; this relationship is illustrated in Figures 21, 22, 24, 25 and 29. The transition is characterised by the interlayering of planar- to wavy-bedded to cross-bedded brown- to green-grey amphibole-bearing arkosic-wackes to sublitharenites (Sederholm Lake strata) and light-grey to pink-grey medium-grained to pebbly subarkose and sublitharenite (JL.L member strata). In a few localities rocks of the Sederholm Lake strata are conformably overlain by felsic flows, tuffs and minor intermixed reworked tuff and subarkose to sublitharenite of the JL.L member; this contact relationship is illustrated in Figures 19 and 28.

Depositional History

The deposition of the Sederholm Lake Formation was characterised by the accumulation of a complex assemblage of largely volcaniclastic and siliciclastic deposits derived in part from contemporaneous mafic volcanic tuffs and flows. Major features relevant in determining the nature of the depostional setting can be outlined in the following:

(i) The presence of well developed thinning- or fining-upward cycles of trough-crossbedded and planar bedded mafic and quartz-feldspar dominated arkose to sublitharenite, with channelled bases and reactivation surfaces
(ii) The occurrence of locally extensive soft-sediment deformed horizons
(iii) Associations of coarse-grained to conglomeratic mafic and quartz-feldspar bearing sandstone with loaded and channelled bases intermixed with mafic volcanic tuffs and flows.
(iv) Conglomerate horizons with pebbles to cobbles of mafic volcanic and layered to soft-sediment folded, mafic sandstone intraclasts.

The presence of such features imply deposition of much of the Sederholm Lake Formation in a tectonically active setting in which braid plain deposits infilled and dominated the Waugh Lake basin. The coarse-grained to conglomeratic arkosic-wackes, subarkoses and sublitharenites resemble coarse alluvium in ancient and modern proximal braid plain depositional regimes (Miall, 1977; Rust, 1978; Rust and Koster, 1984; Collinson, 1986). The accumulation of sediments took place in a dynamic setting in which extensive reworking of contemporaneous deposits of mafic volcanic flows and previously deposited volcaniclastic and siliciclastic sediments could occur. The setting was characterised by contemporaneous sedimentation, volcanism, erosion and resedimentation in a terrestrial basin. The remarkable occurrence of mafic-bearing sandstone and quartz-feldspar-dominated sandstone lithofacies co-existing within the same depositional basin indicates the influence of two distinct source areas:

(i) An internal source for the mafic clastic debris; this material was supplied by reworking of contemporaneous sediments and volcanics.
(ii) An external source for the quartz-feldspar clastic debris; this material would have been supplied from a cratonic source area (i.e. the Churchill Structural Province).

The infill history of the Sederholm Lake Formation represents deposition in a tectonically active alluvial basin (Miall, 1977) with a volcanic component. The depositional interval represents a second phase of reactivation during evolution of the Waugh Lake basin. This phase was characterised by the transition from felsic volcanism (DL.U member; upper assemblage of the lower megacycle) into intermixed mafic volcanism, sedimentation and syn-depositional tectonism in a marginal continental setting.

JOHNSON LAKE FORMATION

The Johnson Lake Formation comprises the upper sedimentary and volcanic megacycle assemblage of the Waugh Lake Group (Table 1; Figure 2). The formation name is derived from Johnson Lake, located 2.5 km south of the southern edge of the map area. Rocks of the formation outcrop along the northwest shore of the lake. The type section is located at section 4I149 (Figure 29), 1.8 km southeast of Sederholm Lake where the formation is 401 m thick. Major reference sections are illustrated in Figures 17, 18, 19 and 22. The measured sequences of the formation range from 238 m (Figure 20) to 452 m (Figure 19) in thickness. The successions are markedly thicker on the north shore of West Waugh Lake (i.e. 452 m thick at section 4I076; Figure 19) and in the northeast part of the map sheet in the area 1.8 km west-southwest of North Waugh Lake where they reach a maximum estimated thickness of 515 m. The Johnson Lake Formation can be separated into a lower member, dominated by sedimentary rocks (i.e. the JL.L member) and an upper member, dominated by volcanic rocks (i.e. the JL.U member; Table 1; Figure 2).

The strata of the JL.L member conformably overlie those of the Sederholm Lake Formation and locally rest disconformably on felsic volcanic rocks of the DL.U member (Figure 1). The sandstones and conglomerates of the JL.L member are conformably overlain by the felsic tuffs, lapilli tuffs and flows of the JL.U member (Table 1; Figure 2). The strata of the JL.U member, on an outcrop scale, appear to be conformably overlain by mafic volcanic rocks of the Niggli Lake Formation. However, on a larger scale the JL.U member / Niggli Lake Formation contact cuts across the strike of the JL.U member strata and locally, as in the southeast part of the map sheet, Niggli Lake volcanic rocks rest unconformably upon sandstones and conglomerates of the JL.L member (Figure 1).

Rocks equivalent to those of the Johnson Lake Formation have been mapped as horizons within the "Quartzite" and "Sericitic, Porphyroclastic Phyllonite" map units of Watanabe (1961) and Godfrey (1963). The latter map unit comprised feldspar augen in a sheared, mylonitic to crushed matrix associated with phyllite, quartzite and crush conglomerate. The Johnson Lake Formation includes the FL (=interlayered felsic lapilli tuff and volcaniclastic sedimentary rocks), FLI (=interlayered felsic lapilli tuff and volcaniclastic sedimentary rocks with larger fragments) and F (=felsic to intermediate flows and tuffs) map units of Salat *et. al.* (1994).

JL.L (Lower) member

The sequences of the JL.L member range from 184 m (Figure 19) to 343 m (Figure 17) in thickness and are dominated by sedimentary rocks. The strata consist mainly of thick-laminated to thin-bedded, medium-grained to pebbly sublitharenite and subarkose, with minor variably intermixed layers of pebble to cobble polymictic conglomerate; subordinate horizons of felsic to intermediate tuffs, flows and reworked tuffs also occur. The volcanic and volcaniclastic beds increase in amount north and northeast in the member.

The type section is located along the south shore of West Waugh Lake and represents the maximum thickness for the member (Figure 17; thickness = 343 m). Major reference sections consist of those illustrated in Figures 15, 16, 18, 19, 20, 22 and 29. The successions on the western limb of the syncline, in the vicinity of Figures 22 and 29, can be subdivided into "Fine Grit" (thickness = 102 m to 107 m) and "Coarse Grit" (thickness = 113 m to 135 m) submembers.

<u>Description</u>

The strata of the JL.L member comprise two major sedimentary lithofacies associations (Plate 3-1 and 3-2) and several subordinate volcanic to volcaniclastic lithofacies associations which occur as minor components in a sedimentary dominated assemblage (Figures 2, 14, 16, 17 to 20, and 29; volcanic lithologies are of significant volume only at Figure 15).

JL.L Lithofacies Association 1:
The strata of the first association consist of planar to undulatory layered, thick-laminated to thin-bedded, medium-grained to granular subarkose and sublitharenite with variably intermixed layers and lenses of very thin- to medium-bedded, pebbly sublitharenite and pebble to cobble, polymictic conglomerate. The conglomerate horizons range from less than 0.2m to more than 0.8 m in thickness. This association comprises the "Coarse Grit" submember in Figures 22 and 29. The strata weather grey, often in buff-grey and pink-grey alternating bands.

JL.L Lithofacies Association 2:
The rocks of the second association comprise planar to wavy layered, thick-laminated to thin-bedded, fine- to coarse-grained subarkose and sublitharenite alternating with layers of thin- to medium-bedded granular to pebbly subarkose and sublitharenite. This sandstone-dominated association constitutes the "Fine Grit" submember in Figures 22 and 29. The strata weather grey, buff- to white-grey, less commonly pink-grey, in colour.

Sedimentary structures are locally well preserved in the sandstones and conglomerates of the JL.L member. They include small to medium scale trough cross-beds (Plate 3-2), scours and small load casts. In a few beds, possible clast imbrication was observed (Plate 3-1). Fining-upward cycles, similar to those observed in strata of the DL.L_{SW} member, are also present. The cycles

The infill history of the Sederholm Lake Formation represents deposition in a tectonically active alluvial basin (Miall, 1977) with a volcanic component. The depositional interval represents a second phase of reactivation during evolution of the Waugh Lake basin. This phase was characterised by the transition from felsic volcanism (DL.U member; upper assemblage of the lower megacycle) into intermixed mafic volcanism, sedimentation and syn-depositional tectonism in a marginal continental setting.

JOHNSON LAKE FORMATION

The Johnson Lake Formation comprises the upper sedimentary and volcanic megacycle assemblage of the Waugh Lake Group (Table 1; Figure 2). The formation name is derived from Johnson Lake, located 2.5 km south of the southern edge of the map area. Rocks of the formation outcrop along the northwest shore of the lake. The type section is located at section 41149 (Figure 29), 1.8 km southeast of Sederholm Lake where the formation is 401 m thick. Major reference sections are illustrated in Figures 17, 18, 19 and 22. The measured sequences of the formation range from 238 m (Figure 20) to 452 m (Figure 19) in thickness. The successions are markedly thicker on the north shore of West Waugh Lake (i.e. 452 m thick at section 41076; Figure 19) and in the northeast part of the map sheet in the area 1.8 km west-southwest of North Waugh Lake where they reach a maximum estimated thickness of 515 m. The Johnson Lake Formation can be separated into a lower member, dominated by sedimentary rocks (i.e. the JL.L member) and an upper member, dominated by volcanic rocks (i.e. the JL.U member; Table 1; Figure 2).

The strata of the JL.L member conformably overlie those of the Sederholm Lake Formation and locally rest disconformably on felsic volcanic rocks of the DL.U member (Figure 1). The sandstones and conglomerates of the JL.L member are conformably overlain by the felsic tuffs, lapilli tuffs and flows of the JL.U member (Table 1; Figure 2). The strata of the JL.U member, on an outcrop scale, appear to be conformably overlain by mafic volcanic rocks of the Niggli Lake Formation. However, on a larger scale the JL.U member / Niggli Lake Formation contact cuts across the strike of the JL.U member strata and locally, as in the southeast part of the map sheet, Niggli Lake volcanic rocks rest unconformably upon sandstones and conglomerates of the JL.L member (Figure 1).

Rocks equivalent to those of the Johnson Lake Formation have been mapped as horizons within the "Quartzite" and "Sericitic, Porphyroclastic Phyllonite" map units of Watanabe (1961) and Godfrey (1963). The latter map unit comprised feldspar augen in a sheared, mylonitic to crushed matrix associated with phyllite, quartzite and crush conglomerate. The Johnson Lake Formation includes the FL (=interlayered felsic lapilli tuff and volcaniclastic sedimentary rocks), FLI (=interlayered felsic lapilli tuff and volcaniclastic sedimentary rocks with larger fragments) and F (=felsic to intermediate flows and tuffs) map units of Salat *et. al.* (1994).

JL.L (Lower) member

The sequences of the JL.L member range from 184 m (Figure 19) to 343 m (Figure 17) in thickness and are dominated by sedimentary rocks. The strata consist mainly of thick-laminated to thin-bedded, medium-grained to pebbly sublitharenite and subarkose, with minor variably intermixed layers of pebble to cobble polymictic conglomerate; subordinate horizons of felsic to intermediate tuffs, flows and reworked tuffs also occur. The volcanic and volcaniclastic beds increase in amount north and northeast in the member.

The type section is located along the south shore of West Waugh Lake and represents the maximum thickness for the member (Figure 17; thickness = 343 m). Major reference sections consist of those illustrated in Figures 15, 16, 18, 19, 20, 22 and 29. The successions on the western limb of the syncline, in the vicinity of Figures 22 and 29, can be subdivided into "Fine Grit" (thickness = 102 m to 107 m) and "Coarse Grit" (thickness = 113 m to 135 m) submembers.

<u>Description</u>

The strata of the JL.L member comprise two major sedimentary lithofacies associations (Plate 3-1 and 3-2) and several subordinate volcanic to volcaniclastic lithofacies associations which occur as minor components in a sedimentary dominated assemblage (Figures 2, 14, 16, 17 to 20, and 29; volcanic lithologies are of significant volume only at Figure 15).

JL.L Lithofacies Association 1:
The strata of the first association consist of planar to undulatory layered, thick-laminated to thin-bedded, medium-grained to granular subarkose and sublitharenite with variably intermixed layers and lenses of very thin- to medium-bedded, pebbly sublitharenite and pebble to cobble, polymictic conglomerate. The conglomerate horizons range from less than 0.2m to more than 0.8 m in thickness. This association comprises the "Coarse Grit" submember in Figures 22 and 29. The strata weather grey, often in buff-grey and pink-grey alternating bands.

JL.L Lithofacies Association 2:
The rocks of the second association comprise planar to wavy layered, thick-laminated to thin-bedded, fine- to coarse-grained subarkose and sublitharenite alternating with layers of thin- to medium-bedded granular to pebbly subarkose and sublitharenite. This sandstone-dominated association constitutes the "Fine Grit" submember in Figures 22 and 29. The strata weather grey, buff- to white-grey, less commonly pink-grey, in colour.

Sedimentary structures are locally well preserved in the sandstones and conglomerates of the JL.L member. They include small to medium scale trough cross-beds (Plate 3-2), scours and small load casts. In a few beds, possible clast imbrication was observed (Plate 3-1). Fining-upward cycles, similar to those observed in strata of the DL.L_{SW} member, are also present. The cycles

JL.U Lithofacies Association 4:
The fourth association comprises intermixed planar to undulatory layered, thick-laminated to thin-bedded felsic tuffs and lapilli tuffs and massive weathered felsic (less commonly intermediate) volcanic flows.

Siliciclastic sequences also occur as layers and thin lenes variably intermixed with the strata of the major lithofacies associations. The siliciclastic beds occur in horizons that range from 1 m up to 30 m in thickness (Figures 10, 19 and 29). The strata also locally contain well preserved trough cross-beds, scours and channel structures, load casts, graded beds and possible clast imbrication. The minor lithofacies associations of the JL.U member include:

(1) Planar to undulatory layered, thick-laminated to thin-bedded, fine-to coarse-grained subarkose and sublitharenite and rare pebble to cobble polymictic conglomerate; major clast types in the conglomerate are similar to those for conglomerate layers in the JL.L member; with minor intermixed felsic flows and tuffs.
(2) Planar to undulatory layered, thick-laminated to thin-bedded, coarse-grained to pebbly sublitharenite and subarkose; with minor intermixed conglomerate and reworked felsic tuff layers.

Depositional History

The sedimentary-dominated sequences, of the JL.L, member consist mainly of coarse sandstone and conglomerate beds with features (i.e. small scale thinning-upward cycles or couplets and scour or channel structures) that resemble channel and bar deposits of proximal to distal braid plain systems (Miall, 1977; Rust, 1978; Rust and Koster, 1984). The braid plain sediments were contemporaneous with minor volcanism. The volcanic and volcaniclastic deposits were subsequently reworked in the braid plain system.

The strata of the JL.U member are thought to represent the accumulation of mainly subaerial volcanic flows and associated airfall and water reworked ash deposits (Fisher 1966, 1977). The volcanic and volcaniclastic strata were associated with and partially reworked within a braid plain depositional system in which coarse sand and gravel deposits accumulated.

The Johnson Lake Formation is a post-reactivation assemblage and probably represents deposits of a second rift cycle which had been initiated during Sederholm Lake Formation deposition. This second rift cycle comprised mafic volcanism and sedimentation (Sederholm Lake Formation), followed by sedimentation in a braid plain regime with minor felsic volcanism (JL.L member) which was succeeded by basin-wide felsic volcanism characterised by the accumulation of felsic tuffs and lapilli tuffs with contemporaneous reworking in a braid plain system (JL.U member).

NIGGLI LAKE FORMATION

The Niggli Lake Formation comprises the upper mafic volcanic assemblage of the Waugh Lake Group. The name derives from Niggli Lake, located 2.5 km north-northwest of the north end of Doze Lake. The mafic volcanic rocks are the youngest succession of the group in the map area (Table 1; Figures 1 and 2). The formation has a maximum thickness of 128 m, which occurs at the type section located 1.7 km north-northwest of West Waugh Lake (Figure 22). The total thickness is estimated to exceed 300 m. This estimation is based on the outcrop width of the formation across the centre of the syncline (Figure 1). Reference sections are illustrated in Figures 17 to 20 and Figure 29.

Strata outcrop in the central part of the map area where they are preserved along the axial portion of the syncline (Figure 1). A large hornblende-biotite diorite intrusive body, present in the northeastern part of the map area, and similar diorite dykes present in strata of the DL.U, JL.L and JL.U members may be coeval with the mafic volcanic rocks.

Niggli Lake Formation strata have been previously described and mapped as the "Basic rocks" by Watanabe (1961) and Godfrey (1963). This map unit comprised various basic rocks including amphibolite, basalt and probable metatuffs in the Waugh Lake area. The Niggli Lake Formation includes the M (Mafic flows and tuffs), Mb (Mafic pyroclastic breccia) and FLb (Felsic pyroclastic breccia) map units of Salat et.al. (1994). Pyroclastic breccias are an important component of the Niggli Lake Formation. However, the separation of discrete felsic or mafic pyroclastic breccia members could not be accomplished on an outcrop scale in the field. This has resulted in the inclusion of the former FLb map unit into the Niggli Lake Formation. In addition, several outcrops previously mapped as the FLb unit were found to be comprised of coarse-grained to pebbly subarkoses and polymictic pebble conglomerates of the JL.L member and felsic tuffs and lapilli tuffs of the JL.U member.

Description

The Niggli Lake Formation consists mainly of fine-crystalline, green, green-brown to green-grey weathered mafic, less commonly intermediate, volcanic flows and tuffs. Compositionally the volcanic rocks are andesitic to basaltic (Salat *et. al.*, 1994). The rocks are generally featureless and commonly contain numerous quartz filled vesicles. These massive weathered, featureless rocks are interpreted as flow horizons. Locally the strata are crudely to well layered (i.e. thick-laminated to very thin-bedded) and in these areas the rocks are interpreted as interflow tuffs. The flows also contain possible rare pillow structures (Plate 3-6). Salat *et. al.* (1994) observed at least two areas where pillow-like structures occurred in the otherwise massive mafic rocks.

The Niggli Lake Formation also contains horizons of pyroclastic breccia (Plate 3-5). The breccia consists of rounded to angular, intermediate to mafic (less commonly felsic) buff-green to brown-grey weathered fragments set in a darker weathered, fine-crystalline mafic matrix. The fragments are generally matrix supported and range from lappili to blocks 1.1 by 0.4 m in size (Appendix I). The breccia bodies occur as irregular shaped masses and as discrete lenses and layers between mafic volcanic horizons. Locally they appear gradational within the mafic successions and in this setting the breccias could represent flow tops.

The Niggli Lake successions locally contain minor interlayers of dark green to brown- and grey-green weathered reworked intermediate to mafic tuff and thick-laminated to thin-bedded, medium-grained to pebbly amphibole-bearing sublitharenite. The volcaniclastic and siliciclastic strata occur as thin interflow horizons and lenses and outcrop in only a few localities (Figure 1).They resemble lithofacies in the Sederholm Lake Formation and may have been accumulated in similar depositional environments. In the southwest part of the map area, fine-crystalline, massive felsic to intermediate flows and probable felsic pyroclastic breccia occur intermixed with mafic rocks immediately above the JL.U member contact, in the vicinity of sections 4I108 (Figure 22) and 4I149 (Figure 29).

Contacts

The felsic flow and tuff dominated successions of the JL.U member are sharply and apparently conformably(?) overlain by mafic flows, tuff and pyroclastic breccia of the Niggli Lake Formation (Figures 2, 17 to 20, 22 and 29). The basal contact appears conformable over the section intervals examined in the field. However, the great range in thickness of the JL.U member, the crosscutting nature of the JL.U member / Niggli Lake Formation contact and the fact that the rocks of the Niggli Lake Formation rest on strata of the JL.L member in the southern part of the map sheet (Figure 1) indicate that the contact is unconformable.

Depositional History

The composition of the volcanic rocks, occurrence of possible pillow structures, and presence of intermixed horizons of pyroclastic breccia (including the presence of possible flow tops) and volcaniclastic and siliciclastic strata indicate an origin as mafic to intermediate volcanic flows for most of the Niggli Lake Formation. The majority of flows are thought to have occurred as subaerial deposits.

The massive pyroclastic breccias with generally angular and large clasts may represent vent and flow top deposits. The clasts are mainly subangular to rounded, and small to moderate in size, that apparently occur as lenses or layers between horizons of massive mafic volcanic rocks, and may represent ground and base surge pyroclastic flows (Fisher 1977; Lajoie, 1984). The thin horizons and lenses of volcaniclastic and siliciclastic rocks probably represent reworking of volcanic flows and breccia in a braid plain system (Miall, 1977; Rust, 1978).

The thick volume of mafic volcanic deposits and the nature of the lower contact suggest that the Waugh Lake basin underwent a final phase of reactivation followed by widespread volcanism during accumulation of the Niggli Lake Formation. This dynamic regime may represent a third and final phase of rift-related extension in basin evolution.

CORRELATION

The lithofacies assemblages of the Waugh Lake Group, although areally restricted in outcrop to the map area and its immediate vicinity, can be tentatively correlated with successions in nearby areas. The correlative sequences are similar in age, lithologic character, and they share a common regional tectonic setting.

Northeast Alberta

The only rocks in northeastern Alberta that are correlative with strata of the Waugh Lake Group consist of low metamorphic grade metasedimentary successions of the Burntwood Group. The strata of this group are preserved in small outcrops, up to 30m in width, that occur along the north shore of Lake Athabasca (Godfrey, 1980, 1986a). The Burntwood Group rocks are interpreted to be late Aphebian and to lay unconformably upon basement gneiss. The strata are cataclastically deformed and are preserved adjacent to the Charles Lake Fault Zone (Godfrey, 1980, 1986a).

The principal rock types include dark grey-green chloritic, phyllitic, thin bedded argillites intermixed with mauve, thin- to medium-bedded arkosic sandstones that contain minor bands of pebbly sandstone. The strata contain turbidites and graded beds. The succession is considered to be a stratigraphic equivalent of the Martyn Lake Formation.

Northwest Saskatchewan

Rocks of the Waugh Lake Group have been correlated by Godfrey (1980) with successions that are preserved in the Thluicho Lake area (Scott, 1978). The Thluicho Lake Group consists of late Aphebian basin deposits that rest unconformably on Archean metasedimentary rocks of the Tazin Group, from which they are thought to have been largely derived. The succession is preserved in two complexly folded basins (Scott, 1978; Ramaekers, 1981).

The Thluicho Lake Group consists of up to 1000m of basal metaconglomerate overlain by meta-arkoses and argillite. The meta-arkoses and argillite contain graded bedding, cross-beds, ripple marks and load casts. The conglomerate succession may be the lateral equivalent of the conglomeratic $DL.L_{NE}$ member and the overlying arkose and argillite strata may be correlative with sandstones of the $DL.L_{SW}$ or JL.L members. The rocks of the Thluicho Lake Group are unconformably overlain by massive felsic breccia of the Ellis Bay Formation. This volcanic succession may be equivalent to the volcanic and volcaniclastic rocks of the Upper Johnson Lake Formation (JL.U member) or Niggli Lake Formation.

The Waugh Lake Group outcrop belt continues across the Alberta border into northwest Saskatchewan where equivalent strata have been defined as the Waugh Lake metasedimentary and metavolcanic complex (Koster, 1961,1971; Koster and Baadsgaard, 1970).

The Waugh Lake metasedimentary and metavolcanic rocks are preserved west of mylonite zones and faults that border a belt of Tazin Group metasedimentary and gneissic rocks. The Waugh Lake rocks have undergone middle greenschist to lower almandine amphibolite facies metamorphism. They contain amphibolite, pegmatite and tourmaline veins, and are estimated to be 1900 Ma in age (Koster 1971; Koster and Baadsgaard, 1970). The Waugh Lake strata contain isoclinal to open folds. A major portion of the differential movement between the surrounding stable basement complexes was taken up by the rocks of the Waugh Lake succession. An unconformity with basement gneisses is assumed since the contacts with other rock units are obscured by faults or not exposed.

The major portion of the complex is composed of fine grained, thick-laminated to thin-bedded biotite-sericite-quartz schists and thin-bedded impure quartzites and metarkoses that are well exposed at Martyn Lake. The strata represent the continuation of the belt of turbiditic Martyn Lake Formation rocks from northeast Alberta.

The Waugh Lake succession is also comprised of conglomeratic sequences that are strongly to weakly sheared, clast rich to clast poor and locally contain intermixed flows, schists and granodiorite veins. The conglomerate contains a matrix that consists of green and rusty quartz-sericite quartzite to subarkose. To the north, the size and angularity of the clasts increase, with blocks up to 1m by 2m in size occurring (Koster, 1961). The volcanic component consists of porphyritic metavolcanic flows, of basaltic composition, with thicknesses of up to 18m. The flows occur as several intermixed layers in conglomeratic schists. The conglomeratic succession is correlated with polymictic conglomerates of the DL.LNE member and the intermixed volcanic and conglomerates with rocks of the DL.B member.

South Central Northwest Territories

The strata of the Waugh Lake Group are tentatively correlated with metasedimentary rocks of the Hill Island Lake assemblage and with the intermixed conglomerates, sandstones and siltstones of the Nonacho Group (Bostock and van Breemen, 1994). The three successions have similar ages, lithologies and depositional histories.

The metasedimentary rocks of the Hill Island Lake assemblage outcrop in the vicinity of Hill Island Lake, located 40 km to 50 km north-northeast of the Alberta-Northwest Territories border (Bostock, 1984, 1992; Bostock and van

Breemen, 1994). The interpreted age of deposition ranges from 2134 Ma to 1934 Ma and the strata are intruded by the 1940 Ma Natael granite. The metamorphic grade ranges from lower greenschist to lower amphibolite facies. The assemblage is preserved along the west side of the Tazin Fault Zone. This structure is the northern extension of the Thainka Lake-Tazin River Fault system of northwest Saskatchewan (Koster, 1971).

The assemblage is comprised of thin bedded, fine- to medium-grained greywacke-mudstone and siltstone-mudstone with rhythmically bedded couplets that are 10cm to 20cm thick. The strata also include laminated mudstone layers and massive siltstone beds up to several metres thick. Minor lithologies include sulphide-bearing mudstone, schist, bands of calcareous siltstone to calc-silicate (present locally in boudin-like lenses) and thin-bedded, coarse-grained sandstone. The greywacke-mudstone couplets include turbiditic layers with graded bedding. The nature and arrangement of lithofacies support correlation of this assemblage with strata of the Martyn Lake Formation.

The Nonacho Group outcrops at Hill Island and Taltson lakes. The latter locality is situated 100 km north of the Alberta-Northwest Territories border at the north end of the Allan Fault Zone (Bostock, 1988; Bostock and van Breemen, 1994). Nonacho Group rocks have undergone lesser amounts of folding, deformation and metamorphism than the rocks of the Hill Island Lake assemblage. The strata have been estimated to range from 2000 Ma to 1906 Ma in age (Bostock and van Breemen, 1994). The deposits may have been part of a much larger sedimentary basin and may have infilled a half-graben (Bostock, 1988, 1992).

The strata of the Nonacho group can be summarised in four lithofacies associations, which in ascending order comprise (Bostock, 1984, 1986, 1988, 1992):

(i) Massive unbedded basal conglomerate with cobble to boulder size clasts of gneiss, quartz, granite and volcanic rocks, set in a granitic sandstone matrix.

(ii) Siltstone, minor sandstone, pebbly sandstone, argillite and schist with graded bedding and rare, isolated granite clasts.

(iii) Polymictic conglomerate and interbedded sandstone; clasts include quartz, sandstone, siltstone, granite, gneiss and volcanic rocks.

(iv) Sandstone with minor interbeds of conglomerate.

The alternating conglomerate- to sandstone-dominated sequences resemble the successions present in the DL.L and JL.L members of the Waugh Lake Group (Figure 2). The volcanic and volcaniclastic component is absent in the Nonacho Group. This difference may result from the nature of the tectono-sedimentary setting of the original Nonacho and Waugh Lake depositional basins.

BASIN MODELS

Models of extensional basins with similar lithologies are described in order to obtain a possible tectono-sedimentary setting for the Waugh Lake basin.

Aphebian El Sherana - Edith River Basin, Northern Territory, Australia (Friedman and Grotzinger, 1994)

The 1830 Ma El Sherana - Edith River basin, in the Northern Territory of Australia, contains terrestrial sedimentary and volcanic rocks deposited during continental extension or transtension. The basin was infilled by braid plain sandstone and conglomerates, turbiditic sedimentary rocks and interbedded mafic and felsic volcanic rocks. These deposits overlie older sedimentary rocks of a 2100 Ma to 1880 Ma orogen related to continental assembly. The evolution of the El Sherena - Edith River basin began about 40 Ma to 50 Ma after denudation of the earlier orogenic belt and is related to post-collisional extension.

Late Proterozoic Continental Margin, Saudi Arabian Shield (Agar, 1985, 1986)

The late Proterozoic Siham Group (Agar, 1985) contains evidence for the development of an active continental margin in the Saudi Arabian Shield. The group comprises a volcano-sedimentary succession, older than the final cratonizing events of the shield, that rests unconformably on basement gneiss. The lower members of the group consist of volcanic deposits associated with carbonaceous shale, exhalative chert and marble, tuffs and related massive sulphides. This succession is overlain by conglomeratic and rhyolitic strata.

In the west, shale beds are associated with mafic and ultramafic rocks emplaced in an extensional tectonic setting. These deep water deposits contrast with shallow marine continental shelf deposits in the east. The infill succession indicates contemporaneous development of a magmatic arc and extensional basin. The continental margin was bounded to the west by a north - south suture zone formed in the final collisional event of shield evolution.

The Bani-Ghayy Group (Agar, 1986) comprises a late Proterozoic volcano-sedimentary succession that post-dates continental collision and rests unconformably on the Siham Group rocks which are associated with an older active continental margin. The strata of the Bani-Ghayy Group were deposited in three separate fault bounded grabens. The grabens were infilled with fault marginal conglomerate, proximal greywacke, local reef limestone and bimodal volcanic deposits. The sedimentary and volcanic rocks are typical of continental rifting environments. The strata are thought to have been deposited in pull-apart grabens that evolved in a regime of north - northwest trending dextral shear zones that post-dated continental collision.

Sedimentary Basins of Idaho and Montana (Janecke, 1994)

Janecke (1994) studied Eocene - Oligocene extensional sedimentary basins of Idaho and Montana that evolved in a compressional regime associated with plate convergence. The basins were confined to a fault-bounded terrane and comprised several grabens. The graben structures preserve up to 2.6 km of conglomerate and sandstone intermixed with tuffaceous sandstone, tuff and minor lava flows. Sedimentation patterns, in the basins, were strongly influenced by syndepositional tectonism along normal faults. The initial movement along these fault zones was closely associated with rhyolitic volcanism.

The setting of Eocene - Oligocene fault bounded extensional basins in a sheared, fault bounded terrane associated with a collisional orogen is analogous to that interpreted for the late Aphebian Waugh Lake, Nonacho and Hill Island Lake basins.

METAMORPHISM

Metamorphic minerals of the Waugh Lake Group consist mainly of biotite, muscovite, chlorite and epidote in the metasediments and felsic volcanic rocks, and actinolite, chlorite, tremolite, epidote and calcite in the mafic volcanic rocks. The mineral assemblage indicates middle greenschist facies to lower amphibolite facies (Watanabe, 1961). Mafic rocks show that chlorite, which is common in the eastern part of the mapped area, becomes less common towards the west. In addition, towards the west, actinolite and tremolite are replaced by newly formed prismatic hornblende. This indicates an increase in the metamorphic grade towards the large masses of intrusives rocks that exist to the west.

The pronounced development of secondary hornblende in the mafic rocks in the western sector could be explained in response to an increased thermal gradient next to the intrusives, whereas the nearby felsic volcanic rocks lack the excess in alumina necessary to crystallize metamorphic alumino-silicates such as andalusite or cordierite. However, near the contact with granitic intrusives, the felsic rocks tend to look more hornfels-like in outcrop, possibly due to complete recrystallization. No microscope study has been done to confirm this possibility.

EVOLUTION OF THE WAUGH LAKE BASIN

Strata of the Waugh Lake Group are preserved along the west margin of the Archean Churchill Structural Province, adjacent to the gneissic and granitic rocks of the eastern edge of the Taltson Magmatic Zone (Godfrey, 1986a; McDonough *et. al.*, 1995). The deposition of the Waugh Lake Group (depositional age range: ca 2.01 Ga to 1.97 Ga; McNicoll and McDonough, 1995) occurred in a regime of regional compression characterised by convergence and subsequent collision between the 2.4 Ga to 2.0 Ga Buffalo Head Terrane (northeast Alberta) and Archean Slave Structural Province (Northwest Territories) into the Churchill Structural Province. Eastward convergence and collision of the Buffalo Head and Slave microcontinents, along an east-dipping subduction zone, was followed by indentation into the Churchill Structural Province (Theriault 1992, 1994). Several adjacent sedimentary basins may have developed along the west margin of the Churchill Structural Province before indentation of these microcontinents (Bostock and van Breemen, 1994).

This compressional regime was also characterised by periods of extension involving rifting. Bostock (1992) suggested that the western edge of the Churchill Structural Province could have been a rifted plate margin for part of its evolution, prior to Taltson Magmatic Zone magmatism (ca 1.99 Ga to 1.90 Ga). The metasedimentary rocks of the Rutledge River basin (cessation of deposition 2.13 Ga to 2.09 Ga), which possibly includes metasediments of the Leland Lakes area, are interpreted to have been deposited in a pre-Taltson Magmatic Zone basin formed by passive rifting and set along the western margin of the Churchill Structural Province (Bostock and van Breemen, 1994). This extensional basin was associated with migration of magmatic activity from west to east across the margin. A subsequent 2.02 Ga to 1.98 Ga eastward sweep of magmatism from Buffalo Head Terrane into the Taltson Magmatic Zone is associated with the Slave - Buffalo Head collision into the Churchill Structural Province (Bostock and van Breemen, 1994). This magmatism would have been contemporaneous with deposition of the Waugh Lake Group.

This continent - continent collision at 1.97 Ga would have caused tectonic thickening and melting of pelitic metasediments and Churchill Structural Province/Buffalo Head terrane crust, which would ultimately be manifested as granitoid intrusive suites of the Taltson Magmatic Zone (Theriault, 1992; Nielsen et al., 1981).

The Taltson Magmatic Zone, of northeast Alberta and the Northwest Territories, is a 300 km long north-trending belt of granitoids, amphibolites and metasedimentary gneisses that form a composite mid-Proterozoic pre-collisional continental magmatic arc (1.99 Ga, 1.97 Ga granitoids) and a continent - continent collisional orogen (1.96 Ga, 1.94 Ga, 1.92 Ga granitoids) between the Buffalo Head Terrane and the Churchill Structural Province (Hoffman, 1989; Theriault, 1992; McDonough *et. al.*, 1995). The 1.99 Ga to 1.90 Ga magmatic belt welds the Buffalo Head terrane to the western edge of the Churchill Structural Province (Theriault, 1994). The Taltson Magmatic Zone is coeval with the Thelon Orogen and comprises its southern extension (Hoffman, 1989; Theriault, 1992, 1994). Arc magmatism resulting from the plate subduction under the Churchill plate would have generated Taltson granitic plutons.

The Taltson Magmatic Zone comprises the Taltson Basement Complex and intrusive granitoid plutons. The Taltson Basement Complex, in northeast Alberta, consists of 3.2 Ga to 2.1 Ga layered granodioritic to granitic gneiss. These rocks are enveloped by 1.97 Ga to 1.92 Ga granitoid plutons of the Arch Lake, Slave, Charles Lake, Colin Lake, Wylie Lake and Andrew Lake suites (McDonough *et. al.*, 1995).

The Taltson Magmatic Zone and Churchill Structural Province margin are extensively fractured by a complex system of fault and shear zones (Godfrey, 1986; McDonough *et. al.*, 1995; Figure 1). The Taltson Magmatic Zone, in northeast Alberta, is interpreted to contain three major north-trending shear zones: i.e. the Charles Lake (equivalent to the Allan Fault Zone of Godfrey, 1986a), Leland Lakes and Andrew Lake shear zones (McDonough *et al.*, 1995). The Waugh Lake Shear Zone within the map area (Figure 1) may be part of this shear system or part of a major north-trending fault system located in northwest Saskatchewan (Koster, 1971; Koster and Baadsgaard, 1970). In the Northwest Territories, Bostock (1984) interpreted the Hill Island Lake - Taltson Lake area as comprising part of an extensive shear system. The shear system includes the Taltson Lake Fault zone (Bostock, 1992) and trends south into the Tatzin River - Thainka Lake Fault zone (in northwest Saskatchewan; Koster, 1971); it merges northwards with the Charles Lake Shear Zone (Bostock and van Breemen, 1994).

Hoffman (1989) postulated that the shear systems of the Taltson Magmatic Zone represent zones of lateral tectonic escape that accommodated indentation of the Buffalo Head and Slave microcontinents into the western edge of the Churchill craton. Activity along the shear zones may have influenced sedimentation patterns within basins along the continental margin. McDonough *et al.* (1995) also found evidence that an active plate margin developed along the western margin of the Churchill Structural Province associated with the evolution of the Taltson Magmatic Zone. Sinistral shear along major fault zones would have been associated with collisional events along the continental plate margin to the west of the Taltson Magmatic Zone. Shear activity in the Taltson Magmatic Zone in northeast Alberta is postulated to have spanned the period 1960 Ma to 1800 Ma (Plint and McDonough, 1995; McDonough *et. al.*, 1995).

It is evident, from an analysis of the regional setting, that deposition of the Waugh Lake Group occurred adjacent to a major tectonic boundary. Waugh Lake Basin evolved in the sheared transitional zone that developed along the western edge of the Churchill Structural Province due to local rifting above an easterly dipping subduction zone between the Buffalo Head and Churchill cratons (McNicoll and McDonough, 1995). A proximal setting adjacent to a major active plate boundary would have a profound influence on sedimentation patterns and volume of volcanic deposits infilling the basin.

The deposition of the Waugh Lake Group is associated with the evolution of a convergent continental margin. However, the lithofacies of the group comprise a typical rift infill assemblage characterised by the presence of bimodal volcanism, periods of reactivation and occurrence of local thickness and facies variations. These facts indicate that the succession may represent the infilling of a rift basin that developed in a back-arc setting that was also influenced by strike slip-fault systems. The transcurrent fault setting is inferred from the occurrence of large scale shears, present in the Taltson Magmatic Zone, with a long history of lateral movement associated with the formation of a collisional orogen (Hoffman, 1989). Representative back arc basin models and examples are outlined in Miall (1981, 1990) and Mitchell and Reading (1986); relevant strike-slip basin settings are analyzed in Mitchell and Reading (1986). This conclusion lends support to an earlier suggestion that the Waugh Lake Group was deposited in tectonically active basins with marginal basement faults (Nielsen *et. al.*, 1981). The composite back-arc / strike-slip basin developed initially during an episode of pre-Taltson Magmatic arc rifting of the western Churchill Structural Province. Extension occurred on the stretched edge of the craton on the landward side of a probable east dipping subduction zone immediately adjacent to the developing arc margin. The final stages of basin history were coincident with initiation of magmatic arc construction.

The evolution of Waugh Lake Basin was probably contemporaneous with that of the Nonacho and Hill Island Lake basins. The cratonic margin setting of these basins may have been geographically restricted to the faulted and sheared terrane bounded, on the west, by the Charles Lake Shear Zone (Langenberg, 1983) and, on the east, by the Tazin Fault Zone in the Northwest Territories (Bostock, 1992; Bostock and van Breeman, 1994) and the Tazin River - Thainka Lake Fault Zone in northwest Saskatchewan (Koster, 1971). The fractured and sheared terrane is composed of amphibolitic, metasedimentary and mylonitic gneisses of the Taltson Basement Complex which have been intruded by granitoids of the Taltson Magmatic Zone (McDonough *et. al.*, 1995; Godfrey, 1986a). This terrane, in addition to representing the former locus of back arc basin development, also comprised a corridor of lateral accommodation between colliding microplates and the western Churchill Structural Province.

The Waugh Lake Group was deposited in a composite back-arc/strike-slip basin. The major lithofacies assemblages and associated tectonic stages of the Waugh Lake basin include a basal rhythmic and turbiditic bedded succession (Martyn Lake Formation) deposited in a shallow to deep marine marginal setting that represents sedimentation in a pre-rift marginal basin. The basal succession is overlain by two, bimodal volcano-sedimentary into volcanic megacycles (Doze Lake Formation = Lower Megacycle; Sederholm Lake - Johnson Lake Formations = Upper Megacycle); they represent the accumulation of two stacked rift cycles. They are succeeded by a thick mafic volcanic assemblage (Niggli Lake Formation). These deposits represent a final phase of rift-related volcanism. The contacts between the Martyn Lake - Doze Lake, Doze Lake - Sederholm Lake and Johnson Lake - Niggli Lake Formations represent major event horizons in basin evolution. The Martyn Lake - Doze Lake boundary represents a gradual transition from a marine basin regime to a tectonically active regime that coincided with the initiation of extensional basin development and deposition of the lower megacycle. The second major event horizon, at the Doze Lake - Sederholm Lake boundary, represents a reactivation event associated with the deposition of the upper megacycle related to the transition from felsic volcanism to mainly coarse braid plain sedimentation. The final major event horizon occurs at the boundary between the Johnson Lake and Niggli Lake formations. This horizon represents a final reactivation event associated with the cessation of felsic volcanism and related volcaniclastic sedimentation, and subsequent extrusion of thick mafic volcanic deposits related to a final phase of extension.

INTRUSIVE ROCK-UNITS

A number of intrusive bodies are found within the Waugh Lake area, and granitic rocks mark the western limit of the Waugh Lake Group (Figure 1). The description of these rock units is largely after Salat *et al.* (1994).

THE COLIN LAKE GRANITE

The Colin Lake Granite (Map-unit CG) crops out extensively in the southwest and fringes the Waugh Lake metavolcanics to the west. These hills offer spectacular glacially rounded exposures of very coarse to pegmatitic leucogranite that contain large wispy and reticulate books of biotite and muscovite. Foliation in the granite may anastomose. Locally, pegmatites are abundant. The feldspar is mostly microcline and is often pink. Garnet can represent several percent of the rock mass.

Rhyolitic and mafic inclusions of the Waugh Lake Group are common. The contact between unit CG and the low-grade metamorphic rocks of the Waugh Lake Group is intrusive in a transitional zone. The Colin Lake granite has been injected within the layered rocks of the Waugh Lake Group in numerous pegmatoidal masses or sheets which decrease in frequency toward the east, away from the main stock. Further east of the contact, only boudins of pegmatitic material are encountered. The pegmatitic material is muscovite-rich and tends to be concordant with the layering. The pegmatitic bands are also sometimes folded into complex folds along with the enclosing metamorphic rocks which, in this area, comprise mainly felsic volcanic rocks. Where tight folding occurs, the distinction between the different units is obscured.

THE WAUGH LAKE GRANITOIDS

Large bodies of intrusive rocks (map-units G, Gb, Gp, S and D) intrude the Waugh Lake metasediments and metavolcanics, mainly to the north, east and south. The contacts are well-defined and are sharp to sheared over a lshort distance. Internal deformation and mineral paragenesis indicate that two distinct suites of granitoids with different ages of emplacement are present.

The first generation of granitoids includes granite, syenite and diorite (map-units G, S and D), which share the distinctive association of hornblende and biotite as the main mafic components, but in variable amounts. These map-units are therefore differentiated on the basis of their felsic content, with syenite consisting exclusively of potassium feldspar and diorite consisting of oligoclase and andesine. Both the syenite and diorite contain small amounts of quartz. The units G contain both plagioclase and K-feldspar. The intrusive rocks are typically equigranular and show on their borders much metasomatism with extensive development of myrmekite and granophyric texture. K-feldspar is strongly perthitic. These granitoids contains internal bands of deformation with good foliation. A sample from the southern body of map-unit G has been dated by McNicoll and McDonough (1995) at 1971 Ma.

By comparison, granites of the second generation, consisting of biotite granites and porphyritic biotite granites (map-units Gb and Gp), show less deformation, are often leucocratic and contain biotite as the main mafic mineral. This is the main reason why these units are considered to be younger than units G, S and D (this still needs radiometric confirmation). The biotite in units Gb and Gp is dark brown and rich in zircon and radioactive allanite. Unit Gp is distinguished by being K-feldspar porphyritic. The leucogranites of unit Gb are generally low in inclusions, but contamination with mafic material at contacts with other rocks results in the presence of tremolite.

THE ANDREW LAKE GRANITE

The Andrew Lake granite (map-unit AG) is a post tectonic intrusive stock, which intrudes Waugh Lake Granitoids. It contains quartz, K-feldspar (microcline) and plagioclase (mostly andesine) in equal amounts. The feldspar phenocrysts range from 0.4 to 4 mm in size. It is poor in mafic minerals, which are represented by biotite, but rich in zircon and allanite inclusions. Apatite is also common in these rocks. The age of this granite is estimated at 1962 Ma (McDonough *et al.*, 1995), which shows that these granites are 10 million years younger than the Waugh Lake Granitoids.

The Andrew Lake granite crops out extensively in the west and northwest of the mapped area. It is also found in several small pods and lenses intruded into the large stock of Waugh Lake granite in the northern half of the mapped area. The Andrew Lake granite can contain abundant xenoliths especially when intruding other igneous rocks.

Map-unit Gb could be genetically related to the late Andrew Lake Granite, rather than to the Waugh Lake suite of intrusions, because it is a relatively undeformed biotite granite with common biotite rich-inclusions.

DYKES

Many mafic dykes were observed, but they are too thin and discontinuous to be presented on the map. A few aplite dykes were observed near the intrusive contacts of metasediments and Andrew Lake granites.

STRUCTURAL GEOLOGY

Rocks in the area are extensively folded. The most prominent structure is the regional syncline of the Waugh Lake Group. Faulting and shear zones are prominent, especially in the eastern part of the area. Cleavage is mainly present in the Martyn Lake Formation.

FOLDING

The overall large scale structure is a synclinal basin, as indicated by westward younging directions on the east-side and eastward younging directions on the west-side of the map area (Figure 1). These youging directions are clearly indicated by sedimentary structures, such as cross-bedding.

The generally fine-grained metasediments of the Martyn Lake Formation contain more folds than in the overlying younger rocks of the Waugh Lake Group. The often coarse-grained clastics of the Doze Lake, Sederholm Lake and Johnson Lake formations are generally massive and show little folding, except in the hinge area of the Waugh Lake syncline and on the west side of the area near the contact with Colin Lake and Andrew Lake granites. In the latter area there are many pegmatitic and granitic dykes and rafts in the gneissic Lower Doze Lake metasediments (see hatched overlay on the map of Figure 1). These gneissic metasediments are also extensively folded. The volcanic rocks are generally fairly massive and consequently do not show much folding either.

The Martyn Lake Formation is folded in many outcrops. Extensive folding is present in outcrop 4I058 on the west shore of Doze Lake (straight west from Mineral Occurence No. 128, see Figure 1). Graded bedding and the orientation of the fold axis indicate that the fold shown in Plate 4-1 is an isoclinal antiformal anticline with axial planar slaty cleavage. The fold axis is plunging 55 degrees to the south. About 15 m south of this fold is a large outcrop with an antiformal syncline and synformal anticline (these 2 areas are separated by a covered interval). These observations indicate that there is an older, probably isoclinal folding phase giving rise to these younging reversals. It is possible that the fold axes of this older folding phase are close to horizontal, making them difficult to observe.

A reversal in younging direction was observed near the base of section 4I047 (Figure 11). A graded sandstone layer shows younging to the the east and 20 cm to the east another layer shows younging to the west and appears to be the same bed (Plate 4-2). The lithologies can be matched for 2 m on both sides of the reversal. No fold could be found in the outcrop that can explain the reversal, indicating that folding with horizontal fold axes, which are either above or below the outcrop plane, is present. A second phase of folding is present with steeply dipping fold axes and an axial planar slaty cleavage. They are represented by S-folds in Plate 4-2. These second phase folds are very pervasive in the Martyn Lake Formation.

These observations indicate that the Waugh Lake area went through a tectonic history, which involved at least two phases of folding.

Prominent folding is present at outcrop 4L035 (553500 E, 6633100 N) where a pebble horizon in the Lower Johnson Lake Formation can be followed for a distance of over 100 m in a general east-west direction (Figure 30). The pebble layer (which is a pebbly sublitharenite) is about 1.5 m thick. The upper part of the pebble layer is shown in Plate 4-3. The limbs of the folds are generally open to close. Pelitic layers in between the pebble layers show some slaty cleavage. Generally the strike of bedding is approximately north-south, which indicates that this outcrop is near the hinge area of the large scale syncline outlined by the Waugh Lake Group in the area. The best estimate of the orientation of the fold axis is 78 degrees to the south-southwest (N203°E), based on 14 bedding plane measurements.

Because of the steep plunge of the fold axis and the presence of axial planar slaty cleavage these folds in the Johnson Lake Formation probably belong to the generation of second phase folds observed in the Martyn Lake Formation. The formation of the large scale regional syncline could have happened during the older phase of folding, because it requires folding around regionally horizontal north trending axes. However, it can not be excluded that the folds of Figure 30 were part of the formation of the regional syncline and were consequently steepened by folding around horizontal east trending axes. However, the absence of small scale folds with east trending fold axes argues against this latter possibility.

SHEAR ZONES

The major shear zone in the area is indicated by the north trending alignment of Waugh Lake and North Waugh Lake and the mappable gossans (composed of rusty schists) in the Martyn Lake Formation (see Figure 1). Three thin-sections of schists from this shear zone that contain sulfides are described in Appendix II. The shear zone is further defined by a pronounced schistosity and by folds with north-trending fold axes. Some of the folds have steeply plunging fold axes, but others have axes plunging between 10 and 20 degrees to the north. These shallowly plunging folds contain axial planar schistosity and are a type of shear folds resulting in C-S fabrics. The folds with the steeply plunging fold axes are folding this schistosity and consequently are younger. The shallowly plunging folds generally display S shapes on the horizontal outcrop surface, indicating west vergence for these folds. These west-verging folds might be related to the east-verging thrust fault on the west side of Doze Lake (see section on Thrust Faults).

These observations indicate that the formation of the shear zones was early in the deformation history and may be related to the tight first folding phase of the Martyn Lake Formation. The shear zone was folded by a second phase of folding with steeply plunging fold axes, which probably also resulted in redistribution of sulfides (see section on mineral occurrences). This phase of folding might be related to strike-slip movement along the shear zone.

The shear zone is intruded by biotite granites (Figure 1), which are not yet dated. This granite looks similar to the 1971 Ma hornblende-biotite granite (McNicoll and McDonough, 1995), which would make this shear zone older than the Charles Lake and Leland Lakes shear zones (McDonough *et al.*, 1995). However, a slight difference in degree of deformation indicates that this biotite granite (unit Gb) is younger than the dated hornblende-biotite granite (unit G). This possibility has to be further investigated.

Other shear zones exist in the Johnson Lake Formation in the central part of the area and in the western outlier of the Martyn Lake Formation. The latter shear zone include gossans and Mineral Occurrences nos. 131 and 135 (Figure 1).

THRUST FAULT

A major thrust fault is inferred to exist at the abnormal contact on the west side of the Lower Doze Lake Formation near Doze Lake. The Doze Lake is below the Martyn Lake Formation at this locality, while it is stratigraphically above, indicating that a thrust fault is present. The thrust fault is west dipping, brings Martyn Lake strata on top of Doze Lake conglomerates and is east verging. Thrust faulting near major shear zones in northeast Alberta has also been noticed by McDonough *et al.* (1995). The east verging thrust fault might be related to the west verging folds in the Waugh Lake Shear Zone. The reversal in verging direction could be explained by a combination of over- and under-thrusting, resulting in tectonic wedging.

STRIKE-SLIP FAULTS

A major fault coincides with a string of small lakes and deep ravines that are aligned with the western tip of the chain of lakes, which extend west of Waugh Lake (Figure 1). Its displacement can be deduced from the offset of the Sederholm Lake Formation. Another fault is well expressed by the dextral displacement of the Andrew Lake Granite in the northwest part of the mapped area and trends east-west. The latter fault is also clearly outlined by topographic features.

Late brittle fault zones exist on both shores of West Waugh Lake. They consist of 5 to 10 m wide hematitic fault gouge with a network of exuded white quartz veins and are geologically similar to the Bonny Fault Zone near Andrew Lake Lodge (Godfrey, 1963; Langenberg *et al.*, 1993). Their direction varies from N90°E to N110°E.

JOINTS

A last brittle deformation is indicated by many conjugate sets of joints striking around N040°E and N140°E.

MINERAL OCCURRENCES ALONG THE WAUGH LAKE SHEAR ZONE

In this section we will concentrate on mineral occurrences along the narrow north-trending Waugh Lake shear zone. This area has the best economic mineral potential of the Waugh Lake area, indicated by assays showing up to 3.2 g/t Au. The area includes mineral occurrences nos. 39, 50, 51, 52, 53, 129 and 130, which are described in detail by Langenberg *et al* (1993) and Salat *et al.* (1994). For a description of the remaining mineral occurrences of the Waugh Lake area, which are shown on the map of Figure 1, the reader is also referred to Langenberg *et al* (1993) and Salat *et al.* (1994).

The Waugh Lake shear zone consists of zones of sheared and rusty weathered schists of the Martyn Lake Formation (Figure 31). The shear zones are associated with varying amounts of sulfides. Three areas were investigated in 1994 at a detailed scale of 1:500 to delineate areas of alteration, to study shear controls on the mineralization and to sample gossan zones. Figure 31 shows the location of the detailed maps (Figures 33, 34 and 35). A total of 46 samples were collected and sent to Loring Laboratories Ltd. of Calgary to be analyzed for gold by Fire Assay with Atomic Absorption (FA/AA) emission spectrometry using a 20 g aliquot and for base metals by Inductively Coupled Plasma (ICP) emission spectrometry. The main results are summarized in Table 4. In addition, the textural relationships of the sulfides with the country rock of Mineral Occurrences 39, 50 and 53 were described from polished thin sections (see Appendix II).

Exploration History

In 1969, Hudson's Bay Oil and Gas flew a series of airborne EM-Magnetic surveys over Permits 24, 25 and 26 (Stamp, 1969). The electromagnetic survey delineated three conductors (anomalies 6, 8 and 9), in the northern part of Waugh Lake, including a 6400 m long and up to 400 m wide north-south trending conductor along the Alberta-Saskatchewan border (Figure 32).

Hudson's Bay Oil and Gas ground checked the airborne survey with vertical loop, horizontal loop, and magnetometer surveys followed by trenching and sampling in 1970 (Burgan, 1971). A 60,000 gamma spike was found adjacent to the airborne EM conductor on a single pass perpendicular to the conductor trend (Figure 32). At least nine trenches are present in this area resulting from the work by Hudson's Bay Oil and Gas.

In 1992, the Alberta Geological Survey (AGS) assessed 88 mineral occurrences in the Andrew Lake - Charles Lake area of northeastern Alberta and collected 169 samples including 41 samples from the Waugh Lake area (Langenberg *et al.,* 1993). Another 40 samples were selected from samples taken by Godfrey (1986b) and analyzed. During the 1993 field season, the AGS collected a total of 34 samples from the Waugh Lake area and defined 9 new mineral occurrences (Mineral Occurrences Nos. 128 to 136, Salat *et al.*, 1994).

Lithology

The rocks in the vicinity of the gossans may be broken down into three main lithologies:

(1) unaltered, interlayered thin- to medium-bedded, fine to coarse-grained quartz arenite to subarkose and rhythmically bedded phyllite, siltstone, and fine-grained quartz arenite,

(2) same as above but highly sheared and altered to rusty weathered rocks containing variable amounts of quartz, biotite, sericite, chlorite, graphite and sulfides, and

(3) dykes and small plugs of fine- to medium-grained, biotite-rich granite.

Alteration

The weathering alteration in the rusty rhythmically layered rocks varies between local (20%), moderate (50%), to pervasive and greater than 80% (see Figures 33, 34 and 35). Figure 33 highlights one of the more highly altered areas where the gossan zone, consisting mainly of limonite, is up to 75 m wide. In the area around trenches 1 to 5, pitted and boxwork weathering characteristics indicate the possible oxidation of a high percentage of iron-bearing sulfides (Plate 4-4).

Mineralization

Prospecting by Hudson's Bay Oil and Gas revealed that the north part of the 6400 m long airborne EM conductor is completely under overburden. The central part has outcrops with graphite and no associated sulfide mineralization. In addition, volcanic rocks are present, which may have a higher magnetic response than the metasediments. It should be noted that Mineral Occurrence 130 (which contains 3.2 g/t gold) is 250 m west of this conductor.

The south section of the conductor passes through a gossan zone containing considerable amounts of sulfides. Numerous outcrops and trenches contain variable amounts of pyrite, pyrrhotite, arsenopyrite and trace chalcopyrite, either disseminated or in veins (Mineral occurrences nos. 39, 50, 51, 52 and 53). This gossan zone should be tested by drilling (including the area around Mineral Occurrence 130 further north).

Six trenches are present in heavily altered, schistose quartz-biotite, quartz-sericite and quartz-graphite schist at mineral occurrence 39 (Figure 33; Plate 4-5). They vary in size from 1x2 m to 2x13 m. A slightly more massive quartz arenite, which is approximately 10 cm wide at trench 5, sample location 4E-039b, contained up to 20% disseminated pyrite and veinlets of pyrite with 5% disseminated chalcopyrite and pyrrhotite. A large amounts of chlorite is present in quartz-rich graphitic schist indicating some local Mg enrichment. The magnetic anomaly is strong enough to deflect the compass. At Trench #3 both sulfides and graphite are present. Pyrite crystallized in a late stage of the deformation (Appendix II, sample WL2-08-21-03).

Trace to minor (up to 2%) arsenopyrite with trace pyrite and pyrrhotite was sampled in several spotty to locally altered outcrops near mineral occurrences 51, 52 and 53 (Figure 34). Two trenches are present in very rusty quartz-sericite schist. Only minor pyrite was found in the trenches (Langenberg *et al.*, 1993). At Mineral Occurrence 50 (in a trench on the lakeshore 200 m north of Mineral Occurrence 51) pyrrhotite, arsenopyrite and pyrite are present and a grab sample contains 416 ppb gold (sample WL2-08-26-02). The sulfides formed late in the deformation history and pyrite may have formed in 2 stages, the last stage after the other sulfides had precipitated (Appendix II). At Mineral Occurrence 53 sulfides formed late, with pyrrhotite forming before arsenopyrite and chalcopyrite forming later (sample Wl2-08-26-05, Appendix II).

The sheared nature of the rocks in the sulfide enriched south part of the airborne conductor indicate that the enrichment is shear-related and that sulfides are remobilized throughout the shear zone. It was also noted that both the amount of alteration of the rhythmites and the percentage of sulfides increases around biotite granite dykes and plugs. Disseminated pyrite can often be seen in the granite near contacts with the metasediments. These granites truncate the shear zones, which indicates that these granites are post-kinematic.

At mineral occurrence 129 (Figure 35) a stockwork of parallel quartz veins commonly 1 to 5 cm wide, but up to 1 m in size cross cuts the rusty, N008°E-trending rhythmites at N058°E (Plate 4-6). Trace amounts of arsenopyrite and pyrite were located at sample locations 4E-022 and 4E-023 where biotite granite dykes are in contact with the rusty weathered metasediments. The biotite granite contains up to 5% pyrite.

Quartz veinlets and veins up to 1 m in width may be located throughout the rusty metasediment zones. They appear very young in age, white in colour and do not contain any sulfides.

Mineral Deposit Model

The preferred location of sulfides in the shear zone indicates that the enrichment is shear-related and that sulfides are remobilized throughout the shearing process. Structural control of mineralization is also indicated by concentration of sulfides along mica crenulations in the schists. The mineralization (redistribution of sulfides) is syn- to post-kinematic in relation to deformation under greenschist facies conditions. This might indicate that the mineralization was contemporaneous with shear zone hosted gold occurrences in originally high-grade metasediments such as Mineral Occurrence 17 near Potts Lake (Langenberg *et al.*, 1993). Mylonitization under greenschist facies conditions took place between 1.86-1.80 Ga (Plint and McDonough, 1995). However, it should be noted that additional dating is needed to establish the precise age of mylonitization along the Waugh Lake shear zone. Disseminated pyrite can often be seen in post-kinematic granites near contacts with the metasediments, indicating epigenetic mineral deposition in relation to the metasediments.

The shear zone hosted gold showings in Martyn Lake strata are a type of mesothermal shear hosted gold deposit. They form the major prospects for gold deposits in the exposed Precambrian Shield of northeast Alberta. These deposits are often associated with arc-related rifts (Sawkins, 1984).

CONCLUSIONS AND RECOMMENDATIONS

The strata of the Waugh Lake Group were deposited in a composite back-arc/strike-slip rift basin and comprise distinct lithofacies assemblages that can be arranged into a coherent stratigraphic framework. The newly defined formations, in ascending order, comprise:

(1) The basal **Martyn Lake Formation** consists of a rhythmically layered metasedimentary assemblage, at least 137m thick, and is dominated by quartzitic sandstone, siltstone and mudstone (which is now phyllite) that contains turbiditic and graded beds.

(2).The **Doze Lake Formation** is the lower metasedimentary and metavolcanic assemblage, 200m to approximately 330m thick, and is dominated by pebble to boulder conglomerate ($DL.L_{NE}$ member), sublitharenite to subarkose ($DL.L_{SW}$ member) and felsic volcanic flows and tuffs (DL.U member).

(3) The **Sederholm Lake Formation** is a distinctive green, brown-green to black weathered assemblage, and is dominated by mafic-rich sandstone and pebbly sandstone, 7 to 91m thick. The formation varies considerably in thickness across the map area.

(4) The **Johnson Lake Formation** is the upper metasedimentary and metavolcanic assemblage, 238m to 452m thick, and is dominated by sublitharenite, subarkose and conglomerate, in the lower half (JL.L member) and by felsic tuff, lapilli tuff and felsic to intermediate volcanic flows, in the upper half (JL.U member).

(5) The **Niggli Lake Formation** is the uppermost formation consisting of a metavolcanic assemblage dominated by mafic volcanic flows and pyroclastic breccia.

Deeply weathered, sparsely mineralized rusty shear zones (gossans) within the Martyn Lake Formation may be related to thrust faulting. These gossan zones contain schists with minor (1-10%) pyrite, trace arsenopyrite and gold contents of up to 3.2 g/t. The preferred location of sulfides in the shear zones indicate that the enrichment is shear-related and that sulfides are remobilized throughout the shearing process. The mineralization (redistribution of sulfides) is syn- to post-kinematic in relation to deformation in the shear zones, which took place under greenschist facies conditions.

It is recommended to continue mapping the belt of Waugh Lake Group rocks south-southwest from Waugh Lake to Johnson Lake to determine if the newly erected stratigraphic system can be applied to these equivalent successions. Radiometric dating of the various igneous rock units could be performed to better constrain the age of shearing and related mineral deposition.

It is recommended that surface trenching of gossans combined with drilling be performed along shear zones of the Waugh Lake area in order to find mesothermal, shear-hosted gold mineralization. Prospecting could also be extended to areas where shear zones intersect belts of high grade metasedimentary rocks west and southwest of the Waugh Lake area. In connection with this, detailed mapping of the high-grade metasedimentary belts (west of the Waugh Lake area) should be initiated to better define their structural setting and mineral potential.

The potential for Kuroko Type Volcanogenic Massive Sulfide deposits could be further investigated. These deposits comprise polymetallic conformable lenses of massive sulfide ore hosted by felsic volcanic rocks, which exhibit close time-space relationships with fragmental volcanic rocks of dacitic to rhyolitic composition. Prospects in the Waugh Lake area would include the volcanic rocks of the upper Doze Lake and Johnson Lake formations and felsic to intermediate pyroclastic breccias in the Niggli Lake Formation.

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APPENDIX I: CLAST SIZE DISTRIBUTION

MEMBER	STATION	LONG AXIS (CM)	SHORT AXIS (CM)	ROCK TYPE
DL-TR	41111-D	35	8	Grey medium-grained sandstone
		36	12	Grey medium-grained sandstone
		25	6	Grey medium-grained sandstone
		31	7	Buff-grey coarse-grained sandstone
DL-LNE	41012	85	50	Quartz; Quartzite
		49	27	Quartz; Quartzite
		46	28	Quartz; Quartzite
		50	24	Quartz; Quartzite
		56	26	Quartz; Quartzite
		57	28	Quartz; Quartzite
		30	5.5	Fine-to coarse-grained quartzitic sandstone
		95	13	Fine-to coarse-grained quartzitic sandstone
		74	7.5	Fine-to coarse-grained quartzitic sandstone
		53	11	Fine-to coarse-grained quartzitic sandstone
		39	2.6	Fine-to coarse-grained quartzitic sandstone
		55	4.5	Fine-to coarse-grained quartzitic sandstone
		40	5	Fine-to coarse-grained quartzitic sandstone
		30	5	Fine-to coarse-grained quartzitic sandstone
		55	4.5	Fine-to coarse-grained quartzitic sandstone
		40	5	Fine-to coarse-grained quartzitic sandstone
		39	3	Fine-to coarse-grained quartzitic sandstone
		40	4	Fine-to coarse-grained quartzitic sandstone

MEMBER	STATION	LONG AXIS (CM)	SHORT AXIS (CM)	ROCK TYPE
DL-LNE	4I036.A-A,C	21	11	Quartz
		15	4	Fine-grained quartz
		140	35	Coarse-grained subarkose
		60	8	Coarse-grained subarkose
		28	4	Coarse-grained subarkose
DL-LNE	4I038	17	7	Quartz
		30	4	Granite
		16	5	Quartz
		15	7	Quartz
		22	13	Quartz
		12	3	Quartz
		50	8	Granite
		13	9	Quartz
DL-LNE	4I049	33	23	Fine-grained quartzitic sandstone
		20	10	Fine-grained quartzitic sandstone
		24	15	Fine-grained quartzitic sandstone
		19	11	Fine-grained quartzitic sandstone
		25	8	Fine-grained quartzitic sandstone
		16	9	Fine-grained quartzitic sandstone
DL-LNE	4I050	36	6	Fine- to medium-grained quartzitic sandstone
		34	8	Fine- to medium-grained quartzitic sandstone
		48	13	Fine- to medium-grained quartzitic sandstone
		50	9	Fine- to medium-grained quartzitic sandstone
		34	7	Fine- to medium-grained quartzitic sandstone
		65	10	Fine- to medium-grained quartzitic sandstone

MEMBER	STATION	LONG AXIS (CM)	SHORT AXIS (CM)	ROCK TYPE
DL-LNE	4I008	17	6	Buff-grey sandstone
		15	4	Buff-grey sandstone
		6	2	White quartzite
		6	3	Granite
		17	4	Buff-grey sandstone
		6	4	White quartzite
		18	6	White quartzite
		20	7	Grey sandstone
DL-LNE	4I111.A	50	6	Grey coarse-grained to granular sublitharenite
		76	10	Grey coarse-grained to granular sublitharenite
		31	6	Grey fine-grained sandstone
		42	8	Buff fine-grained sandstone
		23	8	Buff-white fine-grained sandstone
		54	7	Buff fine-grained sandstone
		36	5	Buff fine-grained sandstone
		79	7	Buff subarkose
		10	5	White quartzite
		13	4	White quartzite
		30	4	Buff coarse-grained to granular sublitharenite
		35	7	Grey fine-grained sandstone
		21	4	Grey fine-grained sandstone
DL-LNE	4I111.G	75	15	Grey fine-grained sandstone
		38	8	Grey fine-grained sandstone
		45	9	Grey fine-grained sandstone
		54	5	Grey coarse-grained to granular sublitharenite
		49	14	Grey coarse-grained to granular sublitharenite
		60	7	Grey fine-grained sandstone

MEMBER	STATION	LONG AXIS (CM)	SHORT AXIS (CM)	ROCK TYPE
DL-LNE	4I146; 147	43	28	White fine-grained quartzite
		35	19	Green coarse-grained subarkose
		20	6	Green coarse-grained subarkose
		12	7	White quartzite
		14	7	White quartzite
		18	6	Grey-green coarse-grained sublitharenite
		14	3	Green fine-grained quartzitic sandstone
		63	20	Green coarse-grained subarkose
		37	8	Green coarse-grained subarkose
		17	3	Green-grey fine-grained quartzitic sandstone
		30	13	White quartz
		12	2	Grey fine-grained quartzitic sandstone
		15	3	Grey fine-grained quartzitic sandstone
		20	7	Grey-green coarse-grained subarkose
		31	16	Grey-green coarse-grained subarkose
		28	6	Grey-green coarse-grained subarkose
		12	0.5	Green-grey fine-grained quartzitic sandstone
		10	0.5	Green-grey fine-grained quartzitic sandstone
		52	21	Green-pink coarse-grained sublitharenite
		74	18	Grey-green coarse-grained subarkose
		32	14	White quartz
		25	8	Grey-green coarse-grained subarkose
		21	4	Grey fine-grained quartzitic sandstone
		23	11	White quartzite
DL-LSW	4I001	10	--	Granite
		20	2	Sandstone

MEMBER	STATION	LONG AXIS (CM)	SHORT AXIS (CM)	ROCK TYPE
DL-LSW	4I029.C	28	7	Quartz
		14	5	Quartz
		21	6	Quartz
DL-LSW	4I091; 092	11	2	Sandstone
		8	3	Granite
		15	2	Greywacke
		15	9	Granite
		15	3	Sandstone
		20	6	Green medium-grained sandstone
		7	3	Granite
		8	4	Granite
		15	7	Green medium-grained sandstone
		19	5	Green medium-grained sandstone
		27	8	Green medium-grained sandstone
		18	4	Green medium-grained sandstone
DL-LSW	4I010	37	12	White quartzite
		13	5	White quartzite
		14	4	Granite
		11	4	Granite
		44	2	Grey fine-grained sandstone
		18	6	White quartz
		21	7	White quartz
		28	2	Grey-green quartzitic sandstone
DL-LSW	4I109.D	40	2	Green-grey sandstone
		22	5	White quartzite
		18	5	White quartzite
		9	3	Pink granite
		25	2	Grey quartzitic sandstone

MEMBER	STATION	LONG AXIS (CM)	SHORT AXIS (CM)	ROCK TYPE
DL-LSW	4I121; 122	37	7	Green-grey fine-grained sandstone
		9	4	Green-grey fine-grained sandstone
		10	5	Green-grey fine-grained sandstone
		7	4	Pink granite
		8	4	Pink granite
		5	2	White quartz
		10	4	Green-grey fine-grained sandstone
		9	5	Green-grey fine-grained sandstone
		13	4	Green-grey fine-grained sandstone
		12	5	Green-grey fine-grained sandstone
		5	3	Pink granite
		14	3	Grey fine-grained quartzitic sandstone
		8	2	Grey fine-grained quartzitic sandstone
		10	3	Grey fine-grained quartzitic sandstone
		15	4	Grey medium-grained greywacke
		6	3	Pink granite
		13	3	Banded phyllite and fine-grained sandstone
		11	2	Grey fine-grained quartzitic sandstone
		21	7	Grey-green phyllite
JL-L	4I026.B	42	9	Sandstone
		28	7	Sandstone
JL-L	4I030	10	6.5	Quartz
		12	7	Quartzite
		15	10	Granite
		17	11	Granite
		52	7	Sandstone
		24	12	Granite

MEMBER	STATION	LONG AXIS (CM)	SHORT AXIS (CM)	ROCK TYPE
JL-L	4I054.B	23	8	Granite
		49	5	Felsic tuff
		15	9	Granite
		14	7	Granite
		14	5	Granite
		20	5	Granite
JL-L	4I057.I	14	10	Granite
		24	11	Grantie
		20	5	Sandstone
		12	7	Granite
		15	4	Sandstone
JL-L	4I074. QI	33	4	Buff-green felsic tuff
		14	2.5	Buff-green felsic tuff
		16	3	Green sandstone
		12	7	Granite
		10	5	Granite
		29	7	Green-grey granular subarkose
JL-L	4I074.S	15	9	Granite
		12	7	Granite
		22	4	Sandstone
		18	3	Sandstone

MEMBER	STATION	LONG AXIS (CM)	SHORT AXIS (CM)	ROCK TYPE
JL.L	41074. W;Y;AA; CC	9	4	Granite
		24	4	Fine-grained sandstone
		12	5	Granite
		13	5	Granite
		15	3	Sandstone
		12	5	Granite
		10	6	Granite
		10	4	Quartz
		16	9	Granite
		7	3.5	Granite
		12	7	Granite
		16	9	Granite
		9	6	Granite
		10	4	Granite
		15	4	Granite
JL-L	41075. O;Q	9	3	Quartz
		27	4	Phyllite
		35	5	Phyllite
		37	12	Granite
		18	6	Granite
		32	11	Granite
		13	6	Granite
		28	11	Granite
		21	10	Granite
		16	8	Granite
		25	4	Sandstone
		13	4	Granite
		17	7	Granite
		30	10	Granite
		13	4	Granite
		9	5	Granite

MEMBER	STATION	LONG AXIS (CM)	SHORT AXIS (CM)	ROCK TYPE
JL-L	4I077.E	25	4	Sandstone
		11	1	Sandstone
		15	14	Granite
		5	2	Granite
		15	3	Sandstone
JL-L	4I087	7	4	Granite
		9	5	Granite
		18	3	Sandstone
		15	2	Phyllite
JL-L	4I100.E	13	7	Granite
		13	9	Buff-grey sandstone
		14	6	Granite
		26	9	Granite
		12	7	Granite
		19	3	Green-grey greywacke
		12	2	Green-grey phyllite
JL-L	4I108.L	36	10	Green coarse-grained subarkose
		20	5	Green coarse-grained subarkose
		12	7	Granite
		10	4	Granite
		15	8	Granite
		21	4	Sandstone
		15	3	Greywacke
		18	10	Granite
JL-L	4I114	13	10	Pink granite
		8	4	White quartz
		10	2	Buff-grey fine-grained sandstone
		11	2	Green-grey greywacke

MEMBER	STATION	LONG AXIS (CM)	SHORT AXIS (CM)	ROCK TYPE
JL-L	4I115	23	2.5	Brown medium-grained greywacke
		10	6	Pink-white granite
		3	2	Pink-white granite
		15	3	Brown medium-grained greywacke
JL-L	4I127.A	18	12	Pink granite
		6	3	White quartzite
		15	3	Buff-grey quartzitic sandstone
		12	2	Buff-grey quartzitic sandstone
		21	12	Pink granite
JL-L	4I028; 057	15	4	Green-grey fine-grained quartzitic sandstone
		10	3	Green-grey fine-grained quartzitic sandstone
		13	4	Brown-green granular sublitharenite
		10	9	Buff-pink fine grained quartzite
		16	7	Pink granite
		15	5	Brown-grey fine-grained sublitharenite
		4	2.5	White fine-grained quartzite
		9	4	Brown-green coarse-grained sublitharenite
		19	13	Pink granite
		9	5	Pink-red granite
		8	5	Pink granite
		17	8	Green-grey fine-grained quartzarenite
		12	10	Brown-grey granular sublitharenite
		15	4	Brown-grey granular sublitharenite
		16	4	Brown-grey granular sublitharenite

MEMBER	STATION	LONG AXIS (CM)	SHORT AXIS (CM)	ROCK TYPE
JL-L	4I137.F	24	7	Buff-grey fine-grained quartzarenite
		13	5	Buff-grey fine-grained quartzarenite
		13	7	Buff-grey fine-grained quartzarenite
		22	5	Grey coarse-grained sublitharenite
		23	10	Grey fine-grained quartzarenite
		18	9	Pink granite
		15	9	Pink granite
		8	4	White fine-grained quartzite
		7	3	White fine-grained quartzite
		18	13	Pink granite
JL-L	4I149.H	21	10	Pink-white granite
		14	3.5	Green medium-grained quartzarenite
		9	2.5	Green medium-grained quartzarenite
		8	5	Grey fine-grained quartzarenite
		6	2.5	White quartz
		12	4	Brown-green medium-grained sandstone
		10	3	Green fine-grained quartzarenite
		15	4	Green fine-grained quartzarenite
		36	17	Pink granite
JL.U	4I085	14	6	Granite
NIGGLI LAKE FM	4L098	1	1	Intermediate to mafic volcanic
		41	20	Intermediate to mafic volcanic
		110	40	Intermediate to mafic volcanic
		56	40	Intermediate to mafic volcanic

APPENDIX II: THIN SECTION DESCRIPTION

By A. Skupinski, consultant, Calgary, Alberta

SAMPLE WL2-08-21-03 (Trench #3, Gold showing #39)

Rock Name: Quartz-Muscovite schist.

Mineral Content:

Rock-forming:	Quartz (subsequent) Muscovite (principal) Biotite (subsequent) Zircon (trace)
Opaques:	Ilmenite (minor) Cubanite (trace) Pyrite (principal sulfide) Chalcopyrite (minor) Goethite (minor) Limonite (minor) Carbon dust (common)

Texture:

The rock consists of strongly crenulated massive, fine-grained muscovite with variable content of biotite and displays a lepido-granoblastic texture. Irregular clusters of fine-grained quartz are mixed with mica micro-folds. The quartz grains are angular and their size is equant. The deformation style of the portions enriched in quartz depend on the grain size. Fine-grained (0.01-0.02 mm) quartz stringers are usually incorporated within mica crenulations. Clusters of coarser grained quartz agglomerations, with subgrain size up to 0.2 mm, behaved more rigidly during deformation. The sulfides are mainly adjacent to coarse-grained quartz.

Carbon dust is commonly disseminated within mica microfolds. Some carbon stripes contain tiny flakes of strongly anisotropic graphite.

Opaque Mineralogy:

Ilmenite is common among muscovite layers. It is fine-grained, 6-20 microns in size. The small grains are idioblastic. The larger grains, up to 0.1 mm in size, are xenoblastic. Grains are elongate parallel to the foliation. Lamellar twinning has been observed in the larger grains. Ilmenite rims are commonly altered to anatase. Unusual tiny and rounded inclusions of cubanite occur in a single Ilmenite grain.

Pyrite forms anhedral clusters amongst quartzose stringers. The clusters are up to 3 cm long. The pyrite is distinctively porous. The oxidation to goethite is common along the pores and grain borders. Trace anhedral chalcopyrite grains are dispersed in the rock.

Comments:

The morphology and equant size of the quartz grains suggests that it is well-sorted pelitic detritus of sedimentary origin. Pyrite crystallized during the last phase of deformation, so that the larger clusters are sometimes cracked.

The amorphous carbon precipitated mostly within plastically deformed portions of the rock. The precipitation was probably synkinematic. The carbon played an active role during tectonic deformation. It prevented recrystallization of the mineral components, helping to prolong plastic deformation of the micaceous layers. Some of the carbon is altered to graphite.

SAMPLE WL2-08-26-02 (Trench #1, Gold Showing #50)

Rock Name: Quartz-biotite-muscovite schist.

Mineral Content:

Rock-forming:	Quartz (principal)
	Biotite (principal)
	Muscovite (subsequent)
	Tourmaline (trace)
	Zircon (trace)
	Cassiterite (trace)
Opaques:	Ilmenite (minor)
	Magnetite (trace)
	Pyrrhotite (major)
	Arsenopyrite (common)
	Pyrite (common)
	Chalcopyrite (trace)
	Marcasite (trace)

Texture:

The rock is fine-grained, schistose and shows grano-lepidoblastic texture. Short shredded biotite and muscovite display a parallel arrangement. Some Muscovite flakes display (001) cleavage oriented perpendicular to the foliation. Quartz forms slightly platy grains, up to 0.1 mm in size, disseminated across micaceous components. Laminar stringers of the mosaic quartz, commonly encrusted with opaques, interlayer the rock. Microcrystalline laths of ilmenite, commonly altered to anatase, are disseminated in biotite. Biotite pleochroism changes along the rock. Some biotite has a dark brown pleochroism, but the majority of flakes display a pale brown reddish pleochroism similar to phlogopite. Olive-brown tourmaline, 0.1 mm in size, occurs in trace amount.

Opaque Mineralogy:

The volume of sulfides is about 5%. They form elongated, usually xenoblastic grains, up to 0.05 x 0.5 mm in size, along the schistosity planes. The sulfides are not intergrown and are entirely unaltered.

Pyrrhotite is most common and forms uniform grains. Pyrite has a granular texture with minor intragranular porosity. Arsenopyrite forms subidioblastic elongated crystals of up to 5 mm in size. Smaller grains are uniform. The larger ones are slightly fractured.

Minor inclusions of pyrrhotite, chalcopyrite and marcasite are noticeable in one large arsenopyrite grain. Arsenopyrite most commonly is adjacent to quartz stringers and accompanied by pyrite. The accompanying pyrite forms uniform grains without pores (this might be a second phase of pyrite growth).

SAMPLE WL2-08-26-05 (Au Showing #53)

Rock Name: Quartz-mica Schist.

Mineral Components:

Rock-forming:	Quartz (subsequent)
	Muscovite (principal)
	Biotite (minor)
	Plagioclase (sericitized relics)
	Zircon (trace)
	Apatite (trace)
	Tourmaline (trace)
Opaques:	Arsenic-bearing Pyrite (main)
	Loellingite (subsequent)
	Arsenopyrite (subsequent)
	Chalcopyrite (minor)
	Pyrrhotite (trace)
	Goethite (minor)
	Limonite (minor)

Texture: .

The rock is distinctly foliated with a lepido-granoblastic texture. Flaky aggregates of fine-grained muscovite and subsequent biotite (0.01-0.1 mm flake size) are intercalated with irregular and lensoidal clusters of mosaic quartz. Individual quartz grains are slightly strained and display an undulatory extinction. They are 0.1-0.5 mm in size. Muscovite layers are locally crenulated. Recrystallization of muscovite is displayed by coarser sized flakes with the (001) cleavage perpendicular to the foliation plane of mica layers. Recrystallization of biotite flakes is less common.

Shear discontinuities parallel to foliation are common along the mica clusters. Fractures cut the rock perpendicular to the schistosity plane. They are commonly infilled with goethite and limonite.

Sulfide mineralization occurs mainly within the quartz clusters.

Sulfide Mineralogy:

Arsenic-bearing pyrite is the principal sulfide in the rock. It forms irregular clusters and grains (0.1-6 mm in size) within quartz. Minor tensional gashes within arsenic-bearing pyrite occur. Along the edges arsenic-bearing pyrite is commonly oxidized to goethite.

Crystals of loellingite commonly occur within arsenic-bearing pyrite. Less frequently arsenopyrite occurs within arsenic-bearing pyrite.. Both loellingite and arsenopyrite display idioblastic shapes of wedges and prisms. The optical difference between them is small. Arsenopyrite is weakly bireflectant, with no pleochroic tints. It is anisotropic with ochre-yellow to pink violet colours. Loellingite is commonly polysynthetically twinned. It displays distinctive acute wedges, which makes it distinguisable from arsenopyrite. It also displays bireflection, pleochroism and anisotropy with yellow/blue colours, which are much stronger than arsenopyrite.

Pyrrhotite occurs in trace amount as inclusions in arsenic-bearing pyrite. Minor chalcopyrite is bordering the idioblastic quartz crystals, that occur within some shearing discontinuities, usually accompanied by goethite and limonite.

Comments:

Arsenic-bearing pyrite is a variety displaying distinctive uneven anisotropy. Such a variety of pyrite is known from other gold deposits. The occurence of sulfides is limited to quartz. This fact is due to the thermal solutions easily circulating along tensional disruptions and intergranular channels in quartz clusters, where deformation was more brittle than in mica clusters.

The earliest sulfide is pyrrhotite. Later arsenic-bearing pyrite is coeval with loellingite and arsenopyrite. Chalcopyrite is most likely the last sulfide.

Table 1: Table of formations, Waugh Lake Group.

Waugh Lake Group (thk = 1120m+)

Niggli Lake Fm (thk + 128+): Mafic to intermediate flows, tuffs and pyroclastic breccia (includes mainly basalt and andesite); minor interlayers of reworked tuff and medium-grained to pebbly sublitharenite.

— — — Conformable ? — — —

Johnson Lake Formation (thk = 238m to 452m)

Upper — JL.U Member (thk = 46m to 268m): Interlayered felsic, less commonly intermediate, tuffs, flows, and lapilli tuffs with minor horizons (up to 30m thick) of medium-grained to pebbly subarkose to sublitharenite and polymictic pebble conglomerate.

— — — Conformable/Gradational — — —

Lower — JL.L Member (thk = 184m to 343m): Planar-bedded to trough-crossbedded medium-grained to pebbly sublitharenite to subarkose, with variably interlayered polymictic pebble conglomerate horizons; locally with minor felsic tuff and reworked tuff horizons; thins to the north and northeast.

— — — Conformable/Gradational — — —

Sederholm Lake Formation (thk = 7m to 91m): Actinolite- and biotite-bearing, planar-bedded to trough-crossbedded, fine-grained to pebbly subarkosic-wacke to sublitharenite with minor interlayers of polymictic orthoconglomerate and mafic to intermediate tuff.

— — — Conformable — — —

Doze Lake Formation (thk = 200m to 330 m)

Upper — DL.U Member (thk = 102m to 118m): Felsic, less commonly intermediate, flows and tuffs with minor interlayered horizons of reworked felsic to intermediate tuffs; includes rhyolitic to dacitic flows and tuffs.

— — — Conformable — — — —?— —?— —?— —?— —?— —?—

Lower:

DL.L$_{SW}$ Member (thk = 95m to 220m): Medium-grained to pebbly subarkose to sublitharenite with minor interbeds of polymictic conglomerate; planar-bedded to through-crossbedded.

— — — Gradational — — —

DL.TR Member (thk = 4m to 11m): Interlayered quartzarenite lenses, phyllite - siltstone - sandstone and pebbly subarkose.

DL.L$_{NE}$ Member (thk = 27m to 119m): Massive pebble to boulder polymictic orthoconglomerate; spheroidal to discoidal quartzite, quartz, granite, and sandstone clasts in a sublitharenite matrix.

— — — Conformable - — — —

DL.B Member (thk = 29m+): Mafic to intermediate flows and pyroclastic breccia.

— — — Conformable/Gradational — — —

Martyn Lake Formation (thk = 200m+): Interlayered thin- to medium-bedded, fine- to coarse-grained quartzarenite to subarkose and rhythmically bedded mudstone (includes phyllite and biotite-sericite schist) - siltstone - fine grained quartzarenite; strata contain turbidites and graded bedding.

—?— — — —?— — — —?— — — —?— — — —?— — — —?— — — —?— — — —?— — — —?—

Basement Unknown

Table 2: Lithology Legend

Intrusive Rocks

- Hornblende-Biotite Granite
- Hornblende-Biotite Diorite

Volcanic and Volcaniclastic Rocks

- Fine crystalline mafic flows; minor intermediate flows and thick laminated intermediate to mafic tuffs.
- Massive intermediate to mafic pyroclastic breccia.
- Massive fine crystalline felsic, less commonly intermediate, flows
- Fine crystalline felsic, less commonly intermediate, flows and minor intermixed felsic tuffs.
- Fine crystalline felsic flows and intermixed tuffs to lapilli tuffs with minor reworked tuff and sublitharenite.
- Fine crystalline felsic tuff; minor intermediate tuff and felsic to intermediate flows.
- Felsic, less commonly intermediate, tuff, lapilli tuff, thick laminated reworked tuff to lapilli tuff with subordinate flows and fine-grained to pebbly sublitharinite to subarkose.
- Fine crystalline intermediate to mafic tuff with minor intermixed lenses to layers of amphibole-bearing, medium-grained to pebbly subarkose and sublitharenite.

Siliciclastic and Conglomeratic Rocks

- Massive weathered, non-stratified to poorly stratified, pebble to boulder polymictic conglomerate.
- Planar to undulatory layered, thick-laminated to thin bedded medium-grained to granular subarkose to sublitharenite and intermixed pebbly sublitharenite and pebble to cobble polymictic conglomerate.
- Planar to undulatory layered, thick-laminated to thin bedded fine- to coarse-grained subarkose to sublitharenite, alternating with granular to pebbly subarkose and sublitharenite.
- Planar- to cross-bedded, actinolitic medium-grained to granular arkosic-wacke to sublitharenite, intermixed with pebbly to conglomeratic subarkose to sub-litharenite.
- Planar- to cross-bedded, thick-laminated to thin bedded, actinolitic fine- to coarse-grained arkose, arkosic-wacke to litharenite and intermixed coarse-grained to pebbly subarkose to sublitharenite.
- Planar to undulatory layered, thick-laminated to thin bedded coarse-grained to pebbly sublitharenite, subarkose, minor conglomerate, and reworked felsic to intermediate tuff.
- Thick laminated to thin bedded, fine- to coarse-grained actinolitic subarkose to sublitharenite and minor intermixed layers of fine-crystalline mafic to intermediate tuff.
- Planar to undulatory layered, very thin to medium bedded, fine- to medium-grained quartzarenite to quartzitic subarkose.
- Rhythmic layered, very thin bedded to thin bedded fine-grained quartzitic subarkose and siltstone with lenticular sandstone intraclasts
- Rhyrhmic layered, thick-laminated mudstone (phyllite) and thin bedded fine-grained quartzarenite intermixed with sublitharenite to subarkose and quartzitic subarkose lenses.
- Thin- to thick-laminated mudstone (phylite) intermixed with thin bedded quartzarenite and quartzitic subarkose lenses.
- Fine- to medium-grained, very thin to thin bedded quartzarenite with minor interlayers of mudstone (phyllite).
- Planar thick-laminated to very thin bedded quartzarenite and intermixed mudstone (phyllite) - siltstone - sandstone; contains turbidites.
- Thin- laminated to very thin bedded, rhythmically layered mudstone (phyllite), siltstone and fine- to medium-grained quartzarenite to quartzitic subarkose.
- Planar thin-laminated to very thin bedded mudstone (phyllite to Biotite-sericite schist).

Table 3: Stratigraphic Symbols

Sedimentary Structures

/////	Crossbeds (mainly trough type)
	Cross-laminations
◡	Scours
	Channels
▲	Graded bedding (normal)
	Soft sediment folds
	Load structures
	Imbrication

Minor Lithofacies, Minerals and Non-Sedimentary Structures

○	Polymictic conglomerate layer (thk<0.5m)
▽	pyroclastic breccia
▬ ▬	Intraclasts; Intraclast conglomerate
△	Fining-upward cycles (thk = 0.1m to 1m)
ep	Epidote; epidote alteration
t	Tourmaline veins
qt	Quartz veins; quartz stockwork
	Shear zone

Miscellaneous Symbols

47-F	Stratigraphic unit
46-1	Rock sample

TABLE 4: Selected results from Hudson's Bay Oil and Gas and Alberta Geological Survey samples

SAMPLE NUMBER	SAMPLED BY	DATE	MINERAL OCCURR-ENCE #	Au (ppb.)	As (ppm.)	Ag (ppb.)	Cu (ppm.)	Zn (ppm.)	Ni (ppm.)	Cr (ppm.)	OTHER ELEMENTS	ROCK DESCRIPTION
1516 (8)	HBOG*	1971	50	/	/	/	40	/	/	/	/	HBOG TRENCH 1
1517 (9)	HBOG	1971	50	340	/	20,400	20	/	170	/	/	" " 1
1518 (10)	HBOG	1971	50	/	/	/	50	/	/	/	/	" " 1
1521	HBOG	1971	39	/	/	/	100	/	100	/	/	" " 2
1520 (6)	HBOG	1971	52	/	/	/	40	/	/	/	/	" " 4
JG-60-139-9	JG +	1960	125	133	/	/	16	/	/	/	/	Tourm.-qtz 2. vein
JG-60-140-2	JG	1960	126	22	/	/	/	102	/	/	/	Quartzite
JG-60-147-7	JG	1960	127	205	800	/	18	/	/	/	/	Qtz. bio. sch.
WL-08-21-01	AGS**	1992	39	11	/	/	/	/	/	196	/	Qtz. bio. sch.+ graph. ; 2%py
WL-08-21-02	AGS	1992	39	17	/	/	55	141	/	/	/	Qtz. bio. sch ; 10% py, po, aspy
WL-08-21-03	AGS	1992	39	29	/	/	62	157	/	/	/	Qtz. bio. sch.; py stringers
WL-08-21-04	AGS	1992	39	9	/	/	53	/	/	205	/	Bio.sch. + Qtz vein; tr. py
WL-08-26-01	AGS	1992	50	28	29	/	/	/	/	197	/	Qtz.vein; 2% py, aspy.
WL-08-26-02	AGS	1992	50	416	14,596	/	/	/	/	/	/	Qtz. bio. sch.; 10% aspy
WL-08-26-03	AGS	1992	51	9	39	/	53	/	/	/	/	Qtz. seric. sch.; 5% py, aspy
WL-08-26-04	AGS	1992	52	/	18	/	/	158	61	211	/	Qtz. bio. sch. ; 5% py, aspy
WL-08-26-05	AGS	1992	53	16	/	/	130	300	177	/	/	Seric. sch.; 10% py, cpy,
HS93070701	AGS	1993	128	36	10	/	20	63	27	188	/	Qtz. vein; tr.py.
HS93070822	AGS	1993	130	3,212	/	/	/	/	/	280	/	Rusty Rhythmites
HS93070823	AGS	1993	130	121	/	/	45	/	/	/	/	Rusty Rhythmites
HS93071210	AGS	1993	131	59	844	/	/	/	/	268	/	Rusty Rhythmites + qtz-tourm veins
HS93071413	AGS	1993	132	28	/	/	34	/	/	/	/	Rusty Rhythmites; tr. py
HS93071721	AGS	1993	133	26	6,571	/	111	/	/	257	/	Rusty Rhythmites; 5%py, aspy
HS93080102	AGS	1993	134	93	/	/	/	/	/	/	/	Rusty Rhythmites

TABLE 4: Selected results from Hudson's Bay Oil and Gas and Alberta Geological Survey samples

SAMPLE NUMBER	SAMPLED BY	DATE	MINERAL OCCURR-ENCE #	Au (ppb.)	As (ppm.)	Ag (ppb.)	Cu (ppm.)	Zn (ppm.)	Ni (ppm.)	Cr (ppm.)	OTHER ELEMENTS	ROCK DESCRIPTION
HS93080507	AGS	1993	135	133	35	/	44	/	/	/	/	Rusty Rhythmites
4E-001	AGS	1994	51	51	/	/	/	94	/	/	/	Qtz. seric. sch; 1% py, aspy
4E-018	AGS	1994	135	55	615	/	36	/	/	/	/	Rusty Rhythmites; tr. aspy
4I-018	AGS	1994	130	59	8,797	/	114	63	25	/	/	Rusty Schists

* HBOG - Hudson's Bay Oil and Gas
\+ JG - Alberta Geological Survey Rock Collection (samples collected by John Godfrey)
++ AGS - Alberta Geological Survey

Figure 1. Geological map of the Waugh Lake area (big map in pocket)

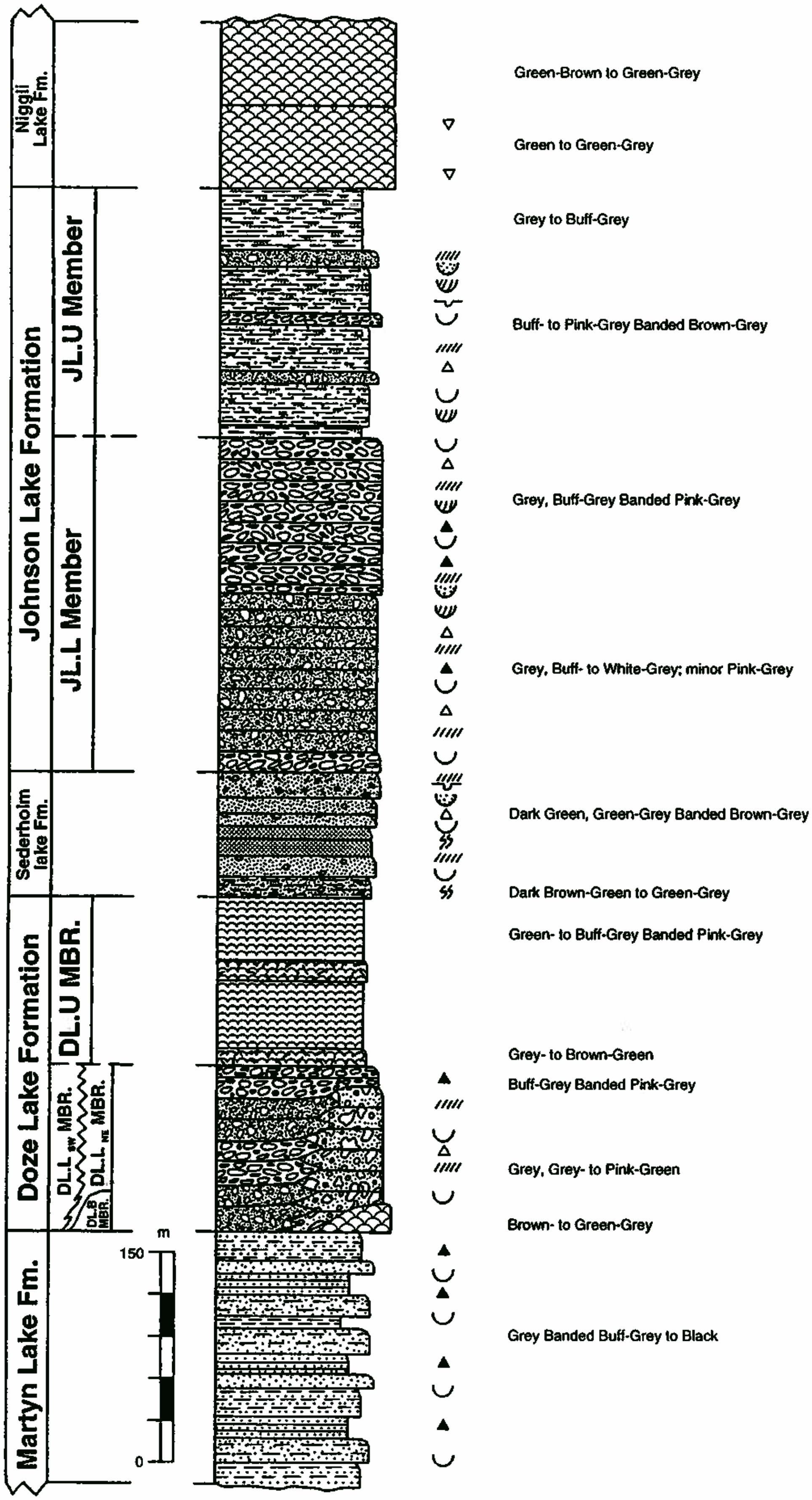


Figure 2: Generalized composite stratigraphic section of the Waugh Lake Group. See legend (table 2) for descriptions of lithologies. All colours in figures are weathered colours.

Figure 3: Section 4I010
Location: E 554388 N 6631717
Thickness: 68 m

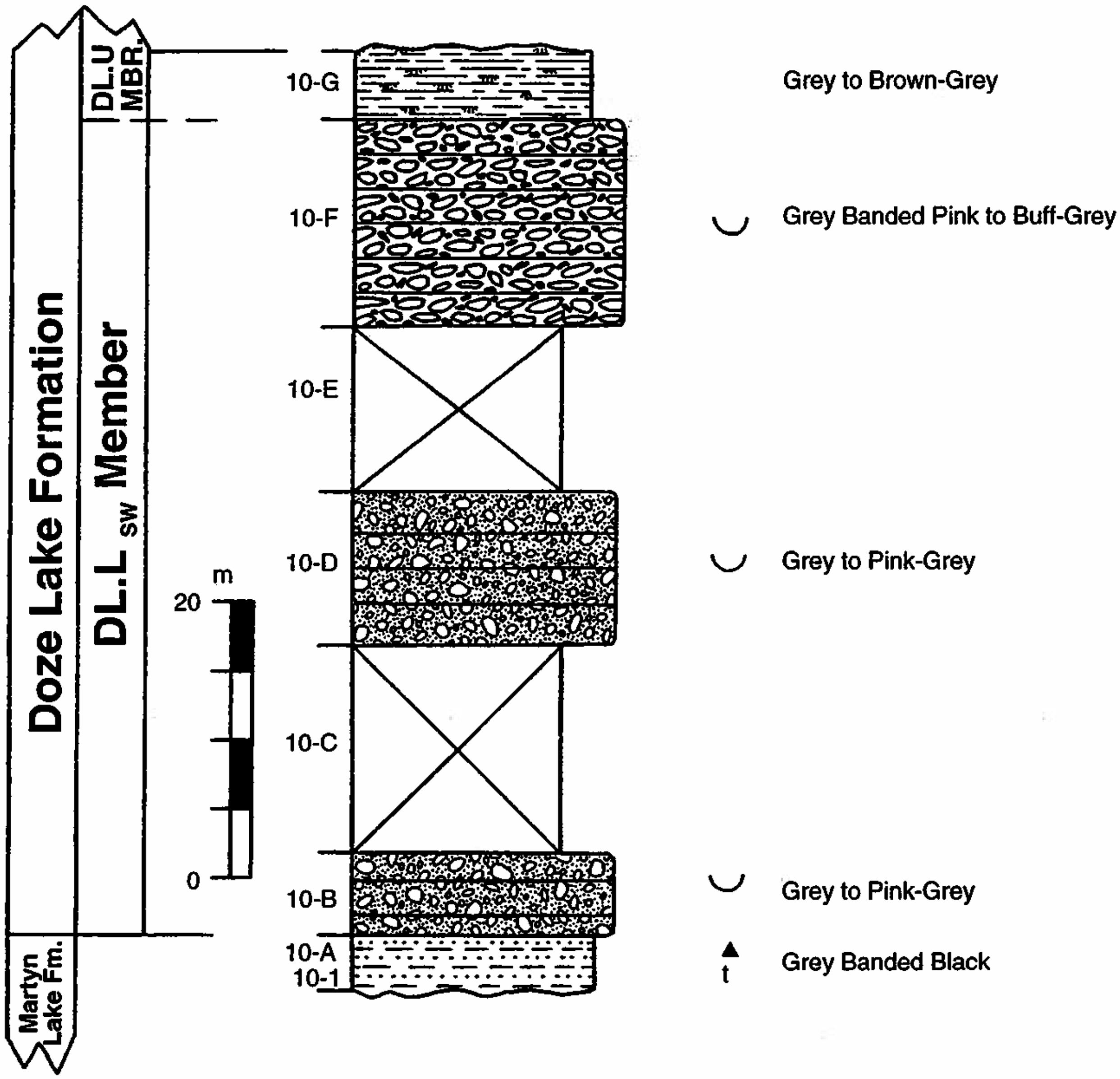


Figure 4: Section 4I012 + 013
Location: E 555648 N 6636152
Thickness: 125 m

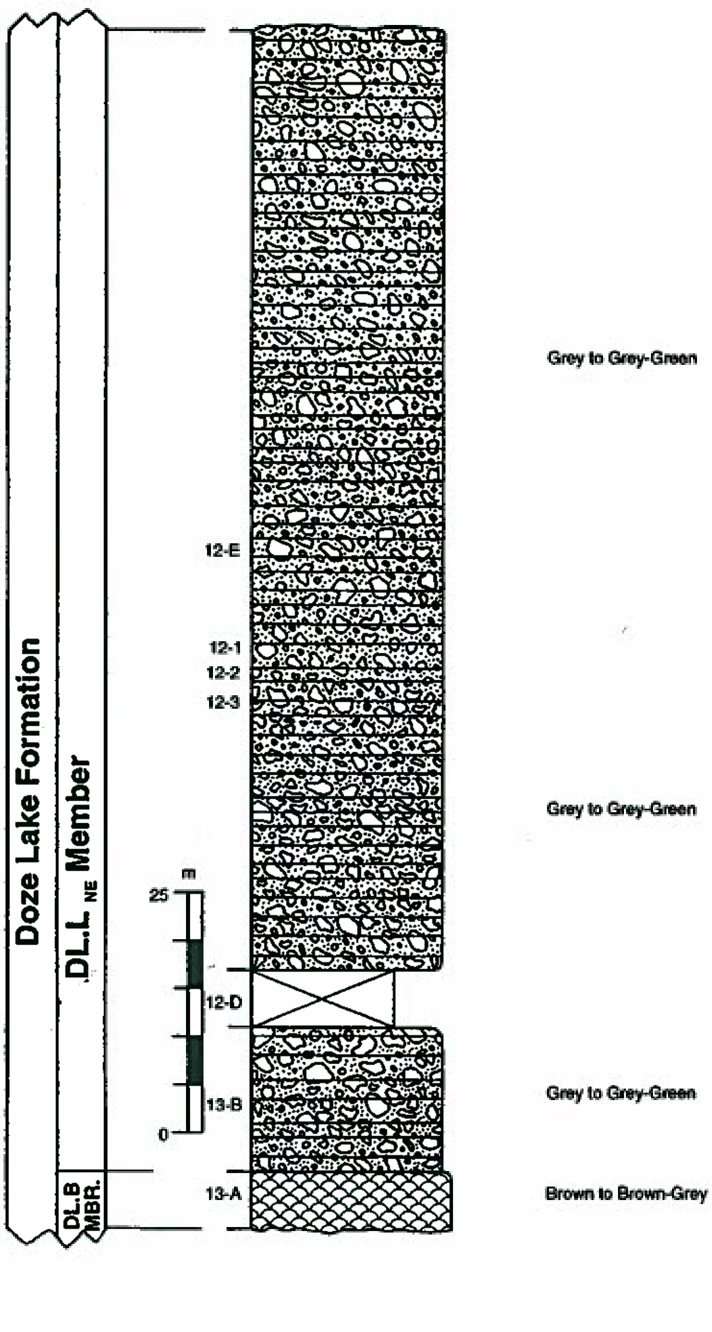


Figure 5: Section 4I016
Location: E 555583 N 6635607
Thickness: 73 m

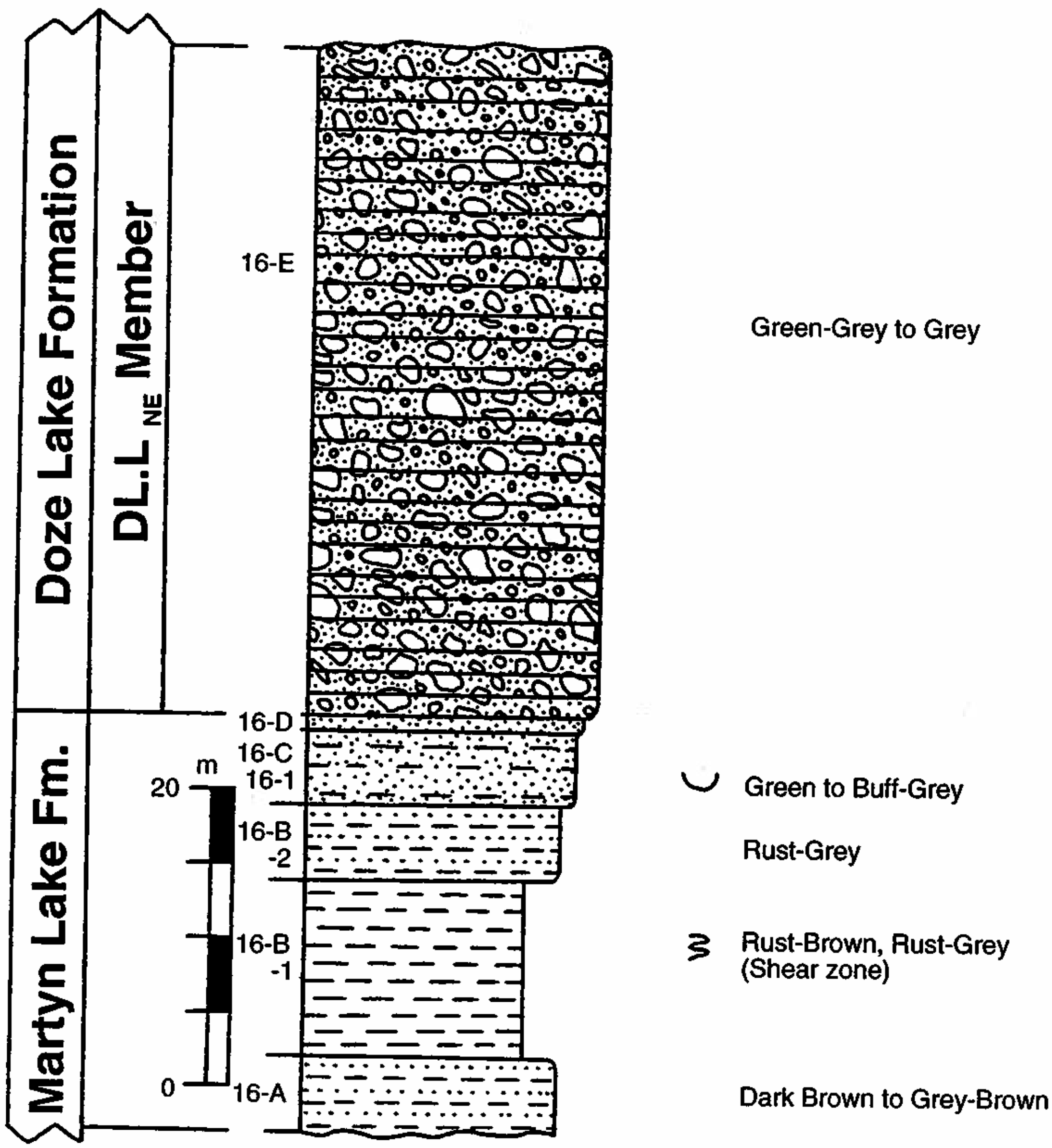


Figure 6: Section 4I026
Location: E 553048 N 6634247
Thickness: 92 m

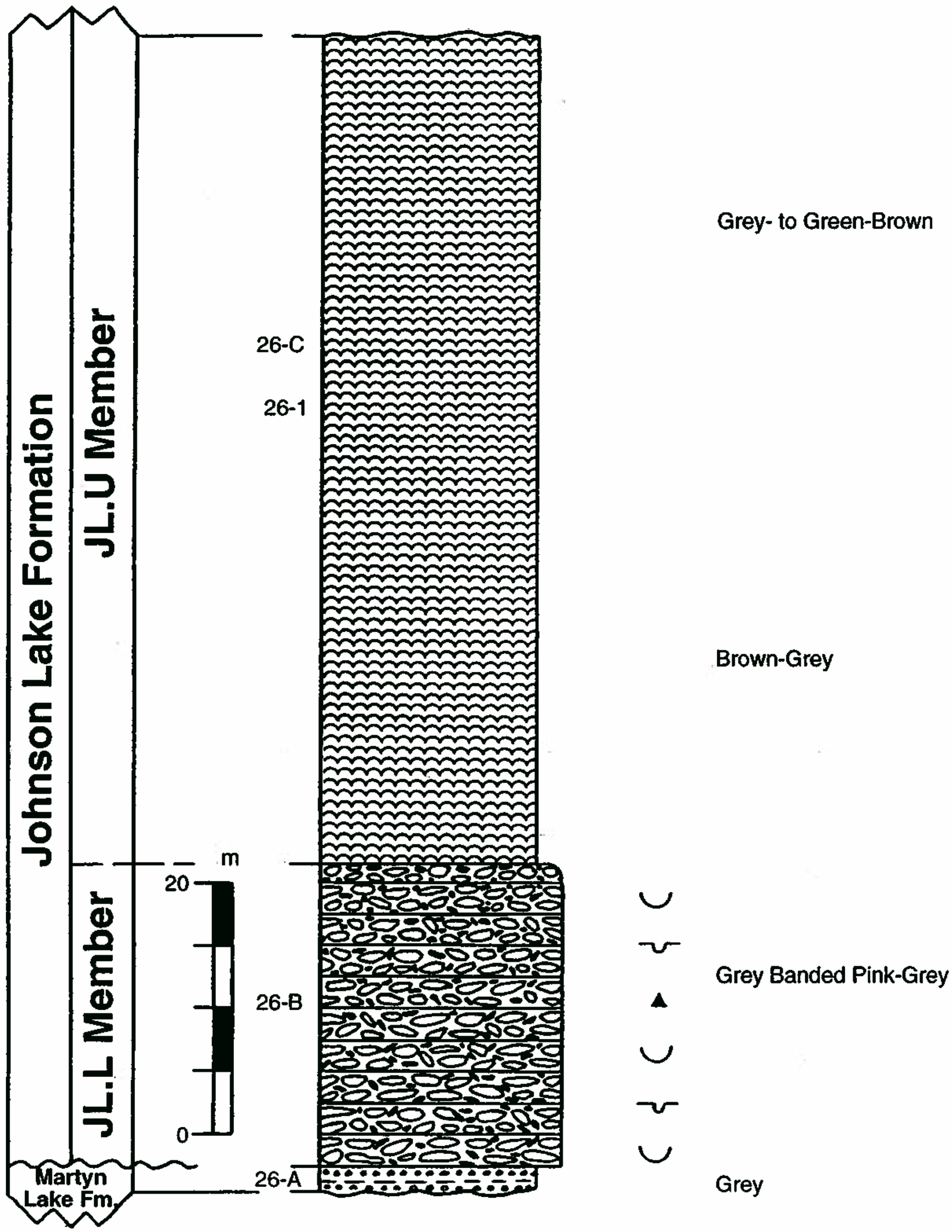


Figure 7: Section 4I036-A
Location: E 555758 N 6636242
Thickness: 58 m

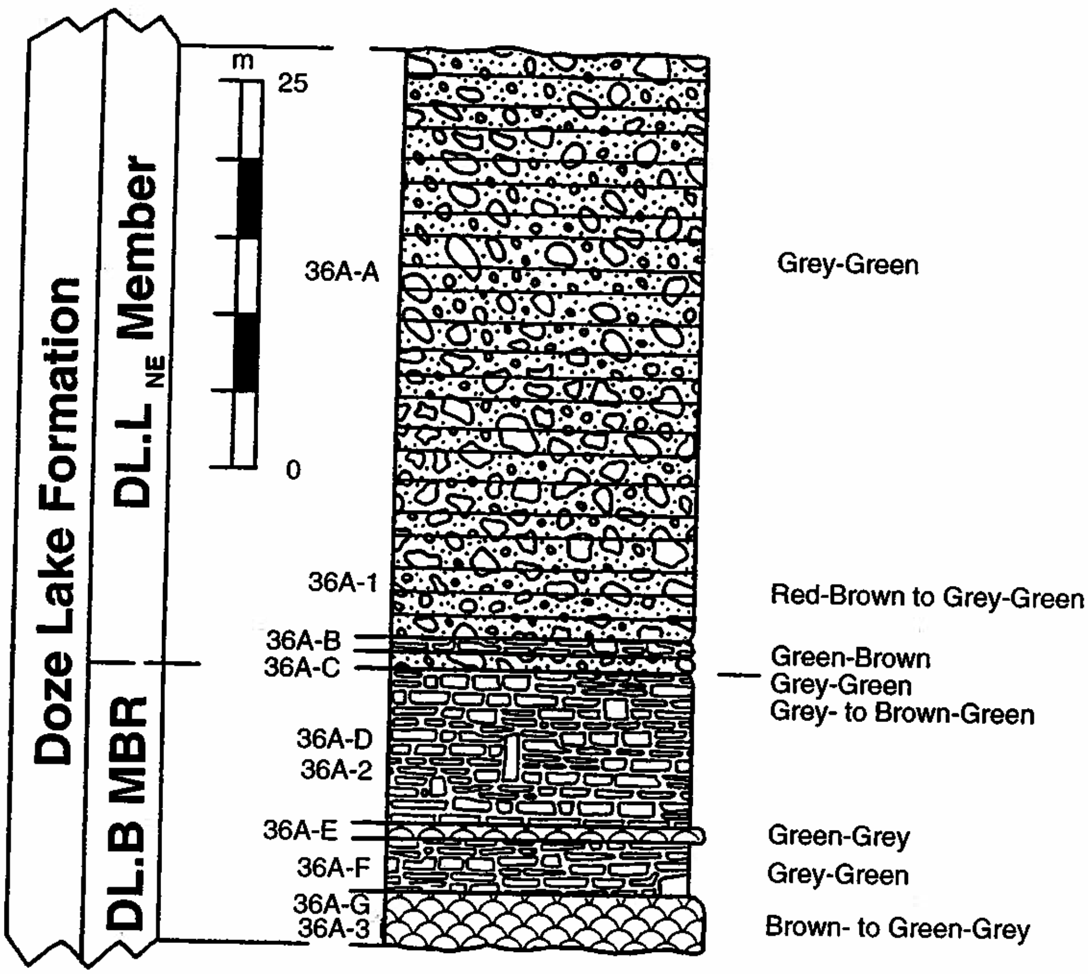


Figure 8: Section 4I036-B
Location: E 555783
N 6636342
Thickness: 32 m

Figure 9: Section 4I36-C
Location: E 555793
N 6636377
Thickness: 25 m

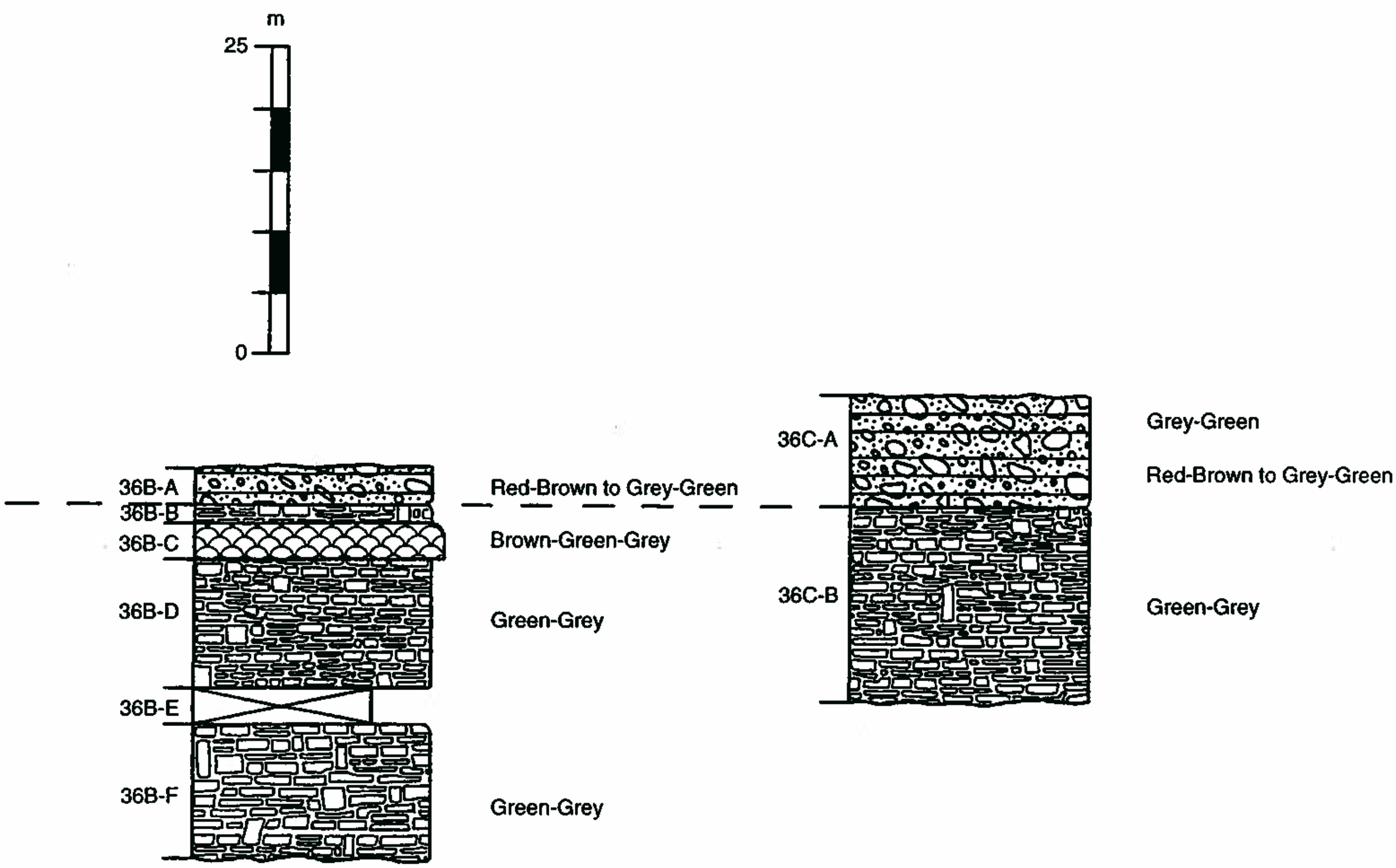


Figure 10: Section 4I046
Location: E 553188 N 6633457
Thickness: 155 m

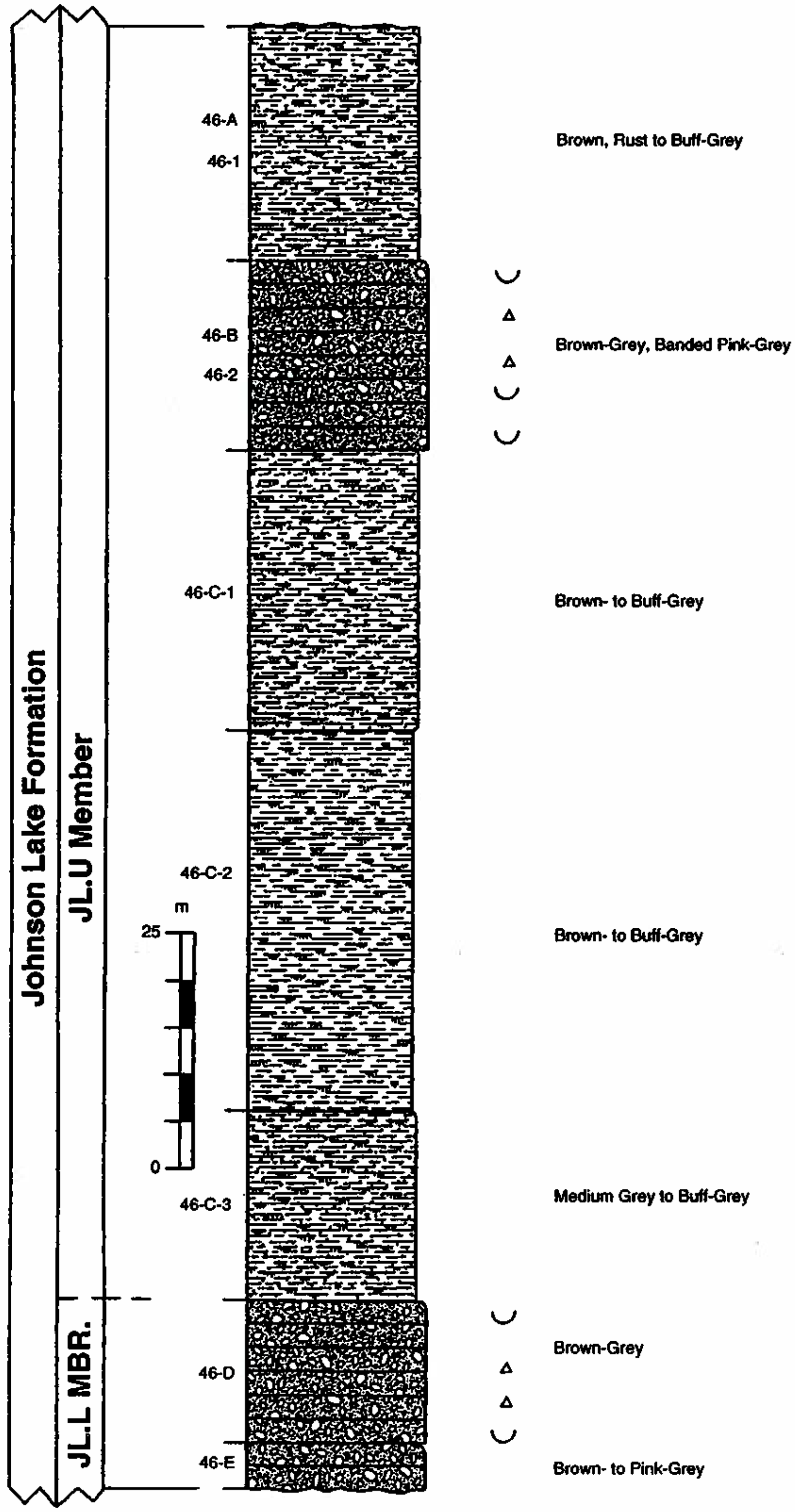


Figure 11: Section 4I047
Location: E 554868 N 6632692
Thickness: 137 m

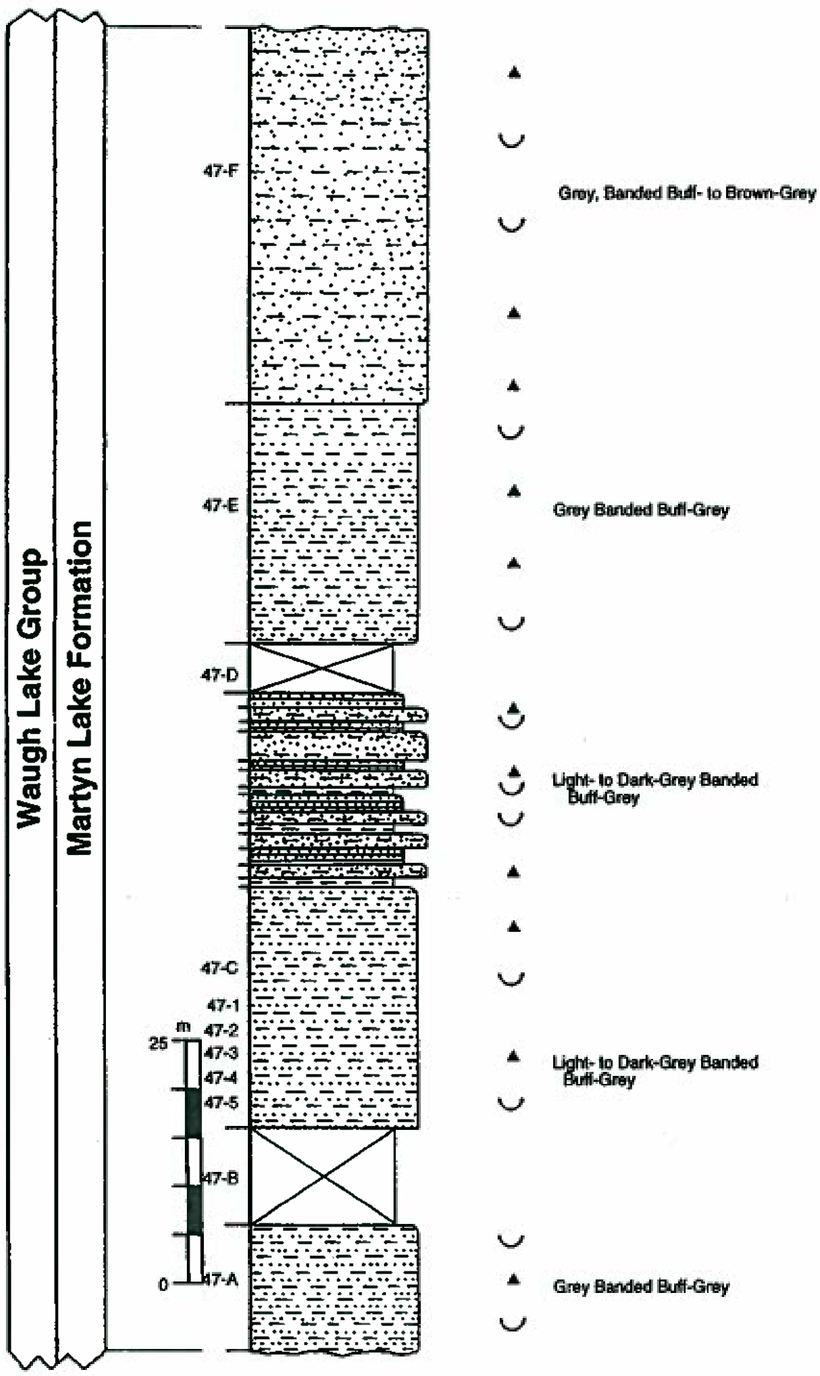


Figure 12: Section 4I049
Location: E 554343 N 6632527
Thickness: 52 m

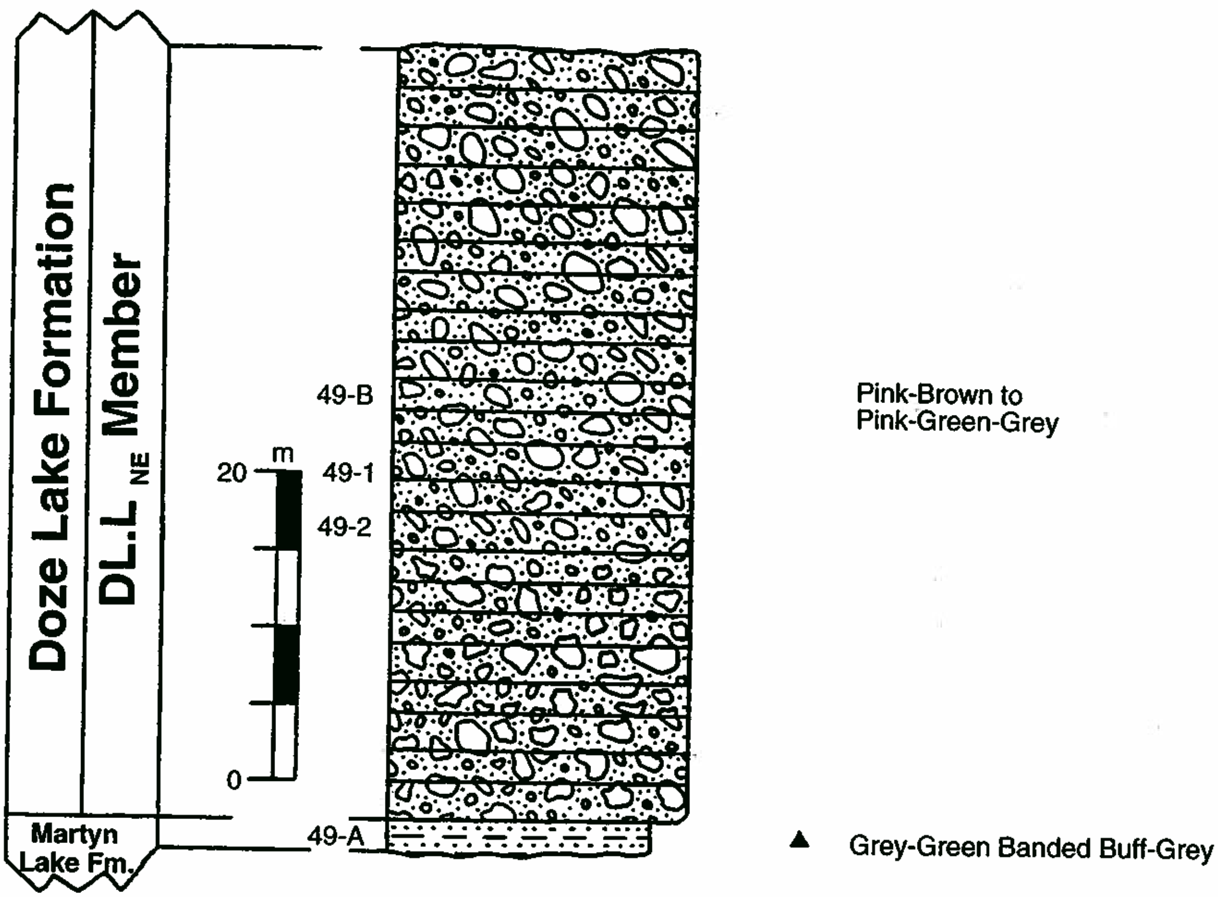


Figure 13: Section 4I050
Location: E 554198 N6632347
Thickness: 66 m

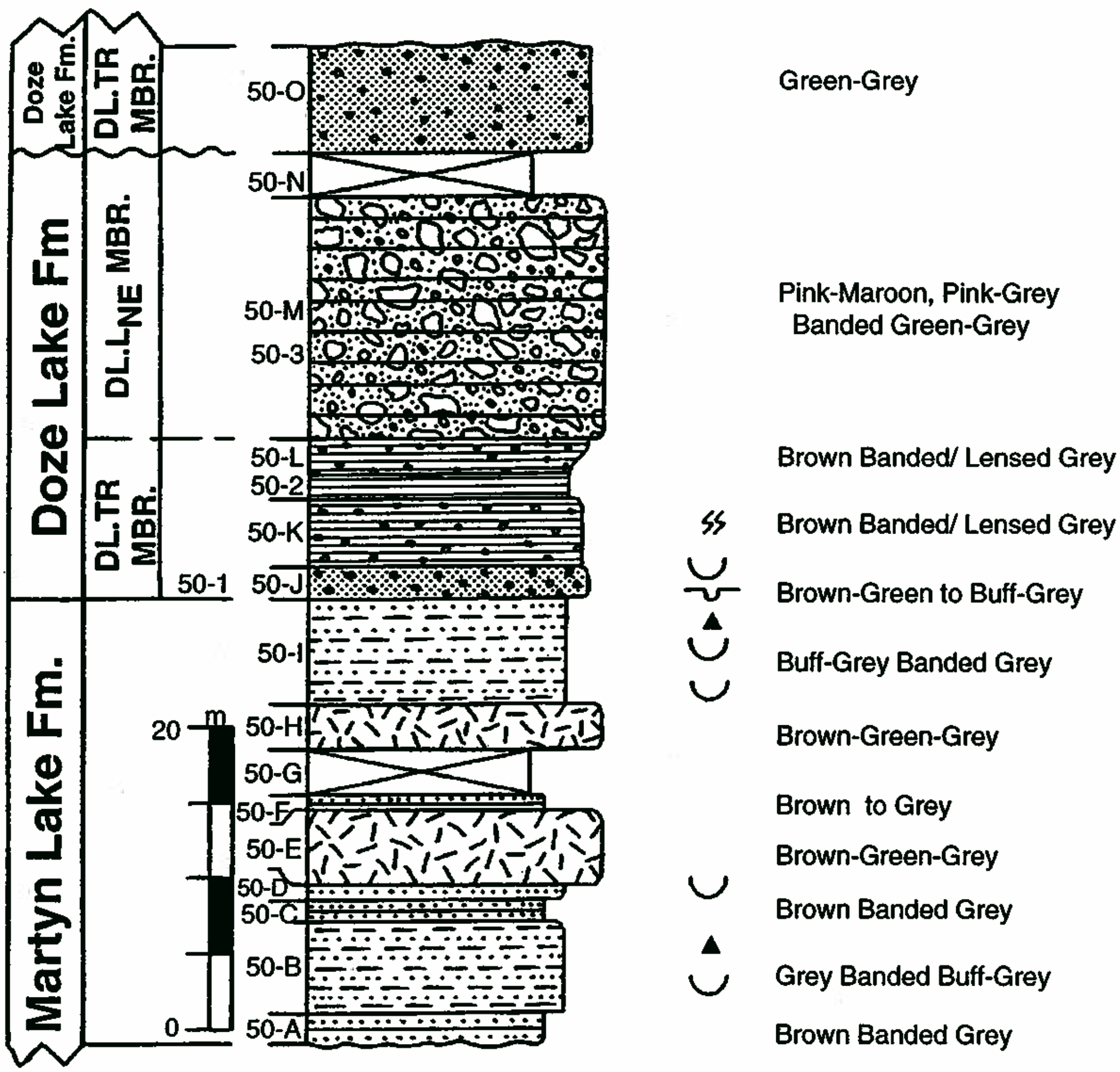


Figure 14: Section 4I054
Location: E 553768 N 6634037
Thickness: 128 m

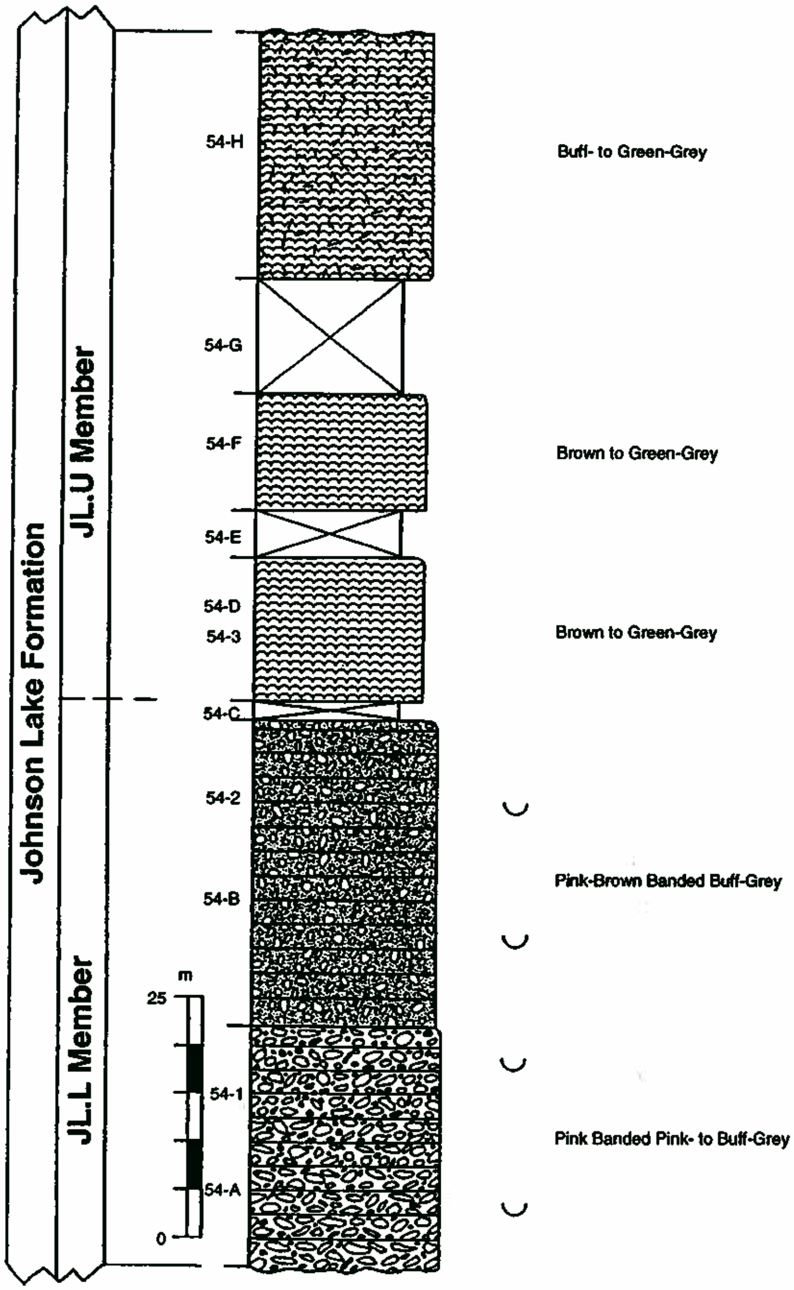


Figure 15: Section 4I055
Location: E 553618 N 6633977
Thickness: 156 m

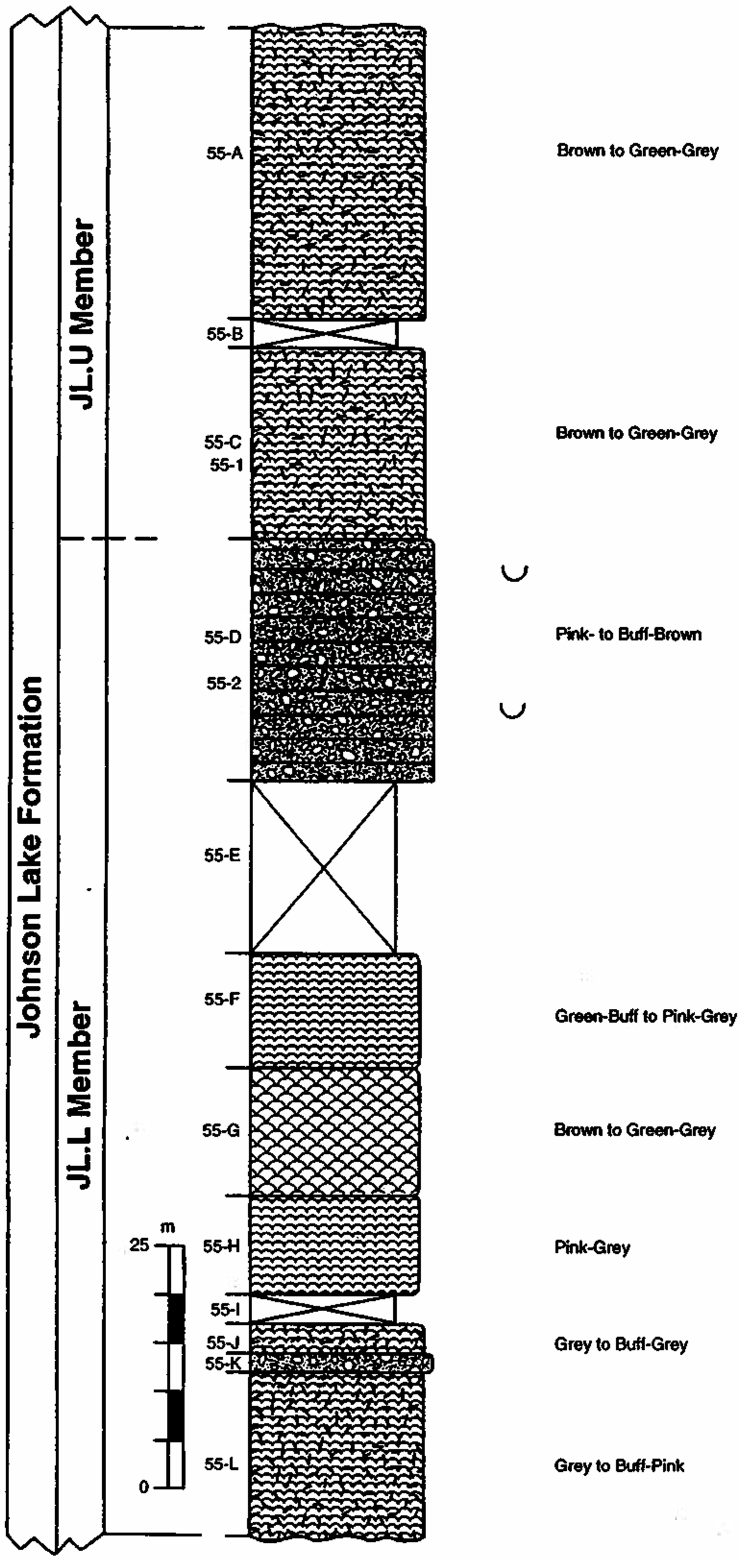


Figure 16: Section 4I057
Location: E 553298 N 6633136
Thickness: 176 m

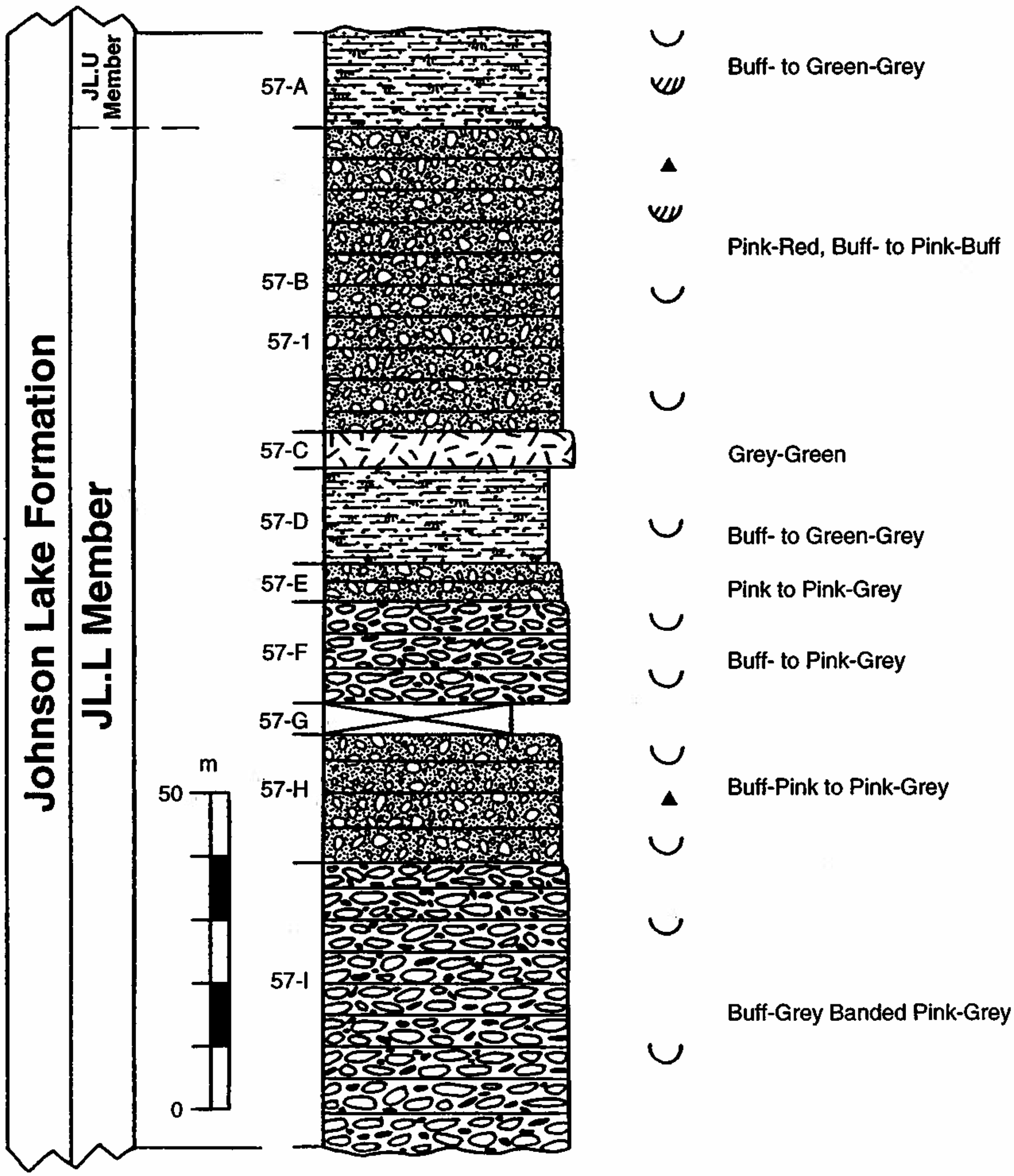
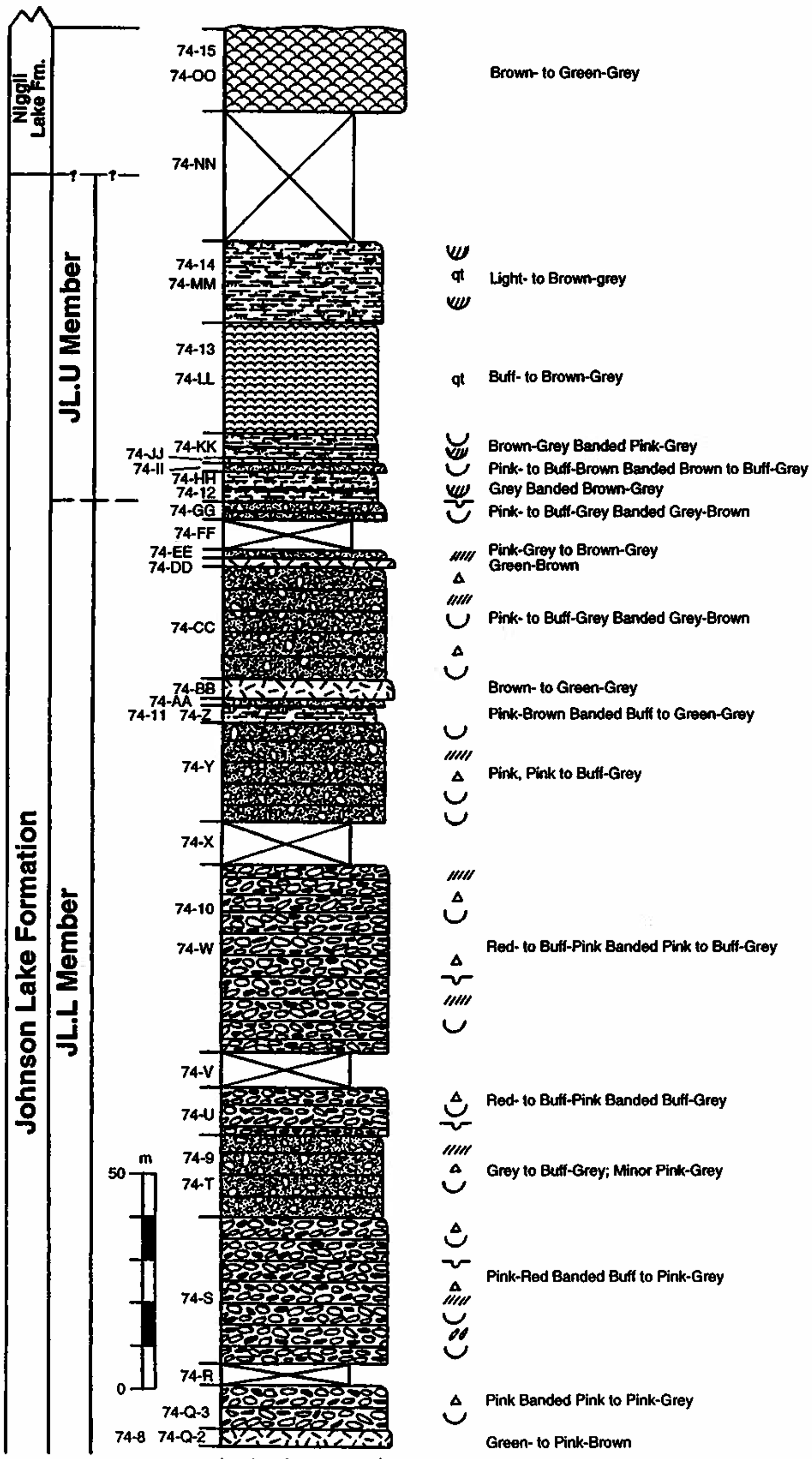


Figure 17: Section 4I029 + 074
Location: E 553053 N 6629057
Thickness: 674 m



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Section: 4I029 + 074 (continued)

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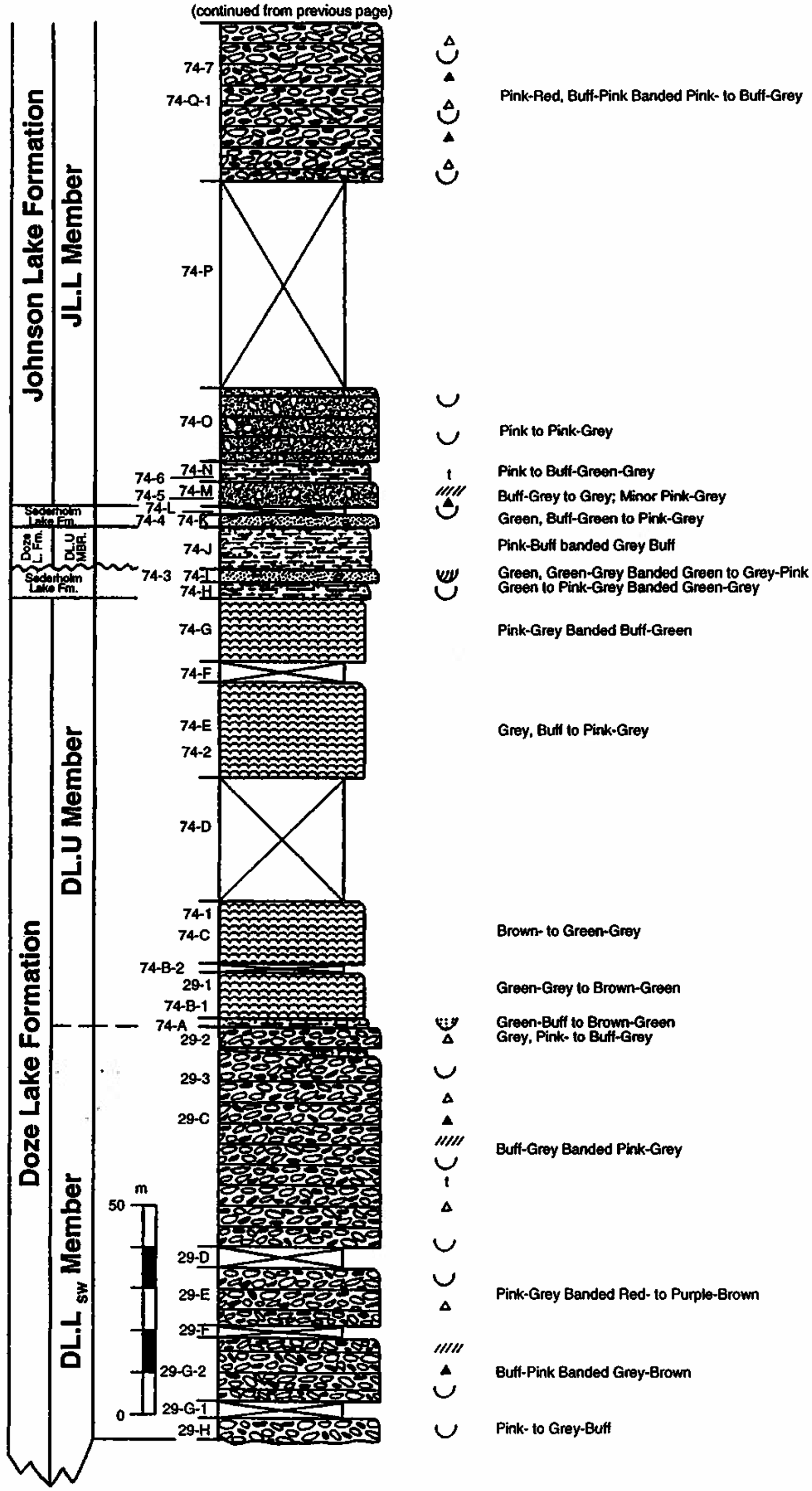
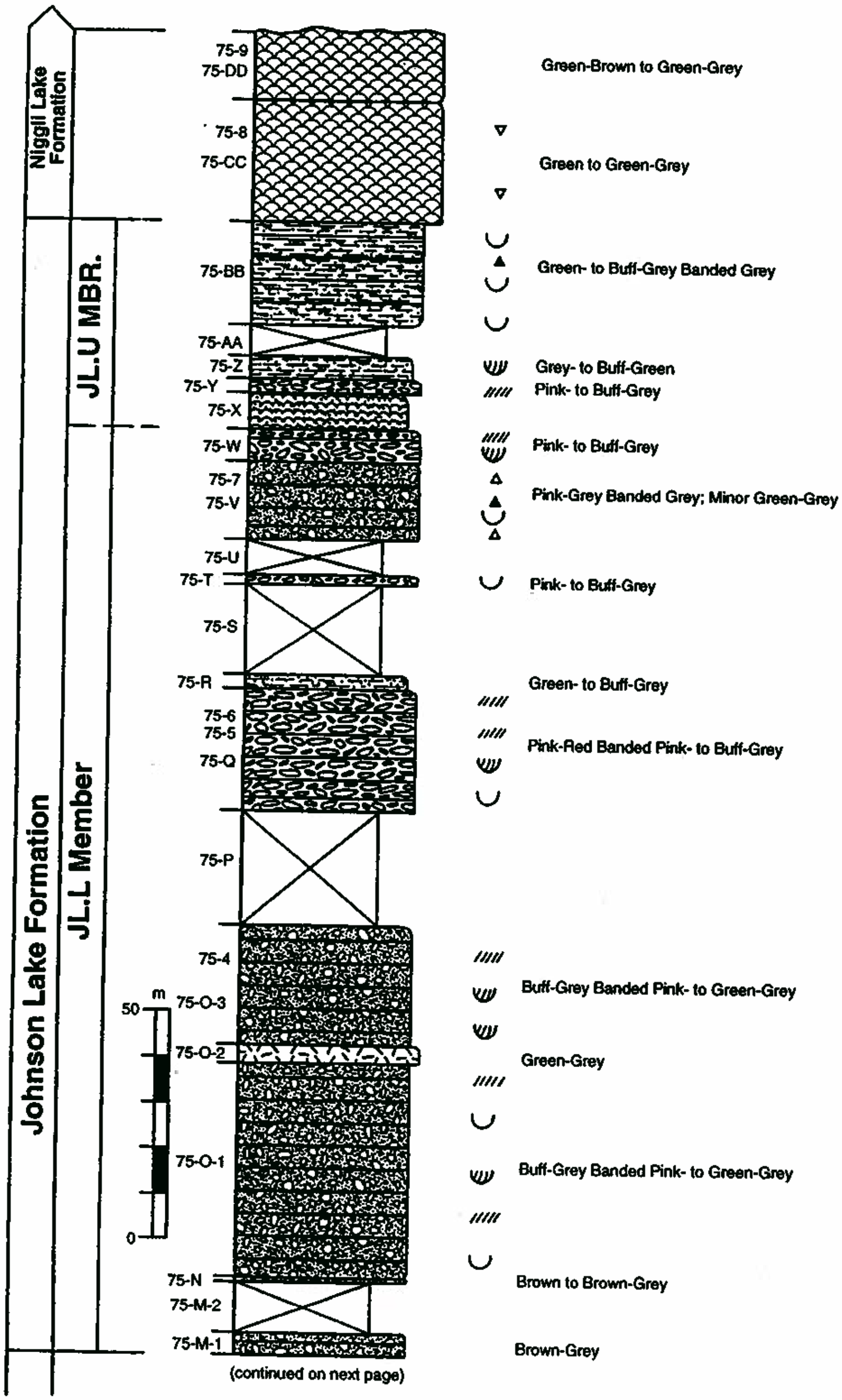


Figure 18: Section 4I075
Location: E 553628 N 6629607
Thickness: 510 m



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Section: 4I075
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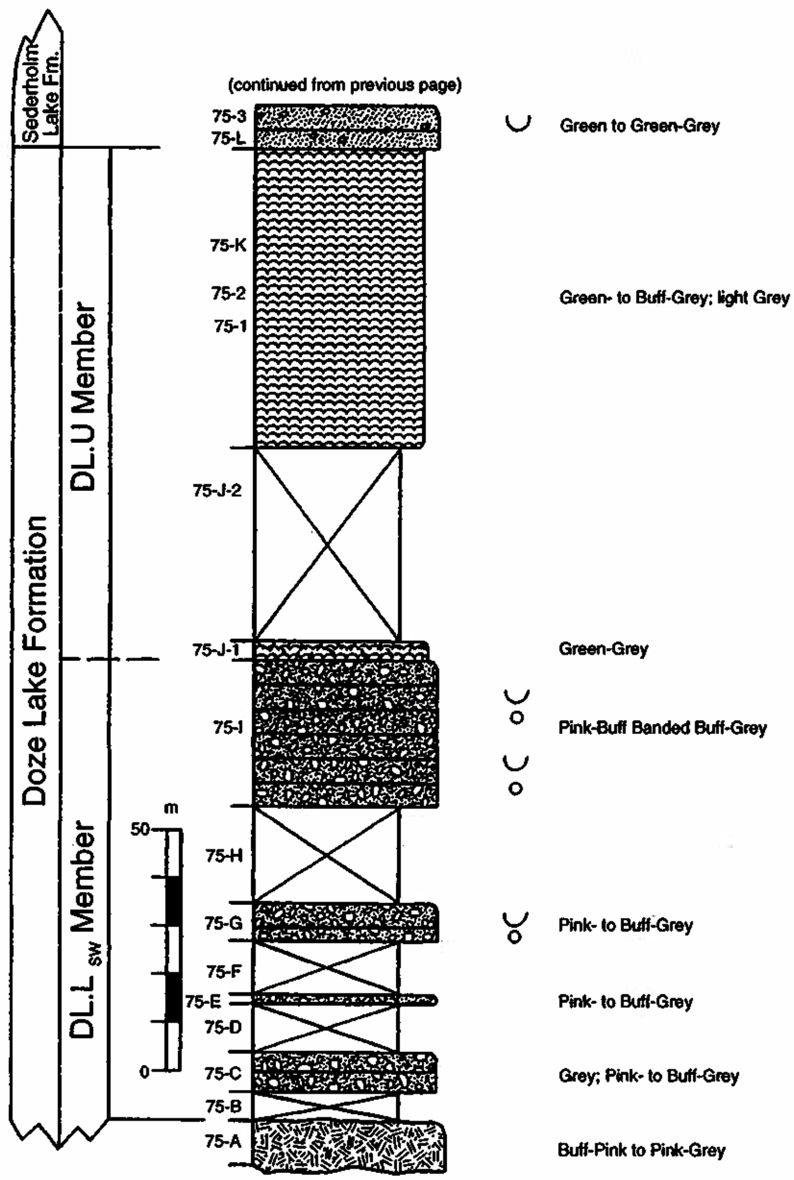
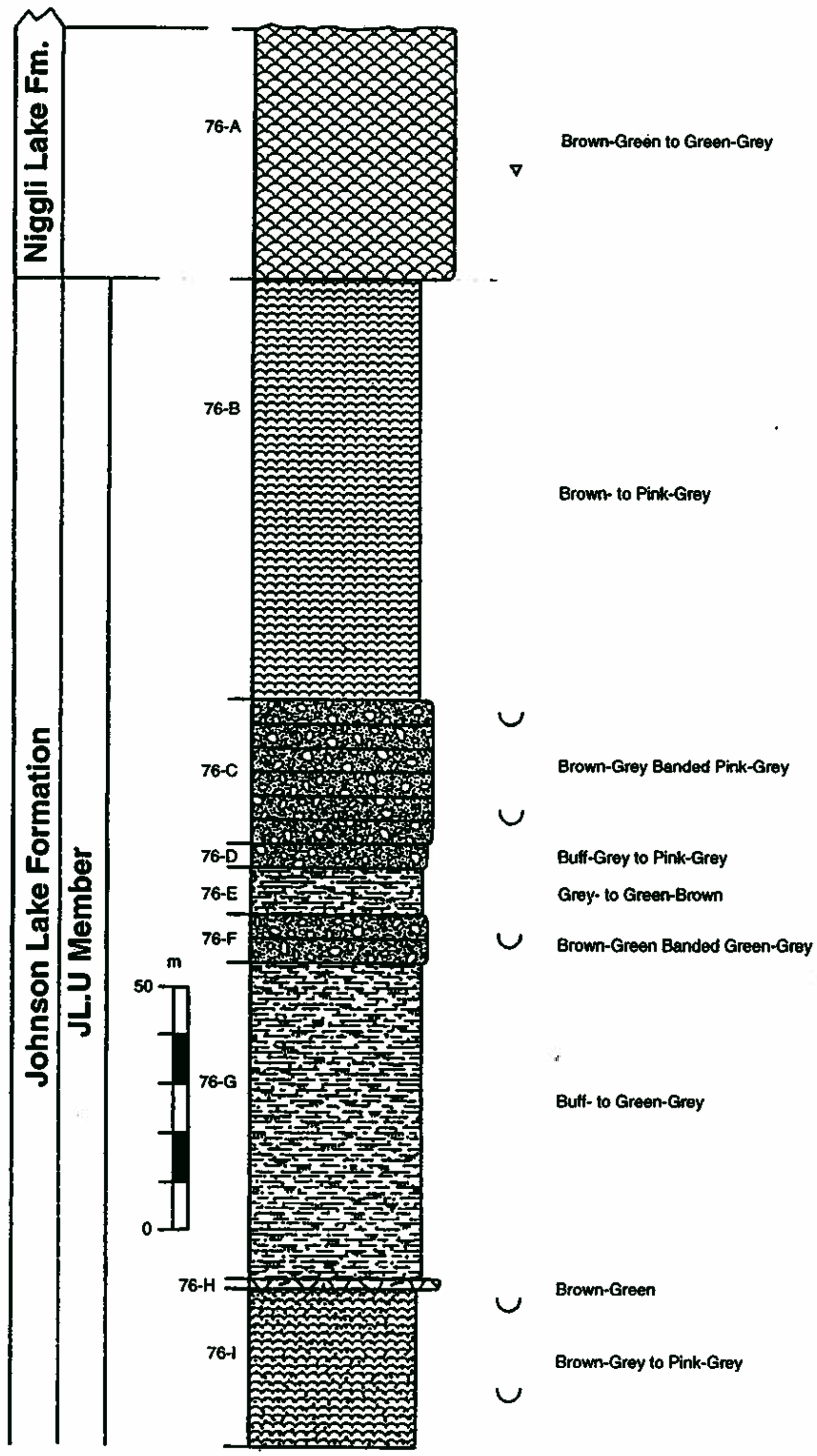


Figure 19: Section 4I076
Location: E 553136 N 6629198
Thickness: 574 m



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Section: 4I076
(continued)

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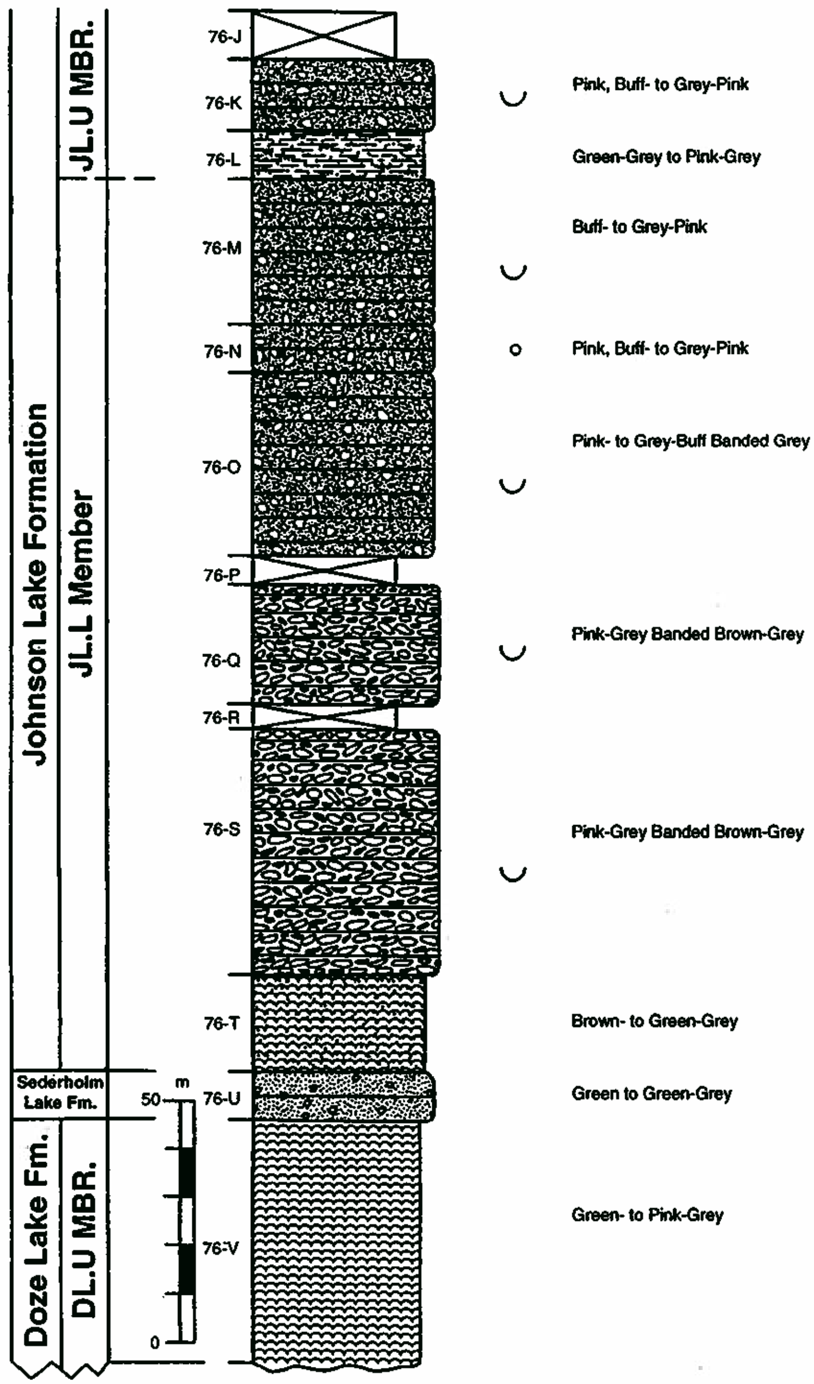


Figure 20: Section 4I077
Location: E 554288 N 6630877
Thickness: 289 m

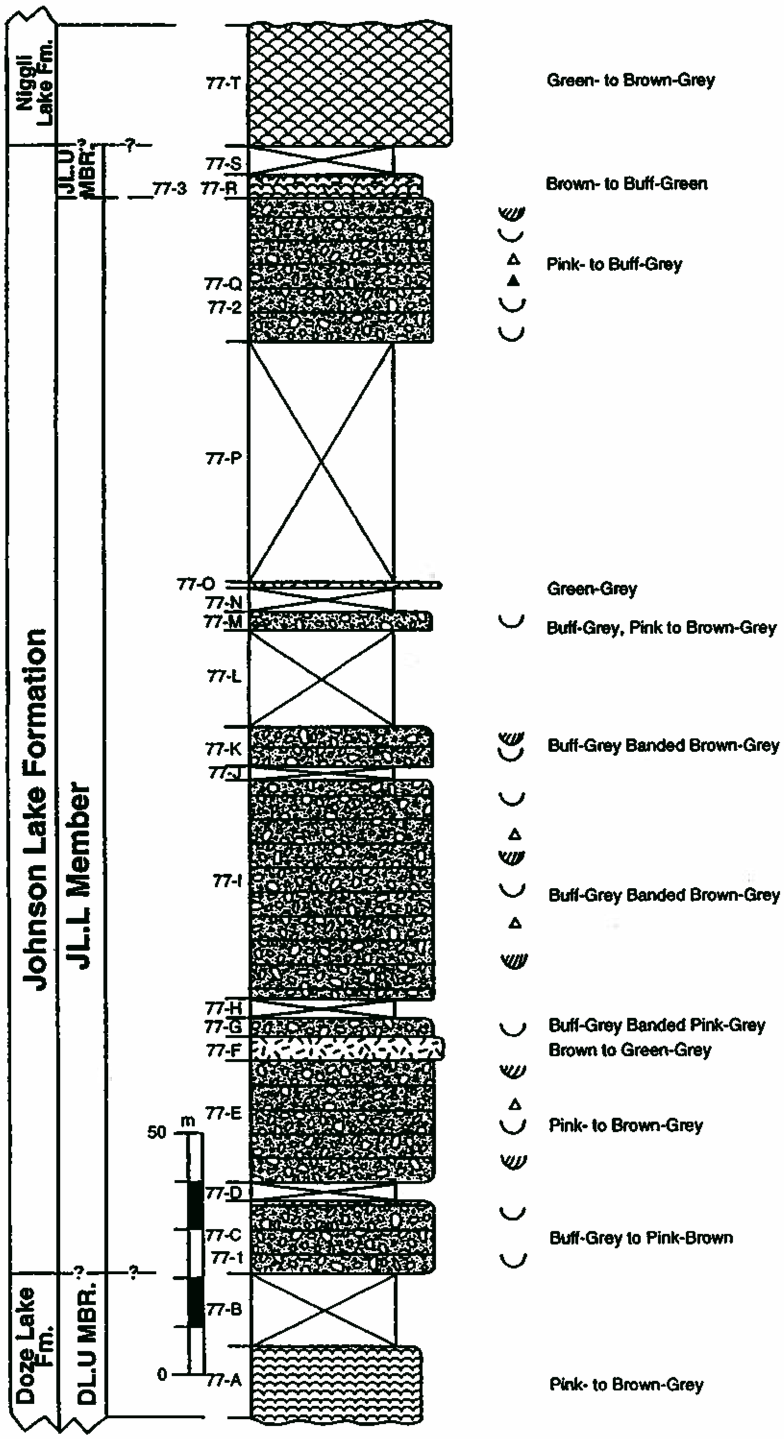


Figure 21: Section 4I093
Location: E 552158 N 6632187
Thickness: 132 m

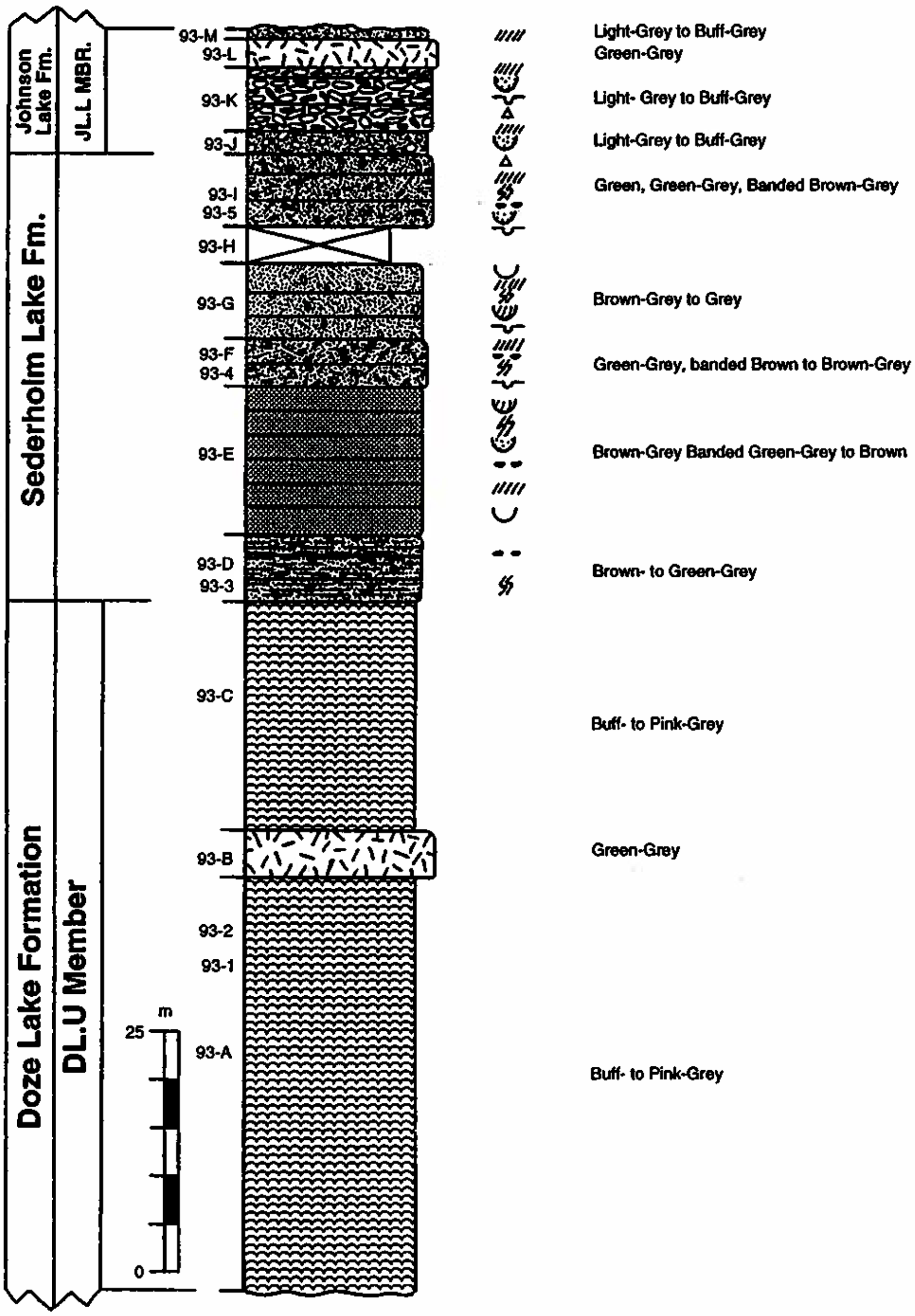
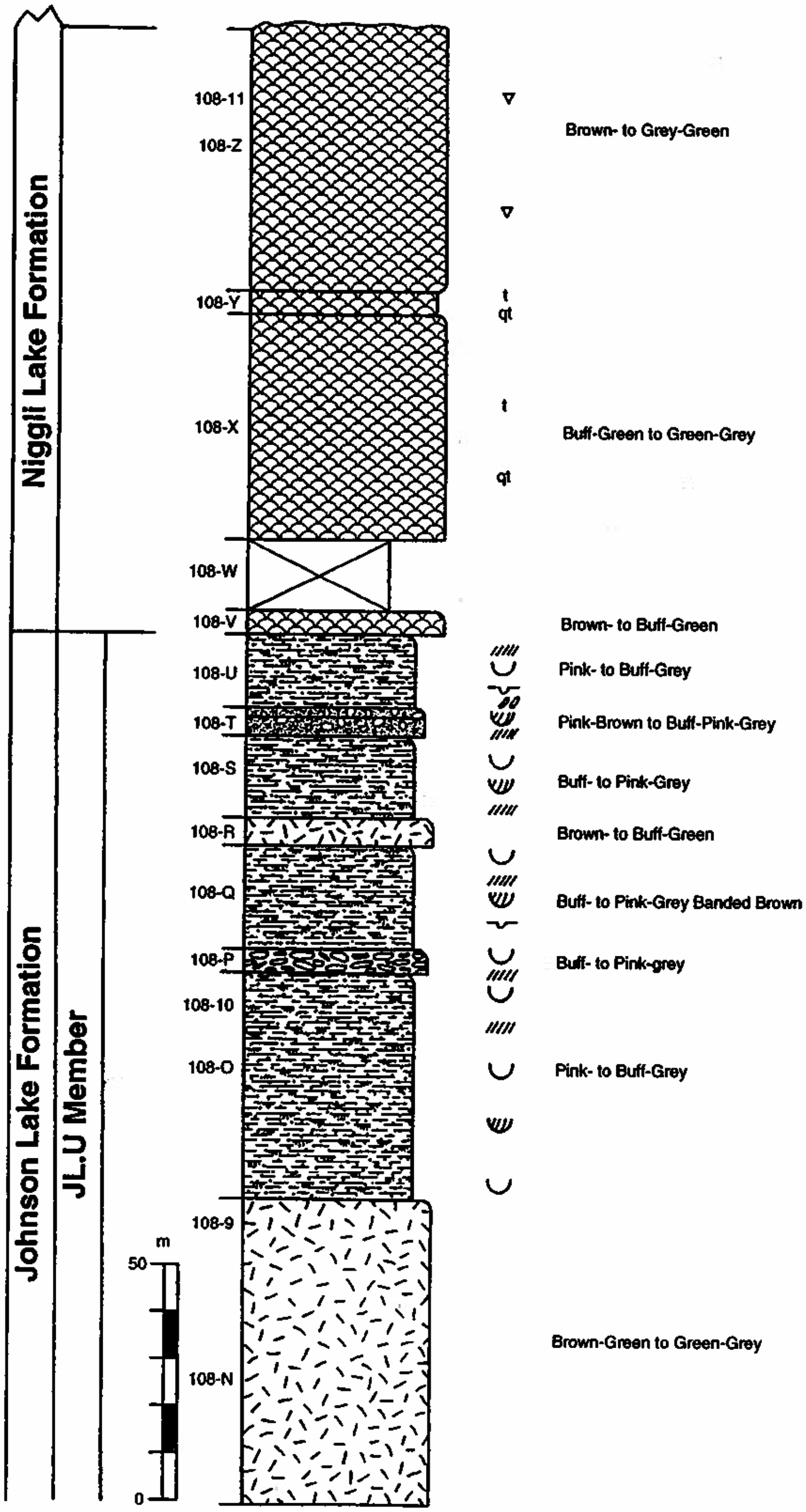


Figure 22: Section 4I108
Location: E 552156 N 6631022
Thickness: 650 m



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Section: 4I108
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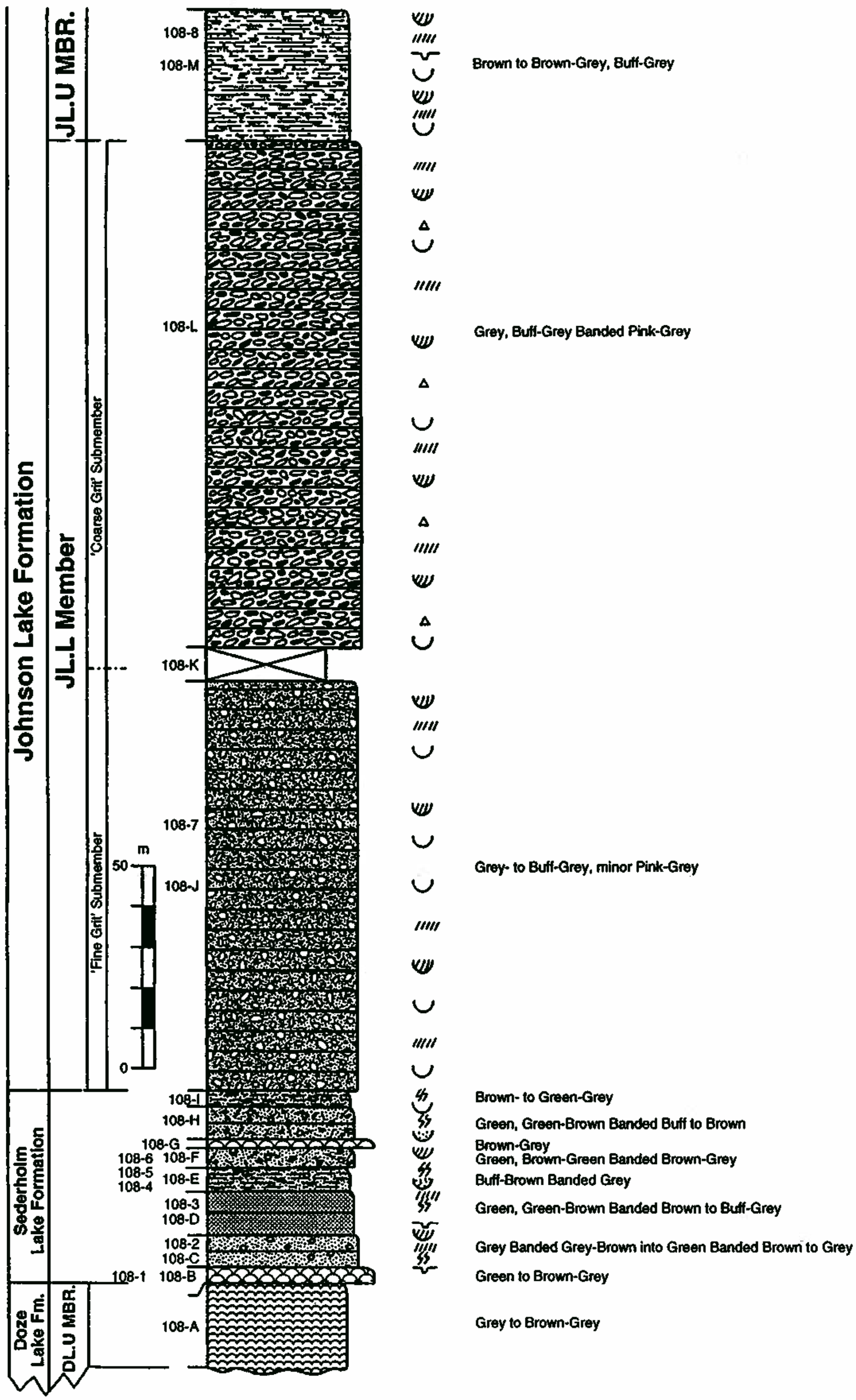


Figure 23: Section 4I109
Location: E 554398 N 6631558
Thickness: 86.5 m

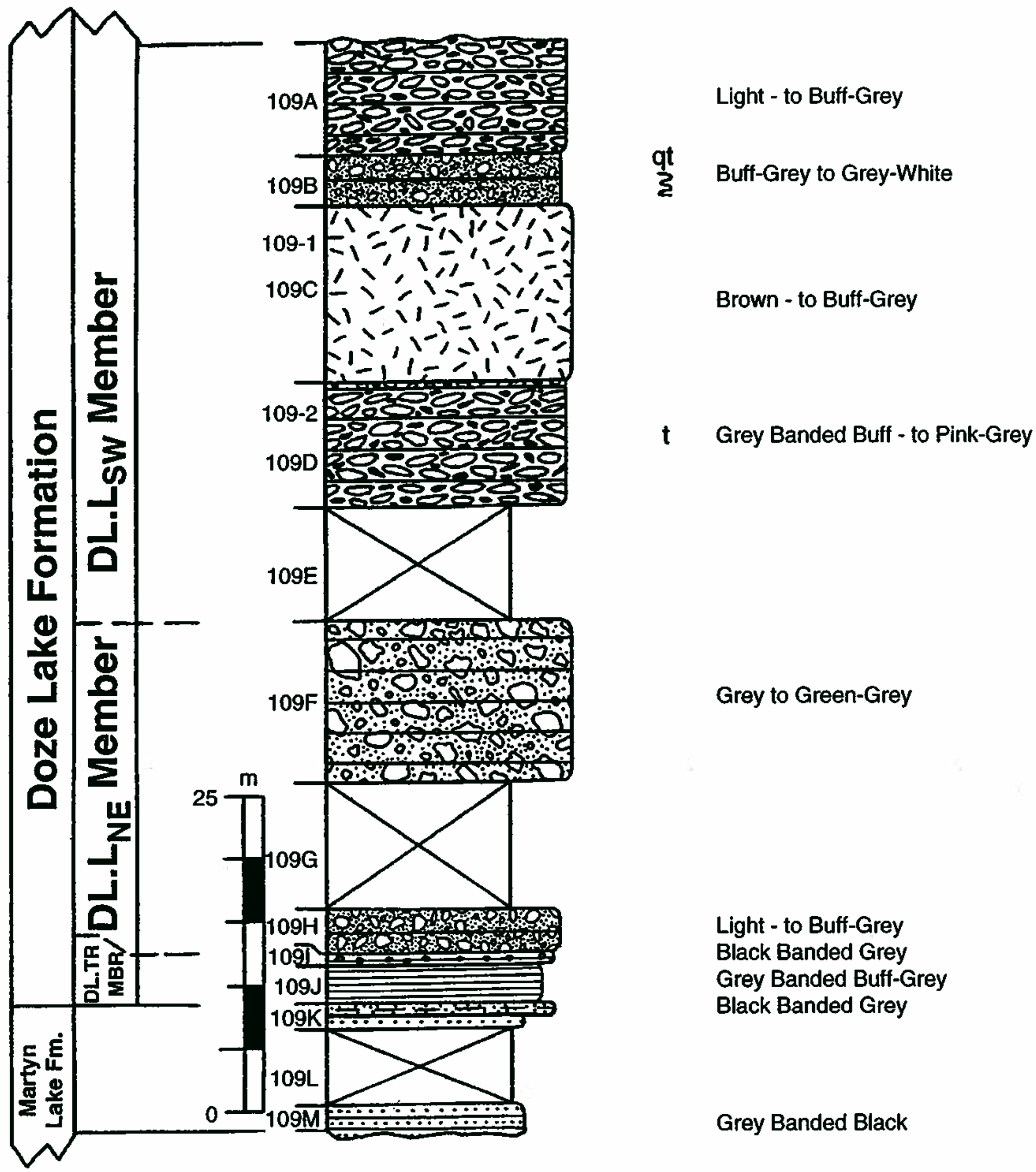


Figure 24: Section 4I116
Location: E 551852 N 6629788
Thickness: 78 m

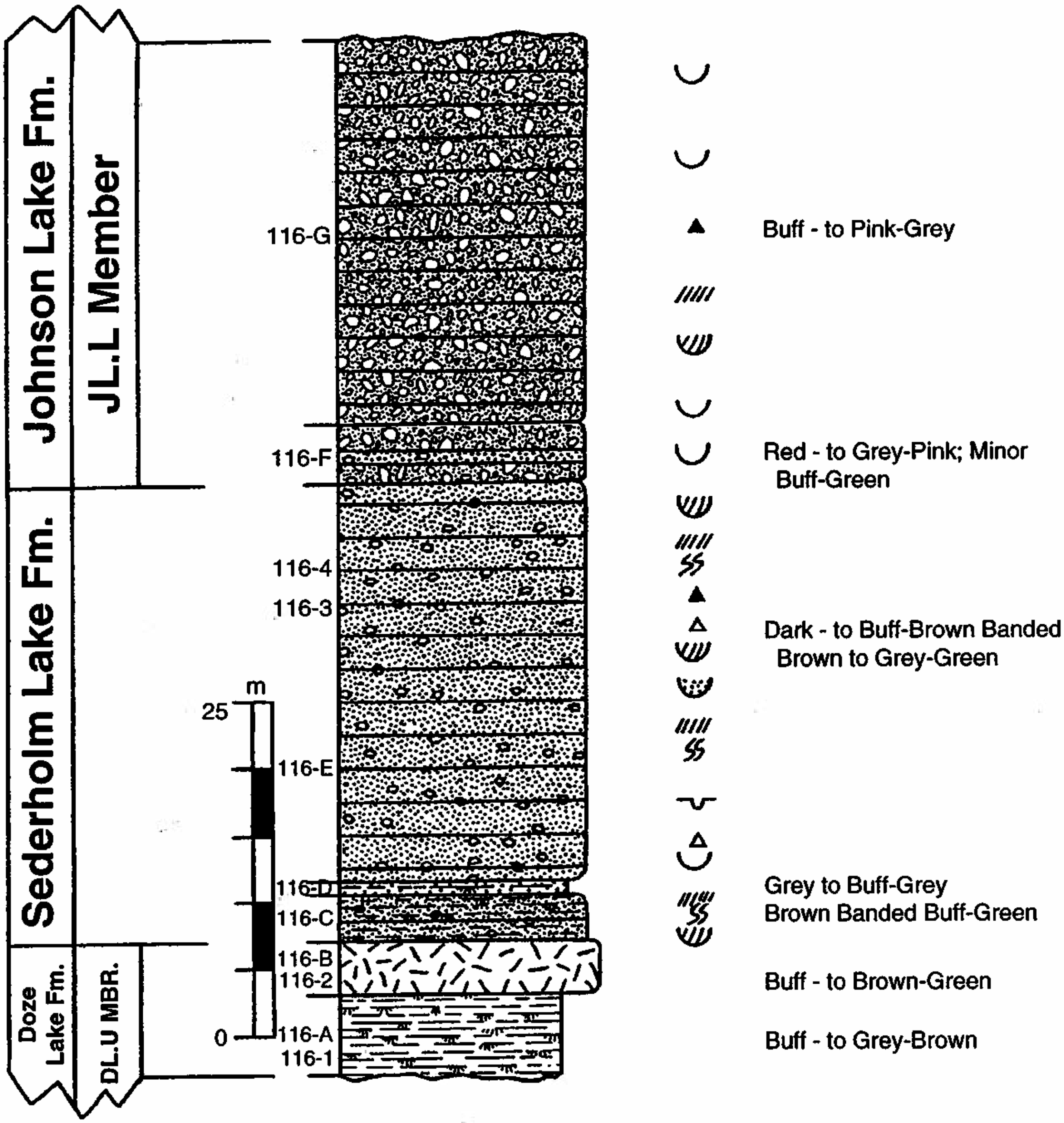


Figure 25: Section 4I124
Location: E 552526 N 6632641
Thickness: 133 m

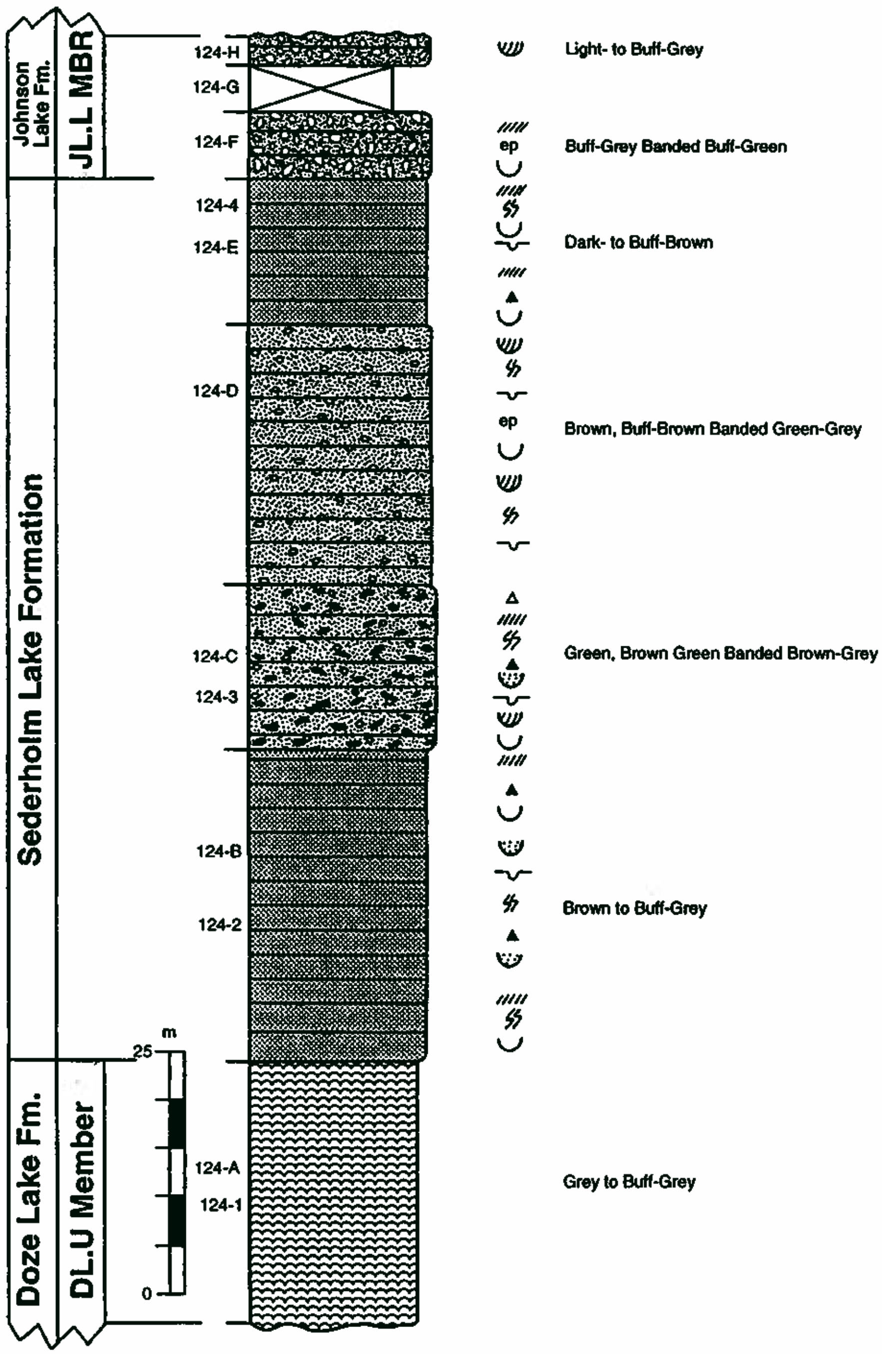


Figure 26: Section 4I126
Location: E 554122 N 6630012
Thickness: 291 m

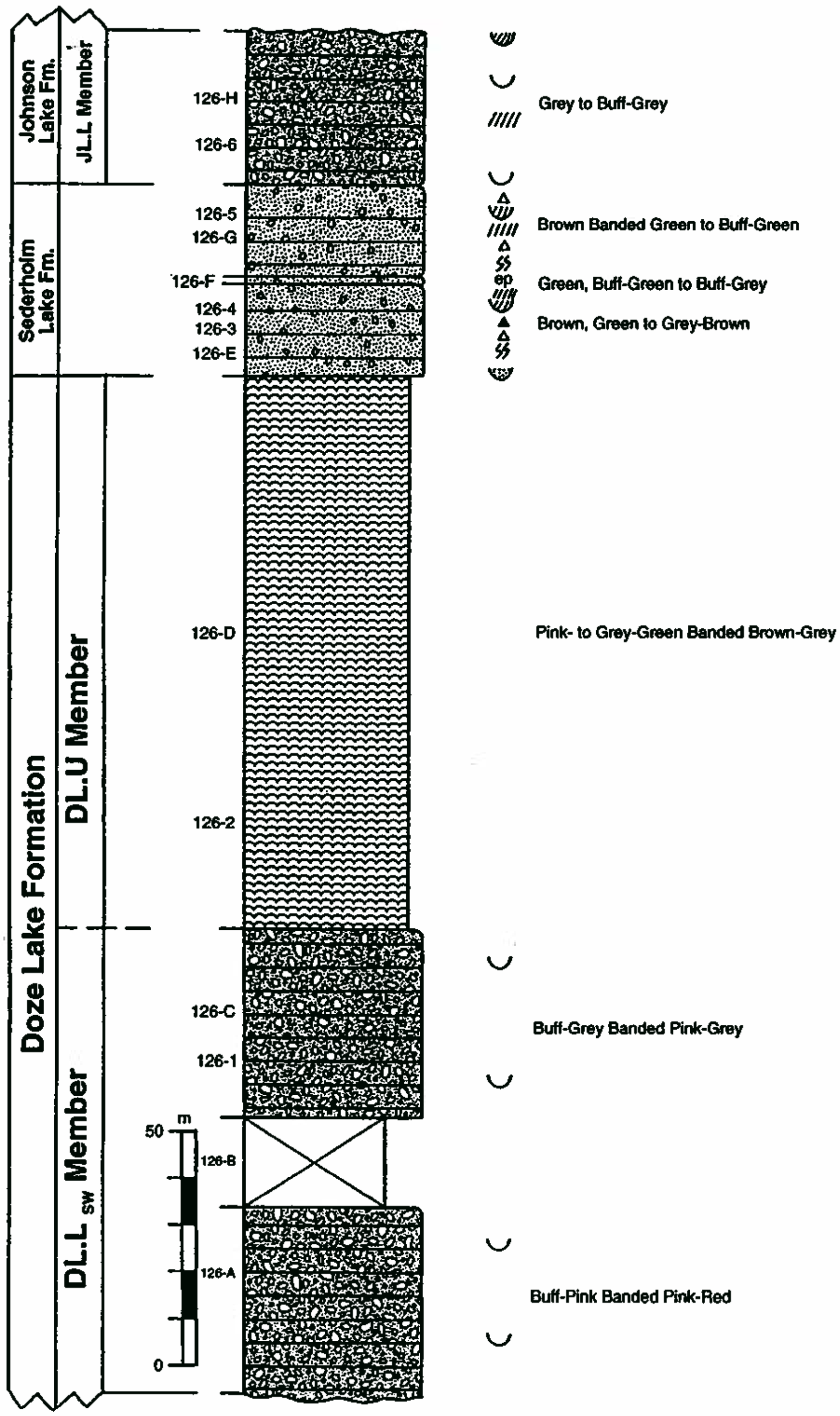


Figure 27: Section 4I130
Location: E 552096 N 6630502
Thickness: 149 m

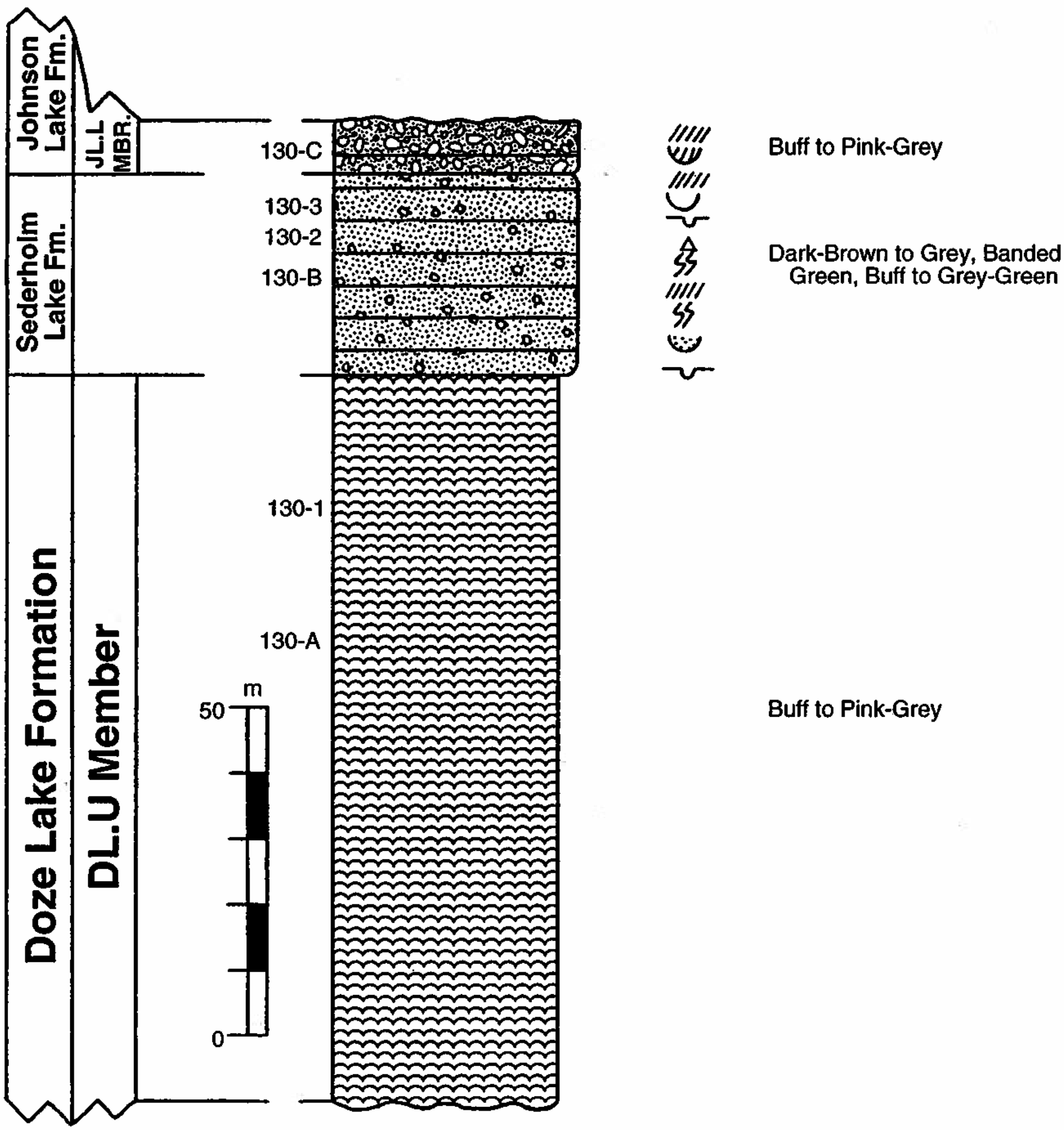
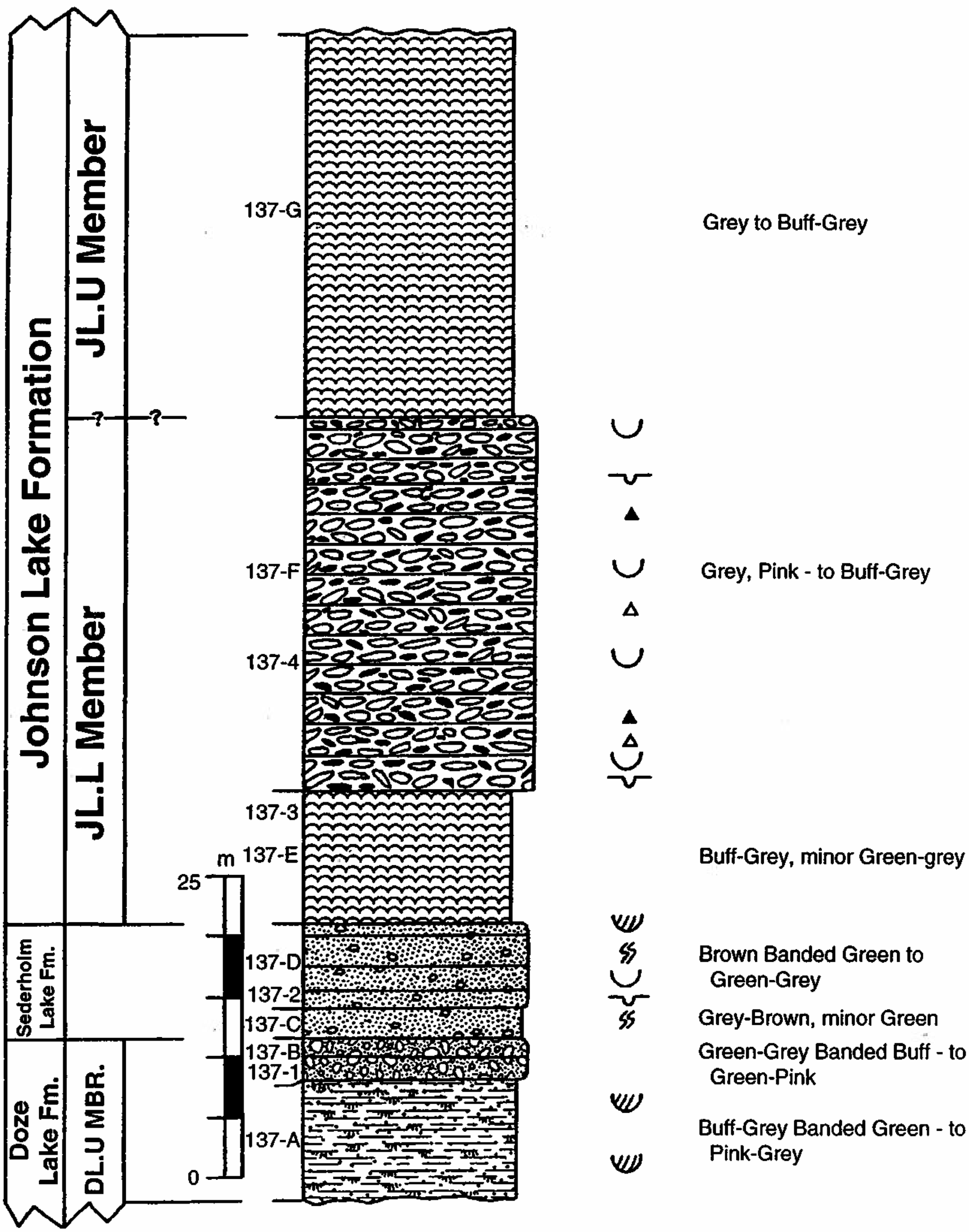


Figure 28: Section 4I137
Location: E 552806 N 6633774
Thickness: 97 m



Section: 4I149
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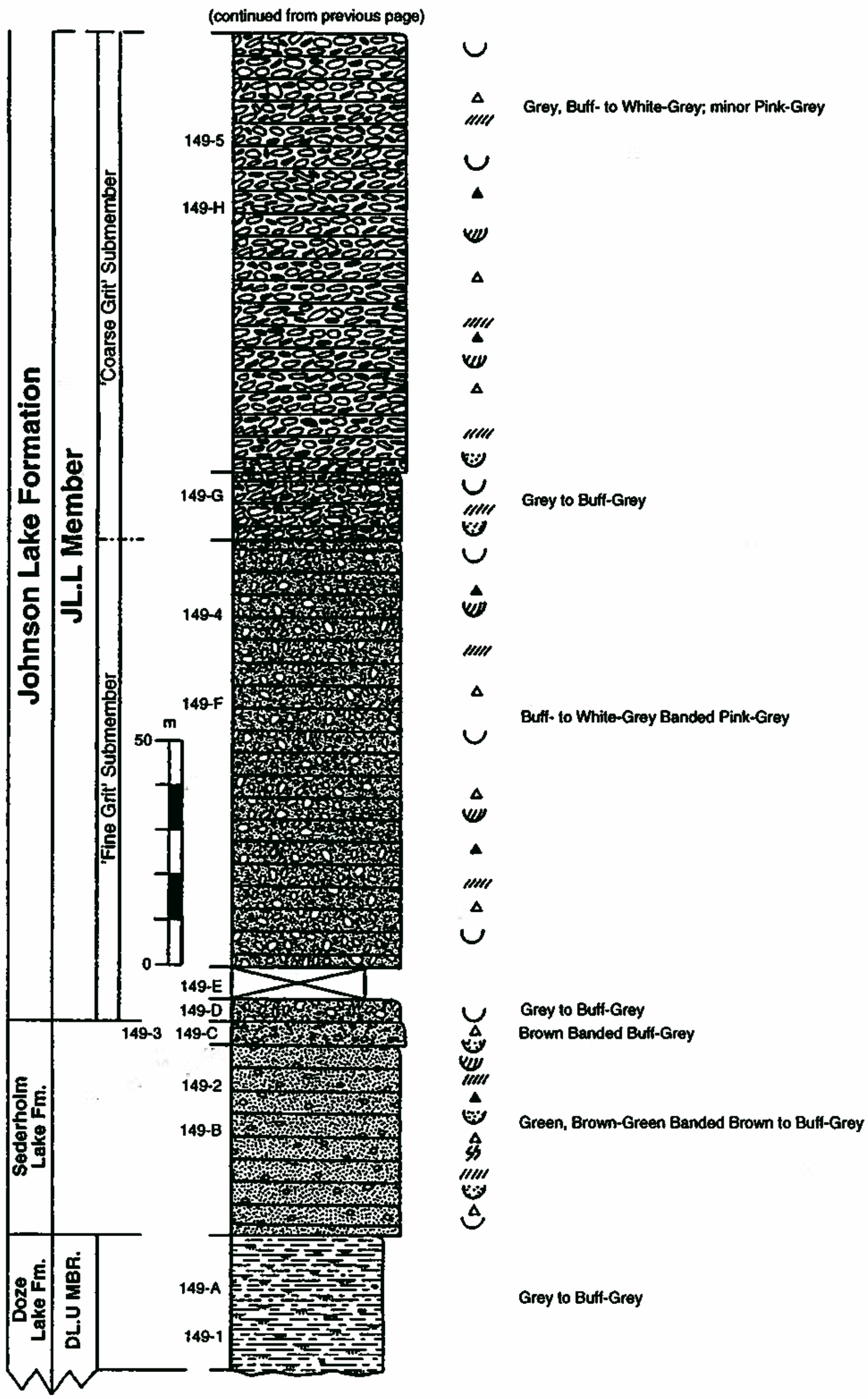
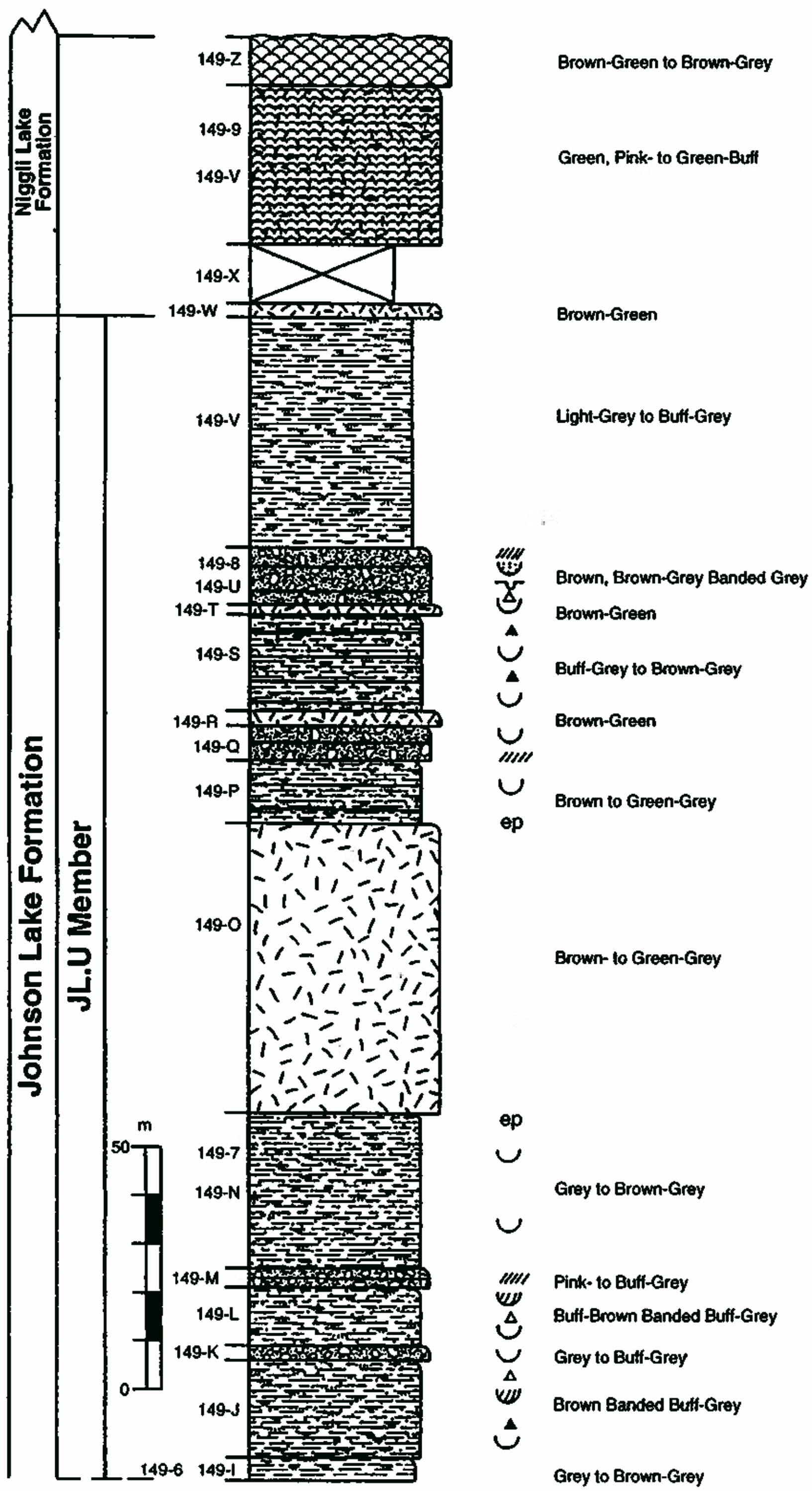


Figure 29: Section 4I149
Location: E 552232 N 661302
Thickness: 596 m



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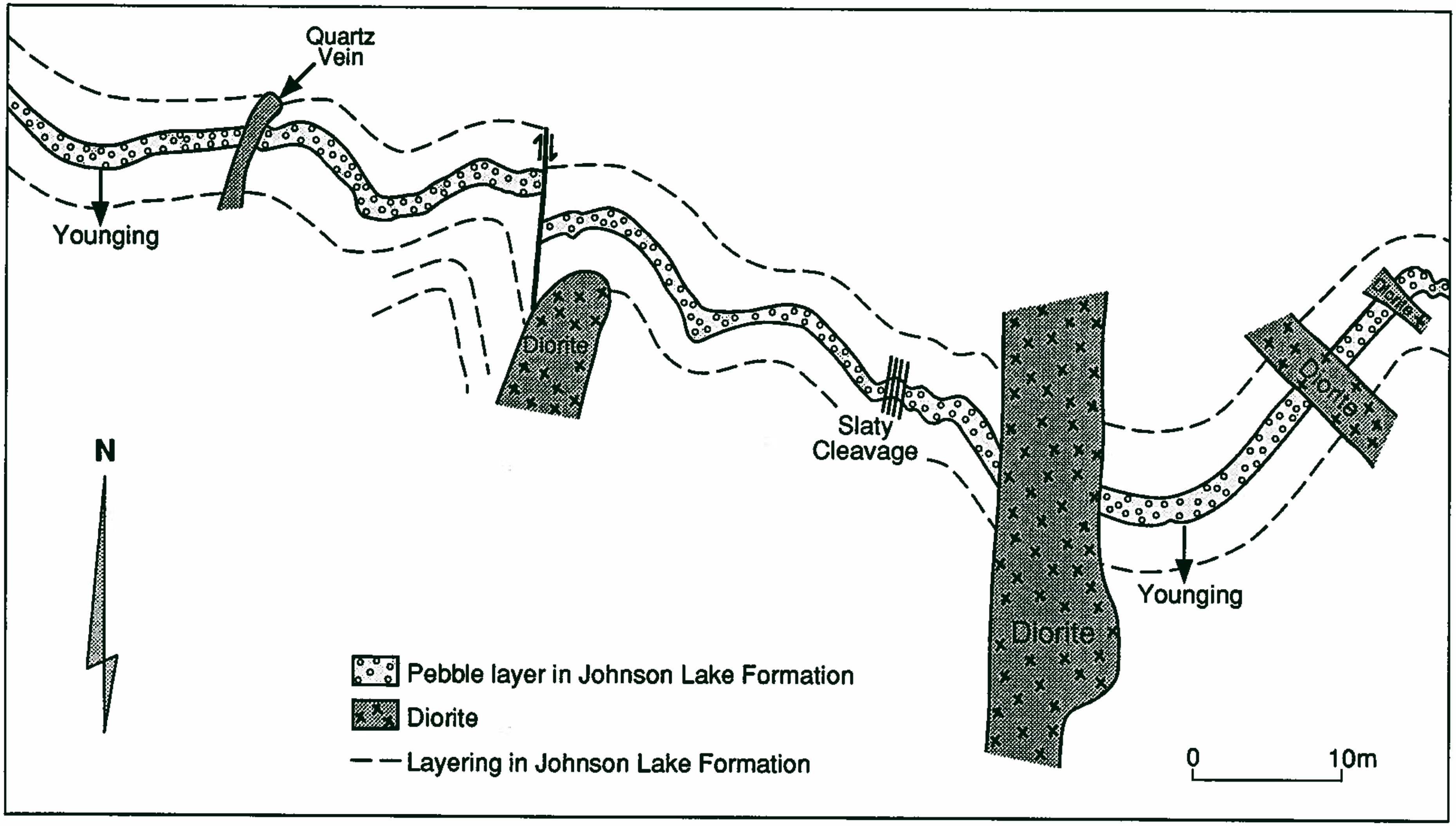


Figure 30. Folding of pebble layer at station 4L35

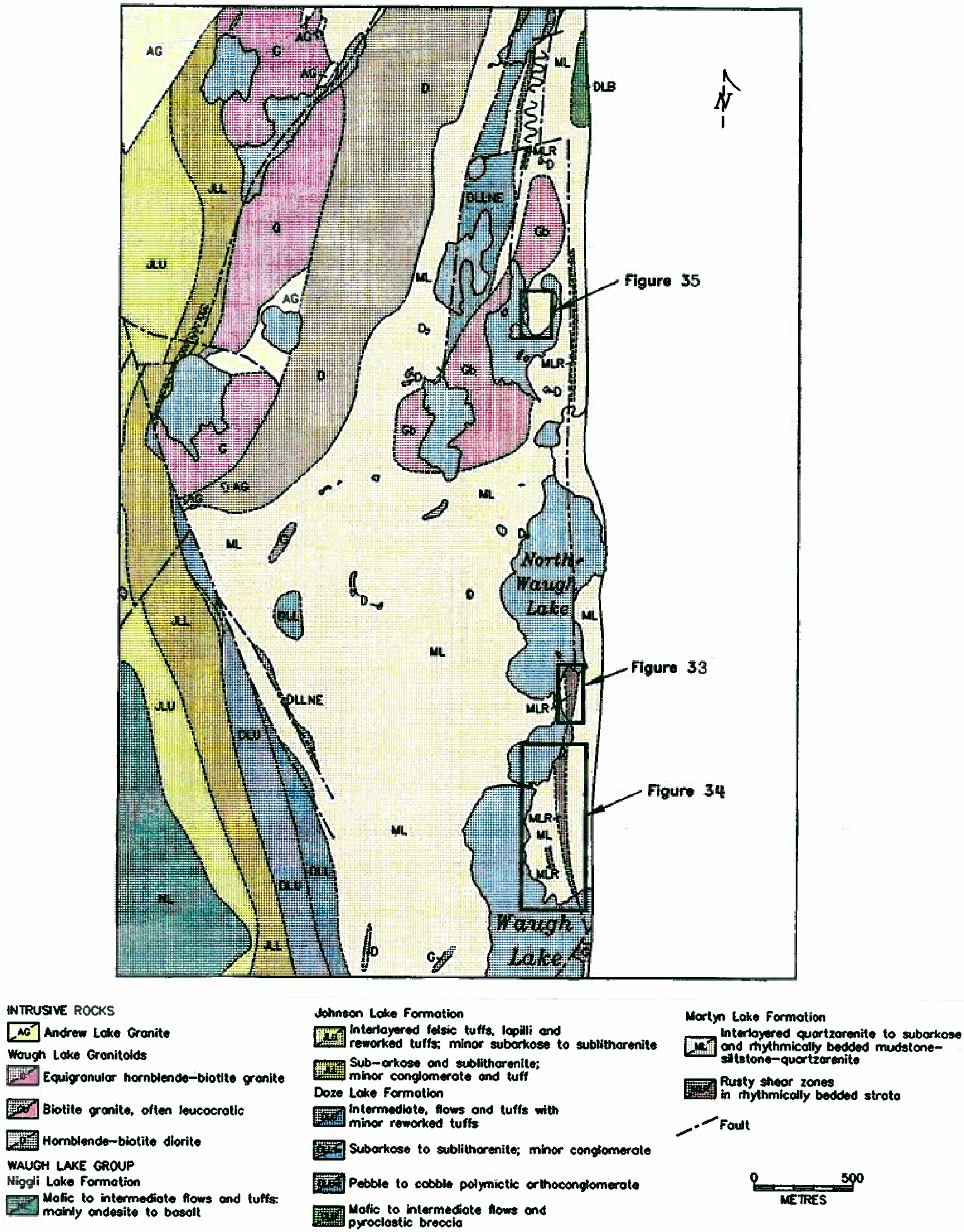


Figure 31: Geology and location of detailed study areas.

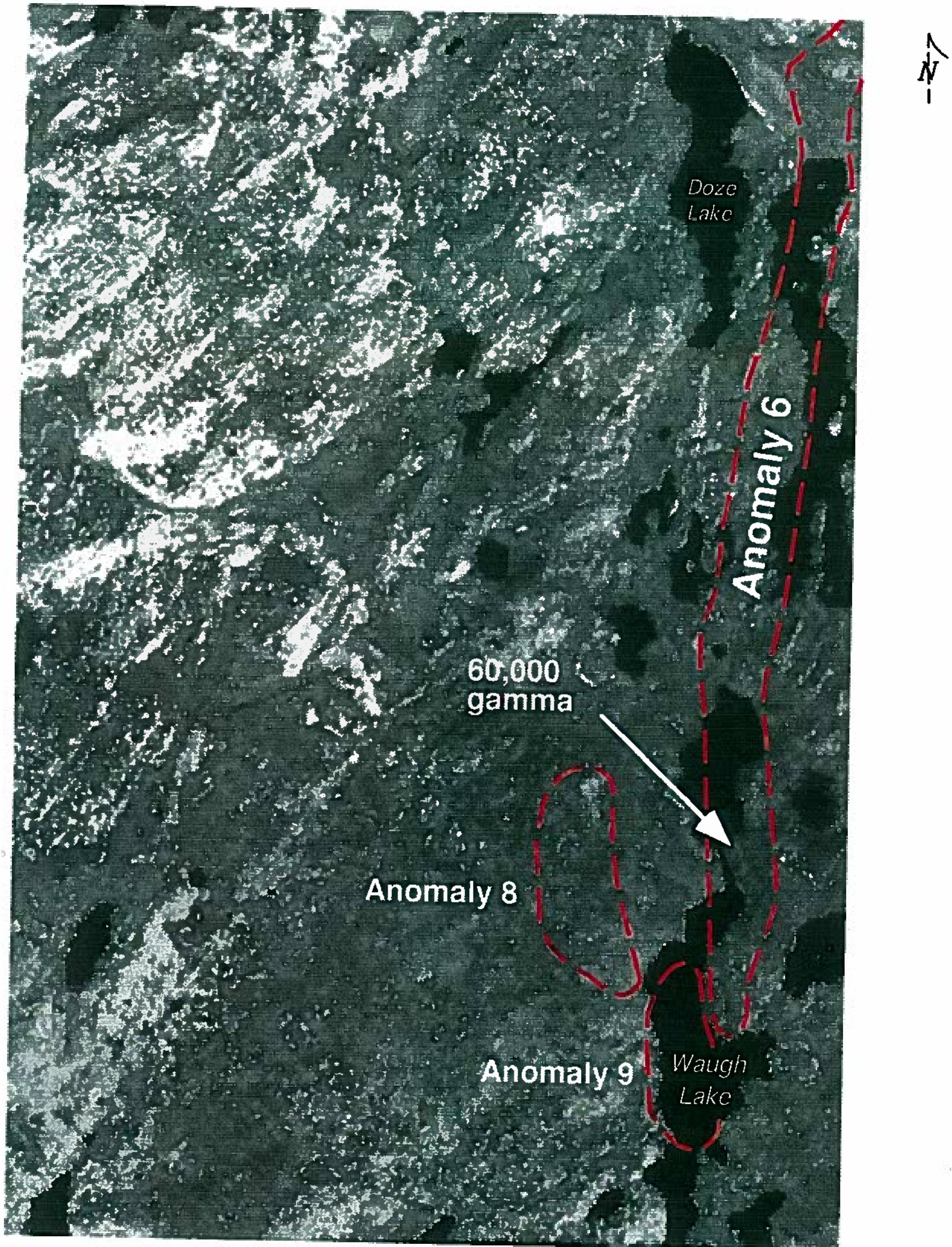


Figure 32. Outline of Hudson's Bay Oil and Gas airborne EM anomalies and location of 60,000 gamma ground magnetometer spike.

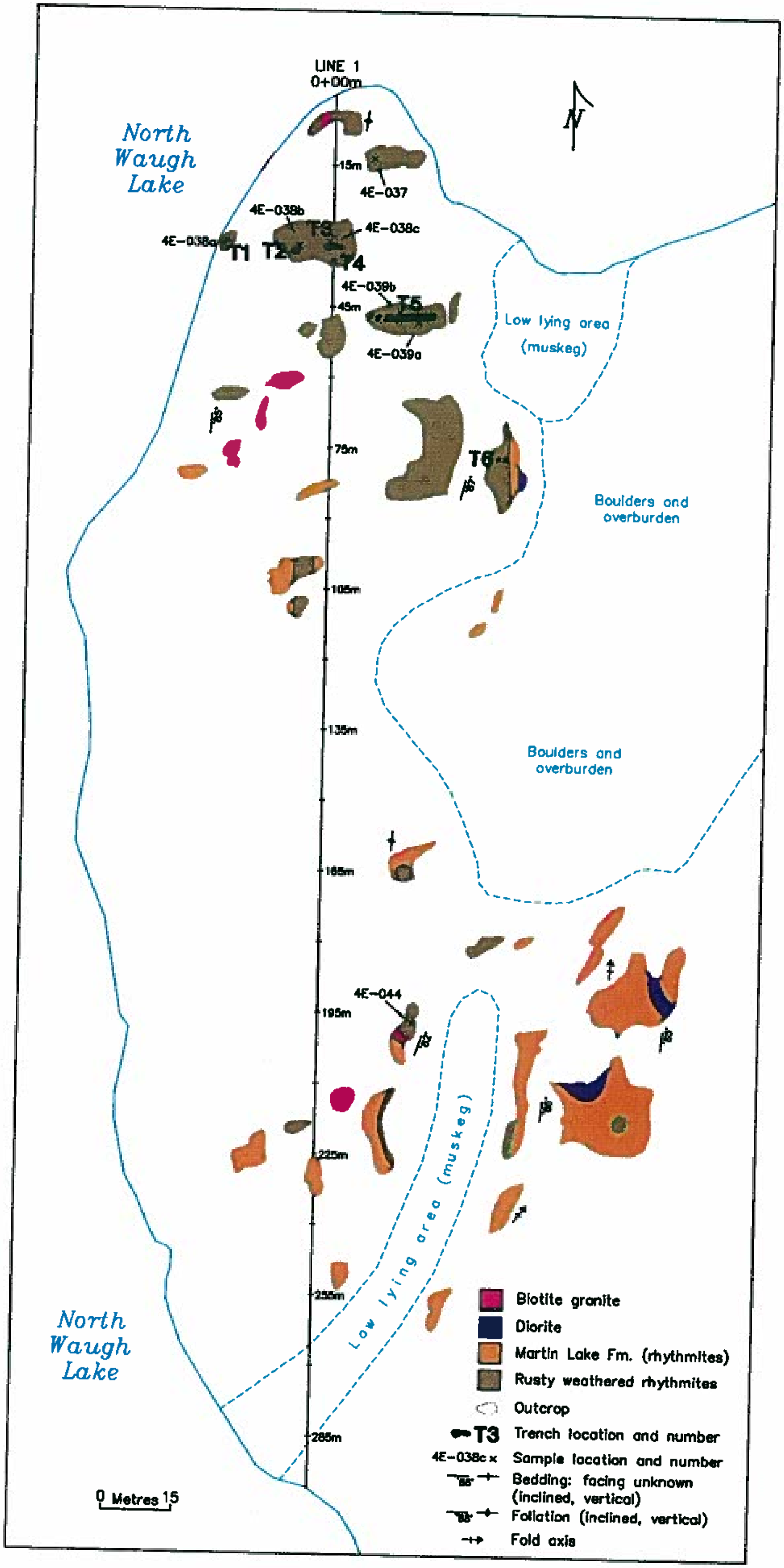


Figure 33. Detailed geology, trench and sample locations of mineral occurrence 39.

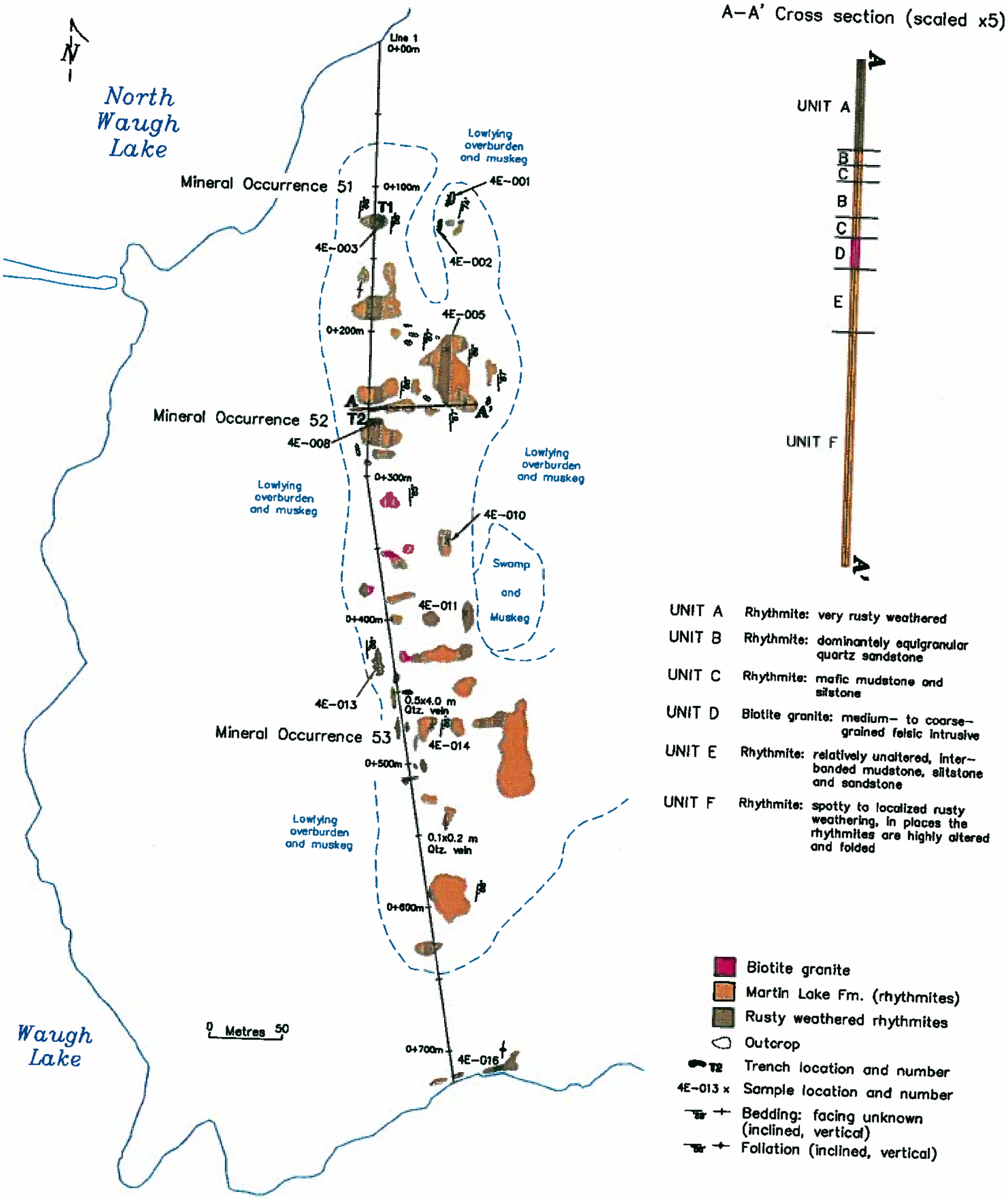


Figure 34. Detailed geology, trench, sample locations and cross section of mineral occurrences 51, 52 and 53.

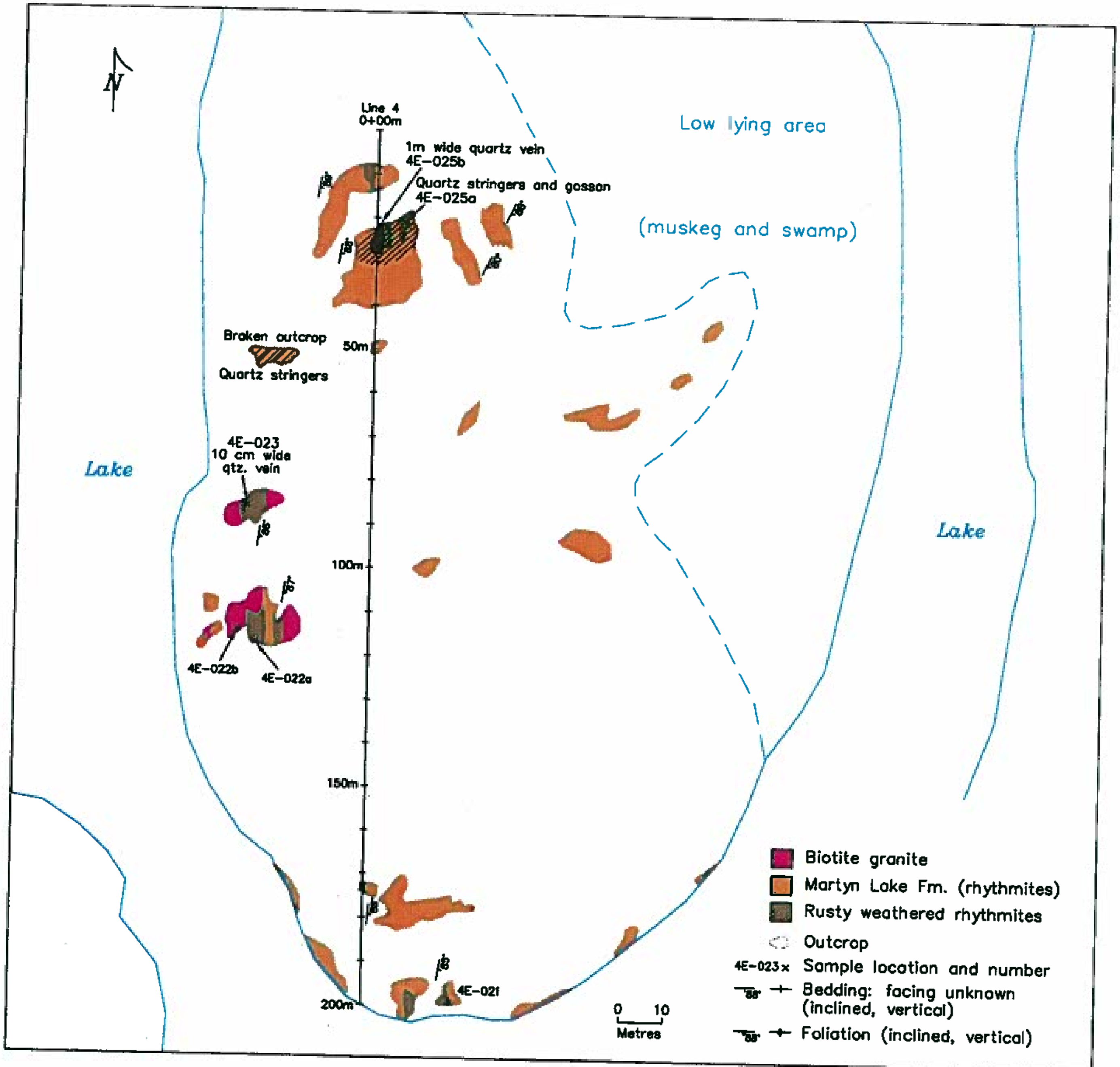


Figure 35. Detailed geology, trench and sample locations of mineral occurrence 129.

PLATE 1

1: Graded turbiditic strata comprised of quartzitic sandstone alternating with phyllite. Martyn Lake Formation at the type section (Figure 11). Tops to the right.

2: Amalgamated quartzitic sandstone horizon intermixed with rhythmic bedded and turbiditic strata. Martyn Lake Formation at the type section (Figure 11). Tops to the right.

3: Detail of undeformed pebble to cobble polymictic orthoconglomerate of the DL.LNE member at section 4I049 (Figure 12). The angular clasts consist mainly of layered fine- to coarse-grained quartz arenite to subarkose.

4: Moderately sheared polymictic orthoconglomerate of the DL.LNE member outcropping 1 km west of the north end of Waugh Lake. The flattened clasts include quartz and fine- to coarse-grained quartz arenite to subarkose. Tops to the right.

5: Fine-grained quartzitic sandstone lenses (intraclasts?) and thin lensed layers interbedded with medium-grained to pebbly sublitharenite of the DL.TR member. The basal Doze Lake Formation strata outcrop at section 4I050 (Figure 13).

6: Pyroclastic breccia in the uppermost part of the DL.B member, immediately underlying conglomerates of the DL.LNE member. The strata outcrop at section 4I036A (Figure 7) along the east central shore of Doze Lake. Tops to the right.

PLATE 1

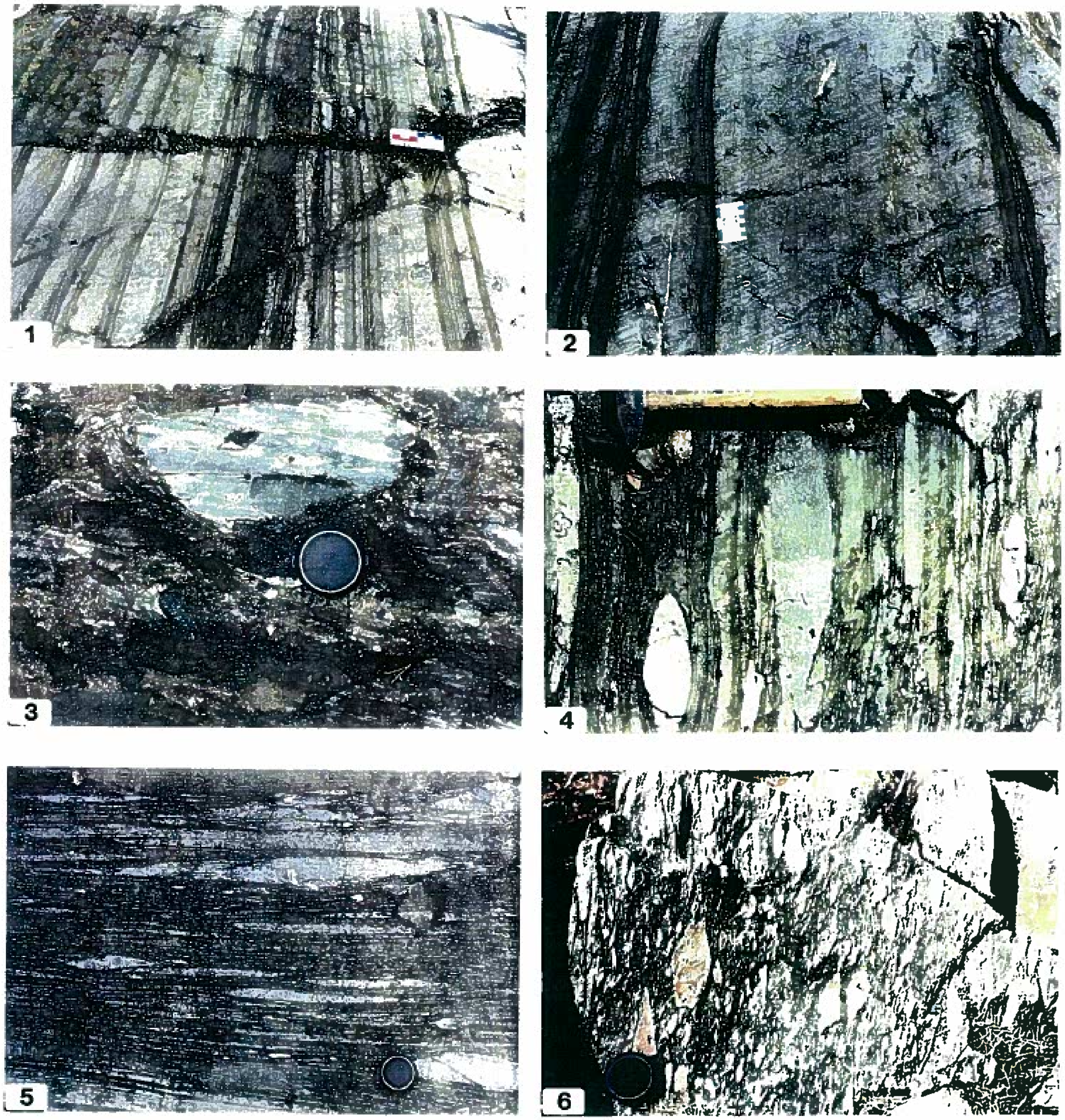


PLATE 2

1: Coarse -grained to pebbly sublitharenite with thin phyllitic laminae and relict primary bedding. DL.LSW member strata at the type section of the Doze Lake Formation (Figure 17), along the south shore of the West Waugh Lake. Tops to the right.

2: Channel structure in coarse-grained to pebbly sublitharenite scoured down into thinly bedded coarse-grained sublitharenite with phyllitic interlaminae. The strata of the DL.LSW member outcrop 450 m east of the northeast shore of Sederholm Lake.

3: Massive fine crystalline felsic tuff of the DL.U member at the type section of the Doze Lake Formation (Figure 17). Tops to the right.

4: Detail of medium-grained to granular, lenticular bedded to cross laminated subarkose and sublitharenite intermixed with reworked felsic tuff. The intermixed volcaniclastic and siliciclastic strata contain small scours and overlie massive fine crystalline felsic tuff (contact at lens cap). The DL.U member strata outcrop 800 m southeast of the north end of Sederholm Lake.

5: Intraclasts of thin layered mafic sublitharenite with soft sediment folds set in a matrix of coarse-grained to pebbly actinolitic arkosic wacke to sublitharenite. The intraclast conglomerate horizon overlies thick laminated fine- to coarse-grained mafic sublitharenite at a scoured contact (location of lens cap). The strata of the Sederholm Lake Formation outcrop at section 4I093 (Figure 21).

6: Scour structures, reactivation surfaces, trough crossbeds (with graded and oversteepened foreset beds) and load casts within intermixed coarse-grained to pebbly subarkose to sublitharenite and darker weathered medium-grained to granular actinolitic sublitharenite. The strata of the Sederholm Lake Formation outcrop at section 4I149 (Figure 29).

PLATE 2

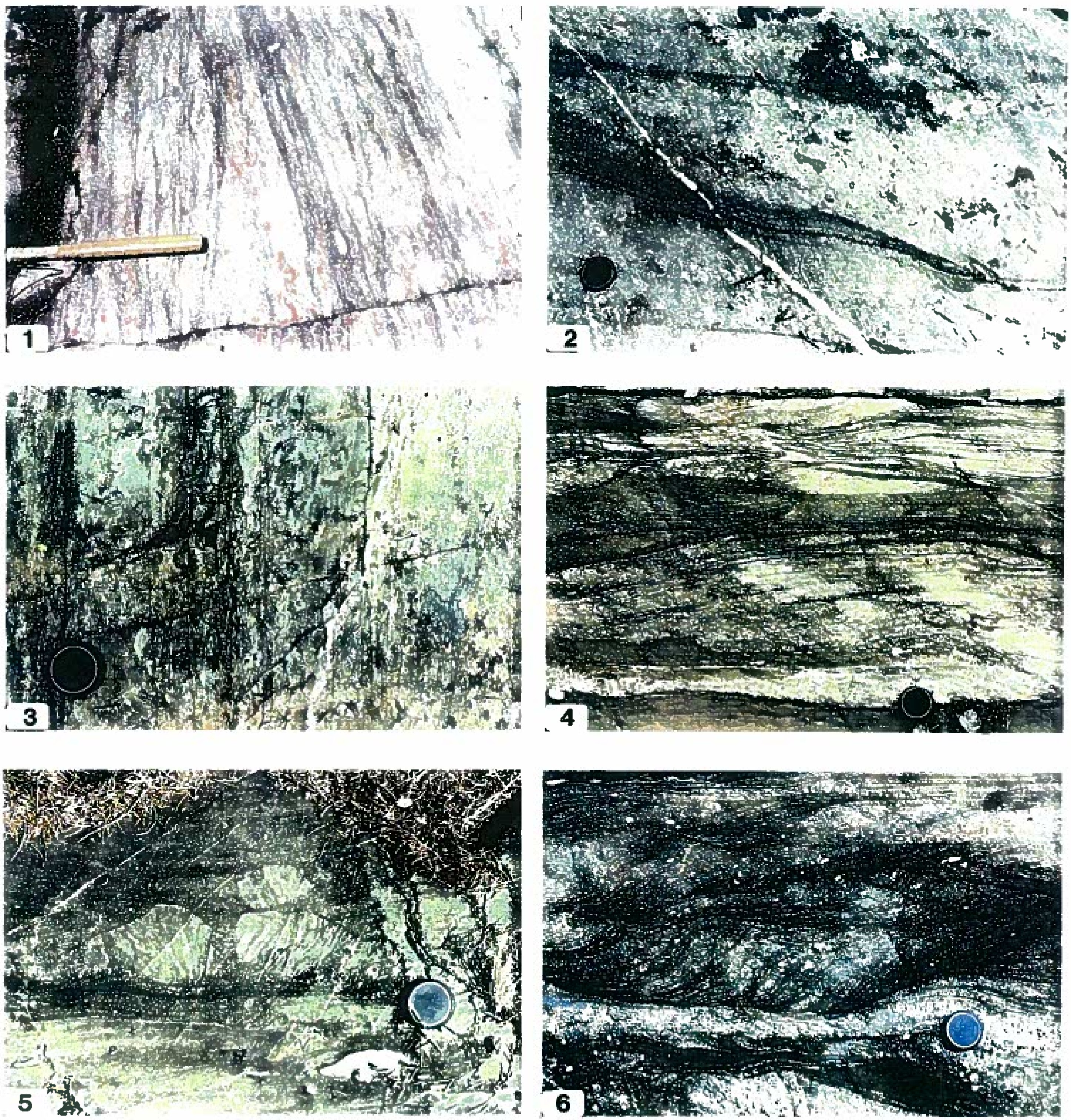


PLATE 3

1: Thick laminated to thin bedded, fine-grained to pebbly subarkose and sublitharenite with possible clast imbrication. The strata of the JL.L member outcrop 1.4 km north of the south end of Waugh Lake.

2: Thick laminated to thin bedded, medium- to very coarse-grained subarkose and sublitharenite with trough crossbeds and reactivation surfaces. The strata of the JL.L member outcrop at section 4I075 (Figure 18).

3: Small scale S-fold in very thin bedded felsic tuff to left of lens cap. The strata belong to the JL.U member and outcrop at section 4I046 (Figure 10).

4: Grey-weathered horizon of fine crystalline felsic tuff with load structures set within a succession of brown-weathered reworked felsic tuffs with thin lenses and lensed layers of coarse-grained sublitharenite. The beds outcrop 1.6 km east of the north end of Sederholm Lake and comprise part of the JL.U member sequence.

5: Pyroclastic breccia in the Niggli Lake Formation. The volcanic rocks outcrop 1.8 km north of West Waugh Lake.

6: Fine crystalline mafic flow with possible pillow structures. The Niggli Lake Formation rocks outcrop in the same area as the breccia of Plate 3-5 above.

PLATE 3

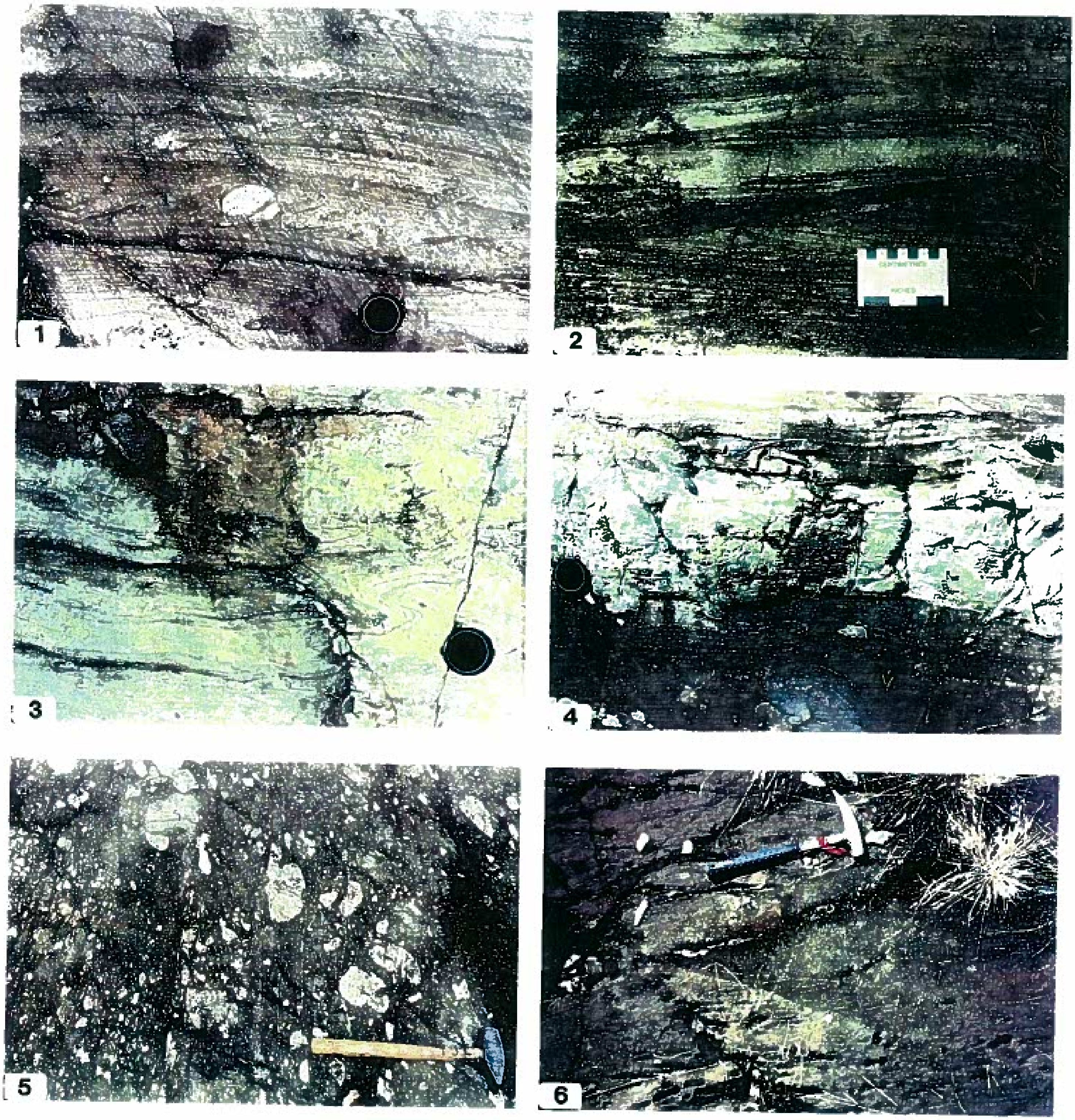


PLATE 4

1: Isoclinal antiformal anticline with axial planar slaty cleavage in the Martyn Lake Formation on the west shore of Doze Lake (outcrop 4l58).

2: Reversal in younging direction as indicated by graded bedding (arrows pointing in younging direction) in sandstone of the Martyn Lake Formation at its type section (figure 11).

3: Folding of a pebble layer in the Lower Johnson Lake Formation with slaty cleavage in pelitic horizons.

4: Pitted and boxwork weathering characteristics indicating possible oxidation of a high percentage of iron-bearing sulfides in the area around trenches 1 to 5.

5: A trench blasted by Hudson's Bay Oil and Gas in heavily altered, schistose quartz-biotite, quartz-sericite and quartz-graphite schist at Mineral Occurrence 39.

6: A stockwork of parallel quartz veins commonly 1 to 5 cm wide, but up to 1 m in size cross cuts rusty, north-trending rhythmites at mineral occurrence 129.

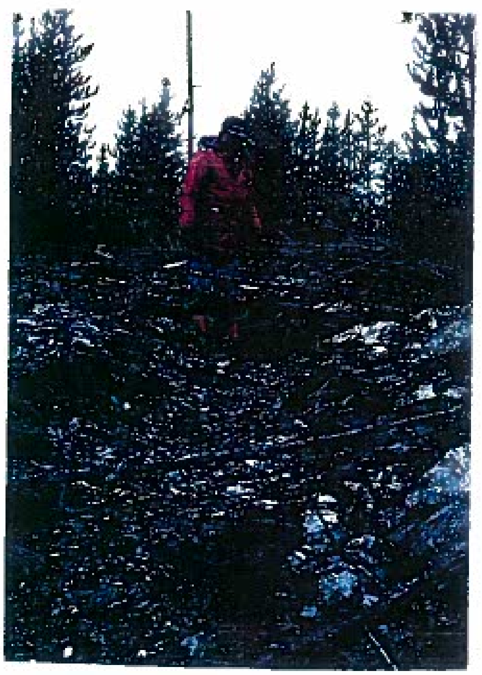
PLATE 4

1

2

3

4



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