GEOLOGICAL SURVEY OF CANADA · 1842 ·

GEOLOGICAL SURVEY OF CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 64-20

THE DUBAWNT GROUP, DISTRICTS OF KEEWATIN AND MACKENZIE

(Report and 3 figures)

J. A. Donaldson

Price 75 cents

1965

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ROGER DUHAMEL, F.R.S.C.
Queen's Printer and Controller of Stationery
Ottawa, Canada
1965

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ABSTRACT

This paper summarizes the initial results of a continuing stratigraphic and sedimentological study of the Dubawnt Group, Northwest Territories. The rocks of the Dubawnt Group underlie an area of more than 30,000 square miles, and probably range in age from late Lower to Middle Proterozoic.

Six formations within the group are named and briefly described. The two lowermost formations compose a red-bed sequence that was gently folded and eroded prior to emplacement of two volcanic formations and an associated intrusive unit. The youngest named formation disconformably overlies the volcanic rocks and consists mostly of cream, light grey, buff, pale pink, and mauve sandstones.

The red-bed sequence comprises more than 5,000 feet of bedded conglomerates and as much as 12,000 feet of arkosic sandstones. The sandstones are characterized by large-scale planar crossbedding in wedge-shaped units, and they typically are calcareous and well indurated. The clastic sedimentary unit above the volcanic rocks forms a widespread blanket deposit, probably less than 400 feet thick that is characterized by abundant festoon crossbedding. In contrast to the red sandstones, the younger sandstones commonly contain interstitial clay rather than carbonate cement and are remarkably friable. Dip directions of crossbedding indicate a consistent northwesterly direction of transport for both lower and upper sandstones. Crestal trends of ripple-marks of both symmetrical and asymmetrical types show relationships to crossbedding that are more complex than commonly observed.

An outcrop of Ordovician limestone was discovered about 20 miles north of Aberdeen Lake, thus substantiating G.M. Wright's earlier postulation (based on observations of abundant fossiliferous limestone blocks) of a Palaeozoic outlier in this area.

THE DUBAWNT GROUP,

DISTRICTS OF KEEWATIN AND MACKENZIE

INTRODUCTION

The Dubawnt Group comprises relatively flat lying sedimentary and associated igneous rocks that were outlined by helicopter-supported reconnaissance in adjoining parts of Keewatin and Mackenzie Districts, Northwest Territories (Wright, 1955, 1957)[1]. The group includes some of the rocks seen by J.B. Tyrrell on his first geological reconnaissance trip across the central barren lands of Canada (Tyrrell, 1898).

The present investigation was initiated primarily as a sedimentological study of the sandstones, siltstones, and conglomerates in the Dubawnt Group, but another important purpose was to resolve stratigraphic relationships within the group. This report presents data gathered during the first field season devoted to the study. Most attention was directed to Dubawnt rocks in the vicinity of Baker Lake, and on the basis of the mapping done in this area, six new formation names are proposed. The formations are briefly described, and preliminary interpretations of depositional environments and dispersal patterns for the sedimentary units are outlined.

Field work was carried out from June 7 to August 20, 1963. The writer thanks J.C. Crawford for his capable work as senior assistant, and T. Wedge for his contributions as junior assistant.

GENERAL GEOLOGY

The Dubawnt Group underlies an area of more than 30,000 square miles, forming a blanket over a basement of Archaean gneisses and associated rocks (Fig. 1). About one quarter of the Dubawnt Group consists of igneous rocks, predominantly volcanic, most of which outcrop within an area bounded by Kamilukuak, Beverly, Baker, and Yathkyed Lakes. Sedimentary rocks south of Baker Lake flank this area on the east, and a vast belt of sedimentary rocks extending northeasterly across the Thelon plain flanks it on the west. For the most part, the volcanic rocks rest upon the sedimentary rocks south of Baker Lake with angular unconformity, and underlie the sedimentary rocks of the Thelon plain, separated from them by a disconformity.

Two formations compose the lower sedimentary sequence, two volcanic formations and a presumably intrusive unit are recognized in the central igneous belt, and one formation is named in the upper sedimentary sequence. Other units can be recognized in the Dubawnt farther west, but names will not be assigned to them until additional mapping establishes their status.

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[1] Names and/or dates in parentheses refer to publications listed in the References.

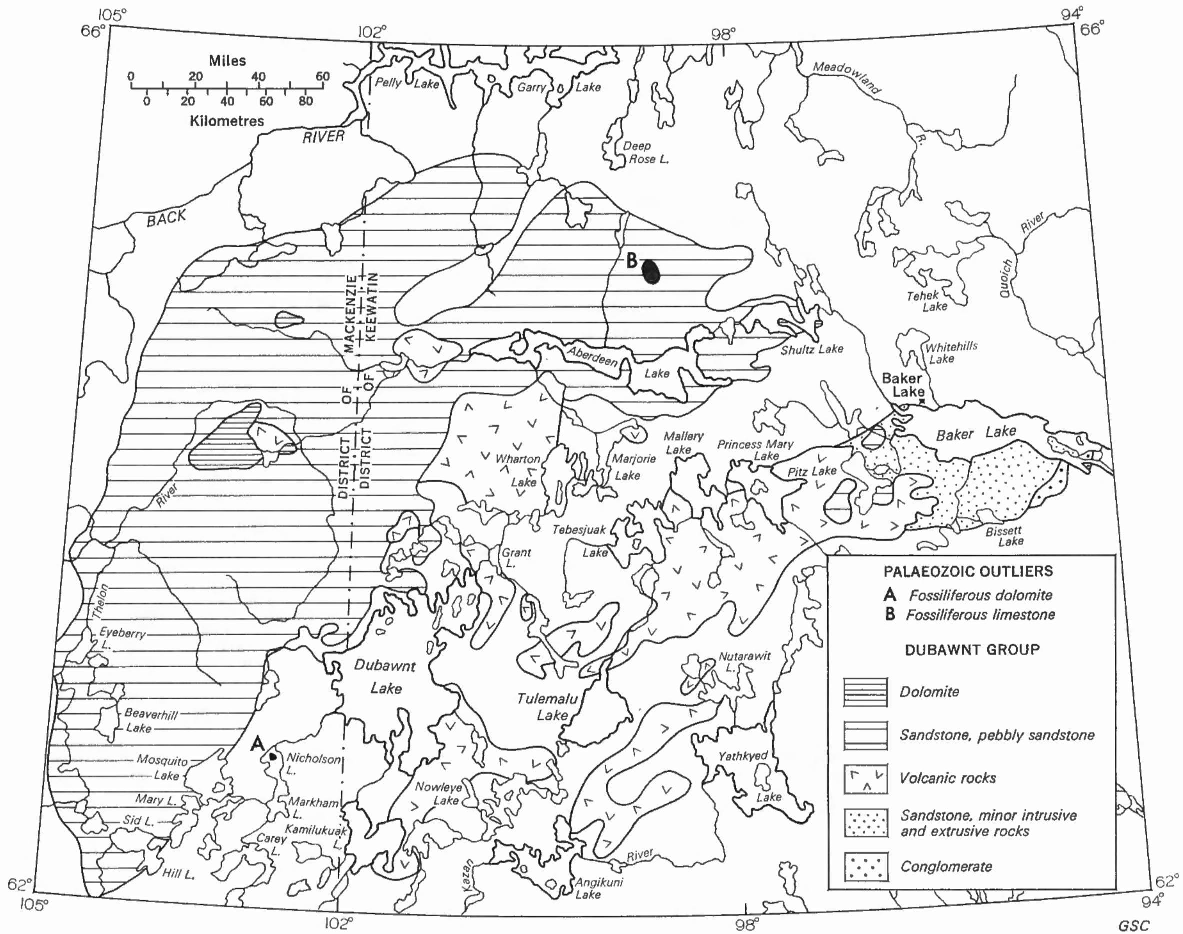

Figure 1. Distribution of Dubawnt and younger rocks, Northwest Territories (Modified after Wright, 1955, 1957)

Basement schist at the east end of Baker Lake has been dated (Lowdon et al., 1963) at 1810 m.y. (GSC 61-102), Dubawnt volcanic rocks have been dated (Lowdon, 1960, 1961; Lowdon et al., 1963) at 1515, 1720, and 1770 m.y. (GSC 59-35, GSC 60-60, GSC 61-100), and a diabase dyke that presumably cuts sandstones of the younger sedimentary sequence west of Aberdeen Lake has been dated at 1360 m.y. (W.F. Fahrig, pers. comm., Sample FA114-62). All these ages were determined by the K/Ar method on biotite. The Dubawnt Group therefore appears to range in age from late Lower to Middle Proterozoic.

Basement Rocks

Because the present study was devoted to the Dubawnt Group, the igneous and metamorphic rocks that compose the basement were examined only where they flank the younger sedimentary and volcanic rocks. Boundaries were refined and samples of probable source rocks for Dubawnt sediments were collected. Wright (1955, pp. 5-7) gives a discussion of lithology and regional distribution of basement rocks, including the Hurwitz metasediments.

South Channel Formation 5000

This formation is named after the waterway leading to the type area at the east end of Baker Lake (Fig. 2). The formation, consisting almost entirely of conglomerate with a few interbeds of sandstone, rests with profound unconformity on basement rocks. One small outcrop south of Bissett Lake and two outcrop areas in the cores of anticlines west of the same lake appear to be the only occurrences additional to the main belt of conglomerate. Exposures across strike in the vicinity of Andrews Lake indicate a local thickness of more than 5,000 feet, but the proximity of sandstone to basement rocks north of Pitz Lake and near Kazan Falls suggests that the formation is probably absent west of Kazan River.

Phenoclasts of typical conglomerates form an intact framework and consist mostly of pebbles and cobbles with apparent modal size class in the range 64 - 128 mm (based on megascopic point counts on planar surfaces, using long diameters for size classification). In order of decreasing volumetric abundance, the constituents are: pink leucocratic granite and granite-gneiss, diorite, white leucocratic granite, white augen gneiss, and minor quartzite, vein quartz, granulite, mylonite, metabasalt, and red felsite. The felsitic pebbles are interesting, in that they are lithologically similar to some of the younger volcanic rocks (Christopher Island and Pitz Formations) described later. The matrix of the conglomerate in most places is massive, uniformly fine grained, and coloured deep maroon, purplish red, or reddish brown. The matrix commonly is somewhat calcareous, especially in the outcrops near Bissett Lake.

A wide range in shape and roundness appears to be characteristic of the South Channel conglomerates. Blocks showing rectangular outlines are chaotically mixed with near-spherical boulders, and this relationship also can be seen in the finer material.

Bedding is indicated by fluctuations in size range, but is most strongly marked by intercalated lenses and layers of sandstone and pebbly sandstone. These sandstones commonly occupy channels in the conglomerates and compose about 10 per cent of South Channel Formation. The pebbly beds are well sorted and crossbedding is common. Curled slabs of mudstone, probably derived from mud-cracked layers, are imbedded in a sandy matrix along the bottoms of some channels.

$_fA_{f\text{-}M}$ Kazan Formation 12,000

The type area for this formation flanks Kazan River where it flows eastward for about 2 miles, west of Martell Lake. Measurement north from the conglomerate area northwest of Bissett Lake indicates a thickness of as much as 12,000 feet. Although the lower part of the formation is poorly exposed, bedding attitudes suggest a conformable relationship with the South Channel Formation.

Maroon, pink, and reddish brown, fine- to medium-grained feldspathic sandstones compose more than 90 per cent of the Kazan Formation. The sandstones are typically well sorted, well indurated, and exhibit thin, planar lamination. The bedding in most places is distinct and commonly is accentuated by differential weathering, especially where slightly calcareous. Planar crossbedding occurs in tabular units several feet thick, but much more abundant is crossbedding on a larger scale in which successive wedge-shaped sets of planar crossbeds overlap each other with low-angle truncations that can be traced for tens or even hundreds of feet.

Reddish brown to deep maroon siltstones and mudstones outcrop on Christopher Island and several islands nearby. They appear to form a relatively continuous sequence above sandstones there, but similar rocks occur as interbeds with sandstones in the type area. Lenticular siltstone and mudstone laminations commonly alternate rhythmically. Some mudstone layers show well-preserved mud-cracks, and mudstone or siltstone chips may be seen here and there in sandy beds that overlie apparent source beds. Ripple-marks of both oscillation and current types are abundant in the fine-grained rocks; both types are characterized by wave lengths between 1 and 15 cm, and ripple indices less than 12. A set of linguoid ripples is exposed on the east bank of Kazan River near Martell Lake, and sets of both current and wave origin commonly show interference patterns.

Christopher Island Formation

The type locality of this formation is Christopher Island and islands nearby where the stratigraphic position above the Kazan Formation can be determined. Several lithologically distinct volcanic assemblages compose the formation, and they typically form mesa-like caps on hills that rise gently from the relatively flat tundra. The maximum known thickness is less than 200 feet, but thicknesses vary because the formation was deposited on a surface that probably had relief similar to that of the present topography.

A long period of erosion must have preceded the volcanism in order to truncate the Kazan and South Channel sediments, and some of this erosion is recorded by detritus in basal tuffaceous sandstones and agglomerates of the Christopher Island Formation. Well-rounded pebbles and cobbles of Kazan sandstone are intimately mixed with similar-sized angular and rounded volcanic fragments in a matrix ranging from essentially sandy or muddy to predominantly volcanic. Such deposits are abundant on islands in the North Channel of Baker Lake and on several hills south of the lake. In general, the tuffaceous sandstones are deep purplish brown to reddish brown and the agglomeratic rocks are dark greenish grey or dark grey. Where bedding is visible in these beds, it commonly is inclined as much as 30 degrees, but because the attitudes show little consistency and are oblique to bedding in Kazan rocks, they probably reflect initial dip rather than structural deformation. Some remarkably well-sorted pyroclastic deposits consist of vesicular lapilli and bombs that are locally welded and show a crude stratification.

Andesites, latites, and trachytes compose the bulk of the Christopher Island Formation. Most of these volcanic rocks are deep purplish grey to reddish brown and weather buff-pink to dull purplish brown. The light-weathering types are generally aphanitic, very hard, and break with a smooth conchoidal fracture; the dark-weathering types tend to be fine grained, moderately hard, and break with a rough irregular fracture. The flows almost invariably are porphyritic, bearing 5 to 30 per cent biotite and pyroxene as phenocrysts less than 5 mm in diameter.

Flow contacts appear to be abundant in the fine-grained volcanic rocks but are rare in the aphanitic varieties which commonly form homogeneous layers more than 50 feet thick. Where flow contacts are visible, such as in the outcrop areas northwest and east of Kazan Falls, they generally are subhorizontal and marked by agglomeratic zones. Calcite-filled ellipsoidal amygdules less than 1 cm long were observed in the upper parts of several flows on islands at the east end of Baker Lake.

An acidic flow (rhyolite ?) southeast of Gull Lake caps one of the most prominent landmarks around Baker Lake. Excellent cliff exposures at this locality reveal intricate flow layering in mauve to pinkish cream volcanic rocks that for the most part are aphanitic and non-porphyritic.

Martell Syenite

Medium-grained, massive, pinkish grey to reddish black syenite forms domical hills in a belt south of Baker Lake. The name is derived from the lake south of the best exposures. The syenites are mostly uniform in texture, structure, and composition, but in several areas west of Kazan River, syenite hills are bordered by trachytic rocks that may represent fine-grained facies of the syenite.

Wright (1955, p. 10) suggested that the massive igneous rocks may form plugs or stocks, but noted that sill-like layers occur nearby. On the flanks of some syenite hills there is clear evidence of near-horizontal floors, and a sill-like shape appears more likely. However, the syenite hills occur in clusters that may equally well represent laccoliths intruded at coincident elevations. Unfortunately, no upper contacts have been observed, and although it is unlikely, the syenites may represent a thick, massive, phaneritic flow.

Pitz Formation

A unit almost entirely composed of volcanic rocks containing abundant feldspar phenocrysts is here named "Pitz Formation", after the lake that lies east of the type locality. The formation is about 200 feet thick, and two members are recognized: a lower one characterized by a mauve to purple groundmass, and an upper one with a deep red to maroon groundmass. Both units contain subhedral chalky white phenocrysts of feldspar, as large as 2 cm in diameter and in amounts up to 50 per cent. Glassy quartz phenocrysts, rounded and commonly resorbed, are also abundant. Each member apparently represents a single flow, and fragments of the lower flow are abundant in the upper.

Cobbles and boulders of Kazan sandstone, as well as granite, quartzite, and other basement rocks, are commonly contained in amounts sufficient to give the porphyritic flows a conglomeratic aspect, but the volcanic nature of the matrix indicates incorporation in flows. Sedimentary lenses do occur at the base of each member but appear to form less than 10 per cent of the formation.

2A > fA

Thelon Formation 400'

This formation is named here and defined as the relatively flat-lying sequence of clastic sedimentary rocks that outcrops for the most part across the Thelon plain north and west of Dubawnt Lake (Fig. 1). Outliers occur as far east as Baker Lake, and are well exposed on hills east and west of Pitz Lake. The formation probably has a maximum thickness of less than 400 feet.

The Thelon Formation comprises sandstone, pebbly sandstone, and locally, conglomerate and siltstone. In most places there is little difficulty in differentiating Thelon from Kazan rocks. Pebbles of Kazan, Pitz, or Christopher Island rocks are common in the Thelon Formation and the horizontal attitude is suggestive, but other criteria also appear to be reliable. In contrast to the deep reds of Kazan rocks, cream, light grey, buff, pale pink, and mauve are characteristic colours for Thelon sandstones. Remarkably friable sandstones are common whereas the Kazan is almost everywhere very well indurated. In further contrast to the Kazan, calcareous cement is rare; instead interstitial white clay is clearly visible in most beds and the maturity of the Thelon sandstones is markedly greater. Ripple-marks in Thelon sandstones were not observed in the Baker Lake area, but are common in the Thelon Formation farther west. Where these structures do occur, they cap sandy beds and are relatively large-scale features compared to the ripple-marks of the Kazan. Festoon crossbedding, extremely rare in the Kazan, appears to be essentially ubiquitous in the Thelon, and planar crossbedding, rare in Thelon sandstones, forms tabular rather than wedge-shaped units. Quartzose sandstones predominate but feldspathic sandstones occur, particularly in basal beds. Pebbles are remarkably well rounded, and extensive beds only one pebble thick and composed of well-sized ellipsoidal clasts are abundant. The crossbeds typically occupy channels, 1 foot to 15 feet wide, that range from linear to sinuous and commonly overlap. Although flat-lying beds prevail, the base of the formation does not appear to be uniformly horizontal. A relationship more complex than that of continuous deposition on an irregular surface is suggested by outcrops of flat-lying basal conglomerate at elevations higher than nearby outcrops of friable and mature sandstones that also are flat lying.

Diabase Dykes

Northwest-trending dykes of diabase cut some of the Dubawnt rocks, including parts of the Thelon Formation. The dykes are relatively tabular, near-vertical in attitude, and many can be traced for great distances. The dyke immediately west of Pitz Lake may be more than 150 miles long (Wright, 1955, p. 15).

will I see it?

Most of the dykes are massive, show a typical diabasic texture, and have fine-grained border zones. Although some dykes are as much as 300 feet wide, grain size in the central parts generally is less than 1 cm. Plagioclase exceeds mafic minerals in abundance, and finely disseminated hematite gives much of the plagioclase a pinkish cast in hand specimens. The major mafic minerals, in decreasing order of abundance, are pyroxene, amphibole, and biotite.

Palaeozoic Outliers

An outcrop of Palaeozoic limestone was discovered about 20 miles north of Aberdeen Lake near abundant limestone rubble reported earlier (Wright, 1955, p. 11). The outcrop consists of flat-lying flaggy limestone that is exposed for more than 300 yards along a stream valley. Large limestone blocks are mainly restricted to an oval-shaped area about 5 miles long by 3 miles wide, and this area probably defines the approximate extent of the outlier (Fig. 1). Fossils collected from the outcrop that establishes existence of the outlier are similar to fossils collected from the previously known outlier at Nicholson Lake (Tyrrell, 1898, p. 54; Wright, 1957, p. 15), but there are marked differences in lithology. Rocks from the locality north of Aberdeen Lake are grey, buff- to grey-weathering, finely crystalline limestones that characteristically are soft and friable. Most of the Nicholson Lake carbonate rocks are pale grey, cream- to pale-buff-weathering, cryptocrystalline dolomites that fracture conchoidally and contain chert concretions.

G.W. Sinclair, Geological Survey of Canada, examined both fossil collections and states that the Nicholson Lake fossils are similar to the Red River fauna of Manitoba (Late Middle Ordovician). He found the Aberdeen collection to be of the same general age, but noted some perplexing differences such as absence of the characteristic form Maclurites. He found no evidence to allow a statement that one of the collections is definitely older than the other.

PALEOCURRENTS

To reconstruct sedimentary dispersal patterns, orientations of both crossbedding and ripple-marks were measured in all sufficiently exposed outcrops containing such structures. Measurements were limited to one per set, but as many sets as possible were measured at each station. Corrections for bedding tilt were made in the field, and only the tilt-corrected readings were recorded. Figure 3 summarizes the data.

The direction of crossbedding dips show consistent and similar trends in both the Kazan and Thelon Formations. Although a greater dispersion does appear between stations in the Kazan Formation, the summary histograms clearly reflect predominant northwestward transportation of sediment during deposition of both units.

Orientations of ripple-marks in the Kazan Formation show an interesting distribution. Symmetrical or oscillation-ripple marks, nearly twice as abundant as current-ripple marks, trend in almost all directions except in the range close to the depositional strike deduced from crossbedding data (Fig. 3). In an early study of fossil ripples, Hyde (1911) suggested that refraction of waves towards parallelism with a presumably linear shore would account for widespread parallelism of oscillation-ripple marks in the Berea sandstone. In contrast, the diverse trends of the oscillation-ripple marks in the Kazan Formation may reflect paleogeographic settings in which wind-driven waves were influenced little by shore configuration, such as flood plains, shallow ephemeral lakes, or extensive tidal flats. Thus the Kazan symmetrical ripples may record prevailing winds normal to the direction of sedimentary transport. It is also possible, however, that the symmetrical ripples were parallel with the shores of rivers. Kindle (1917, p. 31) reported this relationship, and the writer observed small-scale symmetrical ripples parallel with the current in the shallow nearshore zones of numerous streams in the study area.

Crestal trends of the asymmetrical ripple-marks show somewhat closer agreement with depositional strike, but down-current directions for 4 of the 16 sets are almost diametrically opposed to the mean crossbedding vector. Meanders or reverse eddy currents can be invoked to explain the opposing ripples for a fluviatile environment, but the relationship might also be explained by a tidal-flat environment where ebb and flood of tides could produce ripples showing both offshore and onshore asymmetry. Common association of mud-cracks with the rippled beds clearly supports a shallow-water environment subjected to repeated withdrawals of the water.

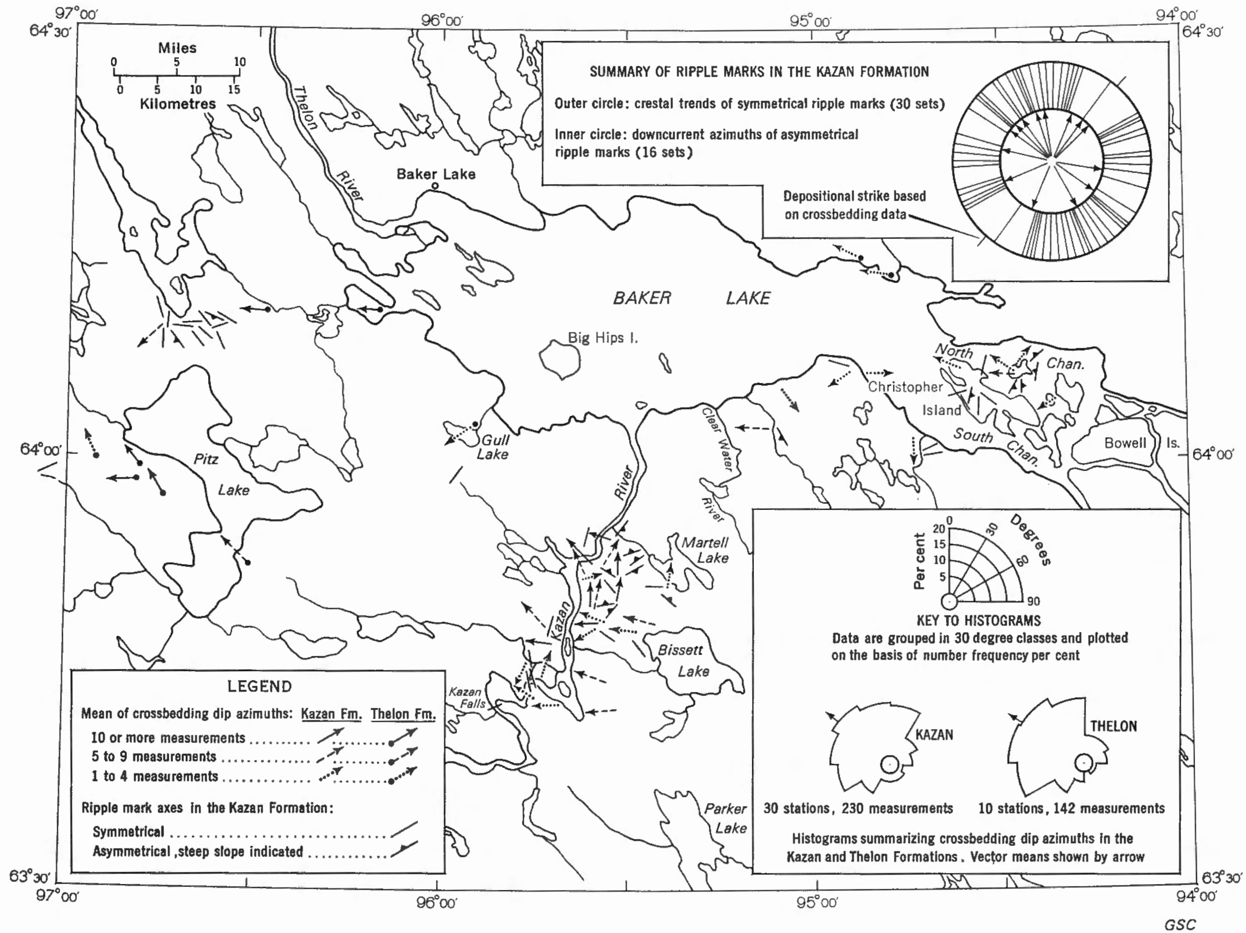

Figure 3. Azimuths of crossbedding and ripple-marks in the Kazan and Thelon Formations, Baker Lake area.

GEOLOGICAL HISTORY OF THE DUBAWNT GROUP

The South Channel and Kazan Formations compose a thick red-bed sequence that probably was deposited in an environment ranging from continental to shallow marine. Frequent subaerial exposure is indicated by abundant mud-cracks, and channels in the conglomerates record scour and fill. The fine-grained sediments that display the anomalous ripple-marks probably were deposited on mud flats that were intertidal, flood-plain, or lacustrine, or some combination of these environments. The wedge-shaped sandstone units showing large-scale planar crossbedding are interpreted as overlapping fore-sets deposited on the fronts of deltas characterized by shifting distributaries. Accumulation in large transverse aeolian dunes is another possibility, but the low dispersion of crossbed azimuths would necessitate unusually consistent winds, and prevailing wind as a control for the orientation of the longitudinal symmetrical ripples in the siltstones would be ruled out. Rapid westward thinning of the conglomerates suggests an easterly source area, and cross-bedding in the sandstones substantiates such provenance, with north-westward transport predominating.

Pebbles of felsite in the South Channel conglomerates indicate earlier volcanism, similar to that recorded by the Christopher Island Formation, and possibly the few isolated outcrops of volcanic rocks not clearly younger than the Kazan Formation are correlative with an eastward source, since eroded. There is no evidence for volcanism contemporaneous with deposition of the red-bed sequence.

The South Channel and Kazan Formations were gently folded and deeply eroded prior to subsequent volcanism. Initial volcanic activity was essentially pyroclastic, and much of the detritus probably was deposited from ash flows. The tuffaceous sandstones grading to agglomerates may represent lahars that resulted from addition of volcanic detritus to consolidated sands and muds on unstable slopes. Quieter extrusion is recorded by the near-horizontal flows of the Christopher Island Formation, but abundance of interflow agglomerates indicates that pyroclastic activity did not altogether cease. The Martell syenites probably were emplaced as near-surface laccoliths at the base of, and within, the Christopher Island Formation. Final volcanism appears to be represented by the porphyritic flows of the Pitz Formation.

Erosion preceded deposition of Thelon sediments, as indicated by well-rounded pebbles and cobbles of Dubawnt volcanic rocks in basal beds. Compositional maturity, in contrast to that of the Kazan sandstones, suggests a more stable tectonic framework and probably most of the Thelon sediments were deposited on a surface of low relief. The blanket-like geometry of the formation substantiates such a setting, but occurrence of some of the most mature and highly friable sandstones in topographically low positions suggests possible rejuvenation during deposition of the Thelon Formation. In view of the abundant sinuous channeling, characteristic festoon crossbedding, and widespread layers and lenses of well-rounded, well-sorted pebbles, a fluviatile environment of deposition is likely. The crossbedding dip azimuths demonstrate that Thelon sandstones in the Baker Lake area were deposited for the most part by northwest-flowing currents.

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