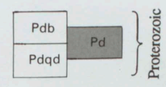
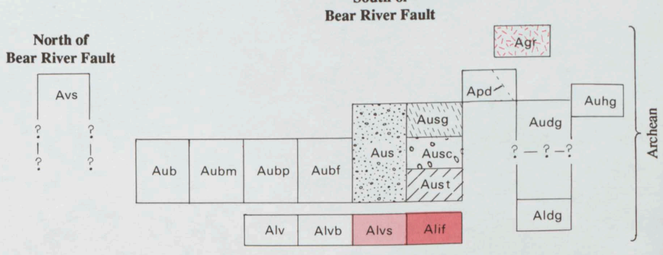
UNIVERSITY OF MINNESOTA
MINNESOTA GEOLOGICAL SURVEY
Priscilla C. Grew, Director

MISCELLANEOUS MAP SERIES
M-64
Sherry Lake Quadrangle

CORRELATION OF MAP UNITS





DESCRIPTION OF MAP UNITS

DIABASE AND GABBRO (EARLY PROTEROZOIC)

Pd Fine- to coarse-grained, ophitic to diabasic dikes with chilled borders that belong to the Kenora-Kabetogama dike swarm (Southwick and Day, 1983). Dikes locally multiple (Pdb) or composite (Pdqd)

Pdb Dikes like Pd irregularly intruded by fine-grained dikes 1.5 to 1 m thick. Consists of a black, aphanitic groundmass containing plagioclase phenocrysts 1 to 2 mm in diameter

Pdqd Dikes like Pd but containing internal zones of medium-grained hornblende quartz diorite. Hornblende in 1-cm clots produces a characteristic spotted appearance. Field relations imply that these zones are intrusive into dikes and not an in-situ differentiation

NORTH OF BEAR RIVER FAULT

Avs Volcanic and sedimentary rocks of Late Archean age, undivided. No outcrops exist in the Sherry Lake quadrangle; however exposures and core holes to the west show a mixed sequence of pillowed and amygdaloidal basalts, minor andesitic to dacitic volcanic and volcaniclastic rocks, and irregular lenses of iron-formation

SOUTH OF BEAR RIVER FAULT

GRANITIC ROCKS (LATE ARCHEAN)

Agr Granodiorite, quartz monzodiorite, and tonalite, informally called the Wasson Lake pluton. In the southwestern part of the quadrangle it has intruded and metamorphosed the lower supracrustal sequence. The largest exposure is variably foliated, gray, medium-grained, biotite- and hornblende-bearing monzodiorite. Strongly foliated, inclusion-rich migmatite occurs near the contact, and finer grained sills and dikes of granodioritic to tonalitic composition are common for several hundred meters northward in the supracrustal rocks

Apd Porphyritic dacite to rhyodacite dikes. Typically 1 to 2 m wide and contain plagioclase and quartz phenocrysts 2 to 5 mm large in a fine-grained quartz-feldspar groundmass

ROCKS OF THE UPPER SEQUENCE (LATE ARCHEAN)—Predominantly pillowed basalt and mafic intrusive rocks, together with lesser amounts of sedimentary and fragmental rocks

Auhg Hornblende gabbro. Dark gray, massive to crudely layered, and medium grained. Composed of magmatic hornblende plus one or more metamorphic amphiboles and altered plagioclase. Forms an elliptical pluton in the southeastern part of the map area and adjacent smaller semi-concordant units

Audg Metamorphosed diabasic and gabbroic sills and rare dikes. Black to dark greenish gray, fine to medium grained, and typically massive, but locally a strongly foliated matrix surrounds relict ophitic crystals. Consists of altered plagioclase and one or more amphiboles that in part replace pyroxene. Epidote, chlorite, sphene, and calcite are minor components. Protoliths vary from pyroxenite to diabase. Considered to be comagmatic with basalts and locally may be mistaken for coarse-textured basalt flows

Aus Sedimentary rocks in the eastern and northeastern parts of the quadrangle. The best exposure, in the northwestern corner of section 10, is a wedge-shaped sequence overlain and underlain by basaltic flows. The lowermost unit is a fine-grained dacitic crystal tuff (Aust). It is overlain by a thick debris-flow conglomerate (Ausc), which is dominated by dacite clasts, but has a pseudomatrix of smaller, flattened basaltic clasts. The conglomerate is overlain in turn by a series of graded graywacke-tuff beds (Ausg). The finer grained of the sedimentary rocks consist of recrystallized quartz, feldspar, and biotite

Aub Tholeiitic basaltic flows and associated mafic volcaniclastic rocks. Typically fine grained to aphanitic, nonporphyritic, dark gray to dark greenish gray. Most contain relict plagioclase crystals in a schistose, recrystallized mixture of amphiboles, chlorite, epidote, calcite, and opaque oxides. Disseminated pyrite is ubiquitous. Associated mafic tuff commonly contains biotite and garnet. Original structures are locally well preserved. Pillowed basalt flows are dominant, though massive and fragmental flow units occur locally. Although individual flows are difficult to trace, generalized subunits were defined by macroscopic similarities where outcrop permits:

Aubm Massive basalt dominant, fine to medium grained

Aubp Pillowed basalt, typically fine grained with thin (< 1 cm) black rinds and rare hyaloclastite. Upper parts of flows are amygdaloidal, especially in the eastern and northeastern exposures

Aubf Fragmental basalt, which varies from pillow breccia and pillow fragment breccia to mafic lapilli tuff and fine-grained, schistose hyaloclastite. One 500-m thick unit overlying unit Aus is exposed just east of the eastern edge of the quadrangle

VOLCANIC AND ASSOCIATED ROCKS OF THE LOWER SEQUENCE (LATE ARCHEAN)—Mixed volcanogenic sequence of calc-alkalic basalt, andesite, and dacite, and local tholeiitic basalt. Grades upward in a very general, interdigitated manner to calc-alkalic volcaniclastic and epiclastic rocks containing irregular lenses of iron-formation and locally thick metamorphosed diabasic and gabbroic sills. Individual rock types are difficult to trace because of both depositional and deformational complexities. The volcanic and sedimentary parts of the sequence are subdivided into generalized "packages" (Alv, Alvb, Alvs, Alif) of like rocks where moderately well exposed

Aldg Metamorphosed diabasic and gabbroic sills and dikes like Audg; may in part be coeval with Aub

Alv Volcanic rocks undivided; typically medium-greenish-gray, fine-grained, porphyritic, pillowed and amygdaloidal flows of andestic to dacitic composition. Flows contain plagioclase and rare quartz phenocrysts in a recrystallized and schistose, fine-grained groundmass of feldspar, quartz, amphibole, epidote, chlorite, and biotite. Locally interbedded with volcaniclastic rocks

Alvb Basaltic flows; typically dark green, pillowed, and amygdaloidal

Alvs Gneiss, schist, and phyllite derived from volcanogenic and epiclastic rocks. Consists predominantly of dacitic to andesitic tuff, agglomerate, and breccia interbedded with siltstone, graywacke, and conglomerate of like composition. Most of the finer grained rocks are quartz-feldspar biotite schists, locally containing some pyrite, sericite, amphibole, garnet, and fuchsite. Aeromagnetic and ground magnetic data indicate that thin, irregular lenses of iron-formation occur throughout unit

Alif Iron-formation; alternating layers of gray chert and magnetite with irregular laminae of pelitic iron silicate and chloritic tuff. Typically pyrite-bearing. Individual iron-formation units are rarely thicker than a few meters. Where outcrops are lacking, units were mapped on the basis of ground geophysical surveys and drill core. Iron-formation is interbedded on all scales with other rock types, in particular with Alvs, and with garnet-bearing carbonate strata and graphitic argillite in the southern part of the map area

GEOLOGIC CONTACT—Dashed to indicate subdivision within larger unit

INFERRED FAULTS—Arrows show relative horizontal movement

OUTCROP-SCALE FAULTS—Arrows show relative horizontal movement

MYLONITE OR BRECCIA ZONE

AXIAL SURFACE TRACE OF FOLDS

Inclined syncline, anticline; F_1 structures developed in first deformation, short dashes; F_2 structures long dashes

Syncline, anticline; upright or with poorly constrained axial inclination (F_1, short dashes; F_2, long dashes)

STRIKE AND DIP OF BEDS

Inclined, vertical; top direction undetermined

Overturned

Inclined, vertical. Stratigraphic top shown by bar and ball

Inferred top direction where bedding attitudes are poorly defined

CLEAVAGE, SCHISTOSITY, FOLIATION

Metamorphic planar structures (S_1) developed in first major folding (F_1)—inclined, vertical

Metamorphic planar structures (S_2) developed in second major folding (F_2)—inclined, vertical

Foliation in intrusive rocks—inclined, vertical

BEARING AND PLUNGE OF LINEATIONS

Plunge direction of minerals, clasts, pillows, and amygdules; may be combined with other symbols—L_1, single arrowhead; L_2, double arrowhead

BEARING AND PLUNGE OF FOLDS

Minor symmetrical folds; F_1, single arrowhead; F_2, double arrowhead

Asymmetrical fold; sense as shown; F_1, single arrowhead; F_2, double arrowhead

AREA OF OUTCROP (typically discontinuous)

DRILL HOLES

Bearing of inclined drill hole (from files of the Minnesota Department of Natural Resources, Minerals Division, Hibbing)

Drill hole, Minnesota Geological Survey test drilling, 1987

X GEOCHEMICAL ANALYSES—Locations of samples plotted on Figure 1. Drill core samples analyzed by Lehmann Exploration Management, Inc.; results on file with the Minnesota Department of Natural Resources. Outcrop samples analyzed by Natural Resources Research Institute, University of Minnesota, Duluth

Base from U.S. Geological Survey, 1964.

SCALE 1:24000

1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 KILOMETER

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

QUADRANGLE LOCATION

Geology mapped 1985-1987. Mapping based in part on aeromagnetic data provided by the Conterminous United States Mineral Appraisal Program (CUSMAP) of the U.S. Geological Survey.

STRATIGRAPHY

Figure 1 shows the stratigraphy of the supracrustal rocks and the chemical differences between two cycles of volcanism. The lower sequence, in the western half of the map area, is predominantly calc-alkalic, though mixed, whereas basalts of the upper sequence in the east are consistently tholeiitic, with interbedded calc-alkalic clastic rocks confined to the uppermost part. The lower sequence grades stratigraphically upward (eastward), becoming more felsic and fragmental, and finally passes to argillaceous and chemical sedimentary rocks deposited in quiet water. A breccia composed of large intermediate to felsic volcanic blocks locally underlies the stratigraphically highest bodies of iron-formation. It may represent "caldera" collapse at the cessation of volcanism of the lower sequence.

The upper sequence (Aub) contains evidence for upward-shoaling processes (Jirsa, 1987). The basal and central parts of the upper sequence consist of massive and pillowed flows whose lack of vesicles and hyaloclastite implies deposition in relatively deep water. This grades upward to more pillowed, vesicular, and fragmental flows. In the uppermost part, mafic volcanism was interrupted by dacitic volcanism and subsequent deposition of a dacite-dominated conglomerate and tuff sequence (Aus). These clastic rocks are overlain by fragmental basalt that contains features indicative of deposition in relatively shallow water. The dacitic clastic rocks appear to be a tongue of sediment shed off the flanks of an emerging felsic volcanic center. Dacite porphyry dikes (Apd) that cut the northern basalt flows (Aub) may represent apophyses of this felsic source. Geophysical evidence implies that the felsic center controlled deposition of stratigraphically higher rocks in the adjacent quadrangle to the east.

The timing of mafic intrusions in both sequences is not well constrained. Some bodies presumably were intruded at shallow depths and are essentially comagmatic with interbedded volcanic rocks. Others, especially in the lower sequence, may have been intruded somewhat later than the enclosing rocks and presumably were parts of feeder systems for the basalt in the upper sequence. The abundance of tholeiitic mafic intrusions near the center of the depositional axis of the Sherry Lake basalts (Aub) implies that this area may have been very near the extrusive conduits.

Granodioritic rocks in the southern part of the quadrangle are the northeastern extension of a multiple intrusion here called the Wasson Lake pluton. It was delineated by geophysical and drill hole data as occupying a large area west and southwest of the Sherry Lake quadrangle. The main part is a foliated granodiorite; however it has a core zone (not exposed in the area of this map) of unfoliated, homogeneous granite containing quartz phenocrysts. Intrusion of the granodiorite had a profound impact on the distribution of supracrustal rocks. A part of the pluton was mapped by Viswanathan (1974) as an early, migmatitic part of the Giants Range batholith. Sims (1972) suggested that the migmatite might be even older and represent basement on which supracrustal rocks were deposited. Schistose inclusions within the granodiorite, however, and small intrusions infolded with supracrustal rocks in the migmatitic border zone imply that it is not.

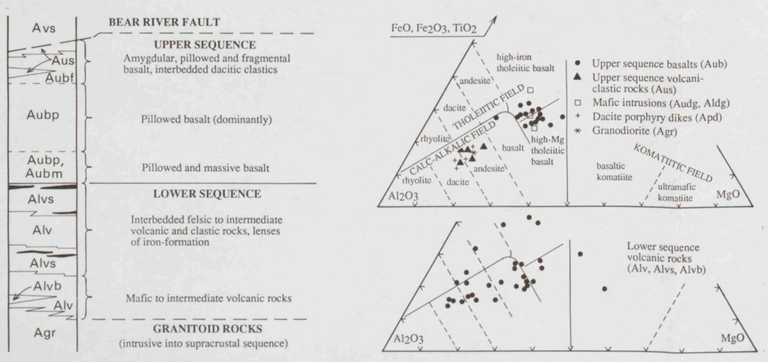


Figure 1. Simplified stratigraphic and geochemical relationships in the Sherry Lake quadrangle. Geochemical plots after Jensen (1976).

METAMORPHISM

All of the supracrustal rocks are metamorphosed above the biotite zone of greenschist facies. The extent of recrystallization is generally large but variable. Assemblages in the mafic to intermediate volcanic rocks contain actinolite, albite, chlorite, and epidote; biotite, hornblende, garnet, muscovite, and calcite are present locally. The quartzofeldspathic (volcaniclastic and epiclastic) rocks typically contain albite, muscovite, epidote, and actinolite; biotite, hornblende, chlorite, and garnet occur as local phases. These assemblages indicate metamorphism in the greenschist-amphibolite transition facies of Turner (1968, p. 303-307) and local assemblages within the almandine zone of that facies. No systematic variation in metamorphic grade or extent of recrystallization exists, but hornblende, biotite, and garnet (at the expense of muscovite, actinolite, and chlorite) are more common in the southern and northeastern parts of the quadrangle, presumably due to proximity to granitic rocks. They also are more common near larger mafic intrusions and zones of more intense deformation.

STRUCTURE

The Archean rocks occur in a generally east-facing homocline that has undergone two main phases of deformation, which produced fabrics and folds, and probably a third phase of minor warping. The resulting structural configuration is best displayed by the broad Z-shape of the contact between upper and lower sequences. The development of this antiform/synform pair cannot be attributed solely to one deformational phase, but rather to overprinting of later (D_2) folds on sequences folded earlier (D_1). Minor folds and cleavage and the style of minor folds vary depending on the location within major folds, the relative ductility of the rocks, and the proximity to intrusions. Both D_1 and D_2 structures are most abundant and intense in the southern part of the quadrangle adjacent to the Wasson Lake pluton where fold interference occurs locally.

Figure 2 summarizes significant features of the structural evolution. D_1 involved the development of a pervasive foliation (S_1) and local folds (F_1). The S_1 cleavage and F_1 axial traces trend to the north-northwest, except where modified by D_2 folding. Thus, the major axis of compressional stress was oriented northeastward. The presence of F_1 folds can be inferred from stratigraphic top directions and the relationship between bedding (S_0) and S_1 planar structures (i.e., structural facing). Small-scale, isoclinal to tight F_1 folds are present locally; however, topping indicators are rare and rock types are interlenticulated, and therefore few large-scale F_1 folds can be depicted. The northwest-trending fold traces in the west-central part of the map area are inferred to be F_1, because quartz veins emplaced along the axial planar S_1 cleavage near hinges were dextrally folded by D_2. In the northern part of the quadrangle, where D_1 structures are only slightly modified by D_2, conglomerate clasts, pillows, and amygdules are elongated by 5:1 to 8:1. The D_1 deformation presumably is related to emplacement of the granodioritic rocks of the Wasson Lake pluton and perhaps other unexposed granitoid rocks to the east. This conclusion is based on field evidence which indicates that apophyses of the granodiorite were emplaced both during and after D_1, but before D_2.

The second deformation (D_2) produced large-scale bending of F_1 fold axes, boudinage and folding of D_1 axial planar veins and dikes, pervasive small-scale folds with Z-symmetry, and dextral shearing. Much of the gneissic fabric of the Wasson Lake pluton can be attributed to D_2. The strikes of D_2 planar structures are consistently west-northwestward and dips are steep to the south. The expression of D_2 fabric ranges from a weak cleavage in the north to a well-developed cleavage and schistosity associated with dextral shear in the south. Lineations are defined by elongated clasts, amygdules, and minerals, and by S_1/S_2 intersections that plunge eastward. The presence of dextral shear is displayed locally by asymmetric pressure shadows around grains and clasts. The combination of dextral structures and apparent north-south shortening indicates that D_2 was a transpressional deformation with major compressional axes oriented north-northwestward. The broad warping of F_2 axial traces probably is the result of a D_3 event that did not produce a fabric.

Two major sets of faults exist. The northeastward strike of the Bear River fault and the apparent offset of geophysical and lithologic markers west of the quadrangle imply at least some component of sinistral strike-slip movement. Although no outcrops occur near the fault, it appears to juxtapose rocks of higher metamorphic rank (greenschist-amphibolite transition facies) to the south against rocks of lower rank (greenschist facies) to the north. Significant vertical dislacement is also a probability. The northwest-striking faults with inferred dextral offset were mapped on the basis of an increase in intensity of dextral shearing in outcrops near linear topographic depressions, together with local, corresponding offset of geophysical markers. Outcrop-scale structures imply that other faults probably exist, but these could not be delineated because exposures and markers do not suffice. These structures indicate that in general the left-lateral, northeast-striking faults predate the right-lateral, northwest-striking ones.

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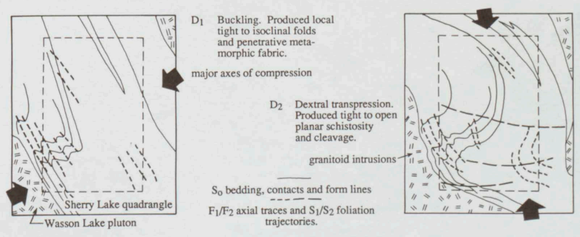

Figure 2. Evolution of major Archean folding.

GEOLOGIC MAP OF THE SHERRY LAKE QUADRANGLE, ITASCA COUNTY, MINNESOTA

By
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1988