DL-1
PRELIMINARY GEOLOGIC DATA DIAMOND-DRILLING FOR GEOLOGIC INFORMATION IN THE MIDDLE PRECAMBRIAN BASINS IN THE WESTERN PORTION OF NORTHERN MICHIGAN

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INTRODUCTION

This report presents more geologic data than appear in the Engineering Report for DL-1, issued in Grand Junctions More geologic information also will follow in a final report on all holes, in which thin sections and chemical analyses will be reported along with correlations among all holes.

LOCATION (Lat. 46°45’30”N., Long. 87°50’28”W.)

Drill location 1 is on rolling forest land in the NW¼ SW¼, section 5, T.50 N., R.28W., Marquette County, Michigan, near a monument with an altitude of 1,152.90 feet, 795.42 feet east and 240.46 feet south of the west quarter corner of section 5. This site is reached by driving three miles on Marquette County Highway 510 generally southwestward from its intersection with County Highway 550 (southeast from Big Bay), thence three miles generally westsouthwestward on the Triple-A Road, thence two miles westward on another dirt road, and thence one-tenth of a mile southward oh a trail, which loops back eastward to the dirt road.

SITE SELECTION

The site was selected, on available State land, by the Michigan Geological Survey because U. S. Geological Survey gravity surveys by John Klasner suggested that it is on the north (upthrown) side of a major fault zone with parallel east-west peridotite dikes, whereas DL-3 is on the south (downthrown) side. The gravity measurements implied that at .DL-1 the Early Precambrian (age W) basement rocks should be at a depth of approximately. 1000 feet, and at a depth of approximately 3000 feet at DL-3.

GEOLOGY

SALIENT GEOLOGIC FEATURES DETERMINED BY DRILLING

Notable observations include the following:

1) Overburden of sand and boulders extends to a depth of 71 feet.

2) The orientation of the hole departed from the intended vertical by increasing degrees to a maximum of 56½° (33½° plunge) at the terminal depth of 2148 feet. At depths greater than 200 feet, all deviations occurred between the bearings of due N, and N.21°E., determined by Sperry-Sun single-shot camera, at depth intervals of 100 feet or 50 feet. The deviation is considered to be an attempt on the part of the bit to penetrate the conspicuous slaty cleavage perpendicularly.

3) Such slaty cleavage has an average strike of N.79°W., and has dips ranging between 37°SW. and 65°SW. Lack of absolute uniformity of dip of this axial-plane cleavage is ascribed to dragging adjacent to post-metamorphism faulting. Both bedding and slaty cleavage were dragged near apparently steeply-dipping essentially east-striking faults. At 1724 feet the cleavage was dipping 42°SW., perpendicular to the hole, so at that depth the strike and dip of the cleavage was N.79°W., 42°SW., perpendicular to the N.16°E, 48°NE. plunge of the borehole.

4) The bedding in the cores appears not to have the same strike as the slaty cleavage (as is the case at DL-3) so that here, at DL-1, the synclinal axis of the Baraga Basin is not horizontal (as is the case at DL-3). Paradoxically, the axis locally plunges southeastward at DL-1 rather than northwestward, as expected from the gross structure of the basin. For example, at a depth of 294 feet, where the N.5°E. deviation of 4½° from the vertical enables us to reorient the core in a mound of clay in the offices so that the core rotates on its axis until the slaty cleavage has the strike of N.79°W. (the average of the relatively uniform values observed at 33 outcrops in the basin), we can measure with a Brunton compass that the slaty cleavage has an attitude of N.79°W., 44°SW., and the bedding has an attitude of N.81°E., 24°SE. On a stereonet, the resulting linear intersection has a strike and plunge of N.65°W., 12°SE., which is presumed to be parallel to the synclinal fold axis, locally. This unexpected southeast plunge implies local structural complexities in the East Baraga Basin.

5) Taking into account the deviation of the hole, most strata dip from 30°SE. to 3°NW., with an average value of 14°SE. Locally, adjacent to steeply dipping approximately east-striking minor fault zones, strata have been dragged so that they dip from 35°-70°NW., as at 84-94 feet, 994-1004 feet, and 2074-2124 feet. These steeper dips are clearly shown in the latter two depth ranges where locally bedding is parallel to the length of the inclined core, whose orientation can be determined from Sperry-Sun single shot determinations.

6) The predominating southeasterly dip of the beds in the same general direction (though less steeply dipping) as the southwesterly dip of the slaty cleavage indicates that DL-1 is on the north limb of the Baraga Basin syncliney which is asymmetrical with a steeper southern limb (as at DL-3).

7) The Michigamme Formation consists principally of black and gray straight bedded or contorted slate in parallel layers or lenses, and massive gray argillite (finer) or graywacke (coarser). All the abovementioned lithologies occur with blebs and bands of pyrite accompanied by silica. Hard, dense, siliceous, massive black graphitic argillite with angular black “rip-up” clasts is a heavy rock which rings when struck with a hammer. Some portions retain slaty cleavage. This distinctive rock occurs between 1894-1960 feet, and sporadically thereafter to the terminal depth, 2148 feet. Algal stromatolites, as much as six inches in length, occur in gray bands at 1992 and 2039 feet. Presumably, these fossils are similar to those described by Mancuso, Lougheed, and Shaw, (1975), Carbonate-apatite in Precambrian cherty iron-formation, Baraga County, Michigan; Econ. Geology, v. 70, p. 583-586. However, unlike those described in that article, such fossiliferous beds at DL-1 are non-phosphatic. Presumably, such phosphatic beds should occur at greater depth at DL-1.

8) Vein quartz in many places is accompanied by pyrite and/or carbonate in ubiquitous cross-cutting veinlets and parallel to bedding.

9) Pyrite occurs at all depth ranges in the hole.

10) No chalcopyrite was observed.

11) No pyrrhotite was observed

12) Carbonate veinlets appear to be more abundant than at DL-3.

13) At 1718 feet, 6” of chlorite with calcite stringers and pyrite may be a metamorphosed or propylitized andesite possibly correlative with the Clarksburg Volcanics.

14) White talcous material (talc or pyrophyllite) along essentially vertical fracture planes from 129-134 feet indicates minor faulting.

15) Additional evidence of essentially vertical (presumably east-striking) faulting appears at 592-622 feet as very broken rock with calcite fracture fillings, at 999-1000 feet by duplication of strata, drawing of strata, fracturing and shearing with quartz, carbonate, and pyrite stringers, at 1775-1784 feet by strongly sheared graphitic slate with over 50% vein quartz, carbonate, and pyrite, at 1895-1897 feet by a sheared graphitic zone with quartz and carbonate veinlets, and at 2085-2088 feet by dragging of strata, intense folding and brecciation, plus abundant veinlets of quartz, carbonate, and pyrite. North is downthrown.

16) No diabase dike was encountered in this hole.

17) Scintillometer measurements of the core by Jack W. Avery reveal that with a background count of 60-70 c.p.s. most of the core registers between 65-100 c,p.s. with two exceptions: Between 86-90 feet black slate and gray argillite cause 100-130 c.p.s., in the impermeable horizon immediately beneath the permeable graphitic porous zone at 83-86 feet. This suggests that uranium-bearing solutions moved down-dip in the porous zone. A second, much thicker, radioactive zone occurs from 1734-2044 feet, with 100-130 c,p.s from cores of mainly black, carbonaceous lithologies.

18) Ammonium molybdate tests of acidized core (1:1 conc. HCl) at 2½-feet intervals by William T. Swenor, technician indicate that no obvious phosphorite occurs in the drilled sequence at DL-1. All tests were negative.

19) Errors in the calibration of depths Involved in the geophysical logging of the hole by Birdwell caused a maximum discrepancy of 14 feet between the actual depths and the designations on the Birdwell logs, so that 2162 feet on the geophysical logs, at the terminal depth of the hole, corresponds to an actual depth of 2148 feet. A given Birdwell depth, y', can be converted to a true depth, y, by multiplying the former by 2148/2162 - ,9935; y - 0.9935y'.

20) Figure 1, on the following page, is a cross section of the gross structure observed in drilling.

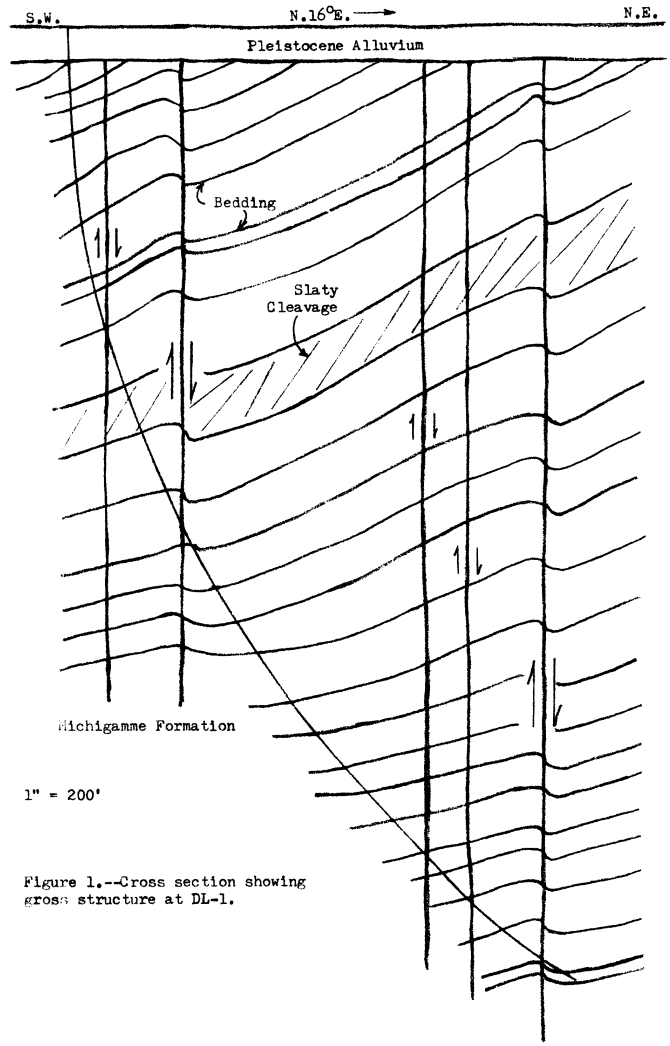
21) The vertical depth to the bottom of the hole exceeds 1800 feet, much greater than the 1000 feet depth to age W rocks estimated by John Klasner on the basis of gravity surveys. (The hole was terminated on November 30, as chronicled in the section on borehole history, still in the age X Michigamme Formation with an anticipated 400-500 more feet to the age W basement.) As at DL-3, this error in the geophysical depth estimate by Klasner probably relates to a much higher greenstone/granite ratio of the concealed age W lithologies, and therefore relates to a much higher than anticipated density for such rocks.

22) Birdwell bulk density data confirm the general impression that cores from DL-1 contain fewer sulfides than cores from DL-3, and hence are less dense. Down to a depth of approximately 250 feet, the Michigamme Formation averages approximately 2.70 g/cm^3; from that depth to 1?50 feet it averages approximately 2.80-2.85 g/cm^3, below the latter depth it decreases to an average of approximately 2.70 g/cm^3.

23) The gamma ray log reveals minor radioactive peaks at Birdwell depths of 86-89 feet, 100-102 feet, 176-182 feet, 1193-1196 feet, and 1576-1580 feet, in addition to a broad stratigraphic sequence below 1696 feet,

24) The neutron log reveals the porous zone at 83-86 feet, mentioned in #17. Generally speaking, high neutron log values (to the right on the logs) correspond to rocks which are more siliceous or pyritic, and less clayey, less micaceous, and less chloritic.

25) Self-potential and resistivity logs apparently suggest relatively thin alternations involving graphitic and non-graphitic laminae down to 1068 feet (Birdwell depth), thicker banding between 1068-1150 feet, thinner laminations, again, from 1150-1207 feet, thinner laminations with more uniform graphite content from 1372-1644 feet, and almost uniformly high graphite content from 1644-2148 feet. At depths less than 1372 feet the graphite content appears to be less uniform than below that depth, which corresponds to an actual depth of 1363 feet.



[Figure 1.--Cross section showing gross structure at DL-1.]

COMPLETE DRILL LOGS

Inasmuch as many valuable details are included in Jack W, Avery's on-site logs, these are being reproduced in their entirety, for the benefit of the public.

RECOMMENDATIONS FOR FURTHER EXPLORATION

No ore grades or tonnages were penetrated by the drill. However, the possibility may exist for thin gently-plunging linear ore bodies where southward-dipping permeable strata intersect east-west vertical Keweenawan diabase or peridotite dikes with sulfides suitable for reducing down-dip-migrating uranyl orthophosphate, carbonate, and dicarbonate solutions to pitchblende. For example, the permeable zone from 83-86 feet was floored by a radioactive impermeable footwall, suggesting that uranyl solutions had moved down the permeable zone. If the strike and dip of this permeable zone continues without change (unlikely)f orthographic projections demonstrate that it should intersect a projection of a Keweenawan peridotite at a depth of approximately 2400 feet, 1½ miles to the south of DL-1, in the NW¼ sec. 17, T.50N., R.28W. Clearly, this is too small a target to be drilled with confidence at such a depth in a formation which deviates holes as much as this. However, the same horizon should intersect the dike at the bedrock surface, more within reach, in the NW¼ sec. 8, T.50N., R.29W., if again, it continues with unchanged average strike and dip observed at DL-1 (again, unlikely). There may be other such permeable strata floored by now radioactive footwalls between DL-1 and the peridotite dike. These possibilities suggest that alpha-radon determinations, radon emanometry, or helium analyses might hold promise if conducted on the up-dip side (with respect to Michigamme Formation) of vertical Keweenawan diabase and peridotite dikes, which can be located magnetically, in an attempt to select possible drill sites for testing for relatively shallow gently-plunging linear ore bodies. The same principle applies to other basins in the region.

If inclined holes initially can be aimed perpendicularly to the slaty cleavage, they may remain straight. For vertical holes 1) use inside-outside double-step bits rather than flat-faced bits, 2) abandon hydraulic advance in favor of letting the rods “float” in deeper holes, 3) use Torque-Trim to minimize friction, 4) use a sharp bit (change more frequently than crews might like), and 5) use a 10-feet long core barrel instead of a 20-feet long barrel, as this part of the string is more limber, and may cause deviation more readily than any other. However, if truly vertical holes are desired in this part of the Michigamme Formation, hammer drilling (followed by extensive geophysical logging) probably would yield straighter holes, but would yield no core.