DL-5
PRELIMINARY GEOLOGIC DATA DIAMOND-DRILLING FOR GEOLOGIC INFORMATION IN THE MIDDLE PRECAMBRIAN BASINS IN THE WESTERN PORTION OF NORTHERN MICHIGAN

James Trow
Geologist-in-Charge
for
Geological Survey Division
Michigan Department of Natural Resources

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INTRODUCTION

This report presents more geologic data than appear in the Engineering Report for DL-5, issued in Grand Junction. 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°38'34" N., Long. 87°41'9" W.)

Drill location 5 Is on a partly forested sandy plain in the NW¼, SE¼ section 16, T.49N., R.27W., Marquette County, Michigan, in an area north of the Dead River Basin, at a point approximately 300 feet north of a monument at an altitude of 1429.83 feet, approximately 415 feet east and 367 feet south of the center of the section. This site is reached by driving northwestward from U. S. Highway 41 on County Highway 510 for approximately thirteen miles, and thence on a dirt road one mile generally westward, to turn south onto a trail at the drill site.

SITE SELECTION

The site was selected by the Michigan Geological Survey because of the intersection of two gravity anomalies which suggests the intersection of two grabens, and hence a maximum stratigraphic section, on gravity maps by John Klasner of the U. S. Geologic Survey. It was considered that the fullest sequence of age X metasediments could be sampled here, rather than at any other location in the Clark Creek Basin.

GEOLOGY

SALIENT GEOLOGIC FEATURES DETERMINED BY DRILLING

Notable observations include the following:

1) Sand overburden extends to a depth of at least 320 feet.

2) The orientation of the hole departed from the intended vertical by increasing degrees to a maximum of 3°, S.10°W., at the terminal depth of 1148 feet. The absence of extreme deviation, as observed at DL-1, DL-3, and DL-7, correlates with less obvious or non-existent slaty cleavage, which where it does exist possesses low dips between 20° and 40°, less steeply inclined than at DL-1, DL-3, and DL-7.

3) One mile west of DL-5, Jack W. Avery discovered an outcrop in which the attitude of the slaty cleavage is N.77°W., 56°SW., steeper than the cleavage observed in the core at DL-5. However, it is presumed that at DL-5 the slaty cleavage also dips generally southwestwardly.

4) The apparent parallelism of the strike of bedding and slaty cleavage implies that this portion of the Clark Creek Basin must be essentially non-plunging; its fold axis must be essentially horizontal near DL-5.

5) Bedding in the cores of age X strata appears to dip in the same direction as the slaty cleavage, presumably to the southwest, so that DL-5 must lie on the northeastern limb of the sync line of the Clark Greek Basin. The dip of bedding planes ranges between 15°-45°SW., with an average value of 30°SW., for age X units. Age W units dip approximately 50°, presumably to the northeast in conformity with the orientation of such strata to the southeast in the 7½' U. S. Geological Survey Negaunee and Negaunee SW Quadrangles. Shearing in the age W rhyolite dips approximately 60°, also presumably to the northeast.

6) The commonly observed parallelism of slaty cleavage and bedding in age X units implies that DL-5 is not on the axis of the Clark Creek Basin syncline. Such parallelism could also imply the presence of isoclinal folding, although no obviously overturned beds consistent with that interpretation were observed in the core.

7) Stratigraphic units penetrated include typical Precambrian X Michigamme Formation slats, argillites, and graywackes (a, b, e, f, and g), chert- and carbonate-bearing beds (c), conglomerates (d and i), and quartzite (h), with a disconformity between units d and e. A Keweenawan, age Y, diabase dike intrudes unit b. The age X units unconformably overlie age W porphyritic sheared metarhyolite tuff (j) and metabasalt (k), both probably correlative with portions of the Mona Schist:

   a) From 339-475 feet gray-green wavy bedded argillite contains a few light gray bands of siliceous greywacke. Pyrite is absent. The green color may be related to the first (sulfur-oxidizing) episode of pyrite oxidation which leaves iron in the ferrous state (see DL-7 Preliminary Geologic Data). Apparently, the second (iron-oxidizing) episode of pyrite oxidation has not occurred here, as it has occurred at DL-7.

   b) From 475-523 feet light to dark gray straight to wavy bedded argillite contains minor pyrite. From 523-602 feet a fresh age Y diabase dike with chilled borders and a metamorphosed xenolith dips from 45°-60°, presumably southward from its relation to bedding. From 602-660 feet dark gray straight thin bedded argillite appears somewhat hornfelsic adjacent to the diabase. Pyrite is very abundant.

   c) From 660-639 feet light gray to white chert and carbonate contain algal stromatolites from 682-683 feet. From 689-695 feet occurs a light gray soft massive argillite and carbonate zone. From 695-698 feet occurs hard chert of light color. From 698-702 feet occurs a light gray soft massive sericitic carbonate zone.

   d) From 702-714 feet a gray-green soft conglomeratic zone appears to me to be mainly volcanic agglomerate, whose volcanic debris imparts the green color. At the base of this unit (713-714 feet) occurs a more typically conglomeratic zone with dark gray argillite pebbles, chert, sericite, and fine clastic matrix impregnated with abundant pyrite and some chalcopyrite. An undulating disconformity occurs at the base of this unit.

   e) From 714-750 feet light gray thin straight bedded hard siliceous graywacke and argillite locally are vuggy and brecciated.

   f) From 750-866 feet gray-green thin straight bedded argillite is commonly chloritic down to 836 feet, below which chlorite content diminishes. Minor sulfides are present,

   g) From 866-884 feet gray thin straight bedded argillite alternates with graywacke and quartzite, which become more common with depth as slates and argiliites diminish with depth. Tan 1-2 mm round blebs (altered feldspar?) occur in the upper portions of this unit.

   h) From 884-996 feet -ray massive quartzite contains a few thin slate beds and minor pyrite. At 900 feet occurs a ¼"-thick seam of graphite and pyrite.

   i) From 996-997 feet gray-green quartzite with a few black phosphatic sand grains grades downward into a basal conglomerate with black phosphatic pebbles less than 1" in diameter (mostly ¼" in diameter). The base of the bed is a ¼"-thick black graphitic seam which overlies a profound major angular unconformity, separating Precambrian X strata, above, from Precambrian W strata, below.

   j) From 997-1059 feet occurs Precambrian W mildly sheared light green porphyritic metarhyolite tuff with quartz phenocrysts. Bedding dips 50°, probably NE, and shearing dips 60°, also probably NE. U=72-76 ppm.

   k) From 1059-1148 feet occurs Precambrian W green metabasalt with abundant sulfides. A particularly massive pyrite and pyrrhotite "strata-bound" zone with traces of gold occurs along with small masses of quartz and carbonates in the upper 6 feet of this unit, directly beneath the metarhyolite. The actual stratigraphic thickness of this metalliferous zone is less than 4 feet. Sulfides continue in diminishing abundance to the bottom of the hole at 1148 feet, with copper traces as much as 2010 ppm.

8) Vein quartz, in many cases accompanied by carbonate, occurs as a cross-cutting veinlet at 355 feet, is common as conformable and cross-cutting veinlets between 456-523 feet, occurs as a

conformable 4” vein at 660 feet, occurs as a conformable 6” vein at 702 feet, occurs at 826 and 836 feet, and especially occurs with carbonate as blobs and veins in Precambrian W metabasalt, from 1059-1148 feet.

9) Pyrite appears to be absent at depths less than 475 feet, and within the cherty carbonates and related lithologies (c) from 660-702 feet. Pyrite is present in greater or lesser amounts in veinlets with quartz and carbonate, as disseminations, and parallel to bedding at almost all other levels.

10) Chalcopyrite occurs in a conglomerate between 713-714 feet, and in a 3”-thick conformable breccia zone at 792 feet, also below 1059 feet level.

11) Pyrrhotite occurs with pyrite in the massive “strata-bound” sulfides in the Precambrian W metabasalt, with particular abundance immediately below the metarhyolite, from 1059-1065 feet.

12) Carbonate veinlets, commonly with quartz, occur at 355, 466-523, 660, 792, 796, and 836 feet within age X strata; carbonate veinlets without quartz are common within the age Y diabase dike between 578-592 feet; carbonate, quartz, and sulfide veinlets occur in the metabasalt of age W, between 1059-1148 feet.

13) Gold occurs as a trace from 20-50 ppb with the sulfides in the age W metabasalt, from 1059-1148 feet.

14) Thin conformable brecciated zones at 462-463 feet, within the interval 477-498, and at 729, 743, 744, 792, and 796 feet suggest slippage.

15) Seams of graphite ¼”-thick, parallel to bedding, occur at 900 and 997 feet.

16) The Keweenawan diabase dike with finely grained chilled margins, 523-602 feet, apparently dips from 45°-60° generally southward, to connect with the major east-striking diabase dike which Jack W. Avery and I located by its negative magnetic anomaly, 1000 feet south of DL-5. Our magnetic measurements suggest that the major dike is at least 300 feet chick, and is essentially vertical. Airborne magnetics revealed such a dike in the vicinity of DL-5, so we ran the north-south magnetic lines on the surface to insure that drilling would sample metasediments rather than diabase.

17) Scintillometer measurements of the core by Jack W. Avery reveal that with a background of 30-40 c.p.s., most of the age X core registers between 45-80 c.p.s. Exceptions include the 30-40 c.p.s. at 710-720 feet, and the 90-100 c.p.s. in a 4” conformable vein quartz, carbonate, and argillite zone at 660 feet. The age W metarhyolite possesses radioactivity comparable to that of age X strata, 50-80 c.p.s. The age W metabasalt possesses low radioactivity with 30-45 c.p.s. Likewise, the age Y diabase dike possesses low radioactivity, 30-40 c.p.s.

18) Ammonium molybdate tests of acidized core (1:1 conc. HCl) by technician William T. Swenor indicate that with one exception, no obvious zones of phosphorite occur in the drilled sequence at DL-5. The exception occurs at 996-997 feet where the basal conglomerate of the age X sequence contains black phosphatic pebbles.

19) Presumably, the Longyear drillers and the Birdwell loggers are in near agreement, this hole is 1148 feet deep, or at most 1149 feet (Birdwell).

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

21) Birdwell bulk density logs reveal that most of the Michigamme Formation ranges between 2.65 and 3.00 g/cm^3, with the exception of a thin zone from 839-841 feet which contains 3.17 g/cm^3. Age W metarhyolite has the same density as the immediately overlying age X metasediments, 2.65-2.70 g/cm^3. Age W metabasalt with sulfides has heavier densities, from 2.90-3.17 g/cm^3. Age Y diabase, 523-602 feet, averages 3.15 g/cm^3.

22) The gamma ray log shows that low intensity materials include overburden, the age Y diabase dike (523-602 feet), some chert and carbonate zones (660-702 feet), and the age W metabasalt (1059-1148 feet). Higher intensities are registered for slates, argillites, and graywackes down to 660 feet, for the conglomerate at 713-714 feet, and for the age W metarhyholite (997-1059 feet).

23) The neutron log shows that overburden is more water soaked than is bedrock; some chert and carbonate layers between 690-702 feet are relatively water free, as is quartzite between 884-996 feet, and metarhyolite between 997-1059 feet. The metabasalt, below 1059 feet, must contain as much combined and uncombined water as do slates, argillites, and graywackes at lesser depths than 660 feet. The diabase dike (523-602 feet) appears to be relatively “dry” with the exception of the zone above the metamorphosed argillite xenolith, 592-595 feet.

24) Self-potential and resistivity logs conspicuously reveal the agglomerate-conglomerate zone (702-714 feet) and the top of the massive sulfide zone in the metabasalt, at 1059 feet.

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, two thin conglomeratic zones, one at 713-714 feet and the other at 996-997, both immediately above erosion surfaces, indicate the presence of horizons at

DL-5 which may be significantly uraniferous elsewhere. The most promising footage encountered in the hole occurs in the Precambrian W strata. The porphyritic metarhyolite tuff contains 72-76 ppm uranium, chemically determined. This probably served as an excellent source for some of the uranium now dispersed in Precambrian X metasediments in the region, and is richer in uranium than any Precambrian X strata encountered in this hole.

The most hope for an ore discovery directly related to this drilling concerns massive strata-bound probably vulcanogenic sulfides with significant traces of copper and gold in the Precambrian W metabasalt, from 1059 feet to the bottom of the hole at 1148 feet. The most spectacular core here is primarily pyrite and pyrrhotite in a massive sulfide zone starting abruptly below the metarhyolite, and it constitutes a stratigraphically 4-feet-thick zone at the top 6 feet of the metabasalt, from 1059-1065 feet. However, the entire footage of matabasalt contains stringers of sulfides, which presumably continue to greater depth. Analyses are as follows:

Footage	Au	Cu
1059-1065	40 ppb	274 ppm
1065-1069	30 ppb	380 ppm
1069-1080	30 ppb	2010 ppm
1080-1090	30 ppb	124 ppm
1090-1100	20 ppb	181 ppm
1100-1110	40 ppb	261 ppm
1110-1120	50 ppb	290 ppm
1120-1130	30 ppb	130 ppm

If one found an outcrop with these characteristics, one would look nearby for another Noranda. The drill may have penetrated the iron-rich margin of base- and precious-metal strata-bound ore. Unlike the gold at the Ropes, Michigan, Morgan, and Fire Center mines in Marquette County, this sulfide mineralization appears to be stratigraphically controlled, and occurs with considerable pyrrhotite, which is missing at the abovementioned explorations, Marquette County may contain another type of copper-gold deposit than the type usually sought there.

The metabasalt may be richer down dip or along strike, which is presumed to trend approximately due west to N.65°W., on the basis of the nearest exposures of Precambrian W strata. Of particular interest is a favorable stratigraphic configuration between “felsic metavolcanic rock” and metabasalt apparently along strike from DL-5, in the SW¼ section 19, T.49N., R.26W., shown by Puffett on Plate 1 of U. S. Geological Survey Professional Paper 788 on the Negaunee Quadrangle. A small ravine locally may be caused by topographically weak massive sulfides. This trend should be examined geophysically and geochemically westnorthwestward toward DL-5, and in the opposite direction as it swings northeastward, as this area is on the margin of of a westnorth-west-trending positive gravity anomaly called to my attention by Robert C. Reed. In other regions, strata-bound sulfide deposits occur on the flanks of positive gravity anomalies.

In addition to surface prospecting southeastward along strike from DL-5, and in addition to subsurface exploration down dip and in both directions along strike from DL-5, explorationists might re-examine the contact between felsic volcanic rocks and metabasalt of the Mona Schist, shown by Cannon and Klasner in the northwest corner of U. S. Geological Survey Negaunee SW Quadrangle (19751 Map GQ-1226), in the SE¼ section 24 and the NE¼ section 25, T.49N., R.28W. Other metarhyolite-metabasalt contacts may be favorable.

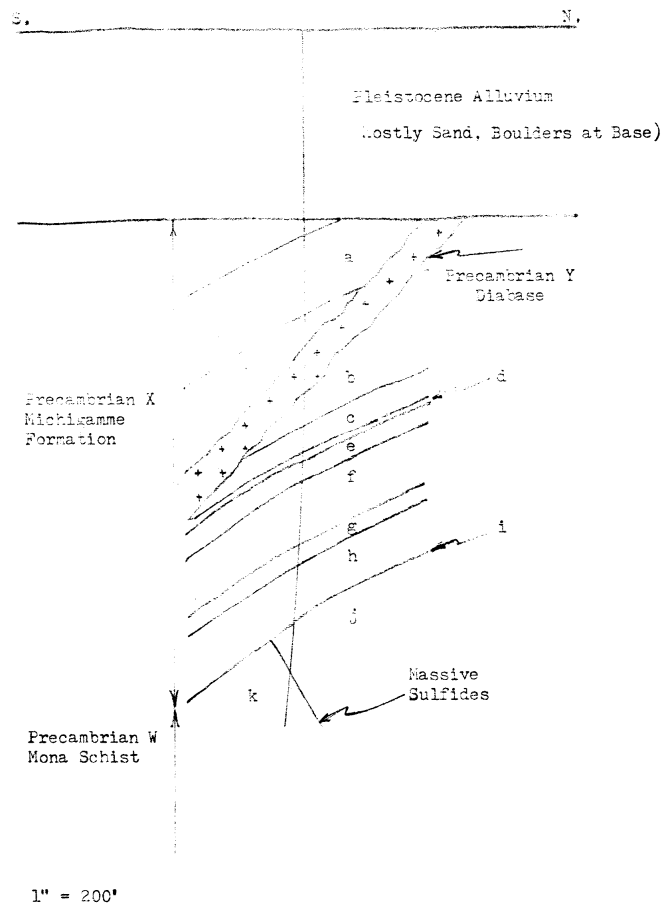

Figure 1.--Cross section showing gross structure at DL-5. For brief description of strata see pages 2-3.