DL-4
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-4 in the Dead River Basin, issued at Grand Junction. More information also will follow in a final report on all holes, in which thin sections, chemical analyses, and correlations among all holes will be discussed.

LOCATION (Lat. 46°35'32"N., Long. 87°46'15"W.)

Drill location 4 is on rolling forested land in the NW¼, NE¼ section 2, T.48N., R.28W., Marquette County, Michigan, on the northeast side of County Highway 573, 70 feet northwest of a bench mark of 1469 feet altitude. The monument at 1469.94 feet altitude is 157.49 feet east and 505.92 feet south of the N¼ corner of section 2. The site is reached by driving approximately twelve miles generally northwestward on County Highway 573 from its intersection with U. S. 41 in Ishpeming.

SITE SELECTION

Originally, the Michigan Geological Survey selected a site several hundred feet to the southeast of the abovementioned location, because of John Klasner's gravity survey for the U. S. Geological Survey. This map suggested that a maximum stratigraphic section of Precambrian X strata would be encountered at the original site. However, a ground magnetometer survey by Jack W. Avery and me showed that the original selection was too close to an east-west negative magnetic anomaly thought to be caused by a Precambrian Y diabase dike. Accordingly, we moved the site several hundred feet northwestward along the road, to avoid any risk of coring solely a vertical diabase dike.

GEOLOGY

SALIENT GEOLOGIC FEATURES DETERMINED BY DRILLING

Notable observations include the following:

1) Mainly sandy overburden extends to a depth of 45 feet, below which bouldery overburden extends to a depth of 76 feet.

2) The orientation of the hole departed from the vertical by increasing degrees to 12° (S.30°W.) at 3126 feet, 50 feet above the terminal depth of 3176 feet. The hole spiraled by starting at ledge to deviate to the northwest, then clockwise to the northeast, then to the southeast, and finally to the southwest. This implies no strong lithologic control of deviation, as was caused by slaty cleavage at DL-1, DL-3, and DL-7.

3) Slaty cleavage dips from 35°-65° with an average value of 55° in the core. Inasmuch as most of the cleavage observed in outcrops in the center of the Dead River Basin dips southwestwardly, it is presumed that the slaty cleavage in DL-4 core also dips southwestwardly.

4) The near parallelism of the strike of slaty cleavage and bedding in the core implies that the sync line is gently plunging or non-plunging at DL-4.

5) Assuming that slaty cleavage uniformly dips to the southwest, bedding of Precambrian X strata in the cores dips mostly in the opposite direction, between 5°-40°NE., with an average value of 25°NE. These observations imply that DL-4 is on the southwestern limb of the Dead River Basin syncline. However, near several faulted zones between 1390-1546 feet, and near a small dike near 2825 feet dragged segments display steeper dips and/or strata which locally dip in the same direction as slaty cleavage, from 20°-30°SW.

6) Inasmuch as the angle between slaty cleavage and bedding varies between 15°-85°, with an average of 50°, DL-4 is not on the axis of the syncline, where slaty cleavage and bedding would be expected to be perpendicular.

7) Stratigraphic units penetrated include Precambrian X K Michigamme argillites, slates, graywackes, and conglomerates in classic turbite sequences (a), chert and carbonate beds with interbedded argillites and conglomerates (b), and graywacke which trades downward into orthoquartzite (c). The latter unconformably overlies Precambrian W granitic rocks (d).

   a) From 84-2966 feet straight bedded to wavy bedded and massive light gray to black graphitic argillite and slate alternate with graded bedded salt and pepper graywacke with rip-up clasts, characteristic of the lowest unit of Bouma's turbidite sequences. These rocks contain abundant disseminated and patchy pyrite, as well as pyrrhotite at deeper levels. Soft-sediment deformation abounds. Below 1670 feet level clastic pink feldspars and quartz sand-sized grains become common; below this level chlorite becomes more common in argillites. Below the 1916 feet level biotite becomes noticeable. The shallowest graywacke-to-quartzite bed occurs between 2358-2375 feet. Algal stromatolites in zones from 3"-5" thick occur at 276I, 2769, 2774, 2856, 2861, and 2907 feet. The shallowest conglomerate appears as a bed 6" thick with pyrite and chalcopyrite at 2832 feet.

   b) From 2966-3019 feet carbonate is a conspicuous sedimentary constituent in argillites, graywackes, and conglomerates. Cherty carbonate occurs within the zones 2971-2973 and 2994-3019 feet. Interesting thin 2"-thick conglomerate zones at 3008 and 3011 feet registered 140 c.p.s. and 240 c.p.s., respectively, when Jack W. Avery tested core with a scintillometer whose background level was 50-60 c.p.s.

   c) From 3019-3119 feet straight bedded reddish-gray graywacke grades downward into gray orthoquartzite which unconformably overlies

   d) From 3119-terminal depth of 3176 feet Precambrian W granitic rocks, the upper portions of which appear to grade into the overlying Precambrian X quartzite, as a consequence of deep pre-Michigamme weathering and eventual metamorphism. These greenish chloritized weathered-then-metamorphosed granitic rocks reveal gneissic foliation which dips more steeply than the bedding in the overlying quartzite, according to David W. Snider. Below this metasaprolite or metaregolith occurs typical granitic biotite gneiss, in which the hole was terminated.

8) Vein quartz appears as concordant and discordant veinlets and in breccia zones at many levels either alone or with carbonates, sulfides, and at a few places with graphite. Quartz occurs at levels below 455 feet.

9) Pyrite appears at almost all levels from 84 feet to the bottom if the hole, in blebs, in thin massive zones parallel to bedding and in brecciated zones,

10) Chalcopyrite occurs with sphalerite in a 1/8"-thick massive concordant format at several levels between 1388-1411 feet. Calcopyrite without obvious sphalerite occurs within the zone 1402-1506 feet, between 1685-1706 in a fault zone with vein quartz, and at 2832 feet in a conglomerate.

11) Pyrrhotite occurs in ¼" bands between 1402-1506 feet, in the zone 2782-2825 feet with pyrite, and mainly without pyrite in Precambrian W granite gneiss at 3127 feet.

12) Carbonate veinlets, in many instances with vein quartz, sulfides, and graphite, occur at many levels as concordant and discordant veinlets and in brecciated zones.

13) Pink feldspar in a 2"-thick aplite dikelet occurs at 2350 feet; green epidote and chlorite occur in veins between 2828-2830 feet.

14) White talcous material (talc or pyrophyllite) occurs as fracture fillings between 84-116 feet.

15) Presumed faulting between 1069-1084 feet is suggested by gouge dipping 70°-90°SW. in sheared, brecciated graphitic argillite with vein quartz and sulfides. This probably is the same zone which appears in the redrilled sequence B from 1053-1056 feet with strongly sheared graphitic gouge. Between 1274-1276 feet graphitic fault gouge dipping 60°SW.' in the opposite direction to bedding, occurs with veinlets of quartz and carbonate. This probably is the

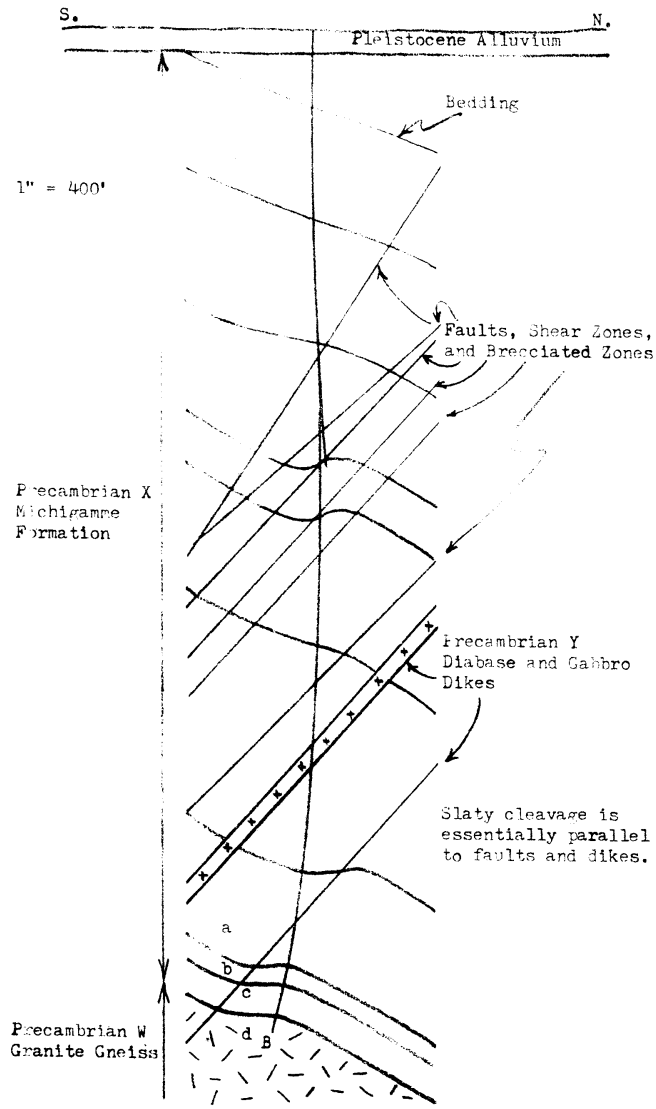
zone observed during the redrilling B at 1316-1318 feet, where sheared graphitic gouge occurs. At 1394-1402 feet a shear zone with vein quartz, graphite, and sulfides is brecciated. At 1540-1545 feet strongly distorted strata are impregnated with vein quartz and graphite. At 1085-1706 feet badly sheared and broken graphitic-chloritic argillite contains veinlets of quartz with chalcopyrite. At 2098 feet a 6”-thick discordant vein of quartz, carbonate, and pyrite is apparently slickensided by minor movement. Where dragging of beds occurs, it suggests that these various faults are gravity faults, with the southern (hanging) wall downthrown.

16) Precambrian Y unmetamorphosed light gray diabase and gabbro occur between 2286-2358 feet, with minor sulfides, with a dip of 55°-60°SW. A minor finely grained dark gray dike occurs between 2825-2827 feet. It appears to dip 55°-60°SW. Apparently these are offshoots from the major vertical east-trending diabase dike which appears to be approximately 250 feet thick, starting approximately 750 feet south of DL-4, according to the negative magnetic anomaly located by Jack W. Avery and me. These orientations suggest that while the major Precambrian Y dikes are vertical east-trending structures, minor offshoots from them apparently were injected along the slaty cleavage of Precambrian X strata.

17) Scintillometer measurements of the core by Jack W, Avery and David W. Snider show that with a background of 40-50 or 50-60 c.p.s. most of the Precambrian X core ranges between 50-80 c.p.s. Exceptions include footage between 1390-1490 feet where values as much as 100 c.p.s, were recorded for strongly cleaved black graphitic slate with massive ¼” sulfide bands with pyrite, chalcopyrite, and pyrrhotite; between 1530-1540 feet 80-90 c.p.s. readings were obtained on similar slates; between 2850-2930 feet values as high as 100 c.p.s. were obtained in black massive graphitic argillite with sulfide bands and slight phosphate content; the highest values were observed in 2”-thick conglomerates at 3008 and 3011 feet. 140 and 240 c.p.s. respectively. Precambrian Y diabase displays background level readings of 45-55 c.p.s. Precambrian W granite gneiss registers 50-70 c.p.s, with minor phosphate (accesory apatite ?) content.

18) Ammonium molybdate tests of acidized core (1:1 cone. HCl) by William T. Swenor, tecnhician, indicate that no obvious phosphorite occurs in the drilled sequence above the 2810 feet level. Below that, slight phosphate anomalies occur within the intervals 2810-2820, 2830-2840, 2890-2900, 2960-2980, 3050-3060, and scattered within 3110-3167 feet.

Figure 1.--Cross section showing cross structure at DL-4. For brief description of strata see pages 1-3.



19) The error in calibration of depth by Birdwell caused a maximum discrepancy of only 2 feet between the actual terminal depth of 3176 feet and the 3174 feet shown on the gamma ray-neutron and caliper-bulk density logs. To correct these two logs to actual depth, multiply the Birdwell log depth by the factor 1.0006.

20) Figure 1, on the preceding page, is a cross section of the gross structure observed in drilling. Warning--the scale of this cross section is only 1” = 400 feet rather than 1” = 200 feet as used in engineering reports on all the other holes of this project. The great depth at DL-4 required a smaller scale to allow the diagram to appear on one page.

21) The Birdwell bulk density lose shows that the Precambrian W and Precambrian X rocks possess densities mainly between 2.70-2.95 g/cm^3. Some very low densities occur at fracture zones at 1686-1696, 1728-1732, and 1789-1792 feet. The caliper log also reveals these as caved zones. The

Michigamme Formation exceeds a density of 3.00 g/cm^3 at only two places, 2972-2974 and 3008-3011 feet. The latter is at the level of the two most radioactive 2”-thick conglomerates encountered. The Precambrian Y diabase and gabbro dike at 2286-2358 feet has a density of 3.13-3.27 g/cm^3.

22) In general, the Birdwell gamma ray log indicates higher radioactivity for Precambrian X strata than in any of the other holes of this project in Marquette County; in general, scintillometer measurements of the core from DL-4 do not surest that most of this core is significantly more radioactive than that from the other holes. At DL-4 the gamma ray log reveals the following hierarchy of radioactivity, from higher to lower:
   a) conglomerates at 3008 and 3011 feet,
   b) sulfide- and graphite-rich slates and argillites,
   c) graywackes,
   d) quartzites,
   e) Precambrian W granite gneiss,
   f) Pleistocene overburden, and
   g) Precambrian Y diabase and gabbro.

23) The neutron log suggests low water content for cherty carbonates from 2992-3018 feet, for quartzite from 3058-3108 feet, and for “fresh” Precambrian W granite gneiss from 3129-the terminal depth. In contrast the graywacke above the quartzite and the metaregolith below the quartzite reveal a higher .water content.

24) The self potential log is not instructive. The first run of the resistivity log has such a, long electrode spacing that it does not reveal much of detailed geologic significance. The lower, mono electric log, portion shows the most sulfide- and graphite-rich zones by low resistivity.

COMPLETE DRILL LOGS

Inasmuch as many valuable details are included in logs by Jack W. Avery and David W. Snider, these are being reproduced in their entirety, for the benefit of the public. It should be noted that inasmuch as deviation from the vertical had reached 3½° by 1356 feet, a wedging was called for. The improper insertion of the wedge resulted in 6° deviation by 1370 feet, so that by the time the hole had reached 1411 feet it was recommended that the hole should be cemented back to just above the wedge, rewedged, and continued. Rods were not pulled high enough and too much cement was used, so that rods were cemented in the hole. Corrective measures taken at Longyear’s expense ultimately resulted in rewedging and resuming drilling from 987 feet. On the D.D.H. sheets the original 0-1411 feet are designated DL-4; the following 987-3176 feet sequence is designated DL-4B.

The reader should realize that these on-site logs, recorded during severe winter conditions, represent a first impression of lithology. Upon review, a revision is suggested concerning Jack W, Avery’s altered intrusive (?) at 142-143, 153-156, 187-193, and 224-230 feet, and beds thereafter referred to a salt and pepper textured ash beds, volcanoclastic sequences, and salt and pepper extrusives or elastics. In the opinions of David W. Snider and me, these are all traded bedded graywackes with ripped up chunks of slate or argillite deposited by turbidity currents in a flysch environment. These salt and pepper beds appear to be examples of the lowest unit of a classic clastic Bouma-type turbidite cycle. Volcanic rocks appear to be uncommon at DL-4.

RECOMMENDATIONS FOR FURTHER EXPLORATION

No ore grades or tonnages were penetrated by the drill. The most significant showings of uranium occur in 2”-thick conglomerates at 3008 and 3011 feet, demonstrating that the uraniferous phosphatic zone exposed on the perimeter of the basin is present, but very thin, at the center of the basin. While it suggests some stratigraphic continuity, it offers little hope for a commercial uranium deposit at DL-4, itself.

Copper and zinc mineralization parallel to bedding appears at several levels, particularly where faulting, shearing, brecciation, and deformation of strata are obvious. The richest sequence, between 1399-1554 feet, contains several statistical samples (one 5-feet sequence every 30 feet) in which the sum of copper plus zinc ranges between 1500-2000 ppm. This zone might be followed up dip to its subcrop immediately below overburden, and probed with geophysical surveys, although abundant pyrite and graphite would cause false anomalies: Hydrothermalists could follow the shear zone up dip and explore ½-mile to the north of DL-4; sedimentary sulfide proponents could follow the stratigraphic unit up dip and explore ½-mile south of DL-4. Perhaps where the southwestwardly-dipping fracture zones (parallel to slaty cleavage) intersect vertical east-west fractures, westward-plunging linear ore bodies may exist. The localization of such fracture zones is critical to the discovery of potential ores of this type. Such vertical fracture zones could occur either north or south of DL-4, and intersect favorable shears or beds either up dip or down dip from intersections in this hole.

Following these favorable shear zones down dip, to the southwest, one might encounter possibly favorable stratigraphic units in the carbonate-bearing strata (b). However, this intersection projects to a level of approximately 2500 feet depth, where exists a possibility for a non-plunging or gently plunging linear ore shoot, striking northwestward. Such a postulated ore body probably would be separated into parts by the approximately 250-feet-thick vertical east-trending Precambrian Y diabase dike, whose negative magnetic signature starts approximately 750 feet south of DL-4.