# GEOLOGIC MAP OF THE KEWEENAW PENINSULA AND ADJACENT AREA, MICHIGAN

By William F. Cannon and Suzanne W. Nicholson

## INTRODUCTION

The area of this map includes the classic geology and mineral deposits of the Keweenaw Peninsula in northern Michigan, renowned for the occurrence of great volumes of Middle Proterozoic flood basalts and the world's largest concentration of native copper. Native copper was mined there continuously from the 1840's to the 1960's. For the earlier part of that period the Keweenawan native copper district was the principal source of copper for the United States. This map is intended to summarize and update a wealth of very detailed geologic maps of the region. This 1:100,000-scale map is part of a set of maps portraying the regional geology of the Midcontinent rift on the southern shore of Lake Superior.

The geology and mineral deposits of the district have been painstakingly studied for many years. Especially significant were the extensive report of Butler and Burbank (1929) and the detailed geologic maps produced by the U.S. Geological Survey (USGS) in the 1950's (see index of mapping). The USGS was aided greatly by the Calumet and Hecla Copper Company which provided USGS geologists with a wealth of exploration and production data that allowed construction of detailed 1:24,000-scale maps for the entire peninsula. These maps are the principal sources of information used to compile this map. We have attempted to preserve as much detail as possible at 1:100,000 scale. For rocks northwest of the Keweenaw fault we have made few changes to previously mapped geology. New data are limited to (1) deposits of chalcocite and native copper discovered since the previous mapping in the 1950's, (2) a more detailed study of rhyolite bodies, and (3) radiometric age determinations. For areas southeast of the Keweenaw fault, new geophysical data and drillholes allow some new inferences about the geology of volcanic rocks covered by a thin veneer of Jacobsville Sandstone.

## STRATIGRAPHY AND TECTONIC SETTING

### Late Archean rocks

Archean rocks are exposed only in the east-central part of the map area. They consist of Late Archean foliated and layered granitic rocks (Cannon, 1986). Archean rocks are extensive in the subsurface throughout the map area and form the basement on which Early and Middle Proterozoic rocks were deposited unconformably.

### Early Proterozoic rocks

Early Proterozoic metasedimentary rocks of the Michigamme Formation are exposed in the southeastern part of the map area. They consist of a thick sequence of graywacke and slate, commonly in graded bedded turbidite layers. Black pyritic slate is locally predominant, mostly in the north and lower in the stratigraphic section. The rocks are part of the Baraga Group, which constitutes the upper part of the Marquette Range Supergroup. In the map area, however, older representatives of the Marquette Range Supergroup are absent, and the Baraga Group lies directly on Late Archean crystalline rocks.

The Michigamme strata were deposited, mostly as turbidites, in the foreland basin of the Penokean orogen north of a series of accreting island arcs, now preserved in northern Wisconsin (Ojakangas, 1994). Samarium-neodymium studies show a mixed provenance for clastic material in the Michigamme consisting of both Archean detritus, presumably derived from the north, and primitive volcanogenic material derived from an Early Proterozoic source, presumably accreted volcanic terranes to the south (Barovich and others, 1989). Deposition can thus be dated at roughly 1850 Ma.

The Michigamme strata were folded about east-northeast-trending axes during the Penokean orogeny, probably not long after deposition. Folds are north verging and thin skinned and do not extend into Archean basement (Klasner and others, 1991). Fold intensity generally increases from north to south; folds are nearly isoclinal in the southern part of the area. Finer grained rocks generally have prominent axial plane cleavage, even in the north where folding is relatively gentle. The area can be divided into a parautochthonous sequence in the north and an allochthonous sequence in the south (Gregg, 1993). These two domains are separated by the shallowly south-dipping Falls River thrust fault near L'Anse, Michigan. Metamorphism is weak and is within the chlorite zone as defined by James (1955).

### Middle Proterozoic rocks

Middle Proterozoic rocks in the map area are volcanic and sedimentary strata composing the Keweenawan Supergroup and lesser intrusive rocks emplaced in them. These rocks were deposited in and marginal to the Midcontinent rift system at about 1100 Ma. The present configuration of Middle Proterozoic rocks is a product of three successive tectonic regimes: (1) extension, accompanied by development of rift grabens and copious amounts of volcanism, (2) continental sedimentation in a basin created by post-volcanic cooling-induced subsidence centered over inactive grabens, and (3) tectonic inversion of grabens in which compressive deformation converted former extensional faults into reverse faults.

The lower part of the section is predominantly continental flood basalts with lesser andesite and rhyolite that was erupted during a time span of about 15 million years (1109–1094 Ma) during crustal extension and formation of rift grabens. The flow sequence becomes progressively thicker toward the rift axis which lies beneath Lake Superior north of the map area (see, for example, Ypl (Portage Lake Volcanics) in sections *A–A′*, *B–B′*, and *C–C′*). Near the rift axis the flow sequence is as much as 20 km thick but has a maximum thickness of about 10 km in the map area (Cannon and others, 1989).

The upper part of the supergroup is predominantly sedimentary rocks deposited in a thermally subsiding successor basin centered over the slightly older extensional rift basin. The lower part of the sedimentary section records the rather rapid change from extension and volcanism to continental fluvial sedimentation. Like the underlying volcanic rocks, the sedimentary strata become progressively thicker toward the rift axis where they attain a thickness of about 7 km.

### Extension and magmatism

The oldest rocks of the Keweenawan Supergroup in the map area are the basalts and basaltic andesite flows of the Siemens Creek Volcanics (Ys) of the Powder Mill Group. These flows mark a sudden onset of widespread flood basalt volcanism along the southern flank of the rift. The formation appears to maintain a relatively constant thickness of 1 to 1.5 km within the map area and for about 150 km to the west (Cannon and others, 1995, 1996) indicating that eruption preceded development of a well-defined graben and that the flows spread as a rather uniform blanket over the peneplaned land surface. The Siemens Creek has not been dated radiometrically but is cut by the Echo Lake gabbro dated at about 1111 Ma (C.E. Isachsen, unpub. data). The Siemens Creek Volcanics is exposed only sporadically near the southwestern corner of the map area, and along the Sturgeon River in sec. 16, T. 49 N., R. 35 W. Volcanic rocks also are exposed on Silver Mountain in sec. 1, T. 49 N., R. 36 W. and sec. 6, T. 49 N., R. 35 W. Those rocks may be Siemens Creek Volcanics but, because they lie across the Marenisco fault from all other Siemens Creek exposures, they are shown on the map as Powder Mill Group volcanics undivided. Elsewhere in the map area, Siemens Creek Volcanics is inferred to lie at shallow depth beneath the unconformably overlying Jacobsville Sandstone within a semicircular area identified from aeromagnetic maps. Because the Siemens Creek Volcanics is reversely magnetized, it produces a distinct pattern of low magnetic attraction in areas of thin Jacobsville cover. The southern and eastern limit of Siemens Creek Volcanics inferred from aeromagnetic data is beneath the Jacobsville and is indicated on the map by a dashed line in the southwestern quarter of the map.

The most voluminous volcanic rocks in the map area are the Portage Lake Volcanics, a suite of dominantly high-aluminum continental tholeiitic flood basalts with lesser andesite and rhyolite. On the Keweenaw Peninsula the formation ranges from 3 to 5 km thick, although the base of the formation is truncated by the Keweenaw fault so that the original total thickness of the formation is unknown. Seismic reflection profiles in Lake Superior indicate that the formation is as much as 6 to 7 km thick northwest of the peninsula beneath the lake (Cannon and others, 1989). All flows appear to have been erupted subaerially. They generally have massive interiors, which grade upward into vesicular tops. The upper few feet of many flows are brecciated. Individual flows range in thickness from a few meters to more than 100 meters, and one flow, the Greenstone Flow, is nearly 500 meters thick. The internal stratigraphy of the formation is well known, both from studies of surface exposures and from extensive drilling done during exploration for native copper. Figure 1 shows details of the internal stratigraphy of the Portage Lake Volcanics.

The formation is composed of about 300 individual flows identifiable in drill core. Some distinctive or unusually thick flows can be traced for as much as 50 km along strike and probably extend farther into areas with sparser data. A radiometric age of 1094.0±1.5 Ma has been determined for the Greenstone Flow near the top of the Portage Lake Volcanics and 1096.2±1.8 Ma for the Copper City Flow near the bottom of the formation (Davis and Paces, 1990). Thus, about 3 km of flood basalts were erupted in about 2 million years at this stage of rift development. Basalt flows vary from low-$TiO_2$ (<2.0 weight percent) basalt with ophitic texture to melaphyric high-$TiO_2$ (>2.5 weight percent) basalt and intermediate rocks. Figure 1 shows the generalized stratigraphic distribution of these two types in parts of the map area.

Several small extrusive rhyolite domes occur in the stratigraphic interval above the Bohemia Conglomerate. Ashfall units are found locally at the base of the domes. Stratigraphically below the Bohemia Conglomerate are several intrusive rhyolite bodies which either cut across basalt flows or form sills between flows. Some may be feeders to overlying rhyolite domes. Geochemically these intrusive and extrusive rhyolites are high silica and are termed Type I (Nicholson, 1992). They are typically sparsely porphyritic with small plagioclase and quartz phenocrysts. Near the town of Copper City, a single intrusive body of rhyolite is distinguished from Type I by the presence of coarse phenocrysts of quartz and feldspar and compositions similar to barren topaz rhyolite. This has been termed Type II rhyolite (Nicholson, 1992).

The Mount Bohemia intrusion has a somewhat different geochemical character. It is a small zoned stock which intrudes the lower part of the Portage Lake Volcanics near Lac La Belle. A massive medium-grained syenodiorite forms the outer zone around a core of fine- to coarse-grained granophyre. In the same area many subconcordant sheets of mafic intrusive rocks also are known from exploration drilling but are too small to show at the scale of this map (Robertson, 1975; Michcan Copper Company Ltd., 1982). A body of intrusive felsite near Indiana Mine (Yfi) lies at the western edge of the map area. It is largely aphyric and brecciated. Its relation to intrusive rhyolites farther northeast on the Keweenaw Peninsula is not known. However, it appears to be similar chemically to the Type II rhyolite. A gabbroic intrusion, informally known as the Echo Lake gabbro, is completely buried by about 300 m of Jacobsville Sandstone. Until recently it was known from only one drillhole in sec. 22, T. 49 N., R. 37 W., where olivine gabbro was encountered beneath the Jacobsville (Waggoner, 1994). In 1997, additional exploration drilling, reported in only general terms in press releases, has confirmed the presence of a layered intrusive body with a strike length of at least 16 km. A conservative extent of the body, based on published magnetic and gravity maps, is outlined on the map.

Elsewhere, dikes of diabase are common and cut both early flows and older basement rocks. Most have reversed magnetic polarity and cause prominent linear negative anomalies on aeromagnetic maps making them easy to recognize and trace, even in areas with few outcrops. The reversed polarity indicates that the dikes were emplaced mostly in the earlier stages of rift evolution, probably roughly synchronous with eruption of the Powder Mill Volcanics, all of which has reversed polarity.

Interlayered with the basalt flows throughout the Portage Lake Volcanics are many interflow sedimentary units. Most are conglomerates with clasts dominantly of rhyolitic volcanic rocks and lesser basalt, all derived from slightly older rift-related units. Less commonly the interbeds are sandstone. The thicker interflow sediments form marker beds and are the principal basis for tracing regional stratigraphic relations shown in figure 1. Some individual conglomerate units have been traced across the entire map area and extend into the region to the west.

### Thermal subsidence and sedimentation

At about 1094 Ma the rate of extension, rift basin formation, and basaltic volcanism began to diminish. Through the ensuing 7 million years the rift system evolved into a sedimentary basin in which subsidence was controlled by thermal contraction of the lithosphere during post-igneous cooling. A great thickness of continental fluvial and lacustrine sediments accumulated and volcanism was nearly absent. Collectively, these sedimentary rocks compose the Oronto Group.

The Copper Harbor Conglomerate was deposited during the transition period. It is composed of both fluvial deposits and lesser interbedded basalt and andesite flows. In much of the Lake Superior region the Copper Harbor and correlative units are dominantly sedimentary rocks. Basalt flows, if present at all, are confined to the lower part of the formation. The Copper Harbor on the Keweenaw Peninsula is somewhat unusual in that flood basalts occur throughout the formation and are present to within a few hundred meters of the stratigraphic top. The basalts, informally referred to as the Lake Shore traps, are thickest near the tip of the Keweenaw Peninsula and pinch out toward the southwest, indicating that a volcanic center, now offshore to the east, remained active for an unusually long period of time after eruption of the Portage Lake Volcanics had ceased. A date of 1087.2±1.6 Ma for flows near the middle of the Copper Harbor Conglomerate (Davis and Paces, 1990) indicates that this eruptive activity persisted for at least 7 million years.

The sedimentary units of the Copper Harbor Conglomerate form a fining-upward sequence dominated by coarse conglomerate near the base and grading to sandstone toward the top. Conglomerates are dominantly pebbles to boulders of Keweenawan volcanic rocks eroded from the flanks of the rift. Clasts are mostly rhyolite with lesser mafic and intermediate volcanic rocks. Clasts of pre-Keweenawan rocks are rare except near the tip of the Keweenaw Peninsula and on Manitou Island where clasts of quartzite are common. Sandstones are lithic arenites and likewise are composed in large part of Keweenawan volcanic rocks. Details of lithology and facies relations were summarized by Daniels (1982).

At the top of the Copper Harbor Conglomerate there is an abrupt change to lacustrine deposits of the Nonesuch Formation. The Nonesuch is composed of massive to laminated siltstone and shale and fine-grained sandstone with a preponderance of reduced-facies units. The absence of interbedded fluvial and lacustrine facies at the base of the Nonesuch, combined with the presence of fine-grained reduced lakebeds immediately overlying the oxidized fluvial sands of the Copper Harbor Conglomerate, suggest the rapid establishment of a lake of regional proportions. Studies of the Nonesuch Formation in the White Pine Copper Mine about 30 km west of the map area indicate the presence of minor growth faults, at least near the base of the formation, so it appears that some regional extension may have persisted during this phase of the sedimentary history (Mauk and others, 1992).

After deposition of a few hundred meters of lakebeds, a return to continental fluvial sedimentation is marked by the base of the Freda Sandstone. The Freda is at least 1 km thick in the map area and the original top is not preserved. Like the underlying Copper Harbor Conglomerate, it is mostly lithic arenite, mostly composed of Keweenawan volcanic rock fragments, but it tends to be somewhat more mature in composition (Daniels, 1982). It appears to be derived from a mixed lithologic source of both Keweenawan volcanic rocks and older basement terranes. By this point in the rift history, streams draining to the basin appear to have originated outside of the rift and were eroding Early Proterozoic and Archean terranes as well as Middle Proterozoic volcanic rocks along the rift flanks.

An additional sedimentary unit, the Jacobsville Sandstone, lies southeast of the Keweenaw fault. The correlation, if any, between the Jacobsville and units of the Oronto Group is not known. Details of the Jacobsville Sandstone are summarized by Kalliokoski (1982). From its erosional edge on the south and east, the Jacobsville thickens northwestward toward the Keweenaw fault and reaches a maximum thickness of about 3 km. The Jacobsville is mostly feldspathic sandstone, a considerably more mature unit than the Oronto Group. It lies with a low-angle unconformity on basalt flows of the Siemens Creek Volcanics indicating a period of gentle tilting and erosion between the early rift phases and deposition of the Jacobsville. The base of the formation onlaps over older rocks of the Michigamme Formation and Late Archean gneisses in the southeastern part of the map area.

The relation of the Keweenaw fault to the northwestern limit of the original Jacobsville depositional basin is not entirely clear. However, most evidence points to deposition during uplift on the Keweenaw fault and related faults, suggesting that the Jacobsville may never have extended far beyond its present faulted boundary along the Keweenaw fault. Two sedimentologic studies show the influence of active faults on sedimentation. Near the tip of the Keweenaw Peninsula alluvial fans extend southeastward from the Keweenaw fault into the Jacobsville resulting in local dominance of conglomeratic facies. The fans indicate uplift along the fault that exposed a highland of Keweenawan volcanic rocks north of the present Jacobsville outcrop belt (Brojanigo, 1984). A second study, about 50 km west of the map area, showed that formation of a widespread conglomeratic facies of the Jacobsville also was related to uplift along the Keweenaw fault during sedimentation (Hedgman, 1992). On the other hand, deformation of the Jacobsville, locally producing vertical dips, is common along the Keweenaw fault. It appears, therefore, that deposition of the Jacobsville was accompanied by reverse faulting on the Keweenaw fault but that faulting outlasted deposition and produced strong local deformation of the sandstone.

### Compression and rift inversion

The final phase in the formation of the Midcontinent rift system is a period of regional compression and formation of major thrust faults. This thrusting resulted in inversion of the central graben of the rift. The Keweenaw fault was the major structure in the map area formed at that time. This steeply to moderately northwest-dipping fault thrust the Portage Lake Volcanics and the overlying Oronto Group rocks, part of the central graben sequence, over the Jacobsville Sandstone that was forming in a flanking basin during the compressional event. Smaller related faults lie both within the Portage Lake Volcanics and beneath the Jacobsville Sandstone. The Marenisco fault, a major thrust to the west of the map area, is less prominent in the map area and is estimated to have only 1 or 2 km of displacement. Interpretation of gravity and magnetic anomalies indicates the fault lies within the area of Jacobsville Sandstone but direct outcrop evidence for the fault is lacking. A magnetotelluric study (Young and Repasky, 1986) indicates about 1 km of vertical offset on this fault about 15 km south of the city of Houghton.

The age of faulting can be approximated from Rb-Sr age determinations. On the Keweenaw Peninsula a suite of alteration minerals in basalt is known from geologic relations to have formed coincident with faulting. These minerals have yielded dates ranging from about 1060 to 1050 Ma with an uncertainty of about 20 m.y. (Bornhorst and others, 1988). West of the map area, uplift of basement rocks by thrust faults also has been dated at roughly 1060 Ma by using reset Rb-Sr ages of biotite (Cannon and others, 1993a). The faulting thus seems to have followed closely the opening and filling of the rift, and overlapped with the final phases of sedimentation in the post-rift thermal subsidence basin.

### Paleozoic rocks

Two areas in T. 51 N., R. 35 W. are underlain by unusual occurrences of Paleozoic sedimentary rocks. Limestone Mountain is a prominent upland about 1.5 km in diameter underlain by deformed Paleozoic strata. About 3 km to the northeast a smaller hill, known locally as Sherman Hill, also is underlain by Paleozoic strata. The Paleozoic rocks appear to lie on the Jacobsville Sandstone which underlies the lower country surrounding these hills. Studies of fossil assemblages show that the rocks range in age from Lower Ordovician to Middle Devonian (Case and Robinson, 1915). Beds generally dip from low to moderate angles toward the center of each outlier (Case and Robinson, 1915). Faults with offsets of at least tens of meters also are present. In the surrounding area the Jacobsville Sandstone also has unusually high dips, ranging up to 70°, indicating a structural disturbance throughout an area of at least 30 $km^2$. The nature and cause of this disturbance is enigmatic. The deformed rocks lie along an east-west discontinuity of magnetic and gravity anomalies caused by rocks in the pre-Jacobsville basement. This discontinuity is aligned with a fault which crosses the trend of the Portage Lake Volcanics to the west and across which the trend of the volcanic flows changes by about 30°. We have termed this zone of deformed and faulted strata the "Limestone Mountain structural zone." We have no ready explanation for its origin inasmuch as post-Devonian deformation of this magnitude is virtually unknown elsewhere in the Lake Superior region.

## ECONOMIC GEOLOGY

### Native copper

The map area includes the famous Keweenaw native copper district, containing the world's largest concentration of metallic copper. Nearly 5 billion kg of copper were produced from the area between 1845 and 1968.

*Table 1.*—Production of copper and remaining identified resources in the principal lode deposits of the Keweenaw Peninsula

[From Wilband, (1978)]

| Lode | Production (lbs Cu) | Resources (tons) | Cu grade (percent) |
|---|---|---|---|
| Allouez | 72,309,664 | 1,000,000 | 1.0 |
| Baltic | 1,301,468,458 | 1,505,000 | .8 |
| Calumet and Hecla | 3,721,535,287 | 2,976,000 | 1.1 |
| Iroquois and Houghton | 86,020,420 | 650,000 | .7 |
| Isle Royale | 341,389,658 | 454,000 | 1.0 |
| Kearsarge | 2,242,636,280 | 8,774,000 | .7 |
| Kingston | 9,959,554 | 4,372,000 | 1.2 |
| Osceola | 530,906,636 | 10,298,000 | .9 |
| Pewabic | 983,502,731 | 5,000,000 | 1.0 |

Substantial resources remain in the ground. A voluminous literature exists on the district. A detailed description of the region and its mines by Butler and Burbank (1929), a more recent summary by White (1968), and the detailed geologic maps of the region indexed and cited below are starting points for those who desire more information. Bornhorst and Rose (1994) prepared a guide for a self-guided field trip of the native copper district.

The native copper deposits are the product of a regional hydrothermal system that precipitated the metal and a characteristic suite of alteration minerals in permeable channelways in the volcanic section. Individual deposits are stratabound and lie along brecciated, amygdular flow tops (amygdaloid lodes of local terminology) and in thin interflow sedimentary rocks (conglomerate lodes of local terminology). A much smaller amount of copper is in veins nearly normal to flows (fissures of local terminology). Some of these veins contained spectacular masses of copper, weighing many tons, and were the principal exploration target in the earliest days of the district. Nearly all deposits were mined by underground methods.

Although the district is now long inactive, substantial amounts of mineralized rock are known to remain in many of the deposits, mostly in deep extensions of partly mined orebodies. About 35 million tons of identified ore were estimated to remain in 20 deposits at grades ranging from 0.5 to 1.9 percent copper (Wilband, 1978). About 1980, exploration drilling at the St. Louis deposit in sec. 20, T. 56 N., R. 32 W., outlined native copper mineralization in a wide shear zone. This deposit is estimated to contain about 8 million tons of ore with average grade of 0.8 percent copper accessible by open-pit mining (Michcan Copper Company Ltd., 1982). More detailed information on deposits and individual mines and shafts is contained in the digital version of this map (Cannon and others, 1999).

Undiscovered deposits are likely concealed in the region. Although extensive exploration was conducted in the region throughout its mining history and has been renewed sporadically since, large areas of incompletely explored ground remain both within and peripheral to the historic mining district. An analysis of the distribution of drilling and mine workings (Bodwell, 1972) showed that, even within the intensely mined parts of the district, large volumes of potentially mineralized rock remain untested by drilling.

### Volcanic-hosted chalcocite deposits

Mineral exploration in the 1970's discovered a suite of copper deposits in the Portage Lake Volcanics that consist of chalcocite and minor native copper (Robertson, 1975; Michcan Copper Company Ltd., 1982). These deposits were further explored and delineated in the early 1990's. Five deposits shown on the map near the end of the Keweenaw Peninsula range in size from about 100 thousand tons to about 4.5 million tons and have average grades from 1.8 to 4.0 percent copper. The deposits resemble native copper amygdular lodes in that the mineralization is concentrated in brecciated flow tops. The inclusion of some native copper within the chalcocite concentrations indicates that the chalcocite deposits are probably genetically related to the nearby native copper deposits. They occur in stratigraphically deeper parts of the Portage Lake Volcanic sequence and immediately east of the most prolific part of the native copper district, suggesting an as yet poorly understood zonation of regional copper mineralization into sulfur-free and sulfur-bearing zones.

### Sediment-hosted copper

Basal beds of the Nonesuch Formation carry anomalous concentrations of copper, mostly in chalcocite, over a large region of northern Michigan. About 30 km to the west of the map area, the White Pine mine recovered copper from this unit for more than 40 years until production was terminated in 1996. From exploration drilling a large resource is known to exist in downdip extensions of the orebody, mostly east of the mine. Exploration drilling along the outcrop belt of the Nonesuch Formation has traced mineralization from the mine into the map area as far as the vicinity of Houghton at copper grades greater than 0.2 percent. However, both the thickness of the mineralized zone and the average copper grade is substantially less than near the White Pine mine (White and Wright, 1966). Economic extraction of this low-grade copper is very unlikely in the foreseeable future.

### Magmatic platinum group element and nickel-copper deposits

A layered mafic complex related to the Midcontinent rift is known beneath the Jacobsville Sandstone in the southwestern part of the map area. A conservative interpretation of its extent is shown on the map on the basis of gravity and aeromagnetic anomalies on published maps. The existence of the body was first verified by a single drillhole reported by Waggoner (1994) who informally called it the

Echo Lake gabbro. In 1996 and 1997 additional geophysical surveys and drilling were conducted in the area by Bitterroot Resources Ltd. According to press releases from that company, their work has established the existence of a sizeable layered intrusive complex, at least 10 mi in strike length, and has discovered significant platinum group element mineralization. One drillhole has intersected an 18-ft-thick interval averaging about 1 ppm Pt+Pd+Au within a 70 ft interval averaging about 0.5 ppm Pt+Pd+Au. Other basal layers of the complex also have untested potential for magmatic nickel-copper mineralization.

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