UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Mineral Resource Evaluation of the Sturgeon River Wilderness Study Area, Houghton and Baraga Counties, Michigan

by

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STUDIES RELATED TO WILDERNESS

STUDY AREAS

In accordance with the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, the U.S. Geological Survey and U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Studies and reports of all primitive areas have been completed. Areas officially designated as "wilderness," "wild", or "canoe" when the act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The Act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. This report discusses the results of a mineral survey of national forest land in the Sturgeon River Wilderness study area, Michigan that is being considered for wilderness designation (Public Law 93-622, January 3, 1975). The area studied is in the Ottawa National Forest in Houghton and Baraga Counties.

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Summary

The Sturgeon River Wilderness Study Area is in the heart of the prolific mineral producing upper peninsula of Michigan. Within 50 kilometers lie major iron and copper districts and promising uranium exploration is currently underway to the east of the area. In spite of this, the mineral resource potential of the area is low.

This study disclosed no metallic mineral deposits that can be mined economically. Minor resources of stone, sand and gravel, clay, and peat exist in the area but warrant little attention because they lie far from present markets.

A complete lack of favorable signs of mineralization in the area, or in extensions outside of the area of rock units from within the area, indicates a very low potential for the existence of undiscovered mineral deposits. The graywacke and slate turbidite sequence of the Michigamme Formation that underlies about 2/3 of the area is not known to contain economically attractive mineralization anywhere in the upper peninsula. Lower Keweenawan basalt and related diabase dikes that underlies about 1/3 of the area, although in some respects similar to middle Keweenawan native copper-bearing basalt north and west of the area, appears to be barren of mineralization both within the area and at all other localities where it has been studied. The Jacobsville Sandstone, the youngest bedrock unit in the area, is likewise barren of significant mineralization in all of its numerous exposures in the upper peninsula.

Pleistocene glacial deposits and river deposits derived from them contain small quantities of heavy minerals including titanium and zirconium-bearing minerals, but no areas that have concentrations approaching economic grade and size were found.

Chapter A - Introduction, Setting, and Summary

by

W. F. Cannon, U. S. Geological Survey

James J. Hill and Peter C. Mory, U. S. Bureau of Mines

The mineral resource potential of the Sturgeon River Wilderness Study Area (figure 1) was studied by personnel of the U.S. Geological

Figure 1 near here.

Survey and U.S. Bureau of Mines in 1975. Mineral resource surveys constitute one determination of suitability of areas for wilderness designation in accordance with the provisions of the Wilderness Act--Public Law 88-577, September 3, 1964 and Public Law 93-622, January 21, 1974 (which deals with National Forest land east of the 100th meridian).

Our survey revealed no deposits of current economic value and a very low possibility that undiscovered deposits of potential economic value are in the area.

Area description.--The Sturgeon River Wilderness Study Area comprises approximately 13,200 acres (53 km^2) and lies wholly within the boundaries of Ottawa National Forest in Houghton and Baraga Counties in the northern peninsula of Michigan.

Figure 1.--Index map of Michigan showing the location of the Strugeon River Wilderness Study Area.

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The area is easily reached by traveling about 5 kilometers north on Forest Service road 191, which joins Michigan Highway 28 immediately east of the town of Sidnaw, Michigan, or by traveling about 15 kilometers south from Michigan Highway 35 from near Alston, Michigan. Forest Service roads 191, 192 and 193 provide access to much of the study area's perimeter. Access to the interior is by foot over adjoining logging trails, now closed to motor vehicle traffic. Railroad tracks of the Soo Line pass within 3 kilometers of the southern boundary of the area.

The northwesterly flowing Sturgeon River and its tributaries have incised deep valleys, mostly through unconsolidated glacial deposits. Elevations range from 1400 feet (427 m) in the south to about 800 feet (244 m) in the north. The most scenic attraction is Sturgeon Falls (figure 2), which is developed over basalt flows, and the gorge carved through basalt and overlying sandstone immediately downstream from the falls (figure 3).

Figure 2 and 3 near here.

Most prominent use of the area has been timbering and recreation. Ownership records indicate that the area may have been considered as a site for hydroelectric power.

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Figure 2.--Waterfalls on the Sturgeon River. Bedrock is basalt flows of the Siemens Creek Formation that dip gently in a downstream direction.

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Figure 3.--Gorge downstream from waterfalls cut through horizontally layered Jacobsville Sandstone and basalt of the Siemens Creek Formation at lower left of exposure.

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Present investigation.--The mineral resource potential of the area was evaluated by several means. Previously collected geologic and geophysical data from many sources were compiled to give a geologic framework on which to base field studies and by which a preliminary assessment could be made.

Field work included examining known outcrops of bedrock for favorable signs of mineralization and sampling the bedrock for laboratory tests. All previously known exposures of bedrock were located and their position plotted on a topographic base map. No additional exposures were found. Because of the very limited number of outcrops in the area, rock units known or inferred to be present in the area were examined and sampled at their nearest known exposures outside of the area. Clay beds in Pleistocene glacial deposits were also sampled for laboratory determinations of their suitability for ceramic uses.

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Geochemical technique was used in the search for buried mineral deposits. This technique involved the taking of samples of soil and stream sediments which were collected throughout the area and analyzed in the laboratory for metal content. Soil samples were mostly from uplands between the stream gorges and were intended to provide background values for metal content. Stream sediments were collected at several places along the Sturgeon River and from each major tributary. Because these streams derive their sedimentary load almost totally from Pleistocene deposits any concentration of metals or other useful minerals in those deposits should result in higher concentrations of metals in the stream sediments than in soil from adjacent uplands. The location of sample sites is shown in figure 4.

Figure 4 near here.

Samples collected by the U.S. Bureau of Mines were analyzed spectrographically for 43 elements by the Reno Metallurgy Research Center of the U.S. Bureau of Mines, Reno, Nevada. Selected samples were analyzed by fire assay methods for gold and silver; copper content was determined by atomic absorption. Uranium scans were performed on all sandstone samples. The Tuscaloosa Metallurgy Research Laboratory of the U.S. Bureau of Mines, Tuscaloosa, Alabama, evaluated ceramic properties of glacial clays.

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Figure 4.--Map of the Sturgeon River Wilderness Study Area showing the locations of sample sites.

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Samples collected by the U.S. Geological Survey were tested for 65 elements by semi-quantitative spectroscopic analysis and selected samples were analyzed for gold by combined fire assay-atomic absorption procedure at the U.S. Geological Survey analytical laboratories, Reston, Virginia. All exposures of bedrock were tested in the field for uranium with a portable scintillometer.

Records of mineral ownership were obtained from the U.S. Forest Service and were updated by examining records at county courthouses of Baraga and Houghton Counties. Bureau of Land Management records were checked for leasing activity.

Representatives of the mining industry as well as state and federal agencies were contacted to obtain their views on the mineral resource potential of the area.

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A complete lack of favorable signs of mineralization in the area, or in extensions outside of the area of rock units from within the area, indicates a very low potential for the existence of undiscovered mineral deposits. The graywacke and slate turbidite sequence of the Michigamme Formation that underlies about 2/3 of the area is not known to contain economically attractive mineralization anywhere in the upper peninsula. Lower Keweenawan basalt and related diabase dikes that underlies about 1/3 of the area, although in some respects similar to middle Keweenawan native copper-bearing basalt north and west of the area, appears to be barren of mineralization both within the area and at all other localities where it has been studied. The Jacobsville Sandstone, the youngest bedrock unit in the area, is likewise barren of significant mineralization in all of its numerous exposures in the upper peninsula.

Pleistocene glacial deposits and river deposits derived from them contain small quantities of heavy minerals including titanium and zirconium-bearing minerals, but no areas that have concentrations approaching economic grade and size were found.

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Chapter B - Geology and Geophysical Interpretation

by

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Introduction

The Sturgeon River Wilderness Area is astride a major geologic contact between Precambrian rocks of two different ages, rock types, and geologic history. About two thirds of the area is underlain by middle Precambrian (Precambrian X) graywacke and slate deposited in a deep ancient sea about 2 billion years ago. These rocks have subsequently been deformed and recrystallized and then deeply eroded. The northern third of the area is underlain by much younger basalt, about 1 billion years old, that was extruded in a continental environment. The basalt flows were subsequently tilted and eroded and then covered by younger sandstone. Much more recently, as little as 10,000 years ago, continental glaciers covered the area. When the last glacier to cover the area melted, the wilderness was covered with a thick blanket of sediments deposited from the glacial meltwaters.

Only locally, near Sturgeon Falls, has erosion removed the glacial deposits to expose the underlying bedrock. Consequently, little is known directly of the bedrock in the area. Aeromagnetic and gravity surveys, however, along with projection of information from outcrops outside the wilderness, provide a means of inferring the general geologic relationships.

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An airborne magnetometer survey of the Sturgeon River Wilderness study area was made by the U. S. Geological Survey in 1947 as part of a larger program to investigate the upper peninsula of Michigan for mineral resources, primarily iron and copper (Balsley and others, 1949). The survey was made with a continuously recording fluxgate magnetometer along north-south flight lines spaced one quarter mile apart and 500 feet above the ground surface. The data were published as magnetic profiles and an accompanying map showing the flight lines with locations of the magnetic peaks and troughs (Balsley and others, 1949). These data were later compiled as a contour map with a contour interval of 50 gammas (Balsley and Smith, 1967). A portion of this map is shown in figure 5.

Figure 5 near here.

The entire upper peninsula has now been covered by similar surveys by the U. S. Geological Survey and the data were recompiled as a single contour map after the gradient of the earths magnetic field was removed, so that only the anomalies caused by the rocks of the earths' crust remain (Zietz and Kirby, 1971). Figure 6 shows part of this map

Figure 6 near here.

including the area of the Sturgeon River Wilderness. Aeromagnetic surveys record variations in the earths total magnetic field, which are caused primarily by differences in the magnetic mineral content of the rocks beneath the surveying aircraft. Although several minerals are magnetic, the most important and common one is magnetite. Small amounts

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of magnetite are disseminated through many types of igneous rocks, and give them characteristic magnetic expressions. The resulting magnetic patterns are used by geologists to map these rocks even where they are covered by soil, glacial drift, or sedimentary rocks, which are commonly much less magnetic. Magnetite also occurs in metamorphic rocks such as iron-formation of the iron districts of Michigan, Minnesota, and Wisconsin.

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Figure 5.--Aeromagnetic contour map of the Sturgeon River Wilderness Study Area and surrounding area from U. S. Geological Survey Map GP-601 (Balsley and Smith, 1967). Contour interval is 50 gammas. The location of the continuous profile shown in figure 12 is indicated by the solid north-south line.

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Figure 6.--A portion of U. S. Geological Survey map GP-750 (Zietz and Kirby, 1971) showing the regional aeromagnetic expression of three geologic terranes in the vicinity of the Sturgeon River Wilderness Study Area.

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Another geophysical method that is useful in this region is measurement of variations in gravity (Bacon, 1966). Dense rocks such as basalt have a higher gravitational attraction than the granitic and metamorphic rocks typical of much of the region. Sedimentary rocks such as sandstone and arkose, on the other hand, have relatively low density and produced lower gravitational attraction.

A large number of gravity measurements have been made in the upper peninsula and have been compiled and contoured as a regional map by L.O. Bacon (1966). The measurements in the Sturgeon River area were made by Campbell (1952) on traverses with station spacing about one mile along roads separated by approximately 10 miles. The gravity anomalies of this map, part of which is shown in figure 7, show a good

Figure 7 near here.

correlation with the regional magnetic patterns so that it is possible to infer the distribution of dense, magnetic units of rocks. In some cases, the gravity data can be used to calculate the approximate thickness of buried rock units.

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Figure 7.--Bouguer anomaly gravity map of the Sturgeon River Wilderness Study Area and surrounding area from Bacon(1966) Contour interval is 2 milligals.

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Physiography

The Sturgeon River Wilderness Study Area lies near the west edge of the Baraga Plains, a gently rolling upland underlain by thick Pleistocene glacial deposits. The wilderness contains deep (as much as 100 meters) steep sided gorges cut into the Baraga plains by the north flowing Sturgeon River and its tributaries. Flat uplands, remnants of the once more extensive Baraga Plains, lie between the gorges. The steep topography of the area is in striking contrast to the gently rolling topography of much of the surrounding area (see figure 8).

Figure 8 near here.

The Sturgeon River is largely a graded meandering stream with a narrow floodplain. Lateral cutting against steep valley sides locally forms oversteepened slopes and results in prominent slumping and landsliding.

Only at Sturgeon Falls in Sec. 16, T. 49 N., R. 35 W. and for a few hundred meters downstream from the falls does the river flow on bedrock. There the river is fast-moving with short reaches of whitewater. Elsewhere it is slow-moving and flowing on unconsolidated Pleistocene deposits or river sand and gravel derived from them.

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Figure 8.--View from Silver Mountain looking southeastward. The Sturgeon River Wilderness Study Area is in the foreground. Steep sided stream valleys in the study area are cut into the Baraga Plains that form the flat upland surface in the distance. Higher hills on the horizon are underlain by graywacke and slate of the Michigamme Formation,

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Lithology

Five stratigraphic units are present in the Sturgeon River Wilderness Study Area. The stratigraphic relationships are shown in figure 9 and their areal distribution is shown in figure 10.

Figures 9 and 10 near here.

Only three of the units, Pleistocene glacial deposits, Jacobsville Sandstone, and basalt of the Siemens Creek Formation are exposed in the wilderness. Diabase dikes of Keweenawan age and graywacke and slate of the Michigamme Formation are inferred to be present with good confidence because a distinctive magnetic pattern that these rocks produce in nearby areas where they are exposed extends into the Wilderness Study Area.

Pleistocene glacial deposits.--Pleistocene glacial deposits form a thick blanket of unconsolidated material over most of the area. The steep stream gorges are cut mostly through this material but because it slumps rapidly, exposures of undisturbed material are rare and confined to areas where streams are actively cutting laterally into valley sides (see figure 11). Most of the material is light brown,

Figure 11 near here.

rather well sorted sand composed mostly of quartz with lesser amounts of feldspar. Heavy minerals generally form less than one per cent of the sand. The sand is well bedded (see figure 11 top) and cross-bedding is common. Locally, gravel beds as much as one meter thick are interbedded with the sand.

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Figure 9.-- Schematic cross section of the Sturgeon River Wilderness Study Area showing the stratigraphic, intrusive, and structural relationships of the rock units in the area.

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Figure 10.--Bedrock geologic map of the Sturgeon River Wilderness Study Area based on magnetic patterns and showing the inferred distribution of Michigamme Formation, diabase dikes, and lower Keweenawan basalt. The extent of the Jacobsville Sandstone away from its only exposures along the Sturgeon River is not known. A thin blanket of Jacobsville probably overlies much of the area. The thickness of dikes shown on the map is the maximum thickness consistent with the shape of aeromagnetic anomalies but because of uncertainties in interpretation they may be thinner than shown.

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Figure 11.--Exposure of Pleistocene glacial deposits in a stream bank along the Sturgeon River. Cross bedded sand (lighter colored material near top) overies a bed of clay (darker colored massive appearing material near center) which is underlain by stratified sand mostly covered by slumped material near the bottom of the exposure.

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Units of silt and clay size particles, generally well intermixed, also make up a large volume of the Pleistocene deposits. They are red-brown to tan colored and generally massive with no discernible internal bedding (see figure 11, center). Units as much as 6 meters thick are exposed along the Sturgeon River but the lateral continuity of such beds is not known.

Jacobsville Sandstone.--The Jacobsville Sandstone is exposed in nearly vertical valley walls along the Sturgeon River near Sturgeon Falls(see figure 3). It is well bedded in nearly horizontal units. Cross-bedding and ripple marks are common. The color varies on a small scale from very light tan to red-brown due to alternate zones in which small amounts of iron are in reduced and oxidized form. In places, such zones follow bedding planes making the bedding very easily visible (see figure 3). According to Roberts (1940) grain size varies from conglomeratic beds with one centimeter pebbles to very fine sandstone. Average grain size is about one millimeter. The sand grains are generally well rounded and in well sorted beds. The average mineral composition near Sturgeon Falls is quartz-50%, potassium feldspar-30%, muscovite-10%, plagioclase-2%. The remainder is mostly heavy minerals. The heavy mineral suite consists of about 10% garnet, 3% leucoxene, 1-2% zircon and the remainder is opaque minerals, mostly magnetite and ilmenite (Denning, 1949).

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Diabase dikes.--No diabase dikes are exposed in the area but their presence is inferred by very distinctive west-trending linear negative magnetic anomalies that are invariably associated with diabase dikes to the east where bedrock is better exposed. There the rock ranges from coarse- to fine-grained massive diabase consisting of plagioclase, clinopyroxene, and rarely olivine as well as small amounts of magnetite and other opaque minerals. The nearest exposure of diabase is at Mt. Kallio, about two kilometers east of the area (see figure 10).

Basalt.--Basalt is exposed at Sturgeon Falls and at several other places for a short distance downstream (northward) from the falls. These rocks were assigned to the Siemens Creek Formation by Hubbard (1975) that he named for rocks near Bessemer, Michigan, about 100 kilometers to the west. Basalt of the Siemens Creek Formation is also exposed on Silver Mountain immediately north of the wilderness area. These rocks were studied in detail by Roberts (1940). At Sturgeon Falls he recognized three separate flows by identifying amygdular zones that formed near the top and bottom contact of each flow. The flows are fine-grained ($\sim$ 1 mm), black, massive basalt. The average mineral content is augite-20%, andesine-45%, chlorite-25%, magnetite and other opaque minerals-5%, and epidote-2%. Amygdules are filled with combinations of quartz, calcite, epidote, potassium feldspar, and ankerite.

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On Silver Mountain, Roberts found at least 14 flows, each from one to six meters thick. There the basalt is metamorphosed and original augite was converted to hornblende which makes up about 40% of the rock. Andesine (40%), calcite (10%), and leucoxene (5%) are other important constituents.

At an exposure about 300 meters downstream from Sturgeon Falls the basalt is overlain unconformably by the Jacobsville Sandstone. Weathering prior to deposition of the Jacobsville has produced a red-brown color in the basalt and a partially dissaggregated rubbly texture. As much as two meters of this soft, rubbly weathered rock is preserved beneath the Jacobsville.

Michigamme Formation.--The Michigamme Formation is not exposed in the wilderness area. Large areas to the south and east of the wilderness are underlain by a monotonous sequence of graywacke and slate of the Michigamme Formation. These rocks are commonly in graded beds .5 to 1 meter thick that range from coarse-grained graywacke at their base to fine-grained dark gray to black slate near their top. The rocks are folded about west northwest-trending axes and cleavage is generally well developed, especially in the tops of graded beds. Areas known to be underlain by the Michigamme Formation produce a characteristic uniformly low magnetic field. The extension of that magnetic pattern from areas where the Michigamme is exposed into parts of the wilderness indicates that much of the area is underlain by similar graywacke and slate.

Stratigraphy and Structure

In spite of sparse exposures of bedrock in the wilderness area, the stratigraphic and structural relationships can be inferred with good confidence because of abundant geophysical data. The geologic map of the area (figure 10) is drawn from aeromagnetic data. Figure 6 shows that the wilderness area and surroundings can be divided into three zones, each with a characteristic magnetic signature. Zone C consists of uniform and relatively low magnetic attraction that is known southeast of the area to be produced by thick graywacke and slate of the Michigamme Formation. Hence, the area of the wilderness in zone C is also inferred to contain rocks of the Michigamme Formation as the principal rock type. Zone B is characterized by very low magnetic attraction. The exposures of the Siemens Creek Formation at Sturgeon Falls and Silver Mountain are in zone B and have been extensively sampled by Kenneth Books of the U. S. Geological Survey for magnetic property studies. He found that they have a strong remnant magnetization acquired when the flows cooled. This magnetization is aligned with the direction of the earths' magnetic field at the time when the flows cooled, slightly more than a billion years ago. The direction of magnetization in the Sturgeon River area is nearly opposite the direction measured in the much thicker series of volcanic rocks of the middle Keweenawan on the Keweenawan Peninsula to the north, so that the flows near Sturgeon River produce magnetic lows instead of highs. Books has found this same reversed magnetization in lower Keweenawan flows near Ironwood, Michigan and at other areas around Lake Superior (Books, 1968, 1972) so the flows in the Sturgeon River area must also be lower Keweenawan.

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Zone A, entirely outside of the wilderness area, is marked by a prominent series of magnetic highs that form an arcuate linear belt that strikes westward without interruption into the exposed Keweenawan basalt near Ironwood, Michigan (King, 1975). A drill hole 40 kilometers west of the Sturgeon River on the crest of this anomaly encountered basalt at a depth of 730 meters (Bacon, 1966). The Jacobsville sandstone covers the area of this magnetic high, which is inferred to mark the southern edge of a thick series of Keweenawan basalt flows that get progressively deeper to the northwest. This deepening is indicated by the magnetic contours which are widely spaced and have lower values in that direction. The gravity data show a broad high in that area, indicating the presence of a large mass of dense rock, such as basalt.

Both zones B and C have a prominent pattern of west-trending negative linear anomalies superimposed on them. These can be seen on the contoured maps (figures 5 and 6) but are even more evident on the original profiles, one of which is shown in figure 12. The sharp

Figure 12 near here.

distinction between zones B and C is also well shown on this profile. These anomalies in other areas are known to be caused by diabase dikes that, like the basalt of the Siemens Creek Formation, have reversed magnetic polarity. They presumably crystallized during the same period of magnetic reversal as the basalt. Because they do not cut anomalies formed by the younger basalts of zone A, they are believed to be feeder dikes for the lower Keweenawan basalt flows.

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Figure 12.--A typical aeromagnetic profile from which the magnetic contour maps were drawn. See figure 5 for the location of the profile. Downward-pointing arrows indicate areas of low magnetic attraction inferred to be cause by lower Keweenawan diabase dikes.

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Figure 9 shows the stratigraphic and structural relationships of the area in schematic form. The oldest rocks are the Michigamme Formation that is probably a thick, folded unit of graywacke and slate. Volcanic rocks underlying the Michigamme Formation well southeast of the area have been radiometrically dated at about 2.0 billion years (Banks and VanSchmus, 1971). Metamorphism that was approximately synchronous with deformation occurred about 1.9 billion years ago. Although the Michigamme is a highly varied formation in many parts of the upper peninsula, the exposures nearest to the wilderness area are uniformly composed of graywacke and slate that was deposited by turbidity currents, probably in deep water.

A long gap in the geologic history of the region is represented by the unconformity between the Michigamme Formation and the Siemens Creek Formation. The basalt flows of the Siemens Creek spread over the erosion surface on the Michigamme. The gravity field in the wilderness area indicates that there the basalts are only a thin sheet and that the Michigamme is present in the shallow subsurface (see figure 13). This

Figure 13 near here.

is consistent with the observed low dips of flows at Sturgeon Falls and Silver Mountain and the position of the area near the southeasternmost edge of the basalt flows.

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Figure 13.--A density model of the Sturgeon River Wilderness Study Area and surrounding area from Bacon (1966) derived by calculating a theoretical gravity anomaly to coincide with the observed Bouguer anomaly. The model indicates that Keweenawan rocks in the study area are thin and underlain at a relatively shallow depth by rocks of low density, presumably part of the Michigamme Formation.

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During eruption of the basalt, nearly vertical feeder dikes brought lava to the surface along east-west fractures. These are the Baraga dikes, which have been described by Graham (1953), Balsley and others, (1949), and DuBois (1962). They were evidently emplaced during an early phase of rifting of the Lake Superior and midcontinent regions coincident with eruption of lower Keweenawan basalt. Shortly afterward much thicker basalt, now forming the middle Keweenawan rocks, accumulated to a thickness as great as 15 kilometers. Although these rocks once probably covered the Sturgeon River area, they have since been eroded. The rift in which the Keweenawan rocks accumulated may have been similar to the present African rift system and extended from Lake Superior to Kansas. The area invaded by the Baraga dikes was one of crustal extension associated with opening of the rift.

After the flows cooled, they were tilted toward the northwest and an erosion surface developed on them prior to deposition of the Jacobsville Sandstone. Exposures near Sturgeon Falls indicate that local relief was 25 meters or more when the area was covered by the Jacobsville. Regional studies by Hamblin (1952) show that the Jacobsville was deposited by generally north- or northwest-flowing streams and occupied a basin nearly coincident with the present Lake Superior drainage basin.

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The age of the Jacobsville is not well known. Unconformable relationships with the underlying lower Keweenawan basalt and overlying Upper Cambrian Munising Formation place only widely spaced limits on the possible age (Hamblin, 1952). It is here provisionally considered to be late Precambrian (Precambrian Y).

A long period with no geologic record separates the Jacobsville and Pleistocene deposits. Outliers of Ordovician sedimentary rocks at Limestone Mountain, a short distance north of the area, suggest that the entire area was once covered with Ordovician and possibly other Paleozoic rocks which have since been removed by erosion.

The Pleistocene deposits are mostly fluvial sand and gravel deposited south of a retreating continental glacier. The fine-grained clayey beds were probably deposited in standing water, perhaps small lakes on the fluvial plane.

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Chapter C - Mineral Resource Potential of Known Deposits

By

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An investigation of the mineral resource potential of known deposits was undertaken by the U. S. Bureau of Mines in 1975. Evaluations were made for deposits of stone, sand and gravel, clay, and peat, as well as a prospect on Silver Mountain just outside of the study area. The study disclosed no metallic mineral deposits that can be mined economically. Minor resources of stone, sand and gravel, clay, and peat exist in the area but because they lie far from present markets they are of little economic value.

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Land Status

Investigations of mineral potential in wilderness areas are based in part on evaluations of historical activities and data. Consideration is given to the past availability (accessibility) of land to individuals and/or industry engaged in mineral exploration. This information can give some insight to the thoroughness with which a particular area might have been evaluated by explorationists during times of continually evolving exploration concepts and methods.

Surface ownership.--U.S. Forest Service and courthouse records indicate that before 1934, when the Federal Government began to purchase National Forest land in the area, most of the land was in private ownership. Although not open to prospecting and location under the General Mining Law of 1872, it is possible that some of the area was accessible to explorationists through either lease option or by actual ownership of surface and mineral rights.

As of July 1975, U.S. Forest Service and courthouse records show that approximately 25 percent of the land surface (fig. 14) is still in

Figure 14 near here.

private ownership.

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Figure 14.--Map showing federal surface ownership within the Sturgeon River Wilderness Study Area.

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Mineral ownership.--With the advent of Federal purchase of lands within the National Forest boundary, mineral rights were severed from most tracts and remain outstanding. Figure 15 depicts Federal mineral

Figure 15 near here.

ownership as of July 1975. Mineral rights on all other tracts remain in private ownership (table 1). After Federal purchase of these lands,

Table 1 near here.

the President's Reorganization Plan No. 3 of 1946, Section 402, provided for the Bureau of Land Management to accept applications for prospecting and mining permits on acquired lands having Federally owned mineral interests. Although representing a small part of the total acreage involved in the wilderness proposal, these Federal mineral lands have been accessible for exploration.

Mining Activity

No active mines are within the Sturgeon River Wilderness Study Area nor is there any record of past mineral production. In a few instances, minor amounts of sand and gravel from within the area have been used in the construction of logging roads. The nearest mineral operations in recent times are small sand and gravel pits located in secs. 24 and 25, T. 48 N., R. 35 W., approximately 1-1/2 miles (2.4 km) southeast of the study area. These pits appear to be worked intermittently to supply local needs.

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Figure 15.--Map showing federal mineral ownership within the Sturgeon River Wilderness Study Area.

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TABLE 1. -- Mineral ownership within and adjacent to the Sturgeon River Wilderness Study Area

T. 49 N., R. 35 W.

Section	Subdivision	Owner
5	Entire	Ford Motor Co.
6	W½ NE; W½; W½ SE; SE SE	Worcester Lumber Co.
6	E½ NE; NE SE	Ford Motor Co.
7	Entire	Ford Motor Co.
8	W½ SW; SE SW; NW NE SW	Worcester Lumber Co.
8	N½; SE¼; NE NE SW; S½ NE SW	U.S.A.
9	Entire	Ford Motor Co.
15	N½; SE¼; N½ SW	Michigan Iron and Land Co
15	S½ SW	Unknown party
16	N½ NE; NE NW	State of Michigan
16	NW NW; SW SW	U.S.A.
16	SE¼; S½ NE; S½ NW; E½ SW; NW SW	Unknown party
17	Entire	Ford Motor Co.
18	E½ NE; NW SE; NE SW	State of Michigan
18	W½ NE	U.S.A.
18	NW¼; W½ SW; SE SW; S½ SE; NE SE	Ford Motor Co.
20	Entire	Ford Motor Co.
21	Entire	Ford Motor Co.
22	E½	U.S.A.
22	W½	Michigan Iron and Land Co
23	Entire	Michigan Iron and Land Co
26	Entire	State of Michigan
27	Entire	Michigan Iron and Land Co
28	W½ SE; W½; SW NE	Worcester Lumber Co.
28	E½ SE; E½ NE; NW NE	Unknown party
29	Entire	Ford Motor Co.
31	N½; SW¼; NW SE	Ford Motor Co.
31	E½ SE; SW SE	U.S.A.
32	E½ NE; NE SE	State of Michigan
32	W½ NE; E½ NW; NW NW	Ford Motor Co.
32	S½ SW	J. Van Evera
32	SW NW; N½ SW; NW SE; S½ SE	U.S.A.
33	Entire	Ford Motor Co.
34	NE NE; S½ SE; SW NW; SW¼	U.S.A.
34	N½ NW; SE NW; S½ NE; NW NE; N½ SE	Michigan Iron and Land Co
35	Entire	Michigan Iron and Land Co

Prospecting Activity

Within the area.--No tangible evidence or record of exploration drilling and test pitting exists within the present study area. The only drilling of record is a water well drilled by the U.S. Forest Service in 1964 at the Sturgeon River Campground (sec. 11, T. 48 N., R. 35 W.). This well penetrated 34 feet (10.3 m) of gravel and boulders and 32 feet (9.8 m) of hard-rock ledge (Doonan and Byerlay, 1973). To our knowledge, a geologic description of the bedrock encountered in the water well is not available.

Silver mountain.--The only physical evidence of prospecting activity in the immediate vicinity of the proposed wilderness is an adit and trench located on Silver Mountain (fig. 16). The prospects

Figure 16 near here.

warrant mention as they are found in rock lithologically and stratigraphically similar to the basalt flows exposed along the Sturgeon River.

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Figure 16.--Map showing the location of the prospect adit and pit on Silver Mountain.

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Attention was possibly first directed to the study area vicinity when Burt (1849, p. 849) described Silver Mountain (approximately 3/4 mile [1.2 km] west of the proposed wilderness boundary) situated on the east boundary of T. 49 N., R. 36 W., on the line between secs. 1 and 6.

> "This mountain-like mass of greenstone trap is, to some extent, metalliferous; in nearly every part, traces of the gray sulphuret of copper were seen, but no well-defined and productive vein was found. On its southeasterly side two or three imperfectly formed veins of quartz and calcareous spar were seen associated with the gray sulphuret of copper; and in some places, with slight traces of green carbonate of steatite."

He then noted that Sturgeon River passed over traprock in falls and rapids about 3 miles SSE of Silver Mountain in T. 49 N., R. 35 W.

Several other early investigators--Foster and Whitney (1850), Wadsworth (1891), and Irving (1883)--reported on the geology of Silver Mountain. Roberts (1940) in his study of the Alston District investigated Silver Mountain, and of more importance described the rock outcrops along Sturgeon River, the focal point of this study.

Silver Mountain, formerly a site of a U. S. Forest Service lookout tower, is a dome-shaped mass of rock rising approximately 300 feet (91 m) above the surrounding terrain. Now designated on National Forest maps as a Scenic View, it is reached by a gravel road leading off Forest Service Road 922. Just off the trail leading from a parking lot is the workings of an adit. A Forest Service plaque notes that mining was carried on here by the National Company some time prior to 1850.

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The adit penetrates basalt for an approximate distance of 140 feet (43 m) along a fault plane which has a bearing of about N. 70° W. and dips 60° to the north. Fault breccia in fragments 2 to 30 centimeters in diameter (covered with talc) are visible in the trace exposed in the back. No significant mineralization was noted during this investigation although Roberts (1940, p. 11) mentioned amygdules carrying traces of bornite and chalcopyrite. Foster and Whitney (1850, p. 68, 69) noted no metallic mineralization in the rock dump at the time of their investigation.

Sites of samples taken within the adit (Nos. 54-60) are shown in figure 17. The samples represent random chips taken every 2-4 inches

Figure 17 near here.

(5-10 cm) through the fault zone in the back and along the ribs over intervals indicated on figure 16. Sample analyses are tabulated in table 2. Very sparse mineralization is indicated by the results of the

Table 2 near here.

analyses; the highest copper value is 60 parts per million (ppm) along with a trace of silver. The depth of the water impounded in the rear of the adit precluded reaching the face for observation or sampling.

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TABLE 2.--Partial chemical analyses of samples from the Sturgeon River Wilderness Study Area.

	Number	Ag	Au	Co	Cr	Cu	Hf	Mn	Mo	Ni	Pb	Sn	U	V	Zn	Zr
Soil samples	12	.12	<.05	4.3	16	14	<100	260	<2.2	8.8	12	<6.8	<320	34	<22	330
	13	<.10	<.05	4.3	15	9.4	<100	350	<2.2	9.4	17	<6.8	<320	26	<22	220
	14	<.10	<.05	5.6	26	14	<100	370	<2.2	12	15	<6.8	<320	61	<22	770
	15	<.10	<.05	4.7	19	9.5	<100	330	<2.2	8.3	24	<6.8	<320	34	<22	110
	16	.12	<.05	3.7	15	8.2	<100	220	<2.2	6.7	12	<6.8	<320	42	<22	340
	17	.35	<.05	320[1/]	15	8.4	<100	290	<2.2	7.5	31	<6.8	<320	28	<22	92
	18	<.10	<.05	11	48	26	<100	420	<2.2	25	17	<6.8	<320	58	<22	570
	19	<.10	<.05	6.5	24	17	<100	470	<2.4	14	18	<6.8	<320	55	<22	270
	33	<.10	<.05	4.7	19	11	<100	340	<2.2	8.3	14	<6.8	<320	38	<22	440
	34	<.10	<.05	4.5	15	47	<100	340	<2.2	8.9	11	<6.8	<320	42	<22	220
	35	<.10	<.05	8.0	27	9.8	<100	260	<2.2	11	15	<6.8	<320	37	<22	540
	39	.14	<.05	3.9	20	9.6	<100	250	<2.2	7.6	12	<6.8	<320	29	<22	660
	42	<.10	<.05	6.8	26	19	<100	360	<2.2	15	15	<6.8	<320	43	<22	520
	44	<.10	<.05	5.1	43	17	<100	410	<2.2	9.5	17	<6.8	<320	47	<22	620
	47	<.10	<.05	4.9	23	11	<100	340	<2.2	7.6	16	<6.8	<320	40	<22	560
Stream sediment samples	26	<.46	<.05	3.6	32	6.9	<21	540	<2.2	9.4	14	<15	<150	67	<15	380
	28	<.46	<.05	3.7	29	4.0	<21	360	<2.2	7.8	15	<15	<150	68	<15	220
	29	<.46	<.05	5.5	67	6.4	<21	670	<2.2	13	15	<15	<150	110	<15	480
	31	<.46	<.05	3.0	41	3.5	<46	320	<2.2	8.6	15	<15	<150	57	<15	200
	37	<.46	<.05	1.6	30	1.6	<22	170	<2.2	3.6	9.9	<15	<150	21	<15	120
	40	<.46	<.05	2.4	24	2.9	<22	270	<2.2	4.5	11	<15	<150	44	<15	200
	46	<.46	<.05	4.2	35	5.6	<22	330	<2.2	8.9	13	<15	<150	55	<15	360
	49	<.46	<.05	3.4	35	4.7	<22	340	<2.2	9.4	14	<15	<150	43	<15	200
Pan concentrate samples	3	<.46	<.05	15	96	9.1	<100	2500	<2.2	35	17	<15	<150	250	85	200
	4	<.46	<.05	16	170	14	<22	4400	<3.2	34	37	<15	<150	390	110	>2100
	20	<.46	<.05	19	130	30	<22	1500	<2.2	51	16	45	<150	210	87	140
	25	<.46	<.05	4.9	25	2.3	<22	530	<2.2	8.7	12	<15	<150	100	<15	250
	27	.54	<.05	27	450	21	220	5300	3.0	50	66	<22	<150	550	160	>2100
	30	.58	<.05	22	380	14	<22	5600	<4.6	44	110	<15	<150	610	240	>2100
	36	<.46	<.05	4.6	44	1.2	<46	1000	<2.2	7.4	8.5	<15	<150	94	<15	480
	41	<.46	<.05	2.2	62	<1.0	<22	470	<2.2	2.7	9.2	<15	<150	74	<15	700
	43	<.46	<.05	20	240	17	<22	8200	<2.2	34	54	<15	<210	510	120	>2100
	45	.51	<.05	16	170	11	<22	2300	<3.2	36	29	<15	<150	300	100	>2100
	48	1.1	<.05	31	530	22	<22	5800	<4.6	59	100	<52	<150	870	270	>2100
	71	tr	n.d.	n.d.	70	40	n.a.	2000	<20	n.d.	<100	n.a.	n.a.	100	n.a.	600
	73	n.d.	n.d.	n.d.	70	30	n.a.	2000	<20	n.d.	<100	n.a.	n.a.	100	n.a.	300
	78	n.d	n.d.	n.d.	100	30	n.a.	2000	<20	n.d.	<100	n.a.	n.a.	100	n.a.	400
Rock samples Basalt	2	<.10	<.05	31	280	92	<100	1800	<3.2	65	15	<6.8	<320	180	63	100
	8	.28	<.05	25	200	130	<100	1500	<2.2	93	18	<6.8	<320	49	73	95
	9	<.10	<.05	37	140	92	<100	2500	<3.2	66	17	<6.8	<320	23	24	150
	51	tr	n.d.	<10	<30	90	n.a.	300	n.d.	<20	n.d.	n.a.	n.a.	<60	n.a.	<70
	52	n.d.	n.a.	<10	<30	40	n.a.	300	n.d.	<20	n.d.	n.a.	n.a.	<60	n.a.	<70
	53	n.d.	n.a.	<10	60	40	n.a.	600	n.d.	<20	n.d.	n.a.	n.a.	<60	n.a.	<70

	54	.1	n.d.	<10	<30	40	n.a.	600	n.d.	<20	n.d.	n.a.	n.a.	<60	n.a.	<70
	55	n.d.	n.d.	<10	<30	40	n.a.	600	n.d.	<20	n.d.	n.a.	n.a.	<60	n.a.	<70
	56	tr	n.d.	<10	<30	60	n.a.	600	n.d.	<20	n.d.	n.a.	n.a.	<60	n.a.	<70
	57	n.d.	n.d.	<10	<30	40	n.a.	300	n.d.	<20	n.d.	n.a.	n.a.	<60	n.a.	<70
	58	n.d.	n.a.	<10	<30	<20	n.a.	300	n.d.	<20	n.d.	n.a.	n.a.	<60	n.a.	<70
	59	n.d.	n.d.	<10	<30	40	n.a.	300	n.d.	<20	n.d.	n.a.	n.a.	<60	n.a.	<70
	60	n.d.	n.a.	<10	<30	40	n.a.	14000	n.d.	<20	<100	n.a.	n.a.	<60	n.a.	<70
	64	n.d.	n.a.	<10	<30	40	n.a.	600	n.d.	<20	n.d.	n.a.	n.a.	<60	n.a.	<70
	66	n.d.	n.a.	<10	<30	40	n.a.	600	n.d.	<20	n.d.	n.a.	n.a.	<60	n.a.	<70
	69	n.d.	n.a.	<10	60	n.a.	n.a.	14000	n.d.	<20	n.d.	n.a.	n.a.	<60	n.a.	<70
Diabase																
	80	n.d.	n.a.	<10	<30	460	n.a.	14000	n.d.	<20	n.d.	n.a.	n.a.	100	n.a.	<70
	81	n.d.	n.a.	10	<30	490	n.a.	14000	n.d.	20	n.d.	n.a.	n.a.	<60	n.a.	<70
Sandstone																
	1	<.10	<.05	3.8	5.6	8.3	<100	1400	<2.2	4.8	<10	<6.8	<320	15	<22	88
	5	<.10	<.05	5.6	29	16	<100	200	<2.2	11	15	<6.8	<320	67	<22	190
	10	<.10	<.05	4.6	22	12	<100	330	<2.2	10	17	<6.8	<320	23	24	150
	11	<.10	<.05	6.2	19	11	<100	280	<2.2	13	19	<6.8	<320	34	<22	170
	23	<.10	<.05	6.2	19	11	<100	280	<2.2	13	13	<6.8	<320	27	<22	180
	50	n.d.	n.a.	<10	<30	<20	n.a.	140	n.d.	n.d.	n.d.	n.a.	<20	<50	n.a.	<70
	61	n.d.	n.a.	<10	<30	30	n.a.	300	n.d.	<20	n.d.	n.a.	<20	100	n.a.	<70
	62	n.d.	n.a.	<10	<30	30	n.a.	300	n.d.	n.d.	n.d.	n.a.	<20	<60	n.a.	<70
	63	n.d.	n.a.	<10	<30	30	n.a.	300	n.d.	<20	n.d.	n.a.	<20	<60	n.a.	<70
	65	n.d.	n.a.	<10	<30	20	n.a.	300	n.d.	<20	n.d.	n.a.	<20	<60	n.a.	<70
	67	n.d.	n.a.	<10	<30	20	n.a.	140	n.d.	<20	<100	n.a.	<20	<60	n.a.	<70
	68	<10	n.a.	<10	<30	<20	n.a.	140	n.d.	<20	<100	n.a.	<20	<60	n.a.	<70
	70	n.d.	n.a.	<10	<30	20	n.a.	60	n.d.	n.d.	n.d.	n.a.	<20	<60	n.a.	<70
Quartzite																
	82	n.d.	n.a.	<10	30	40	n.a.	140	n.d.	<20	n.d.	n.a.	n.a.	60	n.d.	<70

n.a. - not analyzed

n.d. - not detected

tr - detected in trace amounts but below limit of quantitative determination.

Samples 1-50 were analyzed at U. S. Geological Survey analytical laboratories, Reston, Virginia. Au was determined by combined fire assay-atomic absorbtion technique. Remaining reported elements were determined by semiquantitative spectrographic technique for which the standard deviation of any single answer should be taken as +50 and -33 percent. Si, Al, Fe, Mg, Ca, Na, K, Ti, P, B, Ba, Bi, Cd, Ce, Dy, Er, Eu, Ga, Gd, Ge, Ho, In, Lu, Nb, Nd, Os, Pd, Pr, Pt, Re, Rh, Ru, Sb, Sc, Sm, Sr, Ta, Tb, Te, Th, Tl, Tm, W, Y, and Yb were analzyed but either not detected or detected in non-anomalous amounts. Samples 51-82 were analyzed by U. S. Bureau of Mines, Reno Metallurgical Research Center, Reno, Nevada. Co, Cr, Sc, Mo, Ni, Pb, V, Zr analyzed by general spectrographic technique. Cu also by general spectrographic technique except for samples 51, 54-57, 59, 80, 81, 71, 73, 78, which were analyzed by atomic absorbtion technique. Elements tested for but not detected are As, Au, Ba, Be, Bi, Cd, Ga, Hf, In, Li, La, Y, Nb, P, Pt, Re, Sb, Sn, Sr, Ta, Te, Tl, W, Zn.

1/ High value due to contamination during sample preparation.

Figure 17.--Map and section of the Silver Mountain prospect adit showing the locations of sample sites.

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A small prospect trench is located about 1,000 feet (305 m) NE of the adit at an elevation of 1,080 feet (329 m). First noted by Roberts (1940), it is presumed to have been opened by the same people who worked the adit. The trench lies within the same rock unit as the adit and has been excavated on a fault zone near the head of a narrow ravine which reflects the fault's trace. The workings are about 22 feet (6.7 m) long, 4 feet (1.2 m) wide, and 6 feet (1.8 m) in depth. Exposed in the face of the trench, the fault zone is about 3.5 feet (1 m) wide and has a strike of N. 46° W. and a dip of 80° NE.

A chip sample of fault gauge and brecciated country rock was taken across the face. Assay results indicate a trace of silver and 90 ppm copper. Random chip samples from over an interval along the NE rib and along the SW rib have lower copper values. The sparse mineralization indicated by the assay data negates the possibilities of any economic value for the prospect.

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High-Silica Sand

Evaluation of analyses for the Jacobsville Sandstone (table 2) indicates that high aluminum, iron, magnesium, and titanium negate the possibility of this sandstone being considered a source of high-silica sand. Whether more pure sandstone underlies the glacial material in the area could not be determined but examination of the few outcrops suggests that it does not. Glacial deposits in the area are not considered likely sources of high-silica sand because of their lack of maturity.

Stone

Before the turn of the century, the Jacobsville Sandstone was quarried as dimension stone at the town of L'Anse, approximately 14 miles (23 km) northeast of the Sturgeon River area and at several other localities near the Lake Superior shore (Kirby, 1964).

Jacobsville Sandstone in the study area is not nearly as well suited to quarry development, even if there were sufficient market demand. The distance to major market areas, the vast quantities of overburden as well as the lack of electrical power and access roads, precludes economic development and limits the potential of the sandstone.

Basalt of the Siemens Creek Formation within the study area is a minor resource of crushed stone and riprap. The distance to markets, the limited areal extent of the outcrops and extensive overburden, plus the lack of electrical power and access roads, limit the possibility of economic development. The basalt at nearby Silver Mountain represents a more likely source of a very large quantity of stone with a developed access.

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Sand and Gravel

Sand and gravel is found in the extensive glacial deposits which blanket the study area. Thicknesses of deposits range from zero to about 100 feet (30 m) in cutbanks along the Sturgeon River. It is estimated that thicknesses of over 200 feet (61 m) are present in some areas, based on topographic mapping.

Moraine deposits of till, lake plain and stream bench deposits of sand and clay, and outwash deposits of stratified sand and gravel are present (Doonan and Byerlay, 1973). In this heavily vegetated area, characteristics of individual deposits are visible mainly in stream drainages. Observations indicate that many of the deposits are composed of fine sands with interbedded silts and clays, which are a deterrent to commercial development.

Coarse water-washed gravels and sands which are more commercially attractive, along with numerous boulders, occur in the Sturgeon River channel and along bars from a point where the river enters the study area in sec. 11 to the south line of sec. 3, T. 48 N., R. 35 W. The distance from major demand centers and high transportation costs effectively limit commercial utilization of these deposits. Because most of the surrounding area is National Forest land, local demand is unlikely.

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Clay

Deposits of clay within the study area are mainly visible in stream drainages (fig. 18). The areal extent of most exposures can be

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Figure 18 near here.

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described in tens of feet. In several instances, deposits are overlain by glacial sands and gravels in excess of 50 feet. All clays are red or tan in color, somewhat gritty, and in a few cases, have small pebbles interspersed in the clay matrix.

Samples were taken and evaluated during this investigation to catalog the clay's ceramic properties (table 3). Only clay sample

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Table 3 near here.

No. 72, table 3, shows any promise of potential use as a moderate weather building brick. All other samples of clay were found not suitable for use in vitreous clay products.

Limited areal extent of the deposits, poor quality, thickness of overburden, distance to markets, and lack of accessibility negate the possibility of their economic development.

Peat

Minor resources of peat are found in swampy lowlands within the study area, for the most part in the SW 1/4 sec. 32, T. 49 N., R. 35 W., and the NE 1/4 sec. 6, T. 48 N., R. 35 W. Because of the lack of local demand and distance to major markets, it is unlikely the deposits will be commercially significant.

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Figure 18.--Exposure of Pleistocene glacial deposits in a stream bank along Sidnaw Creek showing a clay bed (darker massive appearing material near center) overlain and underlain by stratified sand.

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TABLE 3. -- Evaluation of glacial clay samples[1]

Sample Number	Sample interval[2] (feet)	Raw properties[3]	Slow firing test: Temp.[4] °F	Munsell color	Moh's hardness	Total shrinkage (percent)	Absorption (percent)	Apparent porosity (percent)	Bulk density (gm/cc)	Potential use
72	2.5	Water of plasticity: 20.8%	1800	5 YR 7/6	2	5.0	20.8	34.5	1.70	Grade MW building brick.
		Working properties: short	1900	5 YR 7/6	2	5.0	20.4	34.2	1.67	
		Drying shrinkage: 5.0%	2000	2.5 YR 6/8	3	5.0	19.1	32.7	1.71	
		pH: 7.3	2100	2.5 YR 5/6	4	5.0	13.8	25.5	1.85	
		No effervescence with HCl	2200*	2.5 YR 3/2	7	12.5	1.9	4.1	2.14	
			2300	---	-	Melted	---	---	---	
74	6.0	Water of plasticity: 20.5%	1800	5 YR 8/2	3	5.0	19.4	33.6	1.73	Not suitable for use in vitreous clay products, too soft.
		Working properties: plastic	1900	5 YR 8/2	3	5.0	19.2	33.5	1.74	
		Drying shrinkage: 5.0%	2000	7.5 YR 8/4	3	5.0	17.0	30.8	1.81	
		pH: 7.7	2100*	7.5 YR 6/4	8	10.0	3.3	7.5	2.25	
		Slight effervescence with HCl	2200	---	-	Melted	---	---	---	
			2300	---	-	---	---	---	---	
75	4.0	Water of plasticity: 22.2%	1800	5 YR 8/4	2	5.0	20.9	35.1	1.68	Not suitable for use in vitreous clay products, too soft.
		Working properties: plastic	1900	5 YR 8/4	2	5.0	20.7	34.9	1.69	
		Drying shrinkage: 2.5%	2000	2.5 YR 7/4	3	5.0	15.4	28.3	1.84	
		pH: 8.0	2100*	5 YR 4/2	6	12.5	0.9	2.2	2.30	
		Slight effervescence with HCl	2200	---	-	Melted	---	---	---	
			2300	---	-	---	---	---	---	
76	7.5	Water of plasticity: 21.0%	1800	5 YR 8/4	2	5.0	20.8	34.7	1.67	Not suitable for use in vitreous clay products, too soft.
		Working properties: plastic	1900	5 YR 8/4	2	5.0	20.4	34.6	1 69	
		Drying shrinkage: 5.0%	2000	2.5 YR 7/4	3	[illegible]	[illegible]	31.7	1.75	
		pH: 7.8	2100*	5 YR 5/4	7	10.0	2.7	6.1	2.28	
		Slight effervescence with HCl	2200	---	-	Melted	---	---	---	
			2300	---	-	---	---	---	---	
77	6.3	Water of plasticity: 20.4%	1800	2.5 YR 7/6	3	5.0	15.9	29.4	1.84	Not suitable for use in vitreous clay products, too soft.
		Working properties: plastic	1900	2.5 YR 7/6	3	5.0	15.1	28.3	1.87	
		Drying shrinkage: 5.0%	2000	2.5 YR 6/6	3	5.0	11.9	23.5	1.97	
		pH: 8.1	2100*	2.5 YR 4/2	7	10.0	2.4	5.5	2.26	
		Slight effervescence with HCl	2200	---	-	Melted	---	---	---	
			2300	---	-	---	---	---	---	
79	4.0	Water of plasticity: 17.2%	1800	2.5 YR 7/6	2	5.0	14.9	28.0	1.88	Not suitable for use in vitreous clay products.
		Working properties: plastic	1900	2.5 YR 7/6	2	5.0	14.6	27.6	1.89	
		Drying shrinkage: 5.0%	2000	2.5 YR 6/8	3	5.0	12.5	24.6	1.97	
		pH: 8.2	2100*	5 YR 4/4	6	5.0	7.0	15.2	2.17	
		Slight effervescence with HCl	2200	---	-	Melted	---	---	---	
			2300	---	-	---	---	---	---	

1/ All data presented are based on laboratory tests that are preliminary in nature, and will not suffice for plant or process design.
2/ To convert sample interval to meters, multiply footage by 0.3048.
3/ Tests indicate the following for all samples: Drying defects - none; Dry strength - good; Bloating test - negative.
4/ Asterisk indicates abrupt vitrification prior to reaching temperature noted.

Chapter D - Potential for Undiscovered Mineral Deposits

by

W. F. Cannon, U. S. Geological Survey

James J. Hill and Peter C. Mory, U. S. Bureau of Mines

The probability that undiscovered mineral deposits exist in the study area is estimated in two ways. First, ore deposits commonly are associated with a characteristic geologic environment (for instance lithology, rock type, or structure) so that by comparing the environments in the study area with those of known mineral deposits elsewhere it is possible to estimate what, if any, types of ore deposits could occur in the area. Second, the potential for mineral deposits can be assessed more directly by geochemical surveys. Ore deposits, even though buried beneath the surface, commonly cause anomalous metal content in soil developed above the deposit, in bedrock in a hale around the deposit, or in sediments in streams flowing across the mineralized area.

Both of these approaches indicate a low probability that undiscovered mineral deposits exist in the area.

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Assessment by Geological Environment

Mineral commodities that have been produced in major quantities in nearby areas include iron from middle Precambrian iron-formations, copper from middle Keweenawan basalt and interbedded sedimentary rocks and from upper Keweenawan shale, and lesser amounts of gold from gold-bearing quartz veins. Also, several small deposits of uranium-rich rocks have been found east of the area and uranium exploration is currently very active in much of the upper peninsula.

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Michigamme Formation.--If the Michigamme Formation in the study area is a graywacke-slate sequence as inferred from aeromagnetic data, the potential for mineral deposits in it is very low. Such sequences, which accumulate rapidly in deep marine basins, are generally barren of metal concentrations. This is certainly true in the upper peninsula for the graywacke-slate sequence of the Michigamme is extensively exposed south and east of the study area and is virtually devoid of any trace of mineralization. The stratigraphically lower part of the Michigamme Formation, east of the study area, contains iron-formation from which iron was produced in the past. That iron-formation, along with surrounding pyritic black slate is the site of several known uranium occurrences and is currently the object of considerable uranium exploration activity. If these units are beneath the study area, they are probably at a considerable depth below the graywacke-slate sequence where exploration is not feasible. The nearest outcrops of the Michigamme Formation to the study area have been field checked with a scintillometer and checked in the laboratory by a uranium scan. They are not anomalously uraniferous.

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Basalt and diabase dikes.--Basalt and diabase, in general, are not favorable host rocks for ore deposits, but the Keweenawan basalts of Michigan are an exception to that rule. Extensive deposits of native copper and associated silver have been mined from middle Keweenawan basalt and interbedded sedimentary rocks north and west of the study area. In spite of this, the basalt in the study area is not considered favorable for copper deposits. All economic copper deposits are in middle Keweenawan rocks whereas the basalt in the study area is undoubtedly lower Keweenawan as indicated by magnetic studies discussed in chapter B. Important copper mineralization is known nowhere in lower Keweenawan basalt or related diabase.

Jacobsville Sandstone.--The Jacobsville Sandstone has been studied widely in the upper peninsula (for instance Hamblin, 1958) and no mineralization has been reported. Its barren nature over a wide area indicates little liklihood that it would contain mineralization in the study area.

Glacial deposits.--The only possible occurrence of metallic minerals in the glacial deposits is as heavy mineral placer concentrates. The stratified, probably fluvial, nature of much of the glacial material indicates that placer concentration is possible, but the geochemical data discussed below shows no indication that such deposits exist in the area.

Deposits of non-metallic materials such as clay, peat, and sand and gravel are abundant and have not been thoroughly explored or measured in this study. The poor ceramic quality of the known clay beds suggests that undiscovered clay beds are likewise of poor quality. Peat is likely to occur in marshy areas, particulary in the southwest part of the study area, but most marshes are small and the great distance from potential markets suggests that no important undiscovered peat resources are in the area. Vast quantities of sand and gravel are in the area but the abundance of similar material throughout the region, much of it closer to points of consumption, negate any large economic potential for sand and gravel in the study area.

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Assessment by Geochemical Survey
W.F. Cannon, U.S. Geological Survey

A geochemical survey of the study area used three sample media: bedrock, soil developed on glacial deposits, and stream sediments consisting of both pan concentrates and grab samples. None of these showed highly anomalous compositions and no suggestion of buried ore deposits was found. A partial listing of analyses is in table 2.

Soil samples.--Soil samples were collected from 15 localities mostly on uplands near the margin of the study area. All were developed on thick glacial deposits and the soil profile consisted of 1-2 cm of organic material at the surface, and 10-20 cm of light gray sandy soil over reddish brown sand. Most samples were taken from 30 to 40 cm below the surface.

Because of the porous nature of the glacial deposits and their great thickness it is very unlikely that a mineral deposit beneath the deposits or in the deposits themselves would be detected in the soil. Groundwater percolates freely downward except in areas of clay beds and there is no mechanism by which metals in anomalous concentrations could diffuse upward to the soil zone. The soil samples were intended to provide background values against which stream sediment samples could be compared. The results of the analyses are shown in table . No anoamlously high values were found.

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Stream sediments.--Eight grab samples of stream sediments and 11 heavy mineral concentrates panned from the sediments were collected and analyzed. Sample sites were chosen along the Sturgeon River and on all major tributaries so that each individual drainage system was sampled. The stream sediments of tributaries are derived totally from glacial deposits, whereas those in the Sturgeon River although, derived principally from glacial deposits, also have a component introduced from upstream portions of the river, outside of the study area. Any concentrations of metals in the glacial deposits should cause higher concentrations in the stream sediments than were measured in soil from the adjacent uplands.

Certain elements such as Cu, Hf, Pb, Zn, Zr, and Ti showed predictably higher concentrations in heavy mineral concentrates than in either grab samples of stream sediments or soil samples (see table 4).

Table 4 near here.

This reflects only that these elements are contained in heavy minerals. Visual estimates are that heavy minerals are generally less than 1% of the stream sediments. Comparison of analyses of pan concentrates with grab samples collected at the same site show no anomalous values in the sediments for those elements with very high values in the pan concentrates.

Thus, there is no evidence of metal concentrates that approach economic grade or size in the glacial deposits.

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Table 4.--Comparison of analyses of some stream sediments and heavy mineral pan concentrates.

Element	Range (ppm)	Median (ppm)
Pan concentrates (11 samples)		
Cu	<21-220	<21
Hf	<1-30	14
Pb	8.5-100	29
Zn	<15-270	110
Zr	136->2100	>2100
TiO_2	13000-87000	37000
Stream sediments (8 samples)		
Cu	1.5-6.9	4
Hf	<21-<47	<21
Pb	9.9-1.5	14
Zn	all < 15	<15
Zr	120-480	210
TiO_2	5000-13000	8000
Soil (15 samples)		
Cu	3.2-13.1	5
Hf	n.d.	n.d.
Pb	4.8-15	10
Zn	<15-21	<15
Zr	81-634	230
TiO_2	4400-10000	7000

n.d. - not detected

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Two pan concentrates had slightly anomalous tin content (45 and 52 ppm). One of these samples (20) was from the point where the Sturgeon River enters the study area and suggests that these small amounts of tin are being carried into the area from some point upstream. The other sample (49) from the Sturgeon River near the mouth of Funks Creek also had slightly anomalous silver (1.5 ppm) and arsenic (210 ppm) values for which there is no obvious source in the study area.

Bedrock.--Seven samples of basalt from the Siemens Creek Formation and 13 samples of the Jacobsville Sandstone were analyzed to search for anomalous metal content. In addition, two samples of lower Keweenawan diabase dikes and one sample of quartzite from the Michigamme Formation from outside of the study area were analyzed.

No unusual concentrations of metals were found in any samples except for the diabase dikes (80 and 81 in table) which contain 460 and 490 ppm copper. In outcrops, these rocks show no unusual concentrations of minerals that are likely to bear copper and no explanation for the high copper content is apparent. Although these values are considerable higher than typical copper content of diabase (~150 ppm) they are far from economic concentrations. Because no higher grade copper concentrations are evident here or in any other similar diabase throughout a large surrounding region, it is unlikely that these values are associated with economically important mineralization.

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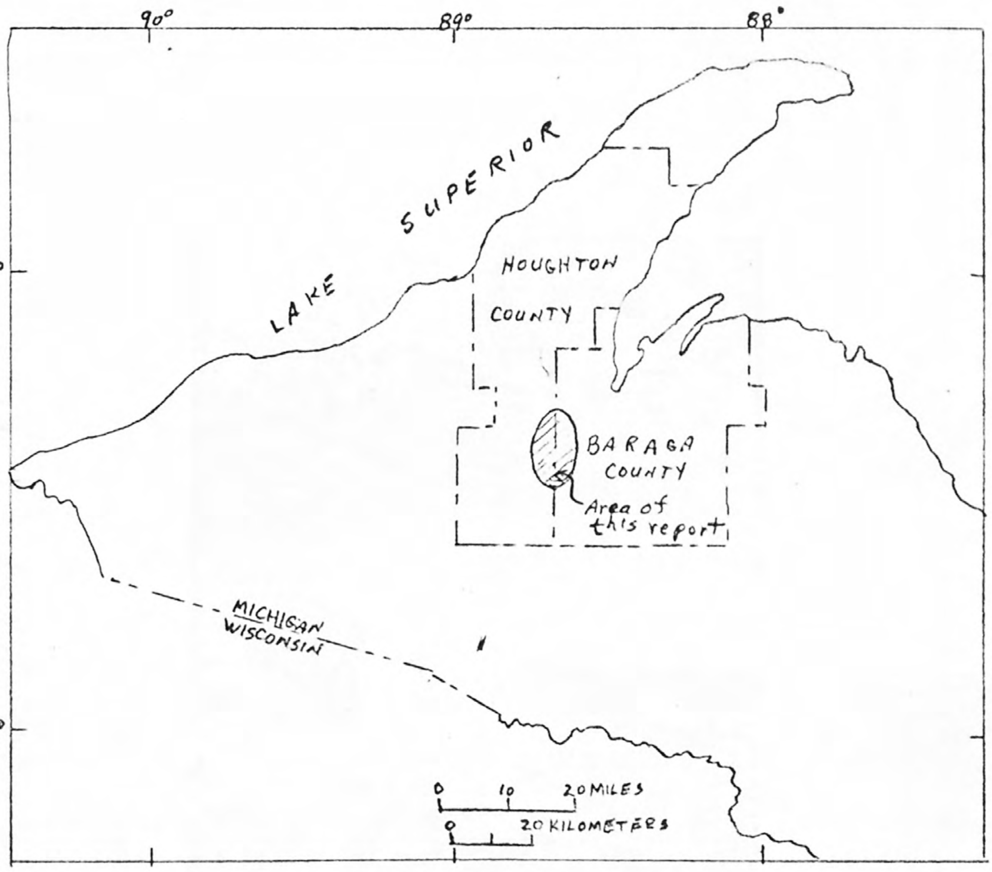

Figure 1

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Figure 2

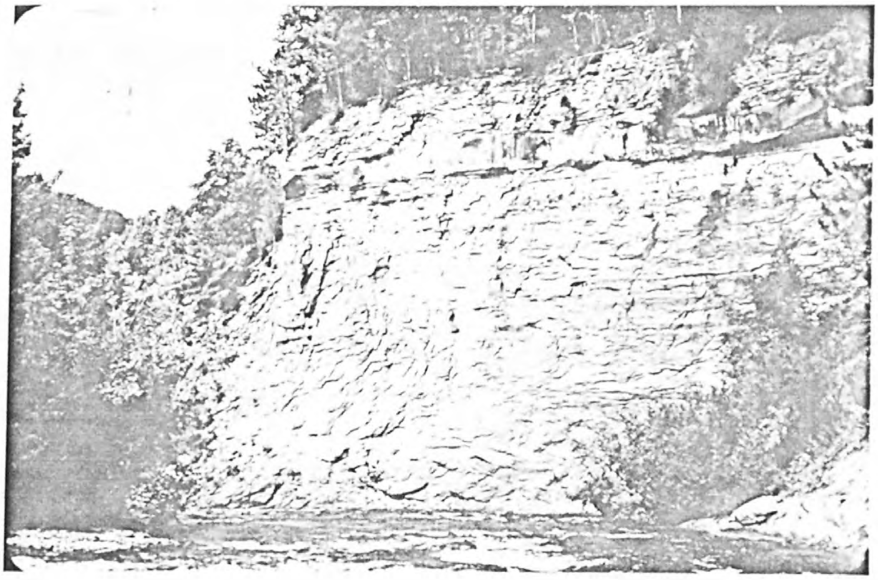

Figure 3

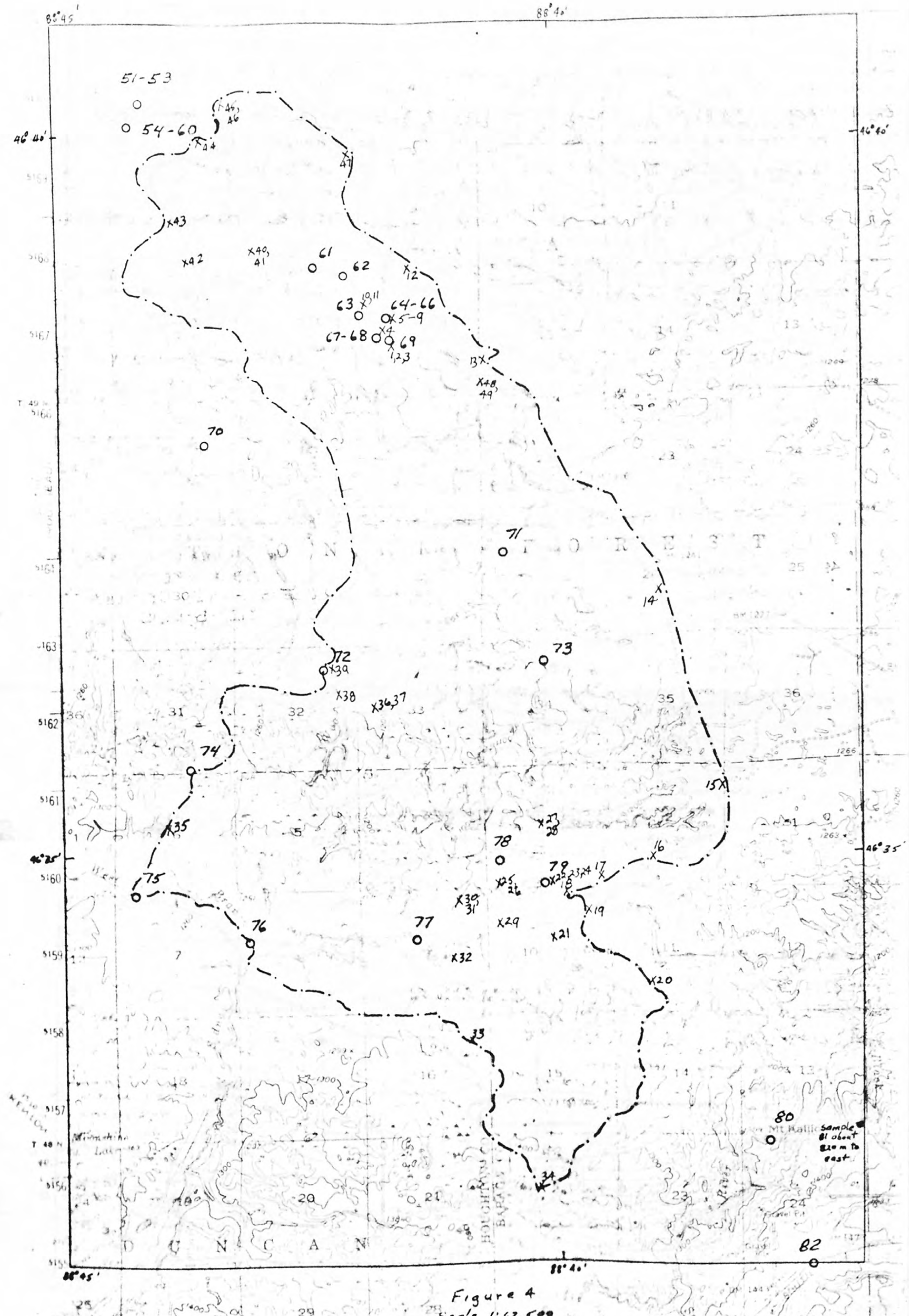

Figure 4
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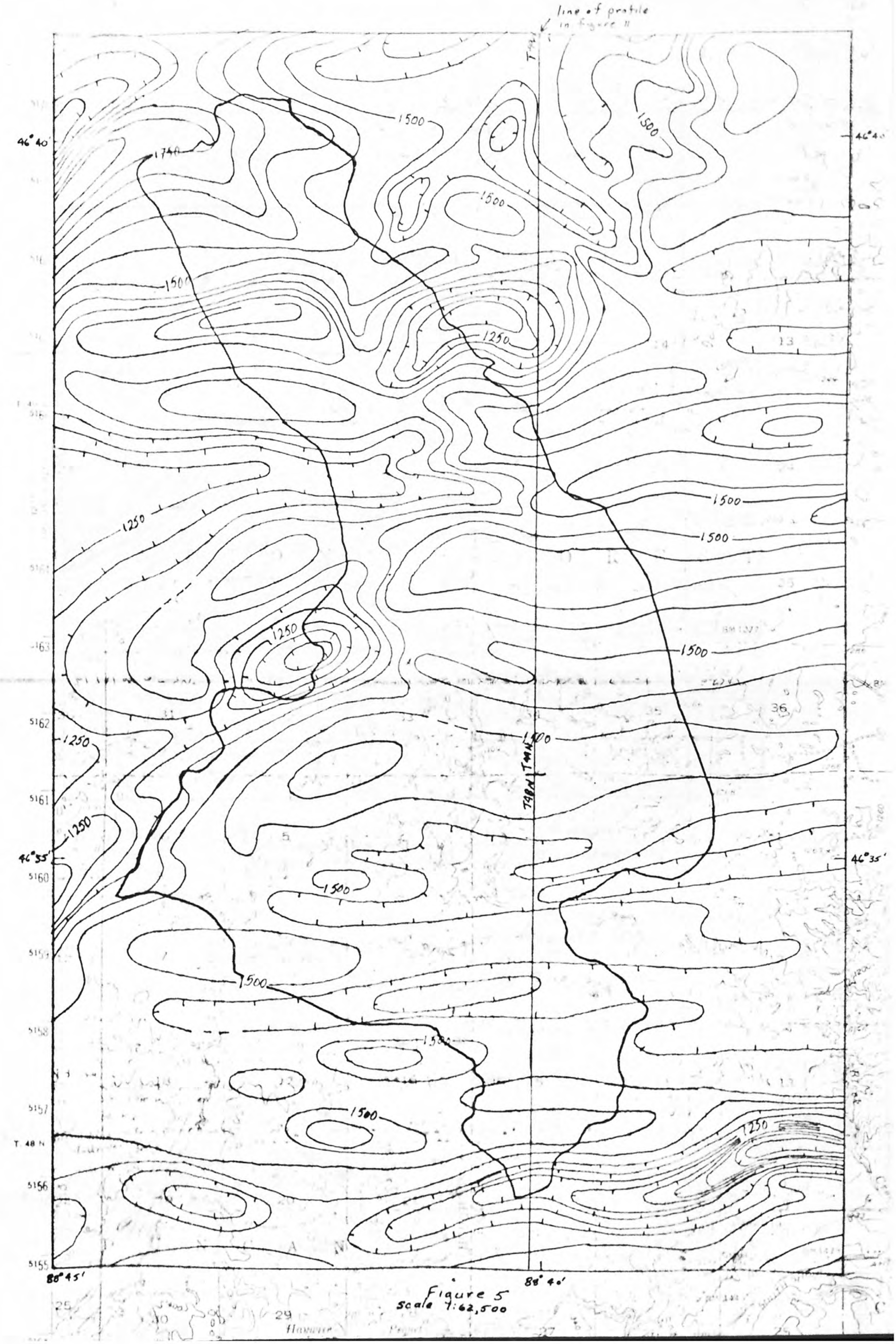

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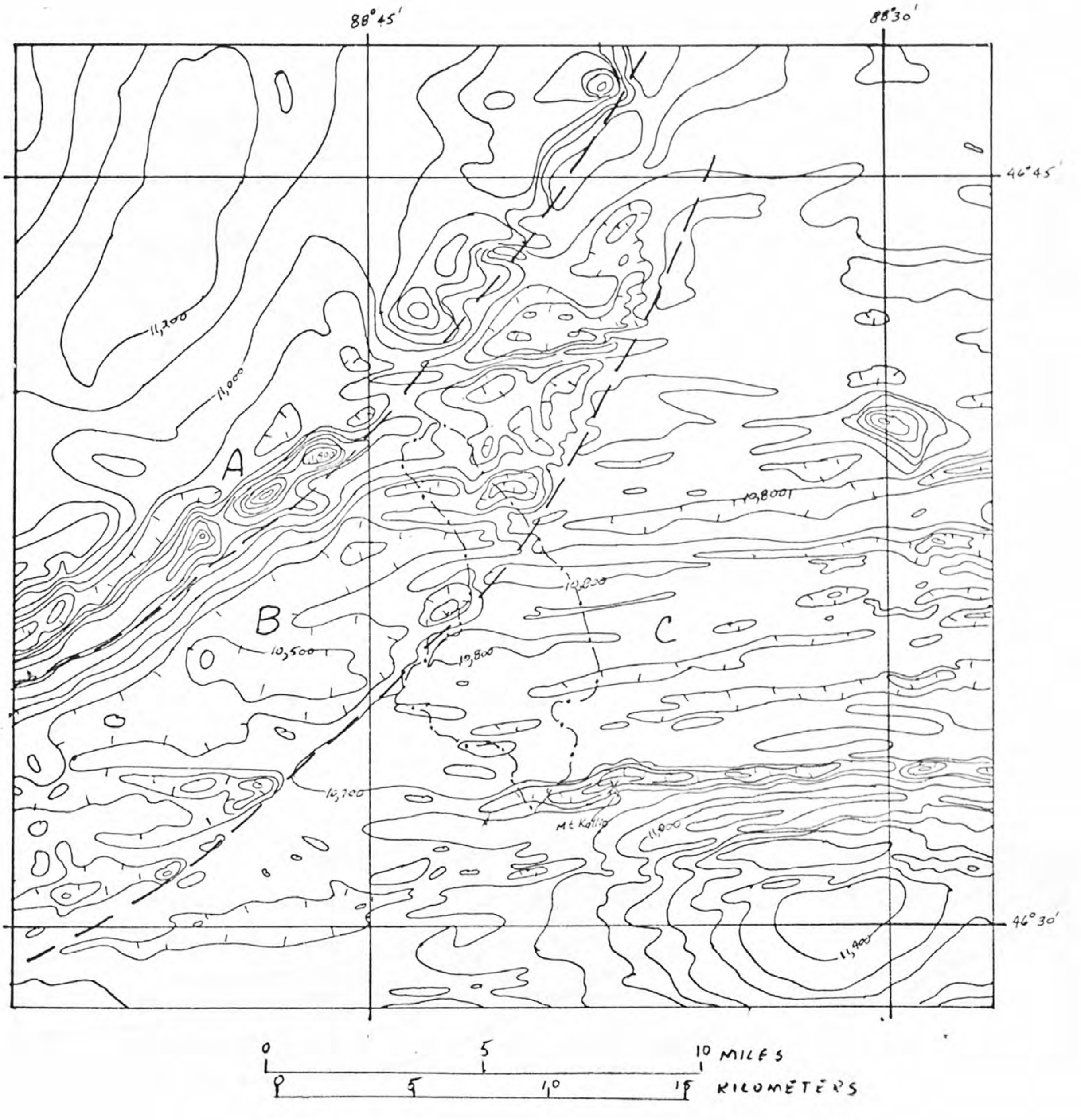

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88°30'
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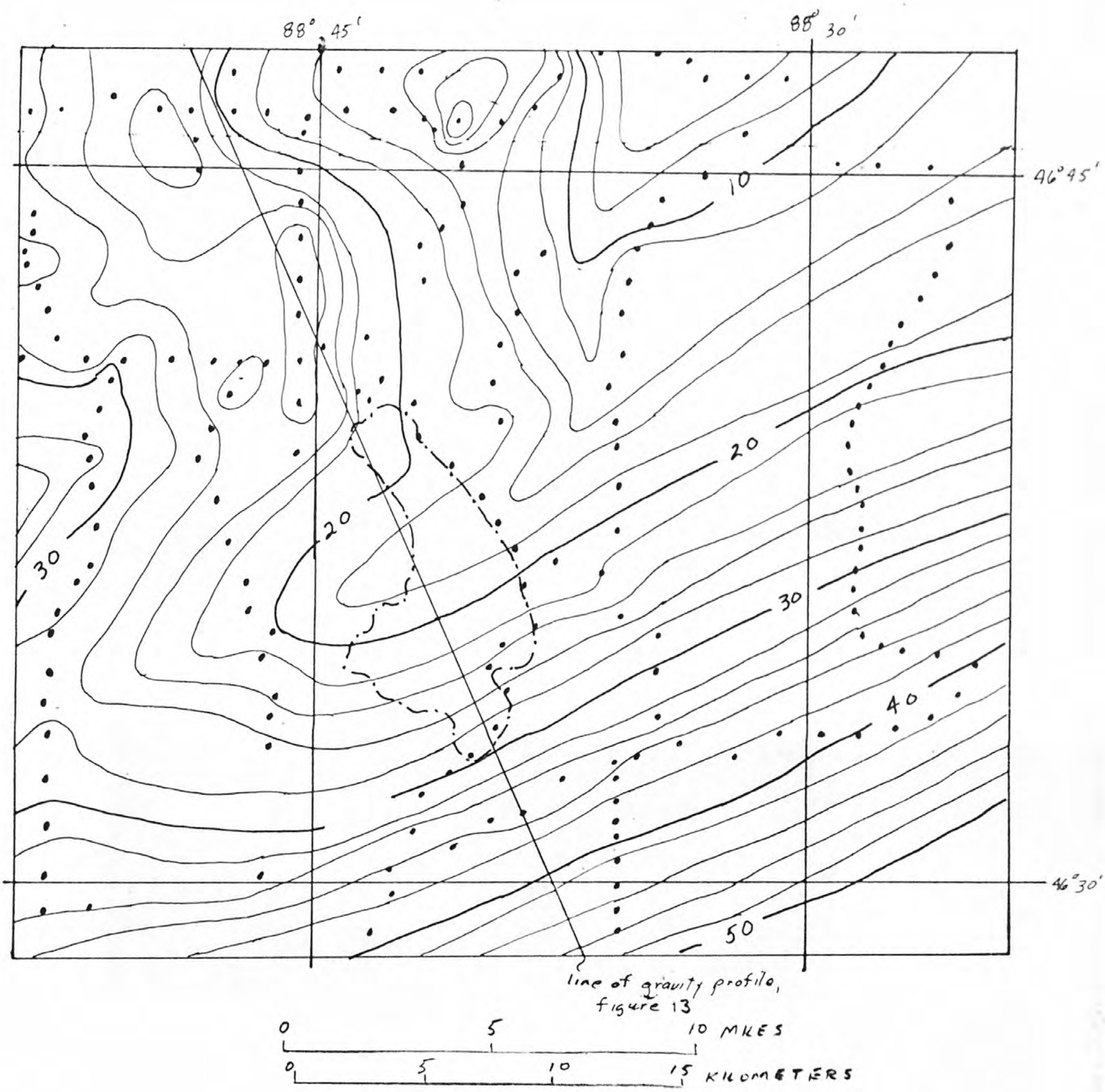
Figure 6



88° 45'
88° 30'
46° 45'
46° 30'
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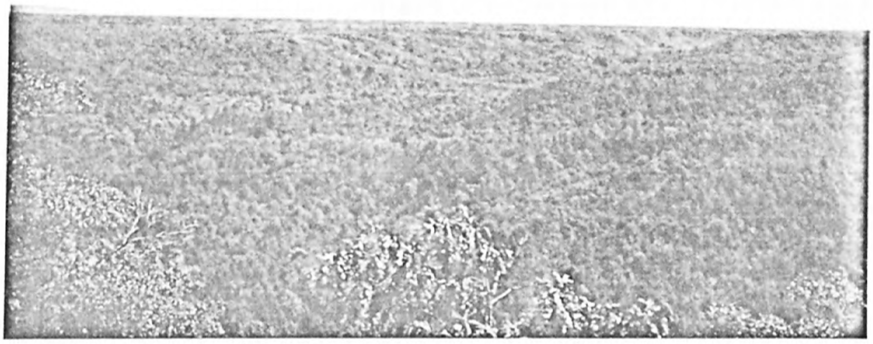
50
line of gravity profile, figure 13
0 5 10 MILES
0 5 10 15 KILOMETERS

Figure 7



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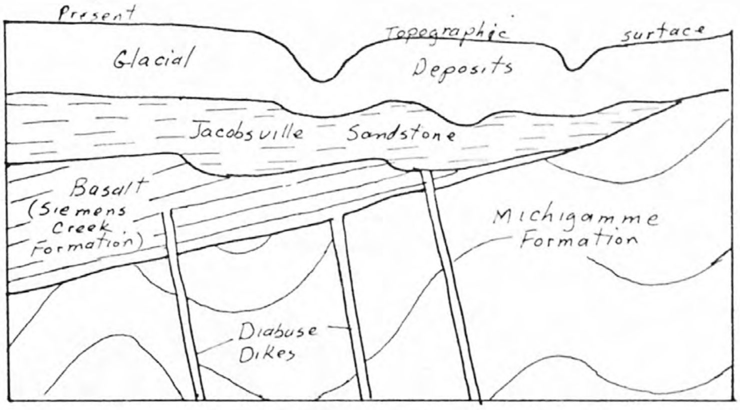
Present
Topographic
surface
Glacial
Deposits
Jacobsville
Sandstone
Basalt
(Siemens
Creek
Formation)
Michigamme
Formation
Diabase
Dikes

Figure 9

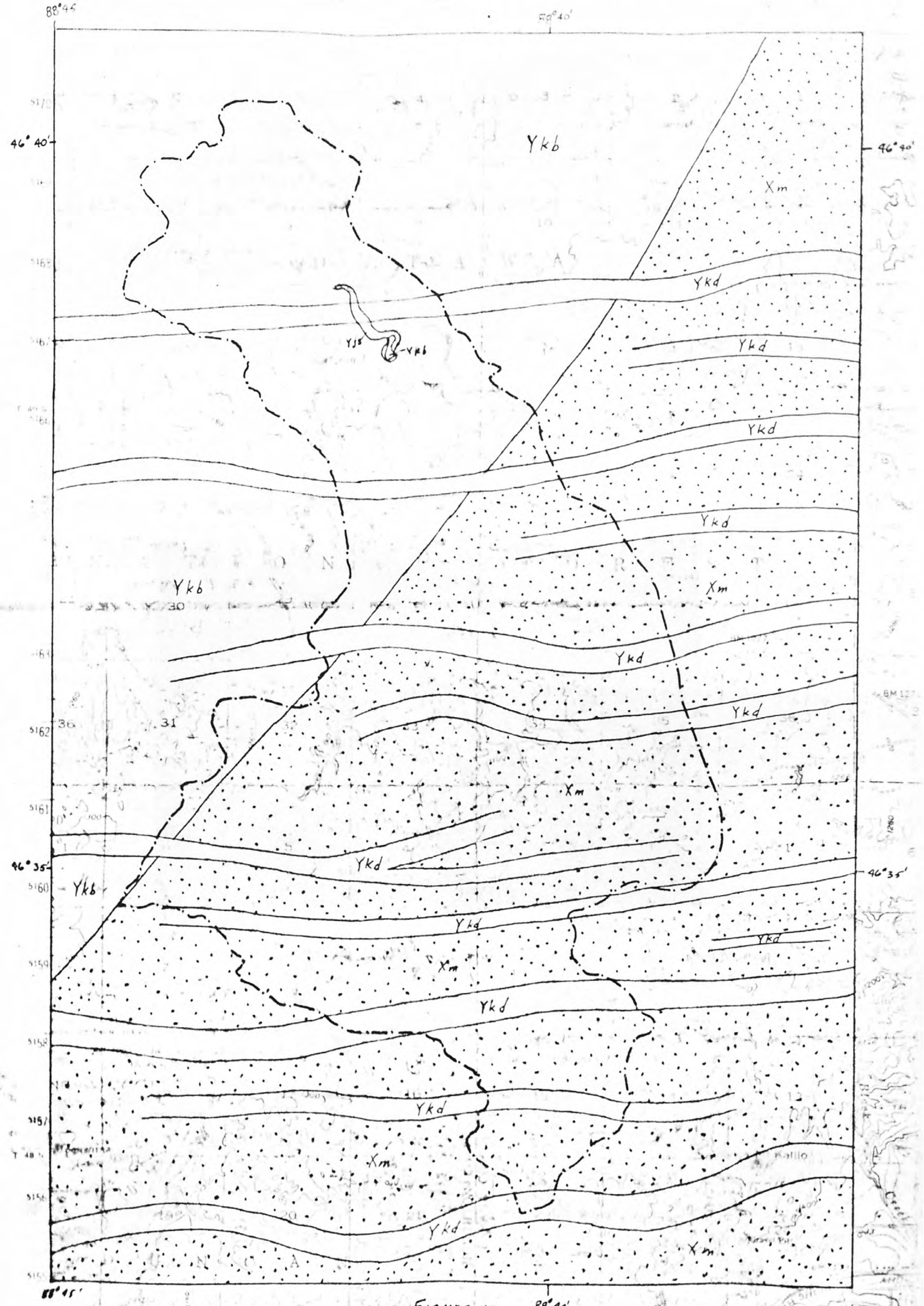

Figure 10
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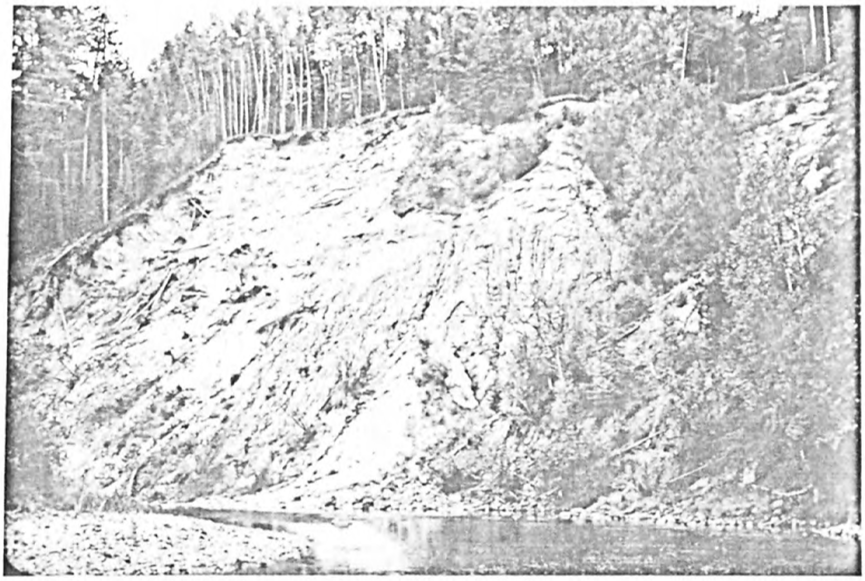
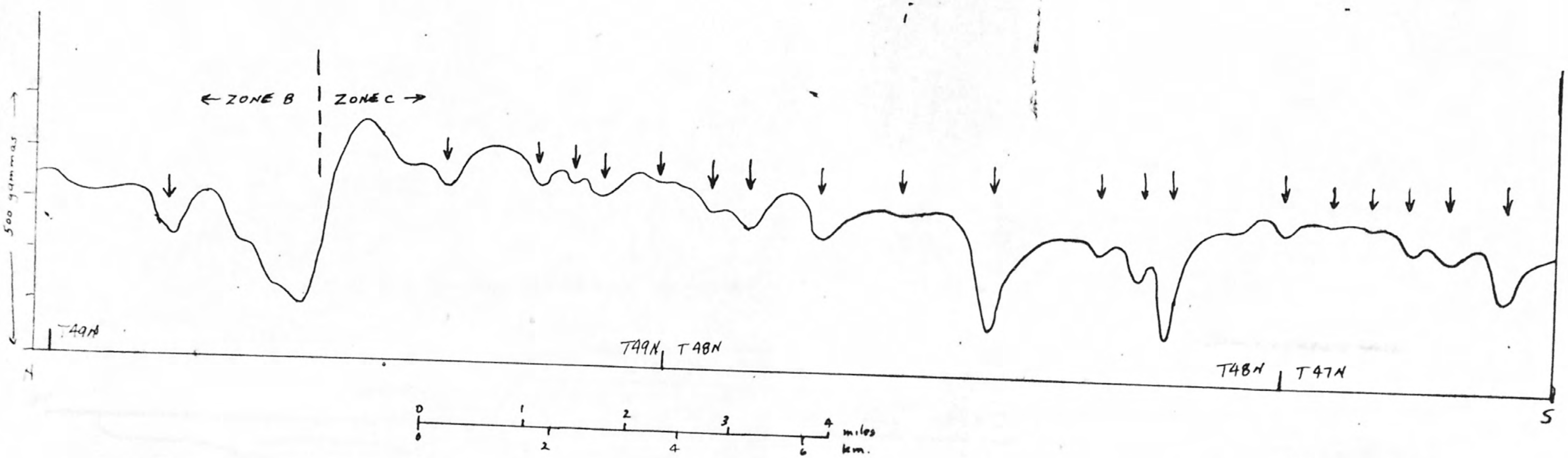


Figure 11



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T49N
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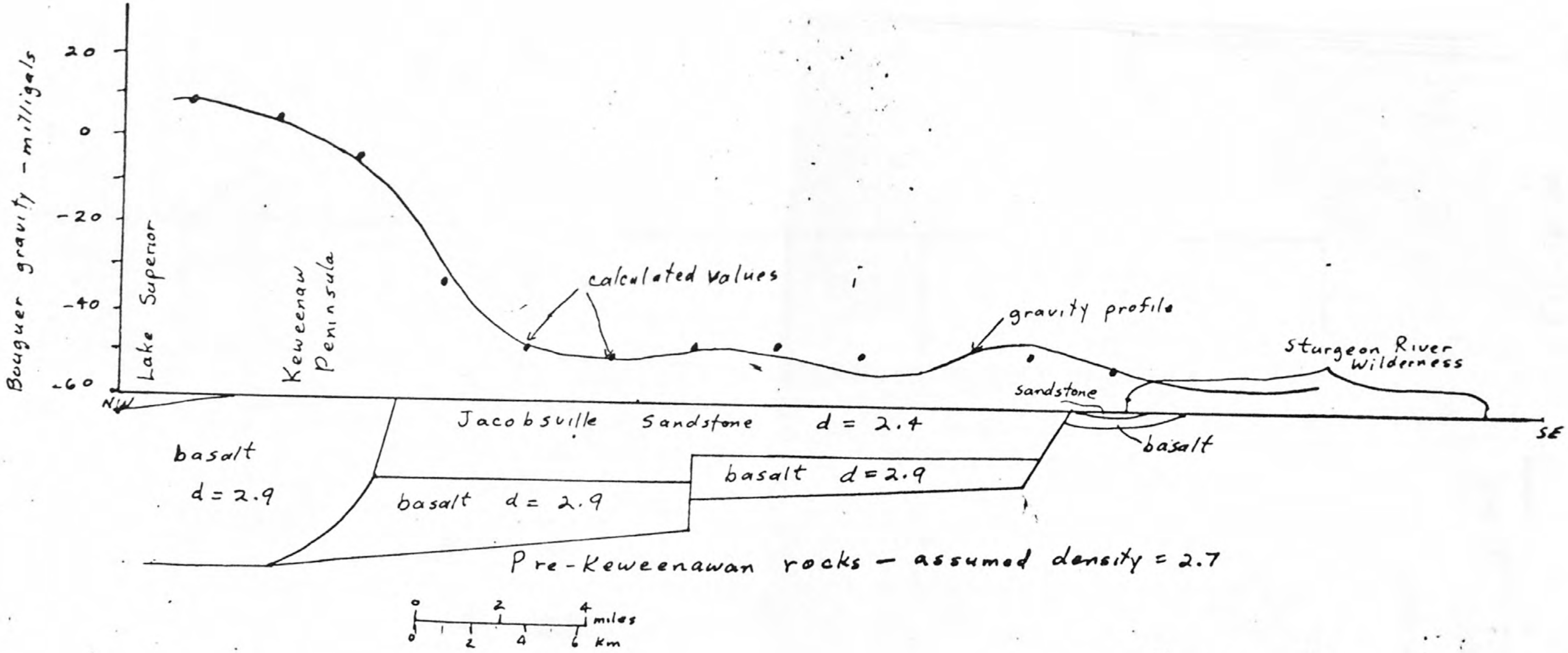
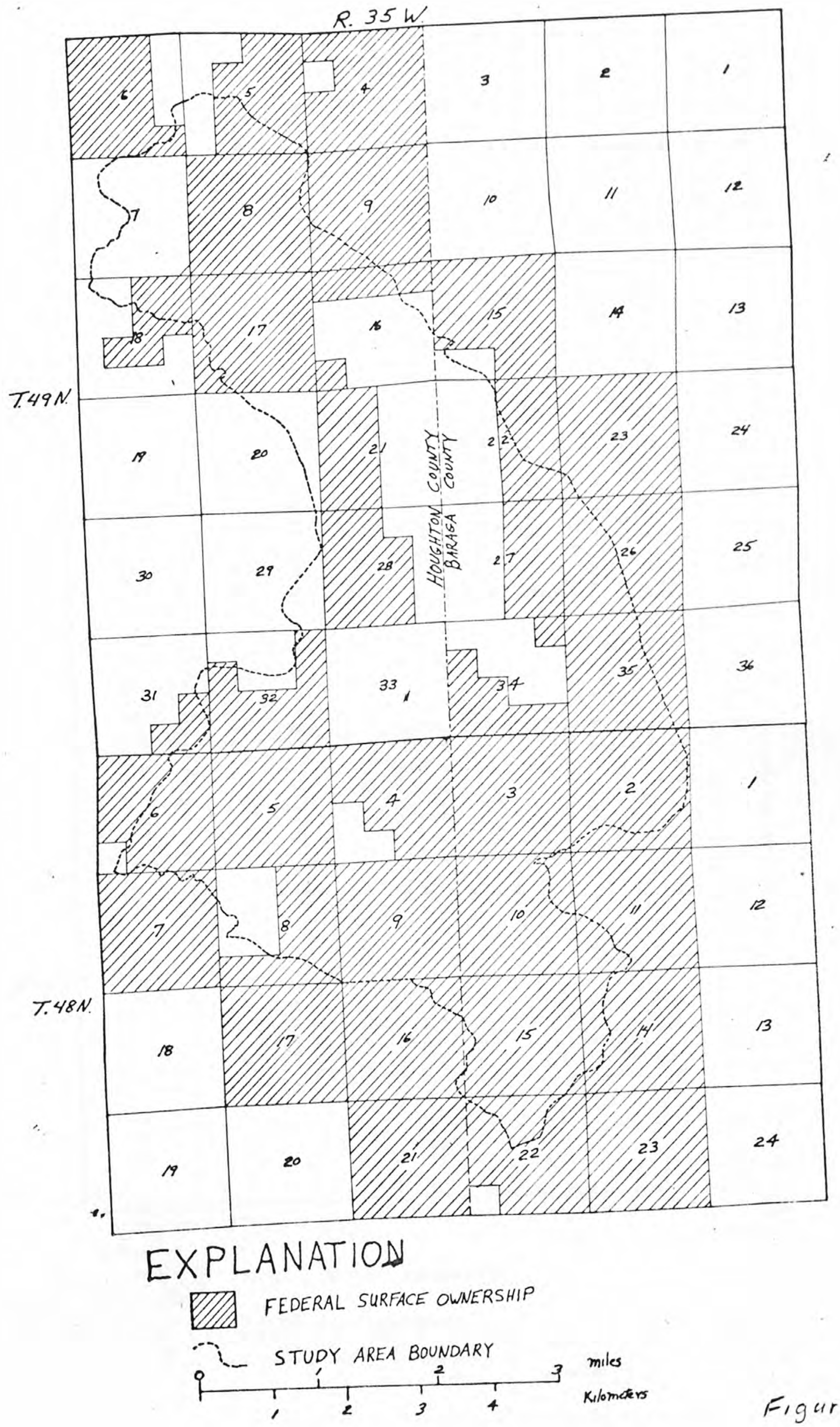
km.

Figure 12



Bouguer gravity - milligals
20
0
-20
-40
-60
Lake Superior
Keweenaw Peninsula
calculated values
gravity profile
Sturgeon River Wilderness
NW
SE
sandstone
Jacobsville Sandstone d = 2.4
basalt
basalt d = 2.9
basalt d = 2.9
basalt d = 2.9
Pre-Keweenawan rocks - assumed density = 2.7
0 2 4 miles
0 2 4 6 Km

Figure 13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EXPLANATION
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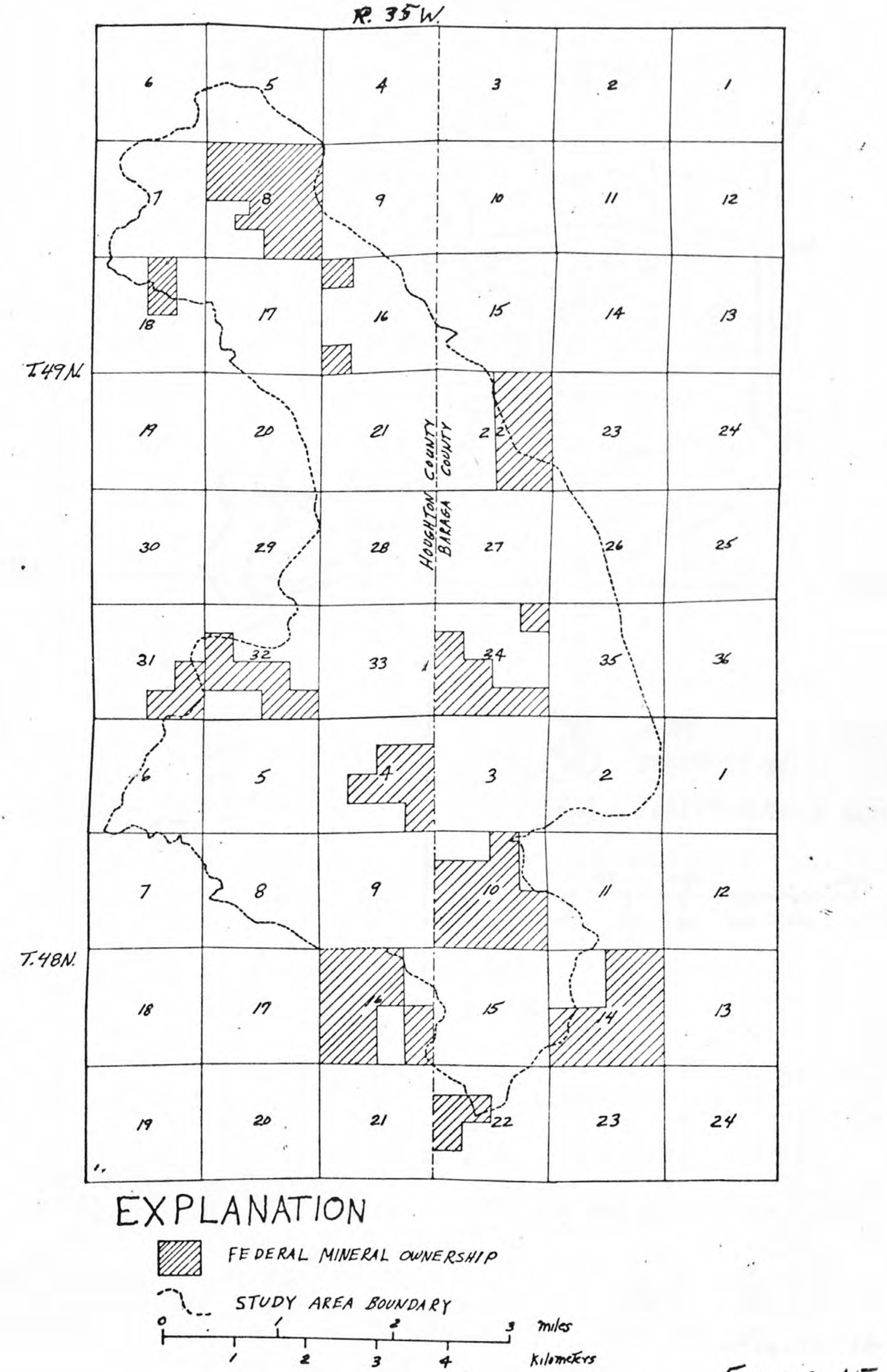
Figure 14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HOUGHTON COUNTY
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EXPLANATION
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Figure 15

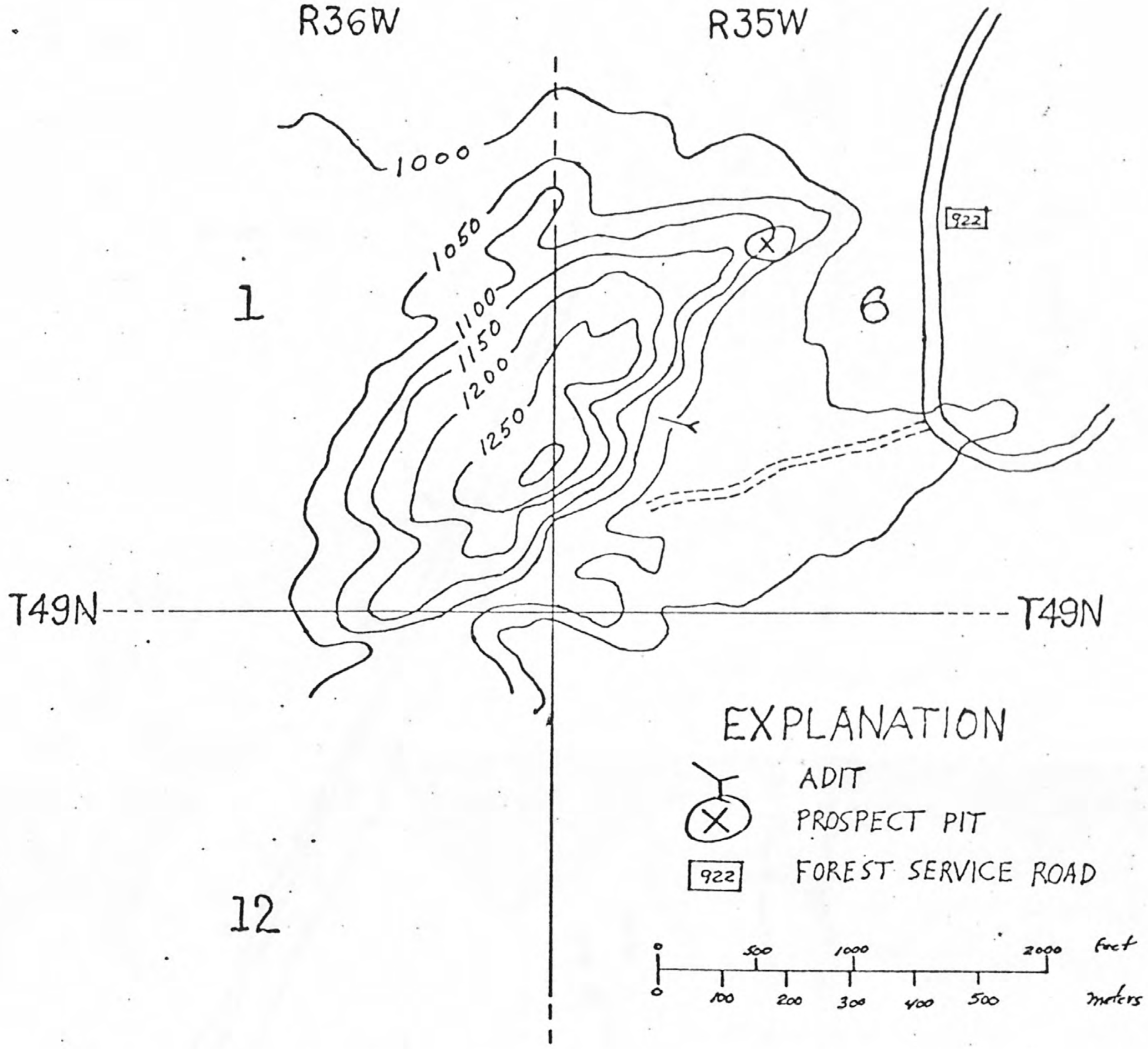
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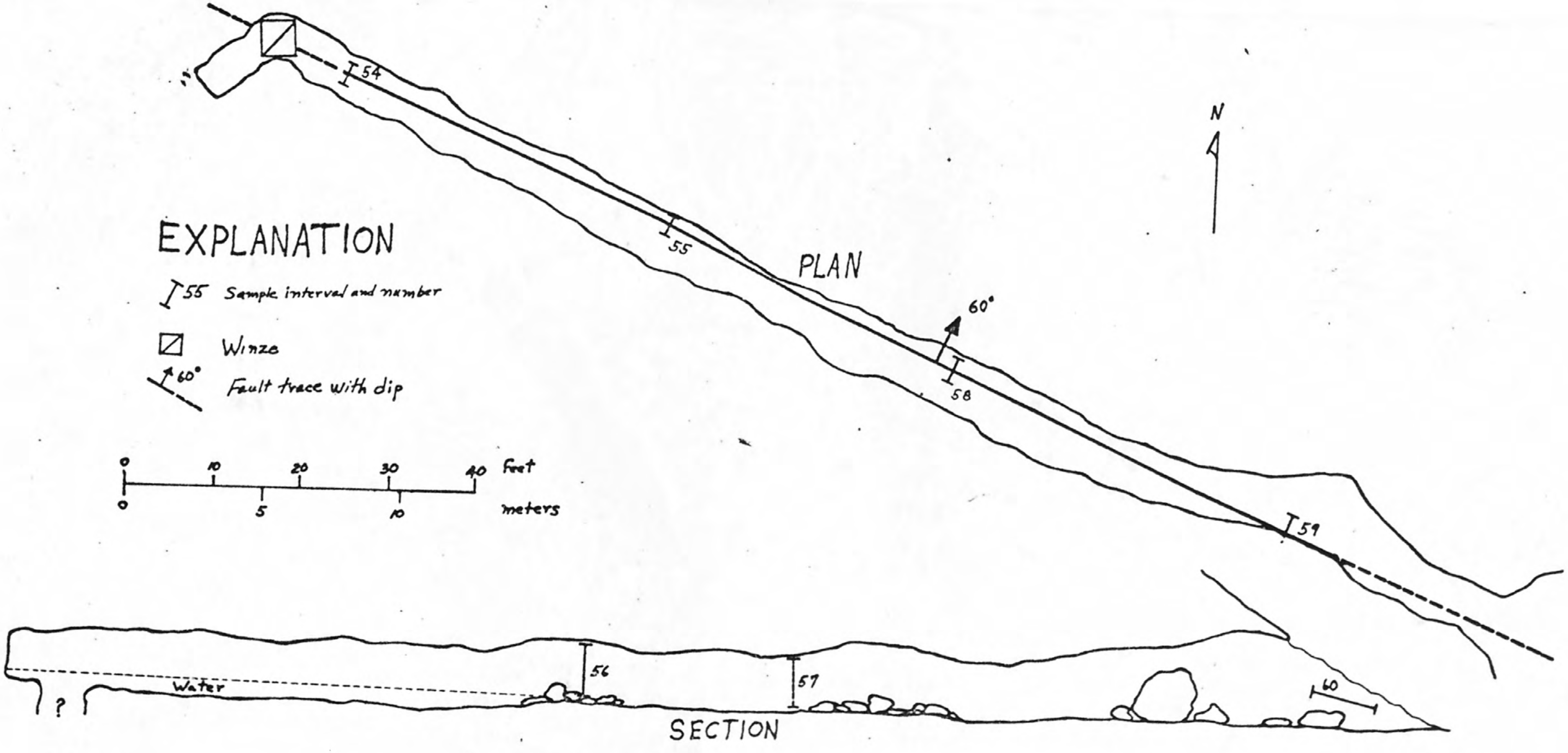
Figure 16


EXPLANATION
55 Sample interval and number
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SECTION

Figure 17

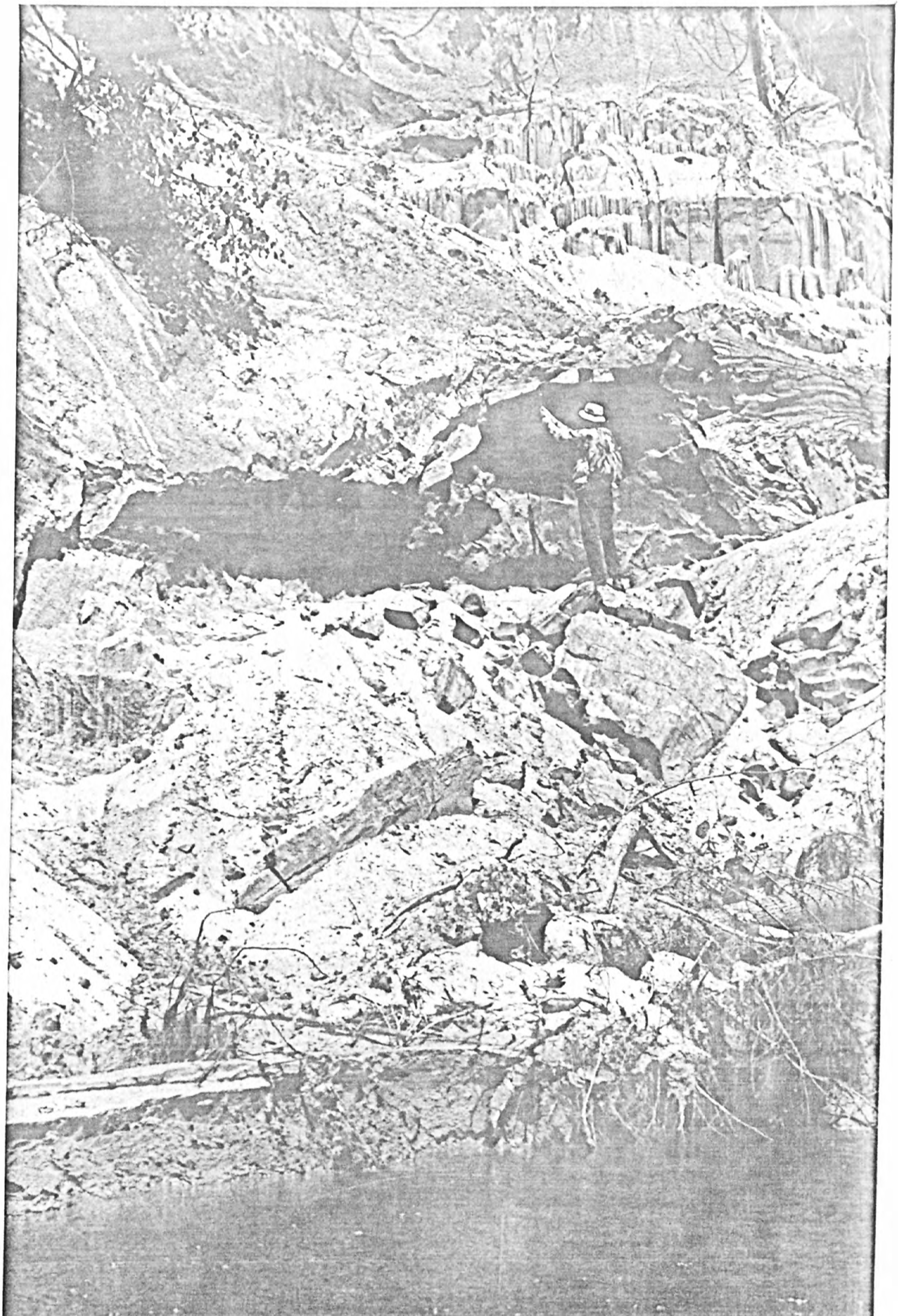

Figure 18