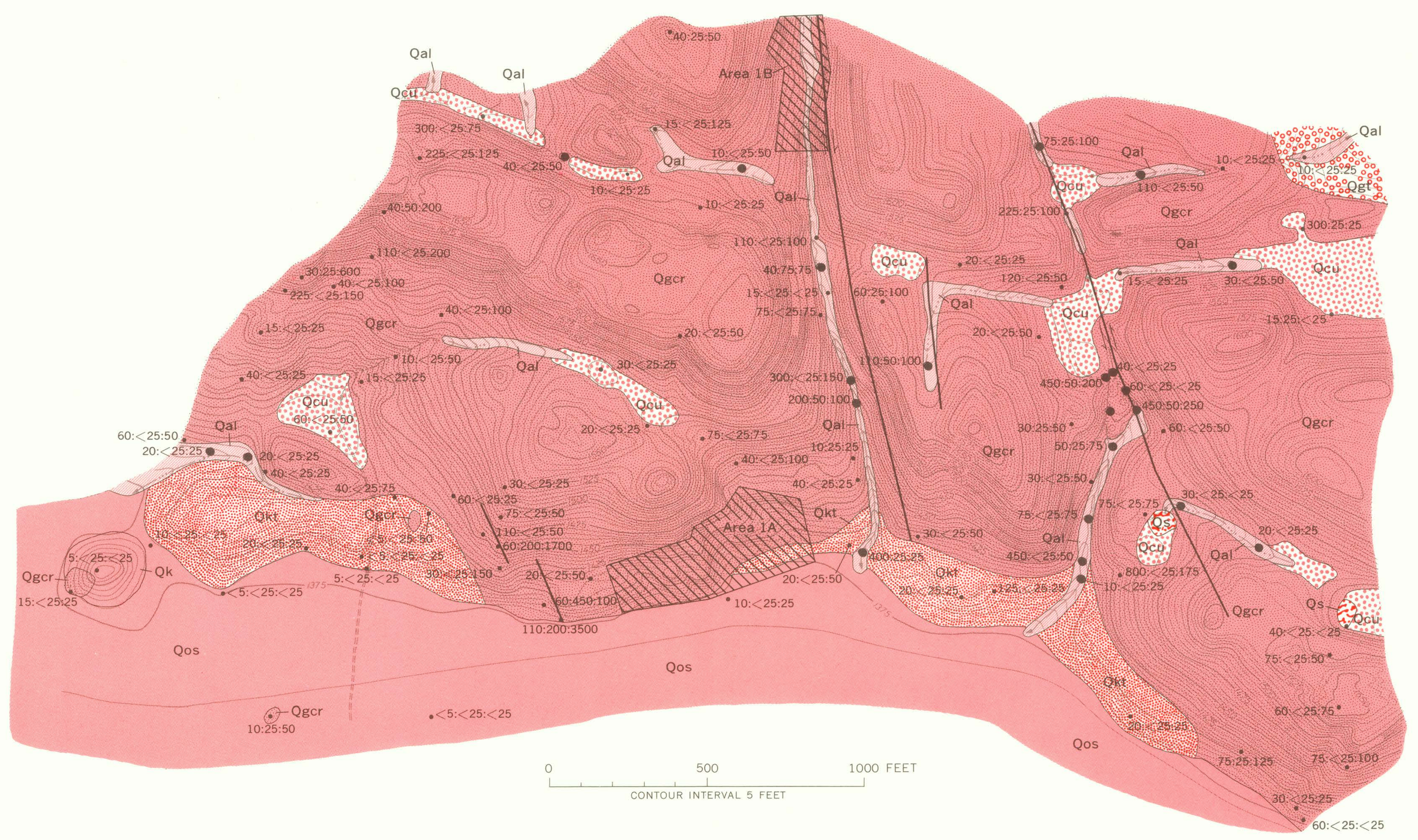
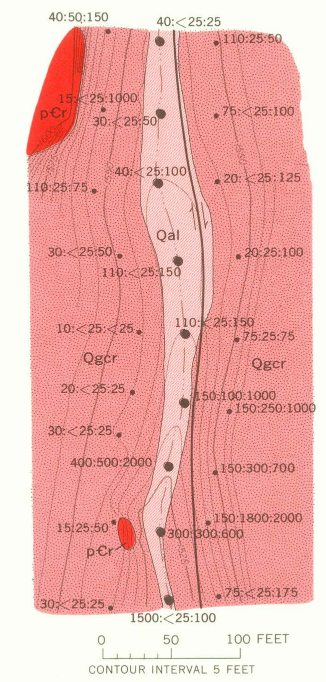
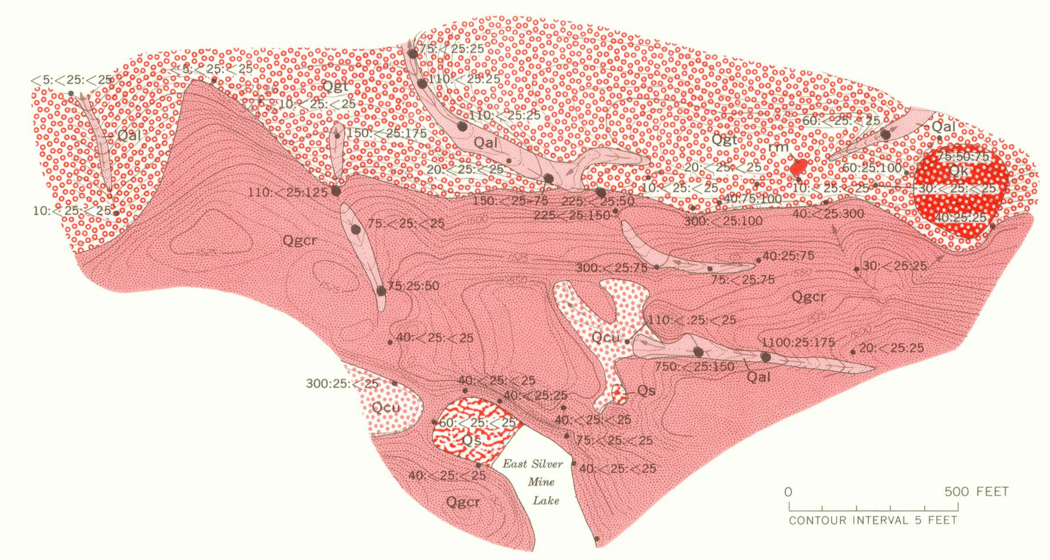
PREPARED IN COOPERATION WITH
THE MICHIGAN DEPARTMENT OF CONSERVATION
GEOLOGICAL SURVEY DIVISION



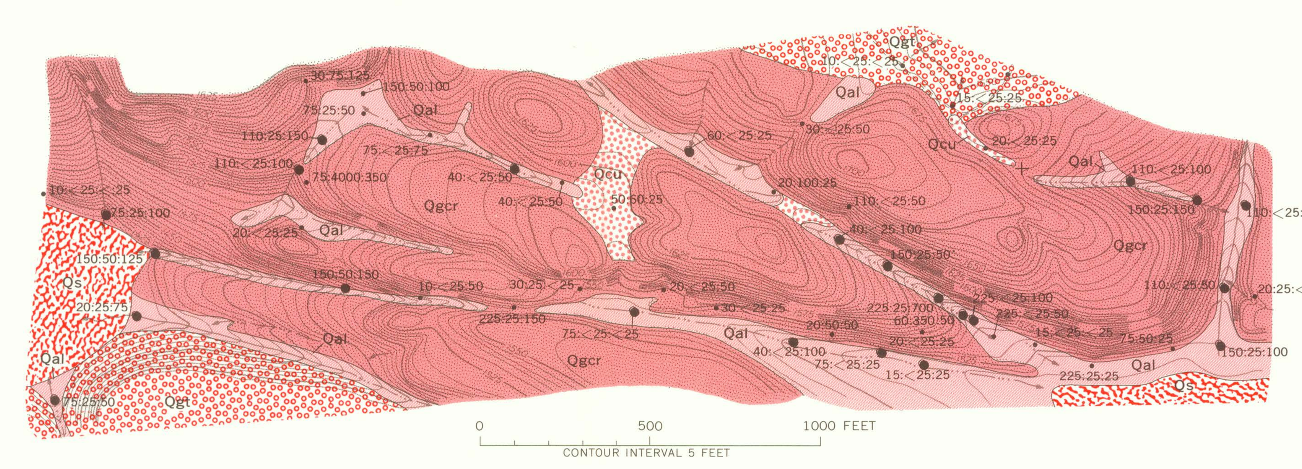
GEOLOGIC MAP OF AREA 1



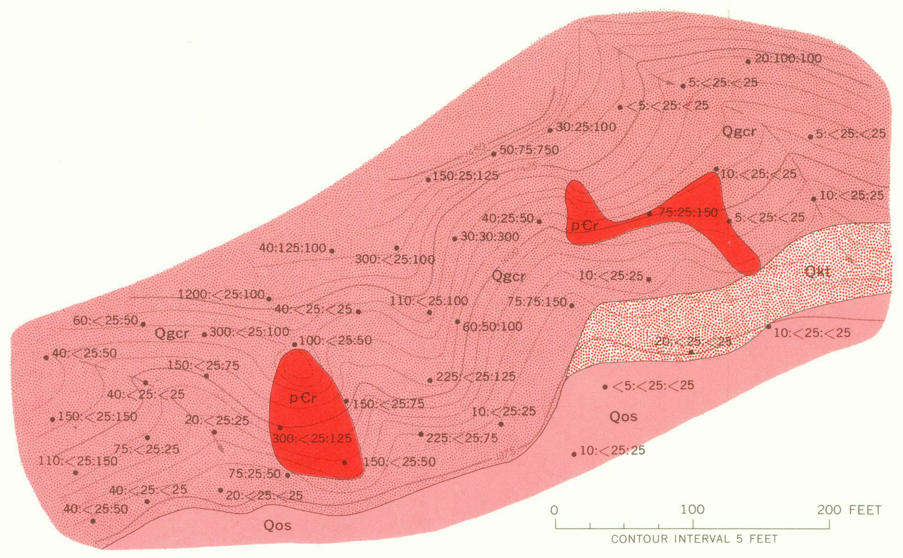
GEOLOGIC MAP AREA 1B



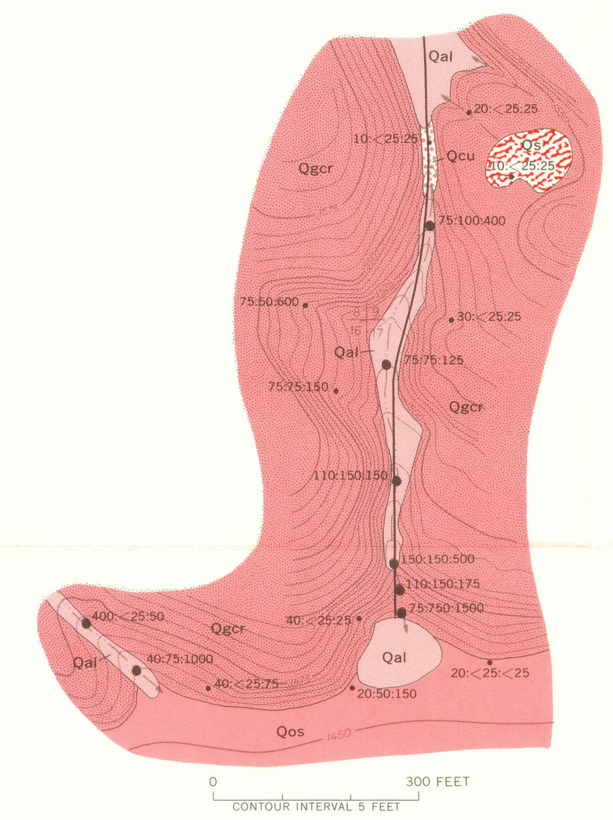
GEOLOGIC MAP OF AREA 2



GEOLOGIC MAP OF AREA 3

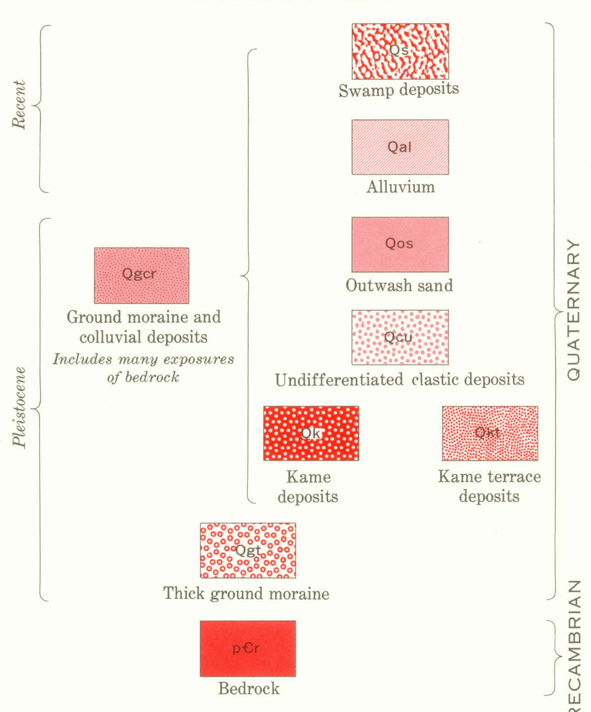


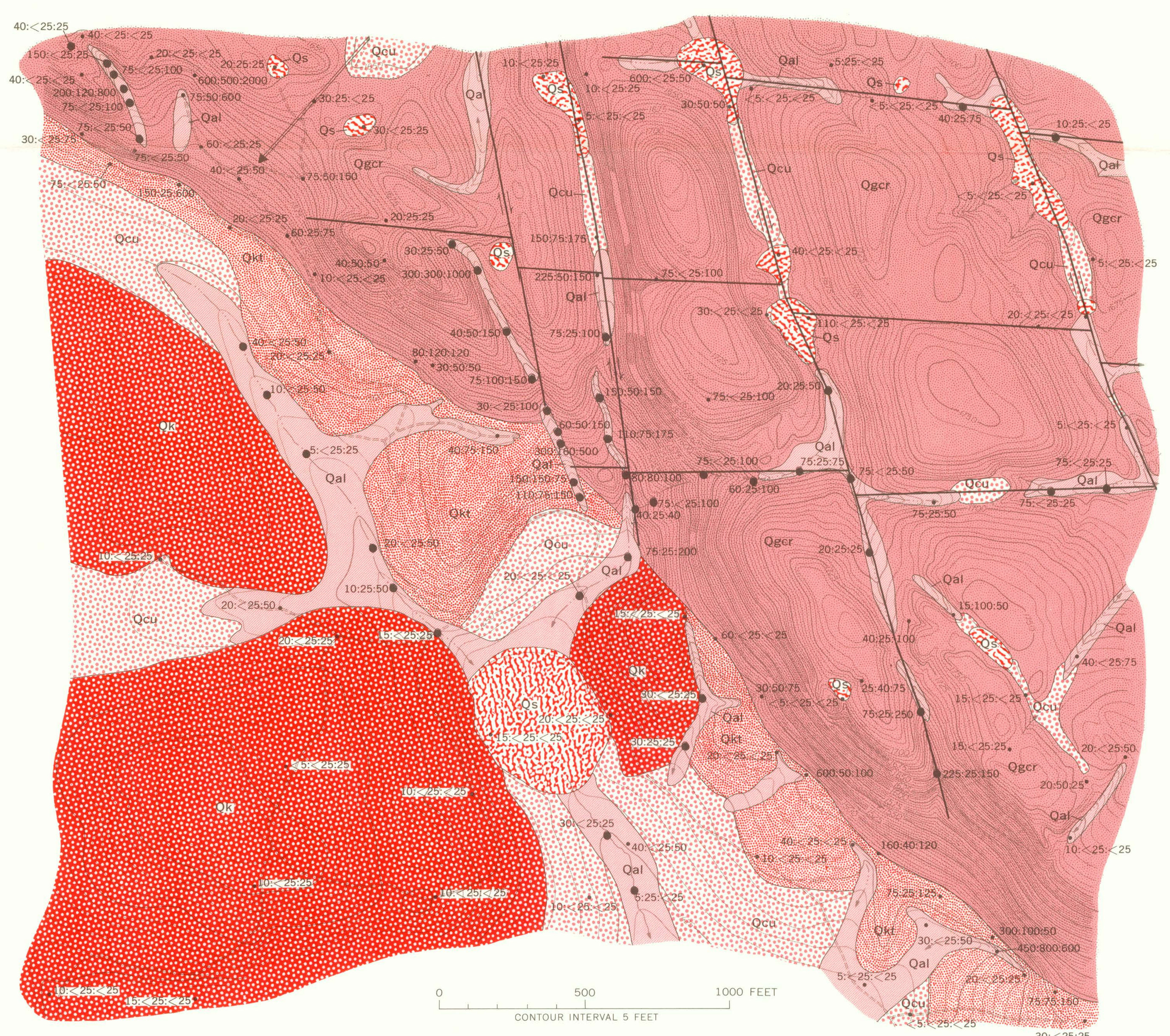
GEOLOGIC MAP OF AREA 1A



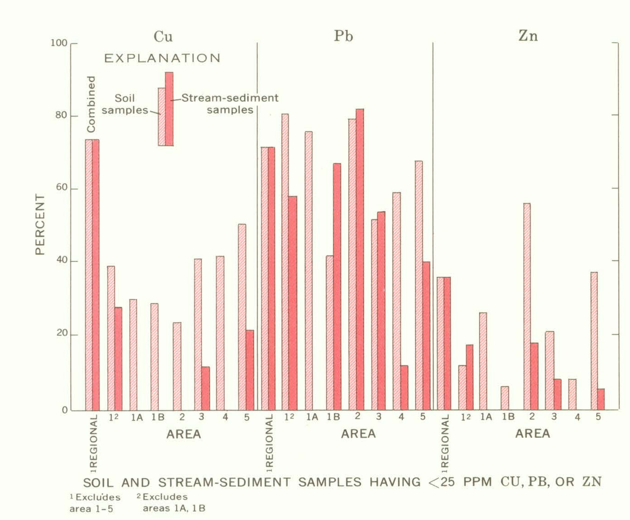
GEOLOGIC MAP OF AREA 4

EXPLANATION FOR GEOLOGIC MAPS

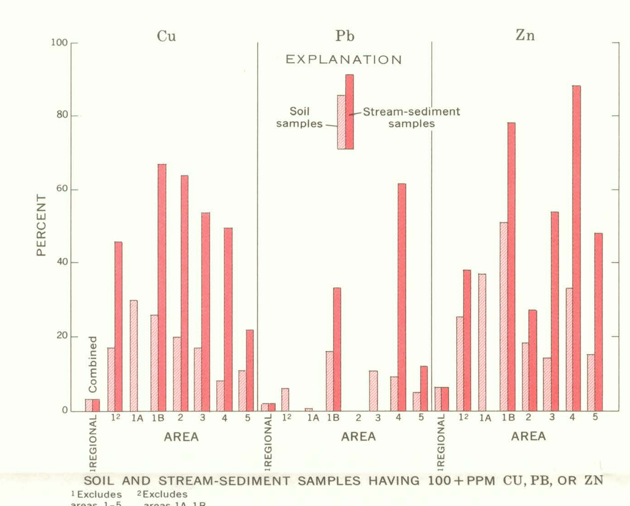




GEOLOGIC MAP OF AREA 5

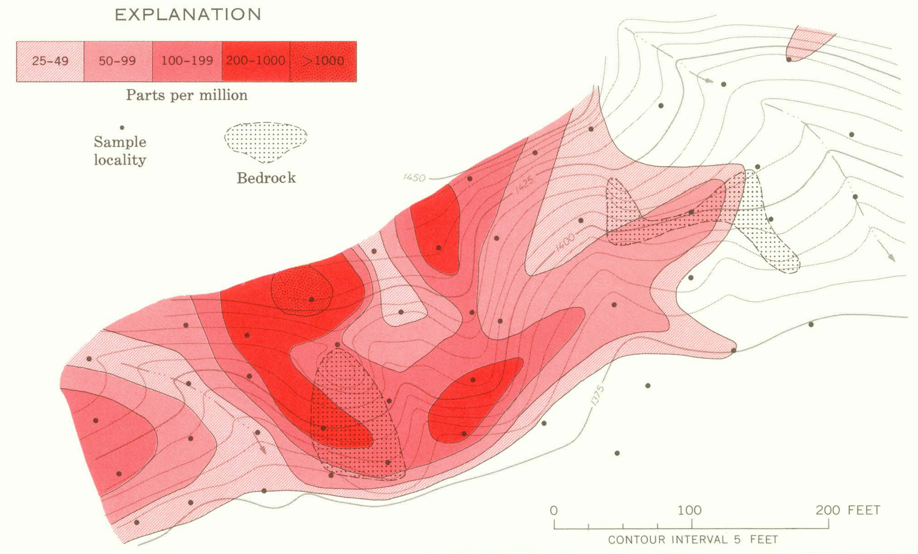


SOIL AND STREAM-SEDIMENT SAMPLES HAVING <25 PPM CU, PB, OR ZN



SOIL AND STREAM-SEDIMENT SAMPLES HAVING 100+PPM CU, PB, OR ZN

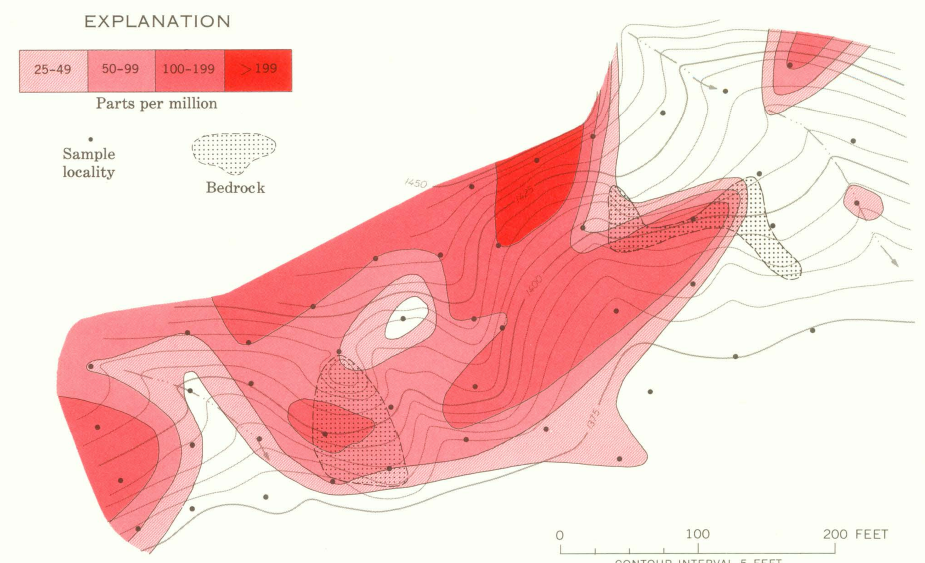
EXPLANATION



COPPER CONCENTRATION, AREA 1A

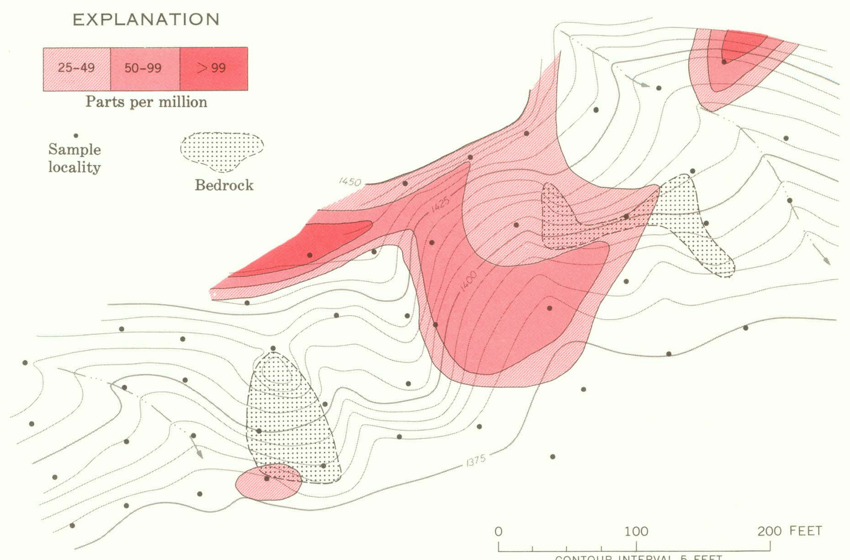
DATUM IS MEAN SEA LEVEL

EXPLANATION

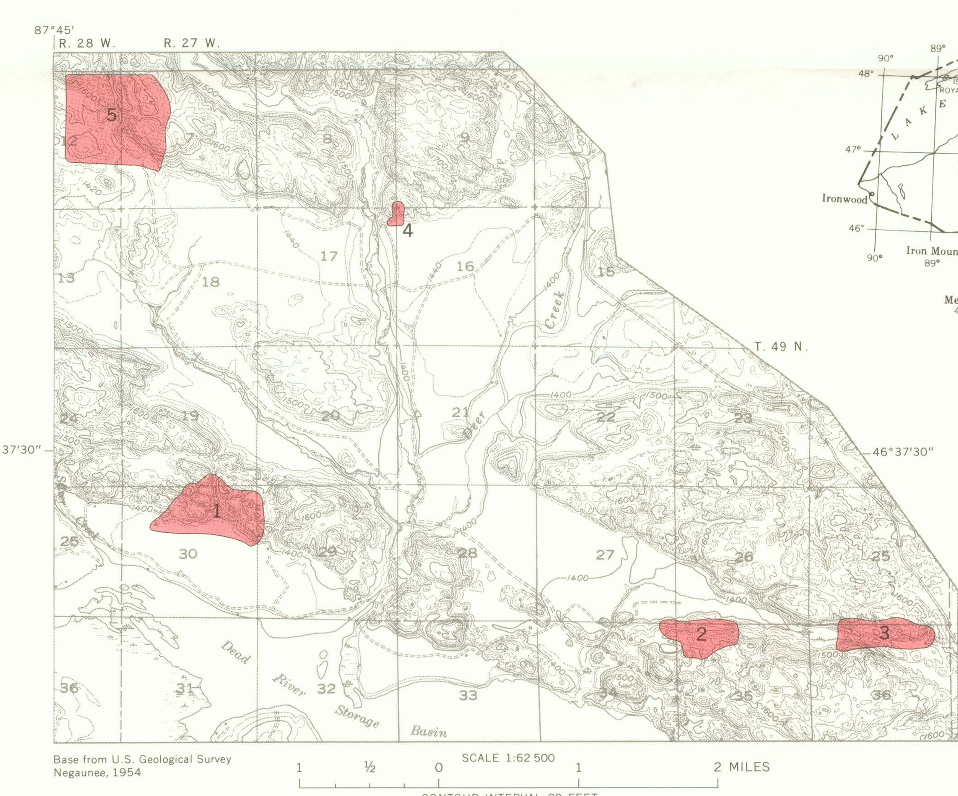


ZINC CONCENTRATION, AREA 1A

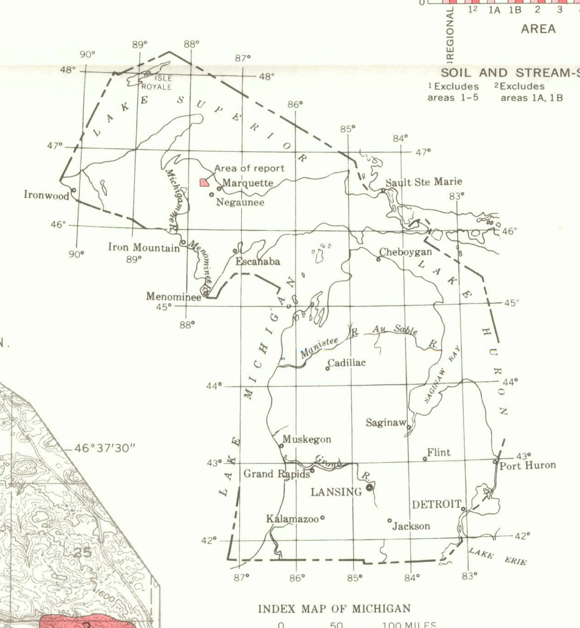
EXPLANATION



LEAD CONCENTRATION, AREA 1A



INDEX MAP SHOWING 5 MAJOR AREAS OF ANOMALOUS CONCENTRATIONS OF COPPER, LEAD, AND ZINC



INDEX MAP OF MICHIGAN

Area	Number of samples		
	Soil	Stream sediment	Total
1 (excluding areas 1A and 1B)	87	24	111
1A	46	0	46
1B	18	9	27
2	34	11	45
3	29	24	53
4	12	8	20
5	92	40	132
Total	318	116	434
Marquette County (excluding areas 1-5)	---	---	682

GEOGRAPHIC AND GEOLOGIC SETTING

Local relief in the west-central part of the Negaunee 15-minute quadrangle is 400+ feet. Altitudes range from about 1,350 feet on Dead River Storage Basin, to more than 1,760 feet, on a hilltop in the south-central part of sec. 1, T. 49 N., R. 28 W. (See index map.) The nearest town is Negaunee (about 6 miles south of the area of the index map). Marquette, the county seat, is located on Lake Superior 9 miles east of Negaunee.

Greenstone of early Precambrian age, which is intruded by quartz-porphyry and diabase sills and dikes, generally underlies three northwest-trending anticlinal bedrock ridges in the five areas. A low ridge in sec. 20, T. 49 N., R. 27 W., about halfway between areas 1 and 4, however, is of middle Precambrian slate (Segerstrom and Raymond, 1966, fig. 2). Lowlands occupy two synclinal areas and also are underlain by the slate. Area 1 is on the southwesternmost early Precambrian ridge; areas 2 and 3, on the middle ridge; and areas 4 and 5 on the northeasternmost ridge. The structural and topographic trends strike west to northwest. The folds are cut by one set of faults which strikes north to northwest and by another which strikes east; locally shears follow bedding and foliation in the greenstone. Pyrite, sphalerite, galena, chalcopyrite, arsenopyrite, and several other sulfides are occasionally seen, particularly where rock is sheared and where it contains veins of quartz and carbonate.

Ground moraine and colluvial deposits thinly and incompletely cover the crests and south flanks of the three anticlinal ridges. Deposits of thick sandy till in which large erratics are rare occur locally near the crests and on north flanks in areas 1, 2, and 3. Gravel deposits occur extensively in kames and terraces at the base of ridges in areas 1, 2, and 5, and thick outwash sand covers lowlands (Segerstrom and Raymond, 1966, fig. 2). Glacial grooves and striae strike southwest in area 5.

COLLECTION AND ANALYSIS OF SAMPLES

Surficial materials in Marquette County were sampled and analyzed for copper, lead, and zinc during 1963-64 (Segerstrom and Raymond, 1966). Additional fieldwork, consisting of detailed plane-table mapping and sampling of soil and stream sediment, was conducted during the 1965 field season in five areas where anomalous amounts of copper, lead, and zinc had been revealed by the earlier studies. Craig Taylor capably assisted in this work. The areas 1-5 are all in the west-central part of the Negaunee 15-minute quadrangle; they range in size from 0.02 to nearly 0.5 square mile each; and they were mapped at a scale of 1 inch equals 200 feet. Three hundred eighteen soil samples and one hundred sixteen stream-sediment samples were taken at locations plotted on the plane-table sheets; their geologic and topographic settings were thereby delineated. Seventy-two of these samples were collected from two small parts of area 1 (areas 1A, 1B), which were mapped at 1 inch equals 50 feet. Chemical analyses of all samples and semiquantitative spectrographic analyses of some of the samples were made by the U.S. Geological Survey.

RESULTS

Results of analyses, in parts per million, for each sampled locality, are shown on the area geologic maps. These results are expressed as the ratios of copper: lead: zinc. The results obtained in area 1A are contoured for each one of the three base metals and are shown on the copper, lead, and zinc maps. The percentages of soil and stream-sediment samples having less than 25 ppm of copper, lead, or zinc, and those having 100 ppm or more of each of the three base metals are shown graphically for each area on histograms.

Comparable percentages which were determined for 682 samples collected in Marquette County outside the five areas ("regional") are also shown. High frequency of anomalous concentrations of copper, lead, and zinc in areas 1-5 is evident from comparison of the histograms portraying percentage of samples having 100-plus ppm and those portraying regional (presumably "background") percentages. High concentrations are shown to be generally more frequent in stream sediments than in soils, except for lead concentrations in areas 1 and 3.

INTERPRETATION OF RESULTS

Analytical results in area 1, which was mapped and sampled in detail because of the exceptionally close bunching of anomalies reported from reconnaissance traverses (Segerstrom and Raymond, 1966, p. 188), show a close spatial relationship between most of the copper and zinc anomalies and two north-northwest-striking shear zones. In the southern part of area 1B, lead anomalies are correlated with one of these shear zones. Other anomalies in area 1 can be ascribed to sulfide mineralization along three less pronounced shear zones. Anomalies of copper and zinc in area 1A and along the northwest edge of area 1 are caused by sulfides locally disseminated in greenstone which is not markedly sheared.

Anomalous concentrations of copper and zinc in areas 2 and 3 may be related to sulfide mineralization in shears that strike west to northwest and that are probably subparallel to bedding and foliation. These shears are not as well defined as the crosscutting shears of area 1, and hence are not shown on the maps; their trends, however, show up in the distribution of mineralized float. A soil sample with very high lead content was collected in the western part of area 3, near float containing galena, which was probably derived from a shear zone about 250 feet to the north.

The anomalies in area 4, mostly lead and zinc, are derived from a north-striking mineralized fault, the trend of which is defined by a valley. Glacial transport from the northeast resulted in deposition of part of the mineralized material in another, smaller valley at the west edge of the area.

Area 5, like area 1, was mapped and sampled in detail because of an exceptional bunching of anomalies encountered along an earlier reconnaissance traverse (Segerstrom and Raymond, 1966, p. 189). Structural control of mineralization is evident in two sets of shears, each of which cuts across bedding and foliation. Valleys and saddles have been eroded in the shear zones; samples taken there tend to show anomalous concentrations of copper and zinc, but rarely of lead. Other anomalies that show up in topographic lows of area 5 can be ascribed to transport toward the southwest by glacial action, mass wasting, or stream erosion and deposition.

REFERENCE

Segerstrom, Kenneth, and Raymond, W. H., 1966, Preliminary results of geochemical prospecting in northern Michigan, in Geologic research 1966: U.S. Geol. Survey Prof. Paper 550-D, p. D186-D189.

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1968

Plane-table base and geology mapped in 1963-65

GEOCHEMICAL PROSPECTING FOR COPPER, LEAD, AND ZINC IN THE WEST-CENTRAL PART OF THE NEGAUNEE QUADRANGLE, MARQUETTE COUNTY, MICHIGAN

By
Kenneth Segerstrom

1968

For sale by U.S. Geological Survey, price 75 cents