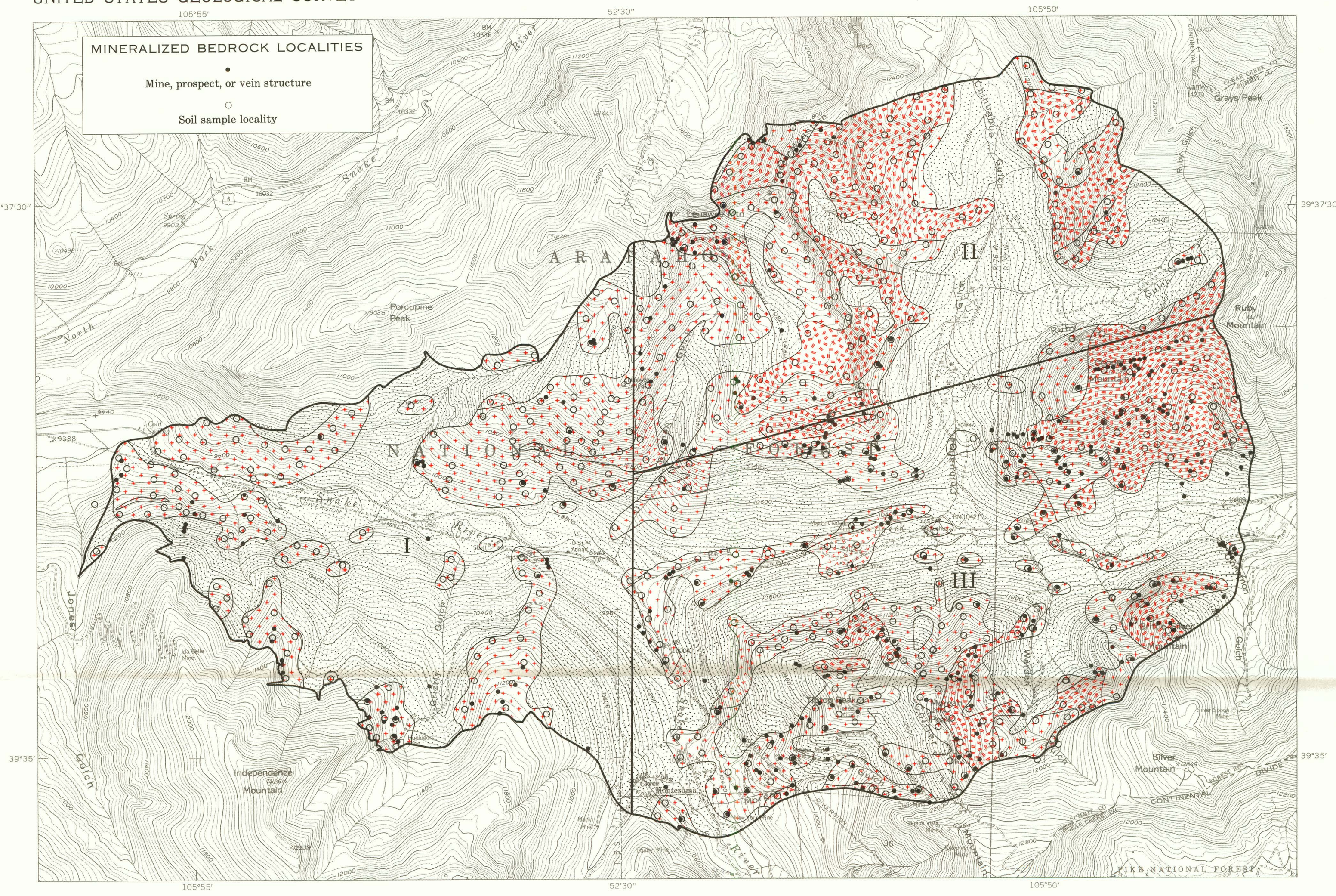
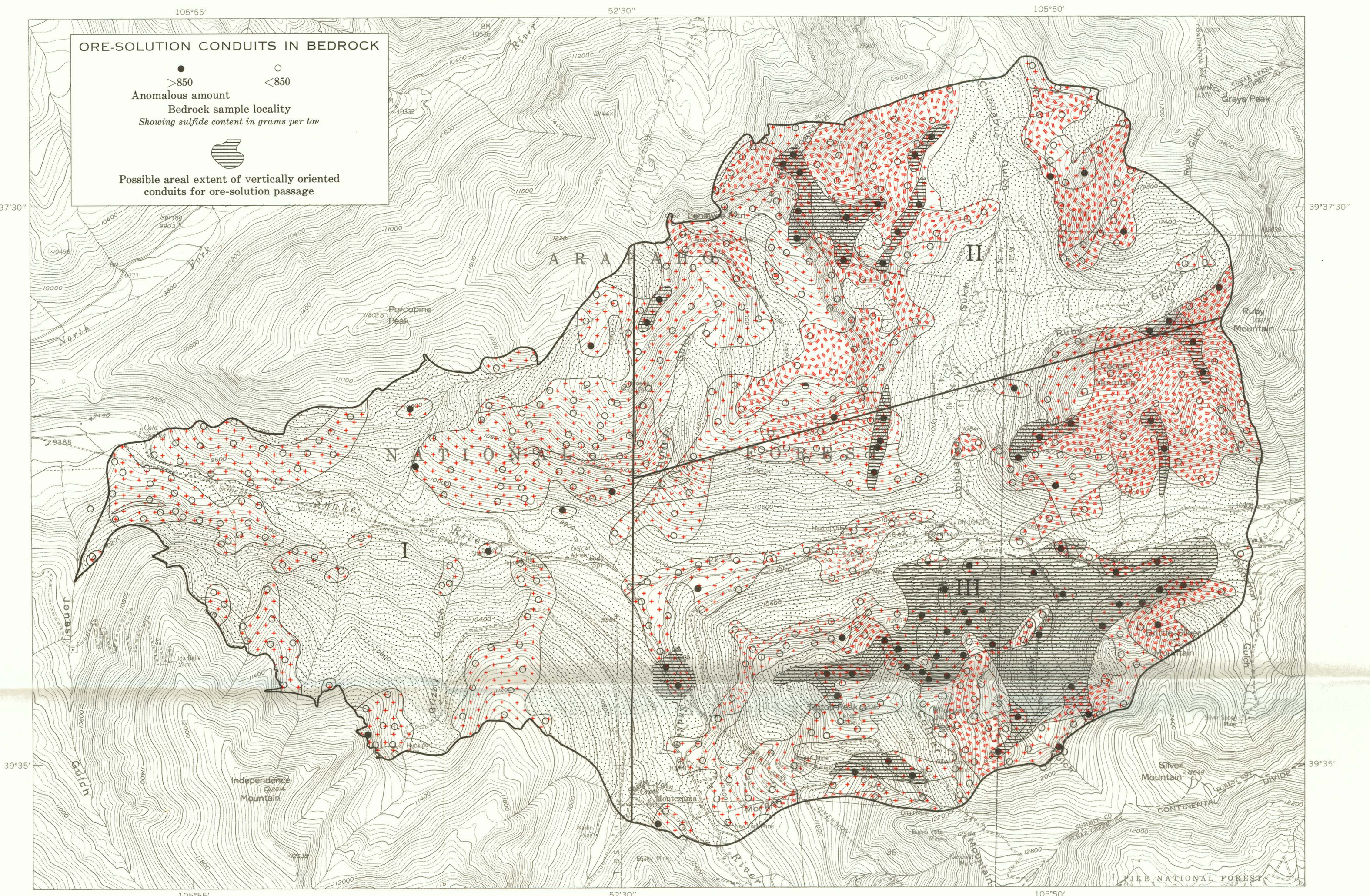
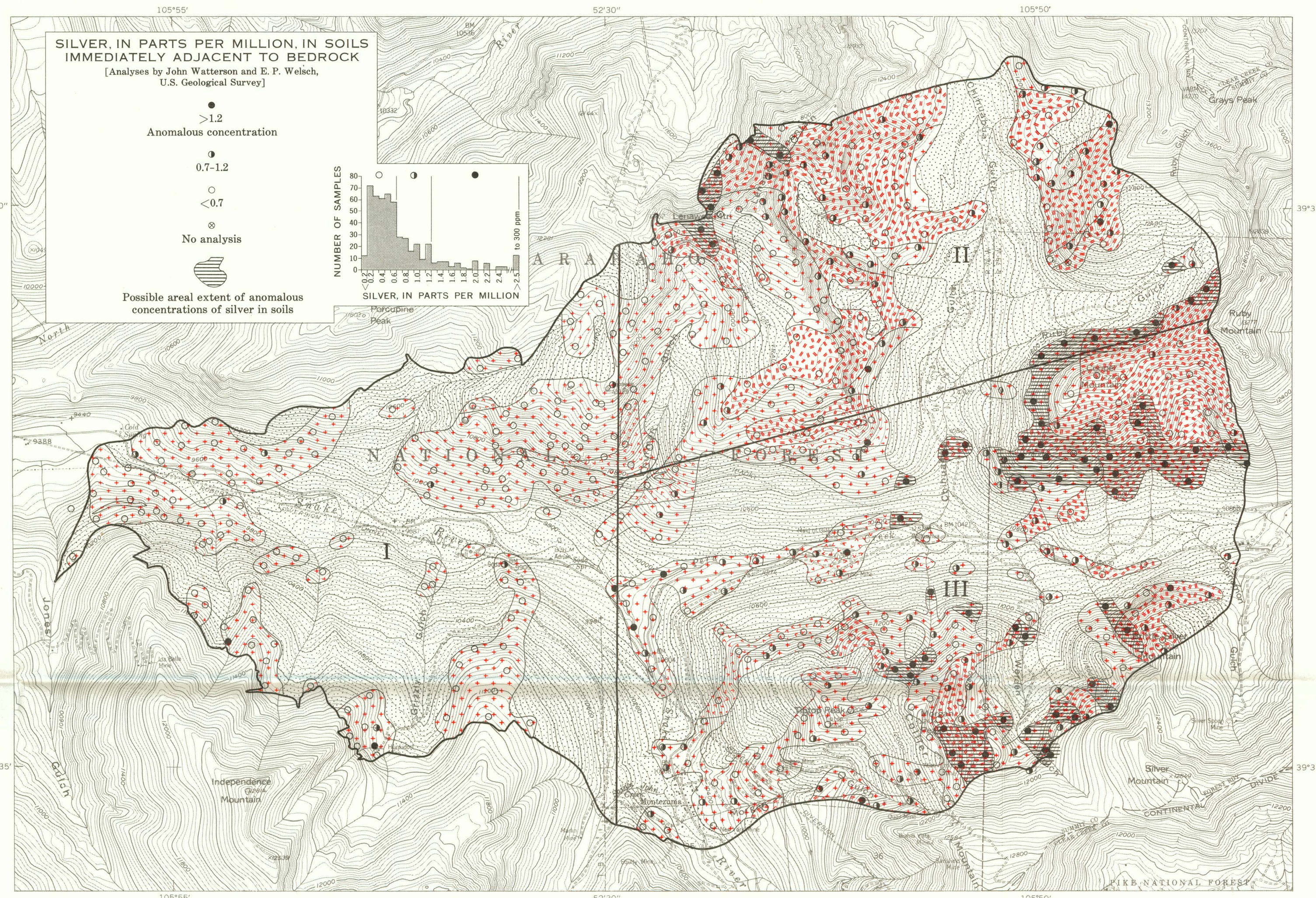
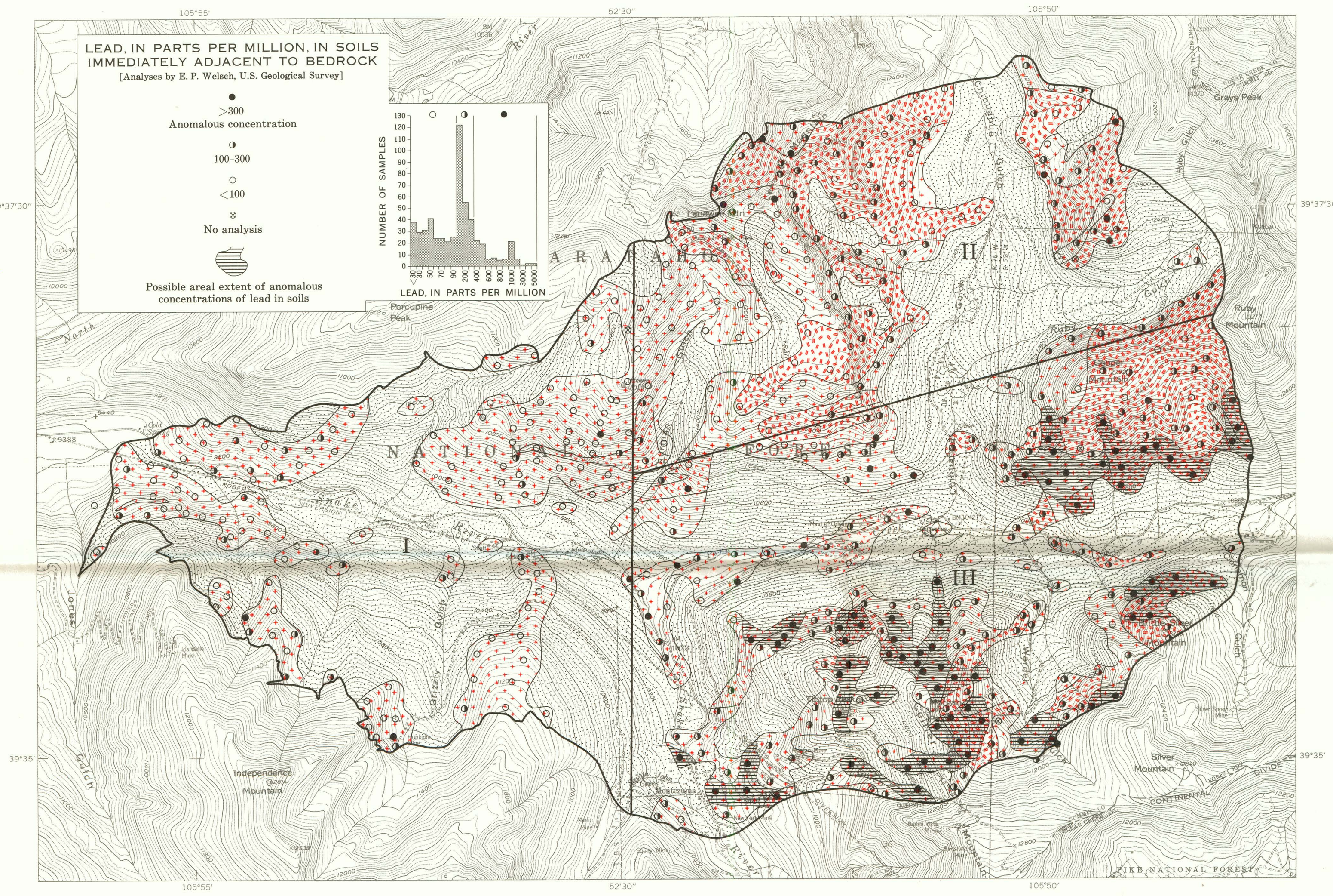
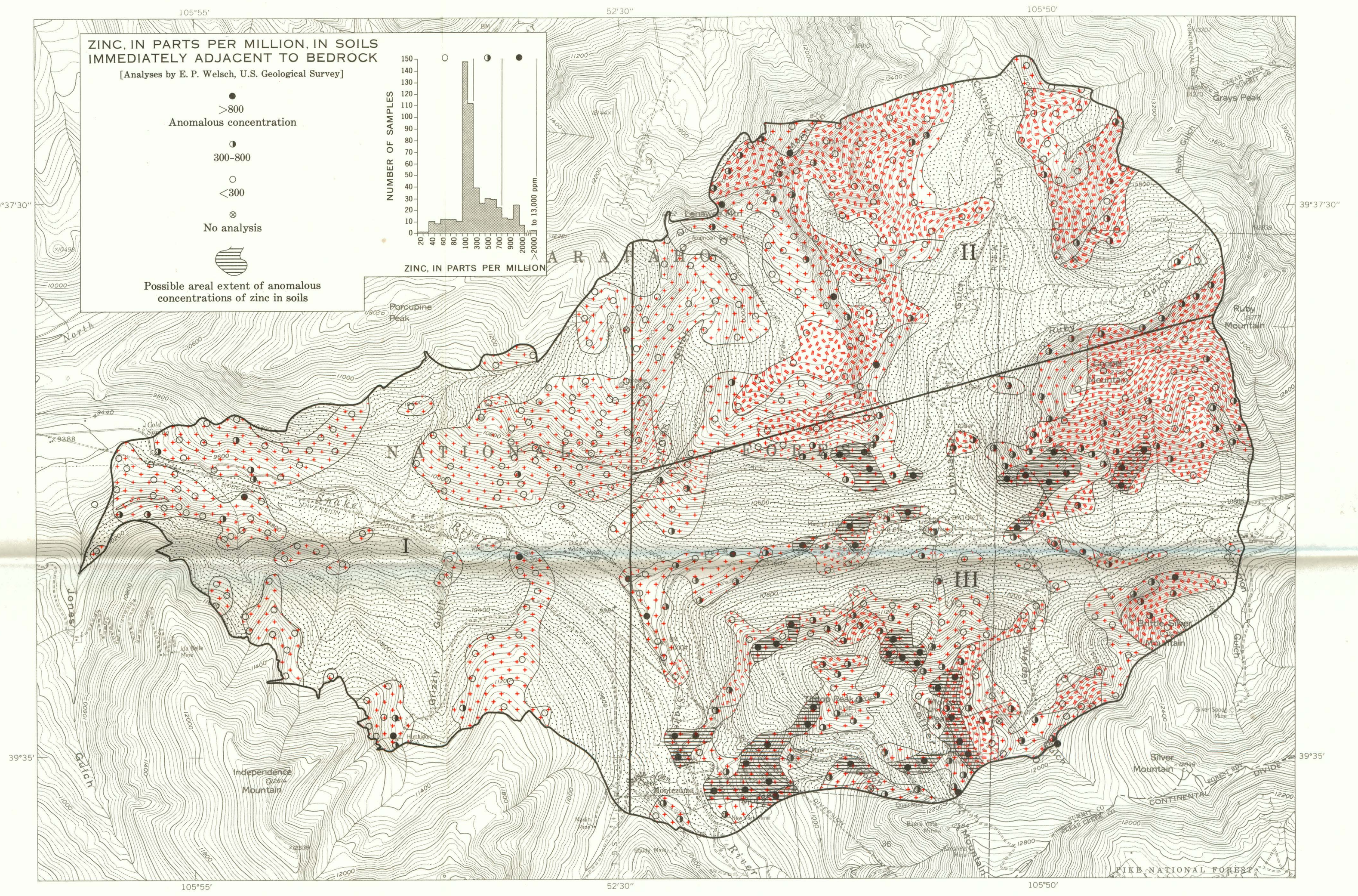
MISCELLANEOUS GEOLOGIC INVESTIGATIONS
MAP I-634

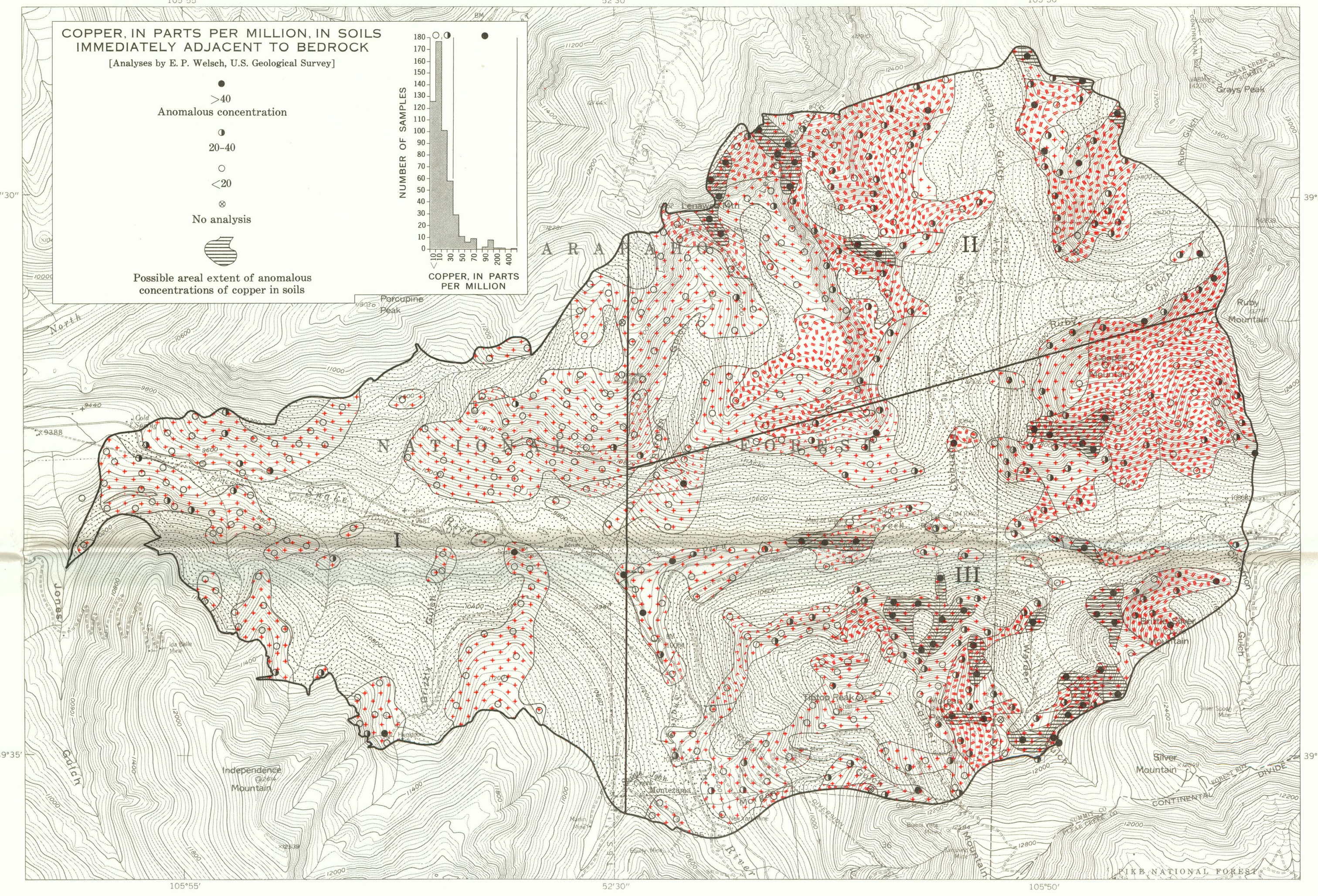


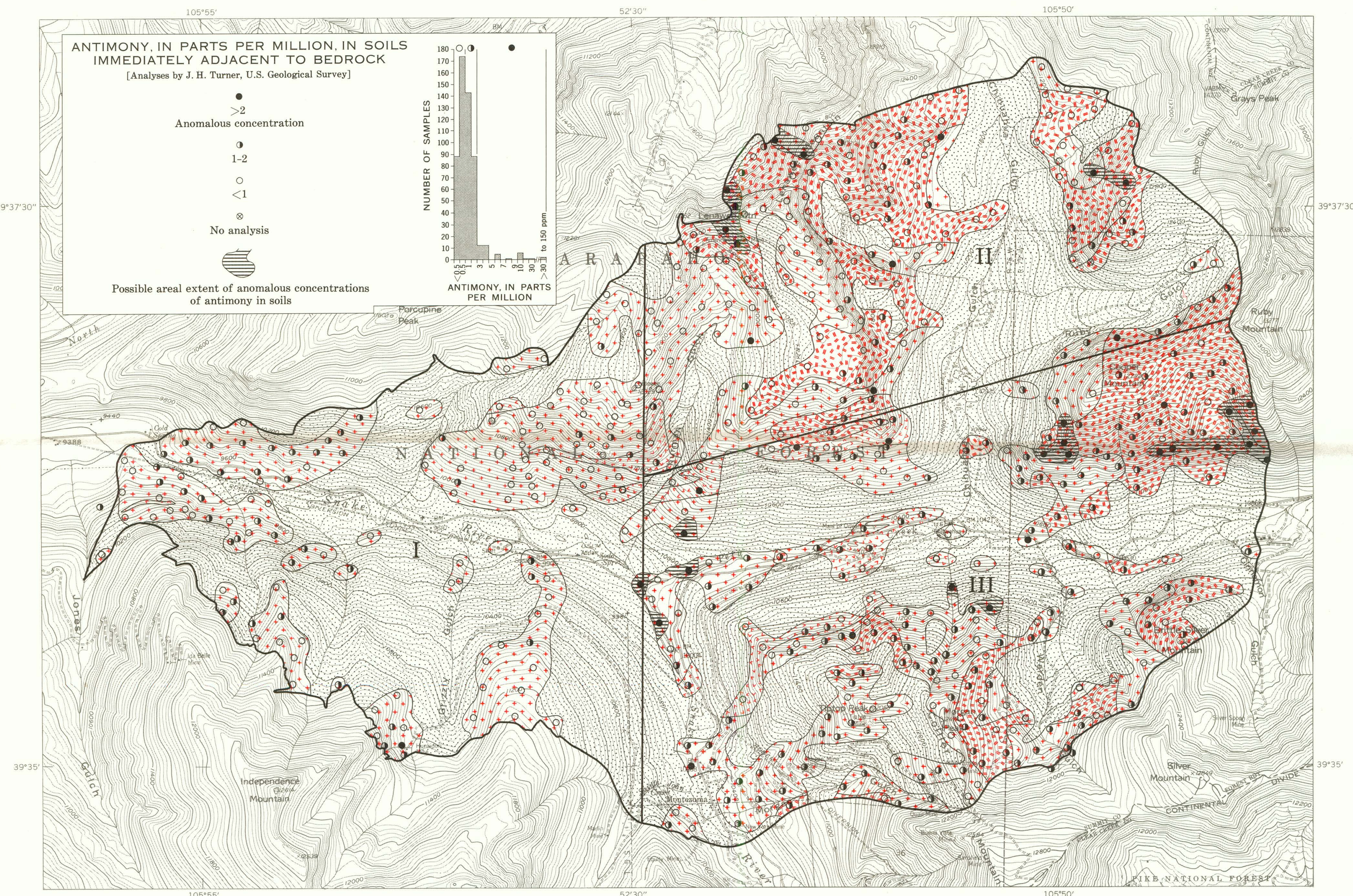


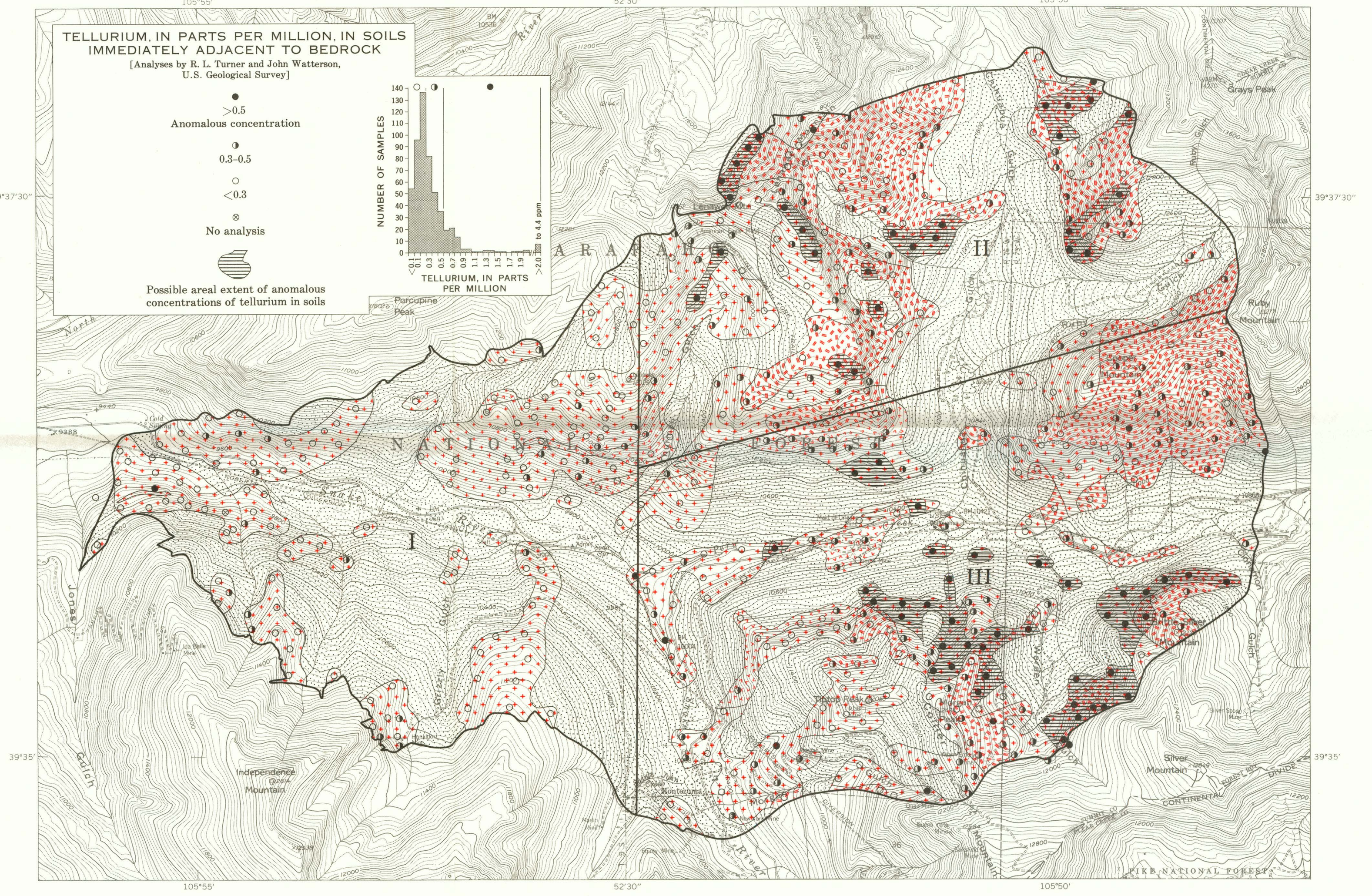


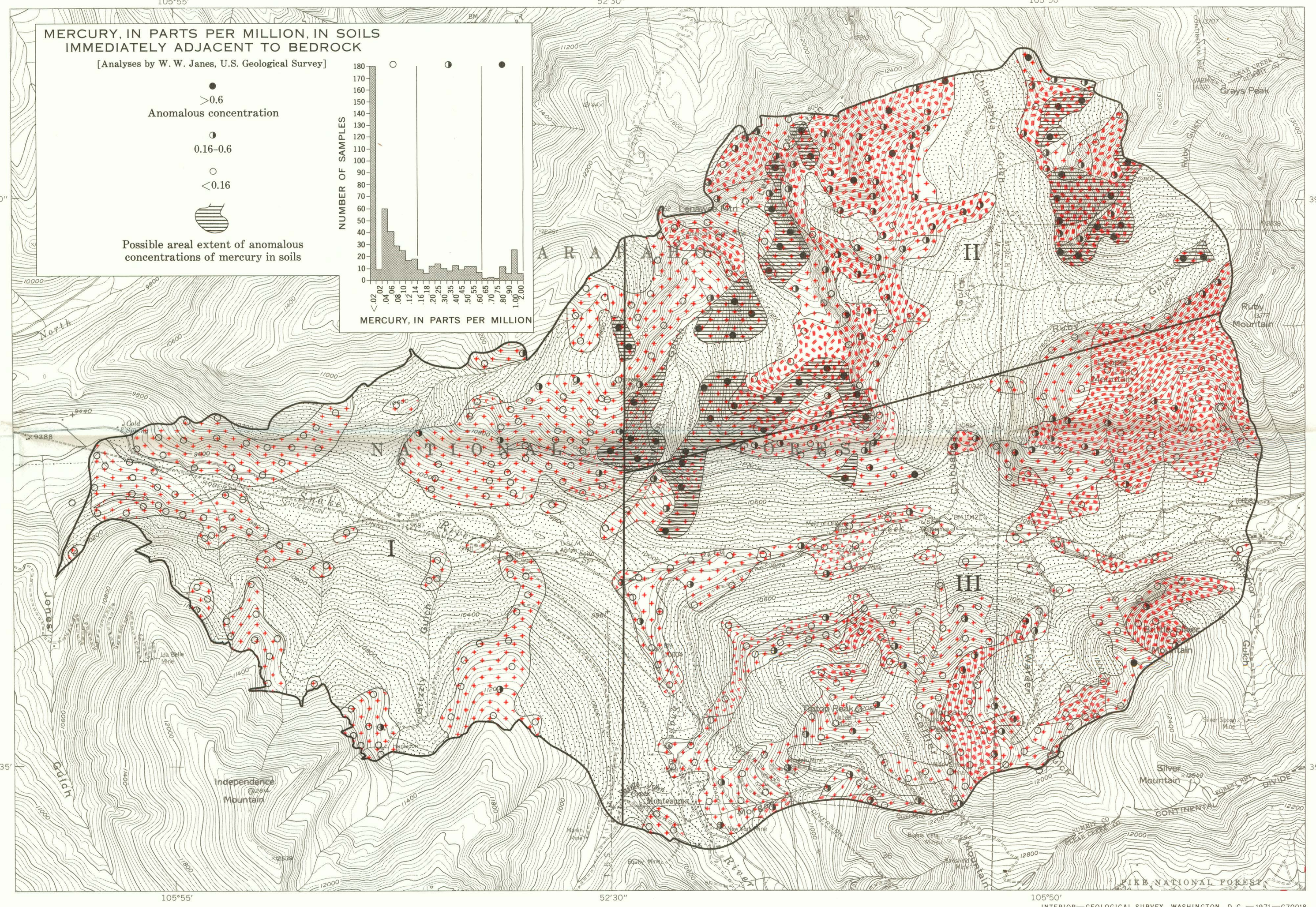












Base from U.S. Geological Survey, 1:24,000
Loveland Pass, Grays Peak, Keystone, and
Montezuma, 1958

MAPS SHOWING SOIL ANALYSES OF INTEREST FOR PROSPECTING THE MONTEZUMA STOCK, SUMMIT COUNTY, COLORADO

SCALE 1:31 680

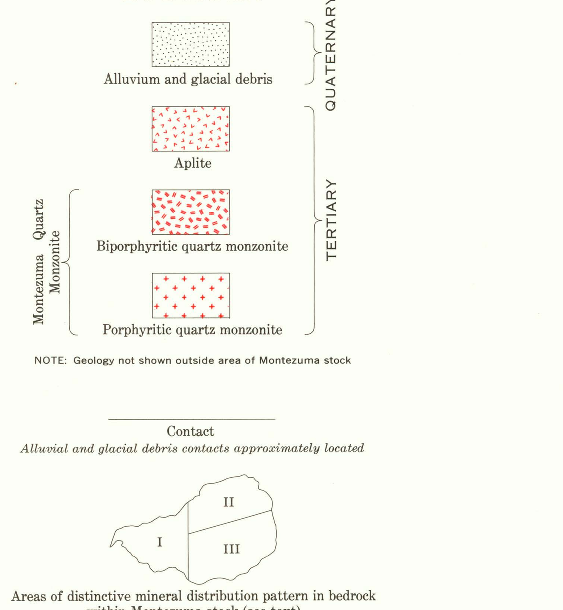
CONTOUR INTERVAL 40 FEET
DATUM IS MEAN SEA LEVEL

By
George J. Neuerburg
1971

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1971—G70018

Geology modified from data supplied by
C. S. Robinson and G. E. Ulrich

EXPLANATION



Areas of distinctive mineral distribution pattern in bedrock within Montezuma stock (see text)

METAL PATTERNS IN SOILS AS INDICATORS OF MINERALIZATION AT DEPTH

The Montezuma stock, south of Loveland Pass in Summit County, Colo., is one of several Tertiary intrusives in the Front Range Mineral Belt. It hosts numerous ore deposits and probably was involved in their origin (Neuerburg, 1968, 1971). Analyses of soil samples from localities adjacent to bedrock exposures of the stock yield data of interest in optimizing more detailed and direct prospecting of the stock.

Intrusive into Precambrian metamorphic and igneous rocks and Cretaceous Pierre Shale (Lovering, 1935), the stock widens appreciably with depth, as shown in the Roberts Tunnel, and is probably a projection off a much larger batholithic mass (Wahlstrom and Hornback, 1962, p. 1497; Warner and Robinson, 1967, p. 101). The stock is composed of biotite-quartz monzonite and is intruded by one or more large granite-aplite masses in the central part and by scattered small aplite sheets elsewhere. Most of the stock is a coarse-grained, largely porphyritic rock; eastern and topographically high parts of the stock are biporphyritic (small fragments of porphyritic quartz monzonite in a markedly finer grained matrix of quartz monzonite). The effects of late magmatic alteration are common and consist of chloritized biotite and saussuritized plagioclase. The stock covers about 16 square miles in a deeply glaciated region; about half of the area is covered with glacial debris. Its elevation ranges from 9,400 to 13,200 feet.

Ore deposits, which are spatially and probably genetically associated with the Montezuma stock, are mainly in the upper part of the stock and in the Precambrian rocks above its gently sloping southeastward extension. These deposits are generally thin discontinuous fissure fillings that are drusy and irregularly and poorly banded. Sulfides are principally pyrite, galena, and sphalerite, commonly with gray copper and chalcopyrite and, less commonly, with silver and bismuth sulfosalts; vein molybdenite apparently occurs only at depth, as in the Roberts Tunnel. Other metallic minerals are sparse, and gold content is insignificant. Gangue minerals are quartz and manganiferous carbonates and, very commonly, barite. Envelopes of hydrothermally altered wallrock around the veins range in thickness from a featheredge to several times the width of the vein.

Characteristics of the ore deposits change vertically. Molybdenite disappears upward; and pyrite and perhaps also sphalerite decline upward in relative importance as vein minerals. The extent and intensity of wallrock alteration decrease upward, whereas the proportions of sulfosalts, barite, and carbonate increase. These variations presumably radiate upward from unexposed sources at varying depths, and illustrate the changing composition and lessening energy of ore solutions with increasing distance from their sources.

The Montezuma stock is subdivided into three areas which are characterized as follows (Neuerburg, 1971):

Area I. A few scattered small prospects and mines; some vein pyrite; moderate wallrock alteration—otherwise, almost no alteration of quartz monzonite; no ore-solution conduits.

Area II. A few scattered prospect pits and small mines; some vein pyrite; minor amounts of wallrock alteration; widespread mild alteration of quartz monzonite; several ore-solution conduits.

Area III. Numerous mines and prospects; vein pyrite conspicuous; major amounts of wallrock alteration; widespread and intense alteration of quartz monzonite; large, partly mineralized ore-solution conduits.

The distribution patterns of rock sulfides in concentrations of less than 850 grams per ton and of zircon, magnetite, chalcopyrite, and molybdenite are random and are interpreted as evidence that the exposed part of the Montezuma stock contributed no material for ore deposits (Neuerburg, 1971). The ore-solution conduits indicate derivation from depth, most likely from the batholithic root of the Montezuma stock.

Soil samples were collected at each of 531 sample localities for the Montezuma stock bedrock. The soils are postglacial—developed upon quartz monzonite and aplite exposed by glaciation—and are variously mixed with local slope wash and windblown particles. They range from humus-poor grus through clayey soil and mull-rich (U.S. Department of Agriculture, 1951, p. 245) sandy soil to humus-rich loam. The samples represent the upper 2 inches of soil, scraped clean of loose organic detritus and screened to −80 mesh. They were analyzed in U.S. Geological Survey laboratories for content of antimony, arsenic, bismuth, copper, gold, lead, mercury, silver, tellurium, and zinc.

On the basis of the analytical data, these elements can be divided into three categories:

A. Arsenic, bismuth, and gold occur only sporadically above the analytical threshold and are spatially random, although detectable values occur mainly in areas II and III of the stock. These data serve no purpose and are not reported further.

B. Silver, lead, zinc, copper, and antimony correlate well with known mineralized areas in area III of the stock and presumably represent particulate detritus from ore deposits, known and hidden. Areal differences in distribution of anomalous concentrations of these elements probably reflect spatial variations in both ore mineralogy and soil chemistry. These anomalies also occur in area II; except for the deposits in Lenawee Mountain, they are small, scattered, and possibly representative of only small veins.

C. Tellurium and mercury have high vapor pressures and may form leakage halos as well as particulate-detritus halos over deeply buried deposits. Tellurium is anomalously rich in soils over large parts of areas II and III of the stock, in part coinciding with an area of extensive ore deposits and high rock-pyrite concentration in area III; this grass-roots anomaly has a tellurium concentration three to four times that in area II.

Mercury is found in anomalous amounts in soils in area II, with some overlap into areas I and III. Area II is mercury enriched as a whole. No areally corresponding anomalous concentrations occur in the mercury-in-bedrock or tellurium-in-bedrock or the mercury-in-magnetite contents in the Montezuma stock. The mercury and tellurium anomalies may reflect leakage halos from mineralized structures at some unknown but perhaps moderate depth.

For a reconnaissance survey made in a heavily glaciated area, the data obtained from a widely spaced geochemical soil survey correlate surprisingly well with known mineralized features. The data further suggest that additional and more detailed prospecting by various methods might be profitable. Area I of the stock shows little evidence that it can be prospected economically—or that it should be prospected. Standard soil sampling techniques applied in detail to area III should more closely delineate anomalies possibly related to near-surface deposits, particularly in and around Warden Gulch and on the south slope of Cooper Mountain. The mercury and tellurium anomalies in area II are best investigated in detail by analyses of soil gases (McCarthy and others, 1969). Such data, in conjunction with maps of the internal structures of the stock, should economically pinpoint exploratory drilling.

REFERENCES CITED

Lovering, T. S., 1935, Geology and ore deposits of the Montezuma quadrangle, Colorado: U.S. Geol. Survey Prof. Paper 178, 119 p.

McCarthy, J. H., Jr., Vaughn, W. W., Learned, R. E., and Meuschke, J. L., 1969, Mercury in soil gas and air—A potential tool in mineral exploration: U.S. Geol. Survey Circ. 609, 16 p.

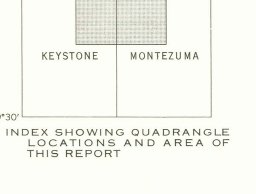
Neuerburg, G. J., 1968, Detecting and tracing ore-bringers and ore-solution channels as a prospecting aid [abs.]: Mining Eng., v. 20, no. 12, p. 47.

——— 1969, Distribution of selected accessory minerals in the Montezuma stock, Summit County, Colorado: U.S. Geol. Survey Misc. Geol. Inv. Map I-608 (1971)

U.S. Department of Agriculture, 1951, Soil survey manual: U.S. Dept. Agriculture, Agriculture Handbook 18, 503 p.

Wahlstrom, E. E., and Hornback, V. Q., 1962, Geology of the Harold D. Roberts Tunnel, Colorado—West portal to station 468+49: Geol. Soc. America Bull., v. 73, no. 12, p. 1477-1498.

Warner, L. A., and Robinson, C. S., 1967, Geology of the Harold D. Roberts Tunnel, Colorado—Station 468+49 to east portal: Geol. Soc. America Bull., v. 78, no. 1, p. 87-119.



INDEX SHOWING QUADRANGLE LOCATIONS AND AREA OF THIS REPORT

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