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GEOCHEMICAL PROSPECTING FOR COPPER AND NICKEL IN THE WULGAI AND TOR TANGI AREAS SOUTHEAST OF HINDUBAGH, QUETTA DIVISION, PAKISTAN

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ABSTRACT

Showings of magnetite, copper, and possible nickel mineralization in the Hindubagh chromite mining district are near Wulgai and Tor Tangi. Several hundred samples of clastic material from dry streambeds in these areas were sieved for the minus-80-mesh fraction and analyzed for copper using 2, 2'-biquinoline and for nickel using alpha-furildioxime. The copper threshold is 75 ppm, and the nickel threshold is 400 ppm. A geochemical map has been prepared that shows nine areas of anomalously high copper and six areas of high nickel. The nickel anomalies may represent secondary dispersion patterns derived from the erosion of nickeliferous ultramafic rocks of the Hindubagh intrusive complex. Copper showings in and near four of the anomalous copper areas indicate that detailed geological investigation and detailed geochemical sampling of rocks, soil, and unconsolidated clastic material are required to determine the source of the anomalies.

INTRODUCTION

The Mineral Exploration and Development Program in Pakistan, sponsored by the U. S. Agency for International Development (formerly

International Cooperation Administration), U. S. Department of State, and the Government of Pakistan, was initiated in 1956 to intensify the exploration and appraisal of Pakistan's mineral, mineral fuel, and water resources. The U. S. Geological Survey and the Geological Survey of Pakistan served as counterpart organizations under this program. This report summarizes the information obtained from prospecting geochemically for copper and nickel in one of Pakistan's metallogenic districts.

The Wulgai and Tor Tangi areas (fig. 1), about 20 miles southeast of Hindubagh, are in the Hindubagh chromite mining district, which is about 60 miles northeast of Quetta, Pakistan. The mining areas are principally south and southeast of Hindubagh in the rugged terrain of the so-called "Hindubagh intrusives." The Wulgai area (pl. 1) is between parallels 30°37'30" N. and 30°40'15" N. and meridians 67°52'30" E. and 67°56'45" E.; the Tor Tangi area (pl. 1) is between parallels 30°37'15" N. and 30°38'15" N. and meridians 67°56'45" E. and 68°E. Geochemical prospecting for copper and nickel in these areas was undertaken in November 1963. Data presented here are as of 1964.

Previous investigations

The chromite deposits and the complexity of the geology have stimulated interest and investigations in the Hindubagh region by governmental agencies and private firms for more than six decades. Small showings of magnetite, and copper, and suspected nickel mineralization were reported in widely scattered places within the Hindubagh intrusives and nearby areas (Crookshank and Heron, 1954, p. 88; Hunting Survey Corp., Ltd., 1960, p. 439, 452; White, M. G., unpublished data).

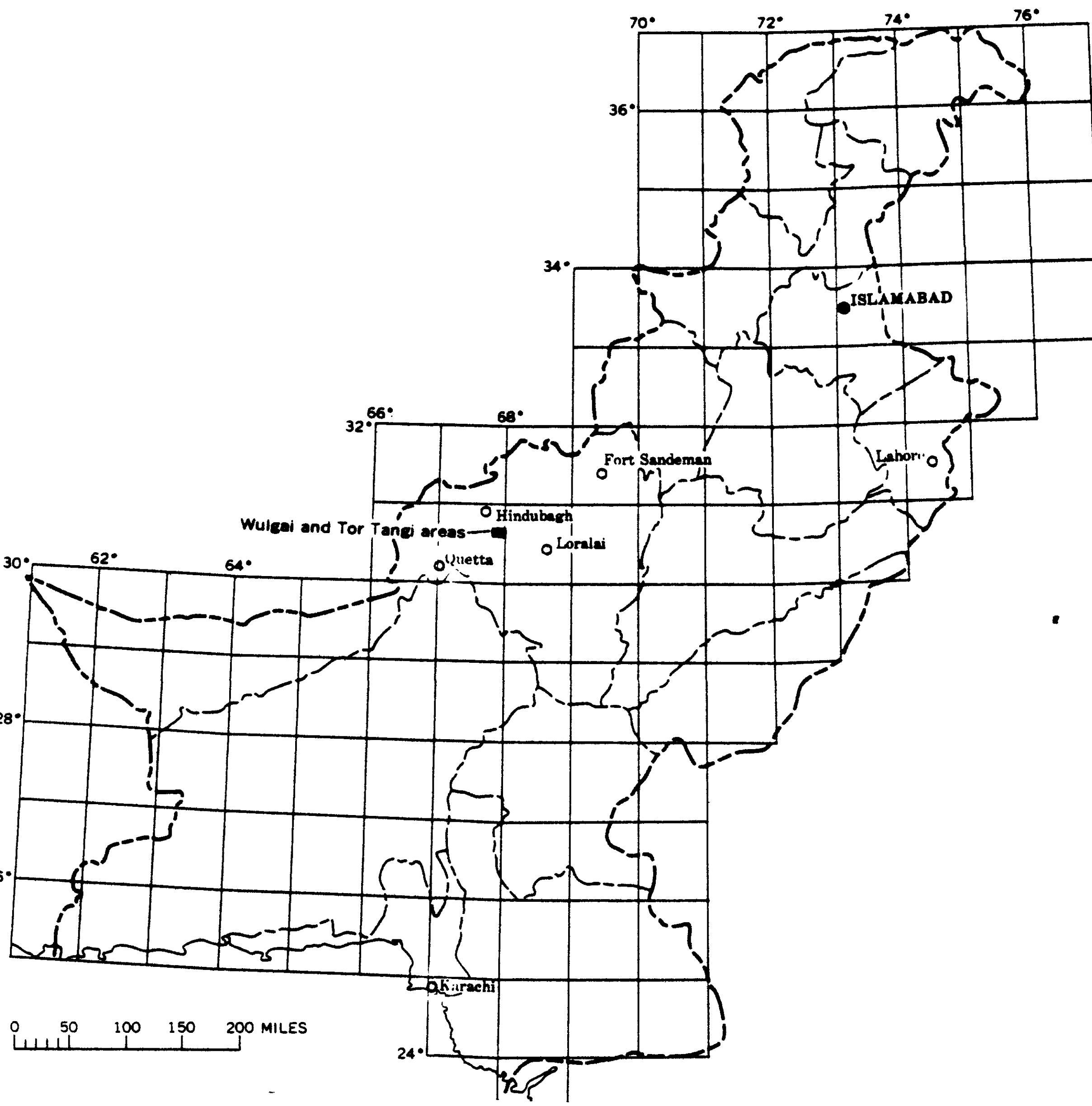

Figure 1. Index map of Pakistan showing the location of the Wulgai and Tor Tangi areas.

A number of exploratory pits, trenches, and adits were dug in some of the mineralized areas by G. E. Davies of Pakistan Chrome Mines Limited (unpublished data). In 1960, R. G. Bogue of the U. S. Geological Survey made two dip-needle traverses across one of the magnetite exposures in the Tor Tangi area. In 1963, R. H. Nagell of the U. S. Geological Survey investigated some of the mineral deposits in the Wulgai and Tor Tangi areas. Recommendations for more detailed prospecting were made which stimulated interest in applying geochemical methods in the Wulgai and Tor Tangi areas.

Purpose and scope of work

The geochemical prospecting program for the Wulgai and Tor Tangi areas was planned to serve several purposes. A reconnaissance drainage survey based on the sampling and analysis of streambed sediment was made to determine if any anomalous chemical patterns were present that might indicate the location of possible undiscovered deposits. Different sampling techniques were tried to determine the best method to prospect these areas, a method which might also serve in similar environments elsewhere in Pakistan. The field operations provided on-the-job training in geochemical methods for members in the Geochemistry Branch of the Geological Survey of Pakistan.

GEOLOGIC SETTING

The Hindubagh intrusions (Hunting Survey Corp., Ltd., 1960, p. 136) are composed of dunite, serpentine, harzburgite, and varieties of peridotite and pyroxenite. This ultramafic massif is believed to be Late Cretaceous to early Paleocene in age (Hunting Survey Corp., Ltd., 1960, p. 136). Sedimentary rocks of Triassic to Eocene age occupy the areas around the intrusive rocks. Dolerite dikes intrude the ultramafic complex and some of the marginal sedimentary rocks. The sedimentary rocks are folded and faulted, and in places they are metamorphosed to marble, schist, and gneiss near the contact with the intrusives (Asrarullah, 1961, p. 1-3; Bilgrami, 1963, p. 573-574).

SAMPLING AND ANALYSIS

Access to most of the sample locations was gained by following deeply incised valleys of intermittent streams that carve the rugged topography of the region. Sampling traverses were restricted almost entirely to stream valleys, because the dry streambeds provided the best source of unconsolidated sediment desired for sampling purposes. The sieved to minus 80 mesh, and the fines were used for analysis.

The samples were prepared and analyzed in a temporary field laboratory by standard geochemical field methods. The pyrosulfate-fusion technique was used to prepare sample solutions for both copper and nickel determinations. Copper was determined with 2, 2'-biquinoline, and nickel with alpha-furildioxime (Ward and others, 1963, p. 19-25, p. 37-38). The field analytical data were checked in the laboratory of the Geological Survey of Pakistan at Quetta. Several samples of malachite-stained rocks collected from outcrops were analyzed by standard wet analytical methods.

DISPERSION OF COPPER AND NICKEL

Copper

According to Hawkes and Webb (1962, p. 364), the average content of copper in igneous rocks is 70 ppm (parts per million). Ultramafic rocks generally have 80 ppm Cu, mafic rocks have 140 ppm Cu, and felsic rocks have 30 ppm Cu.

Bilgrami (1961, p. 1733) reports average copper values ranging from 92 to 208 ppm for some of the typical rocks of the Hindubagh intrusive complex. The values cited above pertain to the various rock types and not to soils and sediments. Most soils and unconsolidated sediments generally contain less copper than the parent rock, except where copper-rich material has been deposited or enriched by aqueous solutions. The average copper content in soils is 20 ppm, and the range is from 2 to 100 ppm (Hawkes and Webb, 1962, p. 364).

Figure 2 shows the frequency distribution of copper in 285 samples of streambed sediment collected in the Wulgai and Tor Tangi areas. The copper content ranges from 10 to 150 ppm. One sample containing only 5 ppm Cu was not plotted on the copper histogram. Eighty-two samples (about 29 percent of the total number of samples) contain 75 ppm Cu or more; these are considered to have above-background values for the areas prospected. The value of 75 ppm was established as the threshold value for outlining the anomalous areas designated Cu-1 to Cu-9 in Plate 1. The eastern closure of anomaly Cu-9 in the Tor Tangi area was drawn from available data, but this anomaly may extend farther east beyond the limit of the map. The distribution of copper-enriched sediment (anomaly patterns in pl. 1) is interpreted to result from the deposition of eroded copper-rich rocks exposed near the anomalies.

Quartz veins are associated with stains of malachite, limonite, pyrite, and possible bornite and chalcopyrite in four of the nine demarked anomalous areas. Ore minerals crop out at the head of the Wulgai Nala near the drainage divide in anomaly Cu-3; in the headward part of the east fork of Tor Kazha Baman Nala in anomaly Cu-5; at several places within anomaly

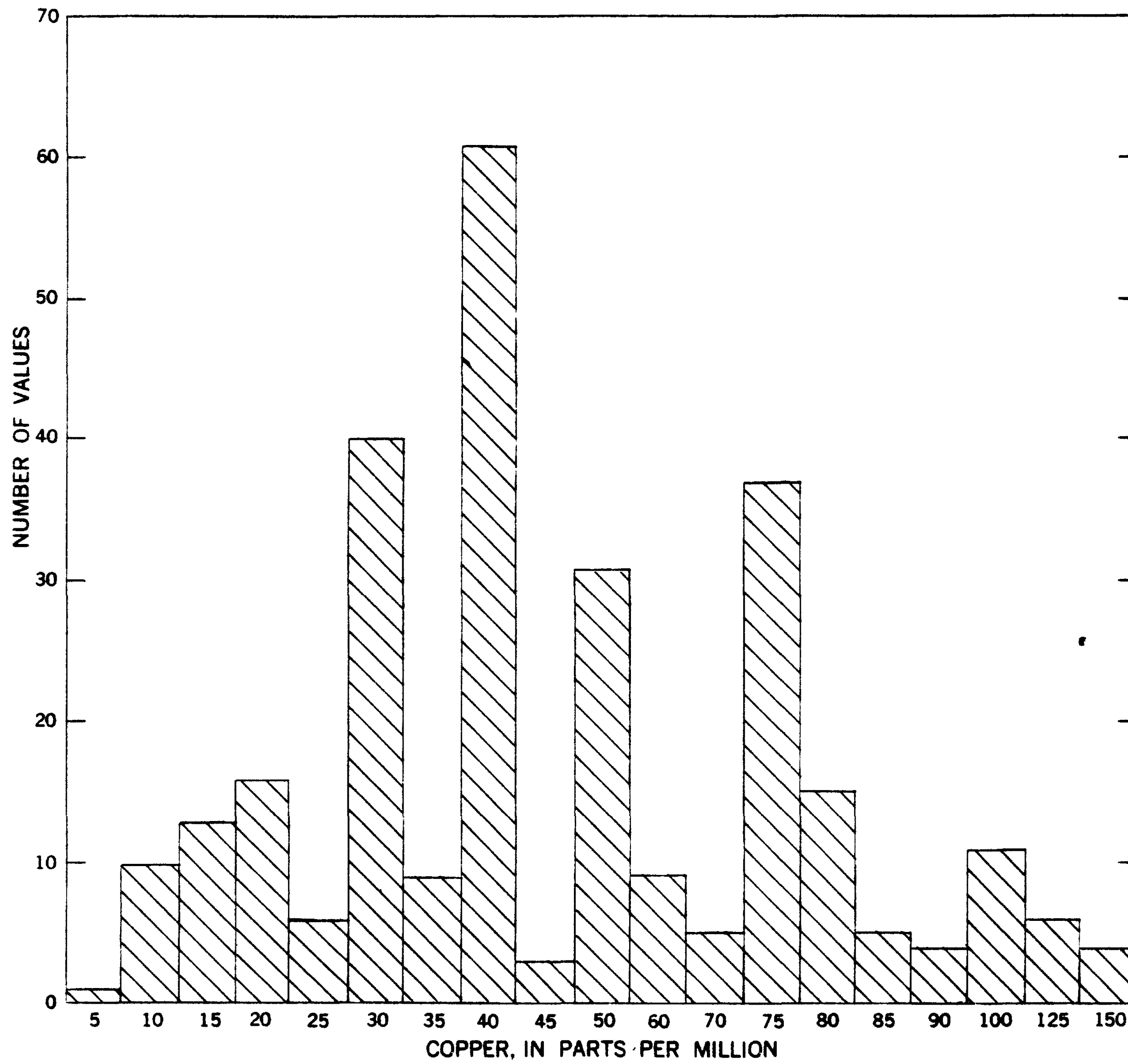

Figure 2.—Frequency distribution of near-total soluble copper in 285 samples of stream sediments from the Wulgai and Tor Tangi areas

Cu-6; and in the headward areas of the south-draining stream valleys in anomaly Cu-9. A few very small showings of malachite and what seems to be bornite are on the southwest side of the Wulgai Nala about a quarter of a mile west of anomaly Cu-2. Some fragments of malachite-stained rock were noted on dump piles in the valley between anomalies Cu-7 and Cu-8. Float of malachite-stained rocks was found in a few of the westernmost dry washes to the south of anomaly Cu-8.

Analyses for copper were made on several samples of mineralized rock collected in the upper valley of Wulgai Nala (anomaly Cu-3). The results obtained by standard wet analytical methods show copper values ranging from 1.9 to 3.5 percent.

Nickel

According to Hawkes and Webb (1962, p. 370), the average nickel content is 100 ppm in igneous rocks, 1,200 ppm in ultramafic rocks, 160 ppm in mafic rocks, and 8 ppm in felsic rocks. The average nickel content in soils is 40 ppm and the range is 50 to 500 ppm (Hawkes and Webb, 1962, p. 370). Bilgrami (1961, p. 1736), in a study of mafic and ultramafic rocks of the Hindubagh intrusive complex, found the highest nickel content to be 1,240 ppm in a specimen of dunite and the lowest nickel content to be 66 ppm in a specimen of quartz dolerite.

The frequency distribution of nickel in 285 samples of streambed sediment from the Wulgai and Tor Tangi areas is shown in Figure 3. The nickel content of these samples ranges from 25 to 1,250 ppm. It was difficult to establish a threshold value for nickel in the Wulgai and Tor Tangi areas, and it is entirely possible that anomaly contrast should be based on local rather than on a regional threshold value. Hawkes and

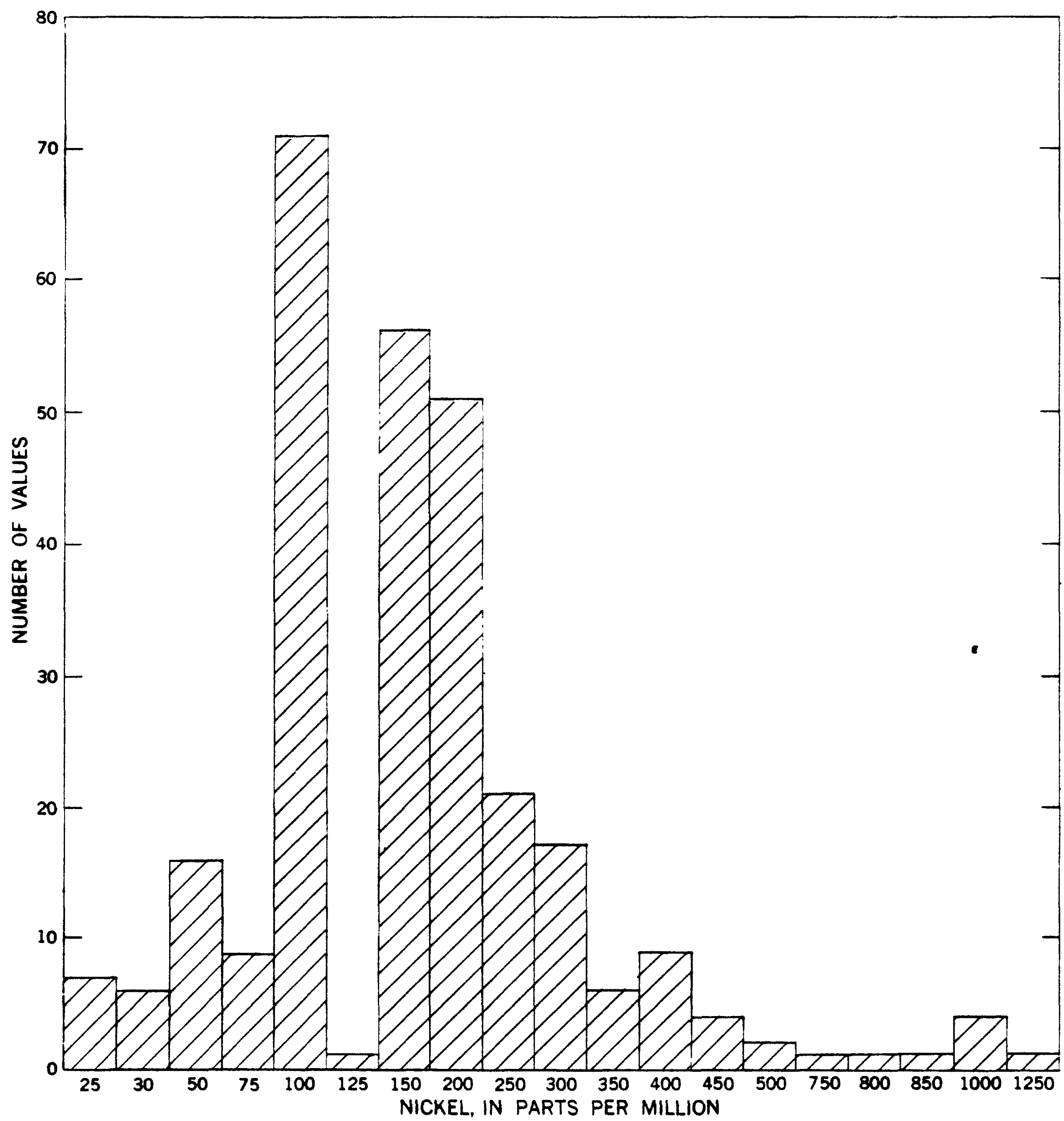

Figure 3.— Frequency distribution of nickel in 285 samples of stream sediments from the Wulgai and Tor Tangi areas

Webb (1962, p. 28) stated, "In soils over homogeneous granite or shale the Ni content will be low and uniform; over mafic igneous rocks it will probably be somewhat higher and uniform; over serpentine it may be very high and somewhat erratic; and over Ni sulfide deposits it may be very high and very erratic."

Serpentine and other ultramafic rocks compose a large part of the Hindubagh intrusive complex. Ultramafic rocks are generally enriched in Cr, Ni, Co, and Mg, and the weathering products of these rocks may contain very high concentrations of all four elements. The anomalous nickel patterns, shown in Figure 2 as areas Ni-1 to Ni-6, may have developed from the erosion of nearby nickeliferous ultramafic rocks rather than from nickel sulfide deposits in these rocks.

In the Wulgai area, the nickel anomalies are based on groups of samples that contain more than 400 ppm Ni. In the Tor Tangi area, one possible anomaly is inferred from a group of samples that contain slightly more Ni than the other samples in that area, but which contain less than 400 ppm, the threshold value used in the Wulgai area.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions and inferences based on the results of geochemical prospecting in the Wulgai and Tor Tangi areas near Hindubagh are as follows:

(a) The analyses of samples of streambed sediment by standard geochemical prospecting tests found nine copper anomalies and six possible nickel anomalies.

(b) Known areas of copper mineralization are either within or very near to four of the copper anomalies.

(c) The nickel anomalies may be nonsignificant geochemical patterns that are due to the erosion of ultramafic rocks having characteristically high nickel content.

(d) All the geochemical anomalies and patterns are believed to be very near the source rocks that supplied the high-background clastic material.

(e) Except for the concurrence of anomalous areas Cu-6 with Ni-6 and Cu-2 with Ni-3, copper and nickel anomalies do not coincide.

(f) Searching for anomalous nickel patterns may provide an indirect means of detecting undiscovered deposits of chromite in the Hindubagh area, because the chromite ore bodies in the Hindubagh mining district are exclusively associated with ultramafic rocks, which give rise to distinctive nickel anomalies.

Recommendations for further study are:

(a) A detailed geologic investigation should be made of the Wulgai and Tor Tangi areas along the trend of the geochemical copper anomalies.

(b) A detailed geochemical survey should be made in an area that includes the possible nickel anomalies of Ni-1, Ni-2, and Ni-3 in the Wulgai area. This survey should be planned to sample and analyze all types of rocks, residual soils, and unconsolidated sediments. This particular study should attempt to develop criteria for distinguishing between patterns related to sulfide mineralization and nonsignificant high-background patterns. In addition to testing for nickel and copper, determinations of chromium and cobalt might provide useful data. The results obtained from this type of detailed survey may provide a workable formula that is applicable throughout the Hindubagh metallogenic province.

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