CHAPTER 7

INTERPRETATION

7.1 Geochemistry of the Elements

8.1.1 Chromium : Chromium is a rock-forming element which is closely associated with magnesium and nickel in the ultramafic rocks, such as peridotite, pyroxenite and serpentinite (Thayer, 1973). Chromium is associated with iron and aluminium in sedimentary cycle. Generally, chromium is widely diffused in most rocks but high concentration is typically in mafic and ultramafic rocks. Chromium is also a normal and abundant constituent of the early crystallized olivine rock or dunite. The dunites contain chromium largely as chromite, but it may be incorporated in the structures of other early crystallizing minerals. In igneous rocks chromium occurs both in oxide and silicate minerals. The only independent chromium minerals of these rocks are the chromian members of the spinel group, viz., magnesochromite, $MgCr_2O_4$ and their isomorphic mixtures (Rankama and Sahama, 1968). In mafic and ultramafic rocks the chromium spinel occurs either as pure chromite or as picotite $(Mg,Fe)(Al,Fe,Cr)_2O_4$, which conseqnently is a mixture of chromite and of the magnesium-aluminum spinel. More significant geochemically is the chromium present only in traces in the structures of silicate minerals. In silicate minerals, chromium is present as a cation outside the complex silicon oxygen framework, and thereby readily replaces ferric iron and aluminum diadochically (Rankama and Sahama, 1968). For the residual sediments chromium is found concentrated as the insoluble chromite, and other chromiferous spinel minerals from gabbroid rocks

(Vudhichatvanich, 1976). The content of chromium in various rocks are presented in Table 7.1

Table 7.1 Content of Chromium, Nickel, Cobalt and Copper in various rock types, soil, stream sediment and river water (After Hawk and Webb, 1962; Andrews-Jones, 1968)

	Cr	Ni	Co	Cu
Igneous rocks				
Ultramafic	2000	1200	200	10-80
Mafic	300	160	45	140
Felsic	25	8	5	30
Sedimentary rocks				
Limestone	5	3-10	0.2-2	5-20
Sandstone	10-100	2-10	1-10	10-40
Shale	100-400	20-100	10-50	30-150
Black shale	10-500	20-300	5-50	20-300
Soil	5-1000	5-500	1-40	2-100
Stream Sediment	130	95	22	57
River water	1	0.3	0.2	7

7.1.2 Nickel : Nickel is widespread in nature and is estimated to be the fifth most abundant element of the earth. The mantle, lying between the crust and the core of the earth is believed to be peridotitic (Cornwall, 1973). Rocks of this ultramafic zone, like similar rocks exposed at the surface, may contain 0.1-0.3 percent nickel. The peridotite and related rocks that have intruded the crust of the earth, and are in part exposed at the surface, probably have been derived largely from mantle. Furthermore, most of the known nickel ore deposits are closely associated with mafic and ultramafic intrusive rocks. Nickel is one of the typical constituent elements of the early magmatic sulfide segregations of the pyrrhotite-pentlandite assemblage. Nickel found therein is first separated as mix-crystals of pentlandite and pyrrhotite (Rankama and Sahama, 1968). At a later stage, pentlandite forms intergrowths with pyrrhotite and only seldom, when Ni:Fe ratio is very high., is pure pentlandite separated. Pentlandite contain 22-23 % Ni and is geochemically the most important nickeliferous sulfide mineral. Like magmatic sulfides, the normal igneous rocks of the main stage of magmatic crystallization are regularly cobalt-and nickel-bearing. However, the bulk of cobalt and nickel found in igneous rocks is incorporated in silicate minerals, being concealed in their structures. The silicate minerals of nickel are both structurally and chemically closely related to the corresponding magnesium minerals and usually occur connected with them. At any rate, nickel has tendency to become enriched in the early crystallized magnesium and ferromagnesium minerals (Rankama and Sahama, 1968). Considerably lower nickel contents are found in augite, amphibole, and biotite. The content of nickel varies in relation to the content of olivine and hypersthene in the rocks. During the weathering, nickel remains largely in the solid products of distribution and is deposited in the hydrolyzate sediments. During the weathering of ultramafic rocks, particularly of serpentinite nickel forms a number of hydrosilicate with complicate chemical composition, and during serpentinization, nickel enters in to serpentine and talc. Residual sediments, such as sandy chert and sandstone, generally contain small amount of nickel from few up to about 50 ppm (Vudhichatvanich, 1976).

The Ni content in some rock types are given in Table 7.1

7.1.3 Cobalt : Cobalt is a metallic element whose abundance in the earth's crust is estimated to be about 20 ppm (Vhay et.al., 1973). The principal concentrations of cobalt are found in mafic and ultramafic igneous rocks. As shown in Table 7.2 the cobalt content progressively decreases in a differentiation series from ultramafic to acidic rocks. The ratio of nickel to cobalt also decreases during differentiation, chiefly becoause cobalt enters the lattice of early crystallizing magnesium silicates less readily than nickel. This has been attributed to a closer ionic radius between nickel and magnesium (Vhay et al., 1973)

Table 7.2 Average cobalt content of igneous rocks (Compiled by Vhay, 1973).

Rock Type	Co	Ni	Ni/Co
Ullramafic rocks	270	1900	7
Gabbro	51	133	2.6
Basalt	41	102	2.5
Diabase	31	65	2.3
Intermediate igneous rocks	14	27	1.9
Felsic rocks	5	5.7	1.1

The concentrations of cobalt in sedimentary rocks are not well known, in part because of the past difficulty in analysis for the small amounts present in most types of rock. The concentation of cobalt in metamorphic rocks depends entirely on the amount of cobalt in the original igneous or sedimentary rock sources. Metamorphic rocks derived from ultramafic and mafic rocks average about 100 ppm. Under oxidizing conditions, cobalt displays a strong tendency to concentrate with manganese (Rankama and Sahama, 1968, Mason, 1958). The concentration of cobalt particularly with manganese oxide, and the separation of cobalt from nickel are especially pronounced in laterite deposits that occur over deeply weathered mafic and ultramafic rocks in tropical areas when rainfall is abundant (Vhay et.at., 1973). The average contents of cobalt in igneous and sedimentary rocks are given in Table 7.1.

7.1.4 Copper : Copper is introduced into accessible part of the earth's crust from unknown deeper sources by igneous and by upward migrating fluids (Cox et.al., 1973). The high affinity of copper for sulfur forms the basis of metallurgical treatment of copper ores. Sulfides and sulfosalts are the most important copper minerals (Rankama and Sahama, 1968). In igneous rock it occurs mainly as finely divide sulfide, principally chalcopyrite and bornite. Copper is concentrated in the igneous cycle in basaltic and gabbroic rocks. In these rocks it is highest in the ferromagnesian minerals such as pyroxenes and biotite where it probably occurs mainly as minute grains of chalcopyrite (Goldschmidt, 1954). During the crystallization of igneous rocks, copper and some other elements that do not fit readily into the structures of silicate mineral may be concentrated to form are deposits. If the magma contains appreciable volatiles, copper may be dissolved and transported with these fluids into veinlets or extensive vein systems (Cox et al., 1973). If as in the case of some gabbroic rocks, the volatile content is low, copper may remain in the intrusion, concentrating as an immiscible copper sulfide fluid. Copper is found in at least trace amounts in nearly all sedimentary rocks.

Marine clays and other fine-grained rocks tend to have more copper than coarsegrained rocks and limestones. Moreover, the average black shale contains about twice as much copper as the average shale (Cox et.al., 1973). Copper contents in some rock types are also shown in Table 7.1.

7.2 Interpretation of Anomalies

Interpretation of geochemical investigation begins with the presentation of samples and analytical results, followed by examination of the data for anomalous situations which may be due to the presence of potential mineralization areas. The interpretation of the results will base on distribution of these elements in the investigated area which had been discussed and summarized in Chapter 4, 5 and 6.

7.2.1 Chromium Anomalies (Fig. 4.17, Fig. 5.4, Fig. 5.6 and Fig. 6.6)

An elliptical NW-SE trending Cr anomaly covers an area of at least 2 square kilometres. The concentration of Cr in stream sediments and soils suggest that distribution of this element is being controlled by local lithology. Almost all of the anomalous area is underlain by ultramafic rocks and some anomalous values continue overlapping into adjacent rocks of weathered sanstone, chert and limestone. The highest Cr concentration of stream sediment concentrates was taken from a tributary on the serpentinized rocks. This sample carried 12700 ppm Cr. Also 22270 ppm of Cr is obtained from stream bank soil sample at almost the same location. The strong Cr anomaly is associated with Ni and Co values of Ni and Co. The overburden directly above the known mineralization zone displays significant Cr anomaly. Some high Cr values present in area outside the ultramafic rocks are due to the tributaries draining from serpentinite areas. This Cr anomaly is considered to be a high priority follow-up with more detailed sampling for further investigation.

7.2.2 Nickel Anomalies (Fig. 4.19, Fig. 5.9, Fig. 5.11 and Fig. 6.9)

The nickel anomalies situate within the ultramafic terrain. Like Cr anomalous zone, it trends NW-SE and covers an area of approximately 2-2.5 square kilometres. In general the nicke-rich belts occur on the serpentinized rocks with some high anomalous values in a down-drainage toward the adjacent rock units. Some high Ni values found outside the ultramafic rocks may be produced by hydromorphic dispersion of Ni metal and such anomalies could also occur in the ultramafic rock itself to render high anomalous values. The anomalous Ni may be related either to the chromite mineralization nearby or to the ultramafic rocks which Ni anomalies occured. In the area of serpentinized rocks, a cluster of anomalous Ni values coincide with the areas of highly anomalous Cr and Co values. The Ni anomalies are highly important like Cr anomalies and it should be necessary to followed up and by more detailed geochemical sampling.

7.2.3 Cobalt Anomalies (Fig. 4.21, Fig. 5.14, Fig. 5.16 and Fig. 6.12)

The cobalt content of stream sediments and soils show large significant anomalies within the area sampled. The distribution patterns for Co are very similar to Ni and Cr anomalies pattern. These anomalies cluster around the central part of investigated area and are coincident with the area of ultramafic rocks which extend to 2 km in NW-SE direction. A high Co content in the underlying ultramafics is almost certainly responsible for these anomalies.

7.2.4 Copper Anomalies (Fig. 4.23, Fig. 5.19 and Fig. 5.21)

Cu in stream sediments and soils show no significant anomalies within the area sampled and also show no correlation with other elements. Outside the ultramafic terrain, only a few small and generally isolated Cu anomalies are scattered throughout the remainder of the sample area. A number of such small Cu anomalies are located over tuffaceous sandstone, sandstone chert and silicified carbonate rocks. These anomalies show no obvious correlation either with geologic structure or lithology within the area and also are believed to have no economic significance.