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THE GEOLOGY OF THE CORUNDUM-BEARING AND RELATED ROCKS AROUND TIMURGARA, DIR

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ABSTRACT

The geology of the Timurgara, Dir, area has been mapped, largely because of the occurrence of ruby corundum associated with some ultramafic bodies intruding the regional hornblende gneisses, quartzo-feldspathic gneisses, and minor phyllites.

The most abundant intrusive rocks are dioritic, themselves intruded by granites. The ultramafic bodies include serpentinites, pyroxenites and the corundum-bearing amphibolites. The relationship of these to the other intrusive rocks is not clear.

INTRODUCTION

Rock samples from Timurgara, Dir, were brought for examination by Mr. Arif Khanzada of Dir Mineral Corporation, in the beginning of 1969. Some of these samples contained square or prismatic crystals of pale ruby corundum surrounded by an 'envelope' of greenish material. Because of the interesting mineralogy and possible economic importance of the rocks, the authors visited the area in order to make a geological map and collect rock samples for further study. This report is based on the study of a number of samples collected along the lower reaches of Tangai Darra and Khungai nalas, and the area between the two. The area (34° 48′N latitude and 71° 50′E longitude) is connected by road with Peshawar through Chakdara and Malakand.

The area (Plate 1) consists mostly of metamorphic rocks (hornblende gneisses, quartz-feldspar gneisses and chlorite-bearing phyllitic rocks) that have been intruded by diorites, with less abundant ultramafic and granitic rocks. The ruby-bearing rock consists mainly of tremolite and is intrusive into the metamorphic rocks, pinching out and reappearing for some miles along its east-west strike.

METAMORPHIC ROCKS

Gneissose rocks and minor phyllites cover most of the area. Except for the phyllites, they have a consistent ENE strike (N 60° to 80°E) and northerly dip. Some of the phyllites strike N 20°E and are deformed and weathered, thinning out to the

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southwest, and probably terminated to the north by intrusions. The change in strike may be due to intrusions or deformation, but the occurrence of low grade chlorite-bearing rocks in the middle of higher grade gneisses is unusual and there is a possibility that the chlorite-phyllite itself may originally have been an intrusive rock.

The phyllitic rocks near the contact of the mafic intrusions in the northwest are fine -grained, porphyroblastic, and schistose. They are composed of chlorite, muscovite, garnet and quartz, with minor ore, carbonate, rutile, and traces of feldspar. The garnet is porphyroblastic, fractured, and contains quartz inclusions; it may be chloritized along fractures. The rock contains microveins of quartz and carbonate.

Hornblende-rich gneisses are the most abundant rocks in the area. They are distinctly banded (light and dark) and appear to be mainly metasedimentary in origin although some may be metaigneous. Some of the bands are fine and so systematically arranged that they may represent original sedimentary layering. In many cases, however, the gneisses are veined, wedged, and folded, due to strong distortion. Many also have well-developed ptygmatic folding. These characters, and the presence of quartz-feldspar gneisses, give them a migmatitic appearance.

The rocks are medium- to fine-grained, and gneissose. The texture of the individual layers may vary and some may have stronger parallel alignment of minerals, and/or be finer-grained than the others. Some of the rocks are porphyroblastic, with large crystals of hornblende and/or garnet in a comparatively finer matrix. Plagioclase and hornblende make up most of the rocks and may be, respectively, saussuritized and chloritized. Epidote and rutile are other constituents. In the south, epidote is common, particularly along certain bands of which it may account for more than 50 per cent. Similarly, some rocks in the northeast have a very high proportion of hornblende or garnet, either in bands or evenly distributed. These four minerals (hornblende, plagioclase, epidote, and garnet) make up more than 90 per cent of the gneisses; iron ore, (?) clinozoisite and rutile locally form other constituents.

One of the amphibole gneisses, occurring near the ultramafic rocks, is composed of about 70 per cent hornblende, 15 per cent of partially saussuritized plagioclase, 5 per cent of iron ore, and 10 per cent of diopside, biotite, epidote and chlorite. It is notable that the biotite occurs in large, sparse, poikiloblastic patches incorporating many grains of other minerals. Some epidote may occur in the form of intimate lamellae in this biotite.

Of the amphibolites, perhaps the most distinctive of all is a fine-grained rock composed of light and dark minerals. It contains distinct but irregular streaks and rounded patches, generally $<$ 1 cm across, of garnet and feldspar with minor epidote. The streaks may not be parallel to the schistosity of the rock. Under the microscope

the rock is seen to be composed of garnet, hornblende, plagioclase, epidote, quartz, ore and biotite. Very similar rocks occur along the Indus River, some miles south of Kamila in Swat Kohistan, and the two may represent the same geological horizon.

Associated with these rocks are thin, distorted layers and bands of quartz-feldspar gneiss of a lighter colour, closely resembling gneissose granite in hand specimen; many of them may be granitic in origin. These rocks occur throughout but are more common in the middle part of the sequence. They may be very weathered locally, and in places are stained brown by iron oxide. Besides quartz and feldspar the rocks may also contain hornblende and well dispersed garnet.

Thin veins of epidote, quartz (abundant in the quartz-feldspar gneisses), and quartz-and-feldspar are quite common in the gneisses. More prominent are thick and irregular veins of quartz, generally less than a few tens of feet in length. The rocks also locally contain various sulphides. The rocks are very similar to some of the gneissose rocks of the Upper Swat Hornblendic Group (Martin *et al.*, 1962) and may be a continuation of them (Davies, 1965).

Blocks of megabreccia make a small proportion of the boulders along Khungai Khwar, although they were not seen in situ. They consist of boulders (some exceeding two feet in length) of amphibole (±garnet) gneiss, quartz - feldspar gneiss, and granite, in a greenish matrix (probably consisting of amphibole, chlorite, feldspar, etc.). The planes of banding in one boulder in a block of breccia may or may not be parallel to those in the others. The breccia might be of primary or secondary origin.

DIORITIC ROCKS

Rocks of plutonic character occupy the northwestern part of the area. They intrude the gneisses and are themselves intruded by granite. Their relation with the serpentinites (see below) is not clear, although the latter apparently are older than the granites. In general, they are very hard, but some may be sheared and differentially weathered; some of these contain mica, whilst others do not. Some also carry garnet, possibly due to assimilation. Small inclusions of metamorphic rocks occur locally; at one place a highly altered inclusion, ten feet long and three feet wide, occurs.

There are minor variations in texture and colour index of these rocks throughout the area. A darker coloured, medium-grained rock is composed of about 56 per cent calcic andesine (or sodic labradorite), 5 per cent quartz, 17 per cent each of pyroxene and hornblende, 2 to 3 per cent each of biotite and ore, and traces of apatite. Plagioclase has both albite and Carlsbad twinning, and some of it is interstitial, along with quartz. The latter has undulose extinction and some may be fractured. The pyroxene is a weakly pleochroic bronzite, with minor clinopyroxene. Bronzite contains unoriented inclusions of plagioclase and iron ore, and thin lamellae of iron ore and a

clinopyroxene. It is selectively altered to serpentine and chlorite: thus some grains are quite fresh whilst others are completely altered except for the cores. Some may be partially altered to or rimmed by hornblende, probably as a result of reaction with the magma. The hornblende is in larger poikilitic patches surrounding pyroxene, biotite, ore, etc. It is either the last mineral to crystallize from the magma, or of secondary origin. It may be slightly chloritized, as also is the biotite.

A comparatively lighter-coloured and finer-grained rock is composed of 60 to 65 per cent plagioclase (almost completely saussuritized); 6 per cent quartz; 15 to 20 per cent serpentinized, greenish pyroxene; 8 per cent poikilitic hornblende; and 3 per cent each of biotite and iron ore. The rocks thus appear to be border-line cases between true diorites, and norites and gabbros. They closely resemble the hornblende-bearing noritic rocks so common in the Hornblendic Group of Swat Kohistan (Jan and Tahirkheli, ibid., p. 4).

The dioritic rocks contain veins of quartz, feldspar, and minor epidote, as well as short, irregularly pinched intrusions of pegmatite, up to six feet thick, containing giant crystals of hornblende, many inches long. Generally the pegmatites run north-south although some may have different strikes.

ULTRAMAFIC ROCKS

These are represented by minor intrusions of serpentinite and other rocks, some of which are highly deformed and weathered. A small body of greyish-black serpentinite occurs in the chloritic schists, close to the contact wth the dioritic rocks in the north. Similarly, minor intrusions (? sills) of serpentinite, and partially serpentinized and/or metamorphosed peridotite, occur roughly along the drainage divide between Tangai Darra Khwar and Khungai Khwar. The rocks probably extend as sills, pinching out and reappearing, for several miles to the east; some of these rocks carry purplish corundum. The country rock at this point, associated with the ultramafic rocks, is a gneiss, weathered brownish and cellular. In this, the hornblende is much less weathered than the plagioclase, imparting a sponge-like appearance to the rock. These ultramafic rocks may be the equivalent of the Himalayan alpine ultramafics, which according to Krishnan (1956, p. 79) are of Cretaceous age.

The rocks are serpentinized to varying degrees, some totally, others only partially. At least one section shows a cataclastic texture. Some of the ultramafics are composed entirely of pyroxene, others are composed of pyroxene (? enstatite) and olivine, with minor opaque minerals, green spinel and calcite. In the fresher samples, serpentine and (?) chlorite are common along fractures, grain boundaries, and cleavages. Serpentine, iron ore, and less commonly calcite, may also occur in 'veins'.

The rock showing a cataclastic texture is composed mainly of serpentine and

(?) talc. Iron ore is more abundant in this rock than in others and is mostly an alteration product, because of its common occurrence along fractures. Muscovite, pyroxene, and minor amphibole (pale green, weakly pleochroic, and distinctly granular due to (?)crushing) are other constitutents.

CORUNDUM-BEARING AMPHIBOLITES

The corundum-bearing rocks are medium- to coarse- grained, granoblastic and are composed of abundant tremolite, with minor quantities of chlorite, serpentine, muscovite, (?) talc, epidote, rutile, iron ore, and pale ruby corundum. A few of them also contain (?) plagioclase, which may form as much as 30 per cent in some. It is very altered and looks clayey-white but in one case at least, where it is less altered, some of it shows faint albite twinning. In another section, small grains of plagioclase are concentrated in an ovoid cluster between amphiboles. It also contains traces of (?) garnet. In one section, some of the amphibole has undulose extinction and is bent or twisted due to stress. It is slightly altered to serpentine and chlorite. The corundum is translucent, purplish, and forms square or prismatic crystals. It is fractured and lamellar-twinned, and is generally surrounded by a green (less commonly yellowish-resinous) 'envelope', which may in turn be surrounded by a thin white rim. The green envelope may be very thin ($<$1 mm) with large corundum crystals (up to 15 mm), or vice versa.

Microscopic examination of the green envelope suggests that it is an alteration product, composed mostly of fibrous material, generally radiating from the corundum. A similar alteration product occurs also along some of the fractures and twin planes, within the corundum.The inner (green) envelope, surrounding the corundum, can be seen in some thin sections to be composed of two zones. The inner one consists of fibrous margarite, and the outer one of radially arranged chrysotile serpentine. This in turn is surrounded by a white outer rim consisting of an inner layer of chlorite, amphibole and clay mineral, and an irregular outer bluish birefringent (? epidote) material. It is notable that the amphibole, in many cases, is more altered to clay and other secondary minerals around the corundum than elsewhere. Chlorite, serpentine, and muscovite may also occur elsewhere in the sections.

The mechanism of formation of the corundum, and its subsequent alteration, associated with the partial serpentinization of the adjacent amphibole, are discussed by Jan *et al.* (1971, in press).

Corundum-bearing rocks have also been reported from some localities in the Shah Dheri, Swat, area. In one of these places (1½ miles southwest of Shah Dheri), the corundum occurs in a greenish massive body bordered by banded hornblende gneisses to the north, and a thin dioritic intrusion to the south. The rock is

composed of amphibole (pale green, pleochroic), garnet (containing abundant inclusions of amphibole and chlorite), and minor chlorite, corundum, and alteration products. The corundum crystals are generally surrounded by light green alteration rims (of ? margarite etc.), particularly when fractures run close to them. A greenish alteration product also occurs along these fractures. The rocks are weathered, friable and fractured, the amphibole being granulated along the fractures.

GRANITIC ROCKS

Minor intrusions of microgranite occur in the area. They are probably common in the gneisses and are quite difficult to distinguish from quartz-feldspar gneisses. They are thin and strongly deformed, as are the rest of the gneisses. There is a small semi-circular outcrop, a few tens of feet across, within the dioritic rocks. The rocks are light coloured, medium-grained and generally gneissose. They are composed of feldspar (making two thirds of the rock), quartz (about 30 per cent), minor muscovite and epidote, and traces of iron ore. The feldspar is mostly sodic plagioclase but some may be potash feldspar. Much of it is saussuritized and some crystals are bent. Quartz is mostly interstitial and shows undulose extinction; muscovite may also be bent and twisted. Some of these intrusions also carry brown (? igneous) hornblende which may be chloritized. Granitic rocks tend to be more common to the south of the area. Some of the latter are porphyritic, and may also contain sphene and garnet.

ECONOMIC FEASABILITY OF THE CORUNDUM

The pale pinkish ruby corundum occurs in a thin horizon along the contact with the ultramafic rocks. The horizon is discontinuous but it reappears some distance to the east. The presence of corundum in the Shah Dheri area suggests that other horizons also contain the mineral. In all the occurrences, the common feature is the disseminated character of the corundum and the small thickness (ca. 20 feet) of the corundum - bearing rock. The corundum occurs as crystals but many are malformed because of alteration.

Corundum is generally used for two purposes: i) as a gemstone, when it is clear and of good colour; and ii) as an abrasive. The mineral in the Timurgara area is of a pinkish colour, rather light for a typical ruby; translucent; and contains fractures, along some of which alteration has taken place. These characters lower the quality of the corundum and it cannot be considered as of gem quality. The small concentration of the corundum, and the hard and sporadic nature of the rocks make it impracticable for abrasive purposes. However, the possibility of greater concentrations of corundum in other localities or of good quality gem occurrences, cannot be ruled out.

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REFERENCES

DAVIES, R.G., 1965—The nature of the Upper Swat Hornblendic Group of Martin *et al.* (1962). Geol. Bull. Panjab Univ., vol. 5, pp. 51-2.

JAN, M.Q. AND TAHIRKHELI, R.A.K., *Ibid.* The geology of the lower part of Indus Kohistan (Swat), West Pakistan. Pp. 1-13.

———, KEMPE, D.R.C. AND TAHIRKHELI, R.A.K., 1971, in press—Corundum, altering to margarite, in amphibolites from Dir, West Pakistan. Min. Mag., vol. 39.

KRISHNAN, M.S., 1956—Geology of India. (Madras, Higginbothams).

MARTIN, N.R., SIDDIQUI, S.F.A. AND KING, B.H., 1962—A geological reconnaissance of the region between the Lower Swat and the Indus Rivers of Pakistan. Geol. Bull. Panjab Univ., vol. 2, pp. 1-13.