NOTICES, ABSTRACTS AND REVIEWS

Geol. Bull. Univ. Peshawar, Vol. 5, 1970, *pp.* 131-134

THE CHROMIUM-BEARING MINERALS OF THE NORTH WEST FRONTIER PROVINCE

INTRODUCTION

During the past few years, many interesting minerals have been reported from the N.W.F.P. Of these, the chromium-bearing minerals — emerald, micas, spinal and tourmaline — merit special attention because of the economic and/or academic importance. Gem quality emerald from Swat and Mohmand Agency is sold at high price and has attracted a lot of people during the past few years. All of the chromium-bearing minerals are closely associated with ultramafic rocks from which chromium was derived by various mechanisms.

In this paper, the writer has tried to gather all the published data available on these occurrences, and has added some new informations.

Emerald.

Swat: Emerald occurs in carbonate-talc rock and in quartz veins near Mingora, Swat (Davies, 1962). The mineral, when enclosed in quartz, is invariably broken by latter fracturing and is of no commercial value; the better crystals are found in the soft carbonate-talc rock. According to Davies, the rock is largely composed of carbonate, quartz and talc, with minor proportion of chromium-mica (fuchsite and chlorite), ore, and (?) chromium-andradite. Jan (1968) has also reported clinozoisite in some of these rocks.

The emerald is very weak green pleochroic and has impurities of dark dusty material, some along the fractures, and may also contain vacuoles. It is uniaxial with refractive indices of 1.587 and 1.596 (both $\pm$ 0.003), and $\Delta = 0.009$. However, Davies (1962) has also reported some to be biaxial with a very small 2V. He writes, "these observations indicate that this beryl has a biaxial (orthorhombic) character, the pseudohexagonal form being due to twinning of orthorhombic units as in aragonite (Winchell, p. 464)".

Mohmand Agency: Emerald from Mohmand Agency was fisrt reported by Waheedudin Ahmad (1966) near Nawe Dand. Recently, the mineral has also been found in Tora Tigga, Kuda Khel, Tsapari, and Dand Kandao (Prang Ghar) of the same Agency (Jan, 1968; Hayat, in press). It occurs in association with quartz veins in calcareous rock, quartz-mica schists, chlorite and talc-carbonate schists. Most of the quartz veins run parallel to the foliation of the schists but some are accorss to it, varying in thickness and length from a few inches to several feet. In Tsapari, epidote is associated with the emerald.

The emerald in these rocks is generally transparent, very weak pleochroic, devoid of fractures and contains only a few inclusions. The mineral is uniaxial negative which refractive indices of $\epsilon = 1.586$ and $\omega = 1.594$ (both $\pm$ 0.003), and $\Delta = 0.008$. In most cases, the grains show well-developed hexagonal prisms and basal pinacoids (Hayat, in press). The emerald ranges from a few mm to an inch in length and good crystals are sold at high price. Unfortuantely, the local people have been using old technique of exploration which has resulted not only in spoiling the gems but also some deposits have been lost.

Chrome-Spinel.

Chrome-spinel of octahedral form, up to 2mm accorss, is disseminated in a soft, fine-grained, dark-green amphibolite from Waziristan. The spinel is feebly magnetic and has a Cr_2O_3 content of 19% (Jan, in press). Beside the larger octahedra, the rock also contains minor quantities of anhedral spinel and traces of an unidentified white birefringent mineral. The amphibole in thin section is colourless to green pleochroic with low birefringence, nearly straight extinction, and has a few dusty inclusions. The rock is probably a metamorphosed peridotite in which spinel has survived metamorphism, or possibly been recrystallised in larger euhedral crystals. A similar sample, with larger crystals, has been reported from Shah Dheri area in Swat by Jan (in press).

Chrome-Tourmaline.

Chrome-tourmaline, in calcareous rocks, has been reported from Alpurai, Swat (Long. 72° 35′ E; Lat. 35° 54′ N) by Jan, Kempe and Symes (in preparation). The rocks are composed of calcite and quartz with minor quantities of fuchsite, biotite, chlorite and ore. They are intruded by a lenticular serpentinite body (over 8 miles long) and quartz veins. Tourmaline occurs in traces near the former.

The mineral in thin section is in distinct grains but some is prsent betwen calcite, or around it in the form of girdles of minute granules adjacent to each other. It is not completely surrounded by quartz anywhere and is either contained in calcite or between calcite and quartz.

The mineral is in anhedral to subhedral grains some of which reach 2mm in length. It is free of impurities and has a few fractures. Its refractive indices ($\epsilon = 1.627$, green yellow; $\omega = 1.660$, deep green; both ± 0.003) are the same as those of a chrome-tourmaline (dravite) given in Deer *et al.*, (1962). The latter has a chrome content of 10.86%. Electron microprobe analysis of the mineral (Jan, Kempe and

Symes) shows a Cr_2O_3 content of 7.3% and V_2O_3=0.2%. The mineral content is thought to have been introduced by silica-rich hydrothermal solutions which passed through or close to the ultramafics, and crystallised along with quartz in thin veins in calcareous rocks. A similar process may have produced emerald in Swat and Mohmand Agency. Jan *et al.*, citing the occurrence of the chrome-tourmalines reported by various people, think that the most common associations for chrome-tourmaline include serpentinites (and other ultrabasic rocks) and carbonates (including dolomites). Also, that they often contain vanadium and occur in association with fuchsite.

Fuchsite.

Fuchsite is locally present in calcareous and other rocks occurring close to the ultramafics in Swat, Dargai, and various parts of Mohmand Agency. The fuchsite-bearing rocks are greenish in most cases except at Mohmand Agency where they are brown with a touch of green, sometimes in layers. They contain siderite and/or calcite, fuchsite, quartz, and minor quantities of phlogopite. Some of the rocks also contain talc, chlorite and clinozoisite. The carbonate minerals are present in large euhedral to subhedral grains which, due to alteration, are brown in parts on edges and along cleavages in most cases. Most of these rocks in Mohmand Agency, apparently, have a high proportion of siderite with brownish-red colour.

Fuchsite is present in large, subhedral, tabular grains. It is pale green, pleochroic and has a high second order birefringence due, probably, to chromium content. The proportion of fuchsite varies from a few per cent to as much as 40%.

In the Dargai ultramafic complex near Harichand occurs a pinkish mineral along fractures in the ultramafic rocks. The mineral has not been investigated by the present writer, however, Dr. Bilgrami (personal communication) thinks it to be a chrome-chlorite (kammererite). It appears that the mineral is produced along fractures by alteration. Similar pinkish, fibrous mineral is also seen in a rock composed of talc, carbonate, quartz and spotty, green (?) nickle compound near Babo village, about 6 miles northeast of Shabqadar in Mohmand Agency. The rock occurs in patches and is closely associated with ultramafics.

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CHROMITE OCCURRENCES IN UTMANKHEL AREA OF MOHMAND AGENCY, N.W.F.P.

The Utmankhel area lies adjacent to Charsadda Tehsil of Peshawar district and its boundary starts about seven miles north of Tangi. A few samples of chromite were sent to the Department of Geology, by the locals, for identification in the fall of 1969. Later on, on the request of the tribal maliks, the author had a chance to conduct a reconnaissance survey to assess the potential of the mineralized area.

In the area under investigation the Peshawar plain skirts the hills where the elevation culminates from 1650 to 5520 feet. The ultramafic outcrops form a linear belt from two to five miles wide and extend for over 25 miles. The important localities in the Utmankhel area from where the chromite has been reported are in the vicinity of Babu, Bucha, Prangghar, Daghai and Balola villages.

During this survey, the author investigated only two localities close to Bucha and Babu. In Bucha area the country rocks consist of slate, phyllite, various types of schist and quartzite, intruded by the ultramafic rocks. There are seven pits, located about one and a half mile to the southwest of Bucha, from where chromite has been mined by the locals. The dimensions of the smallest and the largest pits were about 4 $\times$1 $\times$2 and 12 $\times$5$\times$2 feet respectively.

The country rocks in the Babu area are also slate, phyllite, schists and quartzite aligned to east-west. The slates are dark-grey, while the phyllites are grey to greenish-grey. The quartzite is light brown and has a minor quantity of sericite. The schists are grey, greenish-grey and yellowish-brown. Talc-chlorite schist, very much weathered and friable on the surface, is most extensively developed. Further north in Babu area, light-grey to greenish-grey rocks are exposed in which large flakes of muscovite are surficially found at places. Epidote and chlorite are in abundance in these rocks while minor muscovite, and traces of biotite and some ore minerals are also detected. An unidentified turbid-looking mineral with high relief is also seen in the form of minute grains.

There is a white talc, with numerous pinkish patches and small surficial green spotty material, associated with the chromite in several pits. The pinkish material might be chromium-chlorite while the greenish material is, probably, a compound of nickle. The rock also contains some magnesite and, at places, big crystals of dolomite. Quartz has also been found in the pits.

From these workings, it appears that mineralization is sporadic and lenticular. Throughout the area, rounded to subrounded pebbles and cobbles of chromite, brought from the adjacent mountains, are scattered in the streams. Chromite, extracted from the pits, is iron-black, while the colour of a few hand-picked samples is brown-black. It is in compact massive form.

The ultramafic rocks are quite extensively developed in the area and therefore chances are favourable to find workable chromite deposits. It is recommended that detailed investigation of the area should be undertaken to prepare a large scale geological map of the ultramafic outcrops, followed by prospecting to prove the sub-surface behavior of mineralization.

Saiful Islam Saif

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WEATHERING PRODUCT OF BASALT AT TUCSON, ARIZONA, USA.

INTRODUCTION

Early literature review shows that the mineralogical composition of basaltic soils varies from place to place due to different environmental conditions. Washington (1922) studied the basalts of Deccan (India) and found that most of these are remarkably similar. They are mainly dense, non-porphyritic rocks with not more than ten per cent of glass. In the majority of cases, olivine is entirely absent and there is small excess of silica. Augite and labradorite make up about 90% of the rocks. Snake River basalts of Oregon (USA) are very similar to the Deccan "traps". Minerals in the soils are formed when climate, biotic and topographic factors operate on parent materials with time. The transformation begins and ends mainly with polymineralic clays of mantle rocks and soils.

Basaltic terrain in Arizona(USA) is made up of clifflike rock outcrops mixed with stony, fine- or medium-textured, shallow soil materials over basalt. The objective of this study is to investigate and identify the weathering products of basalt rock at Tucson.

MATERIAL AND METHODS

A basaltic soil sample, developed on the top of basalt rock in Tucson mountains, located at NE 1/4 Sec. 11 R 9 NE 16 (Arizona, USA), was taken for study. The climate of the area under the present study is semi-arid. Temperature of the area varies from season to season; being highest in the month of July (mean=86.2° F) and lowest in January (mean=49.7° F). The annual mean precipitation, potential evapotranspiration and actual evaporation are 13.39, 41.86 and 13.39 inches respectively (Boul, 1964).

Separation of Clay Fraction.

After passing the soil sample through 2 mm sieve, it was washed with distilled water three times through centrifuge. The soil sample was heated with sodium acetate solution (pH 5.0) at 80° C for overnight and then washed with sodium acetate solution. Later, it was treated with 30% hydrogen peroxide so that the organic matter was destroyed (Jackson, Kittrick and Hope, 1963). The sample was put once again at 80° C in water bath until the reaction was subsided. It was decanted and then added citrate buffer (pH 7.0). After stirring, the sample was put in a water bath and added one spoon of sodium dithionate so that free iron oxide was removed. Rinsed with 1. 0 N magnesium acetate at pH 7.0 and then washed twice with saturated 10 N magnesium chloride solution; it was finally washed with de-ionized water with the help of centrifuge until no more chloride ion was detected. In the last two washing supper centrifuge was used, the speed of which was kept at 1800 rpm for twenty minutes.

The clay fraction was dispersed with de-ionized water in the centrifuge, for 5.3 minutes, the speed of which was adjusted with tachometer at 750 rpm. The completely frozen clay sample was put in polythene beaker in lyophilization apparatus and allowed for complete dryness.

Identification of Clay Minerals by Powder X-ray Diffraction Method.

A small quantity of the clay powder was introduced in capillary tube (prepared from lithium borate called "Lindaman" glass). The tube was fixed in the 114.6 mm camera properly with the help of wax. Then it was exposed to X-ray for suitable estimated time, using Cu Kα and Fe Kα radiation along with nickle filter. After developing, fixing and washing, the photograph was allowed to dry, and the distance between lines on the film was measured. Distances of the lines from the punch hole on the film were measured on both the sides. Then the individual reading from the left centre reading were calculated and converted in mm and D spacing. Finally consulted was the "Fink" index to the powder diffraction, 1963, ASTM.

DISCUSSION AND RESULTS

In the begining, Cu Kα tube was selected along with nickle filter for diffraction. The film in the camera was exposed for four hours but the photograph was not clear. Then the time of exposure was increased from six to eight hours and subsequently up to twelve hours. With twelve hours exposure, a clear photograph was obtained but with a dark background. The dark background was due to iron content in the soil sample. Iron in the sample emitted X-ray flourescence upon irradiation by the Kα copper lines resulting in fogging of the film. Another target was selected and the film was exposed to X-ray for twenty three hours, but again the photograph was not clear. Then helium gas was tried and the exposure time was again kept for twenty three hours and thus a clear photograph was obtained as compared to others. The outcome of the two photographs was selected, one when copper tube was used as a target, another when iron tube was used as a traget along with helium gas. Illite, chlorite, muscovite, anatase, tridymite and megnetite were found to be major constituents, and paragonite, sodium-calcium orthosilicate, iron-titanium oxide, biotite and hydrated sodium-carbonate were found to be minor constituents. Other minor constituents were also detected but required furhter confirmation.

The complex pattern of these photographs shows that the basaltic soil is very complex mixture of various clay minerals. Many of the arcs overlap each other and most of the lines on the film are diffused bands. The diffused bands and absence of sharp lines on the photograph could be explained in the following way:

The intensity of packing of clay powder was not dense and so a few planes have contributed towards diffraction. For particles less than about 0.22 micron in diameter, the diffraction maxima become broad and diffused.

It is obvious from these minerals that the parent material of the soil is of Quaternary origin (Jackson, 1965).

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VOLCANIC ROCKS FROM KALAM, UPPER SWAT

INTRODUCTION

Green and pink mottled volcanic rocks occur about three miles northwest of Kalam. A detailed investigation of these rocks has not been carried out so far, and the purpose of this paper is to give a preliminary report on the petrography of some of them. Kalam (35°23′ N, 72°30′ E) is a small town in Swat Kohistan, about 60 miles northwest of Mingora, with which it is connected by a metalled road which may be closed for traffic in winter for some time because of heavy snow falls.

The volcanic rocks have been shown by Bakr and Jackson (1964) to cover an area at least 23 miles in length and 7 miles in width, with a general NE trend. The area has not been previously mapped and it is not clear how far they extend laterally. Some specimens were collected by Mr. M. Qasim Jan from a locality about four miles northwest of Kalam. A few of these samples are distinctly banded and pink in colour; others are mottled green and pink, and may be composed of pyroclastic material cemented together by lava. The pyroclastic material in many of these rocks consists of small fragments (generally $<$ 1 cm) but some may be large. The following report is based on the study of three thin sections cut from rocks apparently different in hand specimen; one of these is a banded dacite, and two are pyroclastic dacite.

PETROGRAPHY

Banded Dacite.

This is fine-grained and porphyritic, and is composed of bands of microcrystalline material varying slightly in granularity; the individual bands are about one millimetre thick. The phenocrysts are mostly of plagioclase ($<$ 1 mm, euhedral to subhedral) and minor quartz. The former forms about ten per cent of the rock and is oligoclase, with a high 2Vz (85° to 90°) and a refractive index slightly higher than balsam. Most of the grains have albite twinning while some have Carlsbad twinning in addition. In some oligoclase phenocrysts there are a few inclusions of magnetite, and chlorite which may be secondary. Many of the phenocrysts have sharp boundaries with the matrix while a few have apparently reacted with the magma and have corroded boundaries. A few phenocrysts of ferromagnesian minerals, altered to chlorite and epidote, also occur.

The groundmass is microcrystalline along certain bands and cryptocrystalline along others. The microcrystalline bands are composed of abundant feldspar (? oligoclase) and quartz, with minor ore. The cryptocrystalline bands appear to be composed of felsic minerals (feldspar and quartz), brownish and greenish ferromagnesian minerals (epidote and chlorite), and iron ore dust. Oblique to the banding are thin veins of felsic minerals; more distinct of these is a fine-grained quartz vein running perpendicular to bands.

Some plagioclase microlites are distinct in a still finer grained groundmass and have some degree of parallel alignment. In some cases they show much stronger flow structure around the phenocrysts. The microcrystalline bands might represent later crystallization of the normal cryptocrystalline material.

Pyroclastic Dacite.

Of the two thin sections of pyroclastic rocks, one has an agglomerate pyroclastic texture, but along some lines a coarse micrograniitic texture is also to be seen. The

III. According to Davies (1956), the Panjal volcanic rocks of the upper Lidar Valley of Kashmir are of Upper Carboniferous and Permian age. The rocks are rich in iron oxides and are basic pyroclastic, and basic and acid lavas. Certain acid magmatic rocks, owing to deformation, are inclined to resemble acid agglomeratic pyroclastics; many of them may be sheared porphyritic lavas. Some rocks are banded; others are ashy, which have been somewhat deformed and recrystallized. Fragments of ilmenite are altered to leuxcoxene, rounded and angular phenocrysts of albite-oligoclase and quartz are present. Chlorite, epidote, and iron ore are seen along the cracks of quartz and feldsapar grains. The groundmass is composed of a granular aggregate of quartz, decomposed feldspar, chlorite, and epidote. Hence it is probable that the volcanic rocks of the upper Lidar Valley can be correlated with the volcanic rocks of Kalam.

CONCLUSION

The characters of the Lidar Valley volcanics and other volcanic rocks of Panjal are so similar to those of the Kalam volcanics that there appears little doubt that the two sets can be correlated. The writer therefore considers that the Kalam volcanics are a part of the Panjal Volcanics of Upper Carboniferous age. Bakr and Jackson (1964) gave these rocks a broad Palaeozoic-Mesozoic age.

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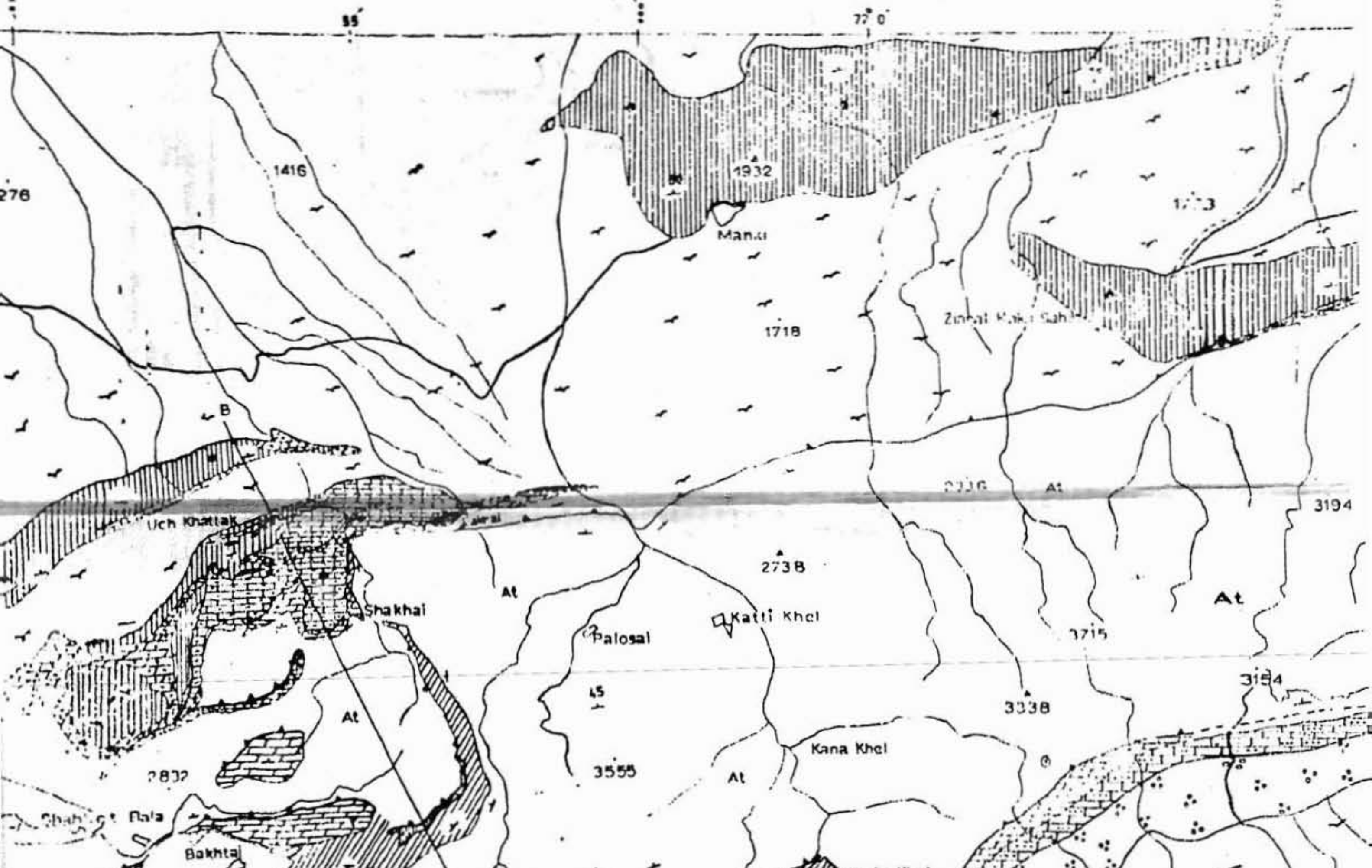
Manzur Sultan



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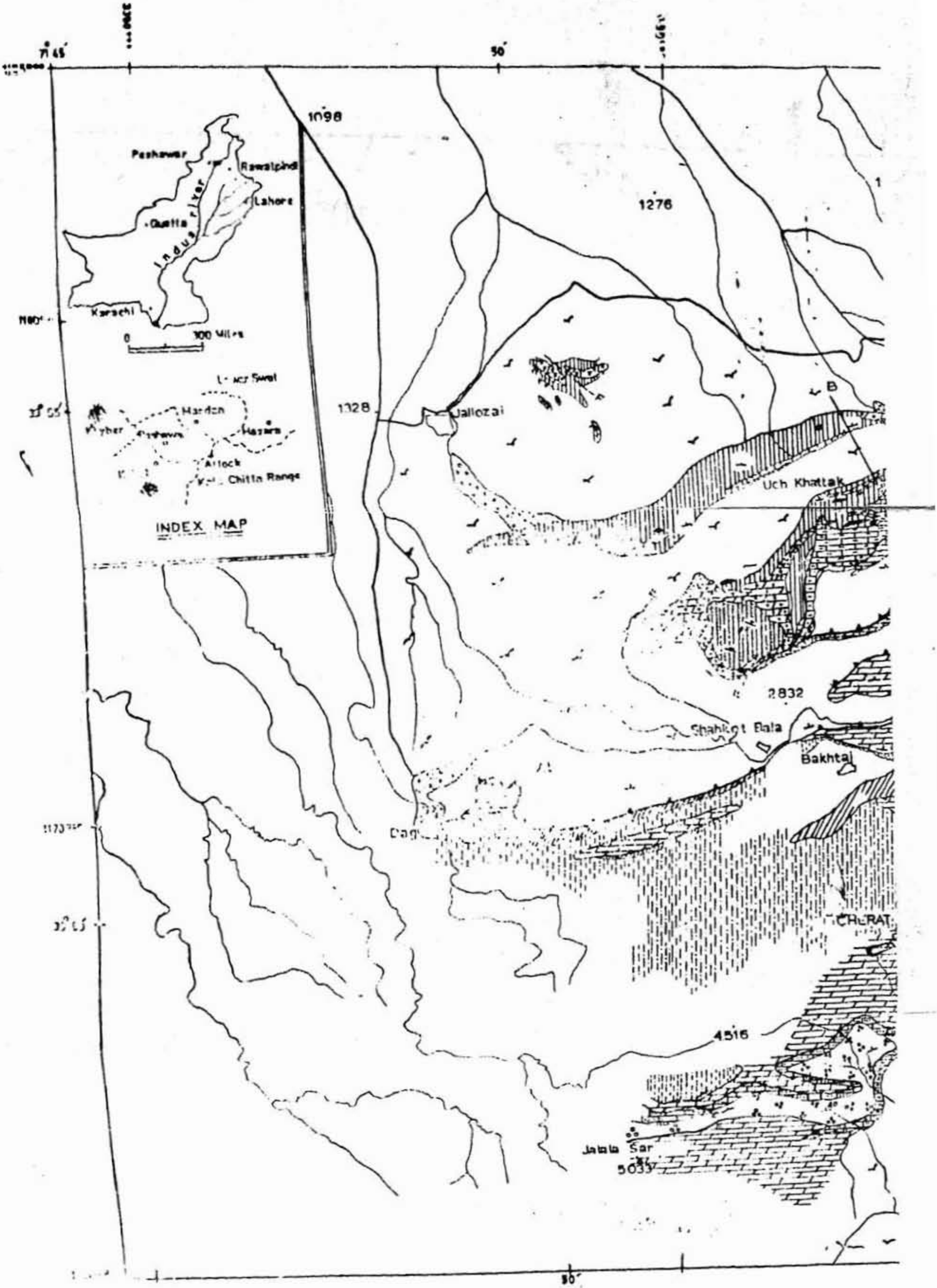
GEOLOGICAL



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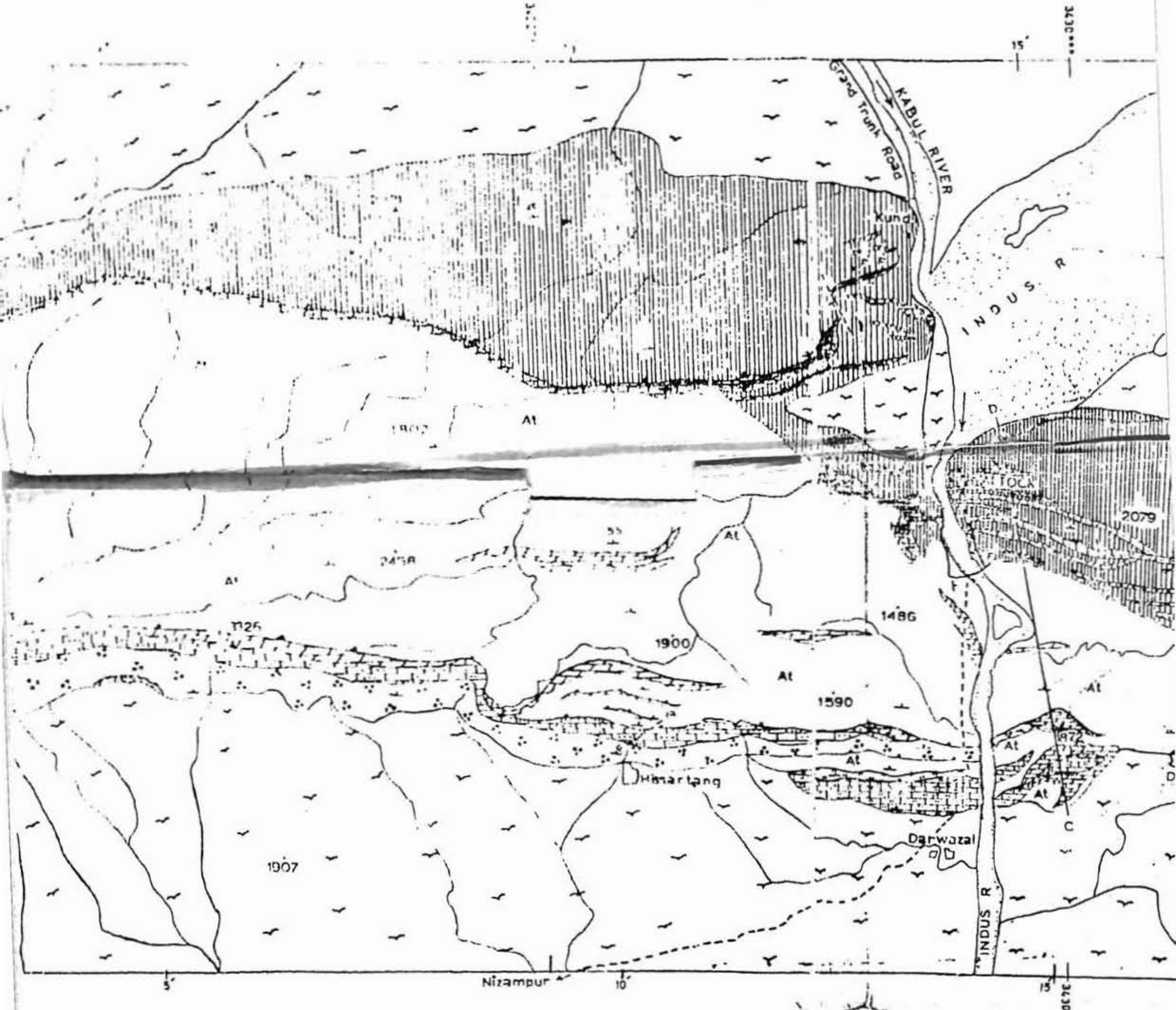

ICAL MAP OF THE ATTOCK—CHERAT RANGE. WEST PAKISTAN.

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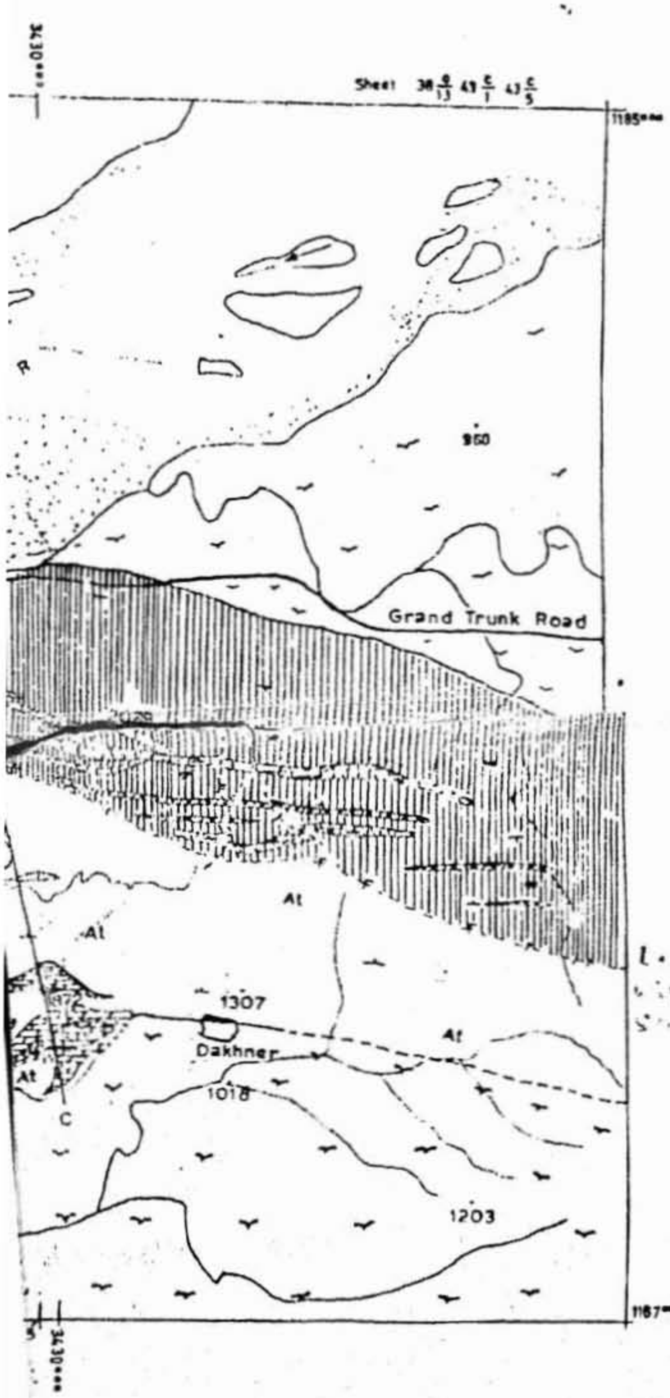

EXPLANATION.

ALLUVIUM	RECENT, SUBRECENT	
JALOZAI FORMATION ---UNCONFORMITY----	PLEISTOCENE	
MURREE FORMATION	MIOCENE	
BAKHTAI SHALE	EOCENE (LOWER)	
LAKRAI CLAYSTONE	EOCENE (LOWER)	
CHERAT LIMESTONE ---UNCONFORMITY----	PALAEOCENE	
HISSARTANG FORMATION	LOWER TO UPPER CRETACEOUS	MESOZOIC
ATTOCK SHALE	MIDDLE JURASSIC-CRETACEOUS	MESOZOIC
DARWAZAI FORMATION ---UNCONFORMITY----	EARLY UPR. TRIASSIC	MESOZOIC
SHAKHI FORMATION ---UNCONFORMITY---	PERMO-CARBONIFEROUS	PALAEOZOIC
KHATTAK LIMESTONE	MIDDLE TO UPPER SILURIAN	PALAEOZOIC
MANKI SLATE	LOWER TO MIDDLE SILURIAN	PALAEOZOIC
SHAHKOTBALA FORMATION	UPPER ORDOVICIAN TO LOWER SILURIAN	PALAEOZOIC
IGNEOUS SILLS		

DIP AND STRIKE, OVERTURNED

CONTACT

FAULTS

ROAD FAIRWEATHER METALLED

STREAMS (CHANNEL WITH REDUCED WIDTH)

NERINEACEAN (NERINEA) GASTROPOD COLLECTED