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NARESH KOCHHAR*

MALANI IGNEOUS SUITE: PORPHYRY COPPER AND TIN DEPOSITS FROM THE TUSHAM RING COMPLEX, NORTH PENINSULAR INDIA

(Figs. 8, Tab. 1)

Abstract: The paper describes porphyry type copper and tin deposits from the Tusham area located 160 km WNW of Delhi. Felsite including welded tuff, quartz porphyry, explosion breccia, and the associated sub-solvus granites belonging to the Malani igneous suite (750 Ma) of western Rajasthan form the various cogenetic members of the Tusham ring complex. Chalcopyrite, cuprite and malachite occur as disseminations in the quartz porphyry and also in tuffs and fluidised explosion breccia; whereas cassiterite is associated with the stock of muscovite-biotite granite. Potassic and phyllic zones have been recognized. The acid volcanics show post-emplacement hydrothermal alterations which are suggestive of porphyry type Cu and Sn mineralisation. The orthomagmatic model of subvolcanic alteration has been suggested for the genesis of these deposits.

Резюме: В статье описан порфировый тип меди и месторождения олова тушамского района располагающегося 160 км на ЗСЗ от Дели. Фельзит содержащий в себе сваренный туф, кварцевый порфир, эксплозионную брекчию и ассоциированные субрастворительные граниты относящиеся к маланийской изверженной серии (750 млн. лет) западного Раястана образуют разные когенетические члены тушамского кольцевого комплекса. Халькопирит, куприт и малахит находятся в виде рассеяний в кварцевом порфире, а также в туфах и флюидальной эксплозионной брекчии; причем касситерит ассоциирован с штоком мусковит-биотитового гранита. Были осознаны калиевые и филлитовые зоны. Кислые вулканиты проявляют пост-обмен гидротермальных изменений, которые намекают порфировый тип меди и Sn минерализацию. Ортомагматическая модель субвулканического изменения была предложена для генезиса этих месторождений.

Introduction

The Malani igneous suite of rocks (750 Ma) comprising acid volcanics (rhyolite, welded tuff, felsite, ash bed, quartz porphyry) and comagmatic high level, subvolcanic Siwana (hypersolvus); Jalor and Tusham (subsolvus) granites occupy an area of 55,000 sq km, and occur on the northwestern flank of the great Aravalli Chain at Jodhpur (Rajasthan) and at Tusham (Haryana). The representatives of the Malani suite also occur at Kirana Hills (Pakistan). The Tusham area is about 400 km northeast of Jodhpur and 466 km southeast of Kirana Hills, the latter happens to be the last outcrop of the shield element in this part of the Indian subcontinent (Fig. 1). Figure 2 summarises the geology of the northern part of the Indian shield and Table 1 gives the geochronology.

* Dr. N. Kochhar, Department of Geology, Panjab University, Chandigarh, India.

Geological Setting

The Tusham area (28° 75′ : 75° 55′) is located 160 km WNW of Delhi in Haryana State and falls within the Survey of India one inch to a mile toposheet 44P/13. The geology of the Tusham area is well studied by the author (Kochhar, 1983; 1984) but the mineralisation in the area has been recently discovered. Detailed work on the mineralisation is being carried out by the Geological Survey of India.

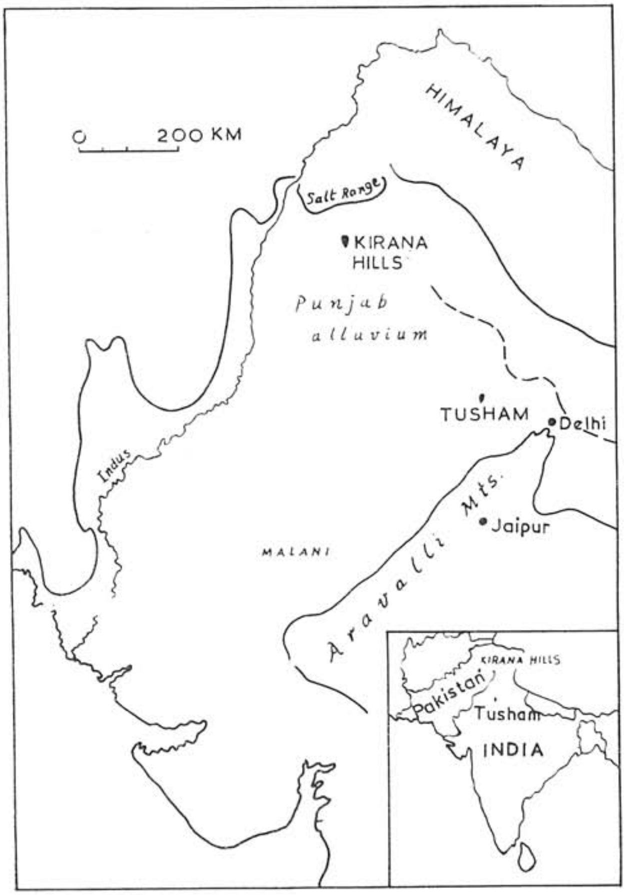

Fig. 1. Location map of the area.

The main theme of the paper is that the acid volcanics of the Tusham area and also of the Malani suite show post emplacement hydrothermal alterations and these are suggestive of hydrothermal Cu and Sn mineralisation.

Felsite including welded tuff, quartz porphyry, explosion breccia and the muscovite-biotite granite form the various cogenetic members of the Tusham ring complex (Fig. 3).

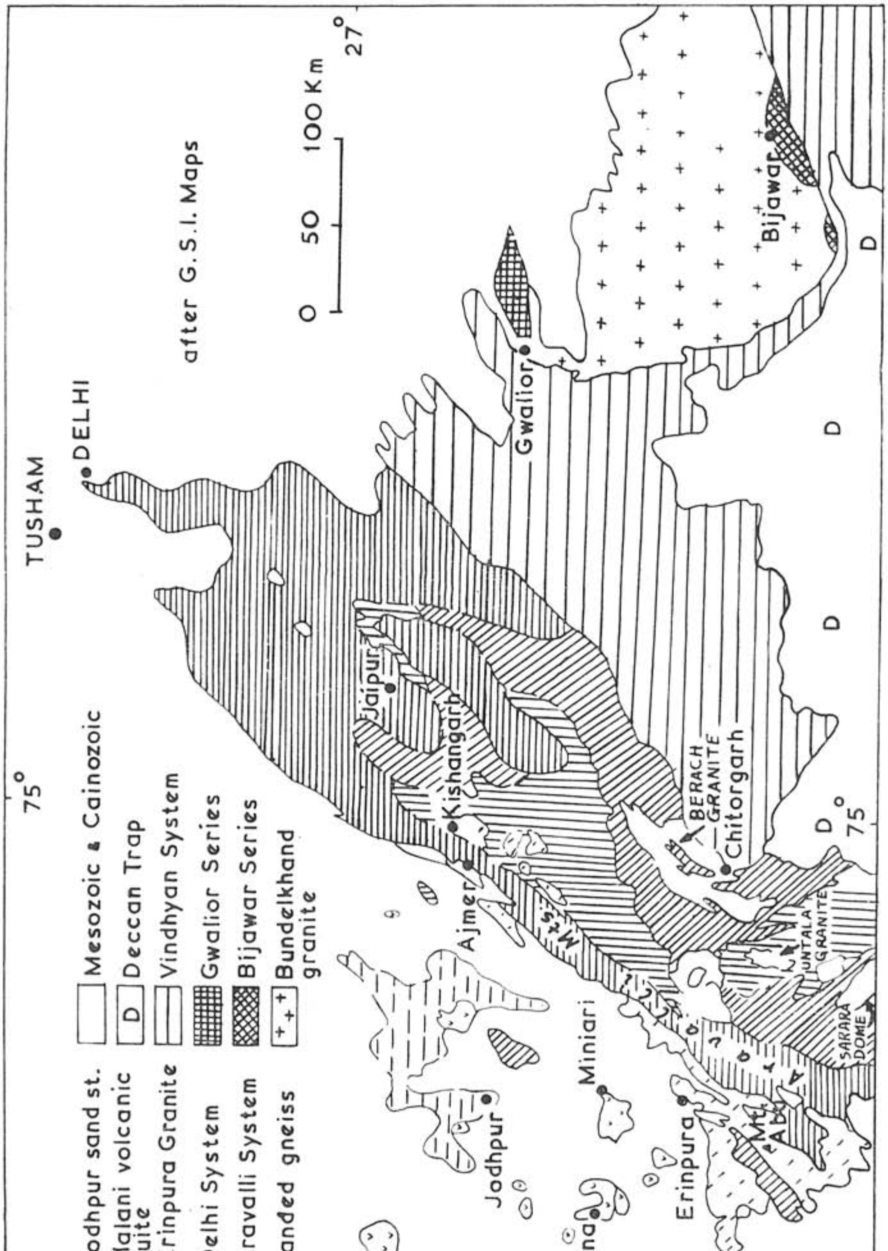

Fig. 2. Geology of north peninsular India.

Table 1

Precambrian geochronology of north peninsular India

Jodhpur sandstone			Vindhyan System 1400—500 Ma
Malani Series:	Malani rhyolites and granites (Rajasthan)		750 Ma
	Tusham area		750 Ma
	Kirana area (Pakistan)		870 Ma
Delhi System			1650 Ma
....		unconfirmity	....
		Raialo Series	
....		unconfirmity	....
Aravalli System			2000—2500 Ma
....		unconfirmity	....
Bundelkhan granite Berach granite			2500 Ma
Banded Gneiss Complex			>2500 Ma

Petrography and alteration pattern

The alteration pattern described here is based on the work of Lowell—Guilbert (1970).

Quartz porphyry: The quartz porphyry occurs in the form of a ring dyke which is elliptical in ground plan. The major external diameter is 0.8 km in NE-SW direction and the minor external diameter is 0.32 km in NW-SE direction. The quartz porphyry has sharp contacts with the overlying felsite.

In hand specimen the rock is composed of phenocrysts of quartz and feldspar embedded in a fine grained biotite rich matrix. The rock is invariably altered to greyish green material. Under microscope the rock consists of phenocrysts of "high quartz" and orthoclase embedded in a microspherulitic groundmass. A few crystals of biotite and muscovite are also encountered. The quartz phenocrysts are cracked, corroded and embayed with inlets of quartz-feldspathic material. Orthoclase occurs as well developed lath shaped crystals which are invariably altered into sericite and kaolinite. A few crystals of albite have also been identified on the basis of polysynthetic twinning but they are very much altered by sericitization (Fig. 4). Biotite of matrix is altered to greenish chloritic material. The quartz porphyry ring dyke marks the potassic zone. As we will see later, there is no clear cut demarcation of different zones, rather there is an overlapping of alteration patterns.

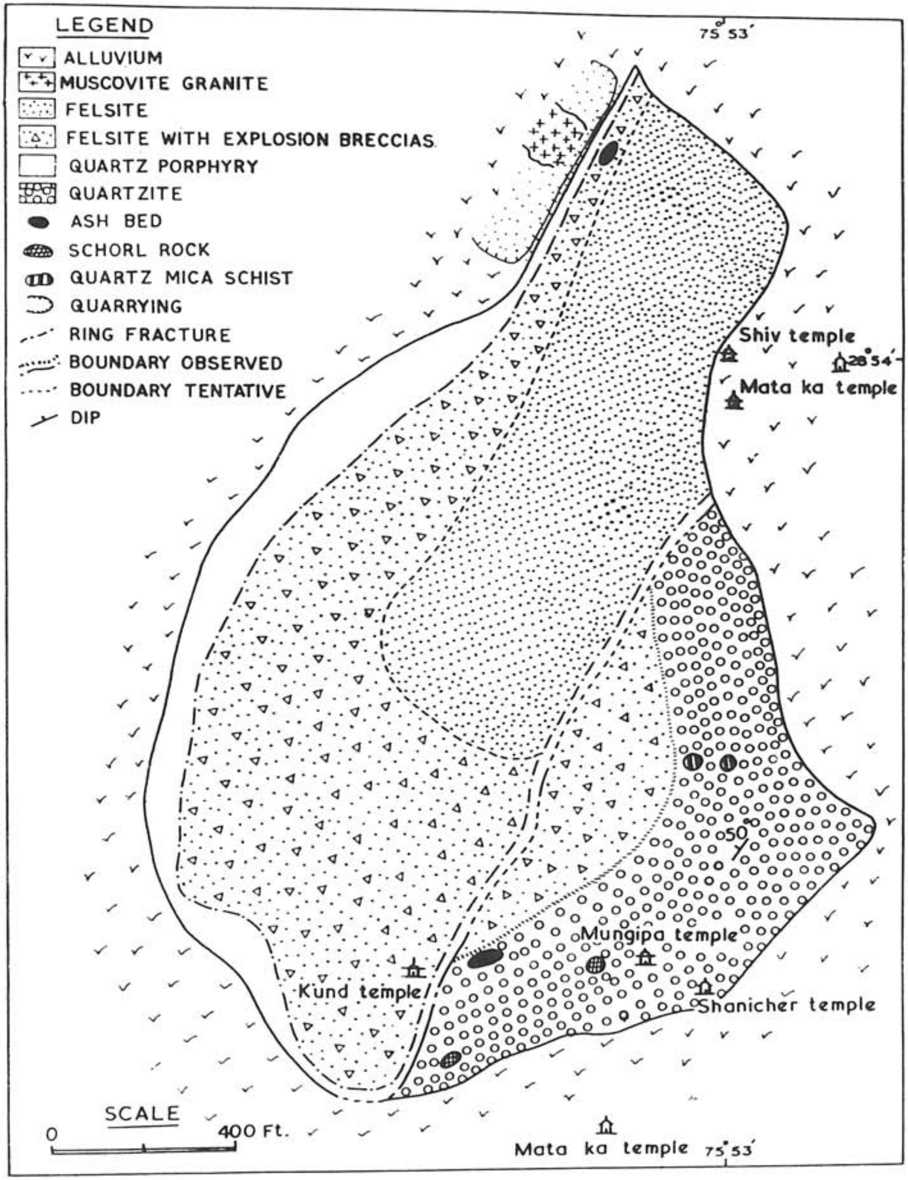

Fig. 3. Geological map of the Tusham area.

Explosion breccia: Explosion breccia is exposed all along the strike of quartz porphyry ring dyke (Fig. 3). The breccias overlie the quartz porphyry and are present in the felsite which have been domed up (resurgent cauldron). The breccias are younger than the ring fracture as suggested by the shape of breccia outcrop and by the occurrence of quartz porphyry fragments in it.

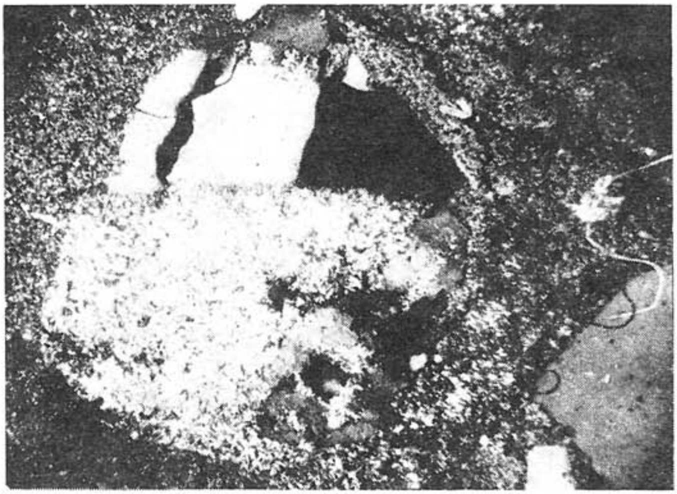

Fig. 4. Partly sericitized albite in quartz porphyry (crossed nicols x 40).

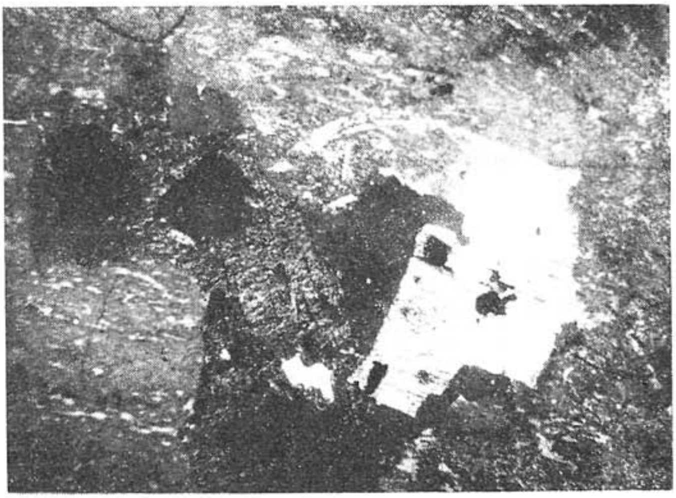

Fig. 5. Biotite replacing plagioclase in explosion breccia (crossed nicols x 40).

From the nature of block it is possible to distinguish two types of breccias. The first is made almost of entirely of discrete sub-angular to angular fragments of quartzite. They are dark in colour and vary in size from 5 cm to 30 cm in diameter set in a matrix of very finely communited felsite. This type of breccia is well developed near Kund Temple. The second type consists of subrounded to rounded blocks of quartz porphyry. They are mostly reddish brown and greenish in colour and vary in size from 12.5 cm to 45.0 cm. The matrix

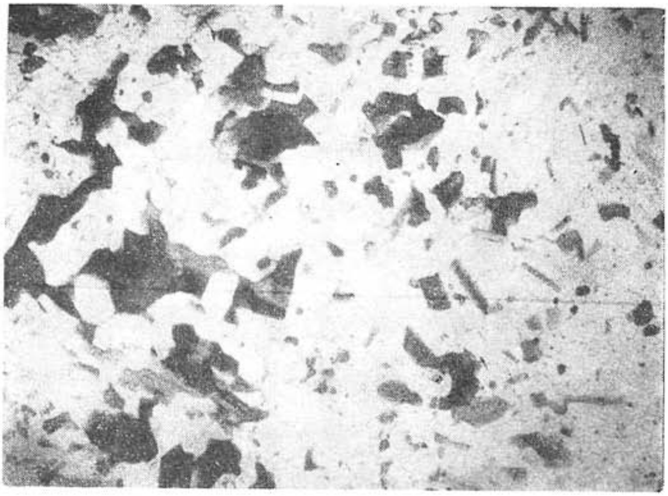

Fig. 6. Biotite in the groundmass of explosion breccia (uncrossed x 40).

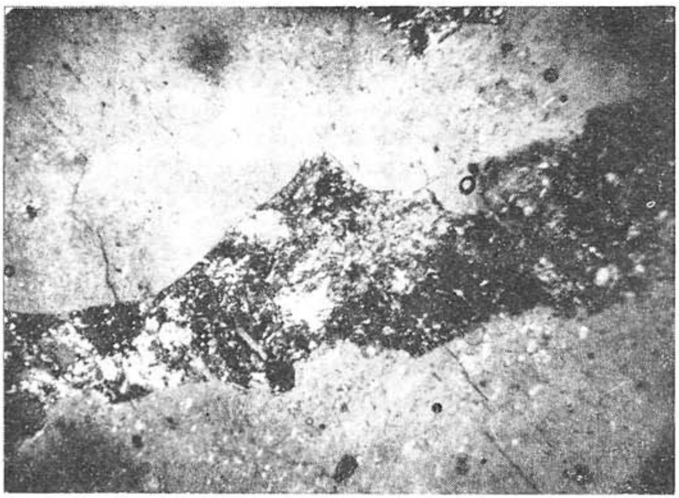

Fig. 7. Sericite veins cutting "high quartz" in felsite (crossed x 40).

is felsite. The angular nature of quartzite fragments contrasts with the rounded nature of quartz porphyry blocks. This rounding has been attributed to the process of fluidisation (K o c h h a r, 1983). Under the microscope subangular fragments of quartzite are embedded in finely communited felsite. Plagioclase is altered to kaolinite and biotite replaces plagioclase (Fig. 5). There is profuse development of biotite in the matrix, (Fig. 6). The breccia zone represents late stage of potassic alteration.

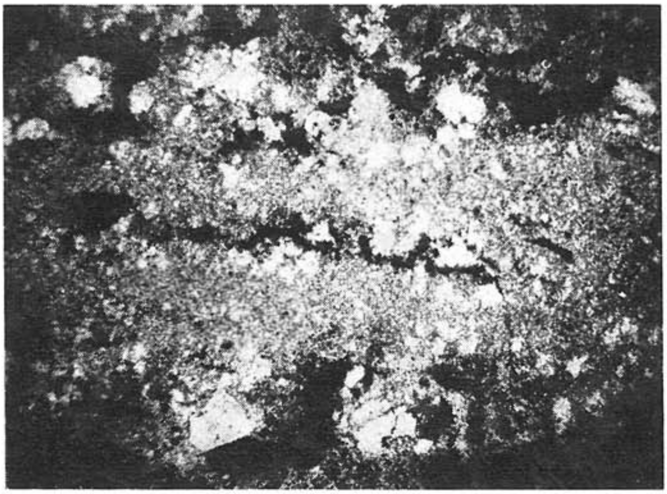

Fig. 8. Sericitized groundmass in felsite (crossed x 40).

F e l s i t e: The felsite occurs on the northeastern side and on the top of the Tusham Hill. The felsites are greyish yellow and purple in colour. The felsites usually contain black encrustation of tourmaline and brownish coating of limonite. Under the microscope, the rock is composed of "high quartz", orthoclase, biotite and oxides of iron embedded in a cryptocrystalline to microcrystalline groundmass showing fluxion structure, micropegmatitic phenocrysts and micropoikilitic quartz. Quartz phenocrysts varying in size up to 2 mm across display the characteristic bipyramidal form. Some of the quartz phenocrysts show embayments and are traversed by veins of sericite (Fig. 7). Orthoclase is sericitized. Biotite is of yellowish brown colour and occurs as sieved tabular crystals. They are partly or completely resorbed leaving a few specks of greenish chloritic material. A few grains of corroded and sieved muscovite are also encountered. Magnetite occurs as octahedral crystals in glomeroporphyritic crystals. It has been oxided to brownish red haematite which has been drawn into strings by subsequent flows. The groundmass is invariably altered to sericitic material (Fig. 8). Schorl rock often stains the felsite. The felsite marks the sericitic zone (phyllic), and the top of felsite marks the propylitic zone. At the contact of explosion breccia and felsite a few pockets of ash bed also occur.

M u s c o v i t e - b i o t i t e g r a n i t e: It occurs as a stock on the northwestern side of the Tusham Hill. It is light coloured, fine to medium grained showing sharp contacts with the felsite. It is subvolcanic. Under the microscope it consists of sieved muscovite, biotite, quartz, orthoclase, oligoclase and minor amount of zircon, apatite and oxides of iron. The texture is hypidiomorphic. The two-mica granite represents potassic zone.

The QAP plot of the Tusham granites fals in the field of alkali granite and the granites correspond to "Granite A" and alkali feldspar granite of S t r e c k a i s e n.

Geochemistry

The most significant chemical feature of the acid volcanics is that these are richer in potash than soda. K_2O varies from 3.10 to 5.20 % and Na_2O varies from 0.3—0.5 %. The low soda content of these acid volcanics is due to post--emplacement devitrification and hydrothermal alterations (Kochhar, 1977). One unaltered specimen of the quartz-porphyry from the eastern side of the Tusham Hill has a "normal" Na_2O content (2.5 %). K_2O is 6.58 % (Dr. L. N. Gupta; personal comm.). Infact the acid volcanics of the whole of the Malani suite show hydrothermal alteration (Kochhar, 1984) and this is strongly suggestive of porphyry type Cu and Sn and related mineralisation in these rocks also. Gaal—Isohanni (1979) have also reported that K_2O content increases in the Precambrian mineralised rocks of Kopsa and Rautio whereas, CaO and Na_2O contents are depleted.

The alkali contents of the granitic rocks is fairly uniform. Soda varies from 2.5 to 3.00 % and potash varies from 4.5 to 6.00 %.

The acid volcanics and the associated granites are rich in alumina. Al_2O_3 content of acid volcanics ranges from 12.33 to 14.53 %, and in granitic rocks from 13.00 to 14.50 %. The molecular proportion of Al_2O_3 exceeds (CaO + + Na_2O + K_2O) in these rocks. They are thus peraluminous.

These rocks have low lime and magnesia contents (CaO: 1.0 %; MgO: 0.5 %). The low lime content is reflected in the nature of plagioclase which is invariably oligoclase. These rocks plot in the alkali granite field of K_2O/MgO diagram of Rogers—Greenberg (1981). The granites belong to A-type granites (Loiselle—Wones, 1979).

TiO_2: 0.25 %; P_2O_5: 0.20 % and SiO_2: 73—74 %.

Mineralisation

There are widespread malachite stains and sulphur encrustations on felsite, explosion breccia and quartz porphyry. Intense limonitisation accompanied by malachite encrustations is observed along the ring fracture zone. The contact zone of quartz porphyry and the overlying felsite and ash bed marked by ring fracture is the most important zone of copper mineralisation. Anomalous copper values as high as 1.06 % against the background and threshold values of 100 and 300 ppm respectively have been reported (Dey, 1978). Copper mostly occurs as malachite and azurite. This is followed by cuprite and chalcopyrite. Other associated primary sulphide minerals are pyrite, sphalerite and galena. Tin occurs as cassiterite and is related to the stock of two-mica granite (muscovite-biotite granite). Drilling for tin is being done at the contact of breccia and felsite near Kund Temple. It may be mentioned here that Kochhar (1973) had suggested that the Tusham and Jalor granites should be explored for tin mineralisation.

The following characteristics of the geology and mineralisation of the Tusham area are in general agreement with features shown by Precambrian porphyry Cu and Mo deposits (cf. Gaal—Isohani, 1979): the epizonal setting of granites and the associated volcanics; the sharp contacts between quartz porphyry and felsite; and granites and felsite without significant effects of metamorphism; the association of mineralisation with the fluidised breccia; and the location of the area on NE-SW trending lineaments.

Genesis

Kochhar (1983) has suggested that the stresses released after the Aravalli-Delhi orogenies gave rise to linear zones of weakness and high heat flow, and along these NE-SW trending weakzones the magmatism of the Malani suite was triggered by mantle plumes.

In the Tusham area the acidic magma of granitic composition gave rise to different cogenetic members of the Tusham ring complex. The magmatic crystallization of quartz porphyry from the acid melt resulted in the release of hydrothermal fluids causing gas charged magma to move through the zone of ring fracture shattering and brecciating impervious quartzite and also carrying with it already solidified quartz porphyry blocks. This resulted in the formation of explosion breccia. The rounding of quartz porphyry blocks is attributed to the process of fluidisation. With the release of volatiles, the melt became viscous and during the continued advance to higher level it crystallised as felsite. On the northwestern side of the Tusham Hill the same magma crystallised as a stock of muscovite-biotite granite. Thus in the Tusham area, there is no clear cut boundary between volcanic and plutonic environment (Kochhar, 1972). The alteration and mineralisation in the area was caused by ore bearing hydrothermal fluids. The emplacement, alteration and mineralisation of the various rock units form single sequence of cogenetic events (cf. Sillitoe et al., 1975). According to Sillitoe et al., (1975) potassic zone is conspicuous by its absence in the Bolivian tin deposits, but in the present case, the potassic zone is very well developed.

In summary it is concluded that the hydrothermal alterations shown by acid volcanics are strongly suggestive of porphyry type copper and tin mineralisation in the area. More work is required in order to understand the alteration pattern at depth and geometry of mineralisation. The study of stable isotopes will throw light on the nature and temperature of hydrothermal ore forming fluids.

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