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MORPHOLOGICAL STUDIES OF ZIRCONS FROM THE HASAN ROBAT GRANITE AND ASSOCIATED ROCKS, ESFAHAN, IRAN,

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ABSTRACT

Zircons in the Hasan Robat granites (HRG) are mostly of pink, light brown and pale yellow in color. Most of the zircons are of idiomorphic shape and the overgrowths and outgrowths are of primary type. The elongation ratio (ER) frequency diagram of zircon from the granitic rocks shows one maximum between 2 and 2.5. It shows that HRG zircons are of magmatic origin. Most zircons of the muscovitc-quartz schist are of subidiomorphic shape. They are colorless, pink, pale yellow in color and indicate variable degree of clouding and corrosion. Cracks are common and at times have developed into microfaults. Majority of outgrowths and overgrows are of secondary origin. It appears that they have developed under metamorphic conditions. The zircon lengths and breadths exhibit seven and three maxima respectively. The elongation ratio (ER) frequency diagram shows 3 maxima. These features suggest that the crystals have been derived from different sources.

INTRUDUCTION

Zircon has been widely used for 1) interpreting the petrogenesis of granitic rocks (Pupin, 1980, 1985; Gupta and Elsdon, 1985; and Kochhar et al., 1991); 2) stratigraphic correlation differentiating amongst sedimentary, igneous and metamorphic terrains (Marshall, 1967; Brindley and Gupta, 1973); 3) paleogeographic interpretation of provenance studies (Scott, 1965) as maturity index in sedimentary rocks (Hubert, 1962), or as a stability index in soil (Barker, 1962); 4) radiometric dating (Corfu and Wallace, 1986); and finally 5) to determine the effects of partial melting on host rocks (Gupta and Johannes 1985).

The usefulness of zircon may be attributed to, i) mechanical and to some extent chemical stability of the mineral, ii) high specific gravity (4.5), iii) non magnetic nature, and iv) ubiquitous occurrence as an accessory mineral in almost all the rock types, especially in acidic and intermediate igneous rocks, clastic sedimentary rocks and their metamorphic equivalents.

HASAN ROBAT GRANITE (HRG)

The Hasan Robat Granite (HRG) is located about 140 Km northwest of Esfahan city-Iran (Fig.1). It is comprised of alkali-feldspar granite, syenogranite and monzogranite types. The diabase sills/dikes cut the granite in E-W direction. The country rocks are muscovite-quartz schist, feldspathic quartzite, biotite schist and hornblende-biotite schist (Fig.1). The HRG are mainly peraluminous to metaluminous and a minor peralkaline component also tectonic environment occurs. The tectonic environment of A-type Hasan

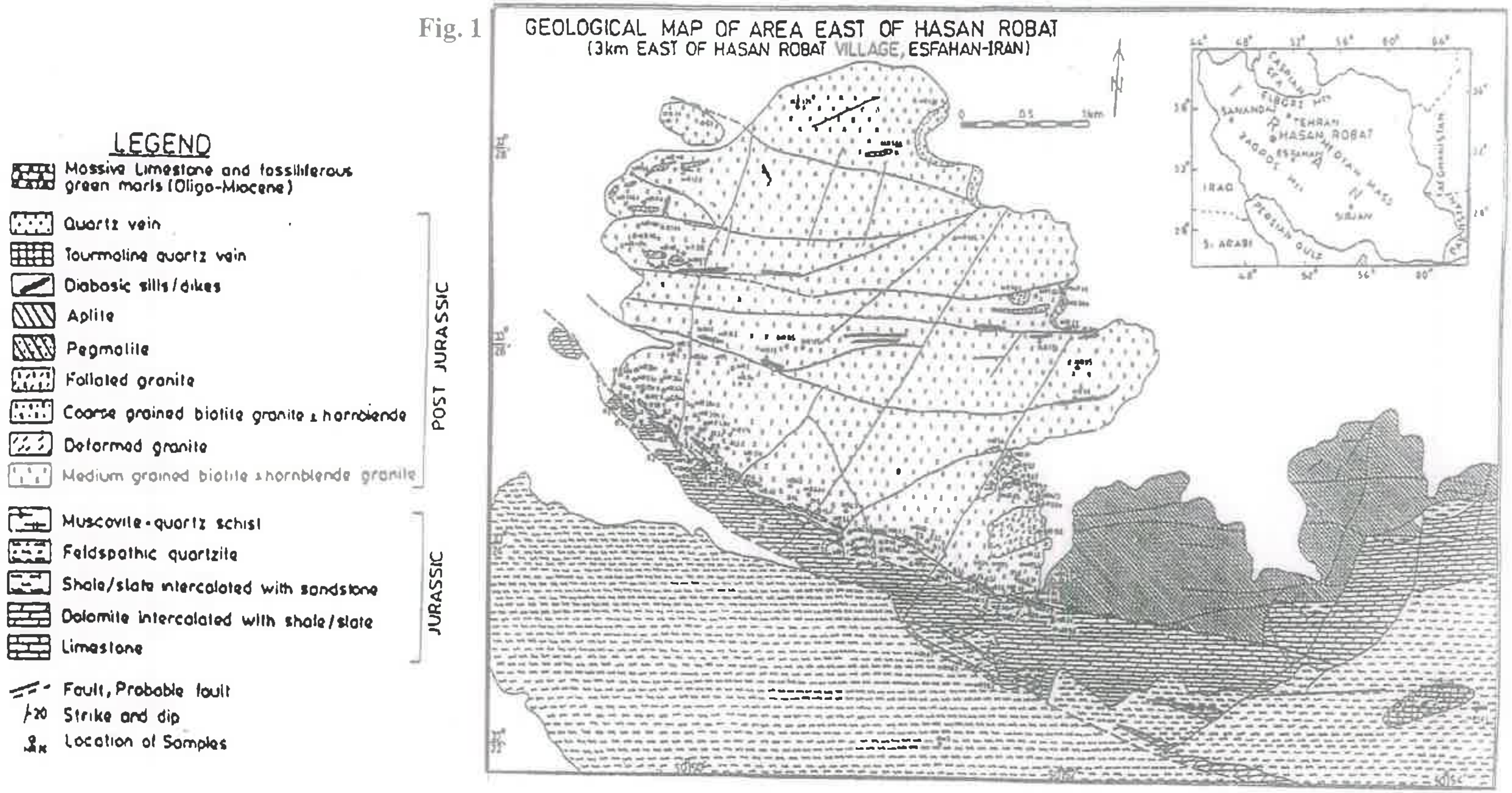
GEOLOGICAL MAP OF AREA EAST OF HASAN ROBAT
(3km EAST OF HASAN ROBAT VILLAGE, ESFAHAN-IRAN)
CASPIAN SEA
ELBORZ MTS
SANANDAJ
TEHRAN
HASAN ROBAT
ESFAHAN
ZAGROS MTS
IRAQ
PERSIAN GULF
S. ARABI
SIRJAN
LEGEND
Massive Limestone and fossiliferous green marls (Oligo-Miocene)
Quartz vein
Tourmaline quartz vein
Diabasic sills/dikes
Aplite
Pegmatite
Foliated granite
Coarse grained biotite granite ± hornblende
Deformed granite
Medium grained biotite ± hornblende granite
POST JURASSIC
Muscovite-quartz schist
Feldspathic quartzite
Shale/slate intercalated with sandstone
Dolomite intercalated with shale/slate
Limestone
JURASSIC
Fault, Probable fault
Strike and dip
Location of Samples

Fig. 1

Robat granite with reference to rift tectonics has been discussed in the light of "within plate" setting. It is suggested that the anorogenic granitic rocks of the Hasan Robat area represent emplacement of magma into a tensional tectonic environment as indicated by the presence of subsolvus, hypersolvus alkali granite of bimodal nature (Mansouri Esfahani, 2003).

Sampling and Analytical techniques

Five samples of granite and one of muscovite-quartz schist were selected for studying zircons qualitatively. Out of these, one granite and one muscovite-quartz schist were used for quantitative study.

About 100 gm of each rock sample was crushed and passed trough 100 mesh ASTM sieve. The crushed material was washed with water and then boiled with 10% HCl for about 15 minutes. The material was properly washed and dried.

Magnetic minerals were separated by Frantz-isodynamic separator using 0.9-1.1 ampere current and backward slope of 15o at CAS in geology, Chandigarh. The non-magnetic fraction was put into bromoform for about 4 hours and the contents were intermittently stirred so as to release the heavier trapped grains from the lighter fraction. The heavier fraction was collected and washed with acetone. It was mounted on glass slides with canada balsam.

Quantitative and qualitative studies of morphological and optical characters were made on one hundred doubly terminated zircon crystals from one biotite-hornblende granite sample and one muscovite-quartz schist. Qualitative study zircon was made on rest for the granite samples.

Morphological and optical characters

The morphological and optical characters of zircon such as crystal habit, color, clouding, and corrosion, authigenic growth, cracks and zoning, from the Hasan Robat granite and muscovite-quartz schist are discussed below.

Zircon in the granites of Hasan Robat area

The biotite granites have 63% of idiomorphic and 35 percent subidiomorphic crystals (Fig.2 a-m). Most of the zircons exhibit prismatic faces with a few simple pyramidal faces at the ends (combinations of 110, 100,111) (Fig.2 b, c, d, e, j, l). The granite-zircons are pleochroic in different shades of pink, light brown and pale yellow. Variation in color of zircons in a granite body has been related to crystallization environment, compositional control, oxidation state of iron and availability of Zr, U, and Th during the crystallization of magma (Gupta and Elsdon, 1985, Gupta and Johannes, 1985; and Kochhar et al., 1991).

Zircon crystals are divided into three kinds depending on the degree of cloudiness (Gupta and Johannes, 1985): clear, little clouded and fully clouded. The Hasan Robat granite contains 80% of clear crystals, 12% of little clouded and 2% fully clouded (Fig.2 a-m).

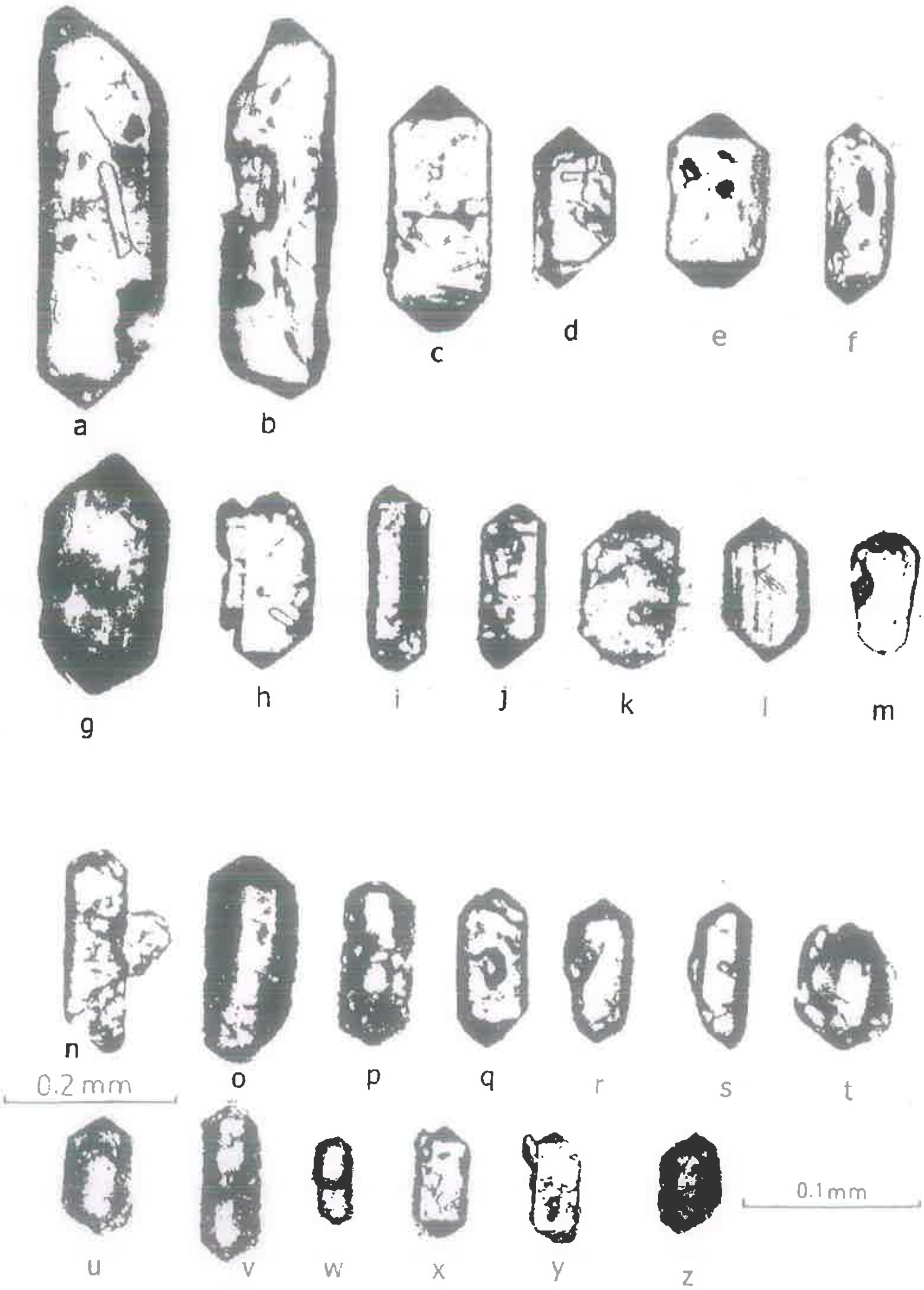

Fig. 2 (a-m) Zircons of granite; (n-z) Zircons of the muscovite quartz shist of HRG.

Clouding and corrosion of zircon (Fig.2 b, l, g) have been attributed to alteration of clear crystal, hydrothermal alteration of late magmatic granite, and alteration of zircon during partial melting of the host rocks (Gupta and Johannes, 1985).

Zircon growths

Zircons in the granites of Hasan Robat area usually show various kinds of primary and secondary growths. The primary growths are in the form of parallel crystals (Fig.2 h). This type of growth is considered as characteristic of magmatic granitoids (Jocelyn and Pidgeon, 1974; Gupta, 1986). The secondary growths occur in the form of enhanced overgrowths (Fig. 2 i), outgrowths and multiple growths (Fig. 2 j). Such growth is considered to be characteristic of anatectic, metamorphic and metasomatic rocks (Dalziel, 1963; Gupta, 1968, 1986).

Zircon overgrowths are in the form of thin layers grown over the nucleus, which may be partially or completely surrounded by new layers of zircon growth (Fig. 2 k). The nuclei and new growths may show different optical characters, e.g., the nuclei may be rounded, sub-rounded to idiomorphic and clouded, whereas overgrowth may be idiomorphic, clear and zoned. Even the color and pattern of cracks in both cases may be different.

Zircon outgrowths are in the form of projected encrustations of a new zircon layer / crystal on one or more faces of a parent crystal. The projected encrustation may occur on a prismatic, pyramidal faces and projection may also be from a pyramidal edge along the length of a crystal (Fig.2 b).

Multiple or irregular zircon growths may results from combination of overgrowth and outgrowth. Occasionally, they may occur in combination with parallel, necked growth and twinned crystals. It may be noted that the parent crystal shows sub-rounded crystal habit whereas the outgrowth may be idiomorphic / subidiomorphic.

Cracks and zoning

Cracks are common in the zircons of the Hasan Robat granite. These are of transverse, oblique and rhombohedral type (Fig. 2 a, c, g). The development of cracks may be attributed to the various types of stress that the zircon grains have been subjected to during and after the formation of the host rocks (Veniale et al., 1968) and to metamictization. Only a few zircons are zoned in the zircon occurring in the Hasan Robat granite (Fig.2 l).

Crystal dimensions

This technique is based on the criteria that zircon having elongation ratios of less than 2 are likely to be of sedimentary origin and those having greater than or equal to 2 are of magmatic origin (c.f. Poldervaart, 1956).

Length and breadth

More than 85 % of zircons of the granitoids have lengths varying between 0.075 and 0.187 mm, and breadth between 0.0187 and 0.093 mm. The length and breadth maxima and range is represented graphically in the frequency diagrams (Fig.3 a-c). The zircon population of biotite-hornblende granite exhibits only one length maximum.

Elongation Ratio

Elongation ratio (ER) of the studied zircons range between 0.9 and 9. The ER frequency diagram for zircon from the biotite-hornblende granite show one maximum between 2 and 2.5 (Fig.3 d). The predominance of idiomorphic zircons with elongation ratios between 2 and 2.5 indicate that zircons of the granites of Hasan Robat area are of magmatic origin. (see Poldervaart, 1956; Gupta, 1972; Brindley and Gupta, 1973; and Kochhar et al., 1991).

Length versus breadth plots for zircons of the HRG show a very limited dispersion of the points. The middle-fit line shows that length is directly proportion to breadth (Fig.3 d).

Typological studies

The crystal habit of zircon reflects the environment in which the mineral has crystallized (Gupta, 1972 and Kochhar et al., 1991). The typological study is based on the relative development of pyramidal and prismatic crystal faces, which appear to reflect crystallization conditions and the composition of the crystallizing medium of zircon population (Pupin, 1980, 1985; Corfu and Wallace, 1986).

Visual comparison of crystal shapes of the Hasan Robat granite with those of the zircon shaped classified by Pupin(1980) depict that the zircon are of P_4, P_5, S_{20}, S_{25}, and J_5 subtypes. These are the combinations of (100), (101), (110) and (21̄1) faces. Occasionally, additional basal face (001) is also developed on the zircons of the granite of the Hasan Robat area (Fig.2 c). According to Pupin (1980), zircon subtypes referred to above crystallize between 800-900° C ± 150° C.

ZIRCON IN THE MUSCOVITE-QUARTZ SCHIST

The muscovite-quartz schist has 39 % idiomorphic crystals (Fig.2 n-z). Rounded and subrounded crystals in the muscovite-quartz schist are more than 60 % (Fig.2 n, o, p, u, v). These also include zircons having irregular outlines. Rounded crystals are only one percent. The zircons are usually colorless, pink, pale yellow and opaque or nearly opaque (Fig.2 u, v, z). Muscovite-quartz schist shows 40 % clear crystals (Fig.2 o, s), 47 % little clouded (Fig.2 n, p, u, v, w) and 13 % fully clouded (Fig.2 z) zircons. Such crystals show the effect of corrosion in the form of irregular outlines (Fig.2 o, p) which have resulted from the degeneration of idiomorphic crystals to subidiomorphic and anhedral forms, reduction of crystal length,

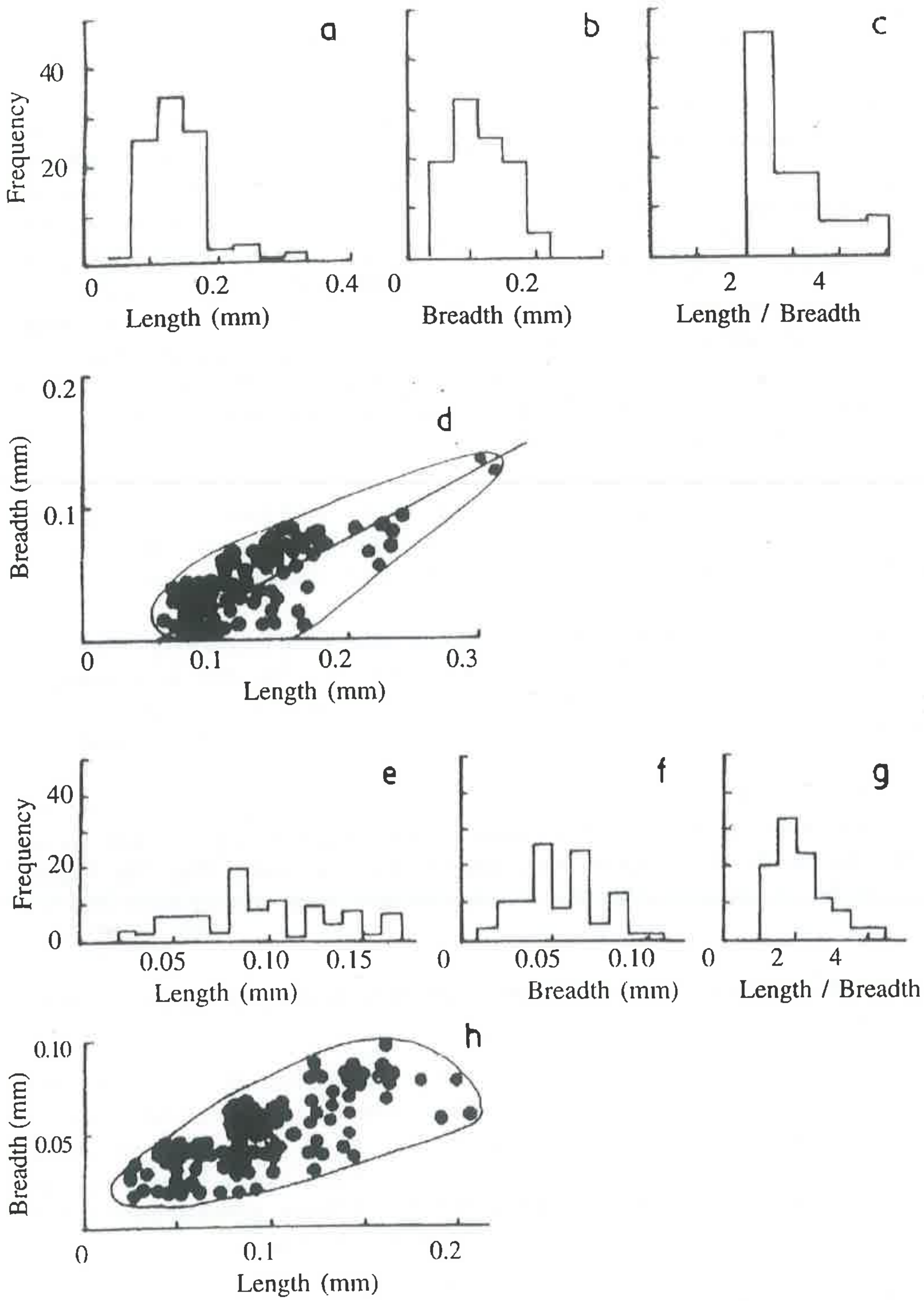

Fig. 3. Length, breadth and elongation ratio histograms (a,b, c) and length/breadth diagram (d) of zircons from biotite-hornblende granite.
Length, breadth and elongation ratio histograms (e, f, g) and length/breadth diagram (h) of zircons from muscovite-quartz schist

lowering of refractive indices, dull lustre and extremely weak birefringence. Also clouding of these zircon crystals may be due to the effect of alkaline solutions during transportation of the sediments and subsequent metamorphism.

Zircons show various kinds of primary and secondary growths. The primary growth is in the form of in parallel growth (Fig. 2 q, s). The variety of secondary growths are in the form of is overgrowth (Fig. 2 u, z), outgrowth (Fig. 2 n, x, y), parallel overgrowth and multiple overgrowth. These are two types of parallel growth, that is: i) composite parallel grown zircons laying on face 100 and united along (100) composition plane (Fig.2 q, y). Such zircons show parallel or nearly parallel extinctions, as the C-axes of both the crystals are parallel; ii) composite parallel grown zircons lying on prismatic face 110 or 100 and showing a tendency to join along a pyramidal face (Fig. 2 r). Secondary growths are relatively more than the primary growths. The secondary growth in zircon is considered to be characteristic of anatectic, metamorphic and metasomatic rocks (Dalziel, 1963; Gupta, 1968, 1986).

Transverse cracks (Fig.2 p, y) are common in the zircon of muscovite-quartz schist i). Occasionally microfaults have developed from the cracks (Fig.2 w). Microfaulting may be due to deformation, which the muscovite-quartz schist has suffered.

Nearly 40 % of zircons of the muscovite-quartz schist have length varying between 0.08 and 0.13 mm, and breadth between 0.04 and 0.07 mm. The data are represented graphically in the frequency diagrams (Fig.3 e, f, g). Zircon population exhibits seven length and three breadth maxima indicating their derivation from several sources.

Zircons elongation ratios (ERs) of muscovite-quartz schist are between 1 and 4.5 and the ER frequency diagram shows three maxima (Fig.3 e, f, g). Length versus breadth plot for the zircon shows wide dispersion of the points (Fig.3 h). Which substances the earlier conclusion that the crystals have been derived from different source

COMPARISON OF GRANITE-ZIRCONS AND MUSCOVITE-QUARTZ SCHIST-ZIRCONS

There is a clear distinction between the zircon characters of the granites and muscovite-quartz schist. As stated above majority crystals of granite are idiomorphic, clear, having ER maximum between 2 and 2.5 (Fig.3 d). In contrast, the zircons of muscovite-quartz schist are subidiomorphic and have several length, breadth and ER maxima (Fig.3 h). The granite has higher amount of primary growths whereas the muscovite-quartz schist has higher amount of secondary growths.

The characters of zircons of Hasan Robat granite suggest that these belong to a single phase of magmatic crystallization whereas those of the muscovite-quartz schist have been derived from several sources.

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