Surface Features on Garnet from Different Sources: Observations from South Kerala, India

V. Nandakumar and D.S. Suresh Babu
Centre for Earth Science Studies, P.B. No. 7250 Akkulam, Thiruvananthapuram 695 031.

The patterns developed on detrital garnets exemplify the hierarchy and intensity of processes suffered by the grains. Different features noticed over the grain surfaces denote chemical, mechanical and mixed origin. Sequential formation of microrelief patterns are observed in a variety of cases.

Introduction: Garnet, being a sensitive mineral to tropical weathering, always possesses imprints of exogenic alteration. Several publications are available reporting the systematic development of micromorphological features on garnet from various localities (Borg, 1986; Hansley, 1987). Eventhough many minerals have been examined by SEM, the different morphological features exhibited by quartz (Krinsley and Doornkamp, 1987) and garnet (Borg, 1986; Hansley, 1987) have attracted the greatest attention of geologists. No detailed work on garnet micromorphology has been reported from Kerala but for the publication of Mallik (1986) and Samsuddin et al. (1992).

Garnet is an ubiquitous mineral in the hinterland and in the alluvial sediments of Kerala. But, it is a rare constituent in the coastal sediments and beach placers. Hence, the study on garnet alteration deserves special attention. However, some sporadic garnet-rich placers are noted in beaches, where source rock is exposed in its immediate vicinity. Intrastratal solution activity is the only mechanism other than provenance which can cause major regional variation in the case of garnet composition and hence surficial patterns (Morton, 1985).

A total of 14 typical clastic surface features of quartz grains have been established (Warney and Cheng, 1981). Mallik (1986) has identified eight mechanically derived features and six chemically formed features on heavy minerals. Not all these features are found to be present on garnet surfaces, but practically no grain is free from the intense development of surficial feature. Gravenor and Leavitt (1981) recognised facet as the most significant imprint on garnet surfaces.

Materials and Methods: Samples have been collected from source rocks, laterites, river sediments, kayal sediments and beach placer of southern Kerala (Fig.1) for garnet separation. Samples from Manavalakurichi (MK) placer has also been observed to compare the morphology. Grains released from both khondalites and charnockites form the garnet population of the area. Selected grains were mounted on standard analytical studs and observed under SEM to study the micromorphological features.

Description of Garnet Morphology: Garnet from rocks and laterites: Garnet grains separated from crystalline rocks show typical conchoidal fracture and angular edges (Fig.2). Electron microprobe analysis done elsewhere shows that most of the garnets from crystalline rocks are of almandine variety (Nandakumar et al. 1991). Ovoidal grains of quartz are seen...
as inclusions in garnets. Grains from sedimentary rocks bear imprints specifically of solution activity for e.g., smooth precipitation surfaces and solution channels with secondary mineral growth and facets. Lateritic samples possess dominantly facet signature (Fig. 3).

**Garnet from stream and kayal sediments:** Alluvial sediments represent the most diversely modified garnet grains as they contain minimum-altered to significantly-altered grains. Partially-altered as well as highly-altered grains of garnet released from different layers of laterites join for subsequent activities in stream channels. Thus, such garnets often contain typical features of lateritic origin and a combination of river-borne physical and chemical
features on the grain surface. Grains from Kayal bottom sediments possess large pits and wavy appearance possibly indicating stagnant water column.

**Garnet morphology in beach sand** : A few grains of garnet found disseminated in beach sand placer may not be the ones transported all the way from hilly terrain. In turn, they might have entered into the transportation track somewhere in between and, therefore, no progressive accumulation of surficial patterns are observed. On the contrary, such grains possess invariably some mechanical features, which are not so common in the alluvial systems.
**Discussion:** All SEM pictures reveal that there is an environment-dependent morphological pattern on garnet grains. The observations are summarised in Table I. Except that some grains show inclusions of round quartz, garnet from crystallines does not differ morphologically. On the other hand, the grains separated from Tertiary sedimentaries not only exhibit a collection of chemical features but also represent the intensity of alteration into its daughter minerals (Fig. 4). In addition, the insignificant quantities of garnet seen in the Warkalai sediments, which were derived from mostly garnetiferous rocks, give clue to the substantial leaching of this mineral during the period of deposition and diagenesis. Morton (1985) has observed the depletion of garnet content with increase in relative age of deposition.

Facet, the feature seen typically on the surface of garnets from the laterites of the area, has been a subject of discussion by many. Some are of the opinion that dissolution effects cause the formation of facets (Simpson, 1976), but others believe that overgrowth is responsible for the formation of facets (Howie *et al.* 1980). As weathering (lateritisation) proceeds, the garnet content gets depleted fast followed by feldspars and ferromagnesian minerals, which points that the widespread facet formation over garnet grains is due to dissolution rather than overgrowth. Subsequent studies have confirmed that such etch patterns of garnet have been formed by intrastratal solutions (Gravenor and Leavitt, 1981; Hansley, 1987).

Though mechanical impact features and chemically derived imprints occur together on the garnets of alluvial sediments, there is always a domination of chemical features, probably representing both lateritic environment and fluvial action. While step-like formations form the major physical impact features (Fig. 5), the hollow solution channels are found as the main chemically derived features in the alluvial garnets. Dissolution process prevailing in the lateritic horizons during percolation and capillary activity gets further triggered during alluvial transportation. It is reported that chemical action supports physical activity and vice versa (Berger, 1986).

![Fig. 4. Typical solution channels with secondary mineral growth seen on garnets from sedimentary rock.](image-url)
Table 1. Morphological relationship between garnet and surrounding environment

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In general, beach sand garnets contain imprints of earlier activities unless masked totally by a later process. Since garnet is less resistant than quartz, the former is more amenable to the environment of entrapment. Therefore, the latest activity gets imprinted over the former as the environment changes. Garnets separated from the two important beach placers, Chavara and MK, have indicated the prominent presence of mechanical features. However, though the hinterland of both these deposits is occupied by garnetiferous rocks of granulite grade, MK deposit (5.5%) is distinct from Chavara (<1%) in the content of garnet. This points that MK is either geologically younger to Chavara or the provenance environment of MK does not favour substantial garnet dissolution. It is reported that MK deposit has originated partly from Teri sands and Teri-deposit is a product of semi-arid climate. The highly dynamic coastal zone probably has a strong control for producing impact patterns rather than etch patterns by chemical action (Fig.6).

Irrespective of the environment of sampling sites, surface textures have been broadly classified into mechanically derived (V-shaped pit, step-like formation, conchoidal fracture)
and chemically derived (circular, oval and irregular pits, oriented V'channels, facet, mamilated surface, secondary growth) patterns. There are certain grains which show a combination of both the types of features (Fig.7). With the help of cross cutting relationships, the sequential development of microfeatures can also be established. This, further supports the action of different processes during temporal and spatial variations.
Facets, pits and mamillated surface have been recognized as the chief surface patterns of garnet (Gravenor and Leavitt, 1981). But, in addition to the above, it is observed that etch V’ or oriented V’ channels are also very common in tropical environment (Fig.7). Though grain surfaces of garnet from sedimentary rocks as well as from alluvial sediments do contain such elongated solution channels, large scale secondary mineral growth along these ‘V’ forms is noted only in samples from sedimentary rocks.

References


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