

Pumices from the Central Indian Ocean Basin

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A better understanding of submarine volcanisms that result in pyroclastics is of universal importance for paleotectonic reconstruction, crustal growth estimates and location of volcanisms throughout the earth's history. Of the volcanogenic components in the world ocean basins, pumices are widely distributed in bottom sediments but despite their areal extent the genesis of pumices is poorly known and large pumice fields are rare. This is because pumices have a low specific gravity and high porosity, properties that enhance their transportation and deposition by wind and water.

Submarine volcanic eruptions in the southern hemisphere are not so well documented in contrast to those in the north. The volcanogenic contributions to the Indian Ocean sediments are significant not only volumetrically but also as indicators of tectonic environments. A few studies in the past concerning the volcanogenic components in the Indian Ocean are informative but these do not pertain to the Central Indian Ocean Basin (CIOB) *per se*. No conclusive picture has emerged regarding the scale of volcanism and areal extent of the dispersed products in the CIOB. Moreover, the source of such products is also enigmatic.

I aim to describe the distribution, morphology and chemical characteristics of pumices from the CIOB and propose alternative explanations to the drift origin for the source of these pumices. In all, data of 1975 stations were computed accounting for more than 10,000 freefall grabs, photograbs, dredges and sediment core operations. These represent more than 5000 pumice clasts collected from an average water depth of 5000 m.

The frequency of pumice was sometimes as high as 7 out of 7 i.e., any station in which 7 freefall grabs were lowered, pumice pieces were recovered in all of them. Larger clasts are common in dredges as compared to smaller ones in grabs because the latter must have escaped recovery through the mesh of the dredge or else were agitated from the seafloor, suspended in the water and transported during the forward movement of the dredge. Based on the concentration and counts, an area of 600,000 sq km (corresponding to 1/9th of the basinal area of 5.7×10^6 sq km) has been identified. This is the largest pumice field in the world oceans.

The pumices are of various colours such as brownish, blackish and buff and are oval, elongated, lineated, sub-rounded, rounded or irregular in shape. Some have a 'sugary' appearance. A statistical analysis of > 4000 clasts show that 84% have no coating of ferromanganese oxides while the rest are either fully or partially coated. Interestingly, both types many a time occur in a single sampler and from the same sediment domain (mainly siliceous).

Petrographically, the pumices show isotropic glass alternating with bands of cryptocrystalline materials. Fluidal texture is distinct and along the flow lines opaque are present. Vesicles are mainly pipe-like while a few are rounded in form. In some cases, quartz crystals, tests of radiolarians, phytoliths, diatoms and manganese micronodules have been noted. XRD revealed quartz to be dominant followed by feldspars (< 5%).

Based on the SiO₂, there are two types of pumice corresponding to trachyandesite (avg. SiO₂ ~60 %) and dacitic-rhyolite (~70 SiO₂). In general, a higher content of total alkalis, K₂O and CaO are noted for the former samples while the latter samples have higher FeO*. A comparison with earlier reports indicates the CIOB pumices to be different from those drifted from Krakatoa but show some similarities to those from the Indonesian Arc Volcanism.

In the Indian Ocean, there are reports of drifting and settling of pumices derived from the Krakatoan explosion in 1883. In contradiction, there are reports that the products of Krakatoa do not occur in any significant amount to the east of 80° E longitude. On the other hand, it is believed that eruption of a seamount near the Ninetyeast Ridge may have contributed the pumices.

Pumices at abyssal depth are considered to be exotic since it is theoretically predicted that vesicular rocks cannot form at such a depth. Paradoxically, discoveries in different geographical areas and geological environments (both on land and in the oceans) have revealed occurrence of pumices at great depths (>3500 m). These studies suggest that submarine eruptions could be a source of pumices.

The above investigations suggest that besides derivation of the CIOB pumices from the neighbouring landmasses, an *in situ* origin could also be possible. There are a number of seamounts dotting the seafloor of the basin and under favourable intraplate conditions these might have erupted pumices. Moreover, the frequent occurrence of pumices in the vicinity of the seamounts seem to support the experimental contention that hot pumice clasts sink rapidly while cooler ones remain afloat for longer times.

In the Indian Ocean, silicic volcanisms have occurred during the Cretaceous-Eocene times, prior to which basaltic eruptions were more frequent. This in turn could

indicate that extreme fractional crystallisation of the abyssal tholeiites found in abundance) resulted in stratified magma chambers with alkali- and volatile enriched silicic melts. Later eruptions of some seamounts (probably those with summit craters) may have resulted in the pumice formation. Alternatively, liquid immiscibility, as a causative process, could have brought about segregation of two different magmatic melts: silicic and basic, based on their viscosity. Such a process of segregation (either vertical or lateral) might have resulted from an intrusion of a basic magma into an acid magma chamber. This mixed magma, rapidly ascended through conduits (seamounts and/or fracture zones) and produced pumices on the CIOB seafloor.

The presence of pumices coated with ferromanganese oxides (a few mm to cm thick) is puzzling. This is because it is generally considered that for accretion of 1 mm of oxides on a nucleus requires about a million year. If this is the case then the pumices with substantial coating of oxides suggest that either such pumices are older than Krakatoa's eruption or else the rate of oxides' accretion is much faster. The faster rate of oxides' accretion could be reconciled to the possibility of volcanogenic-hydrothermal (VH) precipitation as a source rather than solely to a hydrogenous source. The reported evidences of VH events in the CIOB attest to this inference.

Alteration of volcanics is ubiquitous in the deep sea and results in the formation of authigenic and secondary minerals. In this respect, the altered pumices have given rise to glass shards as well as to phillipsite, a zeolite that generally requires a silicic precursor for its formation.