

SCG67-10

Room:414

Time:May 1 16:45-17:00

Long-distance magma transport from oceanic island arc volcanoes

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Long-distance lateral magma transport away from volcanic centers is emerging as a common phenomenon where the regional stress regime is favorable. It should also be recognized as an important factor in the construction and growth of island arcs, and a potential trigger for devastating eruptions. In this contribution, we report on recent investigations into the magma dynamics of Izu-Oshima volcano: an active basaltic volcano with an extensive fissure system.

Geophysical observations in the Izu-Bonin intra-oceanic island arc indicate that magma periodically is moved away from the main basaltic composite volcanoes. When Miyakejima erupted in 2000, seismic activity migrated about 30km northwestward from the volcanic centre (Geshi et al., 2002). This event is interpreted to reflect magma injection and dike propagation at a depth range between 12 and 20km (Kodaira et al., 2002). Long-distance lateral magma transport has also been identified at the Nishiyama volcano on Hachijojima Island using petrological, geochemical and structural studies of satellite vents (Ishizuka et al., 2008). Nishiyama has provided evidence for two types of magma transport: Primitive magma moving laterally for >20km in the middle to lower crust (10-20km deep) and short distance transport (<5km) from shallow, differentiated magma reservoirs. Of these the long-distance transport seems to be controlled by a regional extensional stress regime, while short distance transport may be controlled by the local stress regime resulting from the load of the main volcanic edifice.

Izu-Oshima is flanked by numerous, subparallel NW-SE trending submarine ridges extending up to 22 km to the NW and SE from the center of the volcano. During a recent diving survey we have identified that these ridges are fissures which erupted basaltic spatter and lava flows. Furthermore, lavas are petrographically similar along each ridge, while there are noticeable differences between ridges. The subparallel ridges are observed to transect a series of knolls, the Izu-Tobu monogenetic volcanoes (ITMV), which are dispersed across this area of the rear-arc. However, there is a consistent petrographic difference between these seamounts and the ridges.

We have found similar, and in some cases a matching, geochemistry between the submarine ridges and subaerial ridges of eruptions found ascending the flanks of Izu-Oshima. This implies that the subaerial ridges and submarine ridges together represent the track of a magma transport episode away from the storage system beneath the central volcano.

ITMV and the transecting ridges are found to have quite distinct geochemical characteristics, indicative of different magma sources. Yet, they are essentially found interspersed in outcrop. The most appropriate scenario for their development is one where ITMV are fed by an "in-situ" underlying source, while the NW-SE ridges are fed by lateral magma transport from Izu-Oshima. Unlike Nishiyama volcano, Izu-Oshima does not show a compositional variation along the length of the ridges, and has no evidence of primitive magmas. Hence, the magma transport is likely to be derived from a crustal chamber where crystal fractionation and plagioclase accumulation has taken place.