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Magmagenesis and Evolution at Damavand Volcano, Iran

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Damavand volcano, 50km north of Tehran in the Islamic Republic of Iran, is enigmatic in several respects. It comprises a composite cone >350km^3 in volume, constructed largely from a series of geochemically and petrographically similar trachyandesite lavas. Its tectonic environment and consequent magmatic trigger is far from obvious. No other volumetrically significant recent volcanism has occurred within 500km of Damavand. Long-term subduction does not appear to have affected the region for at least 20Ma. Similarly, the volcano is not located in a region of obvious extension, but rather atop an orogenic mountain belt. The Alborz Mountains, upon which the volcano has developed, are the result of plate collisions associated with Tethyan closure. The basement immediately subjacent to the volcano comprises a passive margin sedimentary sequence, deformed by compressional faulting and (possibly later) strike slip movement parallel to the axis of the orogen. The crust appears to be only c. 30km thick, suggesting that the mountains are supported by a thermal anomaly rather than a thickened root. The lavas and associated pyroclastic deposits are uniformly crystal-rich, with a complex assemblage of feldspar + pyroxene + magnetite + apatite ±amphibole ±biotite ±olivine. These phases commonly show extreme reaction textures and zoning, with abundant melt and mineral inclusions. The range of ages so far determined through $^{40}Ar/^{39}Ar$ dating suggests activity over a period from at least 800,000 to 20,000 years. The volcano stratigraphy at Damavand indicates that an older, eroded, centre underlies the current cone. In the lowermost part of the section, olivine basalts are intercalated with the earliest trachyandesites, although they were likely derived from small local vents. The basalts are enriched in incompatible trace elements, with similarities to OIB. Sr and Nd isotopic compositions indicate time-integrated bulk-earth-like incompatible element characteristics of the source ($^{87}Sr/^{86}Sr$ ~0.7045, $^{143}Nd/^{144}Nd$ ~0.51264). There is a significant compositional gap between the basalts and trachyandesites, and any direct genetic relationship between them is questionable. On the one hand, isotope compositions are similar ($^{87}Sr/^{86}Sr$~0.7044-0.7049, $^{143}Nd/^{144}Nd$~0.51252-0.51263). On the other, incompatible trace element patterns are distinct (Figure 1a). The trachyandesites are depleted in most incompatible trace elements compared with the basalts - only Rb, Cs, U and Th are significantly enriched. To some extent the depletion may be ascribed to fractionation of trace-element enriched accessory phases such as apatite and zircon (apatite is ubiquitous, commonly occurring as euhedral crystals up to 5mm in length). The occurrence of small cumulate xenoliths with mineralogies similar to the "phenocrysts" in the lavas, taken together with the disequilibrium textures among mineral phases, suggests that 1) crystal extraction has defined some of the geochemical trends among the trachyandesites, but 2) disruption of cumulates and dispersal back into the fractionated liquids has provided most of the crystals actually seen in the lavas. The disaggregation and dispersion of cumulate phases into the liquids may be responsible for the highly scattered nature of geochemical trends, reflecting the superimposed effects of extraction and accumulation (Figure 1b). This homogenisation process may also explain the remarkably small range of compositions displayed by Damavand erupted products over nearly 1Ma of activity.

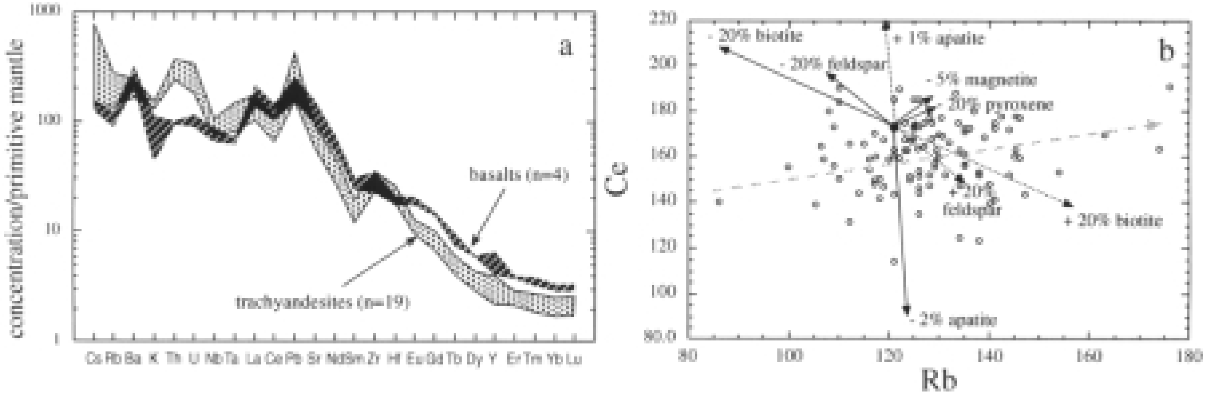

Figure 1: a) Trace element distribution of basalts and trachyandesites from Damavand. b) Trachyandesite trace element data indicating effects of crystal extraction and accumulation, leading to scatter of whole rock data (total SiO_2 range; 57-64%).