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Hydrous Mantle-derived Magmas in West-central Mexico: The Andesitic Aqueduct

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Although experiments have suggested that andesites, broadly defined, could be generated by water-saturated partial melting of a hydrous mantle, the mineralogical and petrological evidence to support this is scanty. In west-central Mexico, among the calc-alkaline lavas, basaltic andesites, andesites, and dacites predominate, whereas basaltic magmas (<52wt% SiO_2) are scarce. Throughout the intermediate lavas, there are two facies:- a less abundant, water-rich and phenocryst-poor group of lavas that require >6wt% H_2O to generate their phenocryst assemblages; and a more abundant group with phenocryst assemblages that require ~2-4wt% H_2O to equilibrate. Thus the ascent of magma in the crust involves water loss, and the typical porphyritic andesite with abundant plagioclase phenocrysts (30-50%) is a feature acquired as a result of degassing more water-rich magmas with ~0-10% phenocrysts. This large increase in crystallinity by degassing contrasts with hydrous basalt, where a small drop in temperature promotes extensive crystallisation, choking the magma at the base of the crust, and so accounting for its virtual absence in the volcanic record. To estimate the amount of water in the feeding magmas of western Mexico, the experimental calibration of $RT\ln\gamma_{SiO}2$ with composition in hydrous liquids has been used. It can be shown thermodynamically that magnesian basaltic-andesites (52wt% SiO_2, 9wt% MgO) can equilibrate with a mantle lherzolite with 8-10wt% H_2O, whereas magnesian andesites (62wt% SiO_2, 5.5wt% MgO) need ~20wt% H_2O, close to their water saturation limit at 1.0 GPa. Such lherzolites containing hornblende have been found as xenoliths in hydrous andesites from Mexico.

Given that mantle-derived arc melts contain 10-20% H_2O, then an estimate of the water flux transported to and through the crust by arc magmas can be made from the observed magma eruption rates in well-characterised volcanic arcs. Within the limits of the estimates, it appears that the water supply from the mantle by arc magmatism is in balance with the amount of water subducted by oceanic crust in unit time. Thus not only do andesites need water for their generation, but they are instrumental in returning water back to the surface.