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GEOLOGIC MAP AND GEOTHERMAL ASSESSMENT OF THE MOUNT ADAMS VOLCANIC FIELD, CASCADE RANGE OF SOUTHERN WASHINGTON

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ABSTRACT

More than 60 Quaternary vents make up the basalt-to-rhyodacite Mount Adams volcanic field and have erupted scoriae and lavas with a total volume of >370 km^3. The Mount Adams andesite-dacite stratocone itself is a compound edifice that includes the high cone above 2300 m (20-10 ka), remnants of at least two earlier andesite-dacite cones as old as 0.5 Ma, and 7 Holocene flank vents. Four other Holocene vents and tens of vents contemporaneous with Mount Adams are peripheral to the stratocone. All of these vents, including Mount Adams, lie within a N-S eruptive zone 55 km long and 5 km wide. The age of all known Mount Adams silicic products (>100 ka) and the heterogeneous mafic compositions of the summit cone and Holocene lavas make it unlikely that the stratocone is underlain by an upper-crustal reservoir. Rather, the stratocone at the focus is built up of fractionated hybrid magmas that rise from MASH zones (melting-assimilation-storage-homogenization). The pyroclastic core of breccia and scoria at Mount Adams has undergone acid-sulfate leaching and deposition of alunite, kaolinite, silica, gypsum, sulfur, and Fe-oxides and has been a constant source of avalanches and debris flows. Most heat supplied from depth to the fumarolically altered core is dispersed by the high precipitation rate and high permeability of the rubbly lava flows so that a hydrothermal convection pattern is not maintained. Summit-restricted fumaroles are weak and diffuse.

INTRODUCTION

Ice-capped Mount Adams towers atop the Cascade crest some 50 km due E of Mount St. Helens (see Fig. 1, C. Bacon, 1990, this volume). The 3743-m andesite-dacite stratocone stands at the focus of a basalt-to-rhyodacite volcanic field containing >60 Quaternary vents. The mapped area of the field is ~1700 km^2, about 40% of which is Mount Adams volcano and its flank vents. The main cone today exceeds 200 km^3, and at least half as much more was eroded during late Pleistocene time from earlier high-standing components of the compound edifice; peripheral basalts add another ~70 km^3.

VOLCANIC GEOLOGY

Nearly all of the high cone of Mount Adams above 2300 m was constructed during latest Pleistocene time, probably between 20 and 10 ka, explaining the abundance of late-glacial till and the scarcity of older till. Products of this eruptive episode on the main cone range from 54 to 62% SiO_2. Contemporaneous and younger peripheral vents yielded lavas and scoriae in the range 48-57% SiO_2, and, along with Mount Adams, they define a recently active N-S eruptive alignment 40 km long and only 5 km wide. If we include vents as old as 0.3 Ma, this zone lengthens to 55 km, trending N 10° W, attesting to modest E-W extension in the upper crust. Basalts within this zone are extremely varied compositionally, ranging from quartz-to-nepheline- normative and from 0.16 to 1.60 wt% K_2O (at 48-49% SiO_2). Andesites also reflect this heterogeneous ancestry ranging from 0.9 to 2.1 wt% K_2O at 57.5% SiO_2.

Beneath the young edifice, eroded stumps of at least two earlier andesite-dacite cones are as old as 0.5 Ma, representing several eruptive episodes and a spectrum of rock compositions that extends continuously from 52 to 69% SiO_2. Coalescing shields of basalt (48-53% SiO_2) peripheral to the stratocone complex interleave with the andesite-dacite lavas erupted focally, demonstrating persistent contemporaneity and absence of systematic secular petrochemical evolution. Adams is the most potassic, petrochemically most "intracontinental", stratocone in the Cascades. Its products contain 2.0-2.6 wt% K_2O at 60% SiO_2 (and 4% at 69% SiO_2), double that of Mount St. Helens.

There have been no recorded eruptions of Mount Adams, and of the 11 Holocene vents, none are known to have erupted products younger than 3500 years. Seven of the Holocene eruptions took place at flank vents 2000-2500 m in elevation and produced a wide range of compositions (49-61% SiO_2; the other four vents are peripheral to the main cone at 1100-1600 m and 48-54% SiO_2).

Dacitic lavas and a few block-and-ash flows (63-69% SiO_2) erupted several times from the focal area and rarely on the periphery, but probably none are younger than 0.1 Ma. A single rhyodacite (72% SiO_2) is undated but also old. The antiquity of all known silicic units, in conjunction with the heterogeneous mafic compositions of the late Pleistocene summit cone and of Holocene lavas erupted around that cone, make it appear unlikely that Mount Adams is now underlain by an upper-crustal magma reservoir.

GEOTHERMAL IMPLICATIONS

Weak H_2S-bearing fumarolic gases still rise from crevasses in the summit icecap. Subjected to this solfataric flux, the breccia-and-scoria core of the stratocone has suffered severe acid-sulfate leaching and deposition of alunite, kaolinite, silica, gypsum, sulfur, and Fe-oxides. Where exposed in glacial headwalls, the 4-km^2 rotten core is a persistent source of avalanches and debris flows, the largest of which travelled as far as 60 km after breaking loose about 5100 years ago, creating the southwest notch and shelf for the perched White Salmon Glacier.

The high precipitation on the stratocone, estimated to be ~3500 mm/y, makes Mount Adams an important site of ground water recharge. The high permeability of its rubbly lava flows suggests that much of this ground water moves rapidly downward and outward from the stratocone, failing to remain in the warmer central region of the volcano long enough to develop a hydrothermal convection pattern but, instead, dispersing and dissipating whatever heat is supplied from depth to the fumarolically altered core. The weak and diffuse fumarolic emissions on the summit are the only manifestations of possible hydrothermal activity anywhere on the stratocone. The warmest spring that we have found on the stratovolcano measured 3°C, on a summer day. Nonetheless, in surrounding areas, springs as warm as 24°C and gradients as high as 50°C/km in heat-flow holes (but generally lower) offer some hope that ground water sufficiently warm for local space heating or agricultural uses might be found by exploring the lowland periphery of the volcano.

CONCLUSIONS

We re-emphasize the fundamental role of the peripheral mafic shields and cinder cones. The andesite stratocone at the focus is a derivative feature, built up of fractionated hybrid magmas that rise from MASH (melting-assimilation-storage-homogenization) zones where mantle-derived basalts are stalled in the deep crust or crust-mantle transition zone. Persistent eruption of andesite and basalt reflects ascent from the lower crust; any establishment of mid-to-upper crustal magma chambers, on the other hand, is likely to engender fractionation to dacite (or more silicic compositions) on short time scales (10^1-10^3y).