N94-16204

EXPLOSIVE MAFIC VOLCANISM ON EARTH AND MARS; *Tracy K.P. Gregg and Stanley N. Williams, Department of Geology, Arizona State University, Tempe, Arizona 85287-1404*

Deposits within Amazonia Planitia, Mars, have been interpreted as ignimbrite plains on the basis of their erosional characteristics [1]. The western flank of Hecates Tholus appears to be mantled by an airfall deposit, which was produced trhough magma-water interactions or exsolution of magmatic volatiles [2]. Morphologic studies, along with numerical and analytical modelling of martian plinian columns and pyroclastic flows, suggest that shield materials of Tyrrhena and Hadriaca Paterae are composed of welded pyroclastic flows [3, 4]. Terrestrial pyroclastic flows, ignimbrites and airfall deposits are typically associated with silicic volcanism [5 - 7]. Because it is unlikely that large volumes of silicic lavas have been produced on Mars [8, 9], we seek terrestrial analogs of explosive, mafic volcanism. Plinian basaltic airfall deposits have been well-documented at Masaya, Nicaragua [10], and basaltic ignimbrite and surge deposits also have been recognized there [11]. Ambrym and Yasour, both in Vanuatu, are mafic stratovolcanoes with large central calderas, and are composed of interbedded basaltic pyroclastic deposits and lava flows [12, 13]. Zavaritzki, a mafic stratovolcano in the Kurile Islands, may have also produced pyroclastic deposits, although the exact nature of these deposits is unknown [14]. Masaya, Ambrym and Yasour are known to be located above tensional zones. Hadriaca and Tyrrhena Paterae may also be located above zones of tension, resulting from the formation and evolution of Hellas basin [3, 4], and, thus, may be directly analogous to these terrestrial mafic, explosive volcanoes.

Masaya, Nicaragua, lies on a chain of Quaternary volcanoes which extends along the Pacific coast of Central America. Volcanoes within this chain are aligned in a series of *en echelon* segments, and the "segment break" which passes through Masaya Caldera is represented by an intense zone of faulting and graben formation [11, 16], and the crust beneath Masaya is anomalously thin [17]. The caldera forms a basin ~11.5 x 6km and ~100m deep; the caldera floor is covered with recent lavas. Evidence for Hawaiian and strombolian activity at Masaya is recorded in the caldera floor along eruptive fissures, and at satellite cones.

Two thick (2 - 6m), well-known, scoria airfall deposits originate at Masaya, and others are observed in the caldera walls. Both deposits are composed of Fe-rich tholeiitic to calc-alkaline basalt scoria, and are clearly plinian [11, 18, 19]. A basaltic ignimbrite, with a volume (DRE) of ~2.2 to 3.4km^3, is exposed near the top of the caldera wall. It displays a 20-35cm basal surge deposit, a co-ignimbrite lag-fall deposit near the vent, typical inverse grading of vesiculated pyroclasts, and normal grading of lithic clasts. The flow had sufficient energy to climb ~80m above the caldera rim, and to transport trees. It is capped by a 50-cm thick layer of vitric ash with occasional accretionary lapilli [11]. A pyroclastic surge deposit directly overlies the pyroclastic flow. The deposit is largely composed of shattered fragments of older lavas and plutonic rocks, and is locally massively bedded and cross-bedded. The surge apparently maintained its integrity for at least 15 - 20km from the volcano, and represents a volume (DRE) of ~4.9 - 6.5km^3. Removal of both the pyroclastic flow and surge volumes from the magma chamber beneath the caldera may have been responsible for caldera collapse [11].

Ambrym Caldera, Vanuatu, has been historically continuously active [12], but, because of its location, has been sparsely studied. Ambrym is a large, broad composite cone ~19km across, composed of basaltic lavas and basaltic ash and lapilli tuffs, with uncommon agglomerates. The large (9 x 12km x ~50m deep) central caldera contains two secondary cones, and their slopes are thickly mantled with recent ash [13]. Ambrym is located at the intersection of the Vanuatu island arc and d'Entrecasteaux Fracture Zone. A gravity gradient across the island suggests that Ambrym may straddle lower density crust to the west and higher density crust to the east [13]. Although detailed stratigraphic data is not currently available, the abundance of basaltic ash, the large, subsidence caldera, and its location above a tensional zone suggest the possibility of basaltic pyroclastic flows on Ambrym's slopes.

Less is known about Yasour, also in Vanuatu, located ~375km SE of Ambrym. It also has been continuously active historically. It is a basaltic andesite (~55% SiO_2) stratovolcano with a central crater ~400m in diameter and ~80m deep. Alternating lava flows and scoria beds are revealed in the crater walls. Historic activity has been primarily strombolian [12], but the morphology of the volcano, and its position near a fracture zone, suggest that field work may reveal evidence for extensive, mafic pyroclastic deposits.

Future work may also reveal mafic pyroclastic deposits at Zavaritzki Caldera, on Simushir Island, Kuriles. Zavaritzki is a shield-like stratovolcano with nested calderas; the external caldera is ~6km in diameter. Although recent activity has been characterized by "rare, weak eruptions" [14], there are traces of ancient plinian and strombolian eruptions in its deposits. The 1957 eruption of Zavaritzki produced several dark eruption columns up to 8km high. An eye-witness describes fallout of dark ash from the column, and walking over new "gray pumice" during an eruptive interval [15]. All known products from Zavaritzki are mafic andesites and basalts [14].

Masaya, Ambrym and Yasour are located in extensional zones. There is no direct evidence for water-magma interactions in the large ignimbrite deposits of Masaya [11] and the deposits of the other volcanoes have not been extensively studied. Rapid rise of mafic magma, facilitated by crustal extension, may allow the magma to reach the surface without degassing significantly. Rapid rise may effectively overcome the "viscosity barrier" of mafic magmas [6, 7] and allow formation of mafic plinian columns.

Deposits associated with Tyrrhena and Hadriaca Paterae are much more widespread than the terrestrial examples discussed here, largely due to environmental, and possibly compositional, differences. A basaltic column should rise 12% higher than a similar silicic column, simply because of increased eruption temperature [11, 21]; ultramafic columns would be even taller. Low atmospheric pressures on Mars should cause eruption velocities to be 50% greater than on Earth, and enable eruption clouds to rise 5 times higher on Mars [22]. Lower atmospheric pressures and temperatures on Mars allow pyroclastic flows to travel a greater distance on Mars than on Earth before falling beneath a critical welding temperature [4]. Finally, the full extent of the terrestrial deposits is unknown, because much of the deposits are submarine. It has been suggested that Hadriaca and Tyrrhena Paterae have been influenced by Hellas basin tectonics, and may be located above zones of tension [3, 4], similar to the terrestrial volcanoes discussed here. Comparison of martian highland paterae to terrestrial examples suggest that Tyrrhena and Hadriaca may have produced extensive mafic ignimbrite deposits, through violent degassing of rapidly rising mafic magma, and not through magma-groundwater interactions.

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