Deep submarine explosive volcanism

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The role water depth plays in inhibiting volatile phase expansion and thereby the depth of explosive eruptions has been the topic of rigorous debate. Due to a misinterpretation of the applicability of the water-vapour curve in previous research, it is assumed that the pressure exerted by the overlying water column is significant enough to inhibit explosive volcanism at depth. This hypothesis assumes that pyroclastic eruptions cannot occur below the critical point of seawater (315 bars or 3150 m water depth). Therefore, most eruptions are interpreted to occur at depths much shallower than the critical point (500 to 1000 m). However, this hypothesis does not fully recognize the role volatile phase expansion (specific volume changes in P-T space) plays in explosive eruptions even at pressures beyond this critical point.

This controversy has lead to debates on the environment of formation of volcanic massive sulphide deposits (VMS), since pyroclastic rocks can be found in both the footwall and (or) hangingwall sequences, and as an alternative they have been reinterpreted as mass flow deposits. The exsolution of water from a crystallizing felsic melt is directly proportional to the solubility of water in a silicate melt and plays a significant role in the explosivity of an eruption. Water solubility is a function of the pressure, temperature and compositional constraints, with water oversaturation resulting in volatile exsolution. The relationship between dissolved volatiles in a melt and the energy released upon exsolution shows that the expansion of the volatile phase is capable of providing enough energy to initiate submarine pyroclastic eruptions in a variety of settings, magma types, and to significant water depths.

To evaluate the possibility of having a submarine eruption at depths of greater than 1 km, we used the 1-d numerical model CONFLOW. This program uses specified melt composition, conduit diameter and length, and the initial temperature and pressure at the base of the conduit to calculate the pressure gradient in a conduit of constant cross sectional area, the enthalpy of the magma, the viscosity of the volatile-magma mixture at specified P-T conditions, the fragmentation depth where $v_g = 0.75$, and the exit velocity of the volatile-magma mixture. Results of the CONFLOW modeling support our hypothesis that volatile phase expansion is capable of providing enough energy to initiate submarine pyroclastic eruptions in silicic magmas to significant water depths.

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