Volatile contents explain high vesicularity of deep sea eruptions

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The submarine Cape Verde plateau lies at water depths of 3000-4000 m below sea level (mbsl). Under these hydrostatic conditions magmas are not expected to degas. However during the Meteor Expedition M80/3 we sampled high to low vesicularity lavas, agglomerates and even pyroclastic deposits. Our aim is to investigate the conditions that caused this range of eruption styles in the deep ocean, and therefore explore sample vesicularities and volatile contents.

Samples erupted on the seafloor at depths of 3150 to 3409 mbsl different textures and vesicularities. The selected samples (n=5) range from low to high vesicularity lavas displaying 7 to 54% vesicles and a single agglomerate. Vesicle diameters are typically small and range between 2 and 35 µm in the moderately to highly vesicular samples. In the sample with low vesicularity the vesicle sizes range from 3 to 900 µm and the larger vesicles are elongated with the lava flow direction.

The samples are aphyric or kaersutite bearing and basanitic to phonolitic. The agglomerate sample, erupted at 3150 mbsl, was the only sample containing clinopyroxene. Seven FTIR analyses of clinopyroxene crystals gave water contents of 1.0 to 3.9 H_2O%. The analyses with 2.2 H_2O% and 3.9 H_2O% were associated with kaersutite inclusions. Excluding those analyses, the clinopyroxene shows 1.0 to 1.5±0.3 H_2O%. Analyses of glass from the samples gave 0.7 to 1.3±0.1 H_2O% and 0.03 to 0.09±0.01 CO_2%.

The water solubility curve indicates that at 3-4 km depth and 1.5 H_2O% the magma would be water undersaturated. However basanites become saturated in CO_2 under such depths with less than 0.1% CO_2. Hence the measured volatile contents of ~1 H_2O% and ≤0.09 CO_2%, would likely create volatile saturated conditions at water depths of 3-4 km in these basanites to phonolites. Volatile oversaturation would promote degasing of a CO_2-dominated fluid phase and lead to high vesicularity lavas. Volatile oversaturation would also explain the more explosive submarine deposits such as agglomerates and pyroclastic deposits.