Interpreting popping rocks from the Mid-Atlantic Ridge near 14°N

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Despite the influence of mantle carbon on melt formation and migration, volatile cycling, and volcanic eruption styles, the amount of carbon in Earth's mantle remains highly debated, with estimates varying by more than an order of magnitude. The popping rock, recovered in dredge 2πD43 in 1985, is commonly considered to be one of the most representative samples of undegassed magmas from the upper mantle due to its high volatile and noble gas abundances. Here, we offer new insight into the geologic context and formation of popping rocks based on a 2016 *R/V Atlantis* cruise to the Mid-Atlantic Ridge near 14°N, which was the first to recover popping rocks *in situ*. The popping rocks were recovered by the submersible *Alvin* from a lightly sedimented pillow ridge and proximal pillow mounds at the transition between magmatic and tectonic segments. We revisit the original model for popping rock formation using seafloor observations, high-resolution bathymetry, vesicle size distributions, major and trace element geochemistry, and noble gas geochemistry.

The dissolved volatile concentrations in popping and proximal, non-popping samples are within the range commonly observed in MORB (e.g., 161–178 ppm CO_2; 0.44–0.50 wt.% H_2O). In constrast, the exsolved volatile concentrations in these popping rocks are amongst the highest ever recorded for submarine mid-ocean ridge basalts (e.g., 2,800–14,000 ppm CO_2; 1.84–7.67 x 10^{-5} cc/g STP ^4He). The recovered popping rocks display remarkably homogeneous trace element ratios and REE patterns, indicating similar mantle sources and extents of melting. These results suggest that the lavas were produced under similar magmatic conditions, possibly during a series of closely timed eruptions. Vesicle size distributions and noble gas ratios suggest that the popping rocks were unaffected by gas loss but possibly experienced bubble accumulation. We explore the implications of these results for popping rock formation and mantle volatile concentrations.