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Small, monogenetic volcanoes: building blocks of the upper oceanic crust

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The study of slow-spreading mid-ocean ridge volcanism provides important insights into the mechanisms of oceanic crustal accretion. This study uses a combination of sidescan sonar and recently developed methods of high resolution bathymetry and video data collection to describe the volcanic features on the Mid-Atlantic Ridge axis at 45ºN in more detail than has previously been possible.

Within most axial valleys lie axial volcanic ridges (AVRs), linear volcanic features thought to be the focus of volcanism at slow spreading ridges. AVR volcanic morphologies have been described independently in a number of studies, through combinations of remote sensing (predominantly through the use of sidescan sonar) and deep towed cameras or submersibles. These different methods have led to classification of volcanic features on two very different scales. While the resolution of the sidescan sonar studies allows only for the identification and classification of features tens to hundreds of metres in size, the photographic and submersible studies describe features from centimetre to metre scale. Until now it has been difficult to reliably link these observations together as no intermediate sensing method has been available. This study uses 1m resolution ROV multibeam bathymetry to address this problem and link features identified at different scales together.

We identify a prominent 22km long axial volcanic ridge within a 1km deep axial valley that ranges from 6 to 14km across. We find that “hummocks” described in previous sidescan sonar studies (of which the AVR is composed) are individual, monogenetic volcanic cones. These cones range from 2 to 200m in height and 40 to 400m in diameter and we identify over 8000 of them on the surface of the AVR. We calculate the average volume of a cone to be 220,000m^3 and estimate the AVR is built of approximately 73,000 such cones. We estimate these edifices form on time scales ranging from less than one hour to several months so are likely the products of single eruptions. Cones of all heights, but particularly those over 70m, are prone to collapse soon after forming. A variety of mechanisms are examined and collapse triggers may include: a) flank over-steepening, b) building on unstable material, and c) cutting by fissuring. Collapse scarps show two strong alignments, one ridge parallel and one at 30° to the ridge trend; however as cones always collapse downslope, these alignments may be due to the slope angles produced as a result of cone emplacement rather than first order controls on collapses themselves.

We estimate the minimum magmatic flux to the surface for this segment to be at least 64,000m^3 yr^{-1}, which is equivalent to producing one average volume cone every 3.5 years.