

Ship Rock Diatreme: is it a Classical Volcano? New Evidence on Magma Ascent and Emplacement Within the Navajo Volcanic Field

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Abstract

The Navajo Volcanic Field (NVF) is an area of late-Tertiary volcanism along the New Mexico-Arizona border near the Four Corners region of the American Southwest. Among the roughly 80 exhumed diatremes that comprise the NVF, Ship Rock and The Thumb are two diatremes that present an interesting problem concerning magma ascent and emplacement within the NVF. Are the diatremes remnants of classical volcanoes with underlying magma chambers, or are the diatremes formed from buds off of upward propagating dike swarms? The 2006 Keck Consortium Geophysics Project collected non-invasive gravity

and magnetic data to image the subsurface of Ship Rock and The Thumb to suggest constraints concerning the formation of these diatremes within the Navajo Volcanic Field. At Ship Rock, we collected over 120 gravity points spaced 500 m apart along 10 lines. We also collected about 65,000 magnetic points that cover an area of 1,570,000 square meters surrounding Ship Rock. The gravity data reveal gravity lows several kilometers away from Ship Rock, probably as a result of thick sedimentary units close to the surface. A steep gradient of 5 mGal/km separates the gravity lows from a strong gravity high immediately to the southwest of Ship Rock. We interpret this gravity high to be uneven basement topography or a magma chamber at depth; further studies are required to determine which of the interpretations is more likely. The Ship Rock magnetic data show the prominent west and northeast dikes extend well beyond their surface outcrops while the southern dike extends only to its visible termination. The magnetic data we collected at The Thumb along ~18 km of lines reveal a linear northeast-southwest trending magnetic anomaly about 105 to 360 nT in amplitude that crosses the diatreme. We interpret the anomaly to be a dike beneath The Thumb. Models of the total field magnetic data suggest a dike at shallow depths of about 0.1 to 4.8 m and widths of about 0.25 to 1.5 m with a steep dip to the northwest. The analytic signal of the dike also reveals a steep dip to the northwest, or possibly en echelon behavior, which is consistent with the en echelon segmentation of the northeast dike of Ship Rock. The presence of a dike at The Thumb suggests that the diatremes in the NVF may have been formed by upward propagating dike swarms. The subsurface geology determined by our geophysical modeling can be compared to other diatremes in the NVF, as well as other maar- diatreme fields to better comprehend diatreme formation.

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