Surface exposure dating of phreatic eruptions at Ubehebe Crater, Death Valley, California

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Phreatic eruptions occur when rising magma encounters groundwater, causing the explosive ejection of pyroclastic debris and blocks of country rock. The Ubehebe crater field is an unusual example because of its location in Death Valley, California, where mean annual precipitation today is < 50 mm. We report a novel application of ^{10}Be surface exposure dating to sandstone cobbles collected from the upper surface of the Ubehebe Crater tuff ring to evaluate whether the eruptions correspond to an earlier, wetter time (e.g., late Pleistocene) or to local hydrologic factors. The cobbles were derived from Miocene conglomerates that underlie the crater field and are exposed in the wall of Ubehebe Crater. Eight ages obtained so far cluster at 0.9 ± 0.1 ka (n = 3), 1.9 ± 0.05 ka (n = 3), and 3.1 ± 0.3 ka (n = 2). Our working hypothesis is that these three clusters represent separate eruption events, of which at least the youngest was from Ubehebe. Our results are appreciably older than a maximum limiting radiocarbon age of 144-305 cal. yr BP (210 ± 30 ^{14}C yr) obtained from charcoal collected from below an inferred Ubehebe ash in a gravel pit ~4 km northeast of Ubehebe Crater (Klinger, 2001, in Machette et al., USGS, 21-24; ^{14}C calibration of Reimer et al., 2004, Radiocarbon, 46, 1029-1058). Our ages are nonetheless much younger than the late Pleistocene. Two interpretations are suggested. 1) Late Holocene fluctuations in precipitation and evaporation, though modest, may have resulted in groundwater levels that were at times higher and more conducive to phreatic eruptions than is perhaps the case today. 2) Sufficient groundwater was generally available for phreatic eruptions at the Ubehebe site, in spite of the arid conditions. The second hypothesis is consistent with volcanic activity over more than 2 kyr, and with the fact that nearly every eruption was explosive. We infer that the aquifer responsible was located within the Miocene because virtually all of the non-basaltic ejecta originate from that level. Additional dating is under way.