The complex geometries of maar-diatremes determined from geophysical modelling techniques. Examples from the Newer Volcanics Province of south-eastern Australia

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The Cainozoic Newer Volcanics Province (NVP) of south-eastern Australia is an intraplate, basaltic volcanic province comprised of over 400 monogenetic eruptive centres. Approximately 40 maar volcanoes have been identified, typically displaying well preserved edifices with no exposure of the underlying diatreme, so geophysical modelling techniques are applied to understand the morphology of their subsurface structures.

High resolution gravity and magnetic surveys were conducted across several maar volcanoes located within the NVP, including the Ecklin maar, Red Rock Volcanic Complex (RRVC), Mount Leura Volcanic Complex (MLVC) and the Anakie maar. The maar volcanoes surveyed display simple (Ecklin and Anakie) and complex (RRVC, MLVC) morphologies and eruption styles, representing a range of the different sizes and eruption styles observed within maar volcanoes of the NVP. Within this region, volcanic rocks tend to have a high petrophysical contrast (higher magnetic susceptibility, lower density pyroclastic deposits and higher density lava flows) with the surrounding host rock (carbonates, siliciclastics and granite (Anakie)), making maar volcanoes ideal for geophysical modelling. The depth, geometry and petrophysical property distributions of the volcanoes diatreme and feeder dykes were determined by 2D forward and 3D inverse modelling techniques.

The Ecklin and Anakie maars display relatively simple geophysical signatures. Long wavelength gravity lows with corresponding magnetic highs are observed across the craters and were reproduced during modelling with the presence of a shallow maar-diatreme structure at Anakie and two coalesced diatreme structures containing a denser central vent at Ecklin. The RRVC and MLVC have more complex geophysical signatures, consisting of short wavelength gravity and magnetic highs superimposed on longer wavelength gravity lows. These anomalies are reproduced during modelling with multiple shallow coalesced diatremes containing dykes and magma ponds.

The complex diatreme geometries revealed from forward and inverse modelling suggest that the eruption histories of these volcanoes are more complex than their relatively simple morphology would suggest. Multiple coalesced diatreme structures indicate complex eruption histories involving vent migration, while preserved dykes within the diatreme suggest short-lived fluctuations between phreatomagmatic and magmatic eruption styles. The shallow diatreme structures observed suggest that soft-substrate behaviour influenced the geometry of the diatreme, and likely contributed to the migration of vents observed at Ecklin, RRVC, and MLVC. The shallow diatreme observed within the Anakie maar is attributed to a short-lived eruption and low water content within the granitic host rock.

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