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"Saucer Sills" of the Offshore Canterbury Basin, New Zealand

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ABSTRACT

Within relatively undeformed passive basins, intrusive volcanic sills commonly exhibit saucer-shaped morphologies, often termed "saucer-sills". The advent of large, semi-regional 3D marine surveys has led to their discovery in multiple basins worldwide and allows their study in unprecedented detail. Saucer sills exhibit a number of common characteristics: they are typically circular to sub-circular in plan, with a sub-horizontal inner sill, a steeply dipping (25-45 degrees) inclined sheet which cross-cuts stratification, and often a sub-horizontal outer sill (Chevalier and Woodford, 1999; Polteau et al., 2008). Overlying sediments often show evidence of force folding (Hansen and Cartwright, 2006). The terminations of the outer sill are commonly the locus of hydrothermal vent complexes, a result of phreatic activity as a result of boiling and expulsion of pore fluids, which have been seen to penetrate hundreds of meters above the sill terminations (Hansen, 2006). Where seen in outcrop or sampled in wells these vents rarely contain any igneous material, instead consisting of remobilised, brecciated and cemented sands and shales derived from the penetrated strata (Svensen et al., 2006). The processes leading to the formation of saucer-sills has been a matter of some study and debate, but outcrop observations as well as experimental and numerical simulations suggest that initially the intrusion develops as a sub-horizontal sill that inflates and deforms the overburden. When the inner sill diameter approaches the overburden thickness, this deformation and uplift causes the stress field at the sill tip to become asymmetrical and the sill branches steeply upwards, crosscutting bedding planes and forming the inclined sheet. When excess magma pressure decreases towards equilibrium with the overburden load, the ascent of the inclined sheet decreases, which causes reduction of flexural strain at the sill tip, with intrusion once more following bedding planes. (Poulteau et al., 2008; Goulty and Schofield, 2008; Galland et al, 2009). More complex geometries have also been described, with networks of interconnected saucer-sills linked by junctions at the lowest points of the inner sills. This implies the possibility that sill complexes can act as through-going magmatic plumbing systems capable of transporting melts over great vertical and lateral distances (Cartwright and Hansen, 2006). Origin Energy Resources was granted two Petroleum Exploration Permits, PEP 38262 & 38264 (later amalgamated into a single PEP 38264) within the offshore Canterbury Basin in 2005 and 2006, with the objective of exploring for Cretaceous-aged structures resulting from the breakup of Gondwana. Further studies led to the acquisition of the Waka 3D over a large basement-cored structure along the southwestern margin of the block in 2009.