Dynamic evolution of the submarine Oamaru volcanic complex: sector collapse, unconformities, eruption-fed density currents, and backset strata

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The 1-2 km diameter Eocene Oamaru volcanic complex, located along the southeastern coast of the South Island, New Zealand, is considered an ancient analogue to the subaqueous deposits of Surtsey. The architecture and lithofacies characteristics of the subaqueous part of emergent volcanoes can only be inferred for edifices formed by modern eruptions. The dissected Oamaru volcanic complex offers an excellent opportunity to view the products of a subaqueous eruption, and to address shallow-water volcanic edifice construction. The Oamaru sequence is enclosed within shelfal carbonate deposits of the east-Otago Tertiary sequence, which provide convincing evidence of its subaqueous nature. Numerous moderate- to low-angle unconformities are recorded in deposits forming the volcanic edifice, and represent slip faces cut onto underlying strata. The slipfaces were formed by slumping of bedded material on the volcano flanks, triggered by oversteepening as a result of deposition during the eruption, or by shaking resulting from eruption explosions or other volcanic seismicity. The syneruptive nature of the slips is shown in the preservation of rotated blocks on or near slip scars that are draped by eruption-fed density currents, and by the similarity of tuff beds above and below the surfaces. The slip surfaces therefore represent complex process-response events associated with various stages of dynamic edifice construction.

Exceptionally well-exposed tuff, lapilli tuff and lapilli deposits, approximately 50-150 m thick and extending near the heart of the dissected edifice, originated from subaqueous eruption-fed density currents. The 2-100 cm-thick units are generally planar bedded with sharp contacts, but in detail are laterally discontinuous with abundant low-angle truncation surfaces or shallow scours. Wavy beds developed locally and, like their planar-bedded counterparts, overlie scours into underlying strata. We interpret these deposits to have been derived from vent-derived, subaqueous, tephra jets. Laminated beds, structureless beds, and both normal and inverse-to-normal graded beds are present, with some beds showing low-angle cross-lamination. Clasts are blocky to amoeboid in shape, with local polymict clasts. These apparently formed by encasement in vesicular to non-vesicular basalt of rip-up clasts, scoria, volcanic fragments, crystals, and glass. The polymict amalgamated clasts may have formed within a slurry in the vent in which water, vesiculating magma and fallback debris were energetically mingled. Clasts from the slurry that were captured in magma formed the polymict clasts, which were subsequently erupted and transported via tephra jets and density currents to the site of deposition. The slurry is inferred to have been strongly fluxed with steam, providing a slow-cooling environment that would have facilitated formation of these complex clasts, here termed *fallback-breccia clasts*. Backset beds formed in scour channels and on slip faces. Larger bedforms, 50-200 cm thick, are defined by these backset beds and locally display sigmoidal foreset geometry. Individual sets are dominated by either lapillistone layers or tuff. Large rotated blocks lying on synvolcanic slips acted as barriers, behind which the bedforms developed preferentially. The large-scale crossbeds record deposition from multiple, high-energy, eruption-fed density currents arising from tephra jets that were emplaced soon after slipface development.