

## **Surtseyan Volcanism over time and Space Exposed at Lookout Bluff, North Otago, New Zealand**

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Cliffs at Lookout Bluff expose basaltic surtseyan successions, interbedded with fossiliferous Eocene marine siltstones. The volcanoclastics, mainly coarse-grained, comprise tuff breccias, lapillistones and tuffs. They are formed by shallow marine phreatomagmatic fragmentation of vesiculating magma. Sedimentary characteristics suggest deposition by primary submarine fallout, modified by contemporaneous resedimentation. Similar-style volcanoclastic deposits are found along the North Otago coastline from Oamaru in the north to Moeraki Peninsula in the south, including the locations Kakanui and Bridge Point.

Although original cone morphologies are not fully preserved and vent locations are ill-defined, flow direction and bedding orientations enable reconstruction of the architecture of the complex. Several monogenetic cones, with a slope angle of 20 - 35°, are closely spaced over an area of 4 x 1.5 km extent. The larger of these coarse-grained edifices possibly reached a maximum height of 80 m, still remaining submerged. Finer-grained deposits with a bedding dip of ca. 5° occur locally between cones. Morphological features used to constrain the sequence of events include (1) a sequence of sediment gravity flows, originating from 2 separate vents, interbedded and deforming one another, (2) discordant contacts between deposits of younger and older edifices, (3) large-scale flank failure with shearing along the basal siltstones and (4) syn-depositional slumps and faults.

Time factors represented in the Lookout Bluff area are complex and differ widely. The time required to produce a single volcanic edifice, each of which accumulated within hours to days, contrasts strongly with the length of volcanically quiet periods (indicated by conformably interbedded non-glaucconitic and glaucconitic siltstones). Furthermore, the timing of volcanic activity ranges from contemporaneous eruptions from two vents to activity widely spaced in time, which depicts the sporadic nature of the volcanism. Recurrence of volcanism similar in style and in close vicinity requires steady conditions and a local, long-lived magma supply.