

## SUB-SURFACE EXPRESSION OF SAND VOLCANOES IN THE AVON-HEATHCOTE ESTUARY INDUCED BY THE DARFIELD EARTHQUAKE; ANALOG FOR SEDIMENTARY STRUCTURES IN THE ROCK RECORD

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Among the deformation features produced in Christchurch by the September 4<sup>th</sup> Darfield Earthquake were numerous and widespread “sand volcanoes”. Most of these structures occurred in urban settings and “erupted” through a hardened surface of concrete or tarseal, or soil. Sand volcanoes were also widespread in the Avon-Heathcote Estuary and offered an excellent opportunity to readily examine shallow subsurface profiles and as such the potential appearance of such structures in the rock record.

At the time of the earthquake the estuary was near to low-tide and the extensive tidal flats were sub-aerially exposed. Several hundred sand volcanoes formed across the tidal flats on the eastern side of the Avon-Heathcote Estuary. Local residents reported a strong sulphurous smell immediately after the earthquake; the result of erupted anoxic, H<sub>2</sub>S rich sands. At the surface, volcano diameter ranged between approximately 20-200cm, with most cones 50-100cm in size. Many were elongate or aligned in a more or less N-S direction and all cones showed a circular or elongate central crater.

Sub-surface features of these sand volcanoes were examined a few days after the earthquake following several tidal cycles. Most surface features had been removed, but subtle topography confirmed vent locations. Cross-sections revealed short subsurface conduits of approximately 25cm diameter and all cases the erupted sediment was fine grey sand. The source depth of the erupted material varied between 10cm and >30cm. The example sourced from 10cm depth also displayed subtle down-warping of overlying sediments in the vent area. In this sand-rich estuarine environment the conduit structures were only visible if they cross-cut black organic-rich sands, bioturbated muds and sands, or shell layers. Many of the conduits were still water saturated and collapsed easily.

The feature most likely to be preserved in the geological record is the thick conduit cross cutting other structures, with or without a thin trace of erupted sediments. Further de-watering of the sands within conduits and source sediments may occur with subsequent overburden, but these could not be seen in fresh, still wet, exposures.