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The Influence of Volcanism on Cool-Water Carbonate Diagenesis in the Canterbury Basin, New Zealand

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ABSTRACT

Cool-water carbonates are typically associated with destructive seafloor processes and rarely with precipitation of marine cements. In the Oamaru area during the Eocene, Surtseyan basaltic volcanic cones erupted into and onto a cool-water carbonate shelf and developed an offshore localised submarine volcanic palaeohigh supporting a carbonate factory dominated by bryozoans, echinoderms and foraminifera. The oceanographic setting at the time of eruption was of temperate marine waters and cool-water carbonates were accumulating on a shelf deprived of terrigenous sediment. This setting influenced porosity and carbonate chemistry of accumulated sediments affecting the diagenetic modifications available during burial. Volcanism also directly affected diagenesis at the seafloor through local hydrothermal interactions during and following eruption events.

Grains produced in the carbonate factory associated with the volcanic palaaeohigh accumulated adjacent to it in broad bryozoan grainstone shoals. Preserved carbonate components are calcitic, with aragonitic bioclasts conspicuously absent, as are terrigenous grains. Loss of aragonite components at the seafloor by dissolution is enhanced in the Oamaru setting by the highly porous nature of the pure bryozoan grainstones where both intra and intergranular porosity exist. The dissolved aragonite components are on the whole fluxed back to seawater and cements are minimal, leaving a highly porous calcitic limestone. This has meant that burial pore fluids are not enriched by dissolving aragonitic bioclasts and burial needs to proceed to pressure dissolution depths to generate pore fluids capable of precipitating porosity restricting cements. Although these calcitic grainstones may ultimately lose inter and intragranular porosity with deep burial they will likely retain high porosity, making them potentially good reservoirs rocks, until pressure dissolution can begin.

Precipitation of marine carbonate cements is limited in the Oamaru example but occurs in two settings. The first is driven by sea-level fall following the cessation of volcanism. Here porous bryozoan grainstones are brought into shallower, warmer waters and precipitation of marine cements has produced a local thin cap of well cemented limestones that have been further altered by subaerial exposure where the top of the palaeohigh has been exposed. The second driver of carbonate cement precipitation is associated with the emplacement of the volcanic cones themselves on top of the porous carbonate sediments. Following eruption the cooling volcanic core has driven hydrothermal circulation resulting in precipitation of carbonate cements. In a well exposed volcanic cone (Kakanui Headland) hydrothermal conduits are filled with microcrystalline carbonate and the cone is draped in a chloritised calcareous volcanic tuff. Here, precipitation of microcrystalline carbonate cement was driven by warm carbonate enriched hydrothermal fluids interacting with seawater. Where pillow basalts have intruded loose carbonate sediments (Boatman's Harbour) these have been baked and well cemented limestone formed between the pillows.

At Oamaru this pile of porous, calcite dominated, largely uncemented, carbonate material has been buried to shallow depths (<500m). The complete removal of aragonitic components at the seafloor suggests that high porosity would remain post-burial until pressure dissolution is well developed. However, hydrothermal circulation and sea level fall have led to localised cements being precipitated in the grainstones on and around the volcanic cones.