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Influence of Volcanism and Associated Magmatic Processes on Petroleum Systems, Oamaru, New Zealand, March 14-16, 2017

Distribution of Carbonate Reservoirs Controlled by Volcanism in the Canterbury Basin, New Zealand

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ABSTRACT

TThe Mid-Cenozoic units of the Canterbury Basin contain multiple cool-water carbonate and greensand sequences formed along a passive margin within a New Zealand wide transgression. Extensive volcanic activity created localized shallow water environments which affected the distribution of potential reservoir facies. Outcrop near Oamaru exposes carbonate facies deposited around these volcanic cones providing a window into the likely geometry of reservoir facies in the subsurface.

The volcanic tuff cones near Oamaru consist of olivine tholeiitic basalts (Waiareka-Deborah Formation) erupted in a field of closely spaced vents. Bedded, poorly-sorted, crystal-rich, lapilli tuffs are the result of monogenetic, Surtseyan-style eruptions forming subaqueous tuff cones on the continental shelf. Locally basaltic lavas were extruded into loose carbonate sediments at inner to mid-shelf depths forming pillows in a bryozoan-rich grainstone that has undergone contact diagenesis.

Surrounding the volcanic tuff cones are highly porous bryozoan grainstone - packstone facies (Ototara Limestone) that may become reservoirs. These facies show limited diagenesis with <3% cementation due to shallow burial depths (<500m). The thickest occurrences range from 45 m to 105 m thick near the volcanic centres, thinning and fining laterally to impure wackestones. Heavily fragmented calcite bioclasts, primarily bryozoans, echinoids, red algae and large benthic foraminifera, make up 37 – 86% of these facies with volcanic lithics present locally up to 10%. The depositional environment is interpreted as a winnowed shoal developed over a submarine volcanic palaeohigh. Moderate to high energy currents were enough to winnow carbonate mud and cause fragmentation. Shallow burial depths mean that diagenesis has not proceeded to loss of porosity, however, with greater burial pressure dissolution and pore-filling cements may be expected.

Overlying the bryozoan grainstones and volcanics are unconformably bounded, alternating packages of glauconite sandstones (Kokoamu and Gee Greensands) and glauconitic packstones (Otekaike Limestone). The glauconite sandstones are porous, poorly cemented, moderately to well-sorted, fine to medium sandstones and are likely to maintain the high porosity needed for a reservoir facies with deeper burial. Sandwiched between these units the glauconitic packstone (Otekaike Limestone) is more variable; it is thin atop the remnant palaeohigh but accumulates adjacent to it as porous, well sorted packstones and glauconite sandstones with variable amounts of carbonate mud. Clean, well sorted material indicates winnowing by submarine currents. Large asymmetric meandering channels are present to the north of the paleohigh filled with cross-bed sets up to 2 m high. Foreset beds alternate between low glauconite bioturbated packstone and highly glauconitic sandstone laminations, with packstones tending to be cemented, and glauconitic sandstones poorly cemented. These alternating packages reflect deposition in a current-winnowed, terrigenous-sediment-starved setting on the older palaeohigh following cessation of volcanism.

The development of a volcanic high in the Oamaru region with multiple tuff cones on which carbonate production could take place allowed for deposition of localized porous cool-water carbonate grainstone facies followed by porous glauconite sandstones. Regional transgression and drowning of the cool-water carbonate factory has the potential to develop a widespread regional seal. In the more proximal Oamaru region the seal is not well developed, however finer grained deeper water facies may be found offshore to the east.