Tubular Carbonate Concretions as Subsurface Indicators of Cold Seep Systems and Hydrocarbon Migration Pathways: Examples from North Island, New Zealand

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Cold seeps are commonly associated with the development of chemosynthetic communities and carbonate mineralisation induced by the anaerobic oxidation of methane. In the modern, such seep carbonates can occur on the sea floor above petroleum reservoirs where an important origin can be from ascending thermogenic hydrocarbons. The geological structures marking the ascent pathways in the shallow subsurface are poorly understood, but one such structure resulting from focused fluid flow may be tubular carbonate concretions.

Several Cenozoic sedimentary formations in New Zealand include a variety of tubular shaped carbonate concretions which commonly have a central conduit that may be empty or filled with later stage cements and/or foreign sediments. Stable oxygen and carbon isotopic analyses suggest that the cements were likely sourced from a mixture of ascending deep thermogenic and shallow biogenic methane. The diversity of tubular concretion morphologies may reflect differences in the tectonic setting, stratigraphic position, and fluid migration pathways during seep field development.

We suggest that the tubular concretions mark the subsurface plumbing network of cold seep systems and offer an opportunity to investigate their evolution based on ancient examples providing a linkage between the subsurface and surface systems. Seep field development has implications for the characterisation of fluid flow in sedimentary basins, the global carbon cycle, the biogeochemical controls on the development of marine communities, and the evaluation of future hydrocarbon resources, recovery, and drilling and production hazards. These matters remain to be fully assessed within a petroleum systems framework for New Zealand's Cenozoic sedimentary basins.