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Tubular carbonate concretions: fluid expulsion structures in the Hikurangi accretionary prism (New Zealand)

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Abstract

Some tubular carbonate concretions were recently interpreted as fluid circulation features in various tectonic settings. The mechanisms of formation of such structures, the origin and the nature of fluids involved, as well as the processes of fluid transfer remain poorly understood.

We document these mechanisms and processes from the analysis of some tubular concretions sampled in Miocene marly sediments from the eastern North Island of New Zealand (Hikurangi active margin). These analyses include microstructural, mineralogical and geochemical characterization of concretions and host rock.

The tubular concretions, 10 to 30 cm in diameter, often present an axial conduit (1 to 5 cm wide) that can be empty or filled with calcite crystals. The indurated cortex of the pipes has similar petrographic composition than the host rock: detrital grains (quartz, feldspars), pyrite (framboids or patches), microfossils (foraminifers, coccolithes) and a fine-grained silty matrix. The cortex is principally characterized by an important carbonate cementation. Some euhedral crystals of zeolite (clinoptilolite sometimes rich in barium) appear in the outer boundary of the axial conduit as well as in some veins within the cortex.

Chemical analyses show important variations between the pipes and the host rock. For example, $CaCO_3$ content ranges from 40 to 85 % in the cortex of pipes and is less

than 13 % in the host rock. Mass balance calculations demonstrate mainly an important input of Ca but also a slight input of Mn, Fe, and Mg, confirmed by microprobe measurements. This cementation increases toward the centre of the pipes. These differences in the chemical composition reveal a simple dilution of elements that do not precipitate in calcite (Si, Al, Ti, Na, K).

δ^{13}C measurements suggest that fluids involved in the cortex formation were rich in organic carbon (cortex: -3 ‰ $< \delta^{13}$C PDB $<$ -6 ‰, host rock $\sim$ 0,13 ‰ PDB). The δ^{18}O data indicate a marine source and relatively low temperatures (-2 ‰ $< \delta^{18}$O PDB $<$ 2 ‰ on tubes as well as on host rock).

Our results shows that these tubular concretions developed from an important ascendant fluid flow under pressure and at relatively low temperature (less than 50˚C). The axial conduits of the tubular concretions are the main drains of the fluid migration. The cemented cortex of the tubes is the result of fluids migration from the axial conduit through the host rock.

Keywords: Carbonate, Tubular concretion, Active margin, Fluid flow, New Zealand.