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Feeder pipes – Expression of the uppermost plumbing system in Oligocene methane-seep deposits, Washington State, USA

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Plumbing systems of methane seeps are complex pathways along which hydrocarbon-rich fluids migrate upward through the marine sedimentary column. Seeps commonly maintain fluid flow over long periods of time, providing a steady supply of methane to shallow sediments and the water column. At greater sediment depths, fluid transport is facilitated by faults and conduits, which enable migration of fluids sourced from deep hydrocarbon reservoirs. In the shallow subsurface, plumbing systems may become successively filled by authigenic carbonates, whose precipitation is partly triggered by sulfate-dependent anaerobic oxidation of methane (AOM). To expand our knowledge on the uppermost plumbing network of ancient seeps, this work investigates fluid conduits that were mineralized by a distinct succession of authigenic mineral phases. These mineralized conduits, which occur below an Oligocene seep deposit from the Lincoln Creek Formation in Washington State, are referred to as feeder pipes here. The concentrically-zoned feeder pipes are 2 to 3 cm in diameter. The mineral phase that formed first is matrix micrite, making up the outer part of pipes. Toward the center, pipes are filled by clear, banded and botryoidal aragonite cement, which is intercalated with yellow aragonite cement. The innermost portions of the pipes are filled by either pipe-filling micrite, microspar, or brownish calcite. The observed paragenetic sequences archive successions of various biogeochemical processes. Clear and yellow aragonite cements are distinctly depleted in 13C, revealing that their formation was favored by AOM. In contrast, later phases including brownish calcite and microspar are enriched in 13C, pointing to precipitation from fluids affected by methanogenesis. Their size and morphology indicate that the pipes were initially produced by seep-dwelling, burrowing organisms. The burrows subsequently acted as preferred fluid pathways. Possible producers of the burrows include various bivalves and callianassid decapods. Based on petrography and stable isotopes patterns, we conclude that the pipes facilitated seepage of methane-rich fluids to the sediment-water interface.