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Prelude to the Toarcian OAE: Late Pliensbachian (Early Jurassic) Cold Seep Carbonates

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We present evidence for methane seepage during the Early Jurassic (185 Ma) in the form of newly discovered extensive occurrences of carbonate concretions that resemble the subsurface plumbing system of better known Cenozoic to Recent examples of cold seep carbonates. Columnar carbonate concretions of up to 1 m in length that are perpendicular to bedding, occur abundantly in the Upper Pliensbachian (upper Amaltheus margaritatus Zone, gibbosus Subzone) in outcrops in the vicinity of Rivière-sûr-Tarn, southern France. Stable isotope analyses of these nodules show depleted C-isotope values that decrease from the rim to the center from -18.8 to -25.7 permil (V-PDB), but normal marine O-isotope values (-1.8 permil). Computer tomographic (CT) scanning of the columnar concretions show one or more central canals that are lined or filled entirely with pyrite and late diagenetic minerals. Septarian cracks are also filled with secondary calcite and/or siderite. Based on our preliminary geochemical and sedimentological observations we suggest that these concretions formed as a combination of the anaerobic oxidation of methane (AOM) and sulfate reduction within the sediment. Previously, these concretions with one, two or more central tubes have been ascribed to the activity of an enigmatic organism, possibly with annelid or arthropod affinities, known as Tisoa siphonalis. Our results suggest tisoan structures are abiogenic. Interestingly, Tisoa siphonalis has been described from many locations in the Grands Causses Basin in southern France, and from northern France and Luxemburg, always occurring at the same stratigraphic level. Upper Pliensbachian cold seep carbonates thus possibly cover an area of several thousand square kilometers, largely distributed across the basin centres of the NW European epicontinental seaway. Our findings may have far reaching implications for understanding the Toarcian Oceanic Anoxic Event, which is interpreted to bear the hallmarks of catastrophic methane release from gas hydrates in the form of a pronounced negative C-isotope excursion. Carbon isotope analyses of Late Pliensbachian bulk carbonate (matrix) samples show clearly decreasing C-isotope values across the margaritatus Zone and reach -3 permil within the uppermost Pliensbachian spinatum Zone. We attribute this decrease to seeping fluids that led to induration and diagenesis. Isotope analyses of coeval belemnite rostra do not document such a negative C-isotope trend with values remaining stable around +2 permil. Hence, if methane was seeping prior to the Toarcian OAE, it appears not to have imprinted global carbon reservoirs.