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Iron-rich coccoidal microcrystals and framboids in submarine, methane-derived carbonate chimneys (Gulf of Cadiz, SW Iberian Peninsula): mineralogy, textures and astrobiological relevance

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Mineral associations and other signatures of microbial activity were studied in submarine, hydrocarbon-derived carbonate chimneys. These vent structures were sampled to a depths ranging from 750 to 1100 metres at the Gulf of Cadiz, SW Spain, under extreme conditions for life: absence of light, deficiency of oxygen, high water pressure and high concentration of hydrocarbon and iron related metals. The chimneys are a result of anaerobic oxidation of methane and other hydrocarbons. Various authors have proposed the existence of direct relations between anaerobic oxidation of methane and sulphate reduction, through a syntrophic interaction of methanogenic archaea and sulphate-reducing bacteria. The walls and covers of the bacteria cells have a great number of chemically reactive sites where some elements are retained, favouring the precipitation of iron sulphides. The mineralogical signatures of microbial activity consist of the development of coccoidal microcrystals of iron sulphides and hydroxides, which are pseudomorphing pyrite, and organized as either isolated framboids or spectacular multiframboidal aggregates. The primary and secondary porosity regions are the main sites where the framboids occur (particularly inside foraminifer tests and inter-clast porosity). Multiframboidal texture represents the mineral, geochemical and biogenic evolution of the sulphate reduction bacteria activity, and is characterized by a mixture of morphologies and habits representatives of the different states of evolution of the simple framboidal texture. The textural evolution ends with: a) the formation

of euhedral crystals, loosing their original framboidal shape and the development of organic matter inclusions parallel to the crystal faces, or b) the formation of prismatic crystals rimming the framboids (Ostwald ripenning). Oxidizing conditions of seawater promotes the subsequent formation of iron hydroxides. The good understanding of biomineralizing process under extreme conditions provides new investigations ways which can be applied to the interpretation and modelling of terrestrial systems and also has significant astrobiological implications. In the Gulf of Cadiz exists a narrow relation between extreme conditions and fluid rich in hydrocarbon vent, and could represent a possible environment of life on Early Earth and others planetary bodies.