



## **The submarine river of Port Miou (France), A karstic system inherited from the Messinian deep stage**

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The Port Miou system (Cassis, France) is a two kilometers long submarine gallery that extends in the limestone series of Calanques (Marseille, France). The average discharge is between 2 to 5 m<sup>3</sup>/s but the water is brackish and cannot be used for water supply. In the 1970s, a dam was built to prevent saltwater intrusion in the cave but these experimental attempts did not succeed in getting rid of the residual salinity which remained near 3 g l<sup>-1</sup> upstream the dam. The use of helium and later rebreathers by cave divers made possible the exploration of a vertical pit down to 179 m below the sea level. At that depth, the water is still brackish. The cave extends further and deeper but the exploration is limited by the present diving technology.

The canyon of Cassidaigne is located a few kilometers south from Port Miou. It cuts the continental shelf where bathymetric studies have shown the presence of dolines. Caves and speleothems have been observed during submarine explorations on the walls of the canyon. This canyon is not connected to a continental valley and it is assumed that it is a pocket valley. Its presence is related to the several lowering stages of the Mediterranean Sea during the Messinian Salinity Crisis. We suggest that during the important drop of sea level of the Mediterranean, the underground river of Port-Miou, flowed several hundreds meters below its current position, and excavated the canyon. At the end of the Messinian crisis, the system was flooded by seawater. The karst water now flows through an upper gallery but the presence of a paleo-drain filled by seawater makes possible a deep marine intrusion into the karst system.

Several geomorphologic clues (bathymetry, submarine valley network...) reinforce the fact that the continental shelf near Marseilles is an important karstic network drowned below the sea level.

This model is supported by the observation in Port Miou of an important quantity of titanium at the upper surface of the cave sediment, upstream of the dam and at the end of the cave. The presence of heavy metals in the sediments of the Port Miou gallery is explained as resulting from the suction of residues of bauxite treatments, rejected in the nearby Cassidaigne deep-sea canyon at a depth of 300 m bsl. This residual product locally called *red muds* very rich in titanium.

The saline contamination of Port Miou could be carried out by a seawater inflow through a deep karstic conduit connected to the canyon of Cassidaigne. A long term monitoring of the springs, indicates that the system is contaminated by a permanent seawater inflow close to 500 l.s<sup>-1</sup>. A laboratory model has been realized that simulates perfectly the functioning.