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Organic Matter Deposition at High Lattitudes: An Example from the Early Paleozoic Tanezzuft Formation (Tunisia)

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ABSTRACT

The preconception that fine-grained sequences are monotonous successions, might lead one to think source rocks as homogeneous sequences with uniform lateral and vertical properties. On the contrary they represent complex sedimentary sequences characterized by strong internal heterogeneities. Integrating data coming from different analyses allows to capture this depositional complexity, otherwise lost when using exclusively simple lithostratigraphic approach. In this work we present the application of this integrated and multidisciplinary approach to the Silurian Tanezzuft Formation. The Tanezzuft Formation is an atypical example of black shale deposition in a world covered by ice-sheet; it consists of an alternation of organic-rich shales and sandstones deposited during the Silurian. The peri-glacial conditions in which the Tanezzuft Formation was deposited makes it a fascinating example of extraordinary paleoceanography settings that greatly influenced depositional processes, thus allowing peculiar conditions of enhanced organic matter preservation. The formation is marked at its base by a layer called “Hot Shale” for the high accumulation of organic matter and for its concentration of radioactive uranium. The basal layer, with peak of organic matter concentration greater than 35% wt., passes upward to “Warm Shales”, in which organic matter concentration decrease to about 15% wt. These incredible naphtogenic properties make the Tanezzuft Formation one of the most important source rocks in North Africa. We present an integrated sedimentological characterization of the Tanezzuft Formation in the North Africa Platform in Southern Tunisia that examines the depositional and paleoceanographic processes that controlled the organic-facies sedimentation (Gambacorta et al., 2016). The study area, located on the northern flank of the Ghadames Basin, is covered by many wells with a huge available dataset, spanning cores, petrophysical logs, TOC and Rock-Eval Pyrolysis data, X-Ray Diffraction, Optical Kerogen Analysis and Palynofacies. Facies maps were generated in order to describe the vertical and lateral facies variation at different scales. Available data indicate a paleo-provenance from SW with an overall coarsening upward trend. Both 3rd order cycles and 4th order parasequences were identified, thus allowing a proper definition of the depositional architecture. Paleo-provenance and sediment origin were investigated using X-Ray Diffraction data. Optical Kerogen Analysis, Palynofacies and Rock-Eval Pyrolysis data were used and interpreted to define the type and depositional dispersal of organic matter. In the studied sequence the organic matter is mainly constituted of Amorphous Organic Matter, Leiospheridae and Tasmanaceae. The deposition at high-latitudes and consequent cold conditions is suggested by the poor content of Graptolites. The definition of the depositional architecture allowed a point to point reconstruction of the original values of TOC and HI. The evaluation of the control played by preservation on the deposition was instead analyzed in a second phase, using a forward modeling approach (OF-Mod, Organic Facies MODeling, by SINTEF (Mann and Zweigel, 2008)). The modeling results were compared with the reconstructed original TOC and HI logs and original TOC and HI distribution maps in order to test the more reliable depositional processes involved. According to the simulation, the best fit with

observed data can be explained as the result of extraordinary water stratification conditions, with lack of efficient water circulation due to both the existence of wide regional isolated basins inherited from complex basement structural settings and the flooding of waste areas due to an important post-glacial sea level rise. The obtained results suggest that the Water Stratification model proposed by Armstrong et al. (2005) is the most reliable, and more in detail, the evidence of phases of intense productivity seems to point to a Strakhov depositional model (Strakhov, 1971). The paleoceanographic evolution of the Northern Gondwana margin is the key to understand not only the processes linked to the accumulation of organic matter in peri-glacial region, but also to predict the lateral and vertical variations of organic-rich facies, to reduce the uncertainties associated with Petroleum System Modeling and, consequently, the risk associated with petroleum exploration.