Drilling below the salt in the Western Mediterranean Sea

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The “GOLD” IODP Project: Global Climate Changes, Extreme Events, Margins formation, Sea-level changes and the limits of Life in the Gulf of Lion, Western Mediterranean Sea.
The Gulf of Lion has appeared in the last years as a unique natural laboratory to study both evolution and interaction of deep processes (geodynamics, tectonics, subsidence, isostasy) and more surficial processes (rivers behavior, sedimentary fluxes, sea-level changes, climate impact...). Here, we present, in the name of a large group of international researchers, the main objectives for a deep drilling **GOLD-1** project at the toe of the continental slope (2400 m water depth) in the Gulf of Lion.

The position of the GOLD-1 drilling is located sufficiently far from the shelf and slope to be saved from the Messinian outstanding erosional event, and also free from salt faulting and salt diapirs that deform deposits. At this position we record the full and very high resolution history of the last circa 30 Ma of earth history within 7.7 km of sedimentary archives without major erosion and hiatuses. It should be emphasized that no academic DSDP-IODP drillings dealing with pre-5million year exist in the Mediterranean Sea.The objectives of the GOLD-1 drilling are numerous, such as:

1) For the substratum, seismic reflexion data (ECORS and SARDINIA data) image quite clearly, at the toe of the slope, the limit between continental crust and transitional substratum where

highly reflective lower crust clearly visible below the shelf, disappears. Refraction data confirm those observations: the upper continental crust thins to less than 5 km, and changes laterally to a relatively thin crust with high velocities which precise nature is still a problem. Magnetic maps also indicate a large smooth domain as sometimes observed at the toe of margins in the world. The aim of the drilling is to bring crucial information on the nature of this puzzling crust. The recognition of paleoenvironments and dating of early sediments on the crust will enable us to have the first paleobathymetric markers to reconstruct the subsidence and thermal history of the margin.

2) The Gulf of Lion receives most of the sediments eroded from the Alps and transported through the Rhône River. We infer that the amount of sediment will vary significantly according to the existence or not of ice sheet and glaciers. We will therefore date and characterize the impact of the initiation and the change in glacioeustatic cyclicities on alpine glacier and ultimately on sedimentation in the deep basin during Pliocene and Quaternary. For the Miocene and older sediments (Oligocene?), the drilling combined to seismic reflection data, will give the nature, the paleoenvironments and dating of deposits enabling to refine the Astronomically Tuned Neogene Time Scale for a very badly known period (Aquitanian, Burdigalian and Langhian).

The Messinian extreme event represents a unique sedimentological, hydrological, oceanographic, biological and probably climatological crisis in earth history. It is a unique case to study and quantify the impact of an outstanding sea-level drop (more than 1500 m, one order of magnitude greater than the Late Quaternary glaciations) on sedimentary river behaviour, deltaic and evaporitic deposition, but it is also a biotic crisis. Furthermore, the amount of messinian deposits (detritics, evaporites and salt deposits) reaches more than 3000 m which corresponds to an enormous depositional rate. Such important erosion and sedimentation must provide crucial information on margin dynamics (isostasic readjustment). So far, DSDP and IODP drillings have reached the upper part of the evaporites only, the beginning of the crisis is still a matter of intense debate and conjectures. Coring all messinian series is crucial to understand the origins and timing of closure and opening of Western Mediterranean connections with the Atlantic and/or Eastern Mediterranean. Our observations suggest a thick series of «lower evaporites», under the halite but above major detritic deposits. Other interpretations suggest evaporites deposition before major detritic phase under variable water-columns. The deep drilling with the R/V Chikyu is the only way to go through the complete serie of evaporites in the Provence Basin, sample the initiation and evolution of the crises, the first deposits related to the lowering of sea-level on one hand and to the salinity crisis on the other.

3) Studying the deep subseafloor microbial communities of the Gulf of Lion and reach the biotic fringe. This drilling represents the first opportunity to study the microbial communities from deep marine sediments of the Mediterranean Sea, the so-called ‘deep biosphere’. This site is particularly interesting to address the question of life’s tolerance to environmental extremes and habitability since extreme conditions such as high P, high T°, salt layers (are there organisms in salt inclusions?) and particular organic matter content are prevailing. The ultra-deep drilling GOLD should reach 7700 mbsf when the present-day deepest detection for molecular signatures of microbes is at 1626 mbsf. Consequently, it would represent an opportunity to reach the biotic fringe and determine the limits of life in terms of depth and physicochemical constraints. This drilling is also interesting to study the questions of dispersal and evolution (isolation during Messinian salinity crisis), and the interaction biosphere-geosphere.

The drilling will also enable to estimate potential greenhouse gases storage in pre-salt reservoirs as well as potential geothermal, hydrocarbon and Lithium resources.

Finally, the drilling could be a site for a deep instrumented observatory.