Preliminary Results of IODP Expedition 339 „Mediterranean Outflow“

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The main target of IODP Expedition 339 (starting at Ponta Delgada, Azores on 18 November 2011, terminating in Lisbon on 17 January 2012) was the contourite depositional system in the Gulf of Cádiz and off the West Iberian margin as a key location for the investigation of the Mediterranean Outflow Water (MOW) and its influence on North Atlantic circulation and climate. The Gulf of Cádiz is the world's premier contourite laboratory and presents a unique opportunity to test current models of contourite formation. it is also a prime target for understanding the effects of tectonic activity on the evolution of the Strait of Gibraltar and on margin sedimentation.

Overall, IODP Exp. 339 had five major objectives:
1) Understand the opening of the Gibraltar Gateway and onset of MOW.
2) Determine MOW paleocirculation and global climate significance.
3) Establish a marine reference section of Quaternary climate change.
4) Identify external controls on sediment architecture of the Gulf of Cadiz and Iberian margin.
5) Ascertain synsedimentary tectonic control on architecture and evolution of the contourite depositional system.

To meet these objectives, five sites were drilled in the Gulf of Cádiz (U1386, U1387, U1388, U1389, and U1390) and two sites off the West Iberian margin (U1385 and U1391) (Fig. 1), with the deep Site U1385 located outside the main core of the MOW. A total of 5447 m of core were recovered (86.4% recovery), and downhole logging was performed in all but two sites (U1385 and U1388).

Based on the shipboard stratigraphy, Miocene sediments have been penetrated at two different sites, implying the strong presence of MOW in the sedimentary record following the opening of the Gibraltar Gateway. Contourite deposits have been identified from ~4.2 to 4.5 Ma, although affected by downslope sedimentation processes and hiatuses. Post-cruise research will establish whether this dates from the first onset of MOW. Pliocene sequences have been recovered at four sites, all of which imply relatively low bottom current activity and generally weak MOW, with evidence for a slow increase in current speed through the late Pliocene. Significant hiatuses appear at around 3.0 – 3.2 and 2.1 – 2.4 Ma at different sites, and are interpreted as a consequence of enhanced bottom currents related to intensified and/or confined MOW flow. Quaternary sediments are generally dominated by contourite deposition and drift development. Two periods of successive current intensification have been noted based on the increase of sandy and silty contourites. The first is from ~2.0 – 0.9 Ma culminating in a regional hiatus of variable duration from ~0.7 – 0.9 Ma, the second ranges from 0.9 Ma to the present with a minor hiatus at ~0.4 Ma.

The contourite deposits recovered are quite uniform in composition and texture. Remarkable is the absence of primary sedimentary structures and an intense bioturbation. Characteristic is a bigradational grading with a large range of partial sequence types in accord with contourite formation models. Unexpected was the quantity and extend of well-sorted and clean contouritic sands. These sands represent a previously unrecognized exploration target for oil and gas reservoirs. However, complex interactions between contourite and turbidite processes have been documented that are not incorporated into current contourite models. Further studies will allow us to resolve outstanding issues of depositional processes, drift budgets and the recognition of fossil contourites in the ancient record onshore.

For the investigation of orbital and millennial climate fluctuations Site U1385 ("Shackleton Site") has been successfully drilled with four holes down to ~150 mbsf allowing the construction of two complete splices dating back to ~1.4 Myr. The seminal work of Nick Shackleton and co-workers (e.g. Shackleton et al., 2000, 2002) have demonstrated the great potential of Iberian Margin sediment cores for high-resolution paleoceanographic and paleoclimatic reconstructions as they can be confidentially tied to Antarctic and Greenland ice core records as well as to European terrestrial archives. A comprehensive post-cruise sampling effort is planned to generate a high-resolution reference record which will greatly improve the precision with which marine sediment records of climate change can be correlated to ice cores and other terrestrial archives. It furthermore appears from shipboard measurements that the same climatic cycles preserved in Site U1385 sediments are also evident in all contourite drift sites, albeit with a 3 – 10 fold higher sedimentation rate. This will provide the base for even more detailed sampling of these sites aided by a very robust stratigraphic correlation with Site U1385. This excellent stratigraphic control will moreover allow to indentify and precisely date hiatuses in the contourite records.

The drilling enabled the dating of major unconformities and minor discontinuities identified on seismic reflectors which is important in order to calibrate the existing seismic stratigraphic framework. The study of the sedimentary architecture of the contourite depositional system is pivotal to distinguish between external controls such as climate, sea level and local tectonics in order to establish a refined sequence stratigraphic model for contourite deposits. Aside of climate variations, tectonic activity appears to have exerted a strong control on margin development, downslope sediment transport and contourite drift evolution. This is particularly valid for the time interval from the closure of the Atlantic-Mediterranean gateways in Spain and Morocco just over 6 Ma and the opening of the Gibraltar Gateway at 5.3 Ma. Based on the timing of

events major tectonic pulses are identified in the sedimentary record, linked with asthenosphere activity. These pulses are related to the closure of Atlantic-Mediterranean connections, opening and subsequent deepening of the Gibraltar Gateway, continental margin instability, basin subsidence, local uplift and diapiric intrusion. These processes influenced the strength and nature MOW flow and, hence, sedimentation processes in the Gulf of Cadiz. The material gathered during IODP Exp. 339 and subsequent post-cruise research will greatly improve our understanding of the timing of these processes and feedbacks involved.

References:
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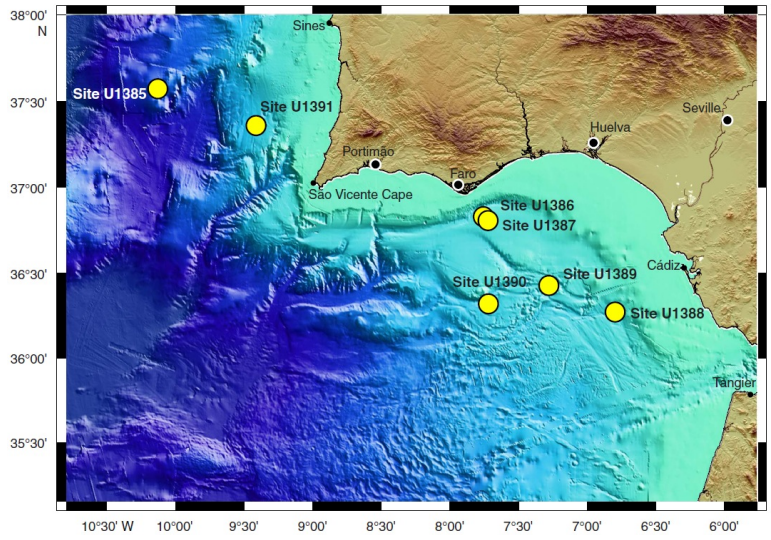

Figure 1 Expedition 339 sites in the Gulf of Cádiz and West Iberian margin.