IODP Expedition 339: Mediterranean Outflow
Site U1390 Summary

Background and objectives

Site U1390 (proposed site GC-02B) is located on the southern Iberian Margin (36°19.110' N and 7°43.077' W) about 130 km W of the Spanish city of Cadiz, in a water depth of 992 m. This is the second of two sites drilled in the 'channels and ridges' sector of the larger Cadiz Contourite Depositional System (CDS). It is located near the western end of a sheeted drift adjacent to the Guadalquivir Contourite Channel ~300 m above the channel floor, and approximately 20 km NW of the of the Guadalquivir diapiric ridge.

This sheeted drift is known as the *Guadalquivir* drift, which is part of a much larger middle-slope sheeted drift system that has been dissected by several contourite channels. Site U1389 lies on the Huelva drift, which is another dissected portion of this same system also under the influence of Lower Core MOW (see "Summary" for U1389). On seismic profiles it shows a well-layered internal acoustic structure with laterally extensive, mainly aggradational seismic depositional units. It lies unconformably above two earlier buried drifts that have been differentially tilted up towards the N adjacent to the tectonically elevated Guadalquivir Bank.

Our primary objective at this site was to recover the Pliocene-Quaternary sedimentary succession close to and affected by tectonic uplift of the Guadalquivir Bank. By penetrating the unconformities between the surface and buried drifts we have been able to evaluate the timing of this tectonic activity and its effects on drift sedimentation. The secondary objective was to further assess drift sedimentation under the influence of the MOW Lower Core.

Site U1390 was occupied on 2 January 2012. Three holes were drilled and cored using the advanced piston corer (APC) and the extended core barrel (XCB) system, achieving the target depth of 350 mbsf in the first hole, U1390A. The second and third holes were piston-cored to refusal. Downhole logging was carried out at Hole U1390A using the Triple Combo and FMS-Sonic tool strings. Overall recovery for Site U1390 was 438 m (98%) with the APC and 248 m (91%) with the XCB. The total cored interval for Site U1390 was 719.5 m and total recovery was 686.3 m (95%).

Main results

Whereas our pre-drilling interpretation had assumed a relatively low rate of sedimentation above base-Quaternary and mid-Pliocene unconformities, instead we found very high rates of sedimentation under the influence of an active Lower Core of the MOW. The unconformities noted on seismic records, therefore, are much younger than expected. The basal unconformity of Guadalquivir drift is from 0.9-1.2 Ma, and the bottom of the hole reached to about 1.3 Ma.

The sedimentary succession at Site U1390 extends for 350 m from the mid Pleistocene to Holocene. It is represented by a very rapidly accumulated and uniform series of contouritic sediment, which has been assigned to a single lithostratigraphic unit that is divided into two sub-units (Sub-Units IA and IB). Unit I is dominated by classic contourite deposition, including calcareous mud, silty mud, sandy mud and silty bioclastic sand lithologies. These are generally organized as bi-gradational sequences and partial sequences, of which base-cut-out normally-graded sequences are more common than top-cut-out inversely-graded sequences. Carbonate content ranges from 21-35%, and total organic carbon from 0.4-1.1%. The division of Unit I into two subunits is based on a marked change at 290 mbsf in the relative abundance and thickness of the silt/sand intervals. These are more prominent in Sub-Unit IB, with the sandy facies making up around 50% of the total.

Calcareous microfossils (nannofossils, planktonic and benthic foraminifera, and ostracods) are mostly common to abundant, with moderate to good preservation throughout. Pteropod fragments are present sporadically. There are two relatively short hiatuses from 0.3 to 0.6 Ma and 0.9 to 1.2 Ma, separating intervals with rapid rates of sedimentation: averaging 75 cm/ky above the upper hiatus and 85 cm/ky below. Holocene sedimentation rates are also very high – around 80 cm/ky. Although age constraints are not yet refined, it appears that the rate below the lower hiatus exceeds 100 cm/ky. This is the highest rate we know of for any contourite drift site.

There is a distinctive variability in benthic foraminifer assemblages, which reveals significant long-term trends as well as short-term cycles of environmental change. Comparable with other sites, the upper 0.9 My of the Quaternary shows typical upper

bathyal assemblages indicative of increased organic matter input and reduced ventilation. The remainder of the Pleistocene shows lower nutrient supply and greater ventilation. The direct role and influence of the MOW at this site requires further study. The shipboard palynological study was carried out at a very coarse resolution but, as for other sites drilled, shows dominance of the four main plant ecological groups that characterize this region – *Pinus*, Mediterranean forest, semi-desert and grasslands.

Magnetostratigraphy proved difficult to resolve closely, in part due to coring disturbance and in part due to presence of hiatuses at or near critical polarity transitions. The upper 230 m of section is within the Brunhes chron, but the deeper section requires more detailed shore-based study to resolve. Strong peaks in magnetic susceptibility in these cores appear to correlate with large amounts of diagenetic iron sulfides (presumably including greigite and pyrrhotite).

As has been observed at the other sites drilled during Expedition 339, physical property data show relatively close tracking of magnetic susceptibility and bulk density in much but not all of the section. These may correlate or anti-correlate with NGR values, and with color reflectance (L* and a* values). Both larger-scale trends and smaller-scale cycles are evident, with some correlation at the small-scale with lithology.

The pore water profiles at Site U1390 show significantly higher concentrations of many elements (including Na, Cl, Ca, Mg, Sr and NH_3) than at any of the other sites drilled thus far, including Site U1389 where the values reached a distinct maximum at around 530 mbsf. However, the high chloride and sodium concentrations are associated with low δD values, which indicates that high salinity may not be the result of in situ salt dissolution. Instead, we suggest that salts were dissolved at depth by pore waters that had been altered by clay mineral dehydration reactions, which can also affect water sodium concentration.

Downhole measurements were made in Hole U1390A to a depth of 350 mbsf, with good quality data obtained due to good hole conditions especially in the upper 270 m. There is a distinct change in log characteristics at around 290 mbsf, which correlates closely with the lithostratigraphic boundary between sub-units and with the change downhole to a more sand-rich lithology. Distinct cyclicity is apparent in some parts of the section, corresponding with both lithological and physical properties data. Nine downhole

temperature measurements were made in the top 110 m of section, yielding a geothermal gradient of 32.0 °C/km.

Highlights

At Site U1390 we penetrated a 350 m section that extends from the mid Pleistocene to Holocene. The site lies under the influence of Lower Core MOW close to the Guadalquivir contourite channel, and shows very high rates of sedimentation, both for the sand-rich and mud-rich sections. With maximum rates of 85 cm/ky (and perhaps in excess of 100 cm/ky), these are the highest known for contourite drifts anywhere. As a result, some of the contourite muds retain a distinctive lamination (albeit discontinuous in character), while the thicker sands are especially clean and well sorted. There are two important hiatuses, at around 0.4 and 0.9 Ma, which reflect episodes of enhanced bottom current flow, in part related to tectonic adjustment of the local topography. Significantly, these hiatuses are correlative across the Cadiz Contourite Depositional System on the basis of seismic stratigraphy, and are recognized as more minor events at our other sites.