Mediterranean undercurrent contourites in the Gulf of Cadiz (Spain) : (I) Pliocene-Quaternary seismic facies and bedform patterns

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The seismic stratigraphy of the central region in the Gulf of Cadiz exhibits three major sequences well characterized in both single and multichannel reflection profiles (Fig. 1). The underlying sequence forms the nucleus of linear diapir structures intersecting the slope in a WSW-ENE direction. The intermediate sequence is composed of several units with discontinuous and parallel reflectors, separated by unconformities. These units are largelly attributed to low-energy, terrigenous deposits, which are characterized by the absence of major channels or erosional/depositional features. The youngest sequence is Plio-Quaternary in age and it shows at the base a major erosional unconformity, which is deeply entrenched in the underlying deposits. This sequence is made of contourite facies which formed on the eastern Gulf of Cadiz continental slope. Here the Mediterranean undercurrent has flowed northwestward parallel to the slope contours since the Pliocene opening of the Strait of Gibraltar.

The contourite facies change westward and downstream because of an interaction between the linear diapiric ridges that are perpendicular to the slope contours and the progressive northwest decrease in speeds of the undercurrent. Coincident with the decrease in undercurrent speeds from the Strait of Gibraltar, the following northwestward gradation of contourite seismic facies occurs: (1) sand dune contourite facies on the upstream mid-slope terrace, (2) sediment-drift facies banked against the diapiric ridges, and (3) smooth slope facies with generally continuous, parallel-stratified reflectors (Fig. 2). Downstream, there are several hundred-meter thick sediment drift wedges of sediment drape deposits and high-energy deposits with irregular erosional surfaces and broad-scale, low-angle unconformities.

In the upstream contourite facies, sonar images reveal a wide variation of bedform fields on the present seafloor, caused by variations in undercurrent speeds, as well as by changes in superficial sediment texture. These bedforms range laterally from (a) 2-D, transverse sand dunes in channel floors, to (b) 3-D barchan dunes that laterally evolve to (c) large, straight-crested 2-D dunes, and to (d) 3-D irregularly-shaped dunes, in the silt-covered slope terrace. In contrast, down-valley Mediterranean undercurrent ribbons flowing along the channels between the ridges modify the basic east to west sequence of contourite facies. The down-valley facies exhibit major erosional truncation, and extensive cut and fill facies on seismic profiles (Fig. 1). Sonographs collected across the channelized central sector show (e) erosional scarps, sand patches or rock-outcrops exposed on channel floors; (f) small and parallel 2-D dunes, or (g) regularly shaped, variably size, 3-D dunes along valley walls.

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The surface contourite and sediment drift facies on the Gulf of Cadiz slope have formed during the present Holocene high sea-level and full development of the Mediterranean undercurrent. Late Pleistocene hemipelagic-drape facies underlying the Holocene surface sand dune and drift facies correlate with the last lowstand and apparent weak Mediterranean undercurrent development. This Late Quaternary history and the facies stratigraphy observed in reflection profiles suggests that the cyclic Pliocene and Quaternary deposition of contourite and sediment drift, alternating with mud drape facies is related to sea level changes and Mediterranean/Atlantic water circulation patterns.

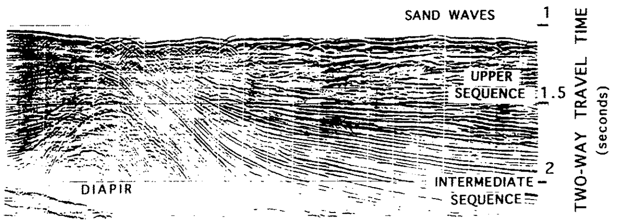

Fig. 1. - High resolution MCS profile from sand wave area showing the three main lithoseismic sequences in the central sector of the Gulf of Cadiz.

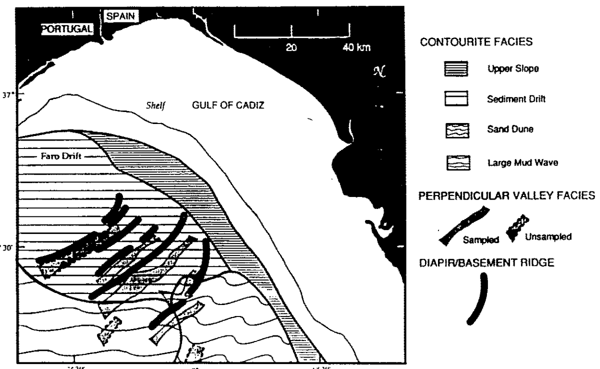

Fig. 2.- Distribution of contourite and other current-deposited facies of the Cadiz margin slope (Modified from NELSON *et al.*, 1992).

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Extensional tectonics along the Dead Sea Rift : the separation of northern Arabia from North Africa?

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The Dead Sea Rift is a 600 km long, 20 km wide geomorphological depression, that shows topographic reliefs of 1,000 to 3,000 m from the axial depression to its mountainous margins in many places. The Rift is the northern extension of the young oceanic spreading center of the Red Sea, and it is built of a series of internal basins, dispersed along the axis of the Rift with 60 - 120 km spacing. The Rift is primarily the product of vertical displacements that downfaulted its floor and uplifted its margins, but some sinistral strike-slip offset affected the Rift as well. The tectonic evolution of the Rift probably started in the Pliocene, subsequent to the termination of the intensive tectonic activity in the Suez Rift in the late Miocene. The transition of the tectonic activity from the Suez Rift to the Dead Sea Rift is due to a probable clockwise jump of the northern edge of the Red Sea spreading center. It is suggested that the morphological and structural similarities between the Suez and the Dead Sea Rifts stem from comparable, though noncontemporaneous, tectonic regimes. The Dead Sea Rift, with its internal basins and its faulted precipituous escarpments, presents an outstanding example of the earliest stages of the evolution of continental break-up and of nascent passive continental margins.

Tectonic interpretation of the voluminous geological and geophysical data from the Rift and its margins is complicated because the information is ambiguous. Part of the data suggests that the Rift is an extensional structure, whereas another part indicates that the Rift is a product of regional sinistral strike-slip faulting. However, it is suggested that the equivocal data are not necessarily conflicting, because the evolution of the Rift is probably associated with resultant displacement of oblique displacement, combining normal and strike-slip faulting. Whereas the interpretation of the oblique offset along the Rift is generally accepted, the quantitative ratio between the extensional and the lateral displacements along the Dead Sea Rift is controversial. There is ground to presume that large downfaulting of the Rift floor and intensive erosion of its uplifted margins obscured and removed critical data that could have provided reliable correlation between the eastern and western flanks. Nevertheless, reconstruction of Triassic, Jurassic and Cretaceous depositional facies zones across the Rift apparently indicates that the lateral displacements along the Rift are approximately 10 km, and various late Tertiary and Quaternary geological features in Syria and Lebanon are in agreement with this interpretation. The amount of displacement by normal faulting is considerably larger than the morphological relief, and seismic reflection profiles suggest vertical offsets that reach 7 km in places. The series of secondary internal basins in the Rift, that seem equivalent to the linear system of axial basins in the northern Red Sea, support the concept that the present Dead Sea is under a tectonic regime that is comparable to the one that affected the Red Sea during the Miocene. These findings are supported by the 25 to 50 percent reduction of crustal thicknesses underneath the Rift. It is suggested that the Dead Sea Rift is an incipient, oblique oceanic spreading center, separating northern Arabia from North Africa.

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