Upslope turbiditic sedimentation on the South-Eastern flank of the Mediterranean ridge

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Piston cores recovered on the outer deformation front of the Mediterranean Ridge (cruises BAN-82 and BAN-84 of R/V *Bannock*) on the Sirte and Herodotus abyssal plains allowed to study in detail turbiditic deposits of Pleistocene and Holocene age with composition clearly showing a provenance from the African continental shelf.

Turbidites were correlated up-slope in different cores and it was suggested that turbid flow coming from the African slope can climb the outer flank of the Mediterranean Ridge after crossing the Sirte and Herodotus abyssal plains during low sea level stands (CITA *et al.*, 1984a; RIMOLDI, 1989). If the turbidites had been deposited on a more or less flat abyssal plain and were later uplifted on the ridge by tectonic movements, unrealistic outward growth rates of 20-60 cm/year and uplift rates of 0.5-1.5 cm/year must be invoked. The grain size distribution and the composition of the Bronze Age Homogenite triggered by the caldera collapse of Santorini also indicated a similar depositional behaviour (CITA *et al.*, 1984b).

Sedimentologic and textural characteristic common to all these turbidites are:

1) Large thickness in the abyssal plains (over 9 m) and lateral continuity of several kilometers. For this reason these deposits can be classified as Mega-turbidites according to BOUMA (1987).

2) Thickness decreasing upslope on the southern flank of the Mediterranean Ridge.

3) Percentage of coarse fraction increasing upslope on the southern flank of the Mediterranean Ridge.

4) Composition of biogenic and terrigenous fraction indicating African shelf provenance.

Detailed grain size analyses performed on a transect of cores from the SE Mediterranean Ridge deformation front facing the Herodotus abyssal plain revealed two additional characteristics:

a) Two different turbidites, named A-turbidites and B-turbidites can be identified on the basis of colour, thickness, and composition. A-turbidites, only a few decimeters thick and often lacking the sand sized fraction, show a clay mineral composition identical to the present Nile derived sediments.

b) The grain size distribution within each B-turbiditic event, investigated through a Fritsch Analysette 20, shows alternation of maxima and minima of the coarsest fraction, with maxima decreasing steadily up-core (Figure 1).

From these observations, we conclude that individual mega-turbidites as they can be described from visual analysis of split cores, are actually composed of several units that can be identified with careful investigation of the grain size. The steady upward decrease of the maximum grain size of the different units suggests that they were produced by sedimentary events of progressively lower energy. Our speculation on the origin of such multiple events suggest that mega-events may occur with the quasi-contemporaneous triggering of several turbid flows in a wide source area. The distal zone of deposition are then reached by the different flows at different times, with highest energy flows first and lowest energy flows last. The upslope increase of the coarsest fraction in each turbiditic unit contrasts with the observation by MUCK and UNDERWOOD (1990) that diluted flows lose less energy than dense flows during an up-slope run because of their higher flow thickness. The genesis of a symmetric or back flow that brings the finest suspended fraction of the flow back to lowest elevations after the flow has reached the maximum elevation is suggested.

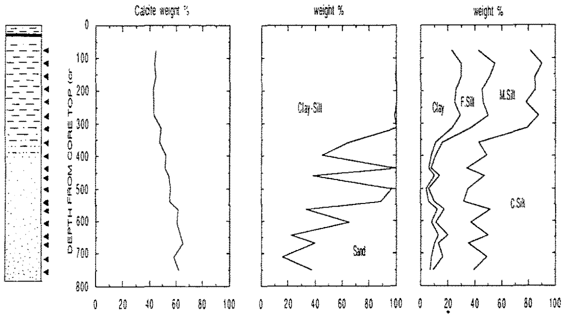

Figure 1 - Lithologic log, calcite profile, and vertical grain size distribution in turbidite 11B from the Herodotus deformation front. Note the alternations in sand distribution within the coarsest base of the turbidite that suggest a composite turbid flow.

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Factors controlling the chemical composition of the Egyptian continental shelf sediments

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The factors controlling the chemical composition of the sediments are the relative proportions of the component minerals of the sea sediments which exert a fundamental control on their chemical composition (RILEY & CHESTER, 1971). Considering the present work for areas under the direct influence of fresh water discharge from the river Nile and drainage waters, it is useful to understand the processes and factors controlling the chemical composition of sediments.

The river Nile is the major source of the metal input in the eastern Mediterranean basin. However, irrigation projects associated with the Aswan High Dam prevent almost completely the discharge of fresh water from the Nile into the sea (SUMMERHAYES *et al.*, 1978).

The present study of the shelf sediments off the Nile Delta between Agami (Alexandria, west) and Arish (east; Fig. 1) is confined to investigate the distribution of the different chemical constituents as well as to define the different factors controlling the chemical composition of the sediments.

A total of 27 surface sediment samples were collected, prepared and subjected for total chemical analysis. The results of the determined major and minor elements [with averages of : Si (20.59%); Al (6.57%); Fe (5.84%); Ca (11.27%); Mg (1.84%); Na (1.36%); K (1.01%); P (0.07%); Ti (0.82%); Ba (0.02%); Sr (0.16%); S (0.29%); Mn (0.09%); Zr (0.02%); V (0.016%); Cr (0.014%); Zn (94.27ppm); Pb (82ppm); Ni (73.8ppm); Cu (40.12ppm) and Co (37.4ppm)] were statistically analyzed. The employed R-mode Factor analysis was used to interpret the interelement associations in the studied shelf sediments. This analysis grouped related elements into a limited number of factors on the basis of their similar behavior. Each factor represents a different geochemical association, possibly caused by mineralogical variations in the sediments. Two Factors were produced (Table 1).

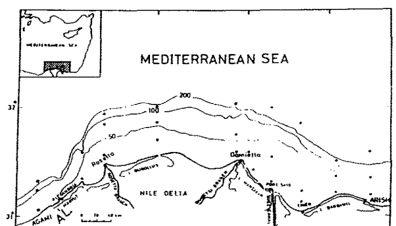
Factor I appears to be a clay factor. It accounts for 76.3 % of the total variance (Eigenvalue = 17.27). It shows a strong association of Al, Fe, Si, Na, K, Mg, Ni, Mn, Ti, Zn and Zr, the elements highly concentrated in clay sediments. Factor II appears to be a carbonate factor. It accounts for 10.6 % of the variance (Eigenvalue = 2.2) and shows an association of Ca, Sr and S, the elements which are highly present in the carbonate sediments.

The mineralogical characteristics of the studied samples reveal that heavy minerals especially opaque, mainly magnetite and ilmenite are particularly abundant at Rosetta mouth, where exploitation visibility studies have been made for ilmenite, zircon, rutile and monazite at Cape Burollus and Damietta sediments gives rise to the high incorporation of elements within the studied sediments. The high association of Fe and trace elements with Factor I is due to the incorporation of Fe with clay minerals. Fe is acting a carrier substance for many trace metals as it fix them largely to the clay (SALOMONS & FORSTNER, 1984).

Table (1): Factor Matrix

Element	Factor I	Factor II
Al	.91088	.44594
Na	.90997	
Fe	.90551	
Si	.90209	
Zn	.86319	.43804
Ni	.86234	.48410
K	.85655	.47533
Pb	.84234	
Mn	.82380	
Co	.81908	.51574
Ti	.79039	.53442
Cr	.77667	.52685
Mg	.77639	
Cu	.77594	
P	.76228	
S		-.93735
Ca		-.90705
V		-.90193
Ba	.47109	.77063
Sr	-.49839	-.76119
Zr	-.64065	.73709

Figure (1): Area of Study



Factor II has high negative loadings for Ca, Sr and S due to the association of these elements with the carbonate sediments covering a limited area to the west of the studied area. Dominant carbonate minerals (aragonite, calcite and Mg-calcite) were found in the carbonate sediments (EL SAMMAK, 1987). The origin of Sr in this area is the product of shell disintegration (EL SAYED, 1985). Ca is closely related to Sr due to the geochemical similarities between them and is highly present in the calcareous test of organisms. S in the sedimentary rocks associates with gypsum and limestone and may be contributed from some skeletons.

The employed factor analysis clarified the factors controlling the elemental composition of the studied area the relationships between mineralogy and geochemistry as well as the interelement associations of the studied elements.

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