Channelised deep sea depositional systems in the Mediterranean : a plan view perspective

Neil H. KENYON

Institute of Oceanographic Sciences Deacon Laboratory, GODALMING, Surrey
(United Kingdom)

GLORIA sidescan sonar data from along 30,000 km of continental margin, worldwide, provides sufficient data for a new classification of deep sea "turbidite systems". The scheme is based on data for slopes with a fall of 3000 m or more. The plan view emphasis is a valuable complement to sequence stratigraphic schemes that are derived mainly from study of seismic profiles and rock outcrops. The simplest classification is into a spectrum of types, distinguished by their channel and lobe characteristics, in which the main control is the long term rate of sediment input. Long term rate of input will be affected by drainage basin size and gradient, and by climate, to a greater degree than to sea level. Thus a spectrum of sequence stratigraphic models is required for this range of types.

The model is tested for the Mediterranean using both published information and new GLORIA data from the Rhone Fan, from west of Corsica and Sardinia and from the Alboran Sea.

The model requires the mature, highest input types to have a point source, a large radial distributary channel system with sinuous channels and low fan gradients. Sinuosity should be greater than about 1.6 in the middle reaches of channels and maximum channel gradients should be less than about 1 in 100. Width to depth ratios are usually less than 50. Sandy lobes are expected to be attached to the ends of the channels. Flows are frequent, possibly in excess of one a year.

Mature lowest input types have a tributary feeder system and a lesser development of, or no, channel-levee systems. Channels are straight, maximum channel gradients are usually greater than 1 in 70 and width to depth ratios can be greater than 150 near channel ends. Channel mouth lobes and basin plains are common and relatively extensive and lobes can be detached from their channel. Flows are infrequent, possibly less than one every 1000 years.

A frequency distribution shows that there is only one of the highest input types in the Mediterranean, the Nile Cone, and that the great majority are low input systems. Thus one can predict from the model that straight channels should be the norm in deep sea depositional systems rather than the more spectacular looking sinuous channels that receive much of the attention.

The Nile Cone is the largest of the Mediterranean systems with a drainage basin of over 2 million km2. There are probably two main sites of input, feeding the Rosetta and Damietta Fans. However it differs considerably from the perceived ideal for a high input fan (e.g. the Indus and Amazon systems), presumably due to tectonic influences. In addition to salt tectonics on the eastern fan surface the deeper fan sediments are being incorporated into the Hellenic Ridge accretionary complex, resulting in the unusually wide fan shape. Limited GLORIA coverage shows that although it has a radial pattern of sinuous channels (KENYON *et al.*,1975), there is no well developed distributary pattern and few avulsions. Sinuosity is less than 1.8, channels are relatively small (less than 20 m deep) and width to depth ratios of >50 are measured. Gradients are higher than the norm (maximum channel gradient >1 in 50).

The Petit Rhone system is close to the norm for a medium to high input type. The drainage basin is about 100,000 km2 and there is a distributary pattern with at least one avulsion (e.g. O'CONNELL *et al.*, 1991). Maximum channel sinuosity is over 2 for the abandoned channel but is only about 1.4 for the newly avulsed and entrenched channel. It is predicted that channel sinuosity will increase as a new channel-levee system is built out from the point of avulsion across the "neofan". The fan is fed by a single relatively steep gullied canyon. The maximum channel gradient (about 1 in 20) is geater than usual for such systems. A medium to low input type is exemplified by for instance the Var and other Provencal systems. The Var system has a drainage area of about 4,000 km2. It is fed by very steep tributary canyons, maximum gradient of about 1 in 5. The channel is relatively straight and wide (up to 7 km) and has a 60 km long levee along its right bank whose location is affected by Coriolis forces. Downslope from the leveed section the channel continues to an unusual bifurcated termination where the channel depths are only 2 m or so.

Low input types are exemplified by the tributary canyoned systems to the west of Corsica and northern Sardinia. These have subaerial drainage basins of less than 1,000 km2. Straight, unleveed and wide channels, with a width to depth ratio of >100, terminate at or just beyond the base of the steep slope. Maximum channel gradients are greater than 1 in 10. The floors of these channels are rough and have high acoustic backscatter, that is believed to be due to the passage of fast moving turbidity currents (first observed off north Africa near the site of the Orleansville earthquake by BELDERSON *et al.*, 1970). On the rise beyond the channel mouths, and above the flat basin plain, there is a pattern of strongly backscattering braid like bars that are up to 15 km long, with a relief of less than 2m. These are suspected to be sandy deposits and may represent a detached lobe, however it is not known whether they result from more than one turbidite event. A 7 m thick transparent layer, 4 m beneath the surface of the Algero-Balearic basin plain, may be a mega turbidite that represents a major depositional event.

The scheme does not hold up well on shallow margins, for instance the Po system has filled its confined basin, or on uplifted margins where the systems cannot achieve a graded equilibrium, for instance the Nile Cone. On the northern margin of the shallow Alboran Sea, with a fall of <2000 m, there are single channels, the Andarax system and another off Marbella, that are unusual in having a higher sinuosity than is normally found on slopes of such high gradient. The very small, straight channelled Crati system (COLELLA and NORMARK., 1984) does not reach the base of slope, perhaps because it is not large enough to bypass the compressional ridges on the southern Calabrian margin.

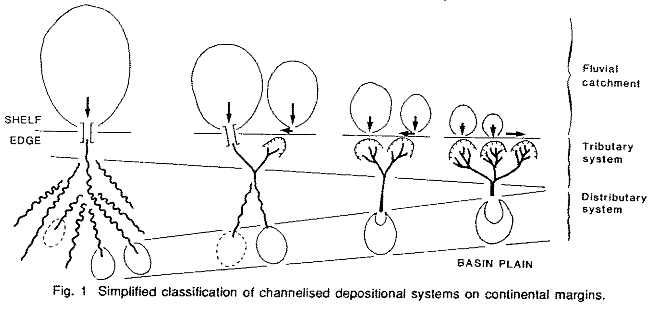

Fig. 1 Simplified classification of channelised depositional systems on continental margins.

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The concept and the estimate of the receiving capacity of the Northern Adriatic for contaminants

Zdenka KONRAD, Mladen JURACIC[1] and Velimir PRAVDIC

Center for Marine Research, Ruder Boskovic Institute, ZAGREB **(Croatia)**
[1] Department of Geology, Faculty of Science, University of ZAGREB **(Croatia)**

The problems of preservation and management of the marine environments require profound knowledge of the mechanisms governing the transport, chemical and biochemical modification, and deposition of a contaminant, or a multiple of these. Problems of identification of the most important contaminant and its potential danger of becoming a critical pollutant have been amply investigated in recent years (DEGOBBIS, 1989 ; DEGOBBIS and GILMARTIN, 1990). Historical data are particularly relevant to understand the influence of terrestrial run-off (FONDA UMANI *et al.*, 1989).

The Northern Adriatic is an extended coastal area of a semienclosed sea whose major problem are land-based sources of contaminants. The involved problems of understanding the mechanisms of transport are exemplified by the complex circulation patterns in space and time (CEROVECKI *et al.*, 1990). Along with studies done by other authors on the hydrodynamics and hydraulic transport phenomena, extensive studies have been undertaken in recent years on several small and medium size Adriatic river mouths, the Krka, Adige and Rasa (PRAVDIC and JURACIC, 1988; BOLDRIN *et al.*, 1989; JURACIC and PRAVDIC, 1991; SONDI *et al.*, 1992).

The results of such investigations show that the suspended particulate matter is a selective and important vehicle for the transport of contaminants from land to sea. Major efforts were expended in quantifying this influence and understanding the mechanisms of transport and deposition. It has been shown that some previously overlooked properties of both the suspended mineral particles, of the amount and nature of the organic coating, and of the nature of the contaminant can determine the extent of the influence. For the Krka River the results indicate that most contaminants are bound to particulates and deposited within the estuary. All indicators show that for the Adige River mouth the mechanism is, in general, twofold : for lead, nickel and chromium there is immobilization by adsorption and sedimentation within the estuary ; copper and cadmium are predominantly transported into the marine environment.

Results of such studies indicate that in assessing the assimilative capacity of the Northern Adriatic as a tool of rational environmental management, and in particular the decisions on the extent of prevention of pollution from land-based sources will require further studies at specific sites, and a thorough investigation of the interaction between dissolved matter and particulates, and between suspended matter and sediments.

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