Formation processes and dispersal patterns of the sediments along the Istrian coast of the Adriatic

by

DIETER MEISCHNER

University of Göttingen (Germany)

New information is presented on the sedimentation and ecology of bottom faunas along the Istrian coast and, more especially, the Limski kanal. The findings are inserted into the general framework of northern Adriatic sedimentation as recently determined by Italian and Dutch authors.

Introduction

During the last few years, there has been a marked increase in information on northern Adriatic sedimentation through Italian and Dutch authors, [BRAMBATI, 1968 *a*, *b* & 1969; BRAMBATI & VENZO, 1967; BRAMBATI & ZUCCHI, 1969; CIABATTI & COLANTONI, 1967; MACCHI, 1968; PIGORINI, 1968; VAN STRAATEN, 1965; VENZO & STEFANINI, 1967]. The knowledge of the sediments along the Istrian coast, however, has remained unsatisfactory.

New information is now available through the work of a group of geologists from the University of Göttingen, who have been working since 1966 at the Centar za istraživanje mora of the " Rudjer Bošković " Institute in Rovinj. This group, consisting of graduates and senior students, is mainly concerned with detailed studies on the relationship between substrate, benthonic fauna, and bottom water hydrography. This type of approach is still rather speculative. Only two papers have been published recently. HINZE & MEISCHNER [1968] discussed the erosion, transportation, sedimentation and diagenetic history of Terra rossa material from terrestrial soils into marine sediments. FÜTTERER [1969] conducted a survey of the parameters governing the grain size distribution and carbonate content.

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Geological framework

The sediments of the northeastern coast of the northern Adriatic are formed under conditions quite different from those of the Italian coast. There, active orogenic movements, erosion of the Alpine and Apennine mountain chains and drainage by large rivers, has caused the accumulation of enormous thicknesses of clastic sediments. This has occurred since the Tertiary, in an area of rapid subsidence. In contrast to this, the recent sediments along the Istrian coast are deposited on the margin of a stable platform of Mesozoic limestone, at a very low rate of sedimentation. The adjacent land mass has experienced a number of phases of karst and red soil formation (Bauxite and Terra rossa) at least since the Cretaceous period. Shallow water carbonate sedimentation has also taken place. The land area has always remained close to sea level. Nowadays only two small rivers drain to the sea from the interior of the Istrian peninsula. They do not contribute considerably to the sedimentation.

The hydrography and the distribution of sediments of the Istrian coast are therefore governed by the regular anticlockwise convection current and superimposed tidal system of the Adriatic. Because

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of low rates of sedimentation and stable conditions, sedimentation and diagenesis of the recent sediments are strongly influenced by the activity of benthonic faunas.

The whole area under consideration here lies within a depth of 50 m. The post-Pleistocene marine sedimentation therefore started with a transgression of the sea over a previous fluviatile area.

Sources and nature of sediments

The main sources and constituents of the sediments are :

1. Eroded red soil (Terra rossa) and calcareous ooze from the northeastern coast.

The Terra rossa is carried to the sea during periods of heavy rainfall mainly during the cold season, and by the deflation of the dried soils during summer. The calcareous ooze may partly originate from wave action on beach gravels. A large part of this material is thought to be produced by boring organisms in the littoral zone.

2. Biogenic calcareous shell, sand, and silt.

The accumulation of shell material is simultaneously compensated by biogenic destruction by predatory animals and boring algae, sponges, and other organisms. The balance between production and destruction may occur at any point along the scale.

3. Suspended material from the Alpine rivers.

The greatest amount of this constituent is brought down by the River Po. It consists mostly of siliceous material (quartz, feldspar, mica, clay minerals, and heavy minerals). The rivers of the northern Italian coast carry more detrital carbonate, mostly dolomite.

4. Reworked Pleistocene, mostly dolomitic and siliceous sands.

MOSETTI [1966] has demonstrated that the Pleistocene relief is still present in the northernmost part of the Adriatic, and is gradually covered by post-Pleistocene sediments towards the south. The Pleistocene sediments consist of fluviatile sands and dunes. A dolomitic province on the Istrian side of the Adriatic can tentatively be distinguished from a siliceous one onthe Itali an side. These provinces overlap some 10 km off the Istrian coast.

Distribution patterns of the sediment

The material derived from the northeastern coast accumulates at various rates and with varying grain size (mud and silt) on the fossil karst relief. This is determined by local exposure. In areas without rapid clastic sedimentation, i.e. within the reach of normal wave action, biogenic debris predominates on local rises and submerged hills, in deeper water. In local depressions, a thick layer of muddy sediment accumulates. The different consistancy of these sediments strongly influences the benthonic associations. The main mass of the fine grained material settles within 5 km of the shore.

An extreme situation is represented in the Limski kanal (Canale di Leme), a fossil valley of a karst river which extends into the centre of the Istrian platform. The sea has invaded this valley for 12 km. Continuous exchange of the water masses results in normal marine conditions throughout the Limski kanal [VATOVA & MILO DI VILLAGRAZIA 1950; Institute « Rudjer Bošković », 1966). The bottom is covered by very soft fine grained sediment solely of Istrian origin, with an admixture of biogenic carbonate [VATOVA, 1931; H. SCHMIDT, 1935; HINZE & MEISCHNER, 1968; PAUL, 1970].

With increasing distance from the coast, relatively coarse sand (Md 180 to 200 microns) with a very high detrital dolomite content, gradually, becomes predominant. Towards the Italian coast, the sand becomes coarser by admixture of siliceous material, as clearly seen from bimodal grain size distribution curves (FÜTTERER, 1969). These sands are interpreted as Pleistocene fluviatile and aeolian sediments, which have been remobilized superficially by the marine transgression and mixed with increasing amounts of recent biogenic and terrestrial material, by continuous bioturbation.

Along the zone of minimal recent sedimentation, organic material forms secondary hard bottoms (" corralligène ") with nodular aggregations of calcareous and soft benthonic organisms. This occurs on the surface of a relatively consistent sandy bottom, in a zone between 5 and 15 km off the coast at a depth of 25 to 35 m.

Towards the delta of the River Po, fine grained siliceous material is again mixed with the sediment, which grades into muddy grounds of considerable thickness of post-Pleistocene sediment. The sedimentation of this material is not yet well understood. With the spring melting of Alpine snow, water contaminated with fresh water and detrital silicates spreads superficially over the whole western area of the northern Adriatic, nearly reaching the Istrian coast [JERLOV, 1958]. The final distribution of the suspended matter is controlled by the pattern of submarine currents. Two clay mineral provinces are, therefore, recognized [BRAMBATI, 1968; PAUL, 1970]. No montmorillonite is found in the zone along the Istrian coast, whereas it is well represented in the sediments of the River Po [CIBIATTI & COLANTONI, 1967; QUAKERNAAT, 1968].

Benthonic faunas

The bottom faunas are found to be well correlated with the physical and physio-chemical parameters of the sediments. Interdependance systems can be recognized to exaggerate the differences between hard and soft bottoms which are primarily caused by mechanical effects. Soft bottoms in near shore depressions have impoverished faunas mostly of soft endobiontic type, while more exposed areas with calcareous sands are inhabited by a rich variety of bottom dwellers. both epibiontic and endobiontic.

Extreme degrees of specialisation are found in the " coralligène " on the one hand and in the muddy ground of the Limski kanal on the other. Both environments are characterised by their delicate edaphic differenciation. The muddy bottom reveals ecological infrastructures of the microbenthos (foraminifera, ostracods) which are produced by bioturbation structures, formation of pellets and larger aggregates of the fine material [VON DANIELS, 1970; HINZE & MEISCHNER, 1968; PAUL, 1970; UFFENORDE, 1970].

Conclusion

On the whole, bottom currents are not effective in the distribution of the sediments along the Istrian coast, but biological factors are more important. An equilibrium does not exist between the hydrographical conditions, bottom morphology, and sedimentation because of the rapid rise of the sea level within the last few thousand years. This holds true even for the Italian coast, where more sediment is available.

At the present state of knowledge, no direct link is apparent between the parameters of recent sedimentation here and those revealed by fossil sedimentary facies.

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