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DISTRIBUTION OF ORGANIC MATTER IN RECENT SEDIMENTS OF TYRRHENIAN SEA (**)

Riassunto — *Distribuzione della materia organica nei sedimenti recenti del Mar Tirreno.* Nei sedimenti superficiali del tratto di piattaforma tirrenica compresa tra la foce del Fiora e l'Isola d'Elba, sono stati determinati la granulometria, l'area superficiale specifica, i carbonati totali e la materia organica. Le concentrazioni del carbonio organico sono risultate essere strettamente dipendenti dalle dimensioni delle particelle del sedimento e quindi dalla loro area superficiale specifica. Allo scopo di eliminare gli effetti della diversa granulometria tra i campioni, le concentrazioni del carbonio organico sono state espresse in $mg.m^{-2}$. Così operando, è stato possibile rilevare che i tenori di materia organica nei sedimenti decrescono procedendo dalla costa verso il largo e che la sua distribuzione risulta in accordo con i risultati di precedenti osservazioni sul trasporto e la deposizione di materiali in sospensione lungo questo tratto del Tirreno. Inoltre, i valori costantemente bassi del rapporto C/N, sembrano indicare che gli apporti di materiali organici sono dovuti soprattutto al fitoplancton.

Abstract — Superficial sediments of the Tyrrhenian Sea continental shelf were analyzed for grain-size, carbonate content and distribution of organic matter. Whereas in the inner shelf there are terrigenous sediments, at the outher edge and in the slope of the shelf the sediments are biogenic (carbonates > 30%). Concentrations of organic matter are similar to those found in ocean shelves, rather than those of other semi-enclosed seas and are distributed according to the grain-size. Above all it is found that organic matter is strictly related to the specific surface area of the sediment, therefore it is mainly adsorbed to the sediment particles. Considerations on the significance of this adsorbed state in environmental pollution researches are presented.

In order to eliminate the effects of grain size, the concentrations of organic carbon were quoted in relation to the unit of surface area ($mg.m^{-2}$). This approach reveals that the highest values occur in the inner continental shelf and the organic matter distribution comes out to be in agreement with previous observations on longshore drift or depositional dynamics.

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Furthermore, the low and constant values of C/N ratio suggest that phytoplankton is the main source of organic matter in this area and contribution of land-derived organic matter is negligible.

Key words — Organic matter, specific surface area, carbonates, marine sediments, Tyrrhenian Sea.

Introduction

There is little information about the organic matter content in the recent sediments of Mediterranean Sea, although it is an important parameter in the study of the physical and chemical processes operating in the sea bottom.

The object of this investigation is to study the distribution of organic matter in the recent sediment of the Tyrrhenian Sea continental shelf. In this area fishing is an important socio-economical activity and the determination of organic substrate levels in sediments can provide information on the nutritional value of the substrate. In addition the organic matter adsorbs many pollutants (Cooper and Harris, 1974; Jones and Jordan, 1979) and the knowledge of its distribution is very useful in the study of sediment pollution.

In this paper, in order to give a more accurate account of the distribution, the organic matter content is related to the grain size of sediments (expressed in terms of specific surface area) and to that of carbonates.

Area of study

The area examined is about 6,000 Km^2 (fig. 1) and includes the southernmost islands of the Tuscan Archipelago (Giannutri, Giglio, Montecristo and Pianosa) and reaches as far north as the Island of Elba. The shore is characterized by the alternation of sandy beaches and stretches of rocky cliffs or small promontories. Besides numerous small streams, three larger rivers: the Ombrone, Albegna and Fiora, carry terrigenous materials to the sea. However, even these three rivers are not much more than streams (average flows about 20 $m^3 . s^{-1}$).

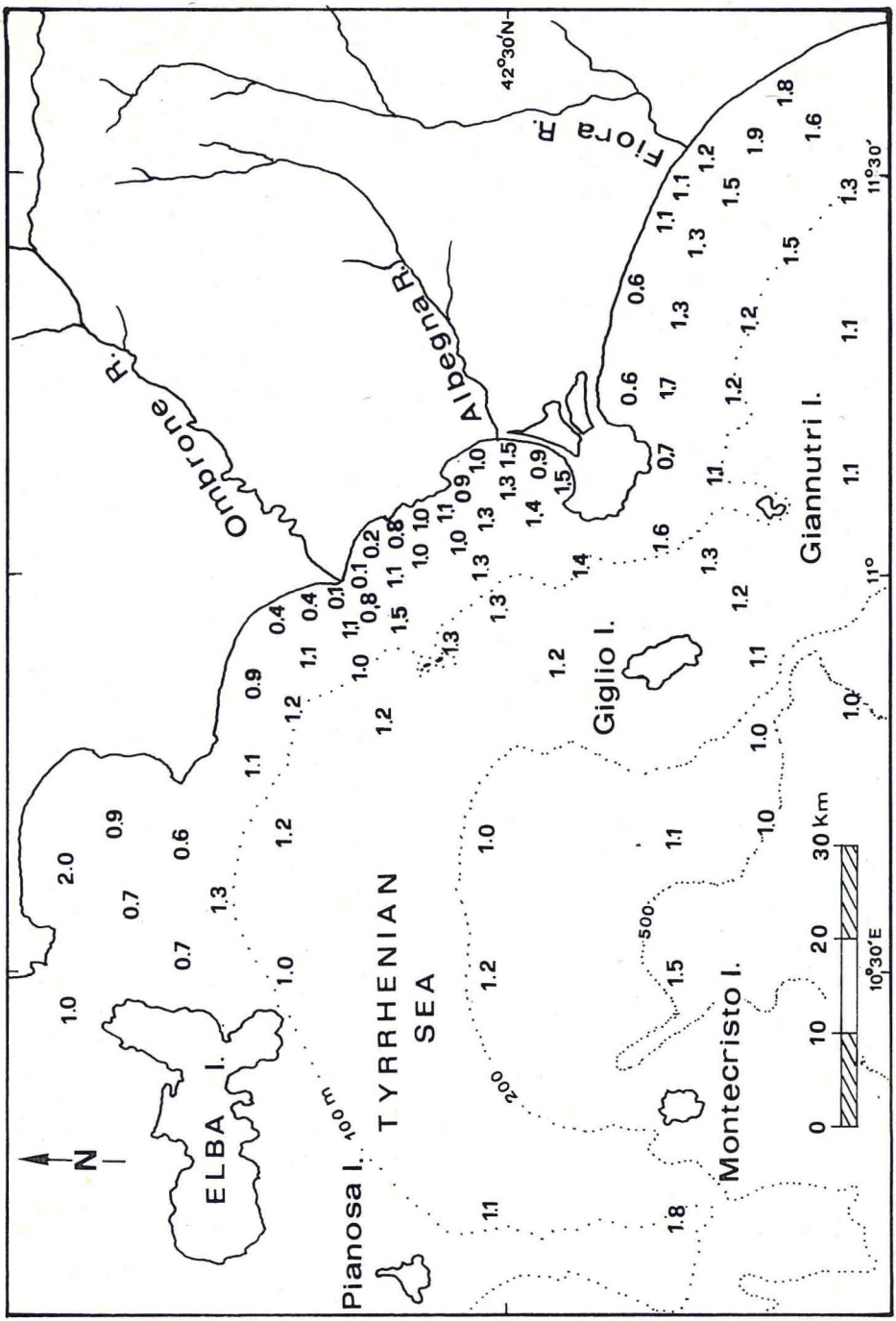

Fig. 1 - The study area and the % content of organic carbon in the sampling sites.

Sampling and analytical methods

Surface sediment samples (the top 3 cm) were collected in water from 10 to 500 m deep, using a Shipek bucket sampler during 4 cruises in 1979 and 1980. In laboratory the samples were stored at —20°C in glass container and before the analyses they were dried at 50°C till constant weight. Before the grain-size analyses, sediments were pretreated with H_2O_2 and HCl (1N) to eliminate the organic matter and carbonates; then they were wet-sieved through a 63 μm sieve. The psammitic fraction (> 63 μm) was sieved in a Ro-Tap sieve shaker (1/2 phi intervals), whereas the pelitic fraction was analyzed with a scanning photosedimentograph Analysette 20 (Fritsch), using $(NaPO_3)_6$ as dispersant (Malesani, 1966).

Total carbonates were determined by reacting 100 mg of powdered sample with HCl and titrating the excess HCl with NaOH (A.O.A.C., 1975).

The specific surface area of sediments was measured with a Sorptometer (Perkins-Elmer Shell Model 212D). Samples were degassed at 180°C for 4 h, then the volume of nitrogen adsorbed at —195°C in a monomolecular layer was measured and the specific surface area was calculated (Lowell, 1979). The V.C. was 4.4%.

Organic carbon and nitrogen were determined with a CHN Analyzer (Carlo Erba, mod. 1102) calibrated with a standard of acetanilide (Gibbs, 1977). The V.C. was 2.7%.

The organic carbon concentrations were normalized to the unit of sediment surface area ($mg \cdot m^{-2}$) dividing the organic carbon values ($mg \cdot m^{-1}$) by the specific surface area measured.

Results

The sediments are mainly constituted by sand in the off-shore as far as a depth of about 15 m; further out, in a narrow belt along the inner part of the continental shelf and around the Island of Giglio, the sediments are composed of sandy silt and silt. A central belt of silty clay follows the rest of the shelf is covered by clayey-silt (fig. 2).

Large areas of sediments have high carbonate contents, mainly calcareous, skeletal debris (foraminifera and mollusc shells).

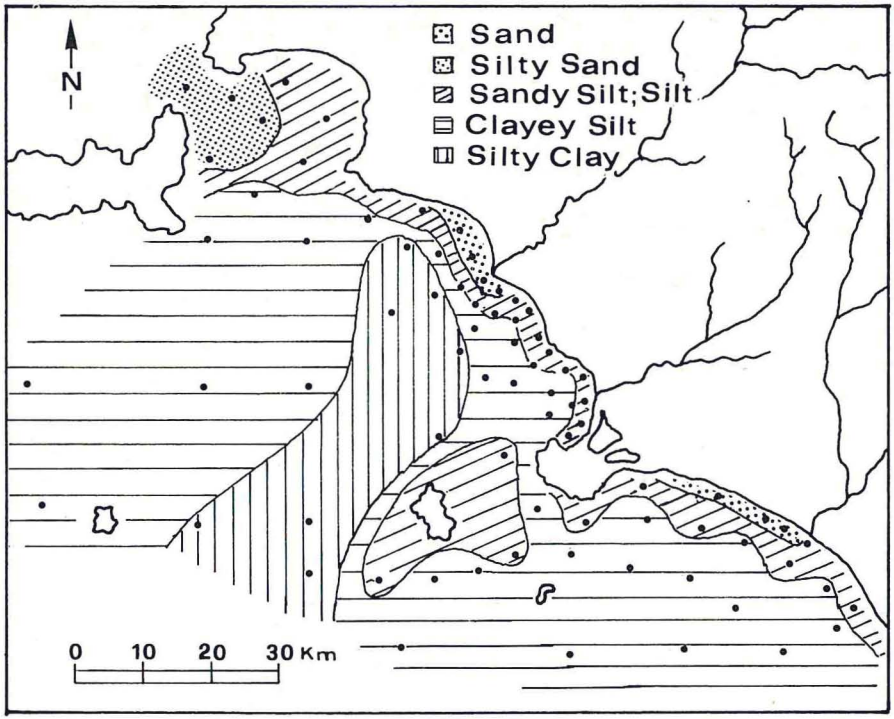

Fig. 2 - Grain-size distribution in surficial sediments.

These biogenic sediments are found at the outer edge of the continental shelf, on the continental slope and around the Elba Island. On the rest of the shell the terrigenous contributions, with a lower carbonate content, are more pronounced (fig. 3).

From these results it comes out that the sedimentary environment features are very variable and it is incorrect to compare the lowest values of organic carbon in the sandy samples and the highest values in the fine lithogenous and biogenic sediments (fig. 1). In fact, as has been observed by many authors in marine and lacustrine sediments (cf. KEMP, 1971), the organic carbon distribution is affected by sediment particle size. Above all, a strictly relation ($r = 0.870$; $P < 0.001$) between the specific surface area of sediments and their organic carbon content was shown (fig. 4). In order to eliminate the differences in grain size, typical of continental shelf sediments, the concentrations of organic carbon were normalized to the unit of surface area; thus they are statistically

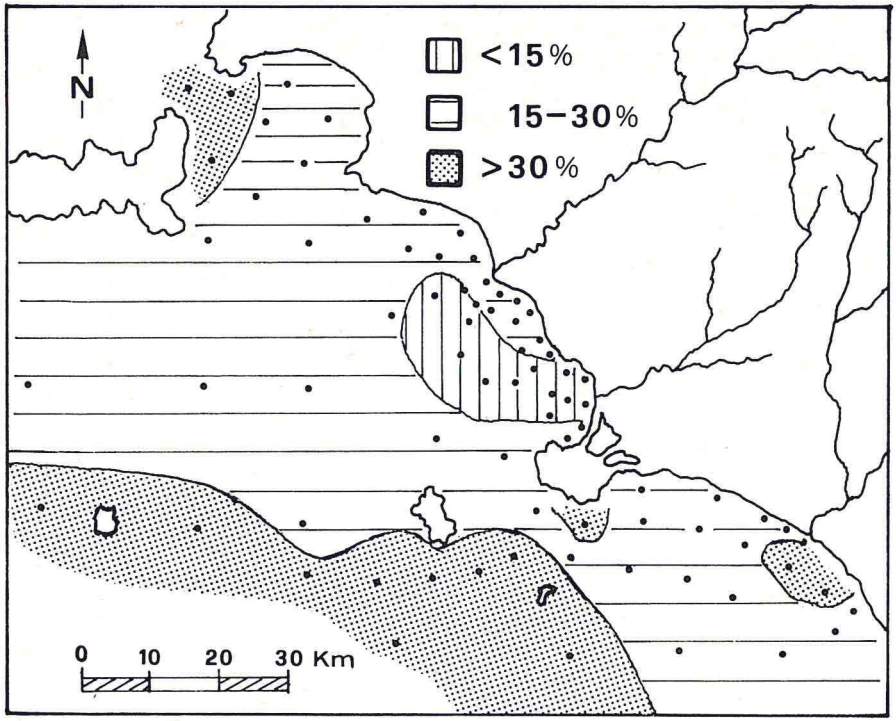

Fig. 3 - Carbonates distribution in surficial sediments.

easier to compare and it is possible to have a more accurate distribution (fig. 5). Excluding the higher values in the shoal in front of the mouth of Fiora River, all the others range between 1 and 0.4 $mg.m^{-2}$. It is evident furthermore, that the highest concentrations of organic carbon are found near the coast rather than to the outer continental shelf, as it appeared in fig. 1.

Up to this point we have dealt with the distribution of organic carbon as a measure of the distribution of organic matter. Our results would have very similar if we had instead considered the distribution of total nitrogen. In fact, in all the area the C/N ratio is nearly constant (average value = 6.5 ± 0.4).

Discussion

The continental shelf of the Tyrrhenian Sea is characterized by fine sediments (from silt to silty clay) and by sand in a very

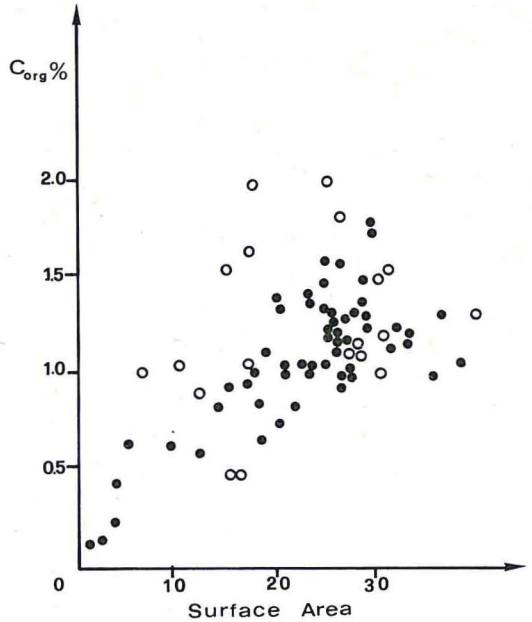

Fig. 4 - Organic carbon content vs. specific surface area ($m^2.g^{-1}$) of sediments. Terrigenous sediments (•); biogenic sediments (°).

narrow belts off the sandy beaches. In the areas with a poor supply of terrigenous sediments, thick deposits of shelly and foraminiferal debris are found: that it to say, the type of sediment that EMELYANOV (1972) found to predominate in the Mediterranean Sea. It has noted, moreower, that in the Mediterranean Sea the concentrations of organic carbon are considerably lower than those observed in sediments from other semi-enclosed seas, such as the Black Sea and the Baltic Sea (TRASK, 1955). The values found in our survey correspond, in fact, to those found by GROSS et Al. (1972) from the surface sediments on the continental shelf of the northeast Pacific Ocean (off the coasts of Washington and northern Oregon).

The relation between the grain size of sediments and their organic content, frequently determines a zonation of organic matter approximately parallel to the coast: the concentration of organic matter rises as the sediment particles size decreases. TRASK (1955) explained this by the similarity in settling velocity of organic constituents and fine particles. Moreover, we found a close relation-

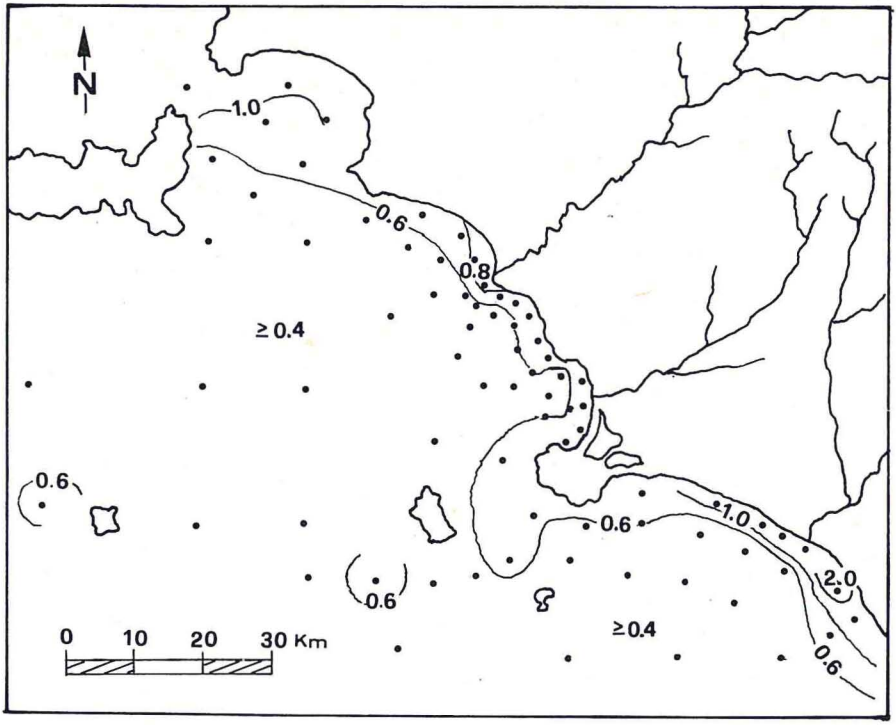

Fig. 5 - Organic carbon distribution; the concentrations are normalized to the unit surface area of sediment ($mg.m^{-2}$):

ship between the organic carbon content and the specific surface area of sediments, which seems to prove that organic matter is mainly adsorbed to the sediment particle, as suggest by BORDOVSKIY (1965).

The adsorbed state of organic matter is particularly important in the environmental pollution research, because organic carbon is considered a 'sink' for the pollutants; therefore it is more accurate to normalize the concentrations of contaminants to the unit of sediment surface ($\mu g.m^{-2}$) rather than to their unit of weight ($\mu g.g^{-1}$) (KUDO and HART, 1974; BALDI and BARGAGLI, 1982).

Thus, studying the distribution of organic matter over continental shelf, it must be born in mind that the notable variations of specific surface area of the sediments throw into shadow the lesser variations of organic carbon content. Normalizing the concentrations of organic carbon to the unit of surface area ($mg.m^{-2}$),

in contrast to the first distribution, the values decrease from the coast to the open sea. On the outer shelf the values are about half as high as those found on the inner continental shelf, where the organic matter from the primary production and that of the *Posidonia* prairies is added to that derived from the land. In particular the higher values occur in a coastal belt corresponding to these zones with high depositional dynamics and a prevalently sandy-silt sedimentation pointed out in the southernmost zone (AIELLO et Al., 1978). Moreover, in front of the Ombrone mouth the organic carbon distribution is in agreement with previous observations on the dispersion of suspended load carried by the river (AIELLO et Al., 1975; GANDOLFI and PAGANELLI, 1976).

The C/N ratio variations are often used to distinguish allochthonous from autochtonous organic components (POCKLINGTON and LEONARD, 1976), nevertheless, in our area, the variation are slight. Probably the contributions of land-derived organic matter are negligible because the rivers have a low average flow. The values of C/N ratio on Tyrrehenian Sea continental shelf, around 6, show that phytoplankton (according to PARSON, 1975) is the main source of organic matter.

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