

GORTANIA - Atti Museo Friul. di Storia Nat.	19 (1997)	53-60	Udine, 31.X.1997	ISSN: 0391-5859
---	-----------	-------	------------------	-----------------

R. MAROCCO, F. PRINCIVALLE

MINERALOGY OF SILT AND CLAY FRACTIONS IN THE SURFICIAL SEDIMENTS OF THE GRADO LAGOON (NORTHERN ADRIATIC SEA)*

COMPOSIZIONE MINERALOGICA DELLA FRAZIONE SILTOSA E ARGILLOSA DEI FON- DALI DELLA LAGUNA DI GRADO (ADRIATICO SETTENTRIONALE)

Abstract - The composition of detrital and clay minerals in the tidal flats of the Grado Lagoon was determined by X-ray diffraction. The spatial distribution of minerals in silt and clay fractions of the surface sediments shown a higher contents of detrital minerals, a marine source and a selective sedimentation inside the lagoonal basins. A prevalence of dolomite over calcite are observed and a geographic gradient of calcite (maximum contents eastwards - minimum westwards) are found.

Key words: Mineralogy, Silt-clay fractions, Grado Lagoon.

Riassunto breve - La caratterizzazione mineralogica dei depositi pelitici (siltosi e argillosi) della laguna di Grado evidenzia una composizione essenzialmente detritica del sedimento, una sua provenienza dal mare e una sedimentazione selettiva all'interno dei bacini lagunari. Emerge inoltre una netta prevalenza della dolomite sulla calcite e, in particolare, l'esistenza di un gradiente geografico della calcite con massimi contenuti ad Est e minimi ad Ovest.

Parole chiave: Mineralogia, Silt-argilla, Laguna di Grado.

Introduction

The distribution of minerals in the lagoonal sediments can be used to investigate the sedimentation processes occurring in these tide-dominated environments. In particular, clay minerals in the clay-sized fraction of sediment are transported and uniformly kept in suspension by the tidal currents and settle when the residual currents are weaker (DRONKERS & ZIMMERMAN, 1982).

Furthermore, with some rare exceptions, they do not undergo significant chemical and mineralogic changes during transport and after sedimentation. For these reasons they may be seen as excellent natural useful tracers to identify sedimentary inputs into the lagoonal basins.

* Paper published with the funds of the C.N.R. (National Research Council) Project " Venetian Lagoonal System".

The aim of this work is to determine the mineral compositions of the easternmost lagoon of the northern Adriatic Sea (Grado and Marano Lagoons) in order to:

- i) complete the study on the source of the deposits of the Friuli lagoons carried out by BRAMBATI (1972);
- ii) investigate the distribution and dispersal pattern of pelitic sediments in the tidal environment and make a distinction between the characteristics of detrital minerals and clay minerals in the silt and clay fractions of surface sediment.

Environmental setting⁽¹⁾

The Grado lagoon (fig. 1a) is the easternmost part of the lagoon system of Friuli - Venezia Giulia, which represents the easternmost end of the Venetian lagoon system (Venice - Caorle - Marano and Grado lagoons). It extends for about 75.5 km² (5 km width and 16 km length), 18% of which is occupied by areas above mean sea-level (insels and marshes; 4%) and enclosed areas (fishing farms, 14%). The remaining area (with average depths of less than 1 metre) include tidal flats (about 75% of the lagoon basins), the dense network of lagoon channels (about 16% of the basins) and subtidal floor ("basin l.s.": about 9% of the lagoonal floors).

The tide has a semidiurnal character with maximum spring range of about 105 cm and minimum neap range of about 20 cm.

The lagoon sediments are essentially sand seawards and progressively increasing the pelite content towards the inner basins (BRAMBATI, 1969; MAROCCO, 1995). BRAMBATI (1972) showed that the clay association present in the Marano and Grado lagoons was illite > chlorite > kaolinite. Furthermore, in the Marano Lagoon small percentages of smectite were also found. Considering that the supplies of tributary rivers to the lagoon are relatively scarce and that those clays are more abundant in a marine environment, the author suggested that the clays are mainly of marine origin and that they are transported to the lagoon by tidal currents.

By extending the area of investigation to the northern Adriatic sea and, in particular, to the Gulf of Trieste (BRAMBATI, 1968; MANTOVAN et al., 1985; OGORELEC et al., 1991), the finest sediments are made up of clay minerals such as illite, kaolinite, chlorite, mixed layers and smectite and by detrital minerals including quartz and feldspars, and especially dolomite and calcite, with the former mineral prevailing over the latter in the western sector of the basin and, viceversa, in the eastern sector. The circumlagoonal soils are basically silt and sand-sized and are characterized by high concentrations of carbonates with the calcitic component (60%) prevailing over the dolomitic one (20%) (BRAMBATI, 1970).

Materials and methods

The surficial sediments of the Grado Lagoon were sampled in 16 stations (fig. 1a and 1b) located only in tidal flat and "basin" (deeper lagoon-floor) in order to concentrate the attention on the areas of accumulation of suspended sediments. Analogous sampling were carried out in 13 stations site in the Marano Lagoon (fig. 1a).

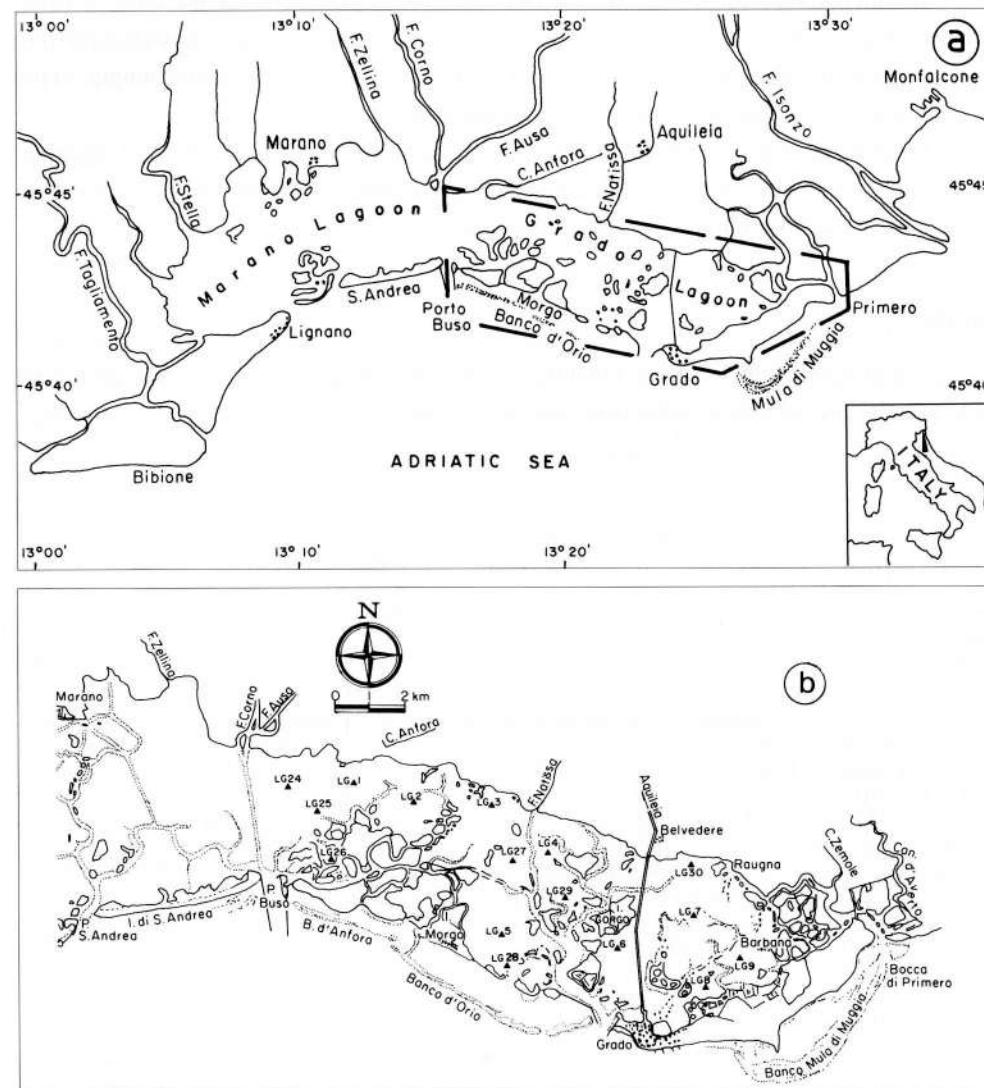


Fig. 1 - a) Map of Marano and Grado Lagoons and study area. b) Location of bottom samples.

- a) Localizzazione della Laguna di Grado e Marano e dell'area in esame. b) Ubicazione dei campioni di sedimento.

1) For a more detailed description of the lagoon environment, see DORIGO, 1965; BRAMBATI, 1969; 1970; 1972; 1974; BRAMBATI et al., 1983; MAROCCO et al., 1984; MAROCCO, 1989; 1991 a; 1991 b; GATTO & MAROCCO, 1992; 1993; MAROCCO, 1995.

Evidence of the changes in mineral proportion within the lagoon system is provided by the areal distribution of the detrital/clay minerals ratio. It can be observed that the detrital minerals in the silt-sized particles (fig. 2), are fundamentally of marine source and spread into the lagoonal basins through the tidal inlets and related channel network.

The sediments are characterized by abundant quartz and dolomite, less abundant calcite, medium feldspar concentrations and low clay mineral contents.

The same analysis carried out on the clay-sized fraction ($<4\text{ }\mu\text{m}$) of the sediments shows (fig. 3) a lower detrital/clay minerals ratio (ranging 1-3; i.e. a high concentration of clay mineral) than the silt-sized fraction (ranging 7-12). Maximum concentrations of clay minerals are present in the area behind the lagoonal inlets and, viceversa, a high concentrations of detrital minerals (especially quartz) in front of Natissa River.

Finally, the sediments of the eastern part of the lagoon show a geographic gradient of calcite, with maximum contents eastwards and minimum westwards.

Discussion and conclusion.

The distribution patterns of the silt and clay fraction minerals of lagoon deposits reflect different sources and transport pathways within the lagoon environment. The silt-sized fraction

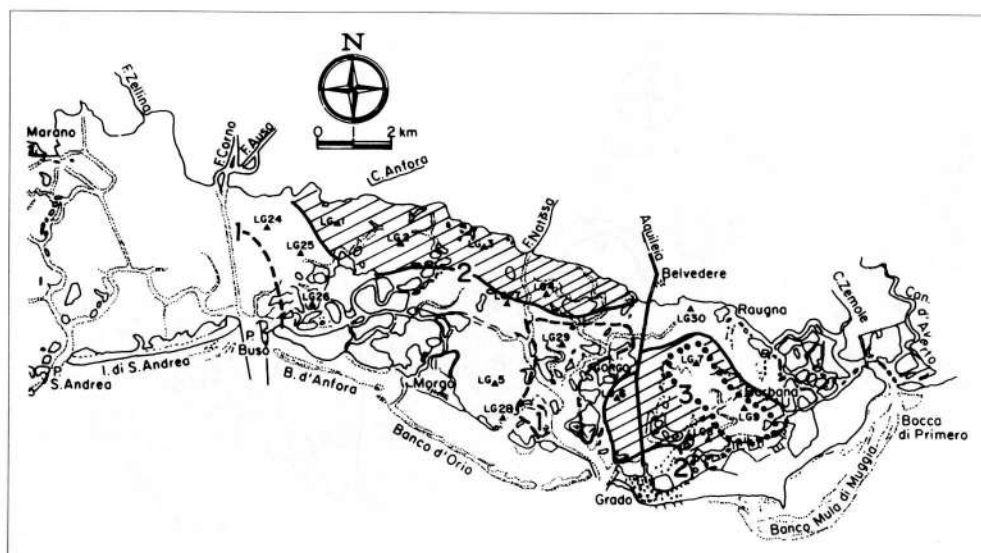


Fig. 2 - The Grado Lagoon: areal distribution of detrital/clay minerals ratio of clay-sized particles of sediments.
- Laguna di Grado: distribuzione areale del rapporto minerali detritici/argilla nella frazione argillosa dei sedimenti.

of lagoon deposits essentially comes from the sea and secondarily from the hinterland. It settles in the lagoon following the tidal circulation and the fluvial plume.

The clay-sized fraction of the sediments also enters in the lagoon essentially from the sea, whose floor is covered by clay minerals in greater quantities than that of the lagoon (MANTOVAN et al., 1985; OGORELEC et al., 1991). It mainly accumulates in the tidal flats connected to the main lagoon channels. The accumulation of clay minerals, however, does not involve the whole canalized area of the lagoon system, but only the basins of Grado, Porto Buso (and Lignano, in the adjacent Marano Lagoon).

The trend of the mineralogical composition of Grado Lagoon-floor (clay-sized fraction) does not significantly differ from that of the adjacent Marano Lagoon, thus testifying the same mechanisms ruling the transport and sedimentation (or re-sedimentation) of pelitic, and especially clay sediments, in both the lagoonal systems.

Nevertheless, one should consider that clays are more abundant in the Marano Lagoon than in the Grado Lagoon. Moreover, in the Marano Lagoon smectite also appears.

As far as the detrital minerals are concerned, it can be observed that quartz and feldspar are virtually constant in the sediments, whereas calcite and dolomite are much more variable either in term of total carbonate contents, or in term of reciprocal proportion. An increase in calcite can be observed going eastwards, which can be explained by considering that calcite and dolomite fundamentally come from tributary rivers and the high percentages of calcite found in the eastern part of the Grado Lagoon are related to the deposits of Isonzo R. channeled into the lagoon by Grado inlet mixed by a paleo-bed of the Isonzo R., which has been abandoned owing to the continuous diversions to the East.

Manoscritto pervenuto il 17.XII.1996.

References

- BRAMBATI A., 1968 - Mixing and settling of fine terrigenous material ($<16\mu\text{m}$) in the Northern Adriatic Sea between Venice and Trieste. *St. Trent. Sc. Nat.*, 45: 103-117.
- BRAMBATI A., 1969 - Sedimentazione recente nelle Lagune di Marano e di Grado (Adriatico settentrionale). *Studi Trent. Sc. Nat.*, sez. A, XLVI(1): 142-239.
- BRAMBATI A., 1970 - Provenienza, trasporto e accumulo dei sedimenti recenti nelle lagune di Marano e Grado e nei litorali tra i fiumi Isonzo e Tagliamento. *Mem. Soc. Geol. It.*, 9: 281-329.
- BRAMBATI A., 1972 - Clay mineral investigation in the Marano and Grado lagoons (Northern Adriatic Sea). *Boll. Soc. Geol. It.*, 91: 315-323.
- BRAMBATI A., 1974 - Il regime sedimentologico delle spiagge dei Banchi d'Orio. *Mus. Friul. St. Nat.*, 91 pp.
- BRAMBATI A., FANZUTTI G.P. & MAROCCO R., 1983 - Suspended matter transport in lagoons: the Grado Lagoon. *Boll. Ocean. Teor. Appl.*, 1: 5-18.
- CARROL D., 1970 - Clay minerals in Arctic Ocean sea-floor sediments. *J. Sediment. Petrol.*, 40: 814-821.
- DORIGO L., 1965 - La laguna di Grado e le sue foci. Ricerche e rilievi idrografici. *Ufficio Idrografico del Magistrato alle Acque*, Pubbl. n. 155, pp. 231, Venezia.

- DRONKERS J. & ZIMMERMAN J.T.F., 1982 - Some principles of mixing in tidal lagoons. *Oceanologica Acta*, S.P.: 107-117.
- GATTO F. & MAROCCO R., 1992 - Caratteri morfologici e antropici della Laguna di Grado (Alto Adriatico). *Gortania, Atti Mus. Friul. St. Nat.*, 14: 19-42.
- GATTO F. & MAROCCO R., 1993 - Morfometria e geometria idraulica dei canali della Laguna di Grado. *Geogr. Fis. Dinam. Quat.*, 16: 107-120.
- MANTOVAN P., MENEGAZZO VITTURI L., PAVONI B. & RABITTI S., 1985 - Sediments and pollution in the Northern Adriatic Sea: a statistical analysis. *Contin. Shelf Res.*, 4: 321-367.
- MAROCCO R., 1989 - Lineamenti geomorfologici della costa e dei fondali del Golfo di Trieste e considerazioni sulla loro evoluzione tardo-quadernaria. *Int. J. Speleol.*, 18: 87-110.
- MAROCCO R., 1991a - Evoluzione tardo pleistocenica - olocenica del delta del F. Tagliamento e delle lagune di Marano e Grado (Golfo di Trieste). *Il Quaternario*, 4: 223-232.
- MAROCCO R., 1991b - Le dune di Belvedere - San Marco. Una antica linea di riva? 1) Considerazioni geomorfologiche. *Gortania, Atti Mus. Friul. St. Nat.*, 13: 57-76.
- MAROCCO R., 1995 - Sediment distribution and dispersal in northern Adriatic lagoon (Marano and Grado paralic system). *Giornale di Geologia*, 57: 77-89.
- MAROCCO R., PUGLIESE N. & STOLFA S., 1984 - Some remarks on the origin and evolution of the Grado Lagoon (Northern Adriatic Sea). *Boll. Ocean. Teor. Appl.*, 2: 11-17.
- ORORELEC B., MISIS M. & FAGANELLI J., 1991 - Marine geology of the Gulf of Trieste (Northern Adriatic): sedimentological aspects. *Mar. Geol.*, 99: 79-92.
- SCHULTZ L.G., 1964 - Quantitative interpretation of mineralogical compositi on from X-ray and chemical data for the Pierre Shale. *U.S. Geol. Surv. Prof. Papier.*, 391-C: 1-31.
- THOREZ J., 1975 - Phyllosilicates and clay mineral. *Ed. G. Lelotte, Dison*, pp. 579.

Indirizzi degli Autori - Authors' addresses:

- Prof. Ruggero MAROCCO
Dipartimento di Scienze Geologiche, Ambientali e Marine
Via E. Weiss 2, I-34127 TRIESTE
- Prof. Francesco PRINCIVALLE
Dipartimento di Scienze della Terra
Via E. Weiss 2, I-34127 TRIESTE