

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".

Sediments were collected in October 1991, by means of a grab, only in the areas not covered by halophyte vegetation. The most surficial part of the sampled sediment (on average 5 cm thickness) was subsampled and mineralogical analyses were carried out by X-ray diffraction. Analyses were performed on two grain size fractions separated by standard pipette method: the 50 - 4 μm fraction (silt) and the < 4 μm one (clay).

The mineralogical analyses were carried out on both granulometric fractions by using oriented preparations, with a scanning angle (2θ) between 2° and 40° . The < 4 μm fraction were also analysed after glycolation (60°C , for 24 h) in the range 2° - 14° (2θ). The samples of the Marano Lagoon was performed only on the < 4 μm fractions (see Table I).

The qualitative analysis of clay minerals was carried out according to the method suggested by CARROL (1970) and THOREZ (1975). The semi-quantitative estimation of clay minerals was obtained following the Schultz's (1964) method.

Results

Clay minerals found in the sediments collected in the floor of the Grado Lagoon include illite, chlorite and kaolinite in decreasing order of abundance. Smectite is absent, or in negligible quantities.

GRADO LAGOON - Silt-size fraction of the sediment								
	detrital minerals	clay minerals	Il	Cl+Kaol	Qz	Feld	Cal	Dol
max	94	13	8	6	46	10	19	44
min	87	6	3	3	28	4	10	24
mean	91	9	5	4	36	6	15	34
s.d.	2.2	2.2	1.7	0.8	5.9	1.8	2.6	5.9
GRADO LAGOON - Clay-size fraction of the sediment								
	detrital minerals	clay minerals	Il	Cl	Kaol	Qz	Feld	
max	76	52	31	12	11	44	9	24
min	48	24	13	5	5	23	0	12
mean	64	36	21	8	7	33	5	16
s.d.	8.9	8.9	6.1	2.1	1.8	6.1	2.1	3.2
MARANO LAGOON - Clay-size fraction of the sediment								
	detrital minerals	clay minerals						
max	56	75						
min	25	24						
mean	46	54						
s.d.	12.1	12.1						

Tab. I - Comparison between the mineralogic composition of the silt and clay fractions of the Grado Lagoon sediments.

- Confronto tra le composizioni mineralogiche delle frazioni siltose e argillose dei sedimenti della Laguna di Grado.

In order of frequency detrital minerals are mainly given by quartz, dolomite, calcite, and feldspars. Table I reports the elemental statistical parameter of the detrital and clay minerals in the silt (50-4 μm) and clay (< 4 μm) fractions of the sediment. It shows as follows:

- a very small variation of the percentages of the single minerals. Except for calcite, that shows an geographic increase eastward, where maximum contents are related to Isonzo River supplies (BRAMBATI, 1969; MAROCCO, 1995), the other minerals are quite homogeneous within the lagoon floor;
- both the silt and the clay fractions show a prevalence of detrital minerals over clays. The detrital minerals average in the silt-sized fraction is about 90%, while in the clay fractions is about 64%. Student's t-test was performed to compare the silt and clay fractions content in the floor of Grado Lagoon. The silt and clay fractions are clearly distinct on the mineralogical basis ($p < 0.001$) except for quartz and feldspars.

Table I shows that when mean size of the pelitic sediments decreases the clay minerals (illite, chlorite and kaolinite) increase, thus compensating dolomite and calcite decrease. On the contrary, quartz and feldspar remain virtually constant.

The comparison between the clay-sized fraction of the Grado and the Marano Lagoons shows that the Grado clay minerals are less abundant than the Marano ones (Student's t-test: $p < 0.001$). These data are in agreement with those reported by BRAMBATI (1972).

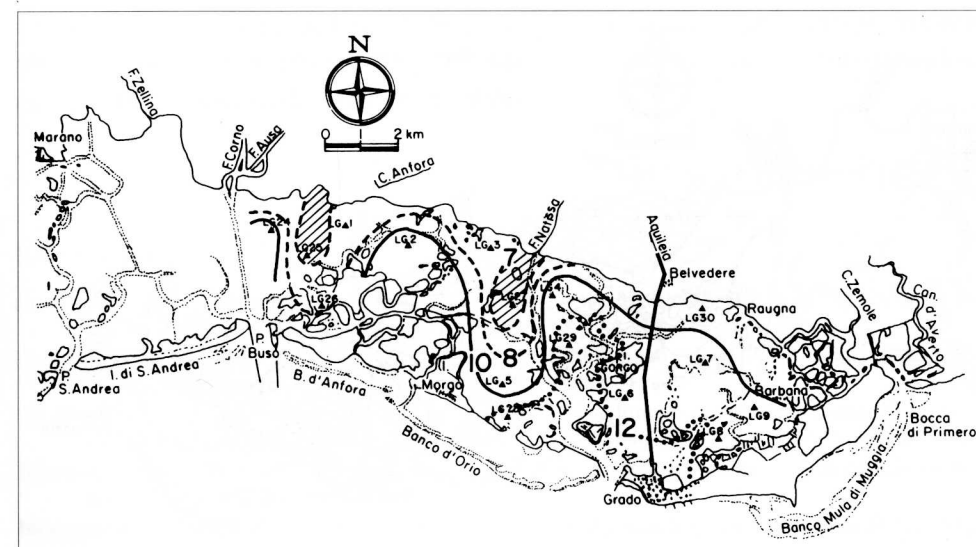


Fig. 2 - The Grado Lagoon: areal distribution of detrital/clay minerals ratio of silt-sized particles of sediments.

- Laguna di Grado: distribuzione areale del rapporto minerali detritici/argilla nella frazione siltosa dei sedimenti.

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

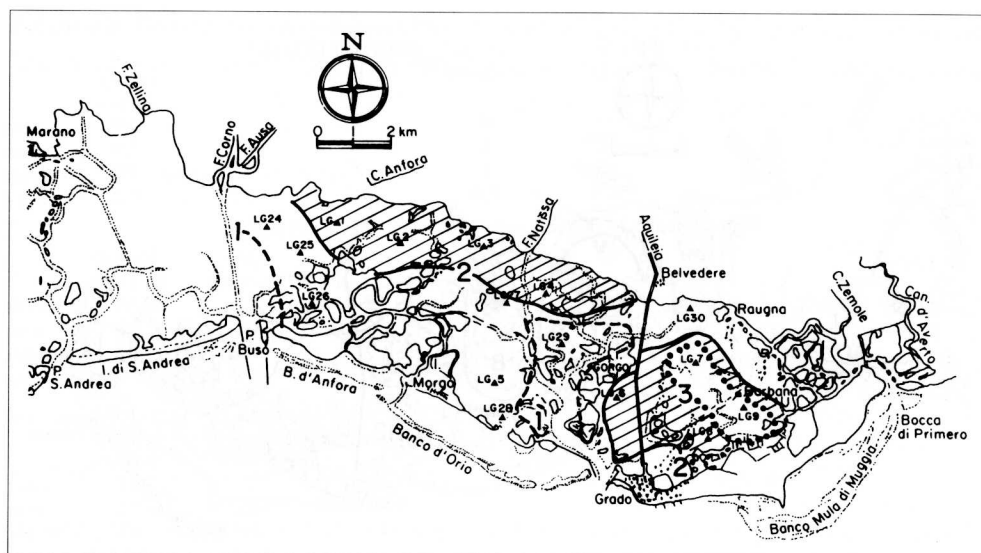


Fig. 2 - The Grado Lagoon: areal distribution of detrital/clay minerals ratio of clay-sized particles of sediments.
- Laguna di Grado: distribuzione areale del rapporto minerali detritici/argilla nella frazione argillosa dei sedimenti.

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 Quadernario*, 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