

GENESIS OF BEACH FLAGGY MARLSTONE BOULDERS BY TRACE ELEMENTS AND ISOTOPIC MEASUREMENTS

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ABSTRACT

During the prospection of Rosetta beach black sands deposits a piled deposit of marlstone boulders was found breaking the homogeneity of the beach. The genesis of this deposit was questionable. Therefore, its origin was studied by trace element and stable isotopic measurements, besides geological investigations and the study of the history of the area. The results obtained revealed that these boulders are of fresh water environment affected by the surrounding sea water rejected on beach during abnormal and strong weather conditions.

INTRODUCTION

The area of east Rosetta extends from the Rosetta estuary to Lake Burullus inlet (*Fig. 1*). In general, this part is a delta neutral beach resulting from the delta growth seawards. The coastal area is generally flat and consists of a single berm; no rocky structures are present. The waves wash up the berm, but seldom cross it except in winter and in stormy conditions. In Rosetta area some sand dunes may interrupt the flatness of the coastal plain. The beach face slope increases from completely flat to relatively steeper nearer to Lake Burullus, and this prevents the sea water to cross the berm in this region. This part is characterized by the loss of heavy minerals and tends to have coarser grain sizes than gentle slopes which have finer particles.

The first part of this beach extends for a distance of about 10 km from the mouth. It is characterized by a complex group of lagoonal lakes of irregular variable shape according to the quantity of water crossing the beach to these lakes. The second part extends from the 10th km to Lake Burullus inlet and is characterized by its flatness and regularity except the presence of some sand dunes scattered on the beach [WASSEF, 1973].

DEPOSIT ACCUMULATION

At a distance about 38 km from Rosetta mouth, there is found an accumulation of carbonate rocky fragments on the nearshore area (*Fig. 1*). This deposit is an anomalous one breaking the homogeneity and the sandy nature of the beach. The size of the rocky fragments ranges between a few cm length to more than 30 cm; the fragments consist of one rock type. Some of the rocky fragments are elongated while others are rounded. This deposit is mixed with shells and foraminiferal organisms stuck to the fragment faces. It starts from the berm as far as about 60 m towards the backshore and extends about 1 km parallel to the beach line. The boulders are hard, greyish in colour, and mostly flat (*Figs. 2 and 3*).

The flat boulders tend to remain lying on their larger side. It seems that joints or stratification divided them into homogeneous but flat or oblong bodies during disintegration. The rounding, however perfect, will but not lead to sphericity but must then result in a disk, triaxial ellipsoid [PETTIJOHN, 1957].

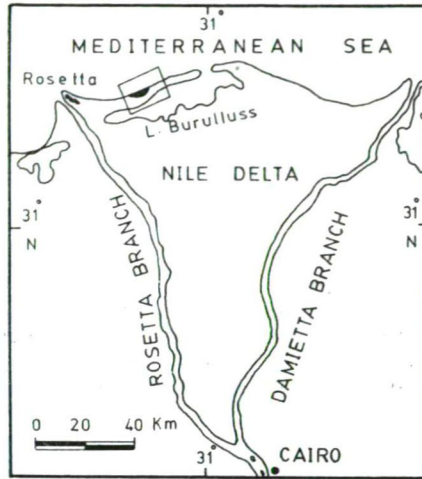


Fig. 1. Location map of the marlstone on Rosetta beach



Fig. 2. General view of the marlstone boulders accumulation on Rosetta beach

CHEMICAL INVESTIGATION

Three samples have been chosen to represent this deposit to be analyzed. The chemical investigation was done by dissolving a crushed weighed part from every sample in 5% HCl. The result showed an average residue (clay) of about 36% of the total weight. The average of the dissolved carbonates was about 64%.

According to PETTIJOHN [1957] it is known that an indurated mixture of clay materials and calcium carbonate, normally containing 25 to 75% clay is marlstone. Then the deposit accumulated on beach consists of flaggy marlstone boulders.

GEOLOGICAL INVESTIGATION

From the geological point of view, this deposit is the only rocky medium on a uniform sandy beach. The grain size analysis of the beach sand below (1 m depth) showed no difference in size from the abundant grains of the whole beach, where the



Fig. 3. A photograph showing the size of the flaggy marlstone boulders on beach (relative to 30 cm rule)

average value of the median is 2.69ϕ [WASSEF, 1973]. Besides, there are no marlstone fragments buried in beach sands. This leads to the conclusion that this deposit is a surface one coming from sea. This idea is supported by the observation of some pieces of different sizes sliding up on the beach face slope coming from sea.

There are two suggested sources likely to feed this deposit. One is the submerged old marine rocks, and the other is the River Nile branch. Because of the large size of the deposit components, it is excluded that the actual Rosetta Nile branch is the

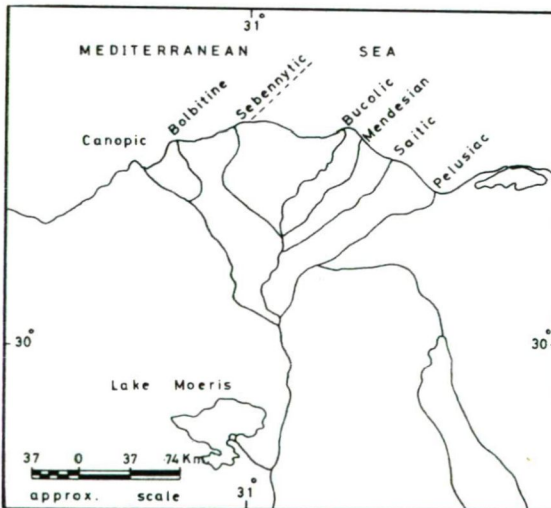


Fig. 4. Map showing the old Nile branches (BALL, 1942, after HERODOTUS 450 B. C.)

source due to the long distance between the mouth and the deposit location. The transportation of fragments of this size cannot be realized for this long distance (38 km) along the beach. The rejection of these heavy pieces on beach indicates high erosion conditions in the area, and abnormal weather conditions especially in winter. These conditions are sufficient to push these boulders as far as the berm. During the occasional storms and abnormal conditions, the water covers this area violently and the erosion due to change of sea level takes place [MCKEE, 1959].

From the historical geology of the area, there was an old Nile branch called the Sebennytic branch mentioned by BALL [1942], after HERODOTUS 450 B. C. (Fig. 4). This old branch is suggested to be one of the sources of this deposit. The ancient site of this old branch estuary is coinciding approximately with the area of the deposit.

To arrive at a decisive conclusion about the origin of this deposit, whether marine or fresh water, two methods have been applied, the trace element analysis beside the oxygen and carbon isotopic measurements.

TRACE ELEMENT ANALYSIS

Among the methods which can be used to differentiate between marine and fresh water sediments, the geological methods are considered the most important. A frequently used geochemical method is the trace element analysis and the consideration of relation between elements which are distinctive with respect to the environment of sedimentation. Some binary relations are very decisive in differentiation between marine and fresh water environments.

KEITH and DEGENS [1959] showed that the binary relation between boron and gallium is useful as a geochemical criterion for the differentiation between fresh water and marine sediments (Fig. 5). POTTER *et. al* [1963] used the boron-vanadium relation as an environmental discriminator between marine and fresh water sediments. This relation is used to get the respective environment of the investigated

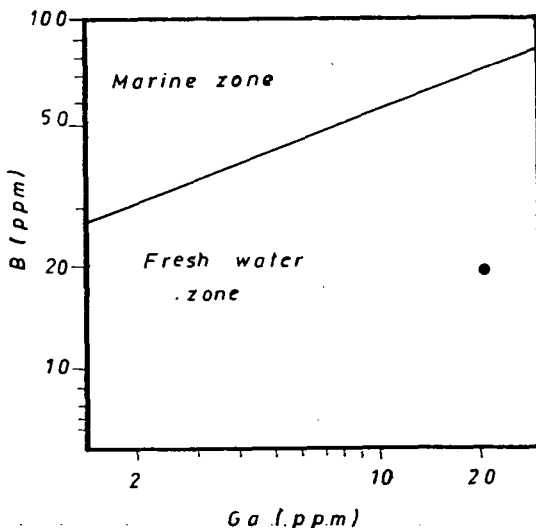


Fig. 5. The location of the average value of boron-gallium content

deposit (Fig. 6). DEGENS *et al.* [1958] explained a triangular diagram using boron-gallium-rubidium ternary relation by which they differentiate between marine and fresh water sediments (Fig. 7).

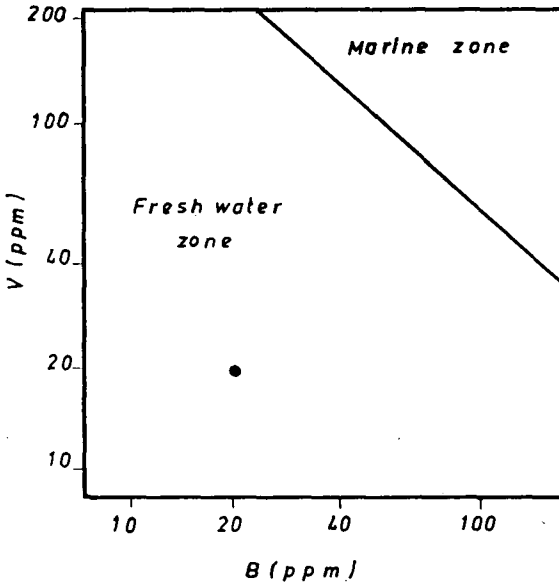


Fig. 6. The location of the average value of vanadium-boron content

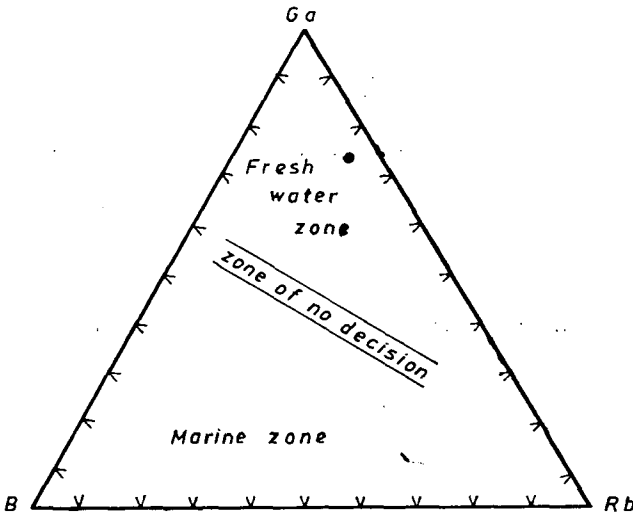


Fig. 7. The location of the average value of boron-gallium-rubidium content

ISOTOPIC MEASUREMENTS

The isotopic analysis of carbonates can be used to determine the environmental origin of the studied carbonate samples.

In this study the isotopic measurements of oxygen and carbon isotopes were

carried out with a micromass ^{602}C mass spectrometer according to the method described by MCCREA [1950] and BOWEN [1966]. The method is briefly: acid decomposition of carbonates under vacuum (10^{-6} Torr) using 100 % orthophosphoric acid. The $^{13}\text{C}/^{12}\text{C}$ ratio is measured on mass range 45—46, and the $^{18}\text{O}/^{16}\text{O}$ ratio is measured on mass range 44—46 with an accuracy of $\pm 0.01\%$. The standard used in this analysis is Solnhofen L. S., NB—20 [BOWEN, 1966]. The obtained results are referred to PDB—1.

KEITH and WEBER [1964] noticed a distinct difference between the isotopic ratios for carbon and oxygen between the marine and the fresh water shells. The $\delta^{13}\text{C}$ values for the marine shells range from +5.2 to +1.7‰ (relative to PDB—1). The fresh water Molluscan shells have relatively depleted $\delta^{13}\text{C}$ values ranging from -0.6 to -15.2‰. Similar differences were noted in the ^{18}O results. EPSTEIN [1951] and LOWENSTAM [1953] provided an isotopic temperature scale which can be used to determine the environmental temperature in which the shells have grown. According to KEITH and WEBER [1964], for the Jurassic and younger samples the best discrimination between marine and fresh water limestone is given by the following equation:

$$Z = a(\delta^{13}\text{C} + 50) + b(\delta^{18}\text{O} + 50) \quad (1)$$

where a and b are 2.048 and 0.498, respectively. Limestones with a Z value above 120 would be classed as marine, those with Z below 120 as fresh water, and those with Z nearer to 120 as intermediate. CLAYTON [1961] described the isotopic fractionation between the CaCO_3 and the water in contact, and concluded that the isotopic composition of CaCO_3 can be affected by the surrounding water.

RESULTS

Elemental Relations

Table 1 shows the trace elements present in the marlstone samples. These elements are estimated using both emission spectroscopy and X -ray fluorescence techniques.

Applying the average result of the boron-gallium binary relation of KEITH and DEGENS [1959], the location is in the fresh water zone (Fig. 5). For the vanadium-boron relation of POTTER *et al.* [1963], the average result is located in the middle of the fresh water zone (Fig. 6). From the triangular gallium-boron-rubidium diagram [DEGENS *et al.*, 1958], the result occupied a spot in the fresh water zone (Fig. 7).

Isotopic Data

Applying the equation 1, the obtained average Z value for the samples equals 122.57 (Table 2), which indicates an intermediate value between the marine and

TABLE 1

Trace elements present in the samples collected (in ppm)

Sample No	Ga	V	B	Rb	Ge	Pb	Sn	Zn	Be	Ti	Cr
1	18	20	20	57	4	5	5	50	1	2000	22
2	22	20	21	55	5	5	5	42	2	2000	32
3	20	20	19	59	6	5	5	58	1.5	2000	36
Average	20	20	20	57	5	5	5	50	1.5	2000	30

fresh water carbonates. The value is not contradicting the result obtained by the trace element technique. This *Z* value is not indicating a typical marine sediment, but fresh water results affected by the surrounding sea water in contact with these rocky samples [CLAYTON, 1961]. The average environmental temperature is calculated to be 26 °C, which indicates warm deposition environment.

TABLE 2

Analytical isotopic data of the studied marlstone samples

Sample No	$\delta^{18}\text{O}$ [‰]	$\delta^{13}\text{C}$ [‰]	<i>Z</i> value	Environmental temperature (°C)
1	-2.18	-1.64	122.85	24
2	-2.74	-1.68	122.49	28
3	-2.39	-1.82	122.38	26
Average	-2.44	-1.71	122.57	26

CONCLUSION

The flaggy marlstone boulders present on Rosetta beach are of fresh water environment, mostly related to the old Sebennyitic branch of the Nile, and are not of the present day Rosetta branch. This large size deposit is rejected on beach by the abnormal weather conditions from a relatively nearer source indicating high erosion conditions in this area.

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