J.K.A.U.: Mar. Sci., **Vol. 4**, pp. 133-141 (1413 A.H./1993 A.D.)

Black Benthic Foraminifera in Carbonate Facies of a Coastal Sabkha, Saudi Arabian Red Sea Coast

M. ABOU-OUF and A. EL-SHATER
Faculty of Marine Science, King Abdulaziz University, Jeddah, Saudi Arabia

ABSTRACT. Black foraminifera occurs in the zone of mixing of carbonate and terrigenous sediments of the coastal sabkha, Saudi Arabian Red Sea coast. The blackening may be due to impergenation of the sediments by dissolved or finely particulate iron sulphides (pyrite). The iron appears to be derived from associated terrigenous sediments and is being precipitated under reducing conditions and in the presence of sulphate-reducing bacteria around centers of organic material such as the foraminifera tests in the sediments. This black material is found preferentially on test surfaces of foraminifera or along sutures.

Introduction

This work is part of a project begun in 1987 to study the coastal sabkha of the Saudi Arabian Red Sea coast. The area of study lies between latitudes 22°45′ and 23° north and longitudes 38°45′ and 39° east. It lies between 10 to 20 kilometers north of Rabigh city (Fig. 1). Figure 2 shows the generalized sedimentary facies of the three cores taken in this area where the black foraminifera occurs within the unit-II of these cores.

Blackened grains in modern carbonate sediments have been reported from Bahamas (Illing 1954), from the Persian Gulf (Murray 1966; Sugden 1966) and from Holocene carbonate sediments of Florida keys, Bahamas, and Tunisia (Strasser 1986). Illing (1954) concludes that the iron-stained sediments found on some of the larger islands in the Bahamas are residual deposits concentrated by the removal of calcium carbonate in solution by percolating rain water. The stained material in the

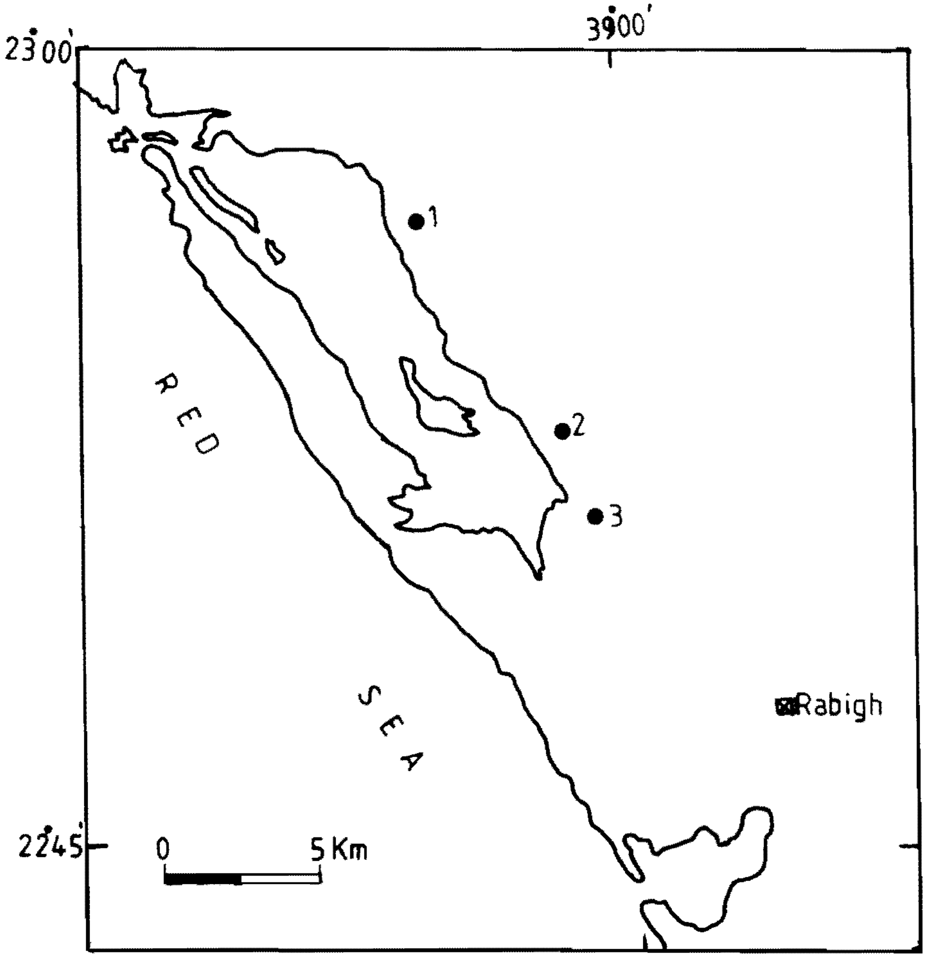


FIG. 1. Location of sediment cores.

Persian Gulf is mainly pellety debris (Sugden 1966) but the processes of staining as described by Sugden (*ibid*) appears to be very similar to that presented in this paper. Sugden (1966) also reports stained pellety debris in limestones of Middle Jurassic and younger age in the Middle East and Britain.

Black fossils have been analyzed by Burollet *et al.* (1979), who found small amounts of alumo-silicates (interpreted as neomorphic clay minerals) to be responsible for the blackening. Houbolt (1957) suggested that the skeletal grains were blackened by the decay of organic matter contained in the shells. Kendall and Skipwith (1969) found blue-green algae to be responsible for the alteration and blackening of carbonate grains.

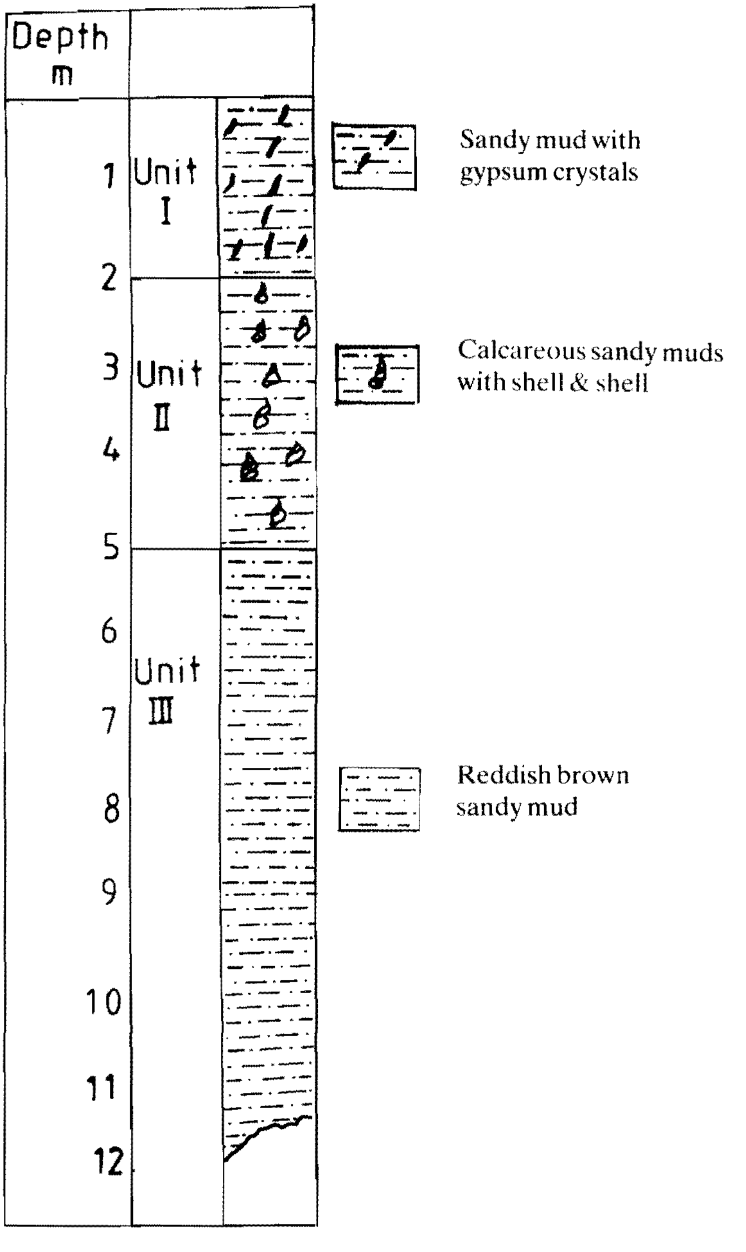


FIG. 2. Generalized sedimentary facies of the sediment cores.

This paper will investigate the occurrence of black foraminiferal tests in the subsurface carbonate facies of a coastal sabkha, Saudi Arabian Red Sea coast, with reference to the probable origin of this blackening material.

General Environmental Characteristics of the Studied Sediments

It is evident from the study of these cores and many others (Behairy *et al.*, 1987 and Behairy *et al.*, 1991) that they are essentially mixed siliclastic evaporite sabkha sediments (Fig. 2): an upper unit (0-2 m) composed of sandy mud displaying scattered millimetre-sized gypsum crystals, a middle unit (2-5 m) composed of grey calcareous sandy mud rich in shells and shell fragments, and a lower unit consisting mainly of reddish brown sandy mud and muddy sands of continental origin. These sediments were deposited in a lagoonal environments near the strande line. The depositional cycles started off with the Holocene transgression where the alluvial deposits (Unit-III) were flooded by the Red Sea water and a shallow lagoonal environment was developed (Behairy *et al.*, 1991). In this environment, the second facies (Unit-II) with carbonate sediments was deposited. The carbonates were mixed with clastic sediments derived from the coastal plain in various proportions. Deposition of these sediments continued until the lagoon became very shallow and further accumulation of sediments was prevented by the action of waves and currents. Sediments were transported by waves and currents to be deposited at the margins of the lagoon to form intertidal flat. This results in the lateral filling of the lagoon and progradation of coastline and wide intertidal and supratidal flats developed, creating conditions favourable for the appearance of evaporitic environments (Unit-I). Thus, early carbonate sediments of this coastal sabkha conditions represent the transgressive phase and the later evaporite sediments represent the regressive phase of a cycle.

From the above and from the foraminiferal analysis of Abou-Ouf (1992), it has been concluded that this lagoon was a hypersaline, and the reducing conditions were prevailing.

Nature and Description of the Material

A diagenetic effect in certain parts of the study area appears to be turning some grains in the sediments black. These sediments are thus speckled in black color where the colored grains are mainly foraminiferal tests which were concentrated from the sediments by a standard floatation technique using carbon tetrachloride.

The black staining occurs preferentially on tests of foraminifera identified in the sediments. These foraminifera, which are subdivided into three groups according to the wall composition of their tests, are: (i) porcellaneous foraminifera (70-98%), represented by five genera (Quinqueloculina, Triloculina, Peneroplis, Sorites and Spirolina); (ii) hyaline foraminifera (0-30%), including two genera (Ammonia and Elphidium), and (iii) agglutinated foraminifera (0-2%), comprising only one genus, Clavulina.

This black staining is present mainly as specks on the outer surface of the two genera, *Sorites marginalis* (Plate 1-a) and *Quinqueloculina masharrafia* (Plate 1-b). In *Spirolina acicularis* (Plate 1-c), *Peneroplis planatus* (Plate 1-d), *Ammonia beccarii* (Plate 1-e), and *Elphidium discoidale* (Plate 1-f), staining may also be preferentially along lines of junctions between chambers (sutures) giving the specimens a black and white striped appearance. The black staining, however, cover most or all the surface test of *Clavulina pacifica* (Plate 1-g), whereas in *Triloculina* sp., the staining appears to penetrate into the walls with decreasing density (Plate 1-h).

Treatment with diluted HCl, H_2O and formic acid (10%) did not indicate that this staining matter is pyrohotite or organic matter (Lewis 1984), and thus the blackening may be due to the presence of pyrite (FeS), particularly all conditions favourable for its formation as will be discussed in the following paragraphs :

Behavior of Iron in the Studied Environment

In the reducing environment, iron is soluble in its ferrous state and in the presence of sulphate-reducing bacteria where it is usually found present as a sulphide (Emery and Rittenberg 1952; Love and Murray 1963). The iron sulphides most commonly occur as pyrite. Van Straaten (1954) found that in the Dutch Wadden Sea, iron sulphide in the upper part of the reducing zone was present in a mono-sulphuric amorphous state and with depth this changes to pyrite.

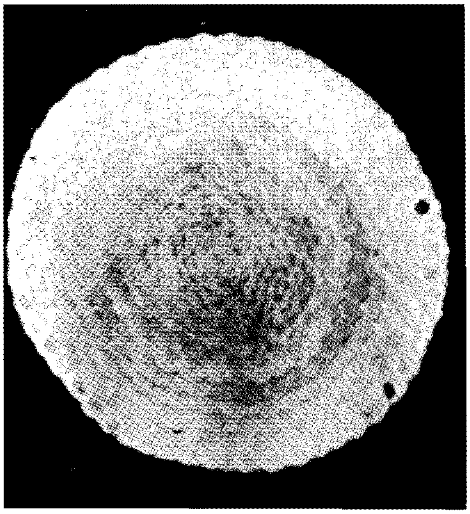
Source for the Iron and its Precipitation in the Sediments

The blackened foraminifera occur mainly in the Unit II (Fig. 2) which composed of carbonate mixed with clastic sediments derived from the coastal plain. These terrigenous sediments contain iron-rich clays and sands (Jado and Zotl 1984). The iron from this terrigenous source is present in an oxidized state, probably as hematite coatings on the sand grains and as adsorbed particles on clay-sized material. As such it will be relatively insoluble in the marine oxidizing environment and will be deposited with the terrigenous sediments. Once the sediment is buried and reducing conditions set in, the oxidized iron, in the presence of sulphate-reducing bacteria, will reprecipitate as iron sulphide.

Preferential Precipitation of Iron on Foraminiferal Grains

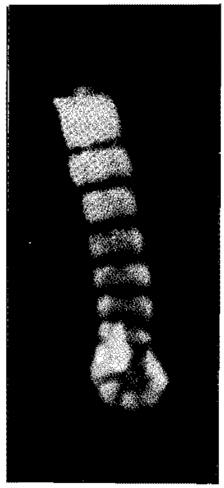
It has been noted frequently that sedimentary iron is located in centers associated with organic matter (Van Straaten 1954; Emery and Rittenberg 1952; Moretti 1957; Love and Murray 1963). Foraminifera tests have a cellular structure and thus form micro-environments within the overall environment. In the oxidizing environment, organic matter is rapidly consumed by bacteria. The foraminifera tests, however, appear to preferentially preserve organic matter in the restricted microenvironment of their tests while in this zone. Thus, when the sediment reaches the reducing zone the foraminifera tests will be centers of organic material which in turn will act as nucleii for iron precipitation in the sediment. Bacteria need organic matter for their life processes, and in turn, are the cause of breakdown of sulphate in sea water making sulphur available for reaction with the reduced iron. Organic matter in the sediment ap-

Plate 1

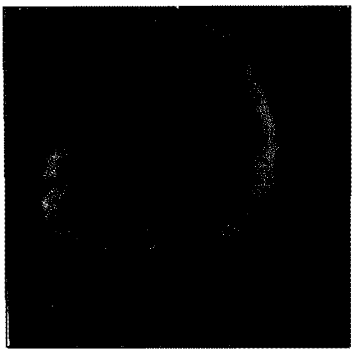


(a) *Sorites magginalis* × 13

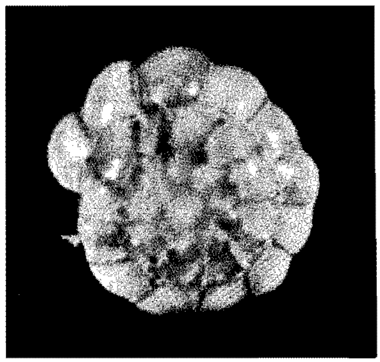
(b) *Quinquloculina masharrafia* × 45



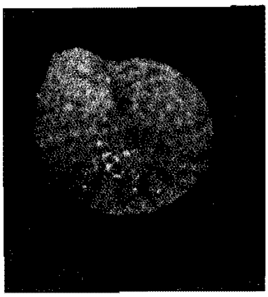
(c) *Spirolina acicularis* × 43



(d) *Peneroplis planatus* × 49

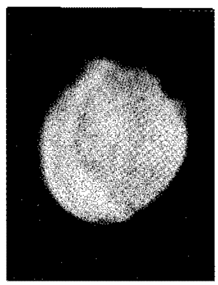


(e) *Ammonia beccarii* × 50



(f) *Elphidium discoidal* × 80

(g) *Clavulina pacifica* × 35



(h) *Triloculina* sp. × 34

pears to be the locus of iron precipitation, because, presumably it determines the location of bacterial activity.

Conclusions

1 – Black foraminifera were recorded in the subsurface carbonate facies of a coastal sabkha of the Red Sea, Saudi Arabia.

2 – This black material may be pyrite as indicated by the primary treatment used in this study.

3 – This material usually occurs as specks on the test surfaces of foraminifera or as staining along sutures.

4 – Zones of black foraminifera can probably be used as tools for tracking reducing environments in the sedimentary sequences along the Red Sea coastal plain.

5 – This black material needs detailed studies to identify its exact composition from chemical and mineralogical points of view. This will provide us more information about the processes of staining and the different parameters of this environment.

References

Abou-Ouf, M. (1992) Benthic foraminifera in carbonate facies of a coastal sabkha, Red Sea coast, Saudi Arabia. *Mar. Geol.* **104:** 187-191.

Behairy, A.K.A., Durgaprasada Rao, N.V.N., Abou Ouf, M., El-Abd, Y. and **El-Ghobary, H.** (1987) Depositional and diagenetic history of evaporitic sediments in a coastal lagoon and sabkha, eastern Red Sea. *Research Proj. No. 145/407, Faculty of Marine Science, K.A. Univ.,* Jeddah, Saudi Arabia.

Behairy, A.K.A., Durgaprasada Rao, N.V.N. and **El-Shater, A.** (1991) A siliciclastic coastal sabkha, Red Sea coast, Saudi Arabia. *Bull. Fac. Mar. Sci., King Abdulaziz Univ.,* **2:** 65-77.

Burollet, P.F., Cassoudebat, M. and **Duval, F.** (1979) La mer pelagienne, les constituants lithologiques, microfacies. *Geol. Mediterr.,* **6/1:** 83-110.

Emery, K.O. and **Rittenberg, S.C.** (1952) Early diagenesis of California Basin sediments in relation to origin of oil. *Am. Assoc. Petrol. Geol. Bull.,* **36:** 735-806.

Houbolt, J.J.H.C. (1957) *Surface Sediments of the Persian Gulf Near the Qatar Peninsula.* The Hauge Mouton, 113 p.

Illing, L.V. (1954) Bahaman calcareous sands. *Am. Assoc. Petrol. Geol. Bull.,* **38:** 1-95.

Jado, A.R. and **Zotl, J.G.** (1984) *Quaternary Period in Saudi Arabia.* V. 2, Springer-Verlag, Wien., New York, 360 p.

Kendall, C.G. and **Skipwith, P.A.D.E.** (1969) Holocene shallow-water carbonate and evaporite sediments of Khor al Bazam, Abu Dhabi, Southwest Persian Gulf. *Am. Assoc. Petroleum. Geologists Bull.,* **53:** 841-869.

Lewis, D.W. (1984) *Practical Sedimentology.* Hutchinson Ross Publishing Company, Stroudsburg, Pennsylvania, 229 p.

Love, L.G. and **Murray, J.W.** (1963) Biogenic Pyrite in recent sediments of Christchurch Harbour, England. *Econ. Geology,* **56:** 873-869.

Moretti, F.J. (1957) Observations on limestones. *J. Sed. Petrol.,* **27:** 282-292.

Murray, J.W. (1966) The foraminifera of the Persian Gulf, 4: Khor al Bazam. *Paleogeog., Paleoclim., Paleoecology,* **2:** 153-169.

Strasser, A. (1984) Black-pebble occurrence and genesis in Holocene carbonate sediments (Florida Keys, Bahamas and Tunisia). *J. Sed. Petrol.,* **54:** 1097-1109.

Sugden, W. (1966) Pyrite staining of pellety debris in carbonate sediments from the Middle East and elsewhere. *Geol. Mag.*, **103:** 250-256.

Van Straaten, L.M.J.U. (1954) Composition and structure of recent marine sediments in the Netherlands. *Leidse Geol. Mededel., Leiden, deel.*, **19:** 1-110.

فـورامنيفرا قاعيـة سـوداء اللون في سحنـة الكربونات تحت السطحيـة في سبخـة ساحليـة - الساحـل السعـــودي

محمد أبو عوف و عبد الحميد الشاطر
كلية علوم البحار ، جامعة الملك عبد العزيز
جـــدة ، المملكة العربية السعودية

المستخلص . لقـد وجدت فورامنيفرا سوداء اللون في النطاق الذي تختلط فيه رواسب الكربونات بالفتاتيات القارية ، وذلك في السبخة الساحلية على الساحل السعودي .

إن طبيعـة هذه المادة السوداء قد تعزي إلى اصطباغ هذه الرواسب بكبريتيد الحديد (البيرايت) والذي قد يوجد في صورة ذائبة أو كحبيبات دقيقة جدًا . أما مصدر هذا الحديد فيبدو أنه قد اشتق من الفتاتيات القادمة من اليابسة والتي ترسبت في ظروف مختزلة في وجود بكتريا مختزلة للكبريتات حول مراكز لمواد عضوية مثل أصداف الفورامنيفرا في الرواسب ، وتوجد هذه المادة السوداء إما فوق سطح أصداف الفورامنيفرا أو على طول خطوط الدرز .