JOURNAL GEOLOGICAL SOCIETY OF INDIA
Vol. 32, Nov. 1988, pp. 426 to 429

PALAEOCLIMATIC SIGNIFICANCE OF GYPSUM PSEUDOMORPHS IN THE INNER SHELF SEDIMENTS OFF MACHALIPATNAM BAY

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Abstract

Pseudo-gypsum crystals have been found in the coarse fraction of the sediments from the inner continental shelf off Machalipatnam Bay. They range in size from 3 to 7 mm and are elongate and lenticular in shape. Bassanite and calcite are pseudomorphs after gypsum. The origin of the pseudo-gypsum has been discussed and it is suggested that these are indicators of late Pleistocene climatic aridity. The bay sediments deposited during late Pleistocene were subsequently eroded by waves and currents due to sea level changes and the coarse fraction of the sediments containing pseudo-gypsum were transported and deposited in the inner continental shelf.

Introduction

Although several workers (Shrivastava, 1968; Nair and Murthy, 1968; Krishnanath 1971; Hashimi 1974; Hashimi and Ambre, 1979) have reported the occurrence of gypsum in the continental shelf sediments off India, there is no published literature on the occurrence of pseudo-gypsum in shelf sediments. This paper documents the occurrence of pseudo-gypsum in the modern sediments off Machalipatnam Bay. The aim of this study is to understand (1) the mode of formation of primary gypsum, (2) the processes of alteration/replacement at the place of occurrence or before transport and (3) the importance of the altered/replaced minerals after gypsum in recognition of palaeoclimate.

Results

White crystals measuring from 3 mm to 7 mm are found in the coarse fraction of the inner continental shelf sediments off Machalipatnam Bay. Crystals occur in the sediments at a depth of 18 to 21 m and are located approximately 36 km from the Bay. The crystals are euhedral, elongate and exhibit well-developed pinacoid and prism faces, whereas some acquired lenticular shape due to the rounding of pyramids (Fig. 1A). Irregular grooves are present on one side of the crystal along the long axis (Fig. 1B), while the other side of the crystal is smooth (Fig. 1C) indicating that these crystals probably grew with their irregularly grooved long axis resting on the depositional surface. Abrasional features are also present (Fig. 1D). Unlike gypsum, these crystals are found to be soluble in 0.5 N acetic acid. The constituent minerals, revealed by X-ray diffraction (Fig. 2), are bassanite and calcite. The coarse fraction of the sediments associated with these crystals have also been studied by X-ray diffraction. Feldspar/quartz content in these sediments varies from 0.35 to

EXPLANATION OF FIGURE 1

Pseudomorphs of gypsum crystals. (A) lenticular and prismatic gypsum crystals, (B) long axis of the crystal showing irregularly grooved surface, (C) long axis on the other side of the same crystal showing smooth surface and (D) crystal showing abrasional features on the sides.

0016 – 7622/88/32-5-426/$ 1.00

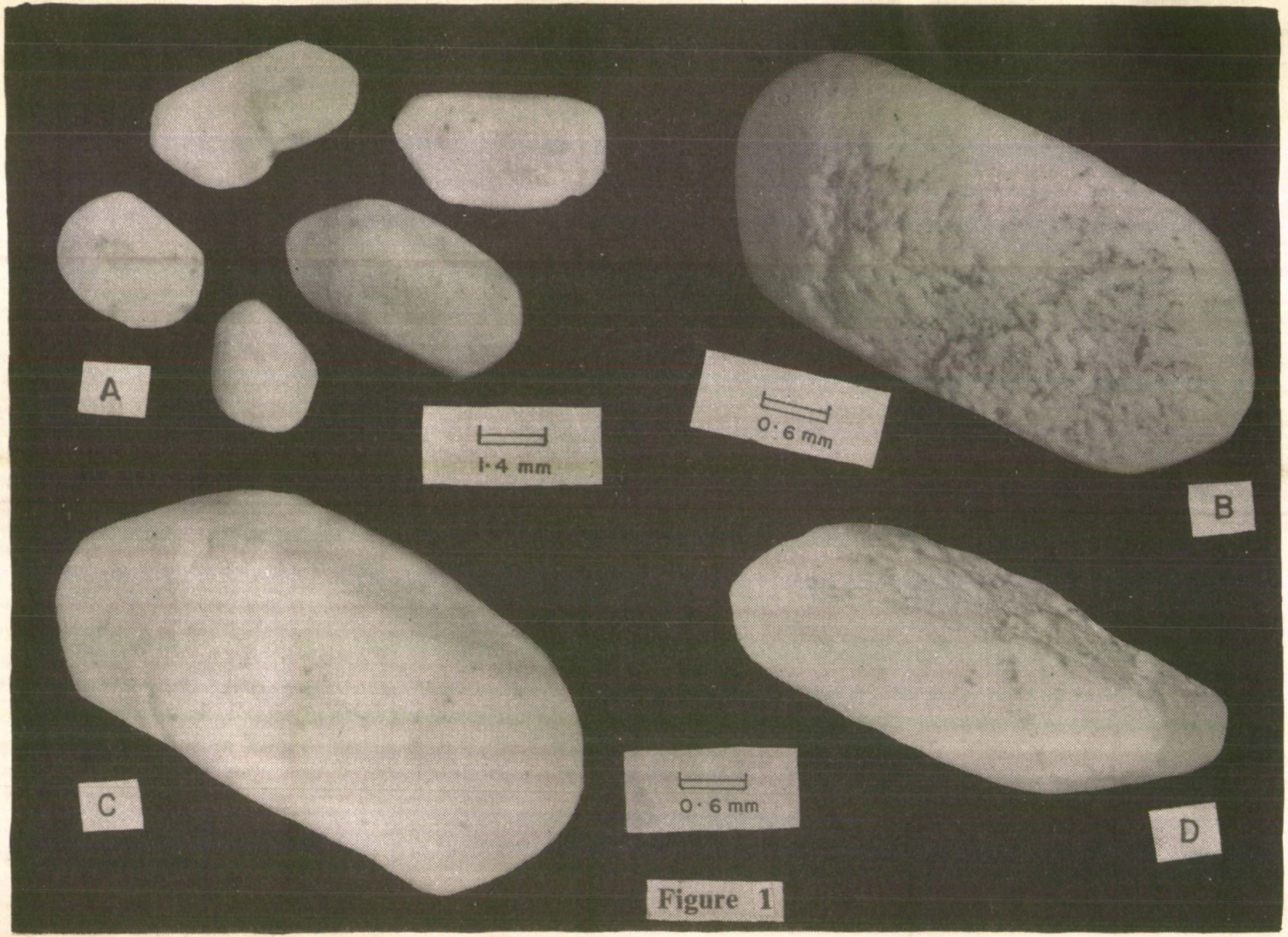

Figure 1

0.75. Feldspar and quartz are derived from the weathering of the rocks from the adjacent landmass and their relative abundance indicates weathering conditions at the time of formation. Abundance of feldspar in the coarse fraction of the sediments can be used as a climatic indicator as high contents indicate either a hot and dry or cold and dry climate.

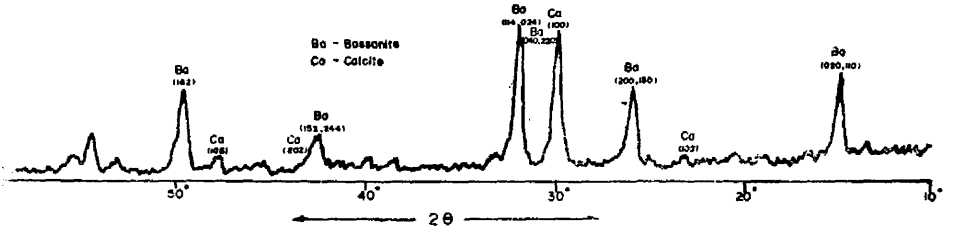

Figure 2. X-ray diffractogram of the pseudo-gypsum crystals.

Discussion

The shape of the crystals suggests that gypsum was the original mineral. Gypsum can form in the coastal sabkha environment either by evaporation of sea water in brine pans and in lagoons or by the evaporation of interstitial water in sediments (Murray, 1964). Alternately, authigenic gypsum can form in carbonate and organic-rich sediments (Berner, 1971). The gypsum crystals under study are large (3 to 7 mm), elongate prismatic forms and occur in the sediments close to the bay. On the other hand, the size of authigenic gypsum crystals reported by several workers (Arrhenius, 1963 ; Krishnanath, 1971 ; Siesser and Roger, 1976 ; Briskin and Schreiber, 1978 ; Xavier and Klemm, 1979 ; Gupta, 1980) is less than 1 mm. Besides, experimental results have shown that gypsum crystals formed during authigenesis in the presence of organic matter are smaller, stubby and lack prismatic forms (Sonnenfeld, 1984). Primary gypsum can, therefore, form only in an evaporite environment. Characteristic features such as grooved surfaces along the long axis of the prismatic crystals, their absence on the other side and abrasional features are evidences that they were formed in coastal environment and transported to present depths. The composition of the present crystals indicates that the primary gypsum was altered to or replaced by bassanite and calcite. Bassanite, semi hydrated calcium sulphate, forms by the alteration of gypsum at about 70 to 90°C (Deer *et al.* 1967) or wherever gypsum is exposed to very dry air (Sonnenfeld, 1984). Since high temperatures are required for the formation of bassanite, it is obvious that the process of alteration/replacement must have taken place in the coastal environment before it was transported to present depths. Gypsum could alter to bassanite in extremely arid conditions. Bassanite is meta stable, consists of open spaces in its structure and, on hydration, converts again to gypsum (Deer *et al.* 1967). In the present study, it occurs as bassanite only. It could be that calcite precipitation had taken place before hydration. Coastal groundwaters are generally rich in bicarbonate ions. Due to intense evaporation bicarbonate-rich groundwater probably substituted carbonate into bassanite displacing some sulphate and resulting in the formation of calcite. Warren (1982) has also reported the occurrence of bassanite along with gypsum in late Quaternary salt lake sediments in south Australia.

The foregoing discussion reveals that gypsum and pseudomorphs after gypsum are formed in sabkha environment and in arid climatic conditions. Humid tropical conditions exist during the present times and there are no coastal sabkhas. It is, therefore, reasonable to infer that the formation of these pseudo-gypsum crystals are indicative of past climatic aridity. As these crystals occur off the bay, these bays should have experienced sabkha-like environment and arid climate in the geological past, probably during the Pleistocene. Feldspar/quartz ratios are higher and are similar to the ratios reported by Hashimi and Nair (1986). High feldspar contents occurring with pseudo-gypsum supports the conclusion that hot and dry climate prevailed in late Pleistocene. Arid climates were predicted over India in the late Pleistocene based on the feldspar distribution in the shelf sediments (Hashimi and Nair, 1986). The erosion of such bays by waves and currents and subsequent transportation resulted in the occurrence of the pseudomorphs in the present day inner continental shelf.

Acknowledgements: The author wishes to thank Dr. B. N. Desai, Director, NIO, Mr. P. S. N. Murty, and Mr. R. R. Nair for their interest and encouragement. Thanks are due to Dr. Ch. M. Rao for critically going through the manuscript. He is thankful to U. Shrisat for photography work.

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(Received: April 1, 1987; Revised form accepted: Nov. 14, 1987)