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CARBONATE DIAGENESIS IN THE COASTAL REEF TERRACES BETWEEN JEDDAH AND YANBU,SAUDI ARABIA.

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Abstract:

Carbonate diagenesis in the emergent reefal terraces occurring in the coastal plain between Jeddah and Yanbu, on the west coast of Saudi Arabia, has been studied. Various stages of preservation and alteration of mg-calcite and aragonite coexist indicating an incomplete and gradual diagenetic processes. Dissolution and mold filling is the primary mechanism of radial fibrous aragonite alteration to low mg-calcite cement. The crystals with sharp rhombic terminations grow from the wall towards the interior of the pores. Fresh water dissolution has intensively effected the aragonite and mg leaching in the inland carbonates, whereas in the supratidal surf-spray zone considerable amounts of the two unstable phases still persist. In the littoral environment, calcite rhombs of phreatic origin scattered over the grain surfaces are associated with acicular aragonite and mg-calcite micrite submarine cements. The arid climate, limited quantities of meteoric fluids and the infiltration rate are considered to be the factors controlling the diagenetic processes in the carbonates of Jeddah-Yanbu coastal plain.

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Letter Section

MARINE TRANSGRESSIONS IN THE WEST COAST OF SAUDI ARABIA (RED SEA) BETWEEN MID-PLEISTOCENE AND PRESENT

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ABSTRACT

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Marine abrasion terraces cut in coralline limestone formations are to be noticed at various elevations in the coastal plain of the west coast of Saudi Arabia. In between Jeddah and Yanbu, three prominent terraces occur at altitudes of 1, 3 and 10 m above the present level. Coral limestone samples from the terraces were dated by the carbon-14 method. The radiometric ages reveal four marine transgressions in the west coast of Saudi Arabia (eastern Red Sea) from the mid-Pleistocene to Present. Sea-level maxima were recorded at about 31,000, 16,600—18,100, 9980 yrs B.P. and mid-Holocene(?). The absolute altitude of the sea levels during the transgressions could not be evaluated because of the tectonic instability of the region. However, it is evident that relative to the first marine transgression (mid-Würm interglacial, upto 31,000 yrs B.P.), the successive transgressions in the west coast of Saudi Arabia occurred at progressively lower levels.

INTRODUCTION

On the west coast of Saudi Arabia, marine erosional terraces of coralline limestone are to be found at various elevations in different parts of the coastal plain (Tihama). Although the terraces are not continuous, they can be promptly identified in many places all along the coast. Nesteroff (1959) describes the older coral reefs and gives the date of a 30-m terrace from Abulat Island off the coast near Al Lith as 35,000 years. A series of late Pleistocene reefs that stand as wave-cut terraces at heights of 1—3, 7 and 12 m above the modern sea have been reported in the Red Sea coastal plain (Sestini, 1965; Said, 1969). Skipwith (1973) observed raised reef terraces north of Umm Lajj at altitudes of 6, 19, 20 and 30 m above the mean sea level. In Tiran Island at the mouth of Gulf of Aqaba, a coral limestone terrace occurs at a height of 520 m above the sea level. However, in the central and southwestern Saudi Arabian coast, the marine terraces are at a lower level compared to their northern counterparts. Although the terraces are generally described as of Pleistocene age (Behairy, 1980), little

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is known about the accurate radiometric ages and the sea-level fluctuations in the eastern Red Sea coast. During an investigation on carbonate diagenesis in the coral limestone formations in the coastal plain between Jeddah and Yanbu (Fig. 1), some samples were dated and from the data the sea-level changes along the west coast of Saudi Arabia have been postulated.

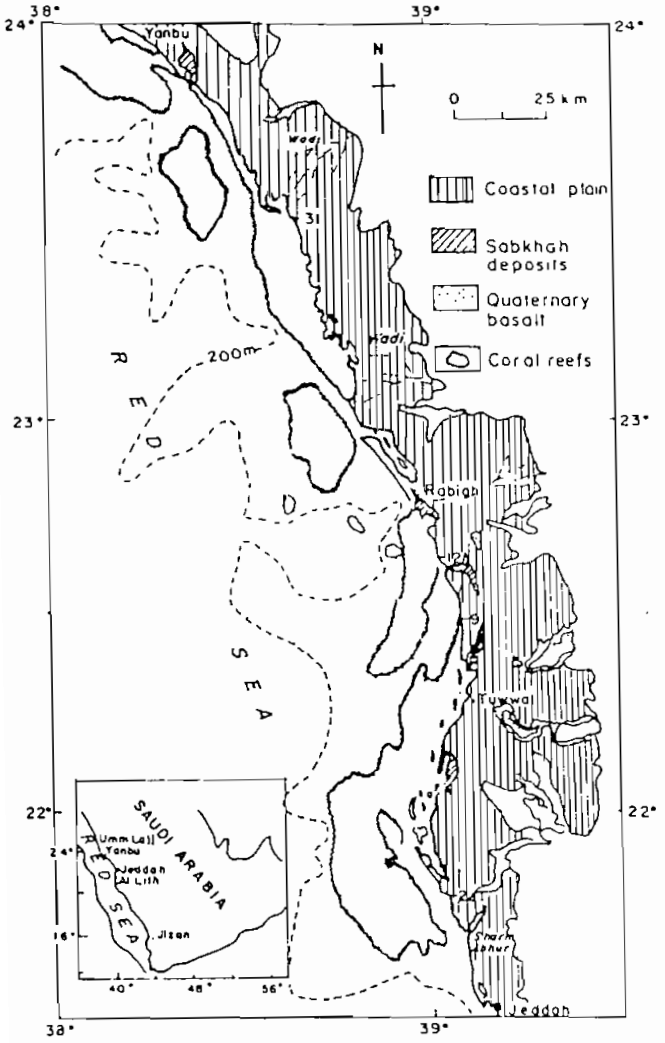

Fig. 1. Coastal plain between Jeddah and Yanbu, west coast of Saudi Arabia.

COASTAL PLAIN

The coastal plain along the west coast of Saudi Arabia was described in some detail by Skipwith (1973) and Chapman (1978). In between Jeddah and Yanbu, the coastal plain rises inland from the coast into an eastern plain covered with alluvial sediments derived from the adjacent high fringing

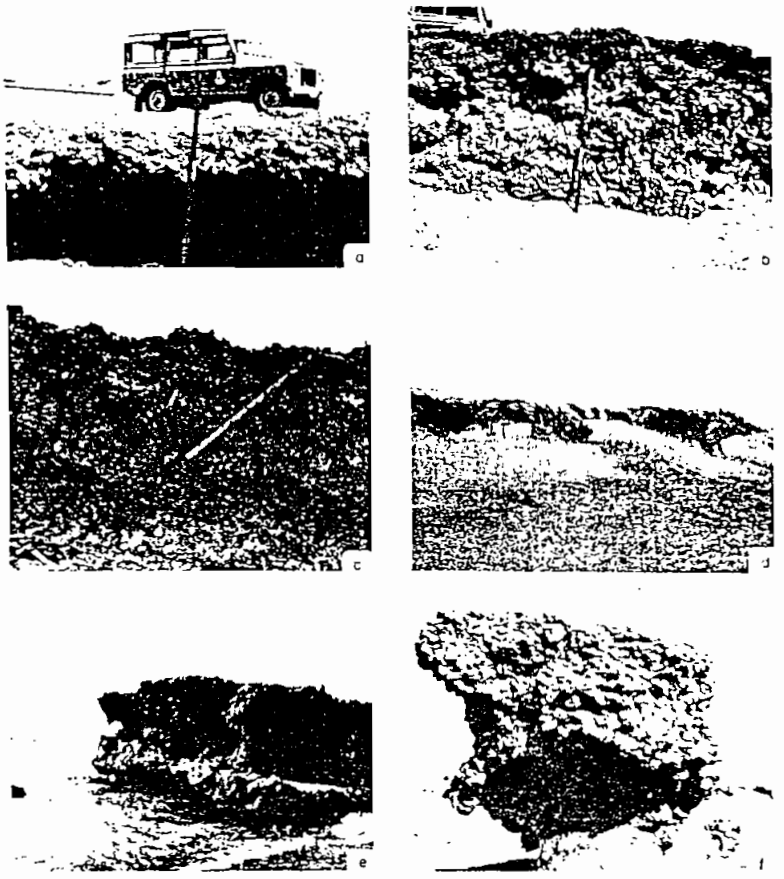

Fig. 2. (a) Terrace I in the coral limestone north of Jeddah, about 1 m above the sea level (b and c) well cut 3-m terraces (terrace II) north of Tuwwal; (d) 10-m terrace (terrace III) located about 500 m from the present shoreline, south of Yanbu; (e) mid-Holocene wave-cut notch in the coral limestone in the coastal region; (f) late Pleistocene sea stack modified by eolian weathering process. In the background is the 10-m terrace.

mountains. The seaward edge is traversed by a number of tidal creeks (Sharms) that are considered to be drowned estuaries formed during lowered sea level and high rainfall in the western Saudi Arabia. Although narrow near Jeddah, the coastal plain widens irregularly towards Yanbu and reaches a maximum width of 40 km at some places. North of Jeddah, three marine abrasion terraces at elevations of 1, 3 and 10 m are noticed in the coral limestone formations (Fig. 2). Terraces I and II are nearer the present shoreline, whereas the terrace III lies at about 500 m from the coast.

The coastal plain and the northwesterly-trending escarpment in its eastern margin were originated during Tertiary tectonism in western Saudi Arabia (Chapman, 1978). Unfortunately very little information is available on subsequent tectonic movements in the region. However, the Quaternary and historic volcanic activity in western coastal Saudi Arabia (Barazangi, 1981) makes the coastal plain an area of questionable tectonic stability. Though there is evidence of some degree of Quaternary tectonism, the coastal plain as a whole does not seem to have behaved as a tectonic entity. Crustal movements appear to be more prominent in the northern coastal plain (Fairhead and Girdler, 1970; Ben-Menahem and Aboodi, 1971), where the Pleistocene coral limestone terraces have been uplifted by the vertical movements along northwest—southeast faults. In the Jeddah—Yanbu coastal plain, large-scale displacements comparable with those in the northern region have not been reported. The only observation is that of Blank (pers. commun., 1980, U.S.G.S., referred to in Barazangi, 1981), who noticed fault displacements (Holocene ?) of up to 0.5 m in the coral limestone, about 100 km north of Jeddah. However, it is difficult to assume localized uplift in the coastal plain that could produce terraces in the coral limestones. It is considered, therefore, that the terraces reveal evidence of major sea level transgression in the west coast of Saudi Arabia.

CARBON-14 DATINGS

Carbon-14 determinations on the coralline limestone samples from the terraces were made in the Laboratoire de Géologie et Géochemie, Université de Nice, France, following standard procedures in mass spectrometry. The data are presented in Table I.

TABLE I

Radiocarbon dates of coral limestones from the west coast of Saudi Arabia

Sample no.	Terrace no.	Height in meters above the HWL	Age (yrs B.P.)
2	I	1	9980 ± 140
9	II	3	18100 ± 370
12	II	3	16600 ± 210
31	III	10	31000 ± 1350

DISCUSSION

Radiometric ages of the coral limestone in the terraces indicate four major marine transgressions in the west coast of Saudi Arabia, between mid-Pleistocene and Present. The first transgression occurred during the interstadial period of the middle Würm (before 31,000 yrs B.P.), when the sea might have extended almost up to the foothills. During this time the coral limestone in the terrace III was deposited and the climatic conditions seem to have been same as in recent times, favouring the coral formation. This transgression corresponds with the high stand of sea level at about the present level during the period 30,000–35,000 yrs B.P. recorded in the generalized sea-level fluctuations curve (Curray, 1965). Milliman and Emery (1968) report a sea level a few meters higher than the present in the middle Würm interstadial (40,000–26,000 yrs B.P.). In the Persian Gulf (Kassler, 1973) and in the east coast of Saudi Arabia (Felber et al., 1978), higher sea levels were recorded around 30,000–35,000 yrs B.P. After 31,000 yrs B.P., the sea level in the west coast of Saudi Arabia dropped. However, the amount of fall is not exactly known as there is no record of terraces or nick points in the continental shelf and upper slope.

The ages of the limestones in terrace II suggest a second transgression with its maximum water level between 16,600 and 18,100 yrs B.P. Such a high stand of sea level is supported by the observations of Fairbridge (1961), who records a more than 15 m rise in the sea level around 17,000 yrs B.P. After 16,600 yrs B.P., the sea level dropped again. The lowering is evidenced by the widespread occurrence of aragonite layers in the Red Sea sediments deposited between 11,000–20,000 yrs ago. Milliman et al. (1969) and Milliman (1977) infer that these aragonite layers were formed under hypersaline conditions in the Red Sea due to the lowering of the sea level hy more than 80 m below the present level.

The age of 9980 yrs B.P. of the limestone in the terrace I indicates a third marine transgression along the west coast. Terrace II was cut during the transgression, that appears to be of relatively shorter duration. Though there are no equivalents of this transgression either in the east coast of Saudi Arabia or in the Arabian Gulf, higher sea levels were reported by Fairbridge (1961) and Curray (1965) around 10,000 yrs B.P. De Pratter and Howard (1981) found evidence for a high sea level before 9000 yrs B.P. and an early Holocene drop in the level to approximately –4 m below the present in the southeast coast of the United States.

There is no direct evidence of a fourth marine transgression in the west coast of Saudi Arabia. However, terrace I in the Holocene reefal limestone cannot be explained without invoking a higher relative sea level. The one-meter-high terrace and the lowstand of the present water level relative to the terrace position suggest the existence of a higher mid-Holocene sea level. Vast coastal sabkhas located along certain parts of the coast also support the mid-Holocene transgression in the west coast. Felber et al. (1978)

record marine transgression and higher sea level during the middle Holocene on the east coast of Saudi Arabia. The sea level was about 1 m above the present level and caused the formation of 1-m terraces in the coastal plain. Faure (1975) observed a mid-Holocene sea level as high as or higher (+1 or +2 m) than the present in the south western Red Sea coastal plain. Mid-Holocene higher sea levels were also noticed along the coastal plain of the Great Barrier Reef province (Hopley, 1979). Fairbridge (1961) and Tooley (1978) report several fluctuations in the sea level during the Holocene.

Although the marine transgressions on the west coast of Saudi Arabia are in general agreement with the observations on the sea-level fluctuations (Curray, 1961, 1965; Fairbridge, 1961), the altitude of the higher water levels differs considerably. Most of the interglacial sea levels and their associated terraces are located below or close to the present sea level. But on the west coast, like on the east coast of Saudi Arabia (Felber et al., 1978), the terraces are well above the present sea level, indicating probable tectonic uplift of the coastal area. However, an estimate of the crustal movements and the absolute altitudes of the sea level during the four marine transgressions cannot be assessed for the present, as there is no information available on the neotectonics of Western Saudi Arabia. The present altitudes and age data show that the successive shorelines of the marine transgressions in the west coast lie lower the more recent is the transgression. The sea level during the middle Würm interglacial was higher than it had been on any subsequent occasion. It follows, therefore, that the shoreline characteristics higher than the 10-m strandline in the northwestern coastal plain must have been raised to their present positions by tectonic uplift. However, further studies and datings of the terraces north of Umm Lajj will give a clear understanding of the effect of tectonism on the sea level fluctuations in the west coast of Saudi Arabia.

CONCLUSIONS

Four major transgressions have been identified on the west coast of Saudi Arabia between the mid-Pleistocene and the Present. Each successive transgression occurred at progressively lower altitude relative to the mid-Würm interglacial highest sea level. The present elevations of the marine terraces above the modern sea level are probably due to tectonic uplift.

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