

## Submarine physiography off Lakshadweep Islands, Arabian Sea

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**Abstract** – Analysis of echosounding, side scan sonar and shallow seismic data, supplemented by 152 sediment samples, collected along 150 km around Lakshadweep Islands, Arabian Sea, revealed that the islands have a very narrow shelf, and an abrupt shelf break occurs at 14 m water depth. The gradient of the slope is very high (1:4 to 1:9) and it has evidences of disturbances. Several well defined terraces occur at 45, 69, 82 m water depth on the continental slope, of which, the most prominent terrace at 82 m (about 150 m wide) is correlatable with similar features reported from the continental shelf of the West Coast of India having an age of about 8900 radio carbon years. These terraces seem to be the manifestations of glacio-eustatic sea-level fluctuations since Pleistocene and the deepest one perhaps represents "Younger Dryas".

The study also revealed that the foot of the slope around most of the Lakshadweep Islands is covered by slump deposits. The continuous seismic profiles off Bangaram island suggest around 75 m thick slump deposits with well defined compressional depressions and main glide plane scar. The slump deposits located at the foot of the slope appear to be the result of episodic slumping from the islands.

### INTRODUCTION

The Lakshadweep region is located at the northern extremity of the aseismic Chagos-Laccadive ridge and consists of 32 coralline islands, 1 atoll, 3 reefs and 5 submerged banks. The islands are aligned in NNE-SSW direction with a lagoon on the western side.

The geological and geophysical studies carried out around Lakshadweep Islands until now were mainly confined to the beaches and echosounding in the shallow depths (SIDDIQUIE 1975, 1980). These studies, however, are not sufficient to elucidate the nature of various physiographic subunits of the shelf and slope regions of these islands. Present studies were concentrated in the shelf and slope region off Agatti, Amini, Kalpitti, Pitti, Bangaram and Kadmat islands (Fig. 1). The purpose of this article is to report the nature of the shelf and slope of these islands and the imprints of sea-level still stands since Pleistocene.

### METHODS

Two oceanographic cruises onboard MV *Colhita* were undertaken in 1986 for the geological and geophysical investigations of the sea around the Lakshadweep Islands. An ORE mud profiler with 4 kW output power and 3.5 kHz frequency was deployed to obtain detailed information about the topmost layer and to identify the nature of surficial sediments. An EG & G sparker system with 4.5 kilo Joules transmitting energy, a Simrad-200 echosounder and E G & G sea-floor mapping system at 50 m range were used for the surveys. The positions along the survey tracks were obtained using a Miniranger MRS III system (accuracy  $\pm$  3m). About 152 surficial sediment samples were also collected from different physiographic subunits of the islands using a La Fond snapper and Petterson grab.

The terminology of WEAR *et al.* (1974) has been followed for determination of shelf break and to define all the topographic features such as terraces occurring on

the slope of the islands. The description of the slump deposits is based on the terminology of LEWIS (1972) and DINGLE (1977).

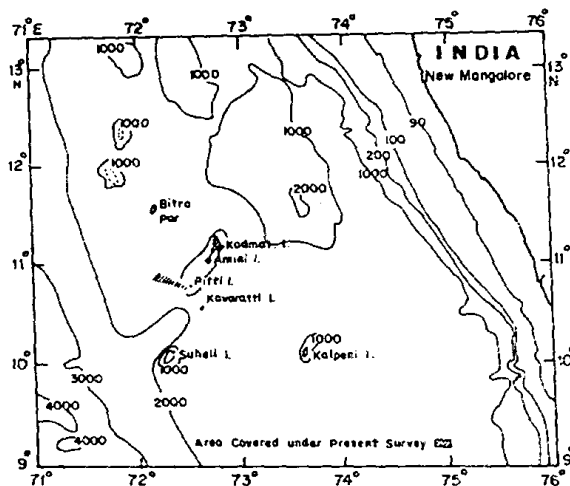


Fig. 1. Location map of study area with general bathymetric contours (m).

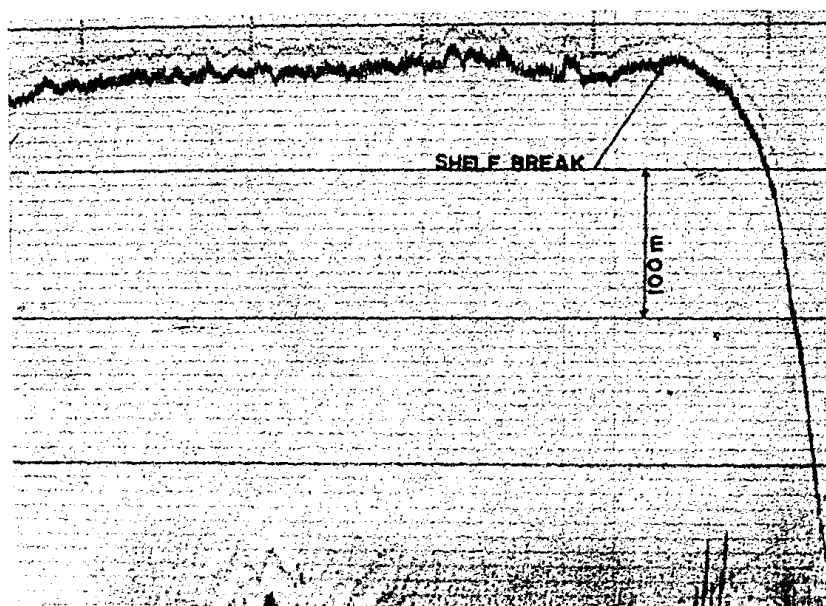


Fig. 2. Echogram depicting shelf and shelf break off Agatti Island.

## RESULTS

The analyses of shallow seismic and bathymetric data indicate a very narrow shelf (about 500 m wide), and abrupt shelf break occurs at around 14 m water depth in all the islands (Fig. 2). The shelf is veneered with coralline sand and pieces of dead coral of varying size. Slopes of the islands are very steep (Fig. 2) which approximate 1:4 off Agatti, Pitti, Kalpitti, Amini and Kadmat islands, and 1:9 off Bangaram.) The slope remains more or less opaque to the seismic signals indicating absence of sediment

cover. This is further supported by the recovery of coralline sandstone in the grab samples from this region. (The slopes of these islands continue down to 1575 m.) Signs of disturbance on the slope have been observed. SIDDIQUIE (1975) reported topographic breaks at 7-12, 15, 21-36 and 43-47 m depths on the shelf of Lakshadweep islands. In addition to the above, terraces at the depth of 45 m, 69 m, and 82 m have also been observed, amongst them the terrace at 82 m is the most prominent (Fig. 3). The existence of terraces between Amini and Kadmat islands is well defined. These terraces are devoid of any sediment cover and correspond well with the global Holocene still stands of sea-level (CURRAY, 1965; MERH, 1987).

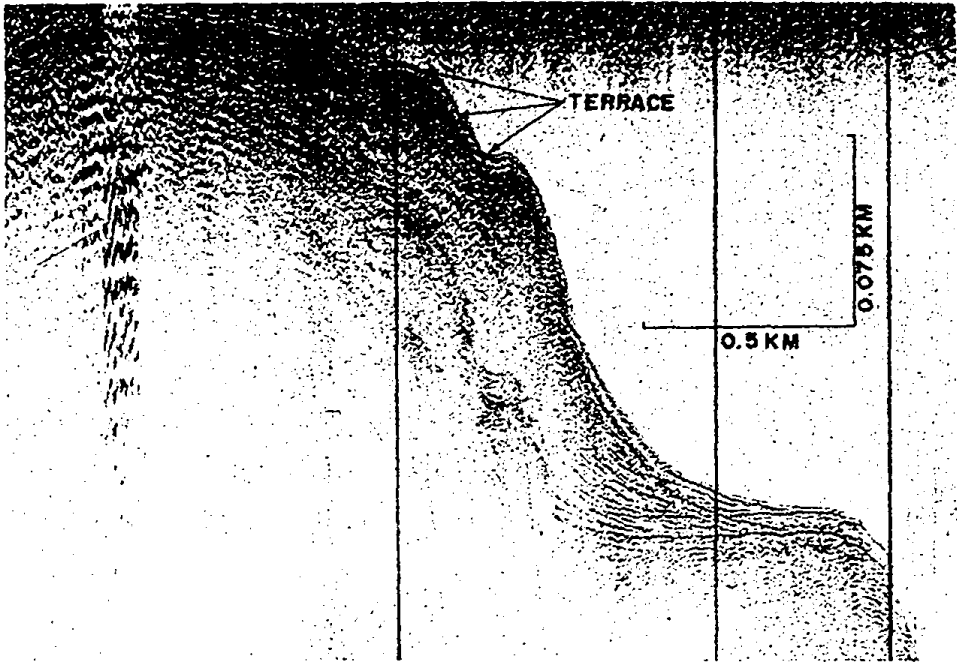


Fig. 3. Submerged terraces at the depths of 45, 69 and 82 m as observed in the seismic record off Bangaram Island.

Slump deposits, comprised of seismically transparent material have been observed at the foot of the slopes (Fig. 4). (The length of these deposits is around 5 km with a width (ROBERTS, 1972) of 75 m.) Detailed examination of these deposits reveals that they have a rather poorly defined head and well defined toe regions. At the head, the fissure zone is not present. The slumped mass is bounded on its surface by smooth convex outline of sea-floor and its under surface by relatively smooth concave glide plane. A prominent bathymetric notch at the upper end of the slumped mass immediately adjacent to the glide plane scar is interpreted as a tensional depression. The toe regions do not show any sign of distension. The foots of the slope, if not covered with slump deposits, have rugged topography of the order of 50 m. Topography is generally smooth beyond the depth of 1700 m with 3 or 4 evenly deposited reflectors.) The grab samples indicate that the topmost layer is olive gray clay. The thickness of these reflectors is uniform (200 m).

## DISCUSSION

The physiographic characteristics of the shelf and shelf break mainly depend upon (1) sedimentation at the wave base in equilibrium with paleo sea-level and (2) wave abrasion in relation to the present sea-level (HEEZEN and MENARD, 1963). The depth of effective wave abrasion is generally 10 m (KING, 1972). The narrow shelf and relatively shallow and abrupt shelf break (at 14 m) of the Lakshadweep islands suggest that the present shelf is very young and is a product of wave abrasion in equilibrium with the paleo sea-levels and sedimentation at the wave base. Presence of the pieces of the dead corals recovered from the shelf suggests the coral rock abrasion as a controlling parameter for the development of the shelf and dynamic sedimentation at the shelf.

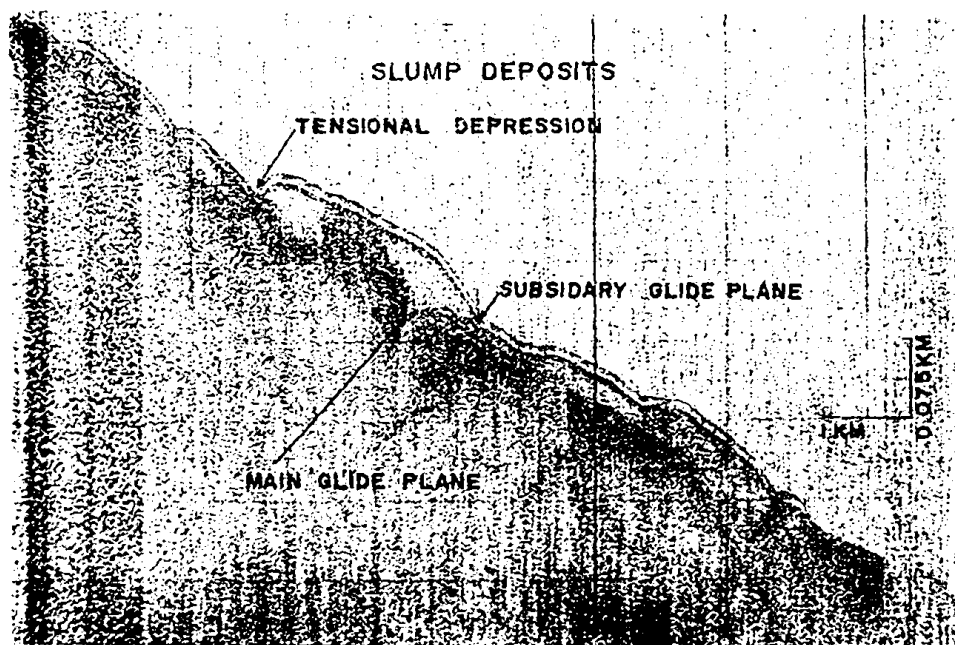


Fig. 4. Slump deposits at the foot of the slope off Amini Island. Fissure zone in the slump is absent. Main and secondary glide planes are smooth.

The submarine terraces at different depths are related to the sea-level still stands since Pleistocene and the prominence of the terrace may indicate the time span of still stand of sea-level at these depths. Quaternary glacio-eustatic and climatic oscillations reported by the existence of similar terraces in the Pacific and Indian Oceans (EMERY, 1962; STODDART, 1971; DAVIES *et al.*, 1971; LEWIS, 1968; NAIR, 1974, 75; SIDDIQUIE, 1975) and they suggest that these terraces are part of a global phenomena. The terraces at 82 m corresponds to similar features at different locations along the West Coast of India having age of  $8900 \pm 132$  years BP (NAIR, 1974,75), and assuming similar age for the terrace at 82 m in the present study, it is proposed that this feature represents "Younger Dryas" (BOYLE and KEIGWIN, 1987; BROECKER *et al.*, 1985) terminated at about 9000 radio carbon years. The prominent size of this terrace suggests a rather long still stands of sea-level during this event. The other terraces are also manifestations of the sea-level

still stands since Younger Dryas, and confirm at least three such events, i.e. at 69m, 48-36m and 30-25 m in this region since then (Fig. 3.) These terraces are, however, not as prominent as at 82 m, and hence, it may be suggested that the duration of the sea-level still stands during these events was of relatively shorter duration.

The symmetry of the slump deposits and the presence of main glide plane scar, less prominent main glide plane and well defined toe region (Fig. 4) may imply that the slump deposits have remained intact and undisturbed, and the processes of their distension is either absent or very slow. The origin of these slump deposits, therefore, appears to be related to the disturbances on the slope of the islands. The rugged sea-floor at the foot of the slope, where slump deposit is absent, suggests that the process of slumping is rather localized and episodic and has a small magnitude. The main source of these deposits, in the present study, could not be delineated due to lack of information on the tectonic nature of the slope. It is, however, provisionally suggested that it is linked with the disturbance on the slope and slow transfer of sediments from the shelf.

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