Reports

Marine Planation of Tropical Limestone Islands

Abstract. Geological studies in the western Atlantic indicate that sea level is now near its highest position since the Pleistocene, and that intertidal erosion at this level has been negligible. The evidence conflicts with the idea that many coral reefs were recently planed down from a higher stand of the sea.

The western Atlantic contains thousands of islands and cays of cross-bedded, friable limestone. The form and structure of these deposits suggest that they accumulated as shore dunes of calcareous sand. Many of the best-preserved cemented dunes rest on submerged platforms approximately 3 to 6 meters below sea level. Consequently, it is judged that the dunes were formed during a low stand of the sea (*1*, *2*).

An outstanding characteristic of these "eolianite" deposits is that the depositional forms of the dunes have, in many cases, been little modified by erosion.

Kaye (*2*) has documented examples of well-preserved "fossil" dunes in Puerto Rico, where depositional slopes frequently extend below sea level, interrupted chiefly by a shallow intertidal nip. Sheltered shores of cays of Bermuda and the Bahamas also provide hundreds of examples of cemented dunes drowned in a few meters of water. Excellent examples form the 100-mile-long archipelago of the Exuma Cays, in the Bahamas. These rocky cays lie in parallel chains along what probably are successive shores of a formerly retreating sea. As in Puerto Rico and Bermuda, the slopes of the dunes are unmarked by high terraces and there has been but little intertidal erosion at present sea level. There is no trace of attached barnacles, mollusks, or corals on these slopes, such as might mark the levels of recent stands of sea level above the present high-tide mark. And there are no unconsolidated marine sediments above the level of modern beaches. The maximum amount of sea-level undercutting that I have observed in the Bahamas is about 4 meters. From historical documents, Kaye (*2*) has shown that the erosion of an intertidal kerf of this depth should require at least 2200 years.

The average rate at which marine terraces are cut in limestone is not known. Nevertheless, widely entertained explanations of reef and island profiles depend on an assumption that the shores retreat rapidly before intertidal erosion.

There is substantial agreement that the sea has risen several scores of meters in the past 10,000 years because of the melting of the continental glaciers. But there is sharp disagreement as to whether the sea reached an appreciably higher level and then subsided to the present stage. It is difficult to establish the exact date at which the present level was reached, but scattered radiocarbon analyses indicate a position within 1 or 2 feet of the present level some 2000 to 3000 years ago.

Radioisotope ages of Bahamian eolianites obtained at the Lamont Geological Observatory are not unequivocal, but they do provide minimum ages of the dune rocks. There is a large discrepancy between radiocarbon and radium-uranium dates. It is probable that the radiocarbon dates, ranging from about 13,000 to 30,000 years ago, are much too young, reflecting contamination through cementation and surface exchange (*3*). A date of 32,300±3000 years was obtained by Broecker and Olson on fossil land snails which I collected from dune deposits at the Queen's Staircase, in Nassau (*3*).

On the other hand, radium-uranium dates indicate an age in excess of 70,000 years and are in fair agreement with a ionium-uranium date for eolianite at the Queen's Staircase, obtained by Tatsumoto and Goldberg (*4*). Heinz Lowenstam (*5*) finds that the dune rocks of Bermuda are too old for dating by radiocarbon. Thus, it appears that radioisotope analyses thus far made indicate Pleistocene dates for the eolianites.

The sand of the dunes is, of course, older, and the cementing agent is younger than the dunes. It is appropriate to inquire whether the radioisotope ages of the eolianite rocks provide a meaningful measure of the ages of the dunes as geomorphic features. I believe that they do, for the following reasons.

The geological relationships indicate that both the constituent (marine) sand and the subaerial dunes probably date from a single eustatic cycle when sea level was high enough to flood parts of shelves and banks. The calcareous sand is composed mainly of aragonite, which, on exposure, becomes quickly stabilized by vegetation and cemented into firm limestone. During times of glacially lowered sea level, exposed calcareous sediments must have become cemented, and the returning sea must then have advanced over rock surfaces.

To judge from the nature of the sediments now accumulating near the limestone outcrops, erosion of the rocks produces only an insignificant quantity of second-generation sand. Consequently, I believe that very little of the lime sands which formed the ancient dunes were derived from the disintegration of older rocks. From the radiocarbon dates it appears that the sands might have originated during the Sangamon stage or a warm interval within the Wisconsin stage (*1*), but it could not have been later. If these conclusions are correct, they have far-reaching implications concerning recent eustatic changes and manifold geological phenomena associated with present sea level.

From this evidence, it seems that the erosion of limestone shores, especially those protected by coral reefs, is too slow to result in extensive planation during brief stillstands of sea level. The present broad reef platforms commonly attributed to sea-level erosion (*6*, *7*) represent a condition of approximate equilibrium between the base level of intertidal erosion and the ceiling of organic accretion. However, only a small part of a typical reef flat is demonstrably the product of sea-level planation of an adjacent limestone shore. This is contrary to the views of students who believe that pre-Pleistocene and interglacial reefs were re-

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Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

peatedly cut down to the levels of the glacially lowered Pleistocene sea (*6*).

From the foregoing, it seems that living oceanic reefs, as well as reefs of continental margins, may be only thin veneers over older foundations (*8*). Fossil reefs well above present sea level, situated in many cases near shelf margins, may represent exposed parts of the Pleistocene foundation. Widely distributed, elevated marine terraces and reefs of the western Atlantic antedate the last time of widespread dune formation, which apparently occurred during the last interglacial stage. Elevated terraces of Pacific islands, frequently cited (with insufficient evidence) as effects of recent high sea level, should be critically re-examined. It seems likely that they also are of Pleistocene age.

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References and Notes

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23 March 1960

Y-Chromosome Inheritance of Hairy Ears

Abstract. A pedigree of hairy ear rims published in Italy in 1907 indicated holandric inheritance. The recent collection of over 20 pedigrees in India appears to show conclusively that the gene for hairy ear rims is in the Y chromosome. This is further evidence of relationship between the Mediterranean race in Europe and the population of India.

When I wrote *Human Genetics* (*1*), an Italian pedigree of hairy ear rims was regarded as a prima facie case of inheritance through a gene in the Y chromosome. But, since the pedigree was published very early (1907) and not in pedigree form, it obviously needed confirmation. While traveling in Africa in 1955, I accidentally observed three cases of hairy ears (*2*) in East Indians, two of whom were from Goa. Their pedigrees, so far as they could be obtained, were consonant with holandric inheritance, but did not furnish final proof.

In a detailed examination of all possible cases of Y chromosome inheritance in the literature, Stern (*3*) rightly suspends judgment about hairy ears, suggesting that unaffected women might transmit the trait, in which case it might be an autosomal character under sex control. Transmission from a father to all his sons, which is the pattern found, shows that the gene cannot normally be in the X chromosome, because a father always transmits his X chromosome to all his daughters and his Y to all his sons.

While studying jungle tribes in India in 1959, I collected over 20 pedigrees of hairy ear rims, generally in three generations, from the ordinary Indian population. The condition proved to be relatively frequent, especially in southern India. Two cases in native tribes, one in the Kotas and one in the Adiyar, were probably the results of miscegenation with ordinary Indian men.

The pedigrees as a whole show beyond any doubt that hairy ear rims are holandric. The inheritance is always from a father to all his sons, except in rare cases of lack of penetrance. Such exceptions are not surprising, for the amount of hair in the groove of the ear rim varies widely, even in the same family.

That the daughters of affected men do not transmit the condition is shown by three sibships in one pedigree, in which a total of ten sons (ages 33 to 54) are unaffected. In two cases there is the possibility of crossover from Y to X, but other explanations are equally likely. The condition generally develops at ages 20 to 25, and it appears to be quite independent of a hairy external auditory meatus, which is frequently found in older men of European descent. The inheritance of the latter condition has apparently never been investigated.

It appears to be significant that hairy ear rims are found in Italians (of Mediterranean race) and in the Dravidian, Indide, or Brown race in India—which is generally regarded as an Eastern extension of the Mediterranean race.

It may also be worth mentioning that in a single Australian aboriginal of the Pintubi tribe, a fringe of hairs, little more than fuzz, was observed in the ear rims (*4*). That this fringe of hairs in the ears may have wider parallelisms is shown by its occurrence in certain species of marmosets and South American monkeys, but not in other species (*5*).

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2 May 1960

Locomotor Activity of Land Crabs during the Premolt Period

Abstract. When maintained in darkness, premolt specimens of *Gecarcinus lateralis*, with or without eyestalks, show variations in level of activity according to six distinct stages. Furthermore, in darkness the rhythmic pattern of premolt crabs with eyestalks resembles that of eyestalkless premolt crabs, the intervals between principal bursts of activity being generally shorter than in nonpremolt crabs.

The spontaneous locomotor activity of land crabs, *Gecarcinus lateralis* (Fréminville), has been investigated in terms of two important characteristics, namely, (i) magnitude or level, and (ii) rhythmicity. It has already been reported that the magnitude or level of activity shown by eyestalkless individuals during the period elapsing between eyestalk removal and molt fluctuates according to six distinct stages, with the level variable during stage I, relatively high in stages III and V, and relatively low or even nonexistent in stages II,

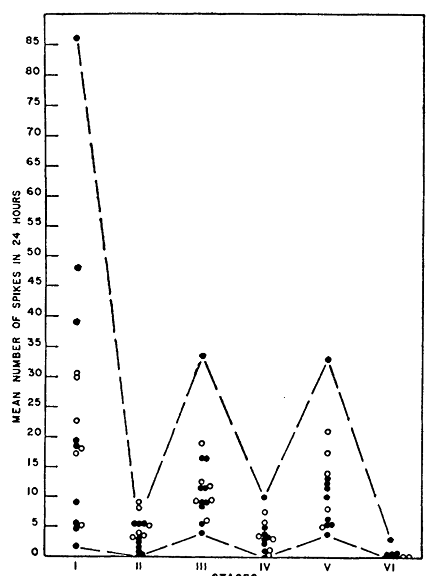

Fig. 1. Variations in level of activity recorded in darkness at 27°C from six specimens with eyestalks (open circles) and ten eyestalkless specimens (closed circles) of *Gecarcinus lateralis* during the period just prior to molt. For explanation of stages, see text.