https://doi.org/10.26749/rstpp.106.17

[*Manuscript received 18.10.1971*]

SANDERS' WAVE TANK EXPERIMENTS AND SHORE PLATFORMS

by

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(with one plate)

ABSTRACT

Comment is made on Sanders' useful wave tank experiments in relation to the erosion of rocky coasts. His findings on wave erosion level are related to observations in the field. Sanders' reluctance to accept that waves can erode a platform by hydraulic action alone is not shared, as it is believed that if the cutting of the notch were allowed to proceed, cliff falls would cause a platform to evolve.

INTRODUCTION

Artificially generated waves attacked model cliffs of plaster and quartz sand in wave tank experiments carried out by N. K. Sanders (1968). The mixture forming the cliff models was varied, and a mechanism was provided for varying the height of the waves and their periodicity.

EXPERIMENTAL ATTEMPT AT PLATFORM FORMATION

Wave attack on a vertical cliff in the apparatus resulted in a concave profile that began below stillwater level and extended well above it. The extension of the profile above stillwater level was greater than that below by a factor exceeding 3. The depth of the profile cut into the cliff proved to be a function of the nature of the cliff material and the length of time of wave attack. Sanders concluded that his experiments ' fail to provide evidence that platforms may be produced by hydraulic action alone in a homogeneous, unbedded and unjointed material '. This conclusion may be incorrect for the reason that the experiment did not run long enough. It is envisaged that, following sufficient undercut, the cliff would collapse, and so in time a platform would come into being. This happens in nature.

EVOLUTION OF PLATFORMS IN NATURE

An interesting parallel to Sanders' experiment is provided by an unusual geologic process on the coast east of Warrnambool, Victoria, Australia. This coast consists of more or less vertical cliffs with occasional steep talus slopes that make possible access to the shore. Typically the cliffs consist of some 15 m of yellow Miocene marine limestone with a vertical cleavage that usually results in vertical breakaways. Above this are Pliocene clays, sands and such terrestrial sediments surmounted by the remains of Pleistocene aeolianite cliff-top dunes. The cliffs are commonly 20 to 40 m high, but do reach 60 m. By analogy with similar structures dated in the Warrnambool area, the cliff aeolianite is regarded as Last Interglacial in age. Its surface consists of a strong calcrete (Last Glacial) so that the softer rock below is in some places eroded, causing extensive overhangs. As a result, from time to time huge blocks of aeolianite fall from the high clifftops into the sea. Their fall is such that, on coming to rest, the aeolian bedding can be at any angle from vertical to horizontal. This variation in fallen blocks proves (following marine attack) that bedding has only minor effects on the erosion of the rock by the sea. Having come from high on the cliff, there are no complicating factors of groundwater and such that some research workers have suggested are significant in the formation of shore platforms in this rock. The placing of the block of aeolianite in the sea is comparable in principle to Sanders placing a block of plaster and sand in the wave-generating machine. It is of interest therefore to know what happens to the aeolianite blocks thus dropped into the sea. As they are numerous, the various stages of development can be observed. Many of them are on inaccessible parts of the coast, but some can be readily observed at Mernane's Bay just east of Childers Cove (see map: Gill, 1947), where one of the blocks has developed a notch and platform 1.5 m wide.

It is proposed to describe these marine-eroded blocks elsewhere but for the present purpose it can be recorded that the erosion begins by the development of a profile like that recorded by Sanders and gradually achieves the profile of a normal platform. The observation of aeolianite platforms in the Warrnambool area over the past forty years makes it apparent that the platform is extended by the landward movement of the notch, accompanied from time to time by cliff collapse or other type of rock fall as a result of this process.

SOLUBLE AND NON-SOLUBLE ROCKS

Aeolianite is a soluble rock, and so one should examine also what occurs in nature with relatively insoluble rocks (all rocks have some solubility in seawater). Dury (1962, Pls 39-40), for example, figures shallow notches on the Dorset coast and on Guernsey which are of the type obtained by

Sanders. These profiles are of course not as smooth as those obtained experimentally because the rocks are not homogeneous. One of the most intractable lithologies I have seen is a Precambrian schist on the coast of Brittany shown by Professor A. Guilcher to an INQUA excursion following the Paris Congress in 1969. At the site the rock was homogeneous, hard and tough. The profile was very similar to the experimental one, and was up on a cliff representing a Normanian shoreline. Fronting the notch was a cobble bed with a juvenile orange-coloured soil. A long stillstand during the Last Interglacial would be needed to produce the shoreline notch in Brittany, one member of the excursion estimating the time required as at least 10,000 years, in spite of being on a *côte sauvage*.

In Australia notches can be seen at the shoreward end of platforms in siltstone, sandstone, decomposed basalt and other rocks, where clearly the platform has been cut by a landward moving notch accompanied by periodic rock falls. By walking along the shore, one can see the various stages in this process. So I think that if Sanders had let his experiment run long enough, a platform would have evolved by means of cliff breakaways.

ARTIFICIAL PLATFORM

Believing that the wave tank could not produce a platform, Sanders cut one in his model cliff with a hacksaw, and set the machine going again. The waves formed a notch at cliff base, and slightly cut back the cliff, the platform, and the former cliff face below the platform; the leading edge of the platform was rounded. Sanders noted this tendency to round off rock faces. This of course occurs in nature with the rounding of boulders, the sides of 'inselbergs' on platforms, the edges of ramparts, and indeed in all areas of the rocky shore. That rounded edges are not more prominent is due largely to the important process of quarrying, whereby the sea removes blocks by corroding along bedding planes, joint planes, palaeosols, and other planes of weakness.

RELATION OF NOTCH-LEVEL TO WAVE-LEVEL

Sanders noted that 'the greatest notching occurred between the level of the broken wave crest and the base of the turbulent zone', and that 'the upper part of the wave produces the highest pressures upon breaking'. He quotes Bagnold's observations to this effect, and it has been widely recognised in nature. It has also been calculated mathematically. However, on the real shore, matters are not as simple as this, because waves of different kinds are present, their height varies with conditions, and the tides vary their level of maximal attack. It appears to me a matter of importance (apparently neglected) that the notch is commonly never reached by waves but only by swash. Where there are shore platforms, the waves commonly break at the edge and a planar mass of high energy water (swash) swirls across the surface and impacts strongly on the notch. Because of channels, platform discontinuities and such, the swash often flows obliquely to the notch and not normal to it. For a number of reasons the terms 'wave-cut nip', 'wave-cut notch' and so on are unsatisfactory. A notch in most of its connotations is an indentation of limited extent, whereas the shoreline structure is rather in the nature of a groove.

Another valuable observation of Sanders is that where there is a shallowing seafloor, the wave is lifted, so that the zone of maximal impact is higher than where there is a plunging cliff. It may be added that where narrowing profiles force the wave or swash to higher speeds, the water may attain higher levels so that the notch in such sites may be higher (as noted by Dury, 1962, p. 99). Dury also noted that with grossly jointed rocks, removal of blocks by marine quarrying may result in some peculiar levels of notching. As a result, he stressed the difficulty of using notches for determining former sea levels. These difficulties are certainly great if one simply treats a notch as a notch, but if ecology is taken into account, most of these difficulties disappear, and the notch proves to be a factor of great value in fixing past sea levels. This can be done with considerable accuracy on aeolianite coasts (Gill, 1972). Where rocks are strongly jointed, or other internal structures are effecting considerable control on the geometry of erosion, then these factors must be taken into account. If one is aware of the abnormalities associated with special sites, such as a narrow inlet, then these also can be taken into account. The more one understands a particular type of existing coast, the more accurately one is able to interpret those structures that have been impressed upon it by past sea levels. This principle applies widely. For example, on the coasts of Victoria, the level reached by the large kelp *Durvillea* is approximately mean low water. However, one can be readily led astray if this statement is applied without discrimination. Where a narrow channel has been formed by the sea eroding along a major joint plane, the compressed waters are standing higher than elsewhere for an appreciable percentage of the time so that *Durvillea* may be found there up to 0.3 m higher. However, if the general level of the top of the *Durvillea* zone along the coast is observed, this provides a remarkably good datum. Such are very important for a continent such as Australia where, because the country is large (shoreline of the order of 20,000 km) and the population relatively small, tide gauges are few.

CONCLUSIONS

Sanders' wave tank observations are valuable, and this author agrees with him that more of this type of work is needed. However, observations on real platforms lead one to consider that a platform could be formed in the wave tank, because when undercutting reached a sufficient stage, the model cliff would collapse.

While wave tank experiments are valuable, it must be kept in mind that they simulate a tideless, currentless, stormless sea without the temperature, salinity, biota, swell, lithology, and other variants that make the situation in nature so complex. Moreover, no pre-conditioning exists as occurred on real shores as a result of Pleistocene transgressions and regressions.

1

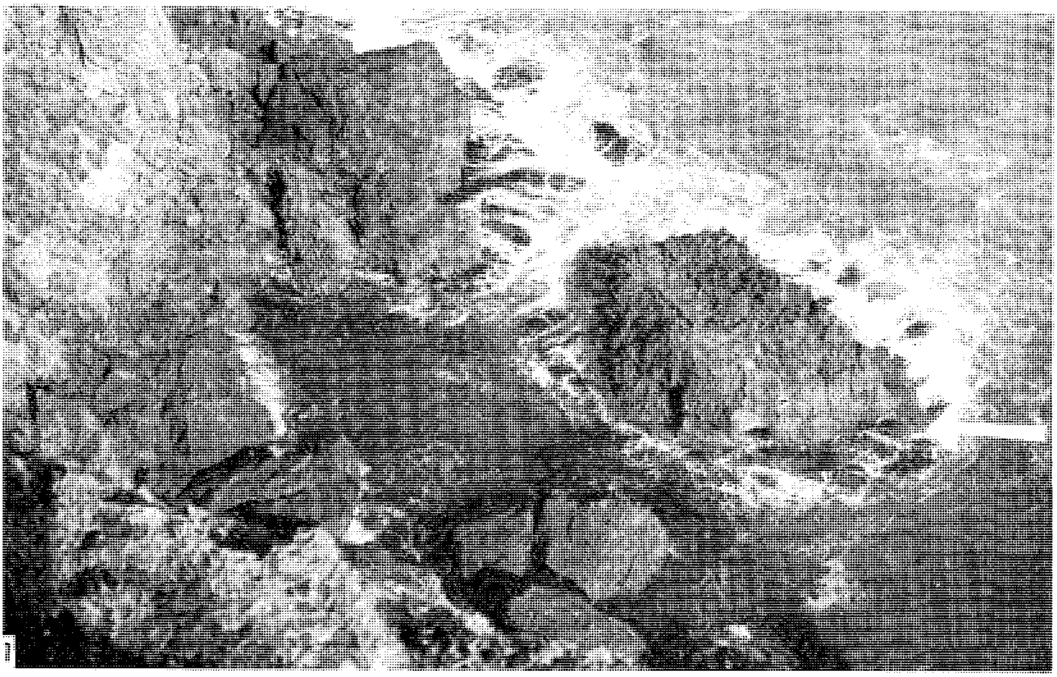

FIG. 1.—Cliffs of Miocene marine limestone at 'The Gardens', west of Childers Cove, Warrnambool-Peterborough coast, west Victoria, covered largely by talus of aeolianite from cliff-top dunes. Large blocks in the sea are aeolianite with various stages of shore platform development. Hempel's Rock is the largest with a platform (arrow) on the seaward side 1.8 m (6 ft) wide, and about half that on the landward side.

2

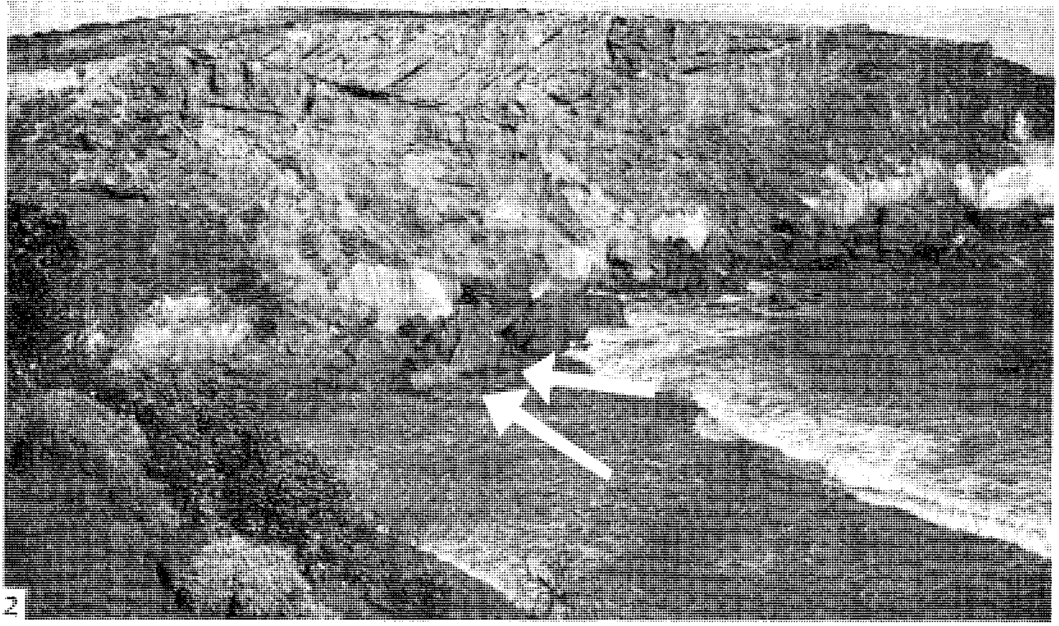

FIG. 2.—Mernane's Bay on the east side of Childers Cove, with the same geology. Arrow on right shows block with notch as in Sanders' wave tank experiment, while arrow on left shows block with shore platform of similar dimensions to that on Hempel's Rock. These blocks dropped into the sea can be compared with Sanders' blocks placed in the wave-generating machine.

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