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# Recent Recession of Tropical Cliffy Coasts

Elevated benches and other coastal forms give evidence of eustatic changes in sea level.

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During the wane of the last major glaciation, returning meltwaters raised sea level some 450 feet. Most of this rise occurred during the last 18,000 years. There is some possibility that 10,000 years ago sea level was about 100 feet lower than it is today. The existing "stillstand" began about 4000 years ago, and since then fluctuations have been slight, probably within a range of a foot or so (*1*, *2*).

All oceanic coasts display effects of submergence. Rising seas overwhelmed and drowned the lower ends of the valley systems in Delaware Bay, Chesapeake Bay, San Francisco Bay, and many other bays, estuaries, and gulfs (*3*). Extensive lowlands became completely submerged; the North Sea and a wide platform that extends from Java and Borneo to the mainland of Asia are submerged lowlands.

Any morphological feature associated directly with the existing sea level must have originated in an amazingly short time. During the stillstand, shorelines have been considerably straightened only where poorly consolidated rock has been exposed to the brunt of wave attack (*4*). The time has been too short for much change to occur along coasts consisting of consolidated, durable rock. The sea cliffs have receded significantly only where the exposed rocks are poorly consolidated or consist of limestone. Many of the best examples of such coasts occur in the tropics.

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## Cliffy Coasts

Coasts with long, more or less continuous, and actively changing sea cliffs vary tremendously in appearance according to kind of rock, rock structure, exposure to wave attack, climatic conditions, geomorphic history, and other factors (*5*). Most sea cliffs antedate the Recent epoch.

According to the traditional concept, a sea cliff (Fig. 1) combines a retreating cliff face, an undercut notch, and a bench that is eroded across bedrock near the notch but that outwardly becomes a depositional wave-built terrace. Beach materials on the bench act as abrasives during storms, and the notch is deepened. Cliff materials that fall or are transported in various ways replenish the beaches or are carried out and incorporated into the wave-built terrace. Examples of the traditional complex certainly exist, but conspicuous changes of this kind are taking place mainly in cliffs of limestone or of rocks that are poorly or only moderately consolidated.

Sea cliffs that face deep water commonly lack beaches or benches. In the absence of abrasive materials, the most powerful storm waves prove to be relatively impotent against walls of massive, well-indurated rock. Sharp and complex changes in hydraulic pressure, frequent alternations between wetting and drying, and activities of water-level organisms have produced inconsequential change during the past 4000 years. High, exposed cliffs near Cape St. Vincent, at the southwestern corner of Europe, remain practically unnotched as they descend into deep water. Granitic cliffy coasts in the vicinity of Rio de Janeiro are stained somewhat but display few abrasional features along the strandline. In protected localities, such as within Norwegian fiords, past sea levels may be ascertained from depositional, rather than erosional, landforms.

Cliffs cut in thick sections of unconsolidated rock are not likely to retain notches for significant lengths of time. An extreme case is a coast where sand dunes are under attack. Such coasts are quite common because dunes accumulated in tremendous volume during low-level stages of Quaternary seas, well into the period that preceded the existing stillstand. Some of the dunes have been cemented into eolianite, especially in the tropics, but many are ineffectively or only partially indurated. Dune heights commonly reach 100 feet or more.

At Baylys Beach, near Dargaville, and at many other places along the west coast of the North Island of New Zealand, sea cliffs cut in dunes stand essentially at the angle of repose of sand. As the cliffs retreat, a concave colluvial slope may develop between their seaward faces and the adjacent wide, flat beaches. For many miles north of the Dra River, in southermost Morocco, high cliffs have been cut in coarser Quaternary deposits with thick layers of gravel, behind one of the longest straight beaches in the world. There is no notch, because unconsolidated sediments immediately slide down to cover the erosional effects of storm waves.

Limestones offer the best opportunities for studying the recession of cliffy coasts. Appreciable changes may have taken place during the Recent stillstand, and evidence is plain as to the agents involved. The best places to study such coasts are in the tropics, where calcareous rocks of Quaternary origin are relatively abundant.

### Notches

The bases of sea cliffs exhibit notches of two kinds: (i) abraded or wave-quarried and (ii) solutional. On limestone coasts practically all notching is solutional.

Opinions differ as to the levels where notches form. Fairbridge (*6*) believes that the maximum undercut below the visor, or notch roof, occurs at about mean sea level. Verstappen (*7*) believes that the floor forms slightly below high-tide level. Kaye (*8*) states that the notches extend between the low-tide wave-trough level and the mean-high-wave level. Wentworth (*9*) notes that nips produced by "solution benching" may lie as high as 5 feet above sea level.

Oahu provides excellent opportunities for studying notch levels because limestone fringes 31 percent of the shoreline (*10*). My observations there indicate that calcareous eolianite and elevated coral flats are commonly notched between sea level and an elevation of 5 feet or more, with visors to about 10 feet higher. Verstappen reports visors twice that high at Batanta, New Guinea (*7*).

Verstappen notes variations in notch shapes that are in agreement with my own findings. On exposed coasts, notch floors are comparatively flat and overhanging roofs incline at angles up to 45 degrees or so. In sheltered locations notches tend to be horizontal cuts with essentially flat roofs. The distance between floor and roof increases with tidal range and with exposure to attack by storm waves. Floor levels are commonly indicated by algal encrustations. Kaye (*8, 11*) notes the development of nips, both above and below the zone of algal cover, that produce double notches in exposed situations.

An excellent demonstration of solution notching occurs in a small cove on the western side of Cabo Rojo, Puerto Rico, where a limestone cliff descends almost vertically. To the west, behind deep, clear water, notching extends more than 10 feet into the cliff, but a short distance to the east a beach consisting of coarse shingle lies at the base of the cliff, and there the depth of notching is only about 3 feet. The shingle is relatively ineffective as an abrasive, and its presence evidently interferes with solution notching.

Morphological forms clearly refute the idea that tropical seawater, saturated with calcium carbonate, lacks the ability to dissolve limestone. Emery's careful investigation of this problem (*12*) has been followed by studies by numerous workers whose explanations may differ but who agree in concluding that calcareous rocks are attacked not only near sea level but also as far upward as they are covered by waves or spray (*13, 14*). Verstappen (*7*) thinks that surface waters are less heavily charged with calcium carbonate than subsurface waters. Guilcher and Pont (*15*) and Emery (*16*) regard alternations between wetting and drying as an important factor. Kaye (*11*) emphasizes the effect of water movements.

Small notches develop around isolated pools of seawater some distance above the level of the higher waves even though times of filling are infrequent. Figure 2 shows a notched pool about 20 feet above sea level on an eolianite island at the end of a tombolo at Palmas Altas, Puerto Rico. Many similar examples occur about a mile east of Kanea Point, Oahu. The dry pools are floored by salt. Salt pans are numerous at a considerable elevation along most eolianite or coral-flat coasts, as in Western Australia between Perth and Broome, where they are commonly found at elevations that exceed 20 feet.

Large erratic blocks of limestone that lie on beaches are ordinarily notched basally, as near Bathsheba, Barbados. Notch depths were measured on a boulder washed ashore during disturbances caused by the eruption of Krakatau in 1883. By 1953 the indicated rate of deepening was 1 foot in 60 years (*7*). Notches typically develop on all sides of such blocks, including the faces that are most sheltered from abrasion.

### Pitted Zone

Conspicuous in the retreating-sea-cliff complex is a pitted zone that extends upward to limits set by occasional spray cover. Edwards (*17*) reports continuing modification of sea cliffs in Victoria and Tasmania, to heights ranging up to 300 feet. The erosional forms vary considerably according to the type of bedrock. Distinct "storm ledges" develop in horizontal layers. Wentworth (*9*) regards spray as an effective agent of erosion to an elevation of 100 feet on Koko Head, Oahu. A similar vertical range has been observed at Pointe des Chateaux, at the extreme east end of Grand Terre, Guadeloupe.

Guilcher (*18*) has studied "karstification" features of limestone-pitted zones with care in various locations and climates. They are attributed mainly to solution, but in some instances there is evidence of biologic aid. Spikes, lapies, irregular pools and pits, natural bridges, and other solution features have also been described by Wentworth (*9*). Kaye (*8*) provides additional detail, including a discussion of pit and pool development both within and beyond the reach of spray.

### Contemporary Benching

Various erosional flats and benches are developing today along retreating cliffy coasts. Some of the broadest start close to the level of lowest tides and rise gradually toward the shore. In some cases the benches are being formed as in the traditional sea-cliff complex (Fig. 1). In other instances they are being developed at various levels above the reach of highest tides, as conspicuous elements in the pitted zone. The retreat of many cliffy coasts involves an orderly migration not only of cliffs but also of all such flats and of the various depositional belts that separate them, such as colluvial slopes, bars, and beaches. Of particular interest are flats being developed within the pitted zone. They are most conspicuous in areas where the stratification of bedrock is essentially horizontal.

Most benches occur within 20 feet of sea level, where wave overwash occurs, but some develop well up in the spray zone (*17*). Seawater moving rapidly enough to erode and dissolve rock reaches considerable elevations (*19*). Wentworth (*9*) reports the twisting and the displacement by several feet of a 7-ton block of tuff at an elevation of 40 feet, and of a 10-ton block of sandstone at 15 feet. At The Blows, north of Carnarvon, Western Australia, benching occurs in reddish sandstone and conglomerate at elevations up to 25 feet, and blocks of rock 8 feet in diameter have been tossed, along with marine shells and other debris, up to levels of at least 20 feet.

Contemporary benching is beautifully displayed in the vicinity of Darwin, Australia. The bedrock section includes both soluble and resistant layers of limestone, sandstone in various degrees of consolidation, kaolinitic clay beds that are readily removed, and concretionary zones that are relatively durable. Notching is conspicuous along the less resistant layers, and benches cap the more durable beds. Flats to elevations of 25 feet or more are swept clean of debris (Fig. 3)—evidence of frequent wave overwash. Near Nightcliff, contemporary crustal movements are also clearly evident. One bench drops from 8 to 2 feet in a distance of 200 yards, but within 1.5 miles rises to 15 feet. In some places benches rise as much as 20 feet in 1 mile. The fault shown in Fig. 3 has a throw of 18 feet.

For more than 2000 miles between the southwestern tip of Australia and the vicinity of Anna Plains, east of Port Hedland, benching occurs wherever rocks are flat-lying or dip gently, most conspicuously in eolianite. The pitted zone is broad in many places and attains elevations of 30 feet and more (see Fig. 4). Numerous salt pans occur inland for more than 100 yards.

A bench at Muriwai, west of Auckland, New Zealand (Fig. 5), has become a classic example of bench formation. Johnson (*20*) photographed it and regarded the flat as in process of formation today. Freedom from talus near the base of the sea cliff proves that waves are capable of keeping the bench clean and that they strike with sufficient force to cause recession of the cliff. The activity of wave action is further indicated by channels created by escaping overwash of storm waves, as shown in Fig. 5, a photograph taken shortly after the crest of a neap tide. Bartrum (*21*) regarded the bench as the product of storm waves, with "water-level weathering" as a contributing factor.

Bedrock "shore platforms" are well developed in New South Wales. Jutson (*22*) considers them to be products of contemporary erosion, a conclusion extended to shore platforms in Victoria and Tasmania by Edwards (*17*). On Mauritius, in the Indian Ocean, an elevated bench is being developed along the line of contact between two lava sheets (*23*).

**Other Flats**

Many benches along cliffy coasts originated during high stands of Pleistocene seas. Other flats, of contemporary origin, are not formed by erosion or solution. In tropical regions coral flats, algal flats, and broad outcrops of beach rock are conspicuous examples.

Coral flats consist of clastic debris in which coral blocks predominate. On their outer rims there may be reefs growing in which all forms of life occupy essentially the same positions after death as during life. Active reefs and coral flats rise to elevations of several feet, their higher parts invariably being out from shore, where waves strike hardest. At low tide many areas lie awash.

Algal flats, or "tidal terraces" as they are called by Kaye (*8*), are made up of pools a few inches to several tens of feet wide, separated by low algal rims. The water in the pools stands from several inches to a foot or two deep and provides an environment capable of maintaining dense populations of fishes, echinoderms, mollusks, worms,

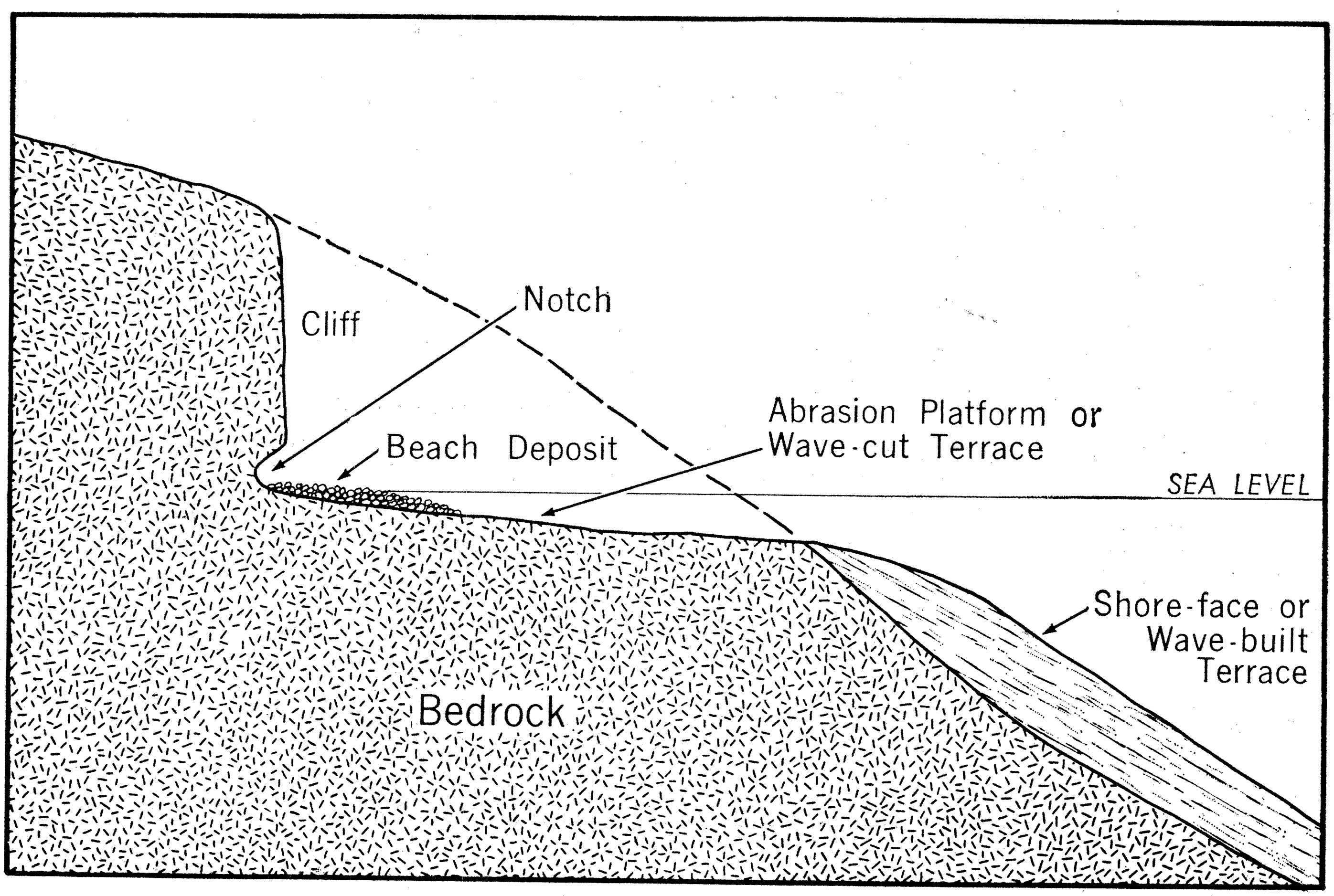


Fig. 1. Traditional sea-cliff complex.

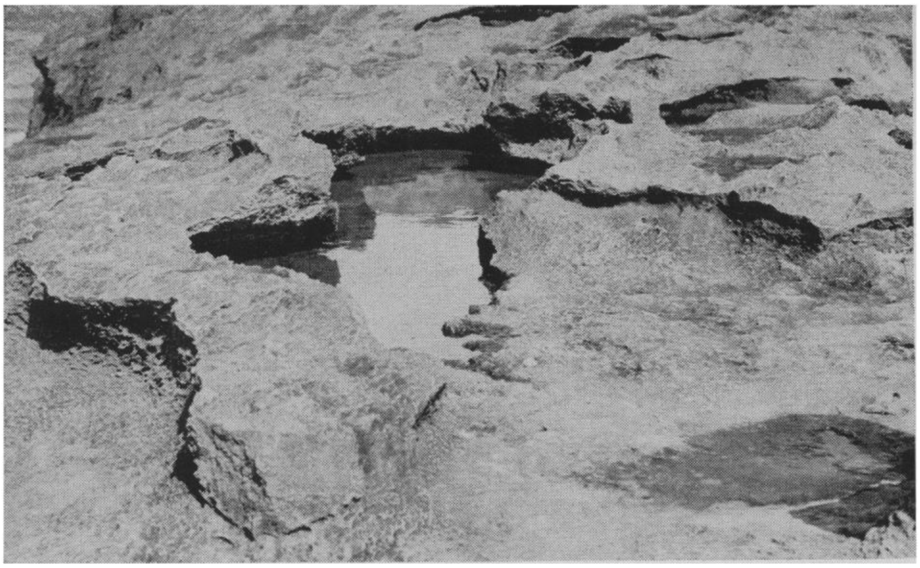

Fig. 2. Solution notches around pools in eolianite 20 feet above sea level, Palmas Altas in Puerto Rico.

Fig. 3. A bench offset by faulting, Nightcliff, Darwin, Australia.

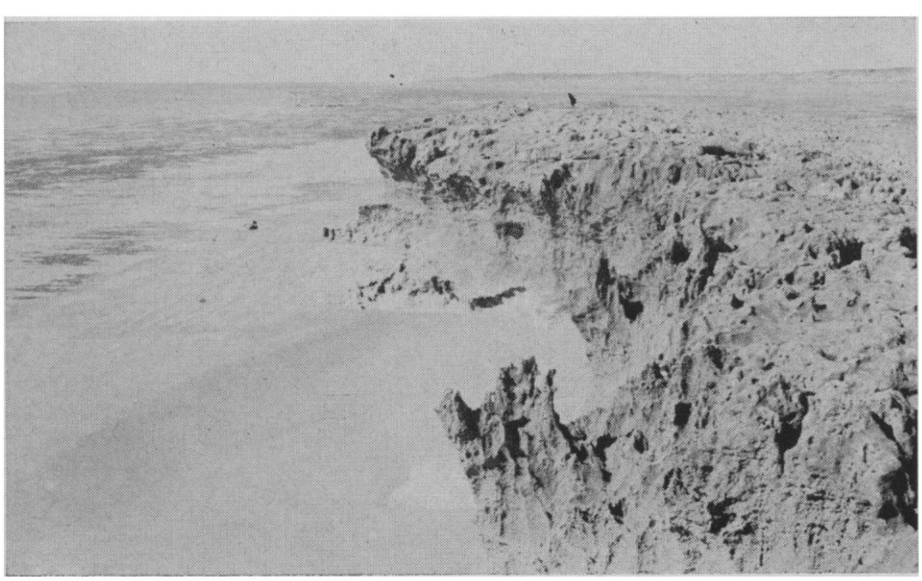

Fig. 4. Pitted zone on a high bench of Pleistocene eolianite, Port Hedland, western Australia.

algae, and other organisms. The pools are arranged in terraces that descend gradually from the highest levels, where water supplies are frequently replenished by the waves, to about mean sea level. Desiccation for a few consecutive hours, such as occurs during lowest spring tides in places along the northwestern coast of Australia, where the tidal range approaches 50 feet, is fatal to most organisms on algal flats.

Algal flats occur at the highest levels in exposed locations. On notch floors the highest pools commonly lie on the landward side. Wentworth (*10*) describes pools on Oahu 40 feet wide. In other locations, however, platforms commonly extend seaward for many times that distance, and they may descend inland toward outflow channels near the strandline, as at Contrabandiers, near Temara, Morocco (*24*).

Broad exposures of beach rock may appear to be platforms of truncated, seaward-dipping sandstone. If there are several bands they may either overlap or be separated by gaps, possibly several tens of feet wide. Beach rock consists of the same material as the adjacent beach, and its dip is initially the same. An appearance of truncation is explained by the fact that the upper limit of cementation in each band was set by the level of the water table under the beach at the time cementation occurred, and this surface ordinarily is flatter than the stratification planes (*24, 25*).

Beach rock is an excellent guide for approximating sea level in places where the tidal range is small, as around the Caribbean. Where the range is excessive, as along the coast of Queensland, north of Townsville, there are outcrops of beach rock at about high neap-tide level, where a spring line develops when the tide drops. Beach rock is thickest where the water table under the beach fluctuates most conspicuously. If there has been considerable recession of the shoreline, inner and younger bands of beach rock may lie several feet higher than the oldest seaward band, for the reason that the ground water originally lay somewhat higher inshore.

Caution is necessary in interpreting levels of the outer bands of beach rock. As most slabs overlie sand or other material that is readily washed away, undermining occurs, resulting in rather complicated structural deformation, in oversteepening, and, in some cases, in forward sliding of slabs to depths several feet below the level where cementation occurred.

## Eustatic Changes of Level

Some investigators regard practically all elevated notches and benches—and especially platforms eroded in bedrock, as at Muriwai (Fig. 5)—as proof of change of level between land and sea. In support of a hypothesis of a climatic optimum or hypsithermal interval, these features, as well as elevated reef flats, algal flats, beach rock, and even such doubtful criteria as fixed dunes, have been cited as indicating that sea level was several feet higher than it is now as recently as from 2000 to 5000 years ago (*26*). On the other hand, there is excellent evidence that there has been no higher eustatic stand within the last 10,000 years (*1, 2, 26–28*).

Horizontally bedded rocks are everywhere susceptible to differential erosion that produces benched topography. Examples abound in inland plateaus. Students of river erosion have been inclined to regard spectacular benches such as those along the Colorado River in Arizona and Utah as not marking intervals of time during which there was a cessation of downcutting. But coastal morphologists tend to adopt an equivalent hypothesis that relates notches and benches to elevated stands of the seas.

Elevated strandlines occur along many coasts that display crustal instability. They are characteristic of arctic regions, and many high-level strandlines, such as those on the islands of Novaya Zemlya, appear to be of extremely recent origin. Verstappen (*7*) describes excellent examples from the island of Daweloor, in the Moluccas. Impressive examples occur along the coast of California and in many other places, in some cases indicating uplift that dates well back into the Quaternary.

The coast of Western Australia appears to be one of the best places to investigate eustatic changes of level because it has been relatively stable throughout the Quaternary. Toward the base of the eolianite sea cliff shown in Fig. 4 there is a shell bed at about high-tide level that extends from the vicinity of Port Hedland eastward for about 200 miles. This same bed, or its equivalent, appears at many places to the south—near the mouth of Greenough River, at Guilderton, at Drummond Cove, and just south of Muderup Rocks, Cottersloe, near Perth. Its level is essentially constant, and in all cases the bed is overlain by Pleistocene eolianite. There has thus been little

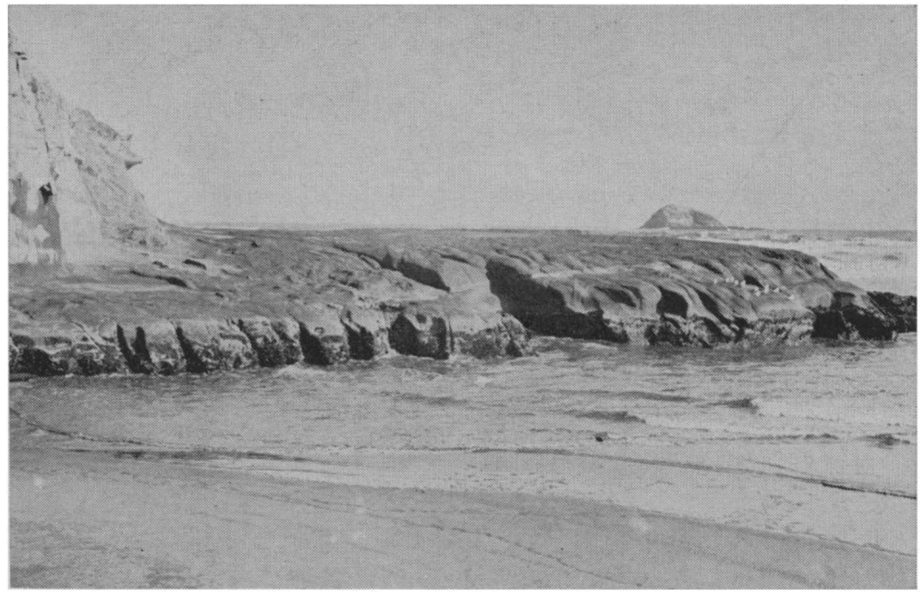

Fig. 5. A bench in bedrock, Muriwai, west of Auckland, New Zealand.

Fig. 6. Remnant of a Pleistocene coral flat, Boundary Beach, north of Carnarvon, Western Australia.

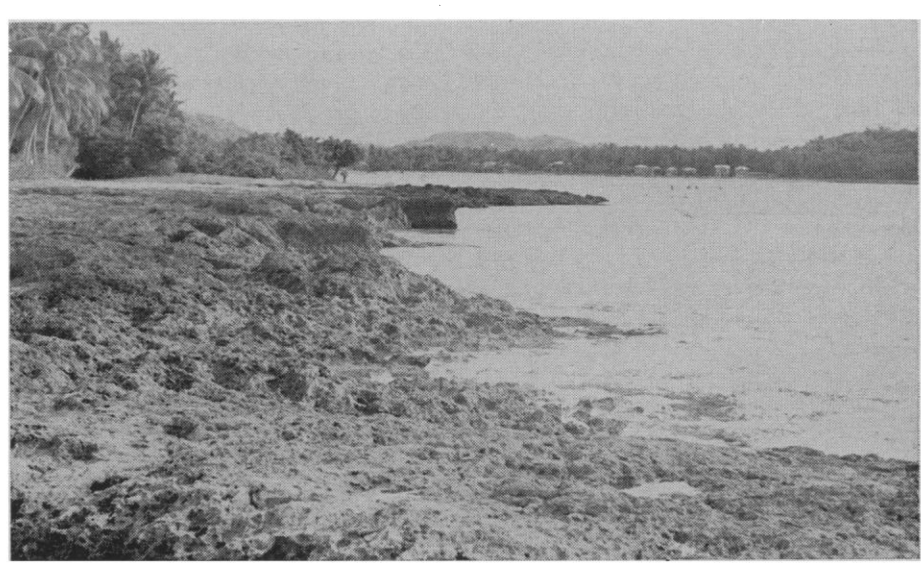

Fig. 7. Pleistocene coral flat, San Esteban, northern Luzon, Philippines.

or no deformation of this Pleistocene strandline.

Among the most interesting features of the coast of Western Australia are Pleistocene coral flats, such as those on Salmon Bay, on Rottnest Island, and along the coast north of Perth. One of the best examples occurs at the southern end of Boundary Beach, north of Carnarvon (Fig. 6). The bench consists almost wholly of clastic coral blocks, but it contains fragments of red sandstone from the Pleistocene sea cliff above. An age of 35,000 ± 3700 years has been indicated for the coral by the radiocarbon-dating technique. When the bench was formed the stand of the sea was apparently slightly more than 10 feet above today's level. Two similar coral flats occur near the mouth of Greenough River, south of Geraldton; the age of the younger has been set at more than 37,000 years. Both of these flats indicate that high stands of Pleistocene seas differed by less than 20 feet from the present-day level. Findings on Rottnest Island are similar. It appears that at least two, and possibly more, high stands of Pleistocene seas reached levels that do not differ greatly from today's level—a conclusion which may indicate that antarctic ice played little or no role in glacio-eustatic changes of level.

## Conclusions

My fieldwork in various parts of the world leads me to the conclusion that the retreat of cliffy coasts through abrasion and solutional erosion during Recent times has produced a whole complex of forms, including conspicuous benches well above sea level where bedrock conditions are favorable. In addition, flats of other origin are being developed at various levels. Broad exposures of beach rock are a marine phenomenon only in that such exposure is a result of beach recession and of the uncovering of materials that had been cemented, under freshwater conditions, along water tables, in some places 6 or more feet above sea level (*24, 25*). Contemporary coral and algal flats are forming in some instances several feet above the level of the highest tides.

Older flats also exist along many coasts. Conspicuous among these are coral flats dating from various stands of high-level Pleistocene seas. These are well developed in Puerto Rico and on other islands of the West Indies, around Oahu, along the west coast of Australia, and in many other places.

The case for eustatic changes of level during the Quaternary is strong (*1–4, 27*). Of particular interest is the similarity in the various stands of high-level Pleistocene seas along the stable coast of Western Australia, where the mean appears to lie within 20 feet of today's level.

The case for a higher stand during a recent climatic optimum appears to be poorly founded (*2, 13, 17, 19, 26, 28*). My examination of literature on the subject and my fieldwork in some of the areas involved leads me to the conclusion that much of the evidence is based on misinterpretation of contemporary benches, coral and algal flats, beach rock exposures, and of forms created during the Pleistocene. Literature on the subject is highly contradictory and confusing. As examples, I might cite descriptions by Stearns (*26*) of benches at levels of 2, 5, and 12 feet on Oahu and elsewhere, and reports by Fairbridge (*6*) of benches at levels of 2, 5, and 10 feet on Point Peron and at other places near Perth. Stearns correlates his 2-foot bench with the Rottnest Terrace of Fairbridge and Teichert (*29*), to which they assign an age of 1000 to 1200 years. Stearns correlates the 12-foot shoreline of Oahu with a similar level on Saipan, for which an age of 20,000 years has been indicated by radiocarbon methods, and also with the 10-foot level on Point Peron, to which Fairbridge assigns an age of 4000 years and which he correlates with the climatic optimum. The climatic optimum is generally estimated to have occurred between 2000 and 5000 years ago (*26, 30*).

It appears that support of the idea that sea level during a recent climatic optimum was some feet above today's level has been waning within recent years among students interested mainly in the borders of the Atlantic Ocean, whereas this idea is still supported by those who work in and around the Pacific. One cause of the dichotomy may be the greater crustal stability around the Atlantic. Another may be the relative absence of Quaternary coral flats in the Atlantic. However, in the West Indies, where they are abundant, neither Kaye (*8*) nor I find evidence of the higher sea stand. We both recognize extensive coral flats of Pleistocene age within a few feet of sea level.

The possibility of misinterpreting the evidence from Pleistocene coral flats may arise both from crustal instability and from inadequate preparation of coral samples for radiocarbon dating. In the vicinity of San Esteban, northern Luzon, for example, a Pleistocene coral flat rises from about sea level to an elevation of 25 feet in a distance of 2 miles (Fig. 7). To the rear of the pitted zone its surface appears so horizontal that, if the flat were eroded, so that only a remnant about a hundred yards long remained, it would be readily identified as a bench; with any elevation between its upper and lower limits depending on the location of the remaining fragment. For dating, any sample from a block of coral must be cleaned as thoroughly as a tooth that is being prepared for filling. The slightest contamination by organic material from recently living creatures renders the result of assays completely meaningless. I strongly suspect that many of the anomalous dates for elevated shorelines are dates derived from inadequately cleaned samples.

In closing, I wish to express my sincere hope that an increasing number of investigators will turn their attention to coastal morphology and that their conclusions regarding the retreat of cliffy coasts and Quaternary changes of sea level will become increasingly definitive (*31*).

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31. The fieldwork upon which this article is based was supported by the Geography Branch, Office of Naval Research [contract Nonr 1575 (03)]. The radiocarbon dates were furnished by the Geophysical Laboratory and Exploration Department of Humble Oil and Refining Company.

# Continuously Cultured Tissue Cells and Viral Vaccines

## Potential advantages may be realized and potential hazards obviated by careful planning and monitoring.

Report of a Committee on Tissue Culture Viruses and Vaccines

The continuing development of new viral vaccines and the widespread growing interest in their general administration to man focuses attention anew on problems accompanying their production and the assessment of their potency, purity, and safety.

During the last 15 years, the art and science of culturing animal cells and their use as growth media for viruses has developed to the point where tissue cultures provide the predominant technique for the isolation, identification, and propagation of these agents. Furthermore, mass culture of mammalian cells has become practicable for the commercial preparation of viral vaccines, such as those used for immunization against poliomyelitis. (Comparable developments of veterinary vaccines are deemed beyond the scope of this report.) We see no indication that the trend toward such applications of tissue culture will not continue.

Three general types of cell culture have been used for growing viruses. First, there are mixed populations of cells freshly explanted from normal animal tissues and cultured, for a relatively short period but not subcultured, in artificial media that usually contain serum. In this way monkey kidney cells are grown for producing polioviruses and also chick embryo cells for measles vaccine. Secondly, there are "cell lines" or "cell strains" (here used synonymously), which are derived by serial subcultures from the first type. Human skin epithelium NCTC3075, monkey kidney epithelium NCTC3526-LLCMK2, and mouse liver epithelium NCTC1469 are good examples. Lastly, there are the cell lines derived similarly from explants of neoplastic mammalian tissues, such as the HeLa line, which originated from a human cervical carcinoma. Under favorable conditions the latter two types can be subcultured indefinitely in artificial media that contain serum or some other source of protein. Some of these lines, including some cited here, have been stabilized and carried for a number of years in chemically defined protein-free media. Until now, primary cultures of the first type have been considered to be the most practicable for large-scale production of viruses. However, in anticipation of the probable need for expanded production of various new viral vaccines, the limitations which are discussed here have turned attention to the possible use of continuously cultured cells.

The procedures necessary to ensure the potency of viral vaccines are well defined and will not be considered here. Because at present the respective viruses must be propagated in living animal cells, peculiar difficulties arise in selecting criteria of purity and safety, most importantly, criteria to ensure the absence of adventitious nonbacterial infectious agents. These difficulties are particularly exigent with the more recently developed live-virus vaccines but to some degree they arise also with inactivated virus vaccines, especially those that rely on borderline conditions of inactivation, because the conditions that suffice to inactivate the virus of the vaccine may fail to inactivate unsuspected adventitious viruses. Paradoxically, smallpox vaccine, which has been in use for over a century and a half and is generally prepared from infected skin lesions of inoculated calves, has been the subject of little concern regarding the presence of adventitious agents other than bacteria and foot-and-mouth virus.

We have accordingly undertaken to evaluate pertinent aspects of current knowledge of the cultivation of animal cells which might be used in the production of viral vaccines, to consider relevant properties of the cultured cells, and to suggest guide lines for the development of a practical program for the use of continuously cultured cells in viral vaccine production.

We agreed readily that continuously cultured tissue cells afford numerous advantages in the propagation of viruses for vaccines. However, because such cells tend to develop characteristics suggestive of malignant change, and theoretically oncogenic activity might be associated with viruses propagated in them, we recognized that present knowledge permits only carefully qualified approval of their appilcation to vaccine production. On the other hand, we were mindful that too cautious an opinion would discourage the continued research needed for better definition of the permissible limits of such application. Meanwhile, continuing develop-

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This article represents the consensus of the authors on the potential advantages and hazards attending the use of continuously cultured tissue cells for the propagation of viruses to be used in vaccines. It is a report made to James A. Shannon, Director of the National Institutes of Health, at his request, by a committee whose members were Henry W. Scherp, Chairman, W. Ray Bryan, Clyde J. Dawe, Wilton R. Earle, Karl Habel, Robert J. Huebner, Karl Reinhard, and Joseph E. Smadel. The authors are staff members of the National Institutes of Health, Bethesda, Maryland.