

of Patagonia have remain horizontal following the last Glaciation. Deep sea corings support this, for there is no evidence of tilting in the entire shelf region. Synchronous shores are horizontal throughout, and at the same altitudes. On the east coast of Patagonia there are also places where synchronic shores are not absolutely horizontal, both north and south of Comodoro Rivadavia. On this last-mentioned shore the 15–22 m shores appear to rise toward the north and join, so that in this oil region there seems to have been an anomalous rise, and near Río Paraná, also, so that northwards from there local anomalies occur, though they are not continuous. RICHARDS and BROECKER (1963) add that the eastern coast of south America is, by and large, horizontal, but that the western coast is anomalous.

I earlier reviewed (1964) J. J. GROOT's and C. R. GROOT's deep-sea cores from Argentina, which throw light chiefly on climatic conditions of the Pleistocene. But there are absolute datings also for their samples. The GROOTS wrote (1967): »Recently TUREKIAN (1964) determined the radiocarbon age of a number of samples from cores from the South Atlantic Ocean. Two of these samples were obtained from Core V15–142, one from a depth of 23–35 m with an age of $10,000 \pm 400$ years, and the other from a depth of 35–40 m with an age of $12,200 \pm 300$ years. The depth of the latter sample coincides with the last glacial-postglacial boundary determined by pollen analysis. Since the end of the last ice age occurred about 11,000 to 12,000 years ago (ERICSON *et al.* 1961), the radiocarbon assay by TUREKIAN provides independent evidence that the palynological interpretation is correct.» The especially abundant occurrence of *Ephedra* pollen here indicates the Last Glaciation, the glacier having already retreated approximately 14,000 years before, but in my opinion, a glacial anticyclonic, cold and dry climate prevailed because then a great part of eastern Patagonia was ice-free.

According to RICHARDS' and BROECKER's short summary (1963) the Lamont Geological Observatory performed the researches giving special attention to the Argentina shelf. On the shelf at a depth of 105 m is a shore, several of whose fossils indicate a cold and shallow sea, which correlates with the Wisconsin Glacial Age (FRAY, *et alia*, 1963). This is in agreement with my researches (AUER, 1956). Several mollusks indicate the late-Wisconsin time and were taken at as shallow a depth as 119 m. Their age dates between 11,100 B.P. and 17,250 B.P. In the vicinity of Puerto Deseado a sample extracted at a depth of 150 m showed a Carbon-14 age of greater than 25,000 years B.P. It may represent the Illinoian time.

In 1963 a number of samples were taken from shore formations in the vicinity of Comodoro Rivadavia from FERUGLIO's shore formations. »A Carbon-14 date of *Chione antiqua* King from an outcrop near the electric

plant of Y.P.F., 5 km north of Comodoro Rivadavia at an elevation of 9 m gave a date of 5350 ± 200 years B.P. (L-740-A). The finding of an elevated beach only some 5000 years old at an elevation of 9 m at Comodoro Rivadavia casts some doubt on the absolute stability of at least that local region.» The Argentine researchers BORDAS (1957) and PARODIZ (1962) have found only two Pleistocene marine ingressions on the Argentine coast, and state that they are due to the movement of the land and that the entire area has been rising and falling epeirogenically since the Pliocene.

FREY and EWING (1963) have made important investigations on the Argentinean shelf and its possible warping. Two or more shell beds comprise a shallow cold water fauna. These shelf layers probably were deposited during a period of transgressing seas. Sea level was lowered a minimum of 60 fathoms (110 m) about 11 000 to 12 000 years B.P. The distribution of cores containing both pebbles and shells of a shallow water fauna suggests a former shoreline where present water depths are 30 to 40 fathoms (55 to 73 m) at a time $15\ 000 \pm 300$ years B.P. Sea level was lowered a minimum of 65 fathoms (120 m), and perhaps as much as 82 fathoms (150 m) prior to 35 000 years B.P. The uniformity of depth in the shell layer below sea level suggests that there has been little if any warping of the Argentine continental shelf since late Wisconsin time. (The spacing is by the author.)

To this can be added following information:

1. VOGEL—LERMAN: Groningen Radiocarbon Dates VIII, 1969. Quoting from page 24: »Atlantic Ocean transgressions investigated with samples from the E coast, Prov. Buenos Aires, Argentina. The problem has been summarized by Lemit (1950), Coll. April 1965 and subm. by C. R. Cortezzi, Museo de la Plata, Argentina $3,530 \pm 35$ B.P. Beside the Paraná River 18 m below sealevel is a 20 cm-thick, heavily compressed peat, and 20 m below ground surface.» Peat underlain by loess deposits and covered by a thick layer of sea clay thought to belong to Querandinense Formation. Coll. and subm. by W. H. van der Molen dates beginning of a marine transgression corresponding to the world wide elevation of sea level. The age is $8,620 \pm 100$ years B.P.

2. »Palo Blanco samples are considered by collector to date Platense ingression and date of Punta del Indio (HUBBS and BIEN, 1967, p. 273) is not considered acceptable if compared with a date from same site of approximate 5,880 B.P.» *Op. cit.* p. 25.

3. On p. 50: »GrN-5189, Palo Blanco 6—13, Buenos Aires, Argentina $2,990 \pm 40$ B.P. Shells *Erodona mactroides* (Daud.) from excavation at La Florida, Palo Blanco ($34^{\circ}52'05''S$ Lat. $57^{\circ}50'56''W$ Long.) S of town Berisso about 1 km from Río de la Plata, Querandinense.»

4. GrN-5631. La Plata 2. $3,530 \pm 35$ B.P. »Scattered fragments of shells from cut in clay along road, at 50 cm depth, near La Plata, prov. Bs. As. Approx. 6 m above present sea level thought to belong to Querandinense or Platense Formations.»

5. GrN-5632. La Plata 3. $34,000 \pm 500$ B.P. »Shells from layer at about 3.40 m depth, approx. 9 m above sea level, in excavation near La Plata, prov. Buenos Aires. Thought to belong to Belgranense ingression. Collector thinks that it is not yet possible to correlate La Plata 2 with other samples owing to scarcity of data and uncertainties about Querandinense and Platense transgressions in different localities. In particular, collector's opinion is that dating of sea level by RICHARDS and BROECKER (1963) is doubtful due to possible displacement by the sea of shells from original depth. Sample Delta Río Paraná (see above) is considered by collector to date Platense ingression, and date of Punta del Indio (see VOGEL-LERMAN, 1969) is not considered acceptable if compared with a date from same site of approx. 5,880 B.P. (IVIC — unpubl.), although no stratigraphic positions are mentioned.»

These datings clearly are not always in agreement with my profiles and the datings for samples in them. I have earlier shown that mollusks give unreliable datings when they are allochthonous. The occurrences presented and examined by me are easily checked in publications and by field observations, when such contradictions would appear.

The most work in researching the Patagonian seashores was done by FERUGLIO (1950), and his results are already considered classic. He did no boring but used the altitudes from sealevel and determined sea beaches and age relationships by mollusk fauna. He made observations in dozens of different locations on the Patagonian shores. He attempted to explain the shift of northern species to the south and of the southern species to the north, and thus solve the problem of climatic fluctuations. The horizontal position of the shores interested him. His critical sense did not allow him to ascertain the climatic fluctuations on the basis of mollusk material. For the shores of Puerto Deseado, for instance, he suggested two alternatives, as KONZEWITSCH (1959) noted (AUER, 1970).

Sealevel displacements and their inter-correlations cannot be determined by shore stand altitudes, as has been explained, for synchronous shores can lie at different elevations. We must then resort to the dynamic movements of sealevel, to the rise and fall of sealevel.

Certain Opinions

Differences of opinion on sealevel displacement, expressed with some acerbity, have widely expanded world literature on the subject. The chief matter of concern is the elevation of the shores and their synchronism. Not before radiocarbon dating proved its value decisively did research find a new and exact basis. The transgressive shores of a fluctuating sealevel are still the subject of special attention. I must disregard here that immense literature to concentrate on imperative occurrences in the northern and the southern hemispheres, in other words, on the comparison of the vertical movements of the coasts of Norway and the Arctic Ocean with those of the eastern coast of Tierra del Fuego and Patagonia, and omit the study of shore elevation.

From the beginning of this century, the phenomenon of land uplift was held to be so unshakable an explanation for the correlation of shores above sealevel that the values of even the most distant shores were considered valid for realizing shore synchronization. This concept began gradually to compete with the eustatic sealevel movement, founded on the increase and decrease in water masses. The former accounted for the wasting of glaciers and the later for their formation. This so-named glacial eustasy is still accepted, though no longer as the sole factor. Opposing glacial eustasy several concepts worthy of consideration have been advanced. One of the most severe opponents is WALCOTT (1972); he very thoroughly grounded his point of view. He wrote: »The movements of the ground are large and require a re-evaluation of what is meant by eustatic sea level change», and adds »no substantial eustatic change of sea level in the past 6,000 years is required to explain postglacial sea levels.» MORRISON (1968) holds climatic fluctuations to be important factors in sealevel changes and connects them especially with eustatic movements caused by the sea's temperature and the temperature fluctuations.

W. H. TWENHOFEL (1951) has summarized KUENEN's (1950) concepts thus: »Changes of sea level are dealt with in the final chapter. Possible recent eustatic changes are noted, but it is pointed out that the data supporting them are not completely trustworthy. Attention is given to the glacial and postglacial eustatic changes of sea level resulting from the extraction of water to make the glaciers and return of the water when the ice is melted. It is noted that the data in general are little more than estimates. Stratigraphy is claimed to prove the occurrence of eustatic movements in the geologic past, though the reviewer doubts that there have been many worldwide rises or falls of sea level. Kuenen concludes that the cause must be sought in the changes in cubic capacities of the basins,

and he decides that deposition of sediments and diastrophism are inadequate to account for the movements that are known. He concludes that even the lesser eustatic movements «cannot be accounted for by processes operating in or at the surface of the crust,» and that «the principal cause must be found in internal factors acting below the crust.»

Even «chance» has been proposed as worthy of note where shores have the same rhythm in altitude. And here I must cite the noteworthy study of JOHN and SUGDEN (1971, p. 106) on the South Shetland Islands. I quote: «Little can be said regarding a comparison of the South Shetland Islands' beaches with those of Fuego-Patagonia. AUER (1960) recognized beaches at 25, 22, 18, 15, 9 and 6 m. Their order of altitude is broadly comparable to that of the South Shetland Islands, but this could be sheer coincidence.» And they continue: «This pattern is generally in agreement with that of Fuego-Patagonia.»

Of special note are BLOCH's (1964) concepts of ocean level fluctuations which are caused by changing albedo in the ice masses. This presupposes volcanic activity and ash. BLOCH notes that GODWIN, SHEPHARD and SUSS, JELGERSMA, and PANNEKOCK and CURRAY find that at the end of the last Glacial Age the sea had risen 40 m, and the sinking began 7,000 B.P., after which the sea fluctuated and rose only 2—3 m. This, they find, would represent eustatic movement. DUBOIS, GODWIN, FAIRBRIDGE and CURRAY state that the rising and sinking alternated so that also after 5,000 the level changed by 2 m.

Sudden changes in sealevel, according to certain researchers, is tectonic, but BLOCH and HESTER (1962, p. 128—129) find that the eustatic explanation is possible. For an Antarctic glacier the albedo is over 90%. Reflection on the surface of the ice is high for both long and short wave radiations. On the ice recrystallization and absorption in long waves take place, although both the long and the short waves are active. What is important is volcanic activity and likewise, loess. Slight reduction in albedo brings about a small rise in the temperature of the glacier, and such an increase in temperature reduces the difference between the polar and the equatorial temperature, and so reduces also the general force of circulation. According to BLOCH this concords with the phenomena occurring with the eruption of Krakatoa in 1883.

According to BLOCH and HESTER, this takes place on the southern continent only in summer — in April — and in the northern hemisphere it appears the following winter. On the Antarctic continent three old eruptions have been ascertained, assumed to have occurred in 100 A.D., 1250 B.C. and 1350 B.C. They are eruptions of the volcano Erebus. If then the magnitude of the Antarctic continent is dependent on albedo, ice is now increasing there, as BROOKS (1949) and LISTER (1959) state. Ice can thus

increase so long as it is white »in virtue of their deficient radiation.» The loess of the surrounding regions is effective for a long time, causes discoloration, reverses the balance of radiation and reduces the polar ice mass.

Researchers of South America are generally of the opinion that the tremendous ice mass is capable of affecting the sealevel to a far greater degree than has been assumed for the fluctuations of sealevel displacements of the whole world, and the general climatic circulation and even longer periods of climatic fluctuations, as well.

Of the numerous, notable papers read at the INQUA congress in Paris (1969), the viewpoints and opinions of GUILCHER must be noted. He says that the latest concepts on »erosional unloading do not imply that the glacio-eustatism is out of date. Its principle remains valid.» To the new methods belongs also the $^{230}\text{Th}/^{234}\text{U}$ -method, in addition to C-14. In his opinion, the two Interglacial shores mean the Holsteinian and the Eemian, now both above sealevel where the surface of the earth has not sunk. The drowned beaches and valleys indicate that the sea was as much as 200 m below the present level. Following the last Glaciation (Würm) the sea began to rise, and the discussions have been heated about the altitude to which the sea rose thereafter. It appears that in one thousand years it has risen 1—3 m. The present situation resulted from the Flandrian transgression at the end of the Würm-Wisconsinian Glaciation. He expresses a number of opinions and touches upon the possibility of a sinking of the ocean floor, as did AUER, 1959. GUILCHER considers critically the significance of the ice masses of the Antarctic continent and of Greenland as regulators of the sealevel. He also mentions the Holocene transgression, and makes the following subdivisions of the Holocene: pre-boreal 9,500—8,000, atlantic 8,000—5,200, sub-boreal 5,200—2,500 and sub-atlantic 2,500 B.P. On p. 89 he expresses his opinion that the sea has been only 2—3 m high in the last thousands of years.

BIGARELLA (1964) in his investigation of the Brazilian coast states that three rises in sealevel have been verified: in 5,900 Y.B.P., 4,000—3,400 and 2,800—2,100 Y.B.P. I am astonished that he does not know my curve, which is for the same period as his. Many other values, especially of the Holocene transgression, might be mentioned, such as URIEN's and OTTMAN's on Río de la Plata, where marine mollusks were found, relicts of the old beaches of the Holocene times.

Whatever one's standpoint may be, it seems to me that to the cosmic forces must be attributed a determinative significance for the reason that here there is in question rhythmicity, both long and short undulatory movements of the earth's crust. The role of cosmic forces is emphasized by the fact that on the ocean floor there have been discovered numerous