textured" sediment and eschew "fine-grained." True enough, but I don't know, as they say in politics, if it will "float."

The volume comprises seventeen chapters, and besides the 35 pages of references, it also carries an invaluable index of 30 pages. A separate glossary is available, on request. The chapters are arranged in five parts, working up from elementary ideas for the beginning students to concepts of increasing complexity. Each chapter concludes with "further readings".

Part I and chapter 1 are introductory and attempt to set up a global perspective, and touch on things like sea-level change, ice ages, and the greenhouse effect.

Part II ranges from particles to rocks, with chapters 2 through 4 treating with sediment types and properties (Chap. 2), diagenesis and lithification (Chap. 3), and finally classification and nomenclature (Chap. 4). Their approach to the latter is logical, that is, descriptive and in general they avoid Grabau's genetic scheme. Nevertheless, a liberal philosophy permits them to add some "genetic interpretations, where they can be reasonably inferred . . . (and) judiciously blended." We are thus encouraged to use turbidite, a clearly genetic inference, but there is no place for tempestite (a storm-generated deposit). We are allowed till, but, curiously, no tillite. Eolian processes are treated but there is no eolianite; nevertheless, its first cousin beachrock gets full attention. Incidentally, although they mention cyanobacteria and algae in contributing to the high pH needed to precipitate the aragonite or high-magnesium cement, they curiously seem to forget the role of solar heating during low-tide stages and the selective leaching out of NaCl and other sea salts during the lithification process (which is achieved in less than a single season). They turn a discrete eye away from the bulky literature on beachrock, generated mainly by physical geographers; much of it is complete nonsense.

Part III is called "From Layers to Sequence—and Seismic Stratigraphy," consisting of two chapters, a brief one on layering (Chap. 5) and a long one on "mesosequence" and up (Chap. 6). The topic of base-level control is critically explored. The classic historical concepts of undathem, clinothem and fondathem are given a little exercise, though, in truth, they rarely get an airing nowadays.

Part IV treats with process and environment in eight chapters. Chap. 7 reviews physical, biological and chemical processes in 48 pages, and does it very well. Chap. 8 outlines the present-day circulation of atmosphere and oceans, including the Mediterranean and euxinic (Black Sea) situation. Figure 8–17, a map of the Mediterranean could have been immensely improved by the addition of five little black arrows for the mouths of the Ebro, Rhone, Po, Danube and Nile, each with the annual (pre-dam) freshwater discharge (with volume in m^3), because paleoclimatic variations of this parameter must be recognized in order to understand a sediment like sapropel. Chaps. 9–14 deal successively with deep-water settings, shelf seas, beaches and barriers, coastal flats, deltas and estuaries, and finally all the non-marine lumped in one (deserts, rivers, lakes and glaciers in 52 pages). In the last series I was sorry not to see a development of the concept of *ephemeral deposition*, so important for the understanding of redbeds (and dinosaur footprints! See p.168). The printer committed the unforgivable "boo-boo" on p. 544 (box 14-3, Figure 1) of printing a nice air photo of the Dead Sea in place of a picture of some Triassic redbed sediments (correctly, in Figure 14–43). The authors use an etymological "bastard" term *peritidal* for coastal areas subject to waves and tides, typically the *Wadden* of the Netherlands (also the *Watten* of the German Frisian Islands, the site of a long-established mud-flat research station, Senckenberg-am-Meer, home of much "Aktuogeologie", unfortunately not even mentioned in this volume.) Ironically enough, the Netherlands Geological Survey, specifically Bob Hageman, named this environment the perimarine area, a term not only with priority, but that is also etymologically correct. Also representative of the perimarine areas are the sabkhas of the Persian Gulf ("sebkhas" in North Africa), which are typical of the subtropics. Incidentally, both Mediterranean and Persian Gulf settings are subject to only minor tidal influences, the rise and fall of the local sea levels being largely the consequence of prevailing or diurnal wind reversal; thus the sedimentation cycles may range from the semidiurnal (land and sea breeze), to the various lunar periods, to the multi-year categories.

Part V takes up large-scale patterns of sedimentary deposits, in three chapters: first, extraterrestrial forcing (an excellent and very unusual inclusion in this sort of text), and next (Chap. 16), the principles of stratigraphy (nice to see this condensed into 32 pages, but really this does not belong here; it calls for a separate textbook). Lastly (Chap. 17) we have "basin analysis," an interesting discussion to wrap up a university lecture course, taking in everything from sea-floor spreading to geosynclines, a historical, almost nostalgic review of its American (Appalachian) underpinning and its European (Alpine) expansion to *flysch* and *molasse*. The last two are subject to discussion, but not much clarification. They are, most certainly, both examples of tectono-sedimentary facies; it could be useful if we had been guided through actualistic models. Somewhat hidden under a misleading headline "Where do sedimentology and stratigraphy stand today? we discover interesting definitions of *mélange, wildflysch, exotic blocks* (not a word about "sedimentary klippes") and deep-sea trenches. A rather unsatisfactory ending, but nevertheless the whole volume is immensely worthwhile, and much of it is spectacular in quality.

Rhodes W. Fairbridge
Columbia University, and
NASA-Goddard Institute for Space Studies
2880 Broadway
New York, NY 10025

Karol Rotnicki (ed.), 1995. **Polish Coast: Past, Present and Future.** Fort Lauderdale, Florida: *Journal of Coastal Research*, Special Issue No. 22, 308p. $37.00. ISSN 0749-0208. ISBN 83-902295-6-0.

This volume is an unusual joint production of the Coastal Education and Research Foundation (CERF) and the Association of Polish Geomorphologists. It is printed (excellently) in Poznan, Poland, which is a significant factor in keeping the price so low; a comparable volume published in western Europe would have to be sold for five times this cost.

Readers should not casually dismiss this volume as a regional compendium. Quite the contrary, it is of very great potential use for any coastal engineers, geographers, geologists, and environmentalists who are interested in 20th to 21st century accelerated sea-level rise (ASLR). In other words, it represents a serious study of the past, present and future impacts of sea-level rise on varied stretches of coastline that have many analogous characteristics to other coastal sectors, for example, in eastern North America and the margins of the North Sea. An admirable initiative has been shown by CERF and we may hope to see future volumes of this sort.

The chapters, 37 in all, by various authors, are arranged in four parts. The first is on general problems (pp. 3–140), and then three regional parts: eastern (pp. 141–212), middle (pp. 213–276) and western (pp. 277–308). The inspiration for this volume emerged from an IGU symposium at Gdynia in 1994, that in turn had evolved from a meeting in Miami in 1989 organized by Norbert Psuty for the IGU Commission on the Coastal Environment and U.S. Army Corps of Engineers, which included a preliminary report on the Polish coast by Karol Rotnicki. Much of the credit for the excellent translation (no mean task!) goes to Mrs. Maria Kawińska.

Over three decades ago this reviewer and his student (Fairbridge & Krebs, 1963) analyzed the most reliable long-term tide gauges of the world to show a rise of mean sea level at 1.2 mm yr^{-1}, and now in 1995 "a general consensus" (with citations) suggests it is 1.0–1.5 mm yr^{-1}. This general averaging is taken by Rotnicki to reflect a global trend such as might be expected from the demonstrated 20th Century temperature rise and steady climb of atmospheric CO_2.

Unfortunately, he fails to refer to the two best long-term records in the Baltic Sea, both within a few hundred miles of the Polish coast, specifically in Finland and at Stockholm, Sweden; the latter spans over 200 years and, after adjustment for the glacio-isostatic crustal rise, shows an essentially straight line or minuscule rise. Nor does the editor cite the regional analysis by Pirazzoli, which shows a large central Pacific region that, during the last half-century, show 0.0 mm "rise." Taking the role of the Devil's disciple, may one not ask: "Where in the world would you look for a tide-gauge record that is not contaminated by (a) fresh-water intake, (b) geostrophic current variations (with geodynamic tilt), (c) glacio-isostatic crustal adjustment, (d) hydroisostatic factors, (e) sediment compaction, (f) plate-tectonic crustal disturbance, and (g) recent volcanism?" I think the answer is clear: "the mid-Pacific atolls"; and not far behind is the tropical Indian Ocean, with its long-term gauge at Bombay and one (alas, now inactive) at Aden. Even in western Europe, at Brest, there is a nearly 200 year record at a site located on ancient crystalline rocks, far from any neotectonic activity and river mouths; as Rotnicki shows in his table (p.5), the recent record for Brest from 1940 until today is 0.0 mm yr^{-1}.

My conclusion is therefore quite clear: granted the reality of a steady CO_2 rise and some degree of global warming since about 1950, any reliance on tide-gauge data is so fraught by demonstrable contamination that it can only be grossly misleading. The scientific world has been misled, and this reviewer formally apologizes for having been a leader in this shocking misconception. This false assumption in no way detracts from the value of the book which contains a tremendous lot of interesting information.

One factor that is not mentioned in the above-cited selection is a rise in storminess, an eighth and possibly most important factor. Public awareness of this recent trend has been little investigated, although the remarkable increase in wave action in the North Atlantic and the significant shift in wave trajectories has been noted in S.E. Australia and in Argentina. The importance of mean wind system shifts in long-term climatic oscillations has been discussed by Lamb (1976). On soft, unconsolidated sediments, the effect of wave approach is liable to create potentially catastrophic beach erosion, such as has been deduced by Bird (1984) to be an almost worldwide problem. In a general synthesis of the Holocene coastal evolution of the United States, Fairbridge (1992) concluded that while local paleogeography was a dominant factor, all the present coasts were subject to the sea-level rise associated with post-Little Ice Age warming. The L.I.A. reached its peak in about AD 1680, when sea level was 0.5–1.0 m below today's, and mean air temperatures were 1–2 °C below present. Comparable negative fluctuations are recognized to have occurred at intervals of 200–500 years throughout the Holocene, with smaller fluctuations of storminess at 11 to 45 yr intervals, associated with solar-lunar pulses. The storminess factor is nicely illustrated in western Florida where the coastal erosion and beachridge fanning directions show that cool intervals dominated by northwesterly storms (southwards shift of jet stream) alternate with warmer stages marked by southerly winds. The latter were associated with higher-than-present sea levels, as shown for example by the more saline-types in the midden shells and their geographic shift upstream in coastal rivers and estuaries (Stapor *et al.*, 1991). Low sea-level stages are reflected by gaps in the archeological records. The same ecologic-archeological fluctuation was shown by Fairbridge (1976) for Brazil, and, with closer inspection, appears to be present almost worldwide. The Rotnicki introduction (p.8) gives appropriate prominence to these fluctuations by reproducing the Mörner eustatic curves for N.W. Europe. In stable regions the above-present MSL beaches can be traced back to about 6000 BP, but in glacio-isostatically uplifted areas the same fluctuations can be followed back to late Pleistocene time (Fletcher *et al.*, 1993). In contrast, in strongly subsiding areas, from the Netherlands (Rhine delta) to Chesapeake Bay, the fluctuations are damped out or scarcely identifiable. These regions of crustal subsidence or severe sediment compaction are precisely those that are most threatened today by ASLR, the main theme of the volume editor.

Most of the chapters in this book tend to concentrate on the 20th century trends and their local expression. To bring the latest trend into focus, the reader is urged to study the earlier, Holocene patterns. If the past patterns show evidence of fluctuations, would it not be reasonable to reconsider the 20th century rise in terms of a normal, *i.e.* natural (non-anthropologic) recovery from the Little Ice Age cooling?

A general review of the Polish Holocene record is provided by Anna Tomczak (Chap. 2). At the beginning of the Holocene, local sea level was 60–80 m below present, but because of eustatic and glacio-isostatic adjustments the entire area remained terrestrial until the "Atlantic" stage around 8000 BP, when rising world sea level (and air temperature) caused a rise in groundwater levels with an expansion of swamps and peat growth. In the Atlantic-2 Chronozone thalassostatic sedimentation began in the estuaries, and swamps turned to lakes. By its end, the shoreline reached the present coast, in subsidence areas even south of the present line.

The end of the Atlantic Chronozone coincided with the beginning of spit formation along the coast, *e.g.*, 5640 ± 120 BP at Hel Spit. I would interpret this as corresponding to a small regression, followed by a rise, because the supply of spit-building sand is favored by a small exposure of the foreshore (Bruun's Rule), but the beachridge itself often overtops earlier ridges. Further minor regressions of this sort are identified by dates at 4810 ± 365 BP (Swina Spit), 4630 ± 120 BP (Kurarian Spit), and 3920 ± 60 BP (Vistula Spit). These span the Subboreal Chronozone, when spit-building appears to have alternated with "organic horizons", which were marked by spreading of peat-forming conditions (*i.e.*, cool, moist summers), *e.g.*, around 3500–3100 BP. During the discontinuous transgressive stage vigorous erosion of upland areas furnished abundant sediment for spit building and around Gdansk (Hel Spit) the total Holocene thickness reaches 100 m. The transgression maximum there was between 6330 and 5640 BP (5400–4500 BC, sidereal), which is the Calais-2 transgression of the North Sea. Problems recognized by Tomcsak include (a) the determination of sea level from buried deposits; (b) possible use of the term Littorina for transgressive stages, even though this shell is not found; (c) the difficulty of littoral deposits surviving during a general transgression; and (c) the dependence of future coastal evolution of offshore structures, still inadequately known.

Chap. 3 (Zeidler *et al.*) deals with modern wind and wave conditions, bringing out (p.37) the "intensification of westerly winds," increased storminess frequency and rising salinity in recent decades. Some GCM studies suggest century-long extrapolations that (a) will greatly increase freshwater intake into the Baltic, but other models suggest (b) decreasing precipitation. Historical storm surges in the southern Baltic have been documented since the 10th century, a notable one being in January, 1467. Accurate modern documentation shows maximum storminess was 1874–1914, with surges reaching 2–3 m above MSL. A return of frequent storms occurred in the 1960's, to climax in January 1983. Although winds from the north and northeast and are most damaging they amount to only 19% in the wind statistics, while those from the west set up the most frequent storm surges in the southern Baltic.

Several Polish tide gauges have over 100 year records and now 21 stations have at least 35 years of data. For the interval 1951–1985 local sea levels have risen 0.8 to 2.9 mm yr^{-1}. The longest record is Swinoujście (Swinemunde), since 1811; it shows a FALL of MSL from about 1825 to 1860 (by 5 cm), followed by a rise of 9 cm to 1926, then a fall of 3 cm by 1936, and then a rise with a sudden crescendo in the 1980's. Other gauges, not so long, are confirmatory. This long record gives no support for the idea of a steady secular rise due to rising temperature or CO_2. The fluctuations are not matched by the data from northern Baltic stations, in Sweden and Finland. Indeed, the Stockholm record of over 200 years (after adjustment for the glacio-isostatic uplift) shows only minor fluctuations over a nearly straight line. We may speculate therefore that regional tectonic factor in the southern Baltic is almost negligible and that sea level is dominated by local factors, *e.g.*, changing freshwater intake from the major rivers, and changing storm frequencies and trajectories, mentioned above. This seems to be confirmed by the individual records; thus Swinoujście had its maximum annual peak around 1905, Kolobrzeg about 1874, and Gdansk in 1912. These maxima suggest an association with increased winter (westerly) wind stress through the Danish straits which would be expected to have various local effects.

The next two chapters (4 and 5) deal with coast erosion, respectively in cliffed and sandy beach sectors, both being useful, if not very revolutionary.

Chap. 6 deals with human settlement history along the coast (Jankowska) and this sheds some light on past sea-level fluctuations. Mesolithic tools have been found below present sea level in several places, mainly near river mouths, notably that of the Odra (Oder). The Linear Band pottery culture appeared around Gdansk Bay by 4000 BC. Funnel Beaker people settled extensively around 3500–2500 BC and megalithic graves are found. A distinctive Rzucewo culture of mixed fishing and herding economy (2500–1800 BC) is clustered mainly around Puck Bay, west of Hel Spit. They began exploiting or working the famous Baltic amber along this shore.

Two curious gaps are noticed in many of the Coastal Settlements. The first is in Later Neolithic (2500–1800 BC) and the second from the Roman time to "early Medieval." Could these riparian gaps be due possibly to the high "Littorina" sea levels oscillations? Jankowska hints that coastal sites of the low-level stages would have been buried by the transgressive deposits. Furthermore, reoccupation during the Lusatian stage (1100–900 BC) was at a time marked by glacier retreat in Scandinavia, and again in early Medieval times. One of the earliest of the latter was at a spot called Salt Island in Kolobrzeg where the people extracted salt form brines in solar pans. About this time seawater salt exploitation became widespread in western Europe from France to Portugal, and in the Mediterranean. Some investigators have suggested that it was the regressions that exposed intertidal mudflats, favorable for preparing salt pans, and so initiated the industry which in places continues to this day. Interruptions occurred only at transgression maxima when the pans were inundated. A port facility in Puck Bay with a jetty extending 300 m seaward was functioning from the 7th to the start of the 12th century. The low sea level of the Little Ice Age is identifiable from a cultural layer from the 15th century with oak piles driven into the sea floor up to 500m from the present shore.

Chap. 7 deals with coastal economic geography, and Chap. 8 considers the vulnerability of the coastal zone to sea-level rise, using various scenarios, and reviews various protection measures, ranging from artificial dunes to concrete riprap, to massive stone dikes or cement seawalls. The risk factors are investigated in Chap. 9 (Rotnicki *et al.*). The entire coastline is divided into units and assessed in terms of present use, facilities and existing protection. They refer to the "continued inadequacy of coastal planning" that is "likely to encourage further development of areas at risk" (p. 134).

The rest of the volume (p. 141, onwards) deals with regional studies, which though of great value are for the most part too detailed for review. Nevertheless, a few notes may be of general interest.

The Vistula delta area debouching into Gdansk Bay, is summarized by Mojski (Chap. 10). The first Littorina transgression was 6.3–5.5 ka in this area. The maximum extent of the Littorina Sea (mid-Holocene, at 2.5 ka) is traceable as a cliff, either in the buried relief or subaerially towards Sopot (NW of Gdansk). Seaward, the terrestrial deltaic deposits interfinger with shallow marine. Peats have been dated at 9690, 9130, 8020, and 6330 BP, at 10–30 m depth (subsidence!), shown in cross-sections. Younger examples between 5415 and 1210 BP include also paleosols. Ancient dunes of the Vistula bar fall into three groups: (a) E–W series (white) in flat banks, 4–10 m high; (b) NE–SW sets (yellowish); and (c) a younger set paralleling the outer beach, containing organic matter in one spot dated 1210 yr BP. Figure 10.6 shows part of the Vistula bar topography, with white dunes on the seaward side, then yellow dunes (elev. >20 m) and finally on the landward (lagoon) side the brown dunes of the Medieval time reaching about 4 m above sea level in close parallel lines 50–100 m apart; they are separated by an irregular escarpment, evidently an erosional phase corresponding to a lower sea level and presumably cut by one of the branches of the Vistula. It seems evident that the Vistula delta has largely built up within a barrier-constrained lagoon, a remnant of which still survives in the east-north-east (the "Vistula Haff"); the main bed of the river has fluctuated from side to side, debouching into the lagoon during low discharge cycles, while breaking out to the sea at high sea-level, high discharge phases. Its deep bed rests on deposits of the last glacial stage ("Vistulian" to the Poles; "Weichselian," the German name, to the international community; "Wisconsinan" in North America). Earliest Holocene deposits (Preboreal substage) rest on a talweg cut to 20 m below present MSL. These were dissected to a depth of 30 m in the Boreal and infilled to about 12 m during the early Atlantic substage, being then channeled once more to about 17 m. This topography was then filled by channel deposits during the late Atlantic to Subboreal (transgression maximum about 2.5 ka) to about −3 m, which in turn are buried by Subatlantic limnic phytogenic deposits (peat, in part) and further channel fills.

The North American reader will see immediate analogies with the Mississippi delta, with its repetitive transgressions, new lobate growth and then channel trench cutting; only the terminology is different. Real differences appear in the human record. By the end of Neolithic times (about 1500 BC) the shoreline ran from the region of Gdansk to the southeast (see map Figure 11-1, in Chap. 11 by J. Cyberski). By AD 1300 (Figure 11-2) the delta had prograded extensively to constrict the (freshwater) lagoon to the northeast, with a second, smaller remnant in the southeast. Historical documentation shows that in the 6th century AD, the Vistula had three mouths, two in the 9th century. In AD 1242 (a high sea level stage) a new outlet was cut by the Stara Wisla (Old Vistula). Embankments were begun in the 14th century. In the Middle Ages, extensive polder development permitted the farming of wheat, and by the 18th century Poland was Europe's largest wheat exporter.

According to T. Basinski (Chap. 12) a large ice dam on January 31, 1840 caused the estuary level to reach 6 m above sea level; by the next day a new exit (the Wisla Smiala) had been cut through the sandy barrier spit, north of Gdansk. To prevent further flooding artificial exits for the Vistula were dug in 1840 and 1889–1995, where secondary deltas began to build out into the Gulf of Gdansk. Engineering controls, however, deprived the delta surface of its normal "top-dressing", and the surface now shows differential subsidence. Up to 2 million m^3 of sediment is now going directly into the sea. Disastrous floods still occur nowadays at times of unusual snow-melt.

The evolution of the Hel Spit (Chap. 15, Anna Tomczak) makes interesting reading. It represents a Holocene accumulation more than 20 m thick, extending well out into deep water where it reaches 100 m. Some 36 km long, it is 200 m to 3 km in width, widening from west to east, and reaching a height of 13 m in some small dunes. Storm-beachridges have added progressively to the east end, which curls round to the south. Deep drilling provides a complete sequence of Holocene development since pre-Ancylus (ice-lake) times, at about −100 m.

Growth of Hel Spit has created an important, almost-closed lagoon at the NW limit of Puck Bay (see Regina Kramarski *et al.*, Chap. 16). This feature, Puck Lagoon, is separated from the bay by a bar of <2 m depth, known as Seagull Shallow (in Polish). Beneath it, at about −14 m is a peat layer, dated 10,230–9540 BP (uncalib.). The rapidity of the Holocene sea level rise is shown by additional peats, at around −4 m, dated 7910, 6070 and 5850 BP (uncalib.). From time to time Hel Spit was broken through, presumably by rapid incidents of sea level rise, and marine fossils reach into a deep part of the lagoon. This spot, Kuznica Deep, was originally about 10 m deep, but has been infilled to 7.5 m and totally cut off from the Baltic since the start of the Subatlantic substage (about 1500 BC). This is an important fact, supporting data from elsewhere that the global, eustatic fluctuations of the last few thousand years have been relatively small, maximum MSL not having exceeded 1.5 m, which would not have been enough to overtop the Hel Spit.

Actualistic studies of Hel Spit are supported by 1:10,000 scale air pictures of 1957 and 1991, changes being calibrated against the dune baseline (Furmanczyk, Chap. 17). At the west end, 0–19 km, there is dominant abrasion in spite (or ? because) of groins. From 19 to 31 km the middle part, abrasion alternates, wave-like, with accumulation; maximum of retreat is 64 m and progradation 47 m. The easternmost sector, 31 km to the tip, is marked only by advance with a maximum of 105 m. The period was characterized by unusual storminess, with catastrophic surges in January 1992 and 1993, when temporary overflows occurred in places. Similar overflows are reported during historical times.

Engineering aspects of Hel Spit are treated in Chap. 18 (Basinski). The dunes are mostly vegetated, with a railway and road following the inner edge which is exposed to the Bay of

Gdansk. Excessive erosion at the west end is clearly due to beach starvation following the construction of jetties for a harbor at Wladyslawowo. A concrete sea wall protects the first 520 m east of it, followed by a 12 km stretch of 162 groins (groynes); the trouble is, as seen elsewhere in the world, the incidence of severe erosion after the last groin. Although groins slow down dune erosion, they do not stop it. The Puck Bay (inner) side of the spit is protected for most of its length by bulkheads, dikes or seawalls. Beach nourishment has begun and a bypass system is planned for Wladyslawowo harbor.

Cliff erosion at Jastrzebia Gora (Subotowicz, Chap. 17) involves a 30 m ridge of Vistulian tills (three), varved clay and fluvioglacials. A sector of "dead" (inactive) cliff exists at the east end, but the middle and west are marked by landslides of 1977, 1987 and 1990, and an earlier one about 1900. Problems of stabilization are briefly discussed. In many ways the Polish coast of the Karwia lowland has much in common with the south shore of Long Island (New York state) with its cliffed sectors at Montauk and its long barrier spits. After storms, in both regions, beds of peat or organic layers are exposed (see Tomcsak, Chap. 20), being radiocarbon-dated to several distinct stages: *e.g.*, 10,070 BP, 7510 BP, 6240 BP to 6040 BP (up to 2.5 m thick), 5450 BP, *etc.* One bore showed a 1 m thick bed, 3220 BP at the top, and 5540 BP at the base. The youngest is a thin organic layer at 590 BP (all dates uncalibrated). They are attributed to interdune swamp accumulation.

The middle sector of the Polish coast (Rotnicki, Chap. 21) is of barrier-lagoon type and active dunes, with some outcrops of Pelistocene cliffs. At its maximum transgression the mid-Holocene coast reach more than 12 km inland leaving an erosional scarp. Marine shells (incl. *Scrobicularia piperata*) suggest a "Littorina Sea" which had several distinct phases as did the thick peat accumulation (up to 12 m thick in places) that underlies most of the coastal plain. The barrier sands had built up meanwhile, and their interdune peats are dated back to 4610 BP (uncalib.). Several lakes persist inside the barrier and are floored by gyttja. The Pleistocene basal deposits are treated in chapters 22 and 23; to some extent they predetermine the shape of the present topography. Chap. 24 (Rotnicki and Borowka) summarizes the evidence of the Littorine invasions. The possibility of an early Holocene invasion (Mastogloia Sea) is discussed. A thin peat overlying the Pleistocene fluvioglacial sands near Lake Lebsko is dated at 9840 BP (depth at −8 m). Although the classical *Littorina* is absent from the overlying deposits, there are six distinct shell layers with typical Baltic species; the upper two are post-Littorina. Alternating layers show brackish or freshwater affinities. The same pattern is shown by diatom studies (Witak and Witkowski, Chap. 26).

Barchans and parabolic dunes are seen on the Leba Barrier (Borowka, Chap. 27), where four stages of intense eolian activity can be identified, dating back to 4000–3500 BP. A second stage was 3300–2500 BP. A third stage was 2000–1500 BP and most intense (dune heights up to 25 m). Podzols (with human artefacts, charcoal) mark the intervening periods. The last phase began around 500 BP (AD 1450).

Modern changes to the Leba Barrier (Chap. 31, Browka and Rotnicki) reveal some cliff recession to expose peats and associated paleosols with large tree trunks in growth positions, today at approximately mean sea level. There are three clusters of dates: 2910 and 2865 BP, 2135 BP, and 1220, 1125, 1065 BP (uncalib.). The wave-like variance between aggradation (up to 85 m) and retreat (80–100 m), is traced by air pictures over 26 years (see Figure 31.4).

The last section of this volume deals with the western part of the coastline, where cliff retreat has also been serious. From 1822 to 1923, the retreat was 40–50 m, and an abrasion platform 4 m deep has developed to a width of 250 m. Groins constructed in 1922 and appeared beneficial until the 1960's when storminess frequency increased and stimulated renewal of groins together with massive revetments in places. In Chap. 34 Rotnicki describes the fate of a medieval church built in the 12th century, then about 1.8 km from the coast; today its ruins are perched on top of an 18 m cliff, directly above the shore. The mean rate cliff retreat is 2.27 m yr. Chap. 36 on the cliffs of Wolin continues the same story but contains also an interesting table of 138 symbols for use in mapping a cliffed coast, which includes also symbols for hydrology, vegetation and land management. This system could be employed internationally in detailed cartography, although, of course, on any one project only a small number of the available symbols would be required. The volume ends (Chap. 37, Musielak and Osadczuk) with summary of the evolution of the Swina River mouth, which includes an interesting comparison with the classical descriptions and maps by Keilhack for the Prussian Geological Survey in 1912 and 1914, now corroborated by radiocarbon dating. For American coastal geologists one may recall that for half a century their own classic work (1919) was a textbook ("Shore Processes and Shoreline Development") by Douglas Johnson, one of the writer's predecessors at Columbia University; Johnson for his part learned many of his basic ideas from Keilhack and others on what is now the Polish coast.

Rhodes W. Fairbridge
Columbia University, and
NASA-Goddard Institute for Space Studies
2880 Broadway
New York, NY 10025, U.S.A.

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