Journal of Coastal Research	SI 39	72 - 75	ICS 2004 (Proceedings)	Brazil	ISSN 0749-0208

Sand Beach Ridges: Definitions and Re-Definition

P. A. Hesp

Department of Geography and Anthropology
Louisiana State University,
Baton Rouge, LA, 70803, USA
pahesp@lsu.edu

ABSTRACT

HESP, P.A., 2006. Beach ridges: definition and re-definition. Journal of Coastal Research, SI 39 (Proceedings of the 8th International Coastal Symposium), 72 - 75. Itajaí, SC, Brazil, ISSN 0749-0208.

Use of the term 'beach ridge' is confusing in the literature because definitions of beach ridges are highly variable and are commonly used interchangeably with 'berm' and sometimes 'foredune'. Thus, the definitions of sand beach ridges are briefly reviewed, and beach ridges are re-defined as entirely wave formed deposits. Berms and foredunes are also defined. Modes of sand beach ridge formation are also reviewed, with four primary modes identified.

ADDITIONAL INDEX WORDS: *Beach ridge, sand beach ridg, berm, foredune,definitions.*

INTRODUCTION

In many countries, the term 'beach ridge' has often been used inter-changeably with 'foredune', and some definitions actually describe both foredunes and beach ridges as the same landform. Foredune-like sand ridges have commonly been termed 'beach ridges' regardless of genetic origin, and the term 'beach ridge' has been commonly applied to sand ridges when the genesis of the ridge is actually unknown. Subaqueous bars, berms, foredunes, transgressive dunefields, and barriers have also been termed beach ridges (e.g. DELANEY, 1963; KING, 1972; COOK *et al.*, 1977; ARMSTRONG PRICE, 1982; WELLS, 1996; SANDWEISS *et al.*, 1998). Recent attempts to review or re-define beach ridges either did not fully examine the various definitions, the confusion over use of terms in the literature, or the modes of origin (TAYLOR and STONE, 1996), or argued for a very broad definition which even included cheniers (OTVOS, 2000). This paper attempts to (i) briefly examine the definitions of beach ridges, (ii) briefly examine the modes of formation, and, (iii) to define, or re-define beach ridges.

SOME DEFINITIONS OF BEACH RIDGES

Johnson does not actually define beach ridges but clearly indicates that he believes they are formed during storm wave activity. He also states (1919, p. 418-419) that:

"Dune ridges, or parallel ridges of dune sand corresponding in all respects with beach ridges, except as regards details of surface form, are to be regarded as resting upon true beach ridges…".

DOEGLAS (1955) provides a diagram of beach and surfzone terms (his Figure 2) and shows that beach ridges lie between the low and slightly above high water levels on the foreshore between the low tide terrace and the first berm. He appears to indicate that they are intertidal ridges or incipient intertidal berms.

DAVIES (1968, p. 70) states that beach ridges *"are subparallel ridges of sand, shell or pebble….". " Sand beach ridges may contain a proportion of wind-blown material, but this is scarce where successive ridges have been built rapidly or in hot, wet regions where dune building is inhibited".*

KING (1972) indicates that beach ridges are equivalent to, or evolve into foredunes when she states that *"sandy accretion features include beach ridges, which may become colonized, grow into coastal foredunes, and eventually become stabilized coastal dunes"* (p. 424).

KOMAR (1976, p. 32) refers to the formation of gravel and shell beach ridges by storm waves (cf. KOMAR 1998, p. 37), but states that the *"more common use of the term beach ridges is in reference to a series of long parallel ridges which are typically spaced from 25 to 500m apart".*

REINECK and SINGH (1975, p.291) define a beach ridge as *"a continuous linear mound of rather coarser sediment near the high water line"* which develops during *"storms and exceptionally high waters".*

Beach ridges have been defined by STAPOR (1982) as *"linear, mound-shaped ridges roughly paralleling the coast"* (p. 160; cf. STAPOR, 1975).

ARMSTRONG PRICE (1982) states that a beach ridge *"may originate immediately back of the active beach as a flood-level ridge commonly of the coarser beach materials, or it may form as an aeolian accumulation caught in the vegetation immediately back of the beach proper"* (p. 160). He further states that where excess amounts of sand are blown onto the ridge, it becomes a foredune. Thus, a beach ridge in his opinion can be either a water laid deposit or an aeolian deposit such as a foredune, or a combination of both.

MASON (1993, p. 57) states that a beach ridge *"is a clastic storm-related facies, deposited beyond the influence of subsequent lower sea levels prevailing during fair-weather conditions."* He indicates that beach ridges are sometimes covered by coastal dunes. He states that *"a beach ridge is any coast-parallel deposit of sands, gravels and (shell or other) debris, that is emplaced, most often, during the waning phases of storms"* (p. 126).

TAYLOR and STONE (1996) follow the definition of Stapor (1975, 1982) above, but add that *"beach ridges are the product of wave and wind deposition occurring at the upper limit of wave runup."* (p. 612).

SANDWEISS *et al*. (1998, p. 367) state that *"beach ridges are linear coastal deposits formed primarily by wave processes near storm and normal high water levels".*

OTVOS (2000) states that beach ridges are *"relict, semiparallel, multiple ridges, either of wave (berm ridge) or wind (multiple backshore foredune) origin."* (p. 84). He further regards cheniers as a special category of beach ridges (p.83). Thus, he combines berm, beach ridge, chenier and foredune into one type.

Berms or Beach Ridges?

Definitions and use of the terms 'berm' and 'beach ridge' have also been confusing in the literature, and the terms have, at times, been used interchangeably. For example, KING (1972) states that *"sandy ridges can form as a berm at the back of a beach either where it abuts against a solid rock coast, or where it lies against a low drift coast, or on a barrier island…"* (p. 424; my italics). VILES (1988a, p. 47) defines a berm as *"a ridge of sand parallel to the coastline, commonly found on the landward side of steeply sloping beaches".* She states that it is a nearly horizontal feature formed by deposition at the upper limit of the swash zone. In defining beach ridges, she states that they are *"accumulations of sediment forming a prominent feature on*

many beaches" and can take a variety of forms: *"Ridges may be formed near the top of shingle or sandy beaches (in sand these are called berms)"* (VILES 1988b, p. 45). *"Ridges may also be formed in association with runnels near low tide level on shallow gradient beaches"* (VILES, 1988a, p.45). King also describes ridge and runnel forms as beach ridges, and indicates that the uppermost, landward ridge may eventually evolve into a foredune (p.434). These definitions appear to include berms, beach ridges, *"sandy ridges", "prominent features",* and intertidal ridge and runnel systems as the same, or similar landform.

MODES OF SAND BEACH RIDGE FORMATION

The following examines beach ridges formed in sand sized sediment, and does not deal with beach ridges (sensu stricto) formed of coarser material (REDMAN, 1864; JOHNSON, 1919; LEWIS, 1932; GUILCHER, 1958; MASON, 1992). Four modes of beach ridge development have been promulgated in the literature and these are briefly outlined below.

Formation by Storm Waves and Elevated Water lLevels

Sand beach ridges may be formed during storm wave and elevated water level events (e.g. JOHNSON, 1919; GUILCHER, 1958; PSUTY, 1965). PSUTY (1965) argues from a detailed study of the stratification of ridges in Tabasco, Mexico, that the ridges are formed on the upper backshore by storm waves and swash which occur when storms in the Gulf create elevated water levels. In contrast, TANNER (1995) argues that the ridges were formed during low energy conditions.

Formation by Fair-weather Waves and Normal Water Levels

CURRAY *et al.* (1969) derived a schematic model and hypothesis for the formation of beach ridges (*"the postulated mechanism of formation of the ridges"* - p. 67) at Nayarit, west coast Baja California Mexico. They stated that the primary beach ridge is formed from emerged bars which accrete during low wave energy conditions. If low wave energy persists *"more sand is piled on the seaward face and on top of the newly emerged beach ridge, and it eventually becomes a permanent beach ridge with dune capping"* (p. 70). NIEDORODA *et al.* (1985) use the CURRAY *et al.* (1969) schematic model and in their diagram caption (their Figure 8-26) they state that the *"point bar is captured by eolian processes during periods of neap tides"* (p. 577). KOMAR (1976, p. 32) utilises the Nayarit Mexico barrier example (CURRAY and MOORE, 1964; CURRAY *et al,* 1969) to indicate that sand beach ridges may form from emerged bars (following de BEAUMONT, 1845).

UL'ST (1957), STAPOR (1982) and others (e.g. TANNER and STAPOR, 1971; 1972) emphasized the predominance of marine processes in the formation of beach ridges. TANNER and STAPOR (1971; 1972) argued that swash processes were most important and berm and beach ridge formation was *"essentially the work of wave run-up in the swash zone.."* (p. 394), and occurred during *"relatively energetic waves"* (p. 397), but not storm conditions. It is not clear in their paper that there is any difference between a berm and a beach ridge (see their figure 1). STAPOR (1975, p. 130) states that the beach ridges in NW Florida were built *"by swash action on a beach face"* but that the conditions necessary for their formation do not occur on either eroding or accreting beaches at present.

CARTER (1986) describes two modes of surfzone bars welding on to the beach face and terms these beach ridges.

Formation by Sea Level Change

TANNER (1995) states that there are four beach ridge types including (i) swash-built ridges, (ii) settling-lag ridges, (iii) storm-surge ridges, and (iv) dune ridges. A swash-built ridge is formed during fair weather and is an old beach. Settling-lag ridges form by *"settling from water"* but there is *"no significant wave work in their construction"* (p. 150). Storm-surge ridges are large (5-10m tall), discrete features with concentric convex-up bedding. Dune ridges appear to essentially be foredunes, and, according to Tanner, may form on top of swash-built or settling-lag ridges. TANNER (1995, p. 152) argues that the swash-built sand beach ridges and swales are formed during a sea level rise and fall of 5-30cm amplitude.

Formation Principally by Aeolian Processes

JOHNSON (1919) indicates that while the sand beach ridges are predominantly aeolian, they owe their form to the presence of a basal beach ridge formed by waves (see line 19, p. 419). MASON (1992, p. 70) describes dune ridges (essentially foredunes?) forming on the backshore and states that *"the construction of a dune ridge involves nucleation about a beach ridge…"*. Much of the early Australian discussion (e.g. DAVIES, 1957, 1968; MCKENZIE, 1958; BIRD, 1960, 1988) variously involves berm formation, cut and fill by waves and subsequent dune development (see HESP, 1984a, 1984b and TAYLOR and STONE, 1996 for partial reviews). HESP (1984a; 1999) has argued that most of the sand beach ridges' formed on open ocean beaches in Australia are, in fact, foredunes formed by aeolian deposition within backshore vegetation, and do not owe their existence to berm or wave built ridges at all.

DISCUSSION and CONCLUSION

Stapor's definition of a beach ridge is very broad, and could apply to several ridge forms including berms and foredunes. Many of the definitions cited above indicate that a beach ridge could be a swash bar, welded or welding bar, berm, beach ridge, foredune, or a combination of these. In addition, many of the modes of origin proposed for sand beach ridges lacks convincing evidence and process data. The general use of definitions by Johnson, Armstrong Price, King and others, has meant that many studies of prograded barriers in the world refer to the ridges on such barriers as 'beach ridges' apparently regardless of whether they are entirely aeolian deposits (and commonly foredunes), entirely marine deposits, or a combination of both, and, therefore we are left with little understanding of the genesis of the ridges.

Re-Defining Beach Ridges and Definitions of Berm and Foredune.

The discussion above indicates that there is considerable confusion in the literature regarding the terminology (and origin) of sand beach ridges, and the formation of beach ridges versus swash bars, berms and foredunes. The author believes that beach ridges should be clearly morphodynamically and genetically distinguished from berms and foredunes, just as TAYLOR and STONE (1996, p. 612) argued for a clear distinction between cheniers and beach ridges.

Beach ridges are here re-defined as swash aligned, swash and storm wave built deposits or ridges formed primarily of sand, pebbles, cobbles (gravel) or boulders, or a combination of these sediments (HESP, 1999). They are typically formed at, or above the normal spring high tide level (KING, 1972). Clearly they may also contain various amounts of other marine sediments (e.g. wood, shell, pumice etc). They are purely or principally marine deposits formed by wave action. This definition should be regarded as the strict sense (sensu stricto) definition in the future. The classic beach ridges are the storm built shingle and cobble ridges such as those at Dungeness and Chesil Beach, U.K. (see KING, 1972, p. 422), but sand beach ridges also occur in coarse to fine sand on some modally low energy beaches (open coast, lagoon or estuary).

A berm is here defined as a shore parallel, non-persistent wave built ridge or terrace formed at the limit of swash runup (HESP, 1999). It may be formed at all tide levels on a beach, but the crest is commonly formed at, or slightly above high tide

level (KING, 1972). Berms commonly display a terrace form with a seaward swash slope or beach face (a 'riser' in fluvial terrace terminology), a marked break of slope at the berm crest and a linear, concave or convex berm top (or 'tread' in fluvial geomorphology) (cf. Coastal Research Group, 1969; HINE, 1979). The berm is, therefore, not just "a nearly horizontal portion of the backshore…" (KOMAR, 1976, p. 13), but comprises the beach face and the berm top. The berm 'crest' is the point or morphological break of slope where the riser meets the tread. The term, berm 'crest', should refer only to the point of break of slope, not the entire berm terrace (top or tread) surface. Every high tide may alter a berm to some degree, and storms commonly erode or destroy lower elevation berms, while sometimes building higher elevation 'storm berms'.

The critical difference between a berm and a beach ridge is that berms are generally not persistent forming part of the intertidal to slightly above high tidal active swept prism. Beach ridges (sensu stricto) typically form above the normal high spring tide level on open ocean beaches or mean water level in lagoons and estuaries and are generally persistent.

Foredunes are genetically and morphodynamically distinct from beach ridges. Foredunes are typically the foremost vegetated sand dune formed on the backshore zone of beaches by aeolian sand deposition within vegetation. They are generally shore-parallel, vegetated, ramps, terraces and convex ridges separated by concave swales (HESP, 1999). However, note that not all foremost dunes on the backshore are foredunes, since other dune types may occupy a foremost position especially on eroding coasts (HESP, 2002).

ACKNOWLEDGEMENTS

Thanks to Michelle Russo for unfaltering technical and library support, and to the Department of Geography and Anthropology, LSU for financial support.

LITERATURE CITED

ARMSTRONG PRICE, W., 1982. Beach ridge plain. In: M.L.Schwartz (Editor) The Encyclopedia of Beaches and Coastal Environments. Encyclopedia of Earth Sciences vol. XV. Hutchinson Ross Publishing Company, Stroudsburg, Penn.: 159-160.

BIRD, E.C.F., 1960. The formation of sand beach ridges. Aust. J. Sci. 22, 349-350.

BIRD, E.C.F., 1988. The origin of foredunes on the coast of Victoria, Australia, J. Coastal Research 4 (2): 181-192.

CARTER, R.W.G., 1986. The morphodynamics of beach ridge formation: Magilligan, Northern Ireland. Marine Geology 73, 192-214.

COASTAL RESEARCH GROUP, 1969. Coastal Environments, N.E. Massachusetts and New Hampshire. Cont. No. 1, Dept. of Geology, University of Massachussetts, Amherst.

COOK, P.J., COLWELL, J.B., FIRMAN, J.B., LINDSAY, J.M., SCHWEBEL, D.A., and VON DER BORCH, C.C., 1977. The late Cainozoic sequence of southeast South Australia and Pleistocene sea level changes. BMR J. Australian gerology and geophysics 2, 81-88.

CURRAY, J.R., and D.G. MOORE, 1964. Holocene regressive littoral sand, Costa de Nayarit, Mexico. In: L.M.J.U. van Straaten (Ed.) Deltaic and Shallow Marine Deposits: 76-82. Elsevier, Amsterdam.

CURRAY, J.R., F.J. EMMEL and P.J.S. CRAMPTON, 1969. Holocene history of a strand plain, lagoonal coast, Nayarit, Mexico. In: A.A. Castanares and F.B. Phleger (eds.), Lagunas Costeras, Un Simposio (Coastal Lagoons, A Symposium). Memoir of the Intl. Symposium on Coastal Lagoons, UNAM-UNESCO, Mexico, Nov. 28-30, 1967: 63-100.

DAVIES, J.L., 1957. The importance of cut and fill in the development of sand beach ridges. Aust. J. Sci. 20, 105-111.

DAVIES, J.L., 1968. Beach Ridges. In: R. Fairbridge (Ed.) Encyclopaedia of Geomorphology.

DE BEAUMONT, E., 1845. Lecons de Geologie Pratique. Paris.

DELANEY, P.J.V., 1963. Quaternary geologic history of the coastal plain of Rio Grande do Sul, Brazil. Louisiana State University Studies, Coastal Studies Series no. 7, Louisiana State University Press: 63pp.

DOEGLAS, D.J., 1955. The origin and destruction of beach ridges. Leidse Geologische meledeligen 20, 34-37.

GUILCHER, A. 1958. Coastal and Submarine Morphology. London, Methuen and Co., 274pp.

HESP, P.A., 1984a; The formation of sand 'beach ridges' and foredunes. Search 15 (9-10), 289-291.

HESP, P.A., 1984b. Foredune formation in Southeast Australia. In: Thom, B.G. (Ed), Coastal Geomorphology in Australia. Academic Press: 69-97.

HESP, P.A. 1999. The beach backshore and beyond. In: SHORT, A.D. (ed.), Handbook of Beach and Shoreface Morphodynamics. New York: John Wiley and Sons, pp. 145-169.

HESP, P.A., 2000; Coastal Dunes. Forest Research (Rotorua) and NZ Coastal Dune Vegetation Network (CDVN): 28pp.

HESP, P.A., 2002. Foredunes and Blowouts: initiation, geomorphology and dynamics. Geomorphology 48, 245-268.

HINE, A.C., 1979. Mechanisms of berm development and resulting beach growth along a barrier spit complex. Sedimentology 26, 333-351.

JOHNSON, D.W., 1919. Shore Processes and Shoreline Development. Wiley, N.Y. 584pp

KING, C.A.M., 1972. Beaches and Coasts. Edward Arnold, London, 570pp.

KOMAR, P.D., 1976. Beach Processes and Sedimentation, Prentice-Hall, 429pp

KOMAR, P.D., 1998. Beach Processes and Sedimentation (2nd edition), Prentice-Hall, 544pp.

LEWIS, W.V., 1932. The formation of Dungeness foreland. Geographic Journal 80, 309-324.

MCKENZIE, P., 1958. The development of sand beach ridges. The Australian Journal of Science 20, 213-214.

MASON, O.K. 1992. A geoarchaeological methodology for studying prograding coastal sequences: Beach-ridge geomorphology in Kotzebue Sound, Alaska. In: L Lewis Johnson (ed.) Palaeoshorelines and Prehistory; an Investigation of Method: 55-81. CRC Press Inc, Florida.

MASON, O.K., 1993. The geoarchaeology of beach ridges and cheniers: studies of coastal evolution using archaeological data. J. Coastal Research 9 (1), 126-146.

NIEDORODA, A.W., D.J.P. SWIFT and T.S. HOPKINS, 1985. The Shoreface. In: R.A. Davis Jr., (Ed.) Coastal Sedimentary Environments (2nd Edition): 533 624. Springer-Verlag, NY

OTVOS, E.G., 2000. Beach ridges definitions and significance. Geomorphology 32: 83-108.

PSUTY, N.P., 1965. Beach-ridge development in Tabasco, Mexico. Annals of the Association of American Geographers 55 (1): 112-124.

REDMAN, J.B., 1864. The east coast between the Thames and the Wash estuaries. Minutes of the Proceedings of the Institution of Civil Engineers, v.23: 186-256.

REINECK, H.-E and I.B. SINGH, 1975. Depositional Sedimentary Environments. Springer-Verlag, NY, 439pp.

SANDWEISS, D.H., K.A.MAASCH, D.F.BELLKNAP, J.B. RICHARDSON III, and H.B. ROLLINS, 1998. Discussion of: Lisa E. Wells, 1996. The Santa Beach Ridge Complex, Journal of Coastal Research, 12 (1), 1-17. J. Coastal Research 14 (1), 367-373.

SHORT, A.D., 1999. Wave-dominated beaches. In: A.D. Short (Editor), Handbook of Beach and Shoreface Morphodynamics: Chpt. 7, 173-203. John Wiley.

STAPOR, F.W. Jr., 1975. Holocene beach ridge plain development, Northwest Florida. Z. Geomorph N.F. Suppl.-Bd. 22, 116-144.

STAPOR, F.W. Jr., 1982. Beach ridges and beach ridge coasts. In: M.L. Schwartz (ed.) Encyclopaedia of Beaches and Coastal Environments. Hutchinson Ross, Stroudsburg, 160-161.

TANNER, W.F., 1995. Origin of beach ridges and swales. Marine Geology 129, 149-161.

TANNER, W.F. and F.W. STAPOR, 1971. Tabasco beach-ridge plain: an eroding coast. Trans. Gulf Coast Assoc. Geol. Soc. 21, 231-232.

TANNER, W.F. and F.W. STAPOR, 1972. Precise control of wave run-up in beach ridge construction. Zeit. Fur Geomphologie 16, 393-399.

TAYLOR, M. and G.W. STONE, 1996. Beach ridges: A review. J. Coastal Research 12 (3), 612-621.

UL'ST, V.G., 1957. Morphology and developmental history of the region of marine accumulation at the head of Riga Bay. Akademiva Nauk Latviskoi SSR, pp179.

VILES, H. (1988a). Berm. In: Goudie, A., B.W. Atkinson, K.J. Gregory, I.G. Simmons, D.R. Stoddart, D. Sugden, (Eds), The Dictionary of Physical Geography, p. 47, Blackwell, Oxford, UK.

VILES, H. (1988b). Beach ridge. In: Goudie, A., B.W. Atkinson, K.J. Gregory, I.G. Simmons, D.R. Stoddart, D. Sugden, (Eds), The Dictionary of Physical Geography, p. 45, Blackwell, Oxford, UK.

WELLS, L., 1996. The Santa beach ridge complex: sea level and progradational history of an open gravel coast in Peru. Journal of Coastal Research 12 (10), 1 -17.