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A Global Synthesis with implications
for management of future coastal change

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Gravel Structures in Ushant, Western Brittany (France): swash aligned features, structural control and palaeo-sediment recycling

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Abstract

This paper is devoted to the understanding of the evolution of two gravel structures, located one km apart on the same island (Ouessant, or Ushant, western most island on the Atlantic coast of France). They have the same spatial extend . In 2D (on air photos) , they display the same shape (crescentic) and dimensions (350m across) but are very different one from an other in age (Eemian and Present), volume (3D) and behaviour (morphological variability). The opposition between these two barriers allows to asses the impact of macro scale (10^3 y) sediment source variation (Orford et al, 2002) on the developpement of the structures.

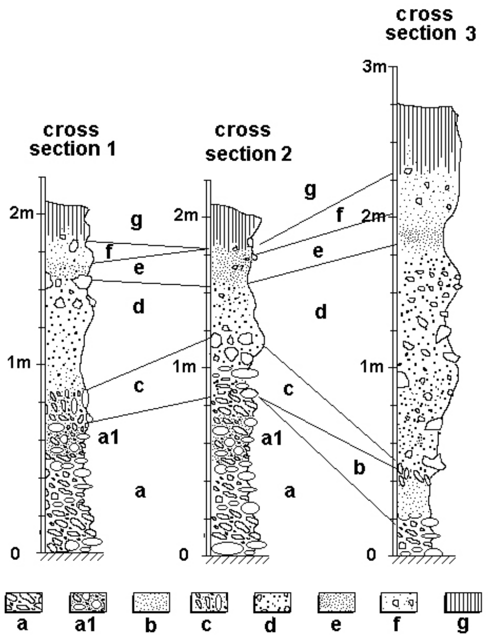

Figure 1. Cross section in Porz Koret, Ushant Island : **a:** eemian gravel beach ; **a1:** same with intermixed aeolian sands ; **b:** aeolian sands, about 90 ka ; **c:** gravel, with geliturbation structures ; **d:** head (undifferenciated) ; **e:** aelian sand (about 20 ka) ; **f:** slope debris ; **g:** holocene and present soil.

In the Island of Ushant (western most island off shore Brittany) dynamic conditions are extreme (in comparison with the main land coasts). True mean wave height, (measured offshore by a buoy) is c 3.5 m with storm waves reaching 7m five times a year. Storm waves are coming from north west to west. Winds above 20m/s (from south west to north west, blowing for more than 9 hours) occur 3 to 4 times a year. These winds usually build a local wind wave climate on top of the swell and produce a local shift of the wave direction. For this reason and because of local refraction, during the storms and inside of the bays western swell turns into a local north western pattern. Tidal range in spring tides is about 5 meters. It goes down to 2 m in neap tides.The coast line is almost entirely cut into various types of granite and schists of various resistance, with cliffs upto 40m high. The past coastline has been erosional, sufficient to form ledges in which modern beaches are fixed. These ledges are most often located along lithological contacts or within local aeras of less resistance (large alveolus). The north western part of the island is cut into a resistant leucogranite that is not much weathered and displays a lot of tors. The south western part of the island is cut in a less resistant granite, weathered and coated by slope formations in which periglacial features are seen (ice wedges) when the sea erodes them. Past interglacial sea-level positions were approximately the same as the present day, as some abrasional platforms are buried under these slope deposits very close to the present coast line (within 3 to 5 meters above present sea-level) .

Two sites show well developed gravel beaches. The first site (Pern) is a 300m wide bay, directly facing north-west (into dominant storm wave direction). The gravel structure is a beach/barrier system and is 6 to 8 m high (measured above low tide), 50 to 90m wide (maximum slope about 8 :100) and 350m long. The gravel have a mean long axis of 30cm and are all comprised of local granite. Some boulders (>1m) are present, scattered at the base (low tide to mid tide level) of the structure.

The second site (Porz Koret) is a perfectly rounded bay, 350m across, opened to the North West, but sheltered from incoming swell by a headland. The gravel beach , with no beach crest and no barrier system is backed by a cliff cut into periglacial slope deposits. The gravel are from local granite and have a mean long axis of 10 cm. The beach is 500m long, 60 to 90 m wide and has a slope of 2 :100.

The two sites have been surveyed and monitored for five years. Sediment size variation has been sampled regularly. Cross sections in the periglacial sediment have been studied , in order 1) to find out where the past interglacial shore line was located and what they were (gravel beaches, sand beaches…) 2) to asses if they could provide materiel to the present beaches. The cross sections (cf figure) consist of Eemian gravel beaches, sand layers, periglacial head deposits with a lot of blocs of all sizes, wind blown loess, Holocene dunes and soil.

Porz Koret may be considered as an active form, as some of the gravel comes from present erosion of granite outcrops in the bay (population 1). But most of it comes from the re-mobilisation of the gravel that were present inside of the periglacial cliff inland which act as source site (population 2). Some of these gravel are gelifracts dating back to glacial maximum (population 2b) and other gravel are dating back to the Eemian beach (population 2a). Almost no input from offshore has been noticed (very reduced poulation 3). Storms tends to scatter the gravel, to even the beach and to destroy the cliff, inputing more material into the system. Storms do mix the 3 populations. Relaxation periods show no evolution and the collapsed material has to wait for the next storm before it is actually sorted and scattered.

The amount of available material seems limited to the volume which is contained into the last sheets of periglacial cover (as eroding present outcrops are few). Pern is an active form, shaped by contemporary dynamics. It reacts to storms and changes its structure accordingly . The spatial variation in the sorting of gravel reflects the intensity of the last incomming storm waves. Each strong storm brings new large gravel in the center of the barrier up to its crest (over topping is clearly dominant above overwashing), and relaxation periods (especially during neap tide periods) see these gravels scatterred, either down slope seaward, either laterally, either back slope. Gravity seems to be the main forcing agent for this after storm re mobilisation. Any break is closed by these processes of remobilisation within weeks. As a whole some 10 to 100 of m^3 of gravel are added to the barrier each year and they mostly come from the surrounding rocky platform offshore (population 3). Some input from the neibouring slope colluvium exist, but doesn't represent a great quantity of material (population 2). A budgetary approach aims at linking: incoming energy of waves, availibility of gravel, lenght of time necessary for producing the gravel and shaping it into a barrier or a beach The wave exposed barrier (Pern) may be considered as an exemple of a fast (10^3 years) generated coastal feature, highly variable and highly resilient . If present accumulation rates are extended into the past 1750 to 2000 years might be able to provide the needed amount of gravel. This is very compatible with the known history of the sea-level.

Porz Koret may be considered as a slowly (10^4 years) generated feature (present day shaping of inherited material, as present dynamics do not seem to provide enough of the needed material from elsewhere) , with little ability to change and to resist violent storms for long. Its particuliar interest lies in the complexity of the various source sites, which have not acted at the same time and have not delivered the same amount of material during the recent history of the feature. In that respect Porz Koret is not in « equilibrium »with present dynamics but with a historical evolution of successives dynamics. It is not only a fossil form , but also a very improbable form in this exposed position. Its resilience is depending on the history of controls on sediment supply.

References

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