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A Global Synthesis with implications
for management of future coastal change

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Quaternary coastal morphology and sea level changes

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Sea-cliff/shore platform and estuary: an overlook of the two main types of coastal morphology along the Ecuadorian active margins

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Abstract

An overlook of coastal morphology along the active margin of the Ecuador suggests that only two main types of coast are observed at the scale of Quaternary processes: sea-cliff and their associated shore-platforms, and estuary coastal systems. Theee two coastal patterns are respectively associated with uplifting and subsiding coasts.

Sea-cliff coast

Sea-cliffs with a vertical shore-face of 2 m to 40 m in elevation constitute most of the coast of the northern margin of the Gulf of Guayaquil, Manabi (Fig. 1 and 2), up to Las Peñas in northern Ecuador (Fig. 3). The most evident areas are the surroundings of the Santa Elena, Manta and Galera Peninsulas.

Figure 1. Rock shore-platform (black area) over soft tertiary rocks, partially covered by sand in the upper beach and sea-cliff. The upper platform is a marine terrace from the last interglacial period. Near Crucita, north of the Manta Peninsula, central Ecuador.

These areas are characterised by nearly horizontal rock shore-platforms, frequently overlooked by Quaternary marine terraces in the hinterland. These terraces are old shore-platforms raised at elevation up to 360 m, in relation with previous interglacial periods (Pedoja, Dumont et al., 2001; Pedoja, 2003). The present shore-platform and sea-cliff are submitted to active erosion (Santana, Dumont et al., 2001). In cases of limited erosion, i.e. in the bays (La Libertad, South and North Manta and East of Punta Galera) the present shore-line cuts the lower marine terrace in a relatively remote position relatively to the paleo-shoreline, thus giving a relatively low sea-cliff. In these bays the sediments issued from small local rivers or coastal erosion are transported along the shore and overlay the rock of the shore-platform, giving the aspect of a sandy beach. However, during El Niño periods the sea level rises 30 to 50 cm higher than the normal one (Moreano, Zambrano et al., 1986; Zambrano, 1996), and the long shore transport probably changes of direction, resulting in the exhumation of the rocky shore platform beneath the sandy beach (beach of La Entrada for example), according to a process described in other areas (Sallenger, Krabill et al., 2002).

In several parts of the coast of Manabi that are in position of bay, the sea-cliff is presently isolated from marine erosion by a narrow margin of colluvium bordering a sandy beach.

This morphology can reflect two processes: the line of the mid-Holocene maximum sea level rising and transgression, if such event do have existed in equatorial zone, or/and the protection of the cliff from further erosion due to long-shore sediment transport, and collapse of the upper part of the sea cliff triggered by precipitation during El Niño periods, as observed during the 97-98 event (Perrin, Jeanneau et al., 1998; Santana, Dumont et al., 2001). Finally, the areas of low coast or estuary are very limited in the segment of uplifted coast characterised by sea-cliff and shore platforms. These areas are related to valleys issued from the hinterland, and are limited to the area of inherited morphology.

Sea-cliff and shore-platform morphology have been observed on soft sandstone and silt of the Pliocene formations (Onzole and Canoa Formations, Fig. 1), as well as on volcanic rocks of the Piñon and Cayo Formations (Fig.2).

The most reliable parameter is probably the moderate uplift (0.2 to 0.4 mm/yr) observed along the coast of the Santa Elena Peninsula and Manabi. A stable plate margin or a low uplift rate leads to the re-occupation of coastal morphology formed during the former interglacial periods (Trenhaile, 2002). This results in a more complex shore-platform and coastal morphology due to the superimposition over relict morphology. Also, a fast uplift results in smaller terraces (Trenhaile, 2002), or about no terraces (Santana and Dumont, 2002).

Figure 2. Rough shore platform over Mesozoic volcano-sedimentary rocks. The upper part of the sea cliff is covered by shallow marine sediments from the last interglacial period.

Estuary coast

On active margins the ongoing tectonics defines the morphology and as a result the main pattern of the drainage. The trend and estuary of a river are precisely controlled by the lines of lower elevation determined by tectonics, downstream to the sea. Despite this observation looks obvious, the implication is generally not considered. This means that on an active plate margin any significant estuary results from the effect and style of recent and ongoing tectonics. The coast of Ecuador is a remarkable example. Important areas of low coast and estuary patterns are observed, the two most important being the Guayas estuary to the south and the Cayapas-Santiago estuary to the north (Fig. 3). Both constitutes the outlet of important rivers issued from the Andean Cordillera, merging to the sea in areas of extended mangrove and tidal channels. Others parameters such as the mesotidal regime and the relatively high proportion of suspended sediments helps to the development of the estuary.

The estuary pattern is characterised by a high instability of the channel, not only in the distal part of the system, but also in his head part, in relation to the high mobility of the drainage network reaching the coast. These high instability and mobility are related to the tectonic activity. It appears clearly that the two large estuaries of Ecuador are precisely limited by faults related to areas of recent subsidence, either along strike slip fault systems as for the Guayas estuary (Dumont, Santana et al., 2001; Santana, Dumont et al., 2001) or subsiding blocks as observed for the Cayapas-Santiago estuary (Santana and Dumont 2002) (Fig. 3).

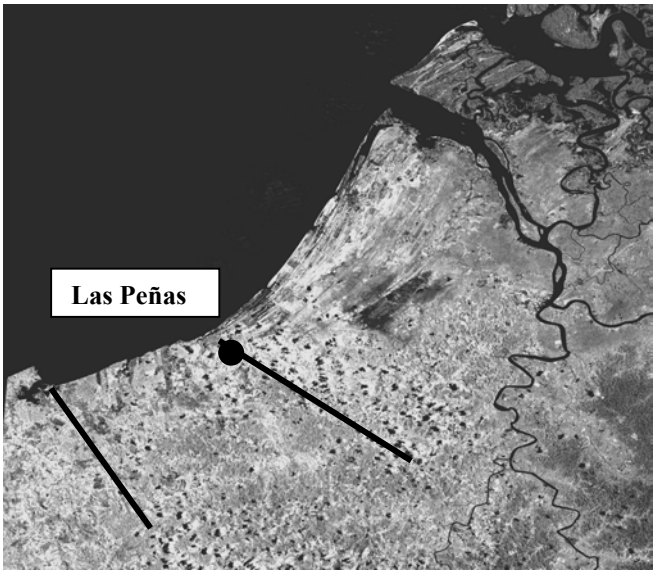

Figure 3. Spot image showing the transition from the area of rock coast in central-north Ecuador to estuary coast in the Borbon area. The saw-tooth coast to the left belongs to the northernmost area of rock-shore platform (Rio Verde and Las Peñas). The Cayapas-Santiago estuary begins east of a NW-SE fault, bounding the area of beach ridges to the south. Drowned beach ridges to the north gives evidence of active subsidence.

Conclusion

The coast of Ecuador reflects two different main patterns, which are erosion sea-cliff/shore-platform construction and aggradation of estuary.

The short-term variation of the coastal margin challenges the identification of long-term processes, because the erosion (i.e. transgression) coast characterises in fact uplifting areas and aggradation coast (i.e. regression) subsiding ones. Also, it should be noted that despite the numerous studies made on coastal morphology, sea-cliff/shore-platform lack of extensive work (Trenhaile, 2002) and structural estuary systems are poorly documented.

Better knowledge and understanding of these coastal systems would lead also to better interpretation of land-trench sedimentary transport, understanding of past marine terraces, and assessment of on-going short and middle variations of these coastlines and related hazards.

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