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Sedimentary facies and architecture of the deltaic deposits of the Camaná Formation, southern Peru

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1. Introduction

Cenozoic rocks of Camaná Formation in Southern Peru have been formed by consecutives coarse grain deltaic flows of short travel and distance. From Ocoña until Quilca, these strata overlay the Proterozoic and Paleozoic rocks that correspond to the Coastal Cordillera. The sedimentary stacking pattern in these deposits consists in several sedimentary episodes succeeding during the Andean Orogeny. However, we can note that sedimentary normal faulting exists within this context and uplift of some blocks such as the Coastal Cordillera.

2. Geological context

In western Southamerica, Nazca plate subduct to the continental Southamerican plate, by mean complex and consecutives tectonic interactions, forming the Andean Orogeny since latest Cretaceous. That Orogeny starts in southern Peru with the origen and migration of the magmatism towards the continent (Pitcher et al., 1985; Mamani et al., 2010), and consequently the formation of back-arc marine basins, and then the fore-arc basins (Sempere & Jacay, 2006). The Basal Coastal Complex acts as basement in Southern Peru, and consists of migmatites, granulites and gneisses (Martignole & Martelat, 2003; Ramos, 2008). This metamorphic block is faulted in a thrust fault way by the Atico-Ocoña-Camaná System Fault (Carlotto et al., 2009) and makes up the Ordovician San Nicolas batholith, causing intrusion and displacement of granites and granodiorites from the Coastal Batholith.

Such a tectonism originated enough sedimentary accommodation space, with some variations, may be due to the variations of the rate of convergence of the Nazca plate (Pardo-Casas & Molnar, 1987; Hampel, 2002), resulting in a complex deltaic system. Coastal Batholith is considered as a barrier that divide the marine Camaná Formation (Pecho & Serrano,1969) in the west side, and the continental Moquegua Formation (Marocco, 1984) in the east side.

3. Description of the sedimentary facies

Sedimentary facies of Camaná Formation, from Ocoña until Quilca have been described and classified according to their similarities in lithology, sedimentary structures and fossil content. These facies were classified inspired in the classification of Miall (1999), and are described in stratigraphic order, and also grouped in offshore, deltaic and fluvio-deltaic facies.

3.1. Non deltaic facies associations: Facies associations Fml, Fm and Ft: offshore and prodelta deposits

3.1.1. Description

These lithofacies are composed of micrites, with grains of quartz and plagioclase (Fml and Fl), also foraminifers, radiolarians and chert, with few bioturbation. Often these are normally graded and interbedded with compact grayish siltstones (facies Fm), with parallel laminations (facies Fml). Usually these facies contains redish layers of medium sandstone. Facies Ft are upward fine sequences from moderate tempestites PT, followed by grayish siltstone, very bioturbated, con Globigerina, some benthic foraminifers.

3.1.2. Interpretation

Facies Fml and Fm are the most distal facies observed in these deltaic flows. The redish layer are very weak tempestites, formed in sporadic turbiditic and distal currents. The next fine and carbonated fractions are product of the gravity accumulation of suspended grains. Facies Ft are particles that also have been formed by gravitity. These facies correspond to distal prodelta environments.

3.2. Deltaic facies associations: Facies associations Stb, St, Stx and Sp: shoreface to swash zone of coarse grain delta

3.2.1. Description

These facies are composed of coarse cemented sandstones, mainly with base of bioclastic tempestites, clinostratified, very bioturbated. In these facies we describe 3 kind of tempestites according to the intensity, Bandurria type (BT) of moderate intensity, Pucchun type (PT), low intensity, and very low intensity tempestites. Above the tempestites, we describe cemented sandstone with grains of feldspars and quartz, bioturbations. This successions end in reworked ashes with parallel laminations (facies Stb), and also with bioclasts (facies Sp). Above tempestites BT and PT we describe coarse grain sandstone decreasing to very fine sandstone, clinostratified, with planctonic forams and radiolarians (facies St), also with glauconite, chert and volcanic glass (facies Stx).

3.2.2. Interpretation

The described facies were formed by the accumulation of consecutives progradational coarse grain deltaic flows, influenced by a Lowstand system tract, which allows these flows to move towards sea and have foresets inclination. The amount of tempestites in the study area is abundant. The tempestites BT of moderate intensity, were interpreted as being formed by the action of strong waves near the beach or back-beach, making some flooding, and after, creating back currents with coarse grains charged along the bottom part, and waves structures (facies Sp and St). The low intensity tempestites PT, are smaller than BT with hummocky cross stratification, and are interpreted as formed deeper and further away from the coast. Also is noted that facies Ft, Fl and Fml, have thin layers of the same material as the tempestites, interpreted as very weak intensity tempestites, and more deep and distal from the beach. The subsequent deposits were formed in a more calmed environment with potential to accumulate finer sediments, and even volcanic ash (Stb and facies Stx).

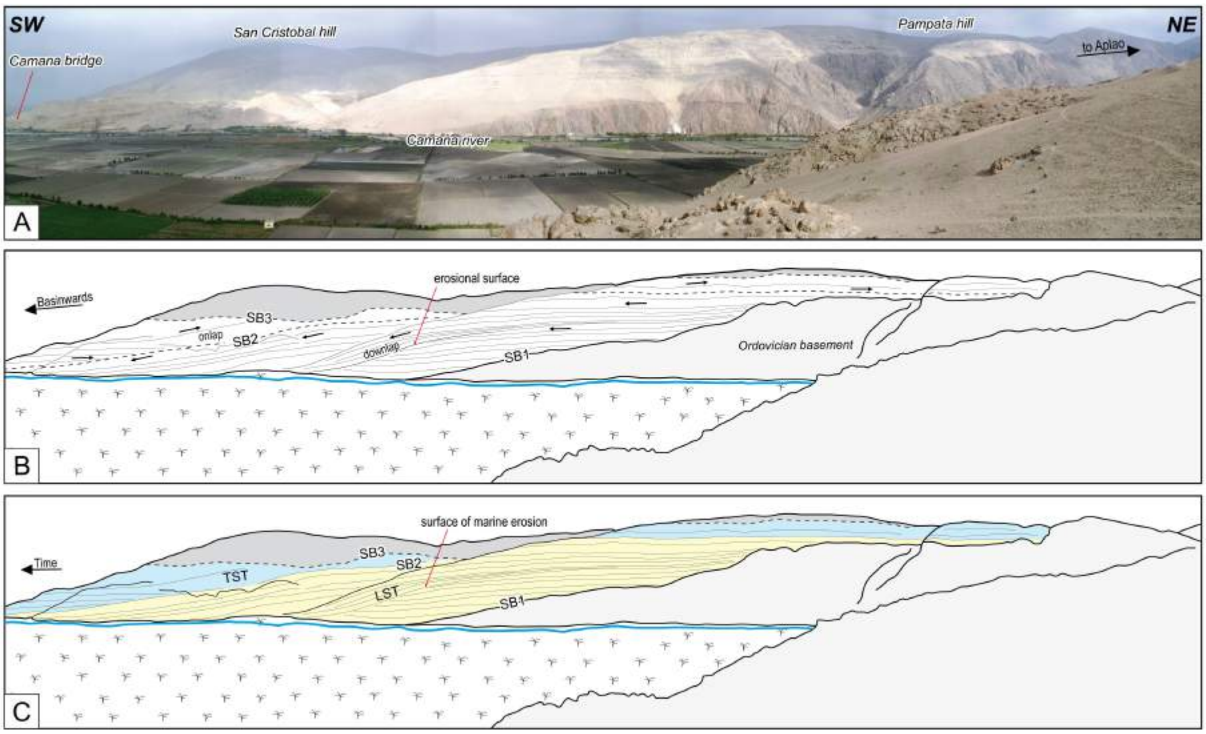

Figura 1. A: View of the outcrops of San Cristobal hill. B: Drawing showing the depositional boundaries. C: sequence stratigraphic scheme representative for the Cenozoic deposits of Camaná.

3.3. Fluvial facies associations: Facies associations Gcn and Gcs: fluvial distal deposits

3.3.1. Description

They are poorly sorted conglomerates, normally graded, composed of pebbles of andesites, riolites, granites, and gneisses, in grayish medium grained sandstone matrix. These layers of conglomerates, reddish sandstones have interspersed with abundant iron oxides, amphibole, and some volcanic glasses. Between these conglomerates there is interbedded sandstone (facies Gcs). Another facies involves the same clusters, mostly clast-supported, interbedded with cemented yellowish sandstones, with some shell fragments (facies Gcn). Above these lithofacies, there are fine sandstones generally massive, reddish with volcanic glass, heavy minerals as amphiboles and iron oxides. This facies association represent the upper part of the sedimentary stacking.

3.1.2. Interpretation

Facies Gcn and Gcs are prograding and retrogradant depositional units, which result of an initial continental sedimentation with abundant debris flows with some channel sands. Later is succeeded by sediments deposited by marine transgressions in episodes that are repeated twice (observable in La Mina outcrops). This sedimentation present topsets, with little subhorizontal layers. Sandstones with abundance of shell fragments and other marine organisms, in both the conglomerates and the matrix, there is no evidence of fossils. This confirms in this area fluvial sedimentation interspersed with marine sedimentation, ending in braided river sedimentation.

4. Depositional architecture and sequence stratigraphy of the Camaná coarse grain delta

Camaná coarse grain delta represent constructive progradational sets and transgressive deposits, which also act in this depositional setting influences of climate factors, and tectonics (uplift and subsidence). In Camaná is able to recognize topsets, foresets and bottomsets.

4.1. San Cristobal hill outcrops

3.1.1. Description

This outcrops show us above the Ordovician basement (Fig. 1) very well the boundaries between LST deposits and TST deposits, where Vega (2002) described as discordance by tectonism. Towards NE, sedimentation begins with topsets that are mostly representative of onlap deposits. In the middle part of the outcrops is more representative progradational flows, composed of coarse cemented sandstone, in upward fining sequences, deposited in several progradational channels basinwards expressed in downlaping and clinoforms of foresets. Inside these bodies there are also several internal discontinuities due to deltaic progradational flows. In the SW side of the outcrops we have the latest progradational flows where the downlaping geometry ending in sharp clinoforms, showing some synsedimentary normal faulting. As a later processes a Transgressive system tract success having onlaping in the next sequences until the top of the outcrops as topset. In these topsets, marine layers are interbedded with continental conglomerates, (observed mainly in La Mina outcrops).

3.1.2. Interpretation

The base of these outcrops represents a prograding and downstepping deltaic lobes, and these may indicate a possible eustatic level fall. On the other hand, we take into consideration the time of uplift of the Cordillera de la Costa that was exposed since Paleozoic times (Wipf, 2006). On these layers is placed a Transgresive tract system, which is represented by onlaping, covering the Lowstand downlaps tract system deposits, which ends round 20 Ma ago (Ar-Ar Sempere et al., 2004). This is followed by new conglomeradic epidodes interbedded with reworked ashes linked to a marked volcanic activation, associated stratigraphically with the Upper Moquegua Formation (Sempere et al., 2004).

5. Discussion

Due to the presence of planktonic foraminifera taked from the facies Fml, Fm and Ft, in Bodeguillas hill and Pucchun, it's possible to point this basal layers as Middle Miocene (~16 Ma, in Ibaraki, 1992), considered as the more distal outcrops of Camaná delta. Going 10 km NE of Camaná, the Panamerican Highway, also planktonic foraminifera from the Early Miocene (~20 Ma, in Ibaraki, 1992), which were taken in layers that correspond in part of sediments forming the Lowstand system tract, showing a pattern of tectonic uplift areas currently highest in the Cordillera de la Costa.

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