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Sedimentological evidence from the east Pisco basin for a western landmass during the Eocene and Miocene

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RESUMEN

Se ha asumido, sobre la base de algunos estudios de depósitos de antearco del Cenozoico marino de la Cuenca Oriental de Pisco (COP), del centro-sur del Perú, que las antiguas costas estaban expuestas al océano abierto casi tanto como la línea costera moderna. Tal suposición puede no estar justificada. En la actualidad, el basamento cristalino entre el umbral del talud superior de la cuenca oeste de Pisco y la COP, es decir el borde externo de la plataforma continental, está expuesto en tierra desde la península de Paracas hasta San Juan de Marcona. Las características de los depósitos marinos del Cenozoico en la COP indican que el borde externo de la plataforma continental podría haberse manifestado como una masa de tierra que en ocasiones sirvió como fuente occidental de sedimentos, durante el Eoceno y el Mioceno temprano a medio. (1) Los lechos eocénicos del delta marino de inmersión noreste de Gramadal, (2) los olistolitoscristalinos del basamento que son cada vez más escasos en dirección hacia tierra en los estratos del Eoceno medio en Puerto Caballas y en el valle del Río Grande, y (3) los extensos bancos de arena del Eoceno tardío, con conjuntos faunísticos dominados por moluscos turritélidos, así como por depósitos de yeso primario al este de Salinas de Otumason consistentes con una anterior presencia de una masa de tierra occidental. Los olistolitos del Mioceno temprano que cubren una amplia franja del valle de Ica parecen haberse desplomado hacia el noreste, lejos del océano Pacífico. La ocurrencia de estratos primitivos deltaicos marinos de inmersión suroeste, del Mioceno temprano, que derivaron sedimentos desde el litoral noreste de una bahía de Ica ancestral, puede haberse conservado solo porque estaban protegidos por una masa de tierra occidental. Análogamente, los deltas marinos del Mioceno medio del área del Laberinto del valle de Ica se desarrollaron en la ladera de sotavento de los afloramientos subaéreos de areniscas de grano fino del Mioceno temprano, y, en la Quebrada Huaricangana, un pequeño delta marino del Mioceno tardío se formó en la ladera de sotavento del Cerro Huaricangana ancestral.

Palabras claves: Peru, Cuenca de Pisco Este, Eoceno, Mioceno, paleogeografía, sedimentología

ABSTRACT

It has been assumed in some studies of Cenozoic marine forearc deposits from the East Pisco Basin (EPB) of south-central Peru that former coastlines were exposed to the open ocean nearly as much as the modern coastline. Such an assumption may not be warranted. At present, a band of crystalline basement rock between the upper slope West Pisco Basin and EPB, the Outer Shelf High, is exposed onshore from the Paracas Peninsula to San Juan de Marcona. Features of Cenozoic marine deposits in the EPB indicate the Outer Shelf High might have manifested during the Eocene and early to middle Miocene as a landmass that on occasion served as a western source of sediment. Northeast-dipping marine delta foreset beds of Eocene age at Gramadal, crystalline basement boulders that are increasingly scarce in a landward direction in middle Eocene strata at Puerto Caballas and in

the Río Grande valley, and extensive late Eocene sandflats with turritellid-dominated assemblages and primary gypsum deposits east of Salinas de Otuma are consistent with the former presence of a western landmass. Early Miocene olistoliths covering a broad swath of the Ica valley appear to have slumped northeastward away from the Pacific Ocean. The occurrence of southwest-dipping early Miocene marine deltaic foreset beds, which derived sediments from a northeastern shoreline of an ancestral Ica embayment, may have been preserved only because they were protected by a western landmass. Analogously, in the Laberinto area of the Ica valley middle Miocene marine deltas developed in the lee of subaerial outcrops of early Miocene fine-grained sandstones and in Quebrada Huaricangana a small late Miocene marine delta formed in the lee of an ancestral Cerro Huaricangana.

Key words: Peru, East Pisco Basin, Eocene, Miocene, paleogeography, sedimentology

INTRODUCTION

The Peruvian margin of South America is characterized by shelf and upper slope forearc basins (Thornburg and Kulm, 1981; Azalgara, 1994). Between 13°S and 16°S, the onshore East Pisco Basin (EPB) lies alongside an offshore counterpart, the West Pisco Basin, separated by a structurally and seismically defined Outer Shelf High (OSH), which is emergent as crystalline basement rock (CBR) from the Paracas Peninsula to Cerro Huaricangana. The EPB is filled with Cenozoic marine sediments that span the early Paleogene to Pleistocene (DeVries, 1998, 2017, 2020). It has been proposed that some of these sediments were deposited in the lee of a western landmass.

OBSERVATIONS

The most compelling evidence of a western landmass is an Eocene marine delta at Gramadal, comprised of overlapping small sets of foreset beds composed of coarse-grained fossiliferous sandstone, several meters thick and dipping northeast, away from the Pacific Ocean (Figure 1). Seaward lie ten kilometers of nearly denuded outcrop of CBR that forms the southeastern end of the fault-bound Cerros Ullujaya - an inferred sediment source for the delta, which lies within a section of Eocene strata deposited nonconformably upon the CBR.

Marine delta foreset beds also occur in the lower Miocene Chilcatay Formation (DeVries and Jud, 2018; Di Celma et al., 2018). Deltaic sediments were transported from a northeastern (inland) shoreline in the area of Ullujaya and an inferred shoreline east of Quebrada Gramonal at the foot of the high-angle normal Monte Grande Fault (DeVries et al., 2021). Could such early Miocene deltas have been preserved along an open marine shoreline? DeVries and Jud (2018) argued that subaqueous marine deltas forming below wave base could have existed on an open coast. Nonetheless, two examples in the EPB indicate that protection from open ocean conditions might be necessary for the survival of such deltas. In the Laberinto area, three middle Miocene marine deltas spilled into an embayment in the lee of an uplifted peninsula composed of subaerially eroded sandstone of the lower Miocene Chilcatay Formation. In Quebrada Huaricangana, above the Río Grande, upper Miocene conglomeratic marine foreset beds hug the lee side of an ancestral Cerro Huaricangana.

Further evidence, circumstantial, for an Eocene western landmass lies in the distribution of CBR boulders in the lowermost Río Grande and above Puerto Caballas (Leon et al., 2008; DeVries, 2017). Downstream from the chacra of Monte Grande are exposures of a Paleogene section with continental red beds and pale yellow estuarine sandstones of the Caballas Formation overlain by rose-colored pebbly sandstones of the Los Choros Member of the Paracas Formation and cream-colored fine-grained sandstones of the Yumaque Member of the Paracas Formation (Figure 2). At the base of the Los Choros Member, piles of olistolithic boulders of CBR, some many meters in diameter, rest upon an angular unconformity (Leon et al., 2008). Two kilometers inland, boulders overlying the same unconformity are much smaller and less abundant. A similar pattern is encountered above Puerto Caballas: boulders of CBR one to three meters in diameter and closely spaced (<5 meters apart) above the modern beach on a disconformity between the Los Choros and Yumaque members become much more widely spaced (50–100 meters) two kilometers inland. While the distribution of the CBR boulders might be controlled by synsedimentary tectonism in the horst-and-graben Eocene topography of the lowermost Río Grande valley (Leon et al., 2008), the distribution might also indicate a western-landmass source.

The possibility of western shoaling and perhaps a

western landmass during the early Miocene is indicated by olistoliths of fine-grained bedded sandstone in the lower Río Ica valley. Olistostromes stretch for six kilometers along the western side of the Río Ica near the areas of Ullujaya and Zamaca (Di Celma et al., 2019) and for ten kilometers along the eastern side of the Rio Ica in the area of Laberinto (DeVries et al., 2021). Analysis of Google Earth imagery indicates that large olistoliths became detached at the southern end of the western outcrop area and slumped to the northeast, away from the Pacific Ocean (Figure 3). A shallow channel in lower Miocene sediments at nearby Cerro Tiza contains large angular CBR clasts and the pachyostositic rib of an Otuma-aged cetacean; the channel's contents may indicate subaerial erosion during the early Miocene of CBR and Paleogene sedimentary outcrop in the westward-lying Cerros Ullujaya.

It had been proposed that the source of early and late Miocene olistoliths in the Laberinto area was the footwall block of the Monte Grande Fault (DeVries et al., 2021). Further study of the olistostromes on the eastern side of the Río Ica may clarify if the Laberinto olistoliths had one or more sources.

Eocene outcrops in the northern EPB may provide additional evidence of a western landmass. North of the Comotrana-Carhuas road, in an area with numerous outcrops of CBR, a conglomeratic point bar deposit with marine mollusks may have an estuarine origin. Close inspection of point-bar bedforms could reveal a flow direction consistent with western highlands. Farther north, east

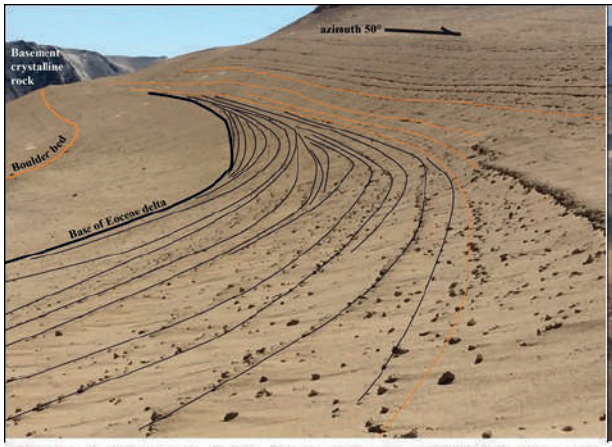

Figure 1. Eocene delta foreset beds with NE dips at Gramadal. Basement crystalline rock in distance. Cobbles in foreground 10-20 cm diameter. NW sediment source inferred to be Cerros Ullujaya.

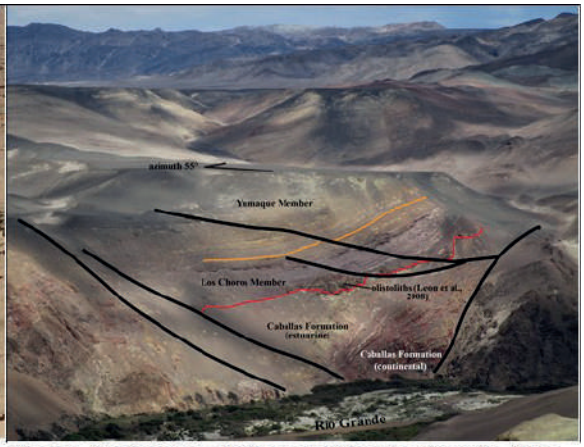

Figure 2. Eocene strata near Monte Grande (Río Grande). Large blocks of crystalline basement rock rest on an angular unconformity between Caballas Formation and Los Choros Member.

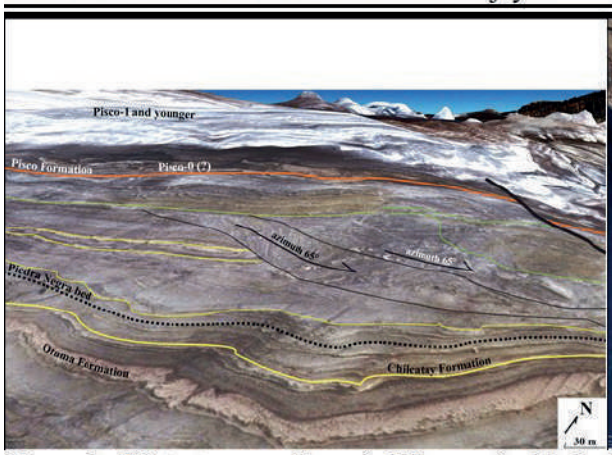

Figure 3. Olistostrome with early Miocene bedded fine-grained sandstone olistoliths transported to NE from an inferred western submarine ridge/landmass in direction of modern Cerros Ullujaya. Scale applies to foreground.

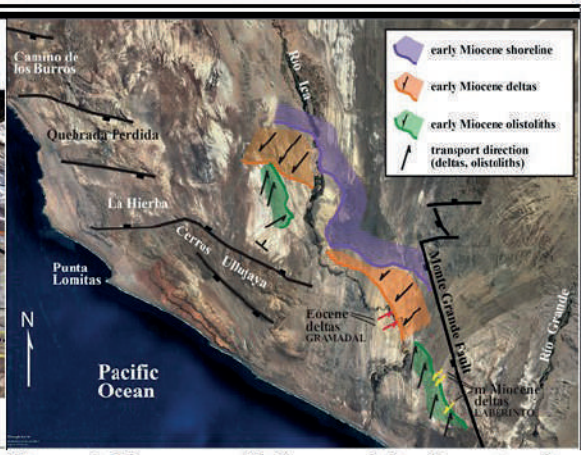

Figure 4. Eocene and Miocene delta foreset and olistostrome slump directions for Río Ica valley. Sediment source inferred to be submarine ridge or western landmass in area of Cerros Ullujaya or footwall block of Monte Grande Fault.

of Salinas de Otuma, upper Eocene sandstones contain a turritellid-dominated molluscan assemblage with abundant individuals of juvenile and adult *Turritella woodsi* and oysters. The fossiliferous deposit might indicate the former existence of sandflats protected from high-energy open ocean waves, as seems to be the case for a turritellid-dominated assemblage with *Turritella infracarinata* along the eastern shoreline of the middle Miocene Bahía Ica Baja (DeVries and Jud, 2018; DeVries et al., 2021). If upper Eocene beds of primary gypsum associated with the *Turritella woodsi* beds represent Eocene salt flats, they might also indicate a degree of protection from the open ocean consistent with a western landmass.

CONCLUSION

The existence in the EPB of a marine delta with northeast-dipping foresets at Gramadal is strong evidence for a western landmass of at least local extent during the Eocene. Additional observations presented here amount to circumstantial evidence for a western landmass during the Eocene and early to middle Miocene (Figure 4). While these observations from the past 35 years were not made with the intention of establishing the former existence of a subaerial OSH, they make plausible the hypothesis that such a western landmass once bordered the EPB. Field work conducted to test hypothesis would likely refine our understanding of the Cenozoic paleogeography of the EPB and thus provide insights regarding paleoecosystems that once supported a diverse marine biota.

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