FOREARC EXTENSION: TECTONICS, SEDIMENTOLOGIC AND STRATIGRAPHIC EVOLUTION OF THE EAST PISCO BASIN

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ABSTRACT

Pervasive transtensional deformation has taken place in the East Pisco forearc basin as a result of oblique convergence. A crooked rhombic fault pattern is present in a narrow extensional corridor in the western part of the basin and may reflect the influence of pre-existing Costal Cordillera fabrics. Regardless of the structural origin of the basin, a tectonic-sedimentary model is proposed that may explain the Cenozoic basin evolution in four distinctive stages:

1. Middle Eocene extension and half-graben formation.
2. Late Oligocene extension, polarity change and full graben formation.
3. Middle Miocene uplift and extension renewal.
4. Late Pliocene to Pleistocene basin inversion and uplift.

KEY WORDS: (Forearc basin, transtension, oblique convergence)

INTRODUCTION

The East Pisco forearc basin was built over a basement varying in age and lithology from Precambrian gneisses and schist, to Devonian granitoids to Jurassic volcanoclastics. Eastward, the Cerrillos Fault limited the distribution of the Cretaceous arc massif rocks. The Coastal Batholith arc magmatism terminated in the Paleocene and migrated eastward. As a result, pervasive regional igneous underplating and regional forearc basin uplift took place until the Middle Eocene worldwide plate reorganization. Oblique convergence, strong coupling and lithosphere heterogeneities were the main factors controlling strain partitioning and strike-slip deformation in the upper plate (Molnar and Pardo Casas, 1987).

Crooked fault pattern may reflect the influence of pre-existing fabrics. However, identification of transfer zones provides important information to explain fault geometry, graben polarity changes, and along strike changes in fault throw. Rhombic fault geometry produced by zigzag faults was a tempting pattern for a transtensional interpretation of the East Pisco Basin. Regardless of the structural origin, a tectonic-sedimentary model is proposed that may explain the Cenozoic basin evolution in four distinctive stages (Fig.1):

1. Middle Eocene extension and half-graben formation.
2. Late Oligocene extension, polarity change and full graben formation.
3. Middle Miocene uplift and extension renewal.
4. Late Pliocene to Pleistocene basin inversion and uplift.

Middle Eocene extension is inferred from the Caballas Formation alluvial fan to fluvial siliciclastic progradation wedges made of material derived directly from fault scarp erosion. As extension continued, the first marine incursion and transgression took place as interpreted from the overlying shallow water, low to high energy Los Choros Formation. Episodic equilibrium between faulting and sediment supply caused repeated and vertical stacked progradational events. Large olistoliths, syndepositional faults, bed rotation, thick debris flows and conglomerates in this formation are interpreted to confirm active faulting. Fault-driven subsidence accounts for marine flooding and deposition of tuffaceous and diatomaceous-rich mudstones of the Yumaque Formation. In addition, large sandstones and mudstones olistoliths are thought to indicate active faulting during deposition.

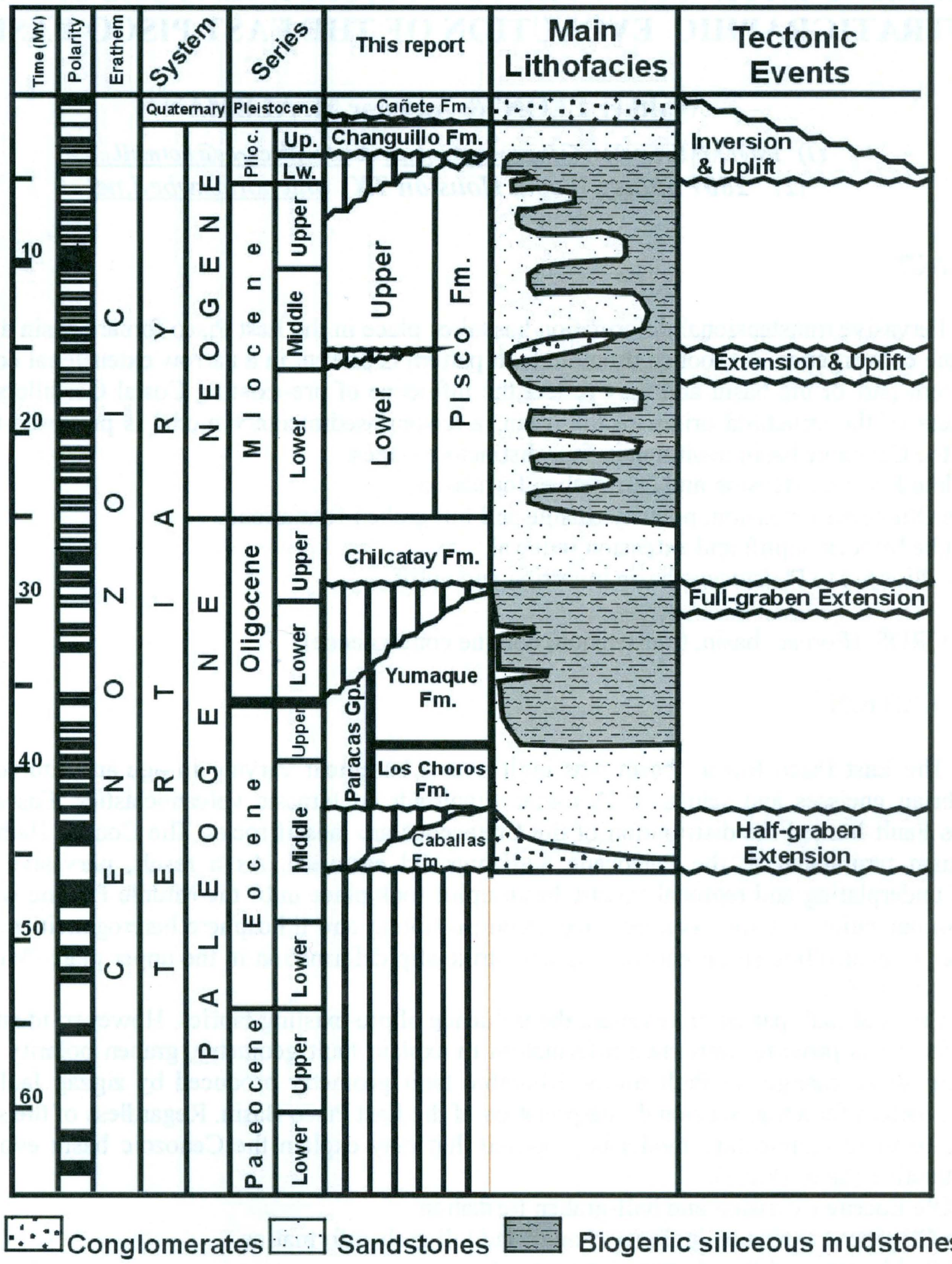
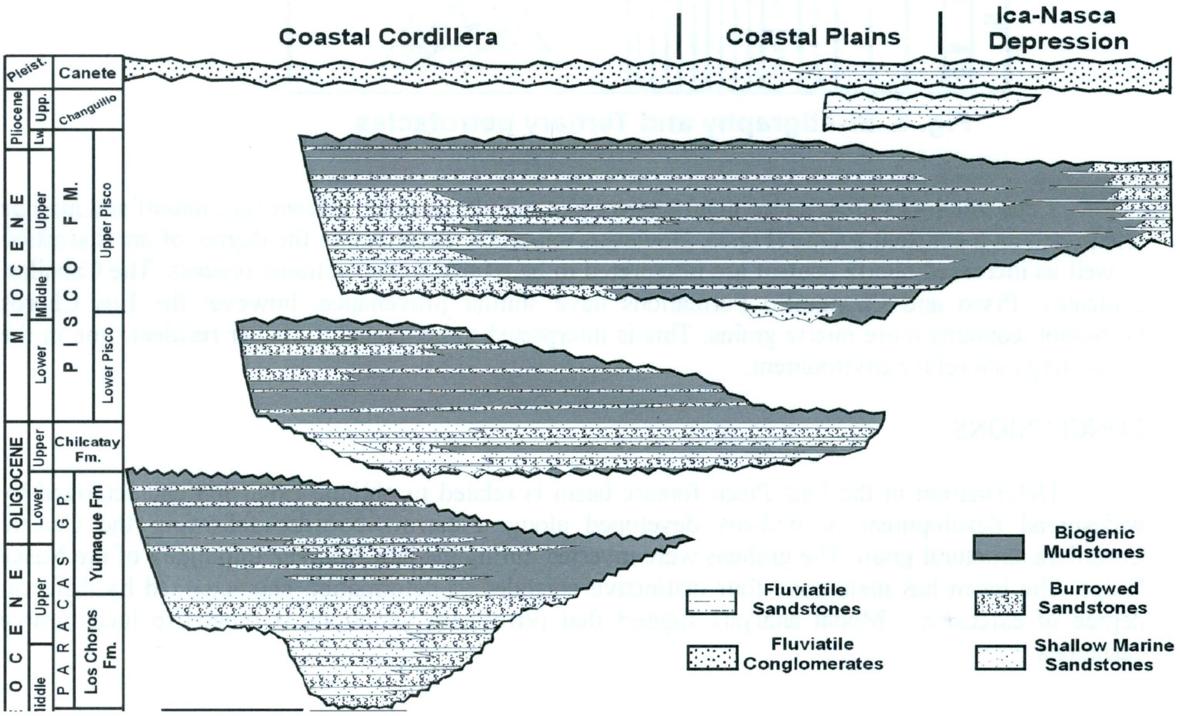


Fig.1 Lithofacies and tectonic events in the East Pisco Basin

A slight angular unconformity, interbedded conglomerates and debris flows associated with the shallow marine sandstones of the Chilcatay Formation are interpreted to be the result of late Oligocene extension (Fig. 1 and 2). Locally, footwall uplift caused fault scarp retreat and alluvial fan deposition was interbedded with near shore facies. Discontinuous, repeated and vertical stacked shoreface progradational events were deposited until the equilibrium between faulting and sediment supply was broken. Glass shards in the sandstones imply important airfall volcanic contribution and rapid beach cementation. Continuous faulting caused marine flooding and deposition of thinly bedded, tuffaceous, and diatomaceous rich mudstones of the Lower Pisco Formation. Distinct thin layers of tuffs, phosphatic pellets, dolomite and diatomites are present throughout the section. Upwelling was not as important in the Pisco Formation as in the Yumaque Formation deposition (Dumbar and Baker, 1988). Isolated interbedded sandstones are interpreted to result from terrigenous input during footwall uplift that moved axially and along the grabens flanks. Structural and depositional history varies along and across the basin and was characterized by either reactivation of boundary faults, formation of new synthetic fault or generation half-grabens with different polarity. The graben polarity change caused full-graben formation exemplified by abandonment or decrease in activity of older boundary faults and development of relatively widely spaced minor faults.

Middle Miocene uplift and short-lived compressional was caused by a change in the regional stress field orientation prior to extension renewal along pre-existing faults. Extension was accompanied by footwall uplift, fault scarp retreat and slight bed rotation and triggered stream incision and rejuvenation. As a result deep scouring caused formation of incised valleys filled with fluvial conglomerates. Continuous fault-controlled subsidence caused rapid incised valley flooding and deposition of the Upper Pisco Formation biogenic and tuffaceous mudstones below storm wave base. Similar to the Yumaque Formation, the presence of dolomite, phosphate pellets, diatomite oozes and laminations are interpreted to indicate upwelling conditions similar to the present day Humboldt Current (Dumbar, 1988; Marty, 1989), . The presence of tuffs and glass shards dispersed in the mudstones records active Miocene arc volcanism to the east. Thick interbedded sandstones are interpreted as episodic terrigenous input during continuous footwall uplift.

Late Pliocene to Pleistocene basin inversion and uplift was the result of subduction of the Nasca aseismic ridge as it migrated southward along the coast beneath the Peruvian forearc basins (Pilger, 1981; Macharé and Ortlieb, 1993). Hence, modification in the regional stress at the plate boundary resulted in regional uplift. This large orientation change in the original stress field was a predictable event since grabens tend not to develop under long-lived stable stress conditions.



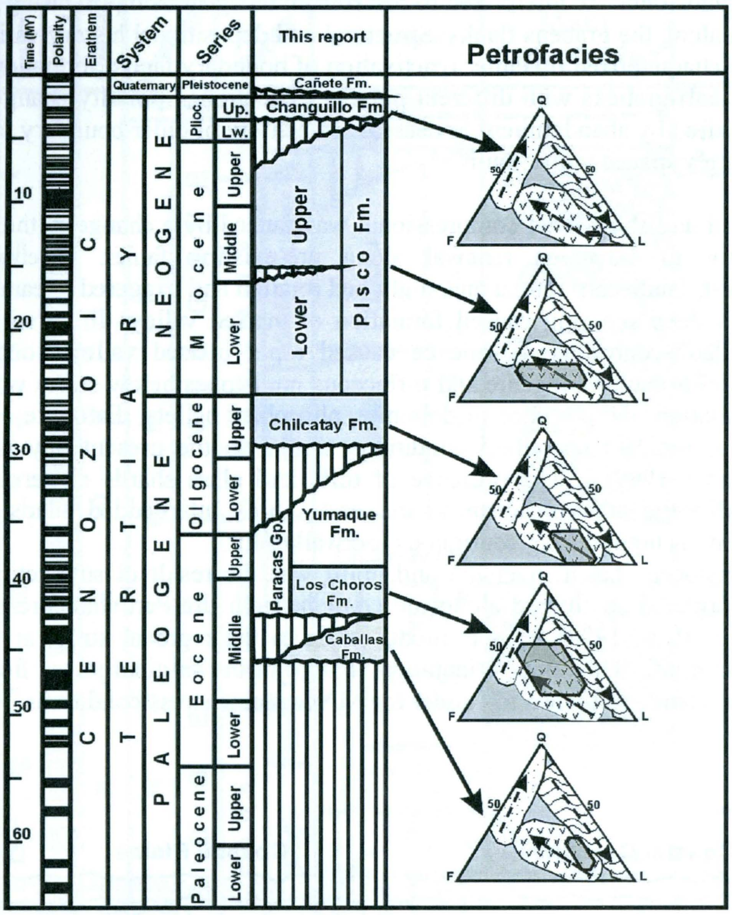


Fig. 3. Stratigraphy and Tertiary petrofacies

Cenozoic rocks provenance diagrams are plot mainly on older volcanic arc massif and may be interpreted as a constant source (Fig.3). However, important variations in the degree of arc dissection as well as increased quartz content are interpreted to be related to depositional process. The Caballas, Chilcatay, Pisco and Changuillo Formations have similar provenance, however the Los Choros Formation contains more quartz grains. This is interpreted to be related to longer resident time in the high-energy shoreface environment.

CONCLUSIONS

Deformation in the East Pisco forearc basin is related to oblique extension characterized by widespread development of grabens developed along a narrow corridor following the Coastal Cordillera structural grain. The grabens were inverted during the late Neogene impinging of the Nasca Ridge. The basin has undergone four distinctive episodes of deformation characterized by different degree of extension. Modal analysis suggest that petrofacies variations is related to local source variations.

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