THE CONTINUUM TECTONIC DURING THE CRETACEOUS-PALEOCENE TIMES IN THE ANDEAN NORTH-PERUVIAN FORELAND BASIN (MARAÑON BASIN)

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GEOLOGICAL SETTING

The Marañon basin is located in the NE slope of the Peruvian andean mountains.This basin, is part of the estructural depression that spreads from Colombia to Argentina and it is found between the Guyan-Brazilian Craton and the Andean Cordillera.Morpho-estructurally, it can assume arbitrary boundaries (Fig. 1).Its south boundary is given by the Contaya-Cushabatay Arc, that is characterized by having a little depression topography. The north border is limited by the Conanaco Arc that divides the Marañon Basin from the Napo basin of Ecuador. Its eastern portion is limited by the Iquitos Arc. This positive structural element that borders the Brazilian and Guyan Cratons joins both cratons, which are separated by the Amazon graben (Morales 1959). Its western portion is limited by the sub-andean thrust belt, that is characterized by having an accidented, thrusting and folding topography, as a product of the Andean orogeny. The Marañon basin contains a thick series of sedimentary rocks that go from the Paleozoic to the Quaternary times. They overlie a substratum of Precambrian granitic rocks (Fig. 3). All of this group of rocks is affected by compressional reactivations of paleozoic and mesozoic extensional faults (tectonic inversions). Laurent and Pardo (1974) had already evidenced extensional paleozoic phenomena that originated uplifted blocks crumbled down towards the Nor-East and South-East of the basin. These apparently extensional phenomena continued to the Triassic-Jurassic times originating like this the Pucará and Sarayaquillo basins. This extensional tectonics was alterned by regional and local uplifts, which were originated either by compressional and/or isostatic phenomena (Gil,1995). A slight erosional unconformity between the Pucara Group (Upper Triassic-Early Jurassic)), seems to show an uplift phenomenon, possibly originated by Flexuring. A slight disposition in onlap towards the base of the Sarayaquillo Formation, which was observed in the Cretaceous Charnella zone, can indicate that this one already constituted a structural height during the jurassic sedimentation. This would evidence a flexuring as a consecuence of the subduction beginning in the peruvian margin (Gil, 1995). An erosion surface located between the Sarayaquillo (Late Jurassic) and Chusabatay Formations (Early Cretaceous) indicate a regional uplift, which is syn and/or post-Sarayaquillo but ante-Cushabatay. The Cretaceous is characterized by the tectonic inversions essencially located in the eastern and central part of the basin. These structures are controlled by the pre-cretaceous paleogeography. Most of them correspond to tectonic inversions of paleozoic half-graben or graben, located at the eastern border, and Triassic-Jurassic in the Central and Western zone. In the Tertiary, an asimetrical foreland basin is evidenced which depocentre migrated to the East, at the same time as the Orogenic Front's (Marocco 1994). In the Neogene series, three important coarsening upward sequences have been observed, which constitute the sedimentary response to 4 continuum tectonic periods: 28-26 - 10Ma, 10 - 7Ma, 7 - 2.7 Ma and 2.7 - 0Ma (Marocco, 1994). The actual structures present an homogeneous deformation of all the Neogene sedimentary series, indicating a late structuration. In the North-East extreme of the Marañon basin, the Cretaceous rocks lie over blocks apparently of Precambrian and Paleozoic age. In the central part and SW over the Jurassic series. The contact with the Paleozoics is in an strong angular unconformity, while the contact with the Jurassic is in a weak unconformity, which is becoming concordant toward the East.

TECTONIC EVOLUTION

For the kynematic analysis of the 8 (Fig. 2) studied structures, tectonic evolution (Palinspastic restoration) sketches were made determining extensional and compressive events (tectonic inversions) (Fig. 4 and 5).

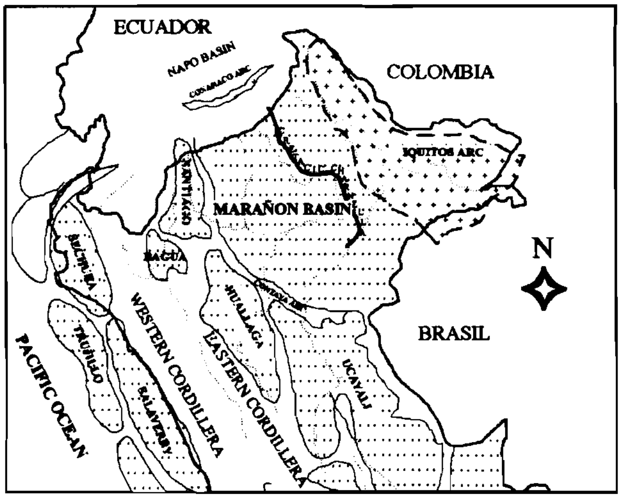

FIG. 1 BASINES LOCATION MAP OF PERU

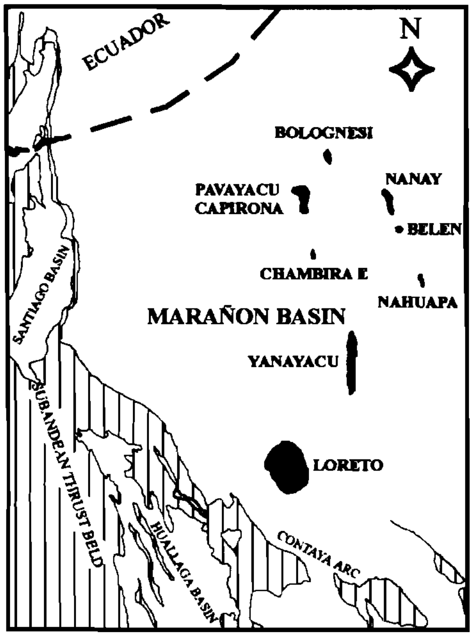

FIG. 2 STRUCTURES LOCATION MAP OF THE MARAÑON BASIN

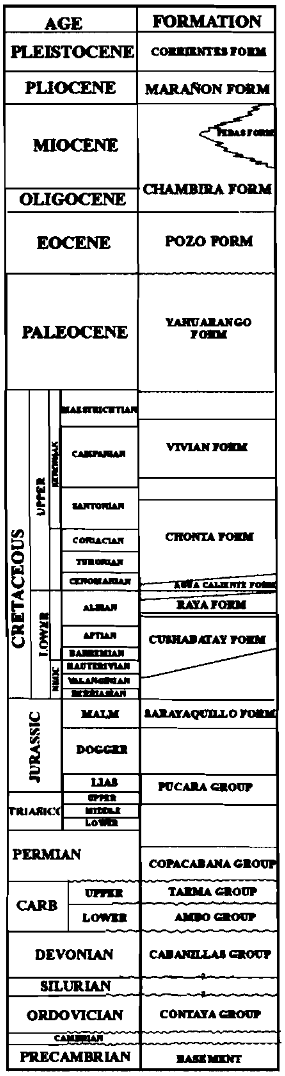

FIG. 3 STRATIGRAPHIC COLUMN OF THE MARAÑON BASIN

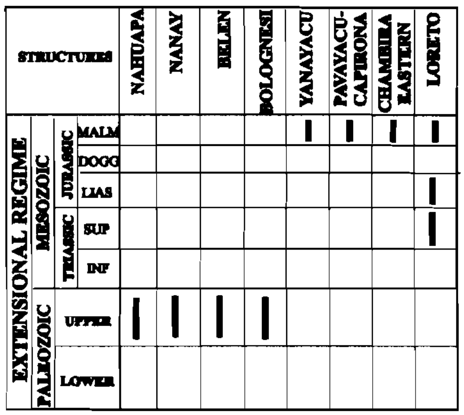

FIG. 4 STRUCTURES EXTENSIONAL REGIME

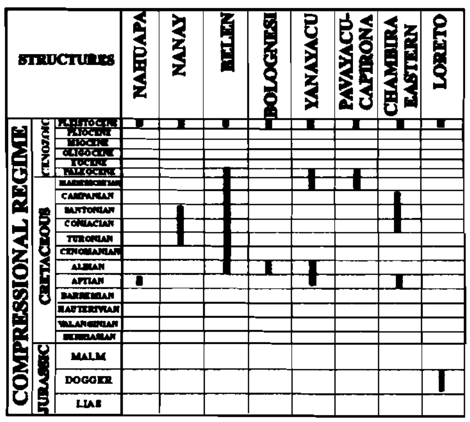

FIG. 5 STRUCTURES COMPRESSIONAL REGIME

Extensional Tectonic. Extensional events of the Late Paleozoic times are registered by the Nanay, Nahuapa, Belen and Bolognesi structures. These structures show very deformed units in sometimes roll-over blocks that directly underlie to the Cretaceous in angular unconformity. Extensional events of the Triassic and Jurassic are evidenced in the Loreto structure where an extensional regime contemporarily happened to the Pucara Group sedimentation (Upper Triassic-Early Jurassic). In the Late Jurassic, the Sarayaquillo Formation is also developped in an extensional general regime, which is evidenced in the Loreto, Yanayacu, Capirona-Pavayacu and East Chambira structures.

Uplift and Flexuring

Uplift and tectonic inversion of the Middle Jurassic inversion (Dogger): Apparently, a first compressive event manifested by a tectonic inversion appears in the Middle Jurassic before the sedimentation of the Sarayaquillo Formation. This phenomenon is evidenced in the Loreto Structure, in which it is possible to distinguish an erosion surface between the Pucara Group and the Sarayaquillo Formation.

Uplift by flexuring of the Latest Jurassic- Earliest Cretaceous: This uplift phenomenon, possibly originated by flexuring, is evidenced by the erosion surface, between the Sarayaquillo and Cushabatay Formations. It is about a regional uplift mainly located in the Cretaceous Charnella zone.

TECTONIC INVERSION OF CRETACEOUS TIMES

Tectonic inversion of the Aptian: The Nahuapa, Yanayacu, and East Chambira structures present little tectonic inversions contemporary to the sedimentation of the Cushabatay Formation.

Tectonic Inversion of the Albian: The Belen, Bolognesi and Yanayacu structures present tectonic inversion synchronically developped to the sedimentation of the Raya Formation (Middle-terminal Albian),and Agua Caliente Formation (Late Albian- Cenomanian). In the Belen Structure, this compressive event apparently spread at least to the Paleocene.

Tectonic Inversion of the Early Turonian: The Belen structure presents a tectonic activity for this time.

Tectonic Inversion of the Turonian-Coniacian: This compressive event is evidenced during the sedimentation of the Chonta Formation and is registered in the Nanay, Belen and East Chambira structures. In the Nanay and Chambira East structures, this compressive phenomenon prolongates until the Santonian, while the Belen Structure, shows a reactivation until the Early Eocene. The Nanay Structure shows a good sign of this deformation, and besides, it presents the absence of the Late Turonian (ROBERTSON, 1990).

Tectonic Inversion of the Santonian: During this period the Nanay and Belen Structures show a tectonic activity.

Tectonic Inversion of the Campanian: Campanian marine deposits are covered in unconformity by Maastrichtian sandstones (Vivian Formation). This erosion is apparently produced at the same time as the tectonic inversions, which are manifested in the Belen and East Chambira structures.

Tectonic Inversion of the Maastrichtian-Paleocene: They are noticed in the Belen, Yanayacu and Capirona-Pavayacy structures.

TECTONIC INVERSION OF TERCIARY TIMES.

All the terciary sedimentary column is locally deformated by tectonic inversions. It is impossible to evidence a syn-sedimentary tectonic in the 3 Neogene sequences. Apparently, the tectonic inversions that affect the tertiary foreland sediments of the Marañon basin are very late, of the Pliocene or Quaternary times.

DISCUSSION

In the peruvian margin, the Aptian is characterized by the absence of vulcanism and by a general regimen in distension (Jaillard, 1993), neverthless, compressive and contemporary events to the Cushabatay Formation are registered in the Marañon basin. In the Late Aptian-Early Albian a slight distension is registered in the peruvian margin (Jaillard 1993), it is impossible to differenciate this phenomenon in the Marañon basin. In the Albian, the activity of a very important volcanic arc is accompanied by the Coastal Batholit location. This period is marked by thick volcanic efusions located in the western part of the peruvian margin and the south of Ecuador, and abruptly end in the Cenomanian. At the same time a very important tectonic phase of compressive character is developped, which corresponds to the Mochica phase (Megard, 1984; Vicente, 1989);

Jaillard, 1994). It is possible that the eustatic regression of the Late Albian-Early Cenomanian could have been reinforced by this tectonic event.
An stratigraphic hiatus of the Early Turonian (ROBERTSON, 1990), restrincted in the eastern border of the Marañon basin (proximal part) could have been originated by a tectonic uplift, it is also posssible that this statigraphic hiatus is originated by later erosions associated to a eustatic emersion (Jaillard 1994).
In the Late Turonian an stratigraphic hiatus is also registered in the Marañon basin, which covers a greater area than the Early Turonian indicating an increasing erosion to the East. According Jaillard (1994) it would be originated by tectonic events at great scale and reinforced the contemporary eustatic regression.
The peruvian phase appears in the Andean Mountains (Jaillard, 1993) culminating the Late Campanian. This deformation is restrincted to the eastern portion of the basin.
Then an importan regression is registered in Central and South Peru as well as in Bolivia. Which explains the almost general absence of all the deposits of the Late Santonian in the peruvian East. This eustatic regression (Haq, 1987), is reinforced by the effects of the Peruvian tectonic.
In the Marañon basin, the marine deposits of the Campanian are covered in unconformity with the sandstones in the Vivian Formation (Maastrichtian), which points out the Late Campanian erosions ocurrence. The same thing has been noticed in the East of Ecuador (Jaillard, 1994).
In the Upper Campanian the greatest peruvian phase is well determined and it is reponsible of greater events such as the Cincha-LLuta overthrusting in the Arequipa zone (Vicente, 1989; Jaillard, 1993). The definite general emersion of all the peruvian andean mountains and of the sedimentary hiatus of the Late Campanian in most of the part of the peruvian margin. This greater event occurs in the Eastern basin, possibly in the Maastrichtian-Paleocene times, due to the fact that some studied structures (Belen, Yanayacu and Capirona-Pavayacu) present a tectonic inversion in this time interval.
The Neogene series of the Marañon basin, present three great coarsening upward sequences that can be correlated to the Quechua 1, 2 and 3 tectonic phases, that reactivate the sedimentation (Marocco, 1994). Besides it is well kown that the litostatigraphic organization in three coarsening upward sequences is also common in the eastern slope of the Ecuatorian and Bolivian andean mountains (Marocco, 1994).

CONCLUSION

In the Marañon basin, tectonic inversions have been produced since the Aptian to the Paleocene. It is impossible to talk about tectonic phases, but of a deformation continuum that is distributed in an heterogeneous way in all the basin. Only the Belen structure seems to have registered the whole deformation continuum. These conclusions agree with Marocco's observations (1990) .Indeed, according Morocco, the Central Andean Mountains initiate their emersion in the Santonian. In the superficial zones of the crust, this compression happens through a tectonic continuum that produces, according the local conditions, fracturation, ductile deformation, or active basin's formations. During the Neogene, a typical basin of foreland basin instalates. A second period of tectonic inversion of pre-cretaceous faults appear during the Pliocene and probably the Quaternary.

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