THE RED BEDS OF THE SAN JERONIMO GROUP (CUZCO PERU) MARKER OF THE INCA 1 TECTONIC EVENT

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RESUMEN

Las Capas Rojas del grupo San Jerónimo eran consideradas de edad Cretácica superior y su origen estaba relacionada a la fase Tectónica Peruana. Sin embargo, la sucesión estratigráfica, observaciones de campo, correlaciones y una datación radiométrica, muestran que esta unidad abarcaría desde el fin del Eoceno medio hasta el fin del Oligoceno inferior y que la sedimentación estaría relacionada al evento Tectónico Inca 1, que en la región se traduce como un *continuum* tectónico compresivo, desarrollando fallas de rumbo, sobre las que se formaron cuencas *pull-apart*.

INTRODUCTION

A red series of continental origin which is more than 5,000 meters thick, which is known with the name of Red Beds (Marocco, 1978) or San Jeronimo Group (Córdova,1986), widely crops out in the region of Cusco and Sicuani. In Cuzco, the San Jerónimo Group has been divided in 3 Formations, Kayra (3000 m), Sonceo (1600 m) and Punacancha (1700 m) (Córdova, 1986).

Former Studies had considered to the Red Beds of the San Jerónimo Group, as the Latest Cretaceous-Tertiary age (Marocco, 1978; Córdova, 1986).The Maastrichtian times, given to the Kayra and Sonceo Formations,was based first on the charopytes presence near the Kayra base, which indicate The Maastrichtian age and then for the "dinosaur tracks" presence near the top of the Sonceo Formation (Córdova, 1986; Noblet et al 1987). Then the Punacancha Formation would be Tertiary, this disconformably overlies the Sonceo Formation. Further studies (Carlotto, 1992), have demonstrated that the San Jerónimo Group overlies on the paleontologycally dated series, which is of The Paleocene-Earliest Eocene times (Quilque and Chilca Formations) (Fig. 1A), that is why it was considered the overthrust in order to explain the supposed abnormal superposition (Carlotto 1992; Jaillard et al 1993).

The field works, the tectonic sections analysis and the stratigraphic correlations gave the benefit of the doubt to the overthrust existence, that is why, it was important to review and look for other ways of datation for the Red Beds. To the South-east of Cuzco, in the SW anticline limb, we have the type section of the San Jerónimo Group where the volcanic tuffs, which were found under the "dinosaur tracks", were sampled to be submitted to a radiometric datation. These samples gave a K/Ar age of 29.9±1.4 Ma (Carlotto et al 1995).

This age, plus the stratigraphic succession, the correlations and structural sections, indicate that the Red Beds of the San Jeronimo Group are before to the Late Oligocene times (28 Ma) and discard the Latest Cretaceous age based in supposed dinosaur tracks. Therefore, they also discard its relation with the Peruvian Tectonic Event.

SEDIMENTARY EVOLUTION AND STRUCTURAL SETTING

The obtained datation only lets us know the top's age of this unit. However, the Red Beds overlie on disconformity to the Chilca Formation of Late Paleocene-Earliest Eocene age. On the other hand, Noblet et al (1987) has made sedimentation rate calculations of the Sicuani's Red Beds (near Cuzco), where by comparisons with the pull-apart and the rift basins, he indicates that these Red Beds could have been deposited in 15 Ma approximately. If we consider these data as valid the Red Beds' base would be of the final Middle Eocene (≈43 Ma).

The sedimentary evolution of the Red Beds is divided in two coarsening upward sequences (Kayra and Soncco Formations) (Fig. 1A). The deposit means are characterized by floodplains that are flown by braided rivers (Córdova, 1986). The first sequence (Kayra Formation) corresponds to the basin opening related to the strike-slip faults, where the coarsening upward sequences indicate that the fluvial sedimentation progrades especially from South to North (Córdova ,1986). The volcanic activity seems weak and null. In the second sequence (Soncco Formation), the rivers proceed preferably from the SE (Córdova, 1986). The development of progressive unconformities predominates in different places, beginning from the inferior limit of this sequence and it is associated to the compression. The volcanic activity becomes more important. The dated sample is located at the top of this Formation, in other words, it is found on the last levels of the progressive unconformities. Synsedimentary tectonic features has been already recognized within the Cuzco-Sicuani basins by Noblet (1985) and Cordova (1986).

Red Bed outcrops appear in the Cuzco region, to the north of a curved structure (Fig. 1B), to the limit between the NE border of the South Peruvian Western Trough and the Cuzco-Puno Swell. These outcrops can be divided in 3 different sectors: In the NW Sector there are folds NE-SW (Fig. 1B), while in the East Sector, the folds have a NW-SE, N-S and E-W direction, it is in this last system, where more spectacular progressive unconformities can be seen. Finally in the Central Sector, mainly gypsum, silts, and limestones crop out in a diapir fashioned way, on which little isolated bodies of the Red Beds appear. Inside of this evaporitic body there are thrustings that make the gypsum levels repeat. Nevertheless, the evaporites also appear in the other sectors delimiting the folds that affect the Red Beds.

What is essential of the structuration as it is observed now, has been acquired during the sedimentation of the Red Beds. The later tectonic effects have not greatly modified it.(Córdova,1986).

GEODYNAMIC CONTEXT

The Inca 1 Tectonic crisis of the Middle Eocene (44-42 Ma) is defined as a short duration event (Soler, 1991). This event corresponds to the anomaly 18 (≈43 Ma) (Pilger, 1983) that indicates an abrupt velocity increase of the Pacific SE and a slight direction modification of the convergence. Also, for the Pacific SE, the anomaly 13 (Pilger, 1983) corresponds to a change of convergence direction between the Farallon and South America plates and a net velocity decrease. The convergence direction passes from N45° (Anomalies 13 - 16) and N70° (Anomalies 13-12).

According to this geodynamic context, we think that the so called Inca 1 Tectonic crisis would be responsible of the beginning of the Red Bed basin functioning and that this would not have behaved only as a short duration crisis, but as a continuum tectonic. Thus the tectonic evolution of the 3 formerly described sectors can be explained considering the average vector of convergence between the Farallon and South America plates of N45°, before the anomaly 13 (Pilger, 1983) and N70°, that is posterior to this anomaly. A senestral strike-slip movement is produced with the NE vector in the fault

segment in the NW Sector. This movement controls the opening of the NE-SW pull apart basin and its posterior evolution, evidenced now by the NE-SW folds. In the East Sector, which is the most complex, the different direction folds seem to define pull-apart basins controlled by old accidents (Cordova 1986). The origin of these pull-apart basins would be related to regional dextral strike-slip motions. In this East Sector, the main efforts NE (N45° to N70°), can produce locally senestral strike-slip faults. Indeed, the progressive unconformities of the Ancaschaca zone and the Occopata one (Fig. 1), can be explained by senestral motions, controlled by old accidents. The progressive unconformities not only had a tectonic control but also they seem to have been controlled by diapirisim phenomena, which have synchronically worked. In the Central Sector, the regional strain NW-SE, produces thrusting. In front of them type Dome structure of evaporites are formed, which explains the great gypsum abundance (Fig. 1C). Little Red Bed bodies are placed over the evaporites and in front of the thrust.

CONCLUSIONS

The Red Beds sedimentation of the San Jeronimo Group, corresponds to the pull-apart basins, controlled by strike-slip faults, as it was previously interpreted (Córdova, 1986; Noblet, 1987). These faults are inherited structures of the Pre-Mesozoic and Mesozoic paleogeography, to the boundary between the Cuzco-Puno Swell and the NE border of the South Peruvian Western Trough. In this compressive context the Cusco region, presented a curved zone with the NW-SE and E-W faults propense to the strike-slip fault development.

The sedimentological evolution, the synsedimentary tectonic structures (progressive unconformities, faults, clastic dykes, etc), clearly show that the Red Beds of the San Jerónimo Group have been deposited under a constant tectonic regime. In a first moment the pull-apart basins individualize themselves and important progressive unconformities are developed right after. This is explained by the regional changes of strain related to the convergence of the plates. All of this is interpreted as the result of the Inca 1 Tectonic Event that starts in the Middle Eocene Times (44-42 Ma) and continues as a tectonic continuum until the end of the Early Oligocene times.

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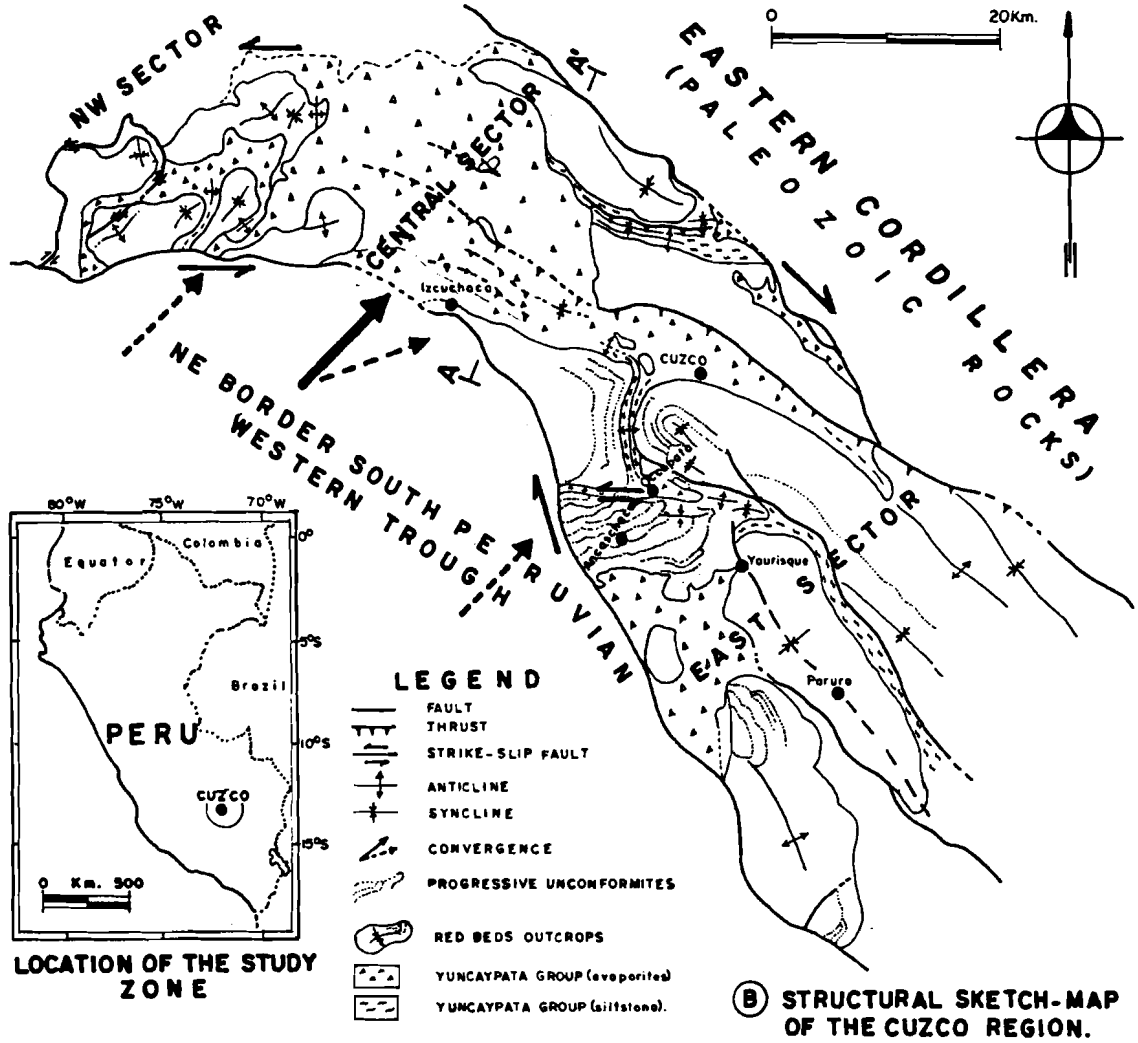
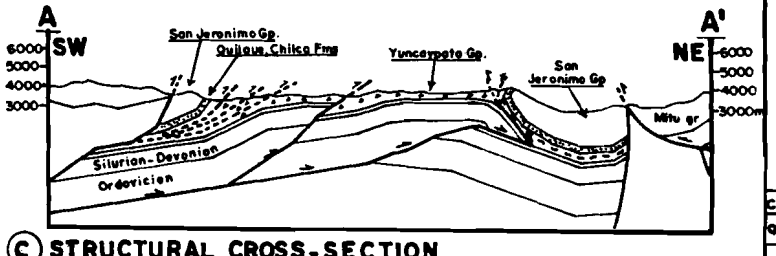

NW SECTOR
CENTRAL SECTOR
EASTERN CORDILLERA (PALEOZOIC ROCKS)
0 20Km.
Izcuchaca
CUZCO
NE BORDER SOUTH PERUVIAN WESTERN TROUGH
EASTERN SECTOR
Yourisque
Paruro
80°W 75°W 70°W
Equator
Colombia
Brazil
PERU
CUZCO
0 Km. 300
LEGEND
FAULT
THRUST
STRIKE-SLIP FAULT
ANTICLINE
SYNCLINE
CONVERGENCE
PROGRESSIVE UNCONFORMITES
RED BEDS OUTCROPS
YUNCAYPATA GROUP (evaporites)
YUNCAYPATA GROUP (siltstone).
LOCATION OF THE STUDY ZONE
B STRUCTURAL SKETCH-MAP OF THE CUZCO REGION.


A
SW
A'
NE
San Jeronimo Gp.
Quilque, Chilca Fms
Yuncaypata Gp.
San Jeronimo Gp
Mitu gr.
Silurian-Devonian
Ordovician
6000
5000
4000
3000m
C STRUCTURAL CROSS-SECTION

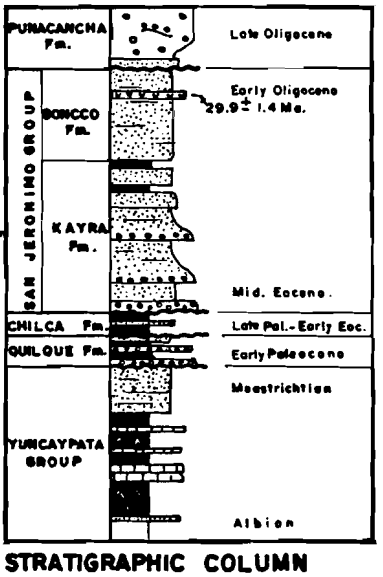

PUNACANCHA Fm.
Late Oligocene
SAN JERONIMO GROUP
CONCCO Fm.
Early Oligocene
29.9 ± 1.4 Ma.
KAYRA Fm.
Mid. Eocene
CHILCA Fm.
Late Pal.-Early Eoc.
QUILQUE Fm.
Early Paleocene
Maestrichtian
YUNCAYPATA GROUP
Albian
A STRATIGRAPHIC COLUMN

FIGURE 1.