

## THE ALTIPLANO-EASTERN CORDILLERA LIMIT IN THE URUBAMBA REGION (CUZCO-PERU)

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### RESUMEN

El límite Cordillera Oriental-Altiplano en la región de Urubamba (Cuzco-Perú) está dado por un alto estructural, controlado por fallas de rumbo, donde convergen cabalgamientos del Altiplano con vergencia NE y cabalgamiento de la Cordillera Oriental con vergencia SW. El Alto estructural corresponde al Umbral Cuzco-Puno que controló la sedimentación, paleogeografía y la tectónica, por lo menos a partir del Paleozoico superior.

### GEOLOGICAL SETTING

The Urubamba region is located between two morpho-structural units: The NE border of the Altiplano and the SW border of the Eastern Cordillera, limited by the valley of the Urubamba river which represents approximately an Intermediate Domaine.

In the Eastern Cordillera of the study zone, a lot of stratigraphic units crop out. Stratigraphic units such as: The Silurian-Devonian, the Early Permian (Copacabana Group), the Permian-Triassic (Mitu Group) and scarcely the Mesozoic (Huancane Formation and Yuncaypata Group). This domaine is characterized by the NW-SE thrusts, which make the Mitu group to repeat and put the Silurian-Devonian rocks in contact with the Mitu Group. These thrusts have a vergence towards the SW.

The Altiplano domaine is represented by the Huancane Formation (Neocomian), The Yuncaypata Group (Albian-Maastrichtian), the Quilque and Chilca Formations (Paleocene-Early Eocene), and finally by the Red Beds of the San Jeronimo Group (Middle Eocene-Early Oligocene). These units are affected by thrusts and fault propagation folds. The folds are plurikilometric of WNW-ESE to NW-SE direction, with axial plane slightly bent to the south (Piuray Anticline). The anticline west limit is cut by evaporite domes (Maras domes, Marocco, 1978). Gypsum seems to come from the Lower part of the Yuncaypata Group.

The Intermediate Domaine is given by strike-slip faults and it is here where two thrusting systems converge. Eastern Cordillera thrusts with SW vergence and the Altiplano thrusts with NE vergence. The strike-slip fault is probably of a dextral motion that takes out Lower Paleozoic rocks to

outcrop in flower structure way. Paleogeographically this Intermediate Domaine would correspond to an structural height (Cuzco-Puno Swell). Various quaternary shoshonite bodies locate along this strike-slip fault system.

All of these domaines are affected by a posterior folding of NE-SW direction and by N-S and NE-SW faults.

A chronology of phases has been deduced from the geological plane analysis. Thus we have that the NW-SE system of folds that really constitute the fault propagation folds, has been originated in the first place in the Altiplano Domaine. After that the thrusts have been formed with SW vergence of the Eastern Cordillera. The strike-slip fault system of the Intermediate Domaine has moved later on; however, this system is older, because it has controlled the sedimentation and the synsedimentary deformation of the Red Beds of the San Jerónimo Group. Finally a NE-SW folding and N-S and NE-SW faults affect the three domaines.

### **GEOMETRIC ANALYSIS**

Semi-balanced cross sections have been constructed out of the superficial geology (AA' Section) restoring it in a no-deformed state and considering the location of the syn-orogenic sedimentation (San Jerónimo Group) (BB' Section).

A common detachment in the Altiplano and the Eastern Cordillera is located in the Lower Paleozoic (Ordovician) which is deadened in the Intermediate Domaine, in front of a structural height, that is originated by the strike-slip fault presence (AA' Section). A superior detachment has also been recognized into the Yuncaypata Group in the Altiplano Domaine. In both domaines it is possible to see fault propagation folds, differentiated by their vergence. Asymetric synclines are developed in the San Jeronimo Group, which present greater thicknesses toward the eastern limbs (AA' Section). In the Altiplano, the structures with vergence to the NE are limited by the structural height (Cuzco-Puno Swell), and mainly affect the whole sedimentary cover. In this domaine, intercutaneous thrust wedge are observed which are associated to a passive backthrust (AA' Section). In the Eastern Cordillera the structures with SW vergence deform the Paleozoic, Permo-Triassic, and Mesozoic rocks, and they are also limited by the structural height of the Intermediate Domaine.

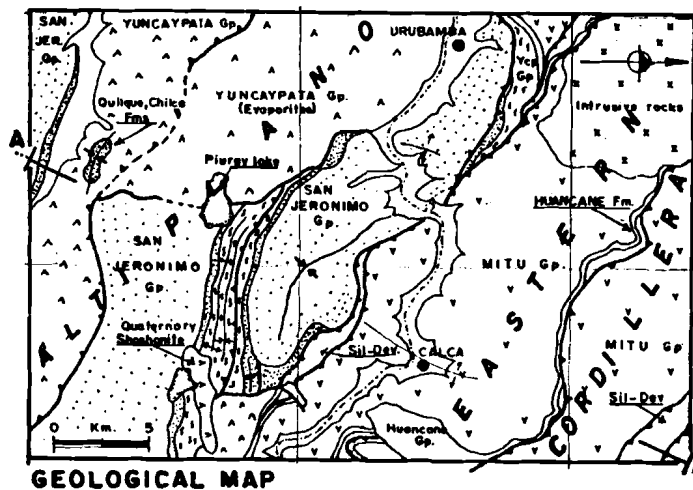
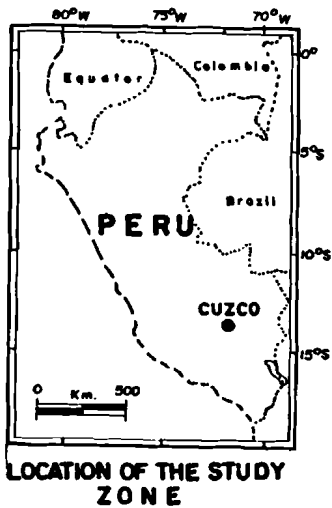
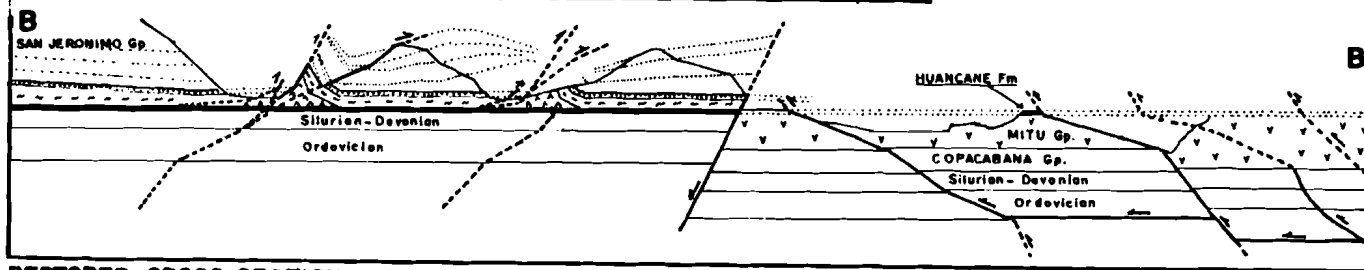
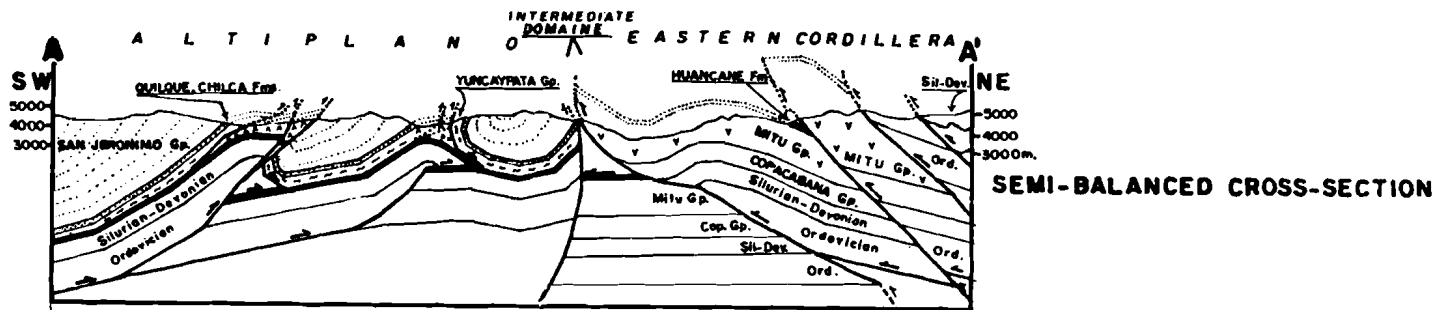
From the construction of the semi-balanced cross section (AA' Section)), a structural shortening of 35% has been calculated.

### **KINEMATIC ANALYSIS AND INTERPRETATION**

The possible ausence of the Copacabana Group in the Altiplano and its presence in the Eastern Cordillera, can explain the existence of a positive zone that controlled and limited the Permian-Carboniferous basin which could be the precursor structural element of the Cuzco-Puno Swell. A very intense distensive tectonic activity developed during the Permian-Triassic, originated the Mitu basin individualization that limits in its western part with the Cusco-Puno Swell, developing variable and more important thicknesses to the NE (BB' Section). During the Late Permian-Early Triassic a positive zone (Cusco-Puno Swell) seems to be already well differentiated. The Eastern Cordillera behaves inestably and contemporarily granitic bodies are placed possibly through normal faults, intruding rocks of the Mitu Group.

The Neocomian sedimentation (Huancané Formation) is established in the three domaines. Nevertheless, the Intermediate Domaine behaved as a high depth with reduced sedimentation. The tectonic regime for this time was more estable.

The Yuncaypata Group is developed over the Intermediate Domaine (Cuzco-Puno Swell)



spreading toward the Altiplano and being more restricted toward the Eastern Cordillera.

The Quilque and Chilca formations, mainly spread in the Altiplano, the structural height controlled and avoided a greater extension towards the Eastern Cordillera. The thickness of these units is more or less constant, but regionally it seems to increase to the SW.

The San Jerónimo Group, is also restricted to the NE border of the Altiplano, this has been deposited in pull-apart basins of NO-SE direction, controlled to the North by strike-slip faults of the Intermediate Domaine. progressive unconformities can be seen inside these basins.

In the Cuzco region the Inca 1 Tectonic event ( $\approx 44-28$ Ma) seems to manifest by a compressive regime that originated a tectonic front with possible vergence to the NE. In front of this structural element developed the San Jerónimo Group sedimentation (Middle Eocene-Early Oligocene) (Carlotto et al 1995). The movement of strike-slip faults of the Intermediate Domaine that partly controlled the sedimentation, seems to be Paleogeographic pre-Mesozoic accidents. The progressive unconformities seem to be the result of thrusts, strike-slip faults and diapiric phenomena, that synchronically worked (Chavez, 1995)

The folding that comes after to the deposit of the San Jeronimo Group, the development by fault propagation folds of NE and SW vergences, the functioning of intercutaneous wedges that originate a passive backthrust and the possible reactivation of the strike-slip faults, could be explained by the tectonic crisis of the Early Oligocene (Quechua Phase 0  $\approx 28-26$ Ma). The strike-slip fault reactivation and an important activity of thrusts with SW vergence of the Eastern Cordillera, seem to be caused by the Quechua Phase 3 ( $\approx 7-6$  Ma) (Chavez, 1995).

## CONCLUSIONS

The Altiplano-Eastern Cordillera, in the Urubamba Region (Cuzco-Peru) is given by an structural height controlled by a strike-slip fault, where the Altiplano domaine thrusts converge with NE vergence and the Cordillera domaine thrusts with SW vergence, The structural height corresponds to the Cusco-Puno Swell that controls the sedimentation, the paleogeography and the tectonic at least since the Upper Paleozoic. The present structure shows that the andean deformations first affected the Altiplano Domaine and then the SW border of the Eastern Cordillera, and they are linked mainly to the Inca and Quechua tectonic events.

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