CENOZOIC EVOLUTION OF THE COCHABAMBA AREA, BOLIVIA

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Resumen La tectónica Andina en la Cordillera Oriental fué iniciada en el Eoceno, formando una cuenca de antepaís en el éste de la Cordillera y al oeste de la zona Subandina. Esta cuenca fue plegada en el Oligoceno superior. Las fallas transcurrentes y las cuencas de Cochabamba fueron activas desde entonces hasta el Pleistoceno superior, cuando tuvo lugar una transferencia de fallamiento al este.

Keywords: Bolivia Orocline Tectonics Shortening Basins Strike-slip

Introduction

The Cochabamba region lies in the heart of the Bolivian Orocline, the origin of which is still a matter of controversy. Studies in the area have concentrated on two principle problems: 1) identifying the relationship of regional NW-trending folds and faults to mappable unconformities at the base of widespread Cretaceous and Eocene sequences in order to assess the relative importance of Andean (post-Cretaceous) and pre-Andean structures and 2) understanding the relationship of these structures to the prominent ESE trending Cochabamba-Tapacari Lineament System (CTL) and associated basins. These studies are then put in the context of recent models for the development of the Bolivian Andes (Sempere et al., 1990, Isacks, 1988).

Structural mapping was supplemented with sedimentological studies of regionally significant sequences and localised basin fills. A programme of K-Ar dating provided the first reliable dates from many of the basins and associated valley fills. The results suggest the history of tectonism in the Eastern Cordillera is more complex than recent published models have suggested (Sempere et al., 1990 and Sheffels, 1990).

Regional folding and faulting

The strong NW-SE tectonic grain of the region consists of c.5 km wavelength, mainly upright, folds, locally with a weak slaty axial-planar cleavage. These are transected by steep faults with both reverse and strike-slip displacements. A very angular post-lower Permian, pre-Cretaceous unconformity can be mapped throughout the region. The observed cleavages clearly underlie this unconformity. In addition all observed overturning is a result of reorientation of earlier folds on the limbs of larger-scale post-Cretaceous folds.

In many cases the angularity of the unconformity prevented further folding. Flexural-slip folds locked at limb dips of 50°-60° were prevented form further homogenous flattening because their post-Cretaceous depth of burial was insufficient to cause cleavage formation. Folding of Cretaceous and younger sequences is largely confined to areas where the unconformity is low angle or where competent units are not present.

Present estimates of shortening in the region (Sheffels, 1990) are likely to be overestimates because cross-section restoration failed to take this unconformity into account.

In the core of the Morochata syncline there is a conformable 500 m transition from fine-grained Cretaceous and Palaeocene facies into coarse conglomerates of likely Eocene age. The same transition can be traced throughout the eastern part of the Cordillera as far south as the Camargo syncline, near the Argentinian border. Sedimentological studies indicate the conglomerates were shed from a mountain front not more than 50 kms to the southwest in what is now in the westerm Eastern Cordillera.

West of Cochabamba the structures of the source area consist of broad folds of Devonian sandstones overlain by Mesozoic and Cretaceous strata. These are preserved locally in the footwalls of east verging high angle reverse faults (eg at Sayari). Nowhere are Tertiary strata preserved. East of the Sayari fault the coarse conglomerates can be found lying on a few metres of preserved Cretaceous sandstones and basalt indicating this area was at or near the uplifting mountain front and was eroding, in contrast to the deposition occurring to the east. In the western Subandes a late-Cretaceous to late Oligocene hiatus indicates this foreland basin was relatively narrow.

Between the Eocene and the late-Oligocene deformation advanced eastwards deforming the Eocene foreland basin. This advance can possibly be linked to the initiation of deposition of the late Oligocene Petaca formation in the Subandes. The low rate of deposition of this formation (<25m/Ma, Sanjinés and Jiménez, 1975) suggests there was not a marked mountain front.

Faulting and basin formation in the CTL

The timing of basin formation and associated faulting in the CTL is key to constructing a kinematic model of the bend region.

The first movements on the prominent ESE fault system possibly coincide with the mountain front advance described above. A series of short wavelength en echelon folds with associated sinistral faults formed during gentle sinistral transpression on the Tapacari fault system. These folds are overlain by the deposits of the Parotani basin, a shallow half-graben formed by transtensive reactivation of the Tapacari fault. Tuffs in the basin have been dated at 20 Ma.

The basin was later subjected to phases of sinistral transpression and transtension, the latter possibly coinciding with the earliest sinistral-normal faulting seen on faults south of the Tunari lineament. Faulting along the Viloma fault clearly predates regional erosion surfaces which were dissected by 500 m by about 7 Ma.

Movements on the Tunari fault, which forms the prominent 2000 m scarp along the north sides of the Cochabamba and Sacaba basins are complex. Displacements on the fault's continuation west of Cochabamba are small, totalling about 5 kms sinistral and 1 km throw down to the south. This pre-dates prominent pediments cut into the scarpline between 3200 and 3800 m. Offsets of regional folds indicate the normal faulting that formed the basins was not accompanied by significant strike-slip.

Conglomerates around the margins of the Sacaba basin onlapped the fault scarps to about 3100 m and pass into fine lacustrine facies in the centre of the basin. Tuffs and fossils indicate an age of 2.2 Ma for these sediments suggesting the Sacaba basin started to form in the late Miocene and that transpressional folding and faulting in the basin is very young. Younger fault movements, forming prominent fresh faceted spurs, dropped the floor of the Cochabamba basin at least 500 m in the Pleistocene resulting in the dissection of the Sacaba basin and the accumulation of a thick Quaternary fill in the Cochabamba basin which is not yet dissected.

Although the area is moderately seismically active there are almost no post-glacial fault breaks. Very young sinistral breaks have been identified along the line of the NW-trending Colomi fault to the east. If motion on this fault is as much as 5mm/yr then the CTL west of the Colomi fault would become inactive. Partitioning of strike-slip between the narrow northern and wide southern Subandes and of strike-slip and extension required to maintain compatibility between the two diverging thrust belts could be taken up entirely within the Subandes.

Conclusions

1) Pre-Cretaceous deformation is more important than thought in the Cochabamba region. There is still a marked deficit between observable shortening and that required by models explaining crustal thickening and orocline formation purely in terms of shortening.

2) A proto-Eastern Cordillera and foreland basin developed in the Eocene, coincident with eastward thrusting in Chile, indicating that a double Cordillera structure developed early in the uplift of the Andes.

3) Displacements on the CTL are smaller, and have a longer history, than thought. The principle role was probably the accommodation of arc-tangential extension, with modest sinistral slip. Transpressive and transtensive phases probably represent changes in the balance between tangential and radial stress in the bend reflecting stick/slip propagation in the Subandes. The CTL west of Cochabamba is presently inactive. Significant partitioning of thrusting and strike-slip is now taking place to the east.

References

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