STRUCTURAL SYNTHESIS OF THE BOLIVIAN SUBANDEAN ZONE

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RESUME: Une synthèse structurale de la Zone Subandine Bolivienne est présentée à partir de coupes équilibrées et d'une nouvelle méthode d'équilibrage de cartes. On met ainsi en évidence et on quantifie les relations chevauchements-décrochements de part et d'autre du Coude de Santa Cruz.

KEY WORDS: Subandean, Bolivia, balanced cross section, map balancing, wrenching, plate convergence.

INTRODUCTION

The Subandean Zone of Bolivia is a complex foreland fold and thrust belt [Sheffels,1988; Roeder, 1988; Baby et al., 1989, 1992] that forms the eastern edge of the central Andes mountains (fig. 1). In its central part (between 16°S and 18°S), this fold and thrust belt forms a bend (Santa Cruz bend) characterized by important transfer zones. From north to south, the structural geometry as the amount and direction of shortening present important variations.

The purpose of this paper is to present a geometric and kinematic study of this complex foreland fold and thrust belt deduced from cross section and map balancing. The geometry of the entire Bolivian Subandean Zone is analyzed and its deformation quantified.

GEOLOGICAL SETTING

The Bolivian Subandean Zone is bounded at the Cordillera Oriental edge by the Main Frontal Thrust (CFP), whereas the orogenic front developed below the Beni and Chaco plains at the eastern edge. The deformation started in the Late Oligocene and is still developing [Sempere et al., 1990]. The material involved in Subandean thrusting in Bolivia consists of a series from Ordovician to Jurassic and a Late Oligocene to recent continental foredeep fill. This pre-orogenic sedimentary series presents lateral variations of facies and thicknesses which play an important role in controlling the structural geometry. From north to south, three structural zones characterize the Bolivian Subandean fold and thrust belt: the Northern

Subandean Zone NW-SE oriented, the Central Subandean Zone which changes from a NW-SE to a N-S orientation and the Southern Subandean Zone N-S oriented. They are described in the following balanced cross sections.

BALANCED CROSS SECTIONS

Construction of balanced cross sections has been made possible due to surface mapping, reflection seismic data, and drilling information provided by the Bolivian State Oil Company (YPFB).

Northern Subandean Zone - between 13° et 16° S - (Fig. 1A): It is characterized by important thrust sheets (10-20 km) and broad synclines filled by Tertiary sediments (piggy back basins with 6,000 m of synorogenic sediments). The main detachments are located in the Ordovician shales, in the Silurian shales, in the Devonian shales and in the Permian shales. The foredeep has a bottom that slopes at 4°. The maximum amount of shortening is 135 km, i.e. 50%.

Central Subandean Zone - between 16° et 18° S - (Fig. 1B-1C): It is characterized by the Boomerang-Chapare transfer zone which is interpreted as a lateral ramp whose propagation was guided by the northern border of a Paleozoic sedimentary wedge, obliquely oriented vis-à-vis the regional shortening direction [Baby et al., 1993]. This sedimentary wedge consists of a continuous series ranging from Ordovician to Carboniferous thinning northwards lies on the Cambrian-Precambrian Brazilian shield, and unconformably covered by an isopachus series of 500 meters of Mesozoic and more than 1,600 meters of Oligocene to Actual deposits. The major decollement is located in the bottom of the Paleozoic sedimentary wedge. The maximum amount of shortening is 130 km, 45%.

Southern Subandean Zone - between 19° et 22° S - (Fig. 1D): An important east verging thrust (Mandiyuti Thrust) divides the southern Bolivian Subandean Zone into two fold and thrust belts that differ according to their thrust system geometry. The western belt is characterized mainly by fault propagation folds and fault bend folds, whereas the eastern belt is characterized by fault propagation folds and passive roof duplexes [Baby et al., 1992]. The main detachments are located in the Ordovician shales, in the Silurian dark shales, in the early Devonian shales, and in the base and top of the Middle to Late Devonian dark shales. The Silurian-Devonian succession is covered by more than 2000 m of late Paleozoic and Mesozoic sandstones with no potential detachments; in some places it is also covered by several thousand meters of synorogenic Tertiary sedimentary rocks. The foredeep has a bottom that slopes at 2°. Total shortening decreases from 20° S (140 km, i. e. 50%) toward the south (70 km, i. e. 30%, at 22° S).

MAP BALANCING

In order to study the lateral variation in structural geometry, surface data and balanced cross sections were integrated to construct a Lower Oligocene palinspastic map of the entire Bolivian Subandean Zone. This method consists to divide the actual structural map in elements characterized by a direction of shortening and an amount of shortening calculated from cross section balancing. Then, every elements are moved to their pre-andean position. The final palinspastic map (Fig. 2) contributes to the understanding of the kinematics of the bending of the Bolivian Subandean Zone. Wrench components of displacement are shown and quantified in the Northern Subandean Zone (senestral) and in the Southern Subandean Zone (dextral).

CONCLUSION

The Bolivian Subandean Zone developed during the N75° convergence between the Nazca and the South America plates [Isacks, 1988]. In the Northern Subandean Zone, SW-NE

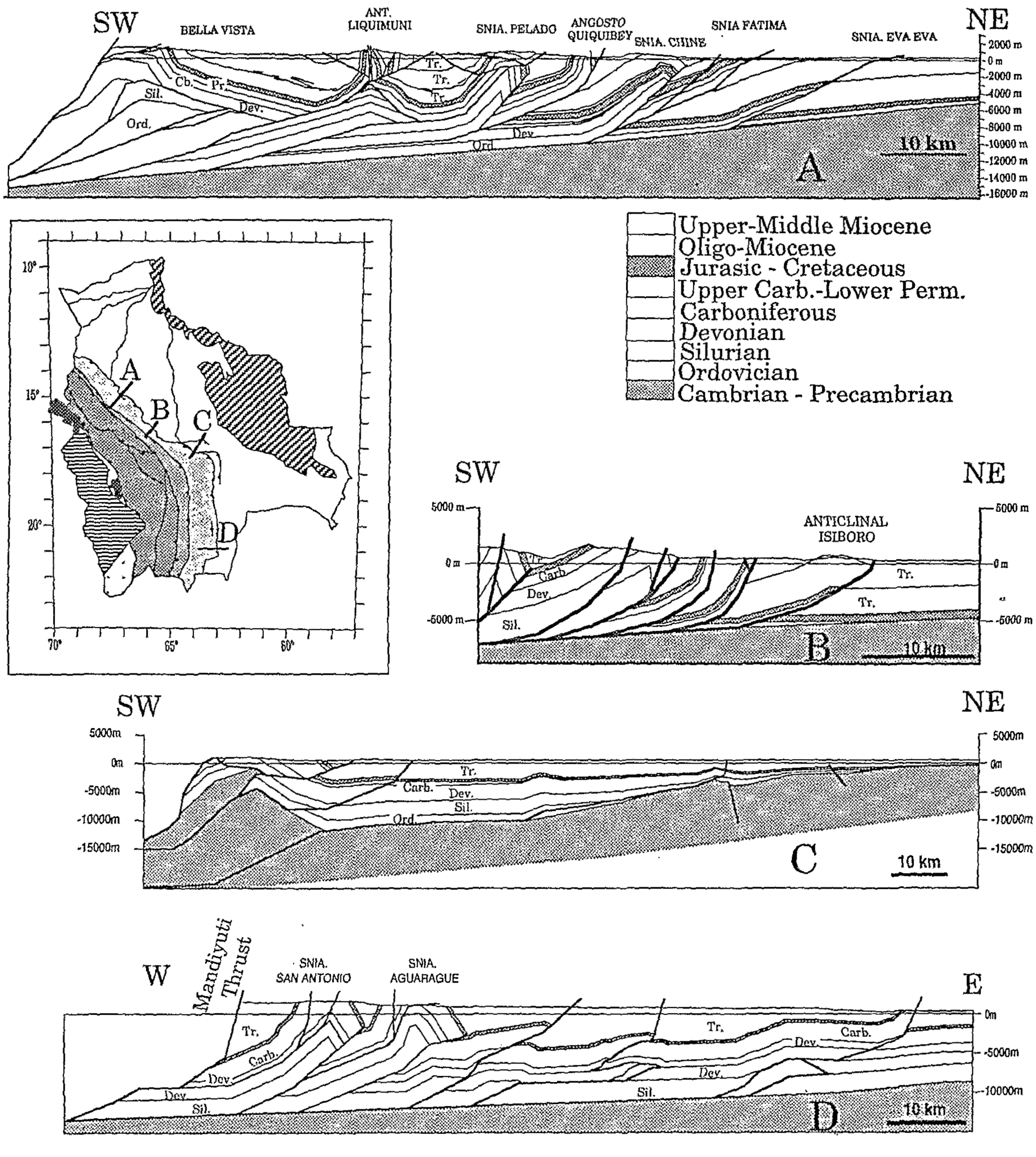

Fig. 1: Balanced cross sections in the Bolivian Subandean Zone

NW-SE senestral wrenching have accommodated the convergence, whereas in the Southern Subandean Zone, it is accommodated by W-E shortening and N-S dextral wrenching. The amount of shortening can reach 140 km and the amount of wrenching 35 km. The structural geometry of the Santa Cruz bend has been controlled by the northern border of the Paleozoic sedimentary wedge.

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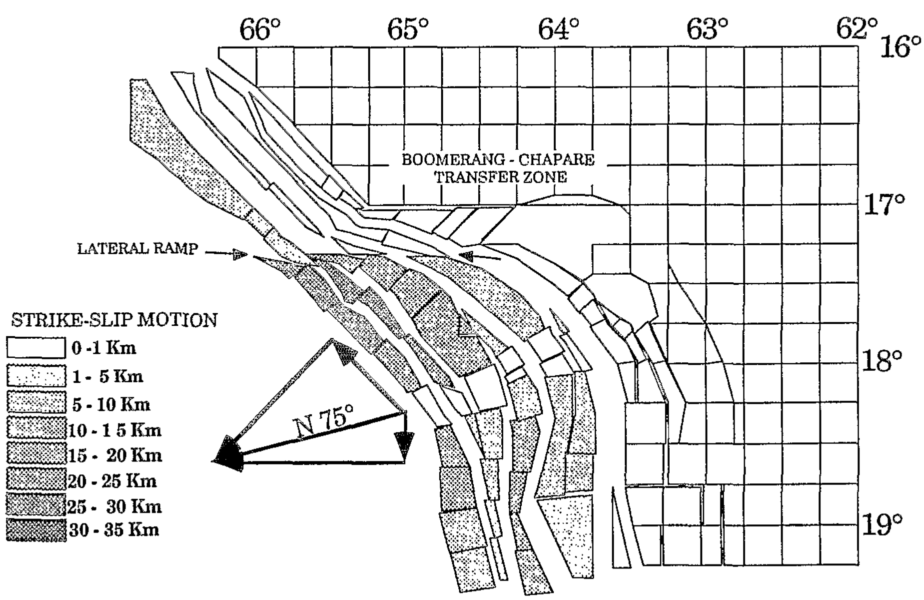

Fig. 2: Final palinspastic map - between 16° and 19° - contributing to understand the kinematics of the bending of the Bolivian Subandean Zone.