THE STRUCTURAL EVOLUTION OF THE CENTRAL ANDEAN FOLD-THRUST BELT, BOLIVIA

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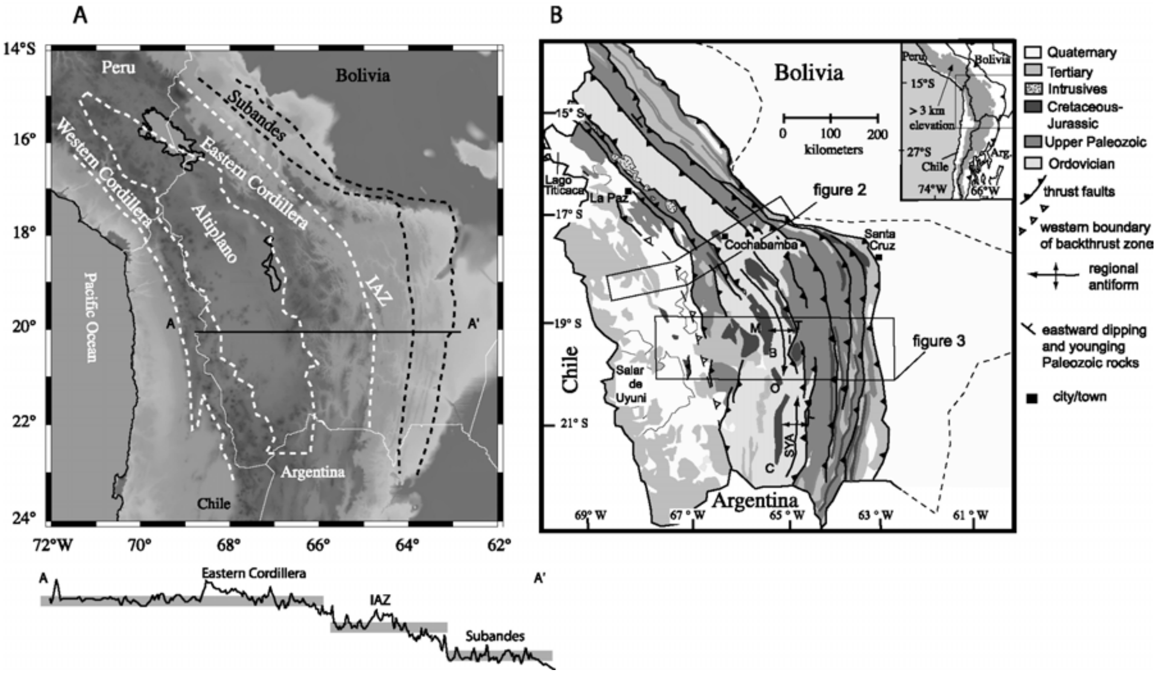
INTRODUCTION

Many of the key questions in Andean Orogenesis center around the nature, timing and amount of deformation within the Central Andean fold-thrust belt. The Central Andes house one of the world's high elevation plateaus with average elevations of 4 km supported by a ~70 km thick crust (e.g. Beck et al., 1996). Although explanations for this broad area of high elevations have ranged from magmatic additions to thinning of the continental lithosphere, the central Andean plateau is now thought to be primarily the result of tectonic shortening and thickening associated with the Andean fold-thrust belt (Isacks, 1988; Sheffels, 1990; Schmitz, 1994). Even though the high elevation plateau is linked to the shortening accommodated by the fold-thrust belt, the kinematic details of the fold-thrust belt and how it evolved with time still remains a mystery. Balanced cross-sections from the arc to the foreland in conjunction with available timing constraints enable sequential restorations of the fold-thrust belt with time as well as provide realistic estimates of shortening. Cross sections through the Andean fold-thrust belt must account for four regional constraints. These are 1) a 12 km structural step between the Altiplano and the Eastern Cordillera (McQuarrie and DeCelles, 2001), 2) pronounced (~6 km) structural steps between the Interandean zone and the Eastern Cordillera and between the Interandean zone and the Subandean zone (Kley, 1996; 1999), 3) a horizontal, shallow level decollement in lower Paleozoic rocks through the west- and east-verging portions of the Eastern Cordillera (McQuarrie and DeCelles, 2001), and 4) an extensive (~100 km wide) zone of west-verging folds and associated thrust faults. The cross sections and kinematic evolution models presented in this paper propose that the best way to fill these 4 constraints is through the stacking of two basement thrust sheets.

BALANCED CROSS SECTIONS

Balanced cross-sections were constructed along two transects (17º-18º S in the north and (19º-20º S in the south) from the undeformed foreland to the volcanic arc (Figure 1).



Support for large, basement-involved thrust sheets is found in significant steps in both the topography and the exposed structural elevation of the Andean fold-thrust belt. The structurally highest basement thrust raised folds and faults in predominantly lower Paleozoic rocks of the Eastern Cordillera with respect to Tertiary rocks in the broad, internally drained basin of the Altiplano to the west and east-verging folds and faults in upper Paleozoic rocks of the Interandean zone to the east. The Interandean zone was in turn raised (both structurally and topographically) with respect to the frontal folds and faults of the fold-thrust belt (the Subandean zone) by a second, structurally lower basement thrust sheet. Thus, these two megathrusts divide the Andean fold-thrust belt into four areas of markedly different structural elevations. The Eastern Cordillera can be further subdivided into two zones of west- and east-vergent folds and thrusts.

The balanced cross-sections and the accompanying undeformed sections were simulated using the computer program, 2D-move (Midland Valley) to produce sequentially restored sections that portray how the Andean fold-thrust belt may have evolved through time. The proposed evolution is based almost entirely on the geometric constraints of the structural cross-sections, but is consistent with available basin migration history (Horton et al., 2001, DeCelles and Horton, in review), ages of overlapping syntectonic sedimentary rocks (Sempere et al., 1990; Jordan et al., 1997) and local thermochronology (Benjamin et al., 1987; Farrar et al., 1988; Sempere et al., 1990: Ege, 2001). The kinematic cross-sections were constructed under the assumption that the faults are in-sequence in the direction of transport whenever possible. Dates indicate local timing constraints and arrow shows the location of the Cochabamba area (Figure 2) and the location of the Tarabuco and Incapampa synclines (Figure 3). Scale is in kilometers.

The proposed kinematic model suggests that the eastward propagation of the structurally highest basement thrust fed ~105 km of slip into the Eastern Cordillera along east-vergent and west-vergent faults. This structure also fed ~90 km of eastward slip into the Interandean zone. The initiation and eastward propagation of a lower basement thrust structurally elevated the Interandean zone with respect to the foreland while feeding ~65 km of slip into the

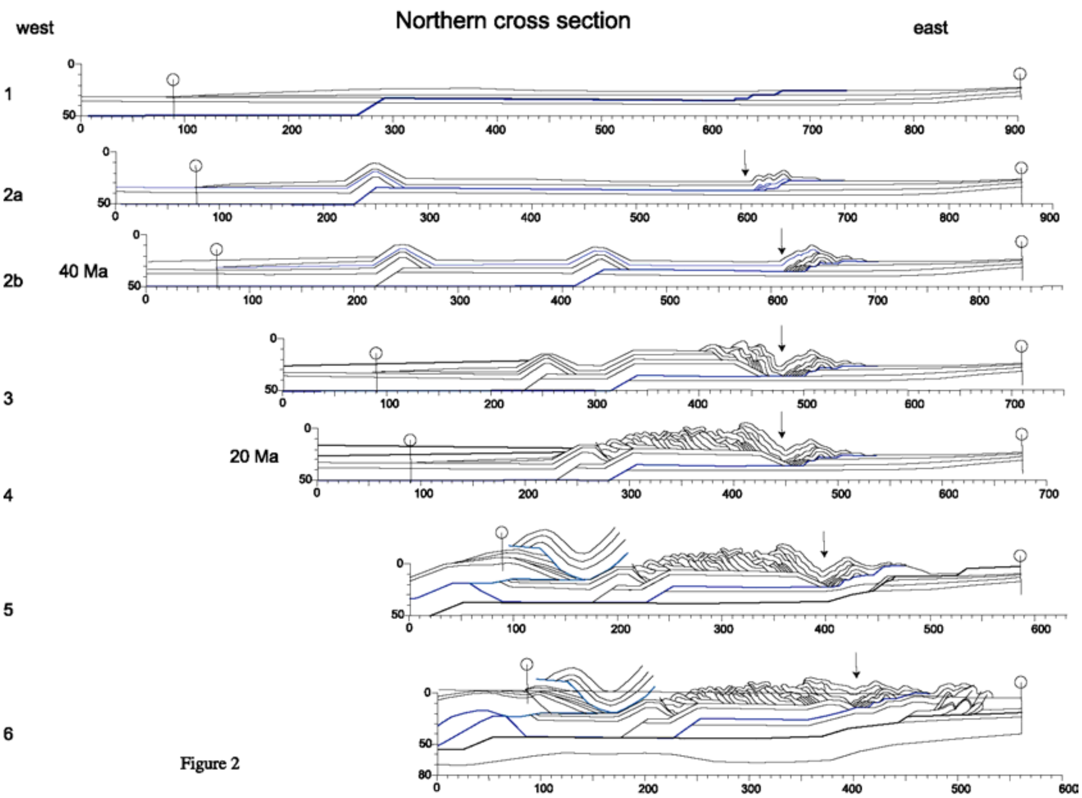


Figure 2

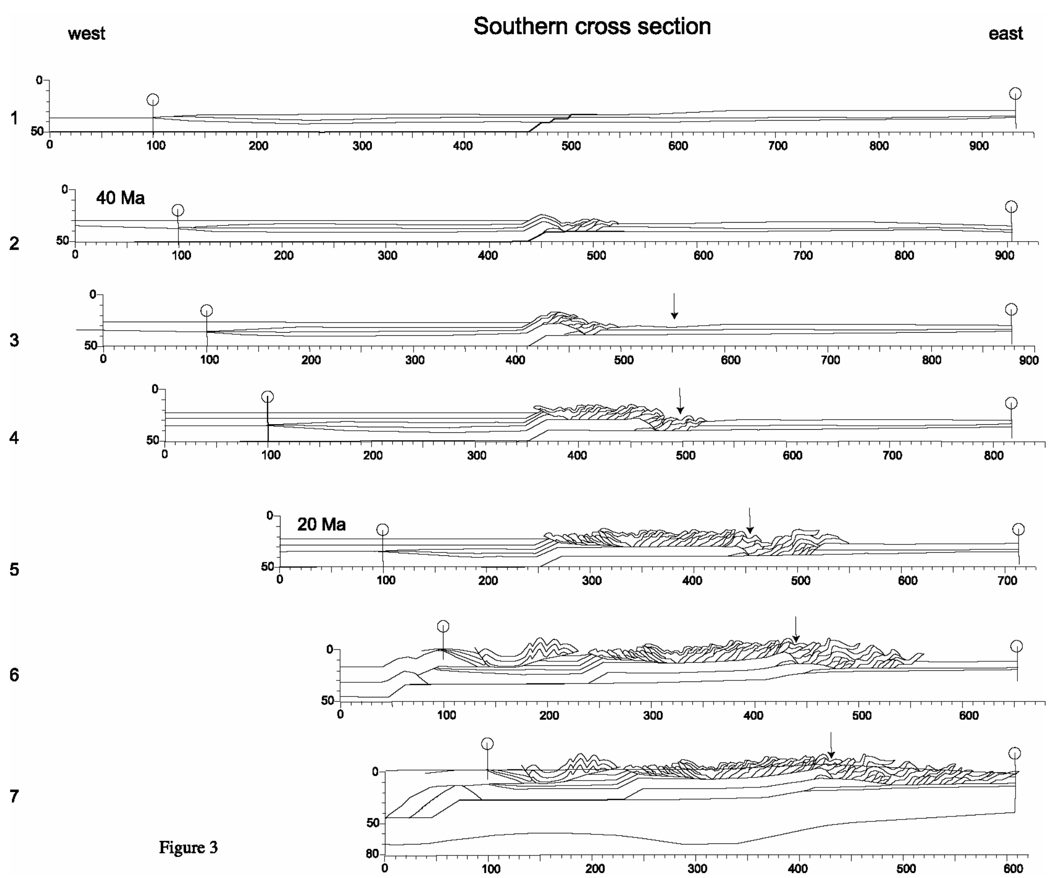


Figure 3

Subandean zone. Out-of-sequence basement thrusting to the west is proposed to have elevated the western edge of the plateau and accommodated ~40 km of shortening within the Altiplano. Total cumulative shortening within the cover rocks of the Andean fold-thrust belt (300-330 km) can be balanced by an equivalent amount of shortening along two basement megathrusts.

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