Temporal and spatial relationship between thick- and thin-skinned deformation in the thrust front of the Malargüe fold and thrust belt, southern Central Andes

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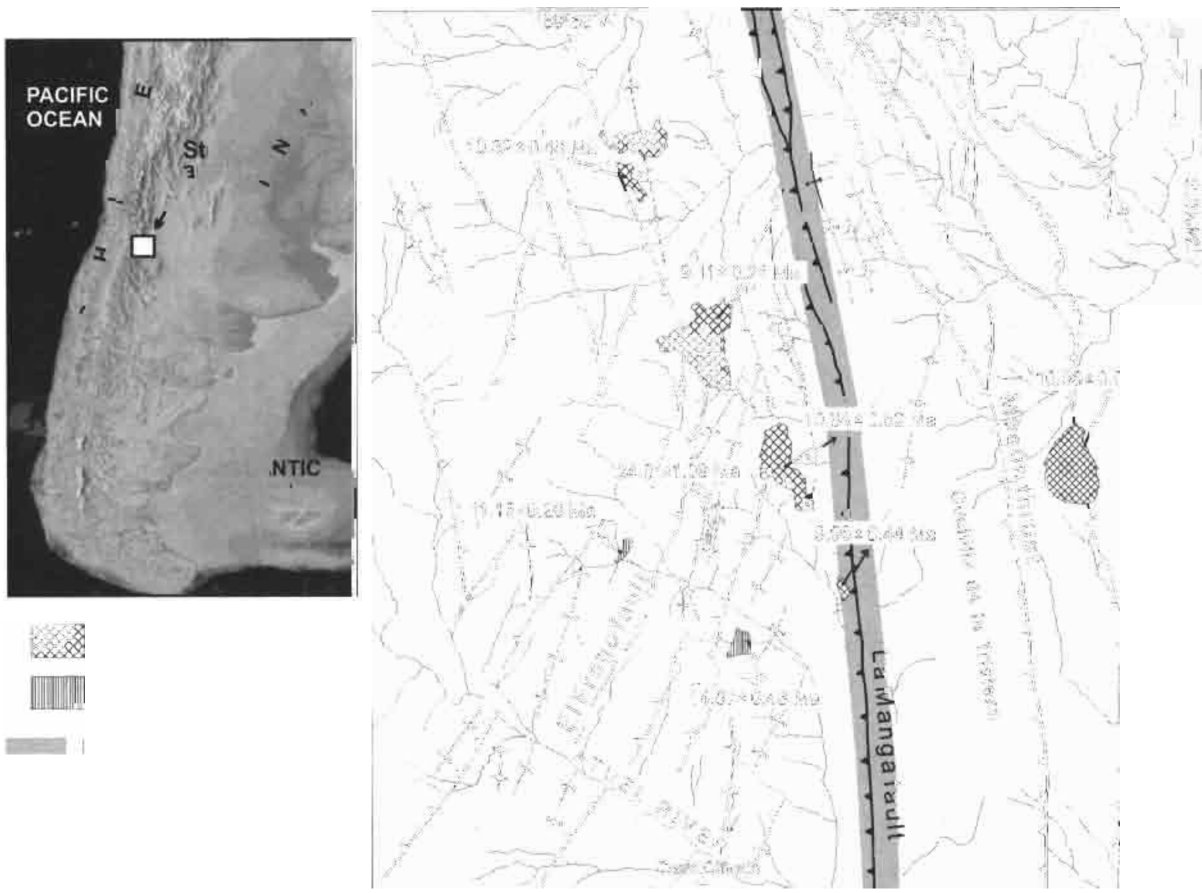
INTRODUCTION

A new kinematic model, which integrates original detailed structural data and new Ar/Ar dating with previous surface and subsurface data and Ar/Ar dating, is proposed for the thrust front of the Malargüe fold and thrust belt (MFTB). The study area, located in the eastern slope of the Cordillera Principal, represents a key area in which to test thin- vs. thick-skinned models, because it affects the Late Triassic – Early Jurassic Atuel half-graben of the Neuquén rift basin (Fig. 1A). The goal of this study is to constrain the timing of uplift of the MFTB by defining of the deformation. We also address the question as to whether tectonic inversion of Mesozoic normal faults occurred first and the resulting basement thrust sheets propagated along a deep detachment into the sedimentary sequence in the foreland, or basement thrusting occurred out-of-sequence after the emplacement of shallow thrust sheets. The presence of pre-existing weaknesses related to rift structures and the occurrence of ductile layers in the cover would support both alternatives.

The MFTB extends from 34° to 36° S and forms part of the Cordillera Principal of the Southern-Central Andes. It comprises: Paleozoic metamorphic and plutonic rocks which constitute the basement of the belt; *Upper* Triassic to *Lower* Jurassic marine and continental rift sequences deposited in the Neuquén back-arc basin; *Upper* Jurassic to Cretaceous platform sequences; and Cenozoic sedimentary and volcanic rocks. This belt developed mainly during the Neogene in response to W-E compression and it has traditionally been interpreted as a thick-skinned orogenic wedge with inverted Jurassic normal faults (Manceda and Figueroa, 1995). Neogene synorogenic continental strata crop out in the Cuchilla de la Tristeza range and eastward, and are represented by three Miocene to Pliocene units separated by angular unconformities: the Agua de la Piedra Fm. (13-10.6 Ma: Baldauf, 1997), Loma Fiera Fm. (10-9.5 Ma: Baldauf, 1997) and Río Diamante Fm. (Pliocene: Combina and Nullo, 1997).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into the sedimentary cover. The El Freno fault has been interpreted as a NNE-trending high-angle blind fault, related by Lanés (2005) to the extensional period. The inversion of this fault is marked by a broad anticline in its hanging-wall. Associated with this thick-skinned structure, small-scale anticlines and synclines with angular hinges (kinks and box-folds) deform the Jurassic sequences, and low-angle thrusts formed above shallow detachments, in thin-skinned tectonic style.

The ***eastern sector*** corresponds to an emergent thrust front system, made up of several NNW-trending thrust sheets involving Cretaceous to Neogene strata in a thin-skinned tectonic style. The oldest sediments involved in the deformation are Cretaceous shales, evaporites and red beds. The Sosneado and Mesón faults uplift the Cuchilla de la Tristeza range and are low-angle thrust rooted into a shallow detachment. Toward the north, both faults split into several thrusts and produce stacking of the Cretaceous sequences (Kozlowski *et al.*, 1989).

We therefore infer that the tectonic evolution of the MFTB involved both thin-skinned tectonics along two shallow detachments within the Jurassic rift sequences (western sector) and Cretaceous strata (eastern sector) and basement involvement along a deeper detachment which accommodates stacking of basement thrust units.

TEMPORAL RELATIONSHIP BETWEEN THICK- AND THIN-SKINNED STRUCTURES

In order to constrain the age of the thick- and thin-skinned deformation, we construct a chronology of deformation based on structural relationships and Ar/Ar dating of tectonic and post-tectonic volcanic and subvolcanic rocks. Twelve samples of andesite and basalt were analysed by laser-induced $^{40}Ar/^{39}Ar$ step-heating procedure on hornblendes and whole-rocks.

Inversion of the Atuel half-graben (15 – 14 Ma): Contractional reactivation of the Atuel half-graben began with rigid displacement of the wedge of rift deposits and the underlying crystalline basement rocks along the La Manga fault. Fault displacement was dissipated in the cover units by folding. Porphyry dikes, assumed to be post-tectonically emplaced in the Cerro Chivato area by Baldauf (1997), indicate that the anticline associated with the first movement of the La Manga fault formed before 14 Ma. A maximum age for this deformation is given by the age of pre-tectonic subvolcanic rocks, cropping out in the Las Bardas creep, dated as 14.87 Ma (Fig. 1B).

Breakthrough of the La Manga fault into the sedimentary cover (13 – 11 Ma): After the partial inversion of the half-graben, faults emanating from the master fault broke through the entire sedimentary section and reached the surface. The time of breakthrough is well constrained by the age of the post-tectonic volcanics and by the angular unconformities between the synorogenic strata. In the thick-skinned area, deformation was accommodated by movement along the La Manga fault prior to 10.84 Ma, the age of the Cerro Tordilla post-tectonic volcanic rocks. In the thin-skinned area, cross-cutting relationships, together with emplacement ages, indicate that deformation and uplift of the Cuchilla de la Tristeza range along the Mesón and Sosneado thrusts must have occurred prior to 10.6 Ma, the age of the Laguna Amarga stock (10.56 ± 0.04 Ma - Baldaulf, 1997) and that of the angular unconformity separating the Agua de la Piedra and Loma Fiera Formations (~10.6 Ma -