

**METAMORPHIC BASEMENT AND THE STRATIGRAPHY OF
OVERLYING VOLCANO-SEDIMENTARY ROCKS AT 18°S :
IMPLICATIONS FOR STYLE AND TIMING OF ANDEAN
DEFORMATIONS**

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Introduction

Uplift and crustal thickening in the Central Andes occurred in Miocene to Recent times. However, the cause, processes and timing of uplift is still poorly constrained and has led to conflicting interpretations. We present new observations from the Chilean Western Escarpment of the Central Andes at 18°S relating to the tectonic style and timing of deformation of the Andean metamorphic basement rocks and their overlying Cretaceous to Tertiary volcano-sedimentary cover.

Belén Metamorphic Basement and overlying Cretaceous to Tertiary rocks

Exposures of amphibolite-facies metamorphic basement rocks near Belén and Tignámar have long been known (Salas et al., 1966, Pacci, 1980). A very rough protolith age between 1.5 to 2.0 Ga was determined by Nd model ages and Sm-Nd by Damm et al. (1986) and Basel et al. (1995). A younger metamorphic overprint between uplift and cooling is documented by K-Ar ages on micas and amphiboles in the range of 490 to 500 Ma. The youngest (and most reliable ??) ages of 360 to 390 Ma on the basement metamorphic age (orthogneiss) is given by Lucassen (1994). Intrusions occurred also between 475 and 507 Ma (Basel et al., 1995). Damm et al. (1994) reported one fission track age of 75 Ma on zircon, indicating a Lower Cretaceous uplift or reheating event.

Detailed mapping at a scale of 1:15.000 over the entire range of basement exposures and its deformed overlying volcano-sedimentary units to the N of the village of Belén led to the following observations:

The Belén basement is overlain unconformably by a basal sequence of basement conglomerates and breccias grading into finer-grained sandstones and siltstones. Carbonate rocks are rare and conspicuously rich in detrital material. The carbonates contain brachiopods of Permian age, while in the basal conglomeratic sandstone we found poorly preserved gastropods. This basal sequence is irregularly distributed indicating a varied shallow marine environment close to a shoreline.

Andesitic conglomerates, breccias, lava flows and quartz-bearing ignimbrites (c. 700 m, Lupica Formation, Salas et al., 1966) overly the basal sequence. Volcanic and volcanoclastic rocks are rarely intercalated by coarse-grained fluvial sediments. Sedimentology and reddish-green alteration suggest a

terrestrial, low elevation environment for deposition. Salas et al. (1966) included fine-grained fluvial and lacustrine sediments of volcano-detrital origin to the south and north as an upper member into the Lupica Formation for which he suggested an Upper Cretaceous to Oligocene age. The latter fluvio-lacustrine sediments could represent a shallow and quiet water environment equivalent to the upper part of the coarse-grained member of the Lupica Formation N of Belén, but may also well be significantly younger (up to only 25 Ma. Muñoz, 1991). This unit is overlain conformably by a series of slightly welded ignimbrites consisting of eight flow units with an estimated total thickness of 500 m ("Belén-Ignimbrites"), and a series of mafic aphyric andesite scoria and breccias. Ignimbrites and breccias are almost entirely unaltered and distinct from the breccias and ignimbrites of the "Lupica Formation". Lupica Formation, Belén-Ignimbrites and younger andesite scoria and breccia are variably folded from open folds in the E to tightly folded in the W with vertical fold planes.

Silicified, xenolith-rich and flat lying ignimbrites disconformably overly these folded Cretaceous/Tertiary strata at elevations between 4300 m and > 5000 m up to the crest of the Western Cordillera which is strongly dissected by glacial kars ("Kar-Ignimbrites"). These ignimbrites are quartz rich and show only limited distribution. They may be related to silicic post tectonic intrusions into the Lupica Formation which are abundant further N between Zapahuira and Putre.

Younger rocks, which are not exposed in the immediate working area, belong to the Oxaya Formation, of which the uppermost welded ignimbrite has been dated at about 19 Ma (Naranjo & Paskoff, 1985; Walfort et al., 1995). These plateau-forming ignimbrites occur from the Altiplano (Condoriri Ignimbrite) to the coast near Arica (Schröder & Wörner, this meeting), and show large vertical displacements due to a second major phase of uplift and a resulting episode of erosion and basin sedimentation (Uhlig et al., this meeting). Our interpretation here, however, is mainly concerned with the older, pre-Miocene history.

Our stratigraphic framework and ages for the different volcanic units and their deformational history suggests an episode of crustal shortening and compressive tectonics in pre-Miocene times which led to an initial stage of uplift, erosion and sedimentation. The metamorphic basement rocks are involved into the compressional tectonic movements: At several places the boundary (i.e. the old land surface) between basement rocks and overlying strata is cut by flat to steeply E-dipping reverse faults and thrusts. Individual basement blocks are found to overthrust the basal sequence and the andesitic breccias of the Lupica Formation, often by not more than 100 m. The western boundary of the Belén basement block is in reverse fault contact to the younger, folded sediments. By contrast, the eastern boundary of Belén metamorphic rocks, which is exposed at elevations between 3595 m and 4000 m, is marked by a N-S trending vertical fault uplifting of the basement in the W against the Lupica Formation in the E (Fig. 1). Both, the W-vergent thrust in the W and the vertical fault in the E can be traced clearly along most of the basement exposure.

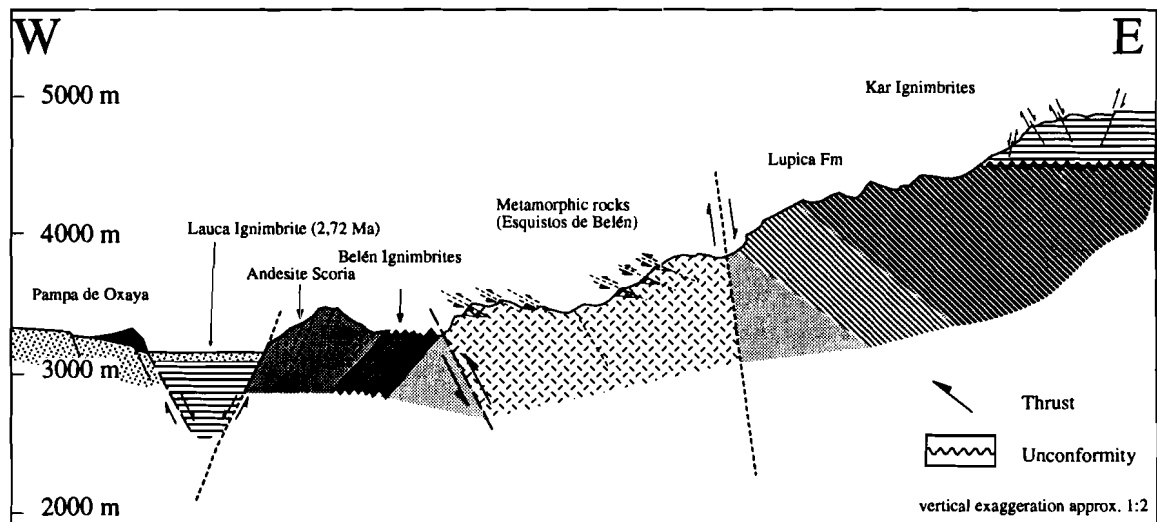


Fig. 1 Schematic W-E cross section through the Western Escarpment of the Altiplano near Belén

Overlying silicified Kar-Ignimbrites are not affected by this folding but show evidence for extensional movements which could be due to either gravitational subsidence near the oversteepened escarpment or to younger extensive movements related to normal faulting of the >19 Ma Oxaya Formation.

Significant crustal shortening in Eocene to Oligocene times involved the metamorphic basement. Distinctly more intense style of folding in the volcano-sedimentary rocks (Lupica Formation) to the W of the Belén basement exposure indicates the possibility of the rigid basement blocks acting as a tectonic back stop or ramp against the more easily deformed sediments. The age of deformation must be older than the Kar-Ignimbrites (which are older than 19 Ma). New Ar-Ar ages of the Kar-Ignimbrites and the folded Belén-Ignimbrites will put a narrow bracket on this compressive movements of the first phase of Andean uplift in this area.

These compressive movements are clearly older than the age and deformation of the Oxaya Formation which is normally faulted resulting in the large Oxaya block. Elevation difference between this block and correlated exposures of ignimbrites from the Altiplano indicate relative movements of at least 1500m.

Conclusions

Field investigations in the vicinity of the Belén basement inliers provide evidence for style and timing of Cretaceous to Tertiary Andean deformations. Permian brachiopods in carbonates and clastic sediments overlying the basement indicate exposure and erosion of the metamorphic basement during the Upper Paleozoic. The younger Lupica Formation, which can be correlated to many other occurrences of similar facies in Northern Chile, is strongly folded. Contacts between the basement and overlying strata range from purely sedimentary to tectonic. The volcanic to volcanoclastic Lupica Formation was observed to be overthrust by the metamorphic basement along W-vergent thrusts. These deformations are related to an early phase of Andean uplift which was clearly compressive in style. Degree and style of folding of the Cretaceous/Tertiary Lupica Formation differ regionally. We explain this by the basement block acting as rigid ramps at the base of the Lupica Formation in Belén.

Normal faulting and lateral extensional displacement of the Miocene Oxaya Formation represents a second major phase of Andean uplift (Uhlir et al. this meeting).

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