A simple shear/ pure shear flexural model of thrust sheet emplacement and foreland basin formation: Application to the Eastern Cordillera and Subandean zone, Central Andes.

Toth J.[1], Yrigoyen M.R.[2], Flint S.S.[1], Kusznir N.J.[1]

1. University of Liverpool, Liverpool, UK.
2. ASTRA Compania Argentina de Petroleo S.A.

A mathematical model has been constructed of the geometric, thermal and flexural isostatic response of the lithosphere to shortening by faulting in the upper crust and plastic distributed deformation in the lower crust and mantle. The model has been applied to late Cenozoic compressional tectonics of the eastern thrust belts of the Central Andes (figure 1) and used to predict foreland basin geometry and stratigraphy. The model predicts the flexural isostatic response to lithosphere shortening, thrust sheet emplacement, sediment loading and erosional unloading. Fault geometry, the amount of compression, detachment depth, the relative lateral position of the pure shear and simple shear and the flexural rigidity of the lithosphere during shortening control the form of the resulting foreland basin and thrust belt topography.

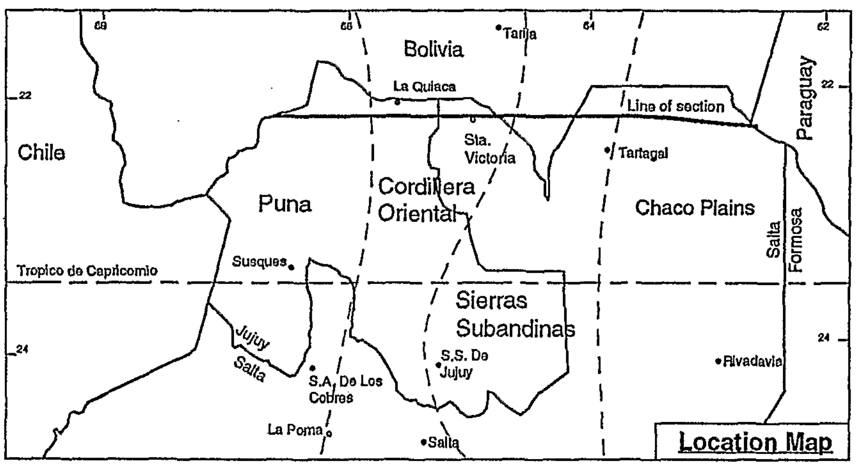

figure 1

Figure 2 shows a model in which three thrust faults, dipping at 35°,detaching at 15km and with 10km, 10km and 8km shortening respectively, are moved in-sequence. The initial thrust produces a flexural foreland basin which is iteratively sediment loaded to base level (figure 2a). The subsequent thrusts incorporate the earlier foreland basins into their thrust sheets (figures 2b,c). The model uses an effective elastic thickness of 5.0km.

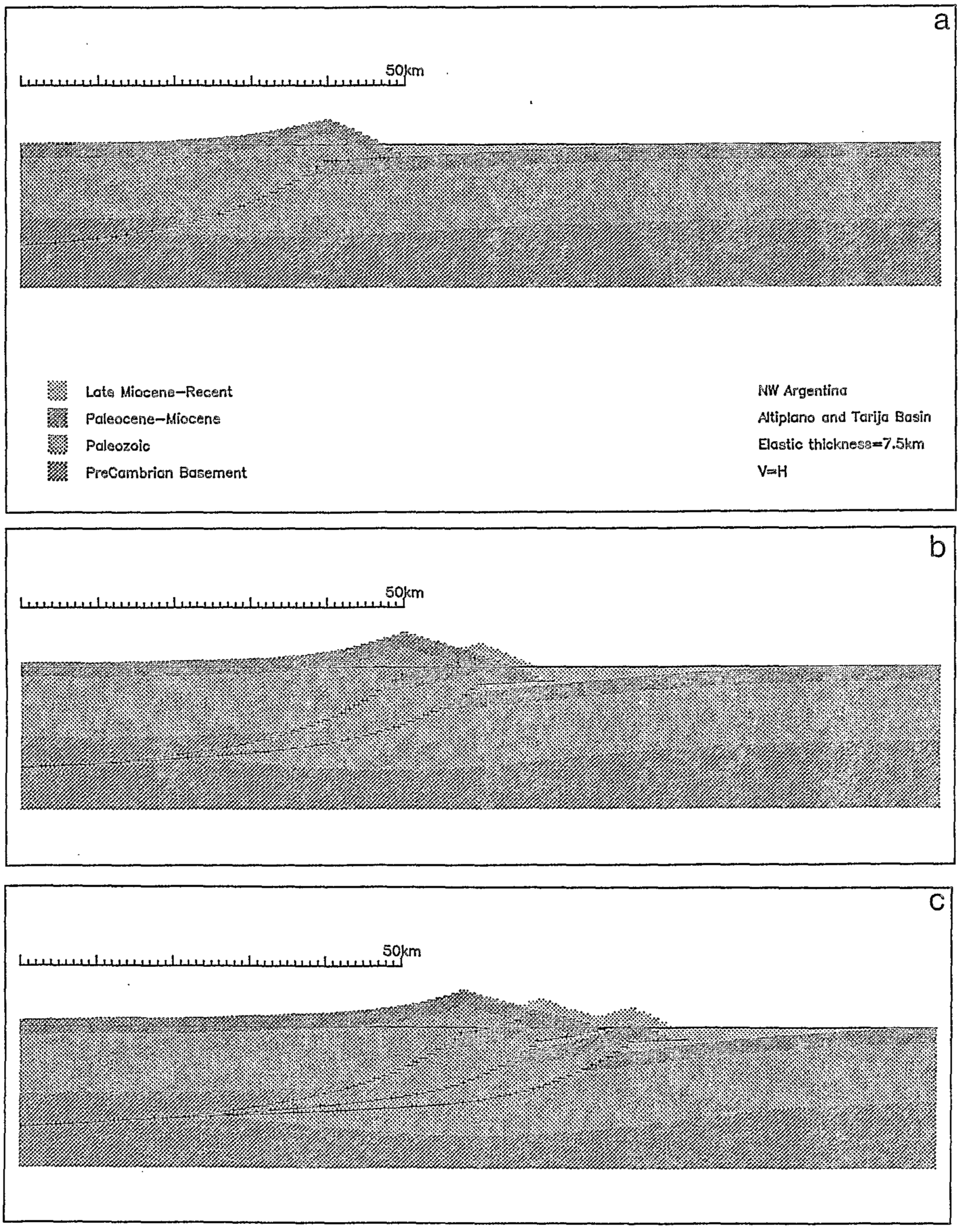
a
50km
Late Miocene–Recent
Paleocene–Miocene
Paleozoic
PreCambrian Basement
NW Argentina
Altiplano and Tarija Basin
Elastic thickness=7.5km
V=H
b
50km
c
50km

figure 2

The Eastern Cordillera and Subandean zones are Late Miocene-Recent thrust belts on the eastern edge of the Puna. Shortening has been estimated by section balancing to be of the order of 100km or more. To the East of the thrust belts the Chaco Plains form an active depositional basin (figure 1). The PreCambrian metamorphic basement across the area dips West beneath the Andes. Unconformably above the basement lies a thick elongate eastwardly tapering wedge of Paleozoic sediments. The Paleozoic thickness increases from 2km beneath the Chaco Plains to 14km at the western boundary of the subandean zone.
Seismic reflection profiles across the Subandean zone show East verging thin skinned thrust faults detaching along horizons within the Paleozoic. The boundary between the Subandean zone and the Eastern Cordillera marks a structural change to deeper fault detachments bringing PreCambrian material to the surface.

In N.W.Argentina the Cretaceous Salta rift basin may be a controlling factor on the evolution of the Andean foreland. Continued postrift thermal subsidence has provided increased sedimentary accommodation space and inversion of the rift structures may control fault positions and geometries.

Using available geological and seismic data to identify fault positions and structural styles the model has been used to predict late Cenozoic crustal evolution, foreland basin stratigraphy and basin geometry along a line of section from the Puna to the Chaco Plains (figure 1). In particular the model allows us to constrain lower crustal structures and fault detachment depths in response to lithosphere shortening. The relative lateral position of the pure shear and simple shear is an important control on crustal thickness and resulting topography.

The initial starting template is shown in figure 3. The progressive formation of

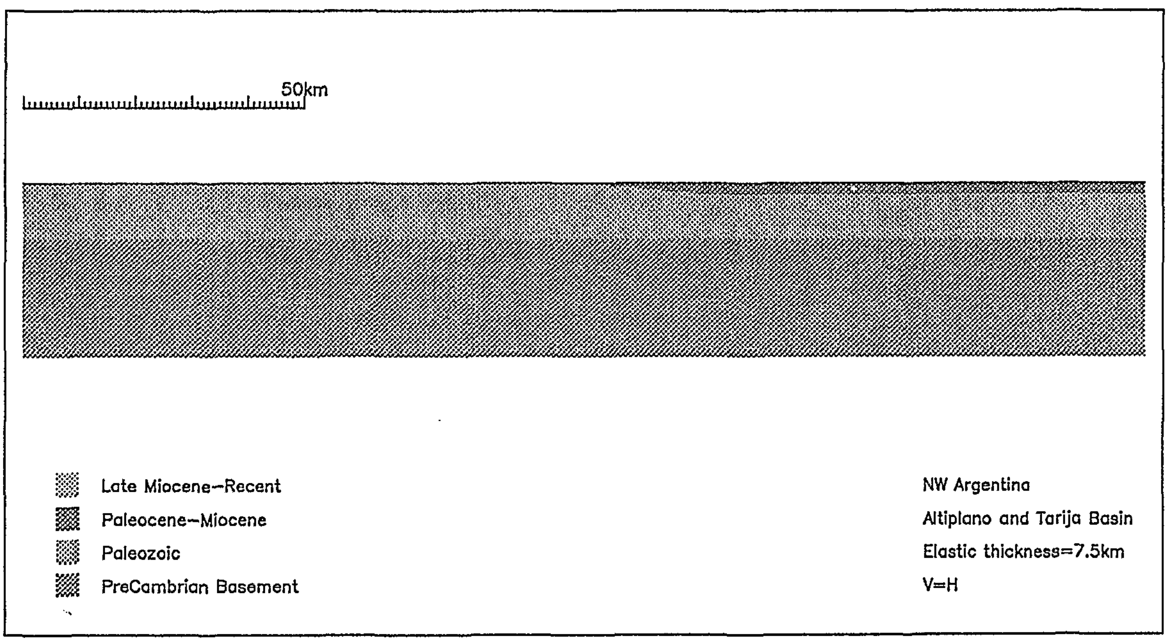

figure 3

thrust belt and foreland basin is show in figure 4. Cumulative total shortening used in the model is 110km. In figure 4a shortening on predominately thick skin thrusts, involving PreCambrian basement, has generated a significant foredeep which has been filled to form a foreland basin of up to 5km depth. In figure 4b the thrust belt propagates on thin skin thrusts detaching within the lower Paleozoic. Figure 4c shows the present day situation from the eastern border of the Eastern Cordillera to the Chaco plains.

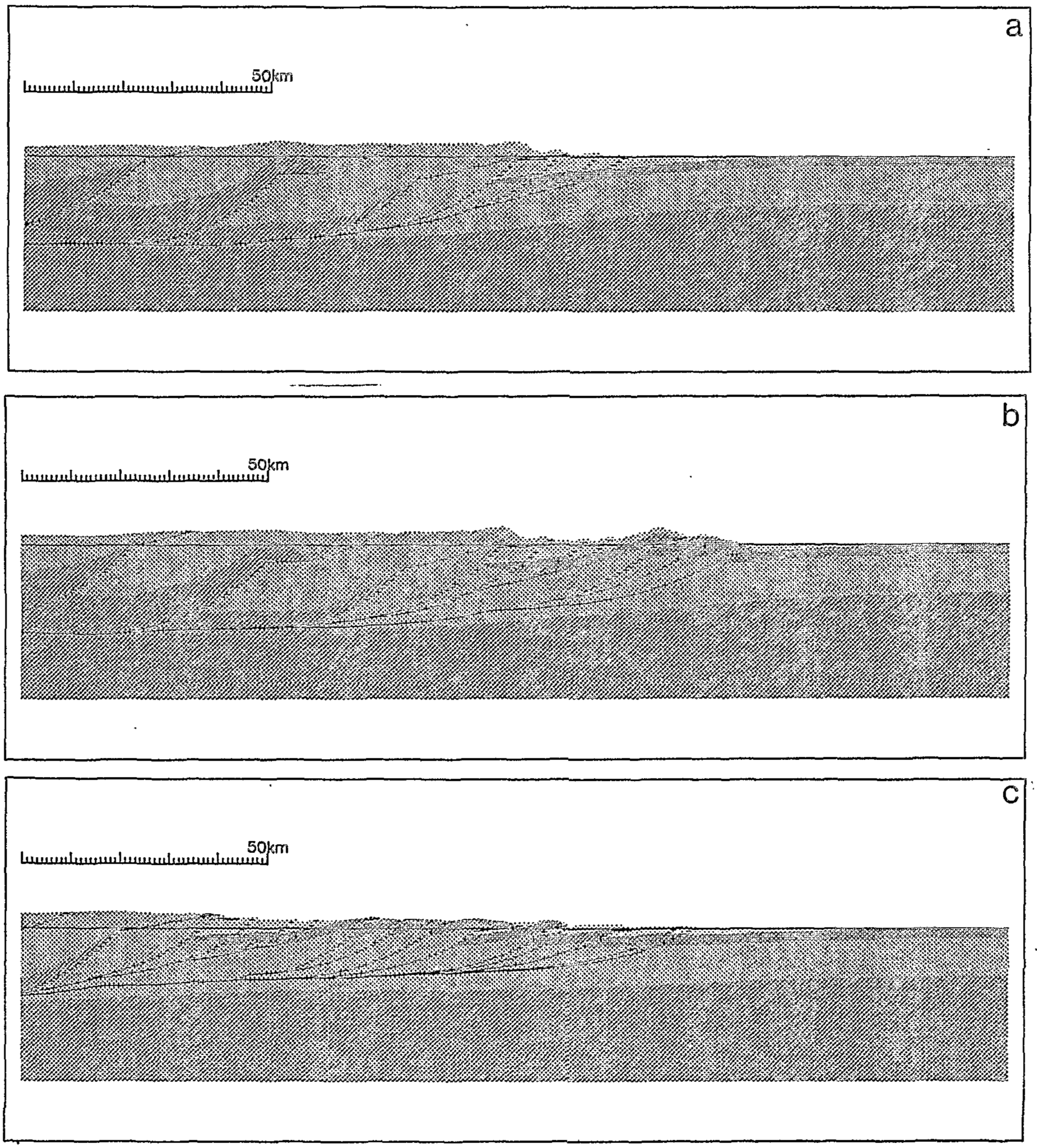

figure 4