THE EVOLUTION OF DEFORMATION AND TOPOGRAPHY OF THE CENTRAL ANDES

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RESUMEN: La deformación y topografía de los Ande Centrales fueron investigados usando un modelo visco-plástico depende de la temperatura de la placa Sud Americana. El modelo predica la topografía solamente en los casos que toman en cuenta que la region bajo del Altiplano se debilita con la temperatura .

Extended Abstract

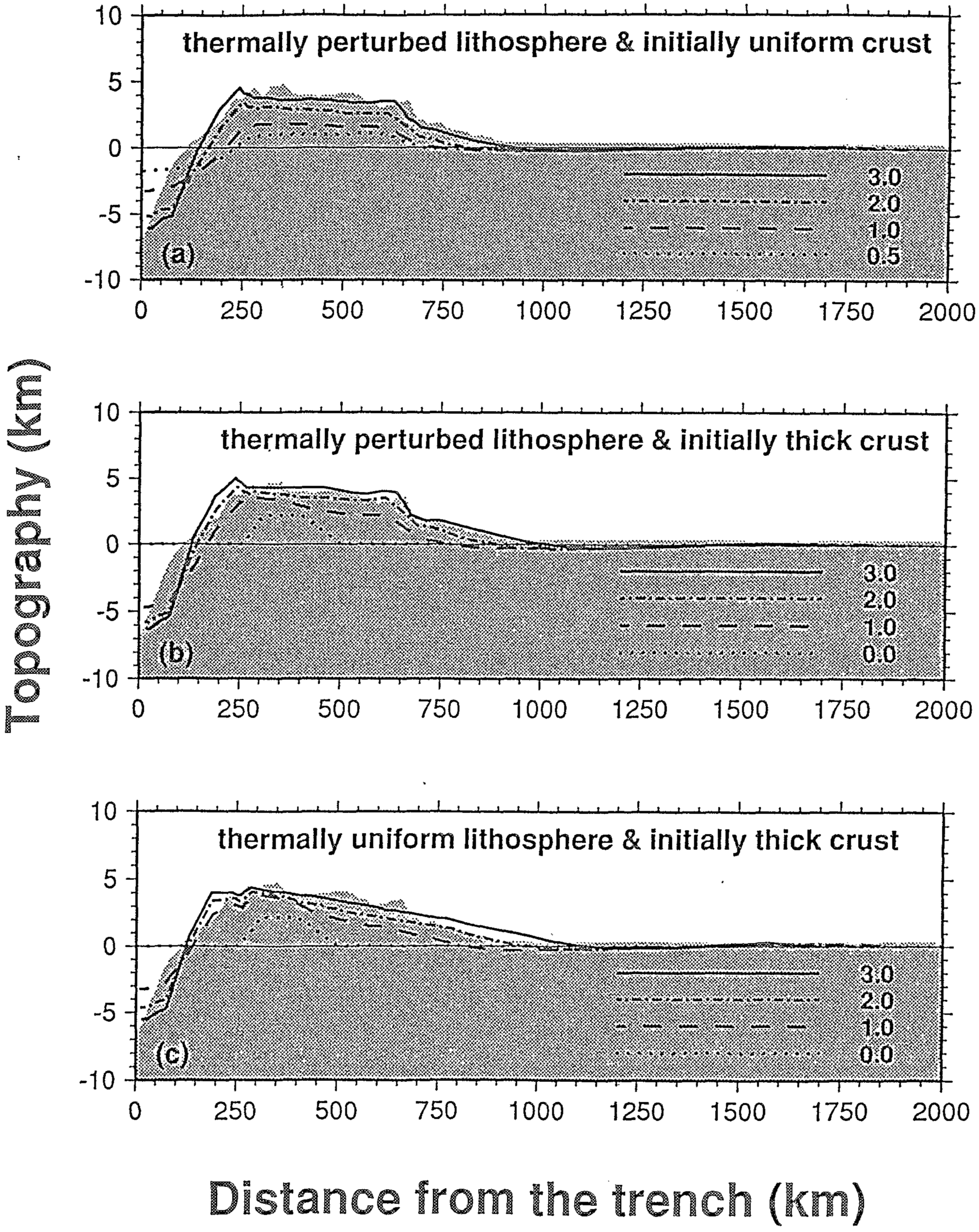
The central Andean topography is characterized by a wide elevated plateau flanked in the west by a steep slope that descends into the deep Chilean Trench and in the east by a gentle slope that subsides gradually toward the Brazilian Shield. The low elevated trench topography is dynamically supported, whereas the high Andean mountain topography is mostly isostatically supported by a thick crust. The last mountain building phase, which thickened the crust and formed the present-day Andes, began 26 m.y. ago, in the Late Oligocene, with the increase of the convergence rate between the Nazca and the South American plates. The time evolution of the Andean deformation and topography is investigated by applying a temperature dependent visco-plastic flow model of continental lithosphere to the South American plate.

The model predicts the observed present day topography profile across the Central Andes, from the trench across the high Altiplano plateau to the Brazilian Shield (Figure 1). Numerical results, combined with observations of the spatial and temporal distribution of igneous activity in the Central Andes, lead to the conclusion that the Altiplano developed and extended to its present width of 400 km as a result of thermal weakening of the lithosphere since Late Oligocene until present. The model also predicts the observed eastward migration of the locus of the Andean crustal deformation with time (Figure 2). At early stages of the deformation, both the crustal and mantle locus of deformation lie in the thermally weak region, which results in crustal thickening in this finite region. At later stages, as the crust thickens, it induces buoyancy forces of larger magnitude, which resist crustal thickening beyond 65 km, and as a result the locus of crustal deformation migrates eastward. The detachment of the crustal locus of deformation from that of the mantle can explain the observed change in deformation pattern from thick-skinned tectonism during early stages of the deformation to thin-skinned tectonism during the more recent stages.

Figures

Fig. 1. A comparison between the characteristic observed topographic profile (shaded) and calculated topographic profiles. (a) Evolution of a thermally perturbed lithosphere that initially has a 35 km thick uniform crust. (b) Evolution of a thermally perturbed lithosphere that initially has 50 km thick crust above the wedge tip (300-400 km from the trench). (c) Evolution of a lithosphere with initially thick crust (same as in b) without thermal perturbation.

Fig. 2. Calculated topography, crustal structure, normal strain rate, and shear strain rate during the initial and final stages of the Central Andes mountain building phase. The locus of compressional deformation of the mantle lithosphere is localized near the wedge tip at all time steps. However, the compressional deformation of the crust diffuses with time and its locus migrates inland and is accompanied by a significant shear component concentrated in the weak lower crust.


thermally perturbed lithosphere & initially uniform crust
(a)
3.0
2.0
1.0
0.5
thermally perturbed lithosphere & initially thick crust
(b)
3.0
2.0
1.0
0.0
thermally uniform lithosphere & initially thick crust
(c)
3.0
2.0
1.0
0.0
10
5
0
-5
-10
0
250
500
750
1000
1250
1500
1750
2000
Topography (km)
Distance from the trench (km)

Fiq. 1

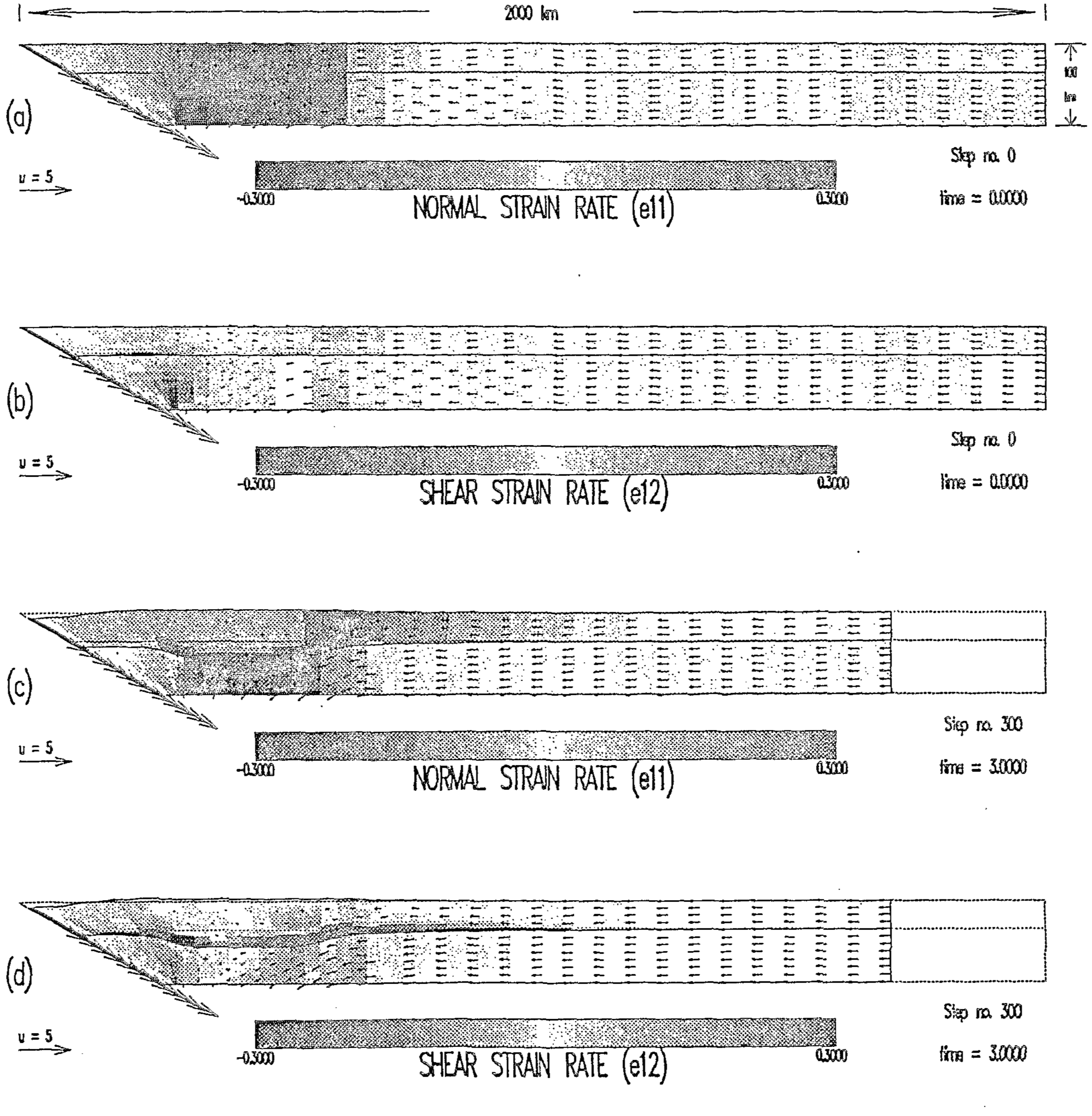

2000 km
100 km
(a)
u = 5
-0.3000
0.3000
NORMAL STRAIN RATE (e11)
Step no. 0
time = 0.0000
(b)
u = 5
-0.3000
0.3000
SHEAR STRAIN RATE (e12)
Step no. 0
time = 0.0000
(c)
u = 5
-0.3000
0.3000
NORMAL STRAIN RATE (e11)
Step no. 300
time = 3.0000
(d)
u = 5
-0.3000
0.3000
SHEAR STRAIN RATE (e12)
Step no. 300
time = 3.0000

Fig. 2