Tectonic erosion in the Central Andes: Use and abuse

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INTRODUCTION

It has long been realized that, north of 36° s.l., the locus of andean magmatism has shifted inbord with time. Tectonic erosion is the main mechanism usually invoked to explain this migration: loss down the subduction zone of 200 to 250 km wide forearc continental crust north of 27° since the Jurassic (several authors) and of 85 km at 34° since the Miocene, the latter during two peaks at 19-16 and 7-3 Ma (Kay et al, 2005).

Most of the additional support in favour of tectonic erosion is provided by geochemical data, such as the eastward increase in REE, K and Ti, registered in the Jurassic mantel-derived andesites from the northern section (Kramer, 1997), and in other source-region contaminants recognized in both the Holocene calc-alkaline volcanic chain of the former area, as well as in the arc at 34° (Stern, 1991; Kay et al, 2005).

How reliable, however, are the assumptions on which these rates of tectonic erosion are based?

TECTONIC EROSION, FACTS AND THEORY

The 18°-27°S segment

According to von Heune and Ranero (2003), the seismic profiles available west of Mejillones peninsula are indicative of reactivated subducting plate grabens infilled by rocks squeezed down from the upper plate. They point out that because of limited knowledge regarding **sediment composition/distribution in both slope and trench, the volume of eroded upper plate material is poorly constrained.** Lamb and Davis (2003), suggest that these plate toe materials may rise back to the surface through a sort of cryptic, reflector-poor accretionary prism. If this recycling does not occur, they claim that the eroded rocks would still "not have the same lubricating effect as the well-stratified and finer-grained trench sediment fill that has smoothed out oceanic basement topography before being subducted". This "dry subduction channel" would thus promote the high boundary shear stress they feel is needed to "support" the Altiplano. Yañez and Cembrano (2003), on the other hand, claim that, "during the Tertiary, the northern segment of the Andean convergence zone shows a stronger coupling due to the older subducting plate at the trench and the slowdown in the convergence velocity". Enhanced coupling would imply a "larger downward bending and extension of the forearc region and at the same time larger compression in the arc-foreland".

Mid to Late Jurassic extension and generation of the 10 km thick pile of bimodal volcanic rocks in the present Coastal range (the "volcanic arc" of most authors) may not have needed such flexural bending. It has been linked to an interaction with episutural rift systems well preserved towards the SSE, in Argentina ("marginal rifting" of Godoy, 2004). The Jurassic arc-trench gap, which account for much of the arc migration may thus have been greatly exaggerated.

Recent extensive erosion of the continental margin is recorded by the progressive truncation of the Coast Range watershed divide north of 20° (Quezada, J. and Cerda, J., 2003), yet no signs of on going arc migration are recognized at those latitudes. Moreover, as Lamb and Davis point out for the northern sector, "it is unclear from the position the Neogene volcanic arc...whether there has been any net trench migration in the last 25 Ma".

The story at 34°

The 85 km of forearc loss calculated by Kay et al (2005) at this latitude are based on "present-day SVZ analogues according to the premise that similar magmas and structures evolve in similar settings"(constant 300 km wide arc-trench gap and subducting plate dip north. A late analysis of that paper (for which I apologize) raises, however, the following objections:

.- No unique volcanic arc was built during the Oligocene. Magmatic activity, mainly explosive and sub-aqueous, took place inside several extensional basins that were inverted prior and during construction of a superimposed, not a 35 km eastward "reestablished" Miocene arc, both events slightly diachronical (Godoy et al., 1999, Jordan et al., 2001).

.- 50 km of arc migration did take place during the latest Miocene to Pliocene. It is, however, a tricky business to ascertain the amount due to fore-arc loss and the percentage of apparent migration linked to crustal thickening. Both late Miocene westward back-thrusting along the Chilean foothills south of 33° as well as deeply rooted late Pliocene to Pleistocene out-of-sequence thrusts along the Argentinean Frontal range may account for part of the shift.

CONCLUSIONS

Most of the regional geology based evidence for tectonic erosion along the northern half of the chilean active margin is not reliable: width of the Jurassic arc-trench gap may have been exaggerated because of marginal rifting, truncation of Palaeozoic structures may actually reflect either a former oblique subduction or later strike-slip translation and part of the migration of volcanic arcs may be apparent, actually related to events of crustal shortening .

Detailed seismic profiles and geochemical data in favour of subduction erosion are, however, now available. They still provide mainly qualitative evidence, hopefully just the first step towards a better understanding of the rates of tectonic erosion.

References

Godoy, E., 2004. On marginal rifting and controls of tectonic inversion during the construction of the Chilean-Argentinian Andes. IAVCEI General assembly. Pucón. (CD, poster 7b/33).

Godoy, E., Yáñez, G., Vera, E., 1999. Inversion of an Oligocene volcano-tectonic basin and uplifting of its superimposed Miocene magmatic arc in the Central Chilean Andes: first seismic and gravity evidences: Tectonophysics, 306, 217-236.

Jordan, T., Burns, M., Veiga, R., Pángaro, F., Copeland, P., Kelley, S., Mpodozis, C., 2001. Extension and basin formation in the southern Andes caused by increased convergence rate: A mid-Cenozoic trigger for the Andes. Tectonics, 20 (3) 308-324.

Kay, S., Godoy, E., Kurtz, A. 2005. Episodic arc migration, crustal thickening, subduction erosion and magmatism in the south-central Andes. Bulletin of the Geological Society of America, v.117, 1/2, 67-88.

Kramer, W., 1997. The Mesozoic magmatic arc in northern Chile: chemical evolution of Jurassic volcanic successions. Actas 7° Congreso Geológico Chileno, 2, 1329-133, Antofagasta.

Lamb, S. & Davis, P, 2003. Cenozoic climate change as a possible cause for the rise of the Andes. Nature, 425: 792-797.

Quezada, J. & Cerda, J., 2003. Incisiones transversales profundas en la Cordillera de la Costa del Norte Grande de Chile: ¿Erosión de un alto topográfico al oeste del Gran Acantilado Costero? Décimo Congreso Geológico Chileno, Proceedings (CD).

Stern, C., 1991. Role of subduction erosion in the generation of Andean magmas. Geology, 19; 78-81.

Von Huene, R. & Ranero, C. 2003. Subduction erosion and basal friction along the sediment starved convergent margin off Antofagasta Chile. Journal of Geophysical Research, 108; NO.B2, 2079, doi:10. 1029/2001JB001569.

Yañez, G. & Cembrano, J., 2004. Role of viscous plate coupling in the late Tertiary Andean tectonics Journal of Geophysical Research, 109, B02407, doi:10.1029/2003J B002494,