THE WEST-ARGENTINE PRECORDILLERA: A PALAEOZOIC BACK ARC BASIN

Werner P. LOSKE

Institut für Allgemeine und Angewandte Geologie
Luisenstr. 37, 80333 München 2, Germany

RESUMEN

Los sedimentos cambro - devónicos de la Precordillera exponen la evolución de parte del margen occidental del Gondwana en el Paleozoico. Las modas detríticas, características geoquímicas y el patrón de tierras raras de las psamitas ponen de manifiesto la evolución de un sistema de margen continental supuestamente pasivo a uno activo. El análisis de minerales pesados señalan un significante cambio gradual en la litología del área de aporte desde un origen cratónico reciclado hasta la exhumación del basamento cristalino. Nuevos datos geoquímicos de lavas sinsedimentarias (almohadilladas), permiten su identificación como basaltos originados en un rift de back arc. Todos los datos presentados conducen a la descripción de un modelo geotectónico que explica la secuencia sedimentaria de la Precordillera como correspondiente a una cuenca tipo back arc.

KEY WORDS: Argentine Precordillera, back arc, detrital modes, REE, heavy minerals

BACKGROUND

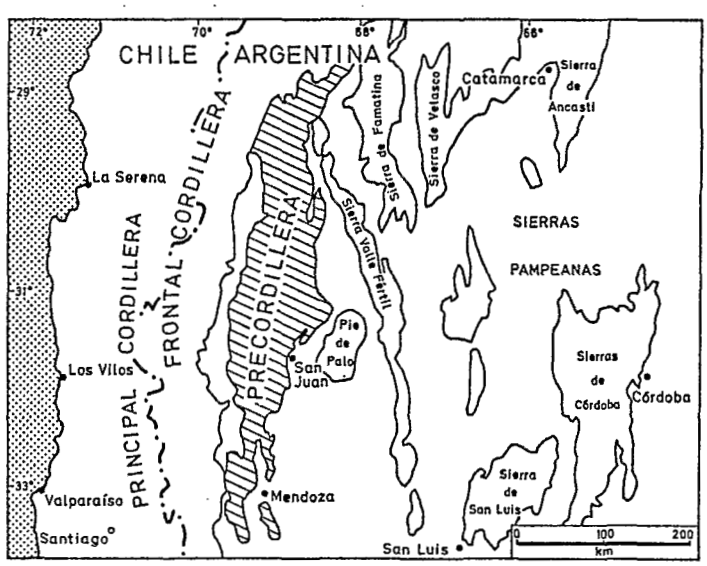


Fig. 1
Geographical location of the Argentine Precordillera

The Precordillera delineates an elongate, some 600 km long N-S striking orogenic belt north of the city of Mendoza (fig. 1). During Cambrian and Early Ordovician times a carbonate platform developed at the eastern margin of the basin, whereas the sediments further west are represented by marine siliciclastics. Non-carbonate sediments of regionally variable thickness were deposited in the whole basin beginning in the Mid-Ordovician.

The geotectonic evolution of the Precordillera has been discussed controversial by many authors. Baldis et al. (1984) believe that the Precordillera developed along a

passive continental margin on continental crust. A similar model emphazising the autochthony of the Precordillera is discussed by González Bonorino and González Bonorino (1991). Ramos et al. (1986) and Ramos (1988) described the Precordillera as a separate Palaeozoic terrane, that developed between the Pampeanas terrane in the east and a Chilenia terrane to the west along an active continental margin. Due to the magmatic arc of the Pampean Ranges in the east of the Precordillera basin, at least the Devonian sediments are interpreted by Ramos (1988) as a fore arc sequence. The inferred Devonian collision of the Chilenia terrane with the Pampean ranges allows for ceasing subduction. Dalla Salda et al. (1992 a, b) describe for the entire western margin of Gondwana a series of microcontinent collisions (slivers from eastern Laurentia) with the South American Continent.

THE PRECORDILLERA's EVOLUTION: ARGUMENTS

Detrital mode analysis sensu Dickinson and Suczek (1979) indicates for nearly all Ordovician-Devonian sandstone samples a passive continental margin environment. Only some of the Devonian sandstones display a "dissected arc" provenance, indicative for an active continental margin environment.

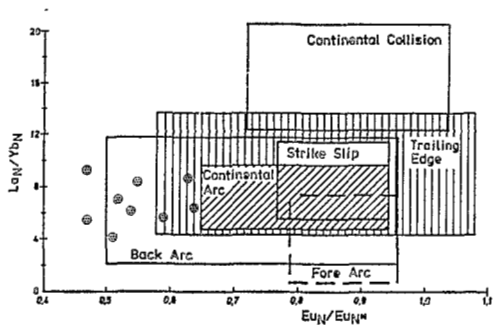


Fig. 2
REE fractionation (La_N/Yb_N) versus Eu-anomaly of the Precordillera sandstones (discrimination fields after McLennan et al. (1990))

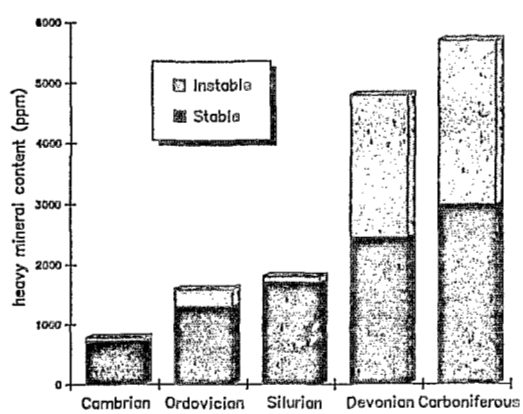


Fig. 3
Mean heavy mineral content of the stratigraphic units
stable minerals: zircon, tourmaline, rutile
"instable" minerals: apatite, epidote, garnet, titanite, zoisite

Environment normalized multielement pattern of the Precordillera sandstones show the flattest pattern if normalized to the mean element concentrations recommended by Bhatia (1983) for a continental island arc.

The rare earth element fractionation (La_N/Yb_N) and the Eu-anomaly show the typical pattern of "trailing edge" or "back arc" regions (fig. 2) if compared with the recommended values of McLennan et al. (1990).

The heavy mineral content of the Cambrian-Silurian sediments is reduced to the stable minerals zircon, tourmaline and rutile (fig. 3). Within the Devonian sediments a remarkable increase of quantity and variability of heavy minerals can be detected (e.g. apatite, epidote, garnet, titanite and zoisite).

Deducing from zircon morphologies, part of the Devonian heavy mineral spectra derived from granitoid source rocks. U-Pb dating of these zircons revealed a crystallization age of about 1100 Ma (Loske 1992 a, b).

Geochemical analyses of synsedimentary pillow basalts (Loske 1992 a) show a typical MORB pattern with an increase of Ba, Th and Nb, due to greywacke contamination of the lavas (Pearce 1983). Deducing from the low $^{87}Sr/^{86}Sr$ initial ratio of approx. 0.705, these rocks are typical nearly uncontaminated back arc rift basalts.

THE PRECORDILLERA's EVOLUTION: MODEL

The oldest sediments reported from the Precordillera region are by Lower/Early Middle Cambrian calcareous and siliciclastic strata (fig. 4 a). Because of the Cambrian magmatism and metamorphism in the Pampean Ranges (Bachmann et al. 1985, 1987) an active continental margin system which evolved during the earliest Cambrian/Precambrian due to subsidence of cold and heavy oceanic crust is the assumed starting condition for the proposed evolution of the Precordillera.

The siliciclastic slope facies documented in Mid-Cambrian/Lower Ordovician sediments in the western parts of the Precordillera basin and the easterly carbonate platform (fig. 4 b) demonstrate stable, continuous subsidence of the basin.

A severe cut in the sedimentation history of the Precordillera is observed in the Middle/Late Ordovician. Firstly the carbonate platform drowned, and secondly synsedimentary pillow lavas were extruded, signalizing the opening process of the back arc basin (fig. 4 c). Because there are no synsedimentary basalts known at least in the Silurian sediments, the opening phase of the back arc basin with formation of oceanic crust can be reduced to some 15-30 Ma. The volcanic arc which should have bordered the western margin of the Precordillera basin is not documented in the Precordillera region due to the problem of outcrop depth. Within the Famatina System, representing the northward prolongation of the Precordillera, the volcanic arc is today already exhumed (Clemens et al. 1992, Mannheim and Miller 1992). Contemporaneously to the rapid extension tectonics in the Precordillera, metamorphism in the Pampean Ranges shows retrograde characteristics and the magmatism is no longer subduction related (Rapela et al. 1990).

The Silurian is still documented by a "crustal stretching" regime (fig. 4 d). Graben and half graben structures (e.g. Villicum Graben) formed along the eastern and probably at the western margin of the Precordillera basin, whereas the central part of the basin remained rather stable and morphologically high, documented by omissions, condensed sedimentation and fine grained sediments. Tectonic activity in the hinterland and beginning erosion of granitoid provenance lithologies is documented by conglomerates containing many granitoid cobbles (Loske 1992 a). Sediments assigned to the Silurian on the western side of the basin are mostly fine grained because of the protection effect of the central Precordillera high.

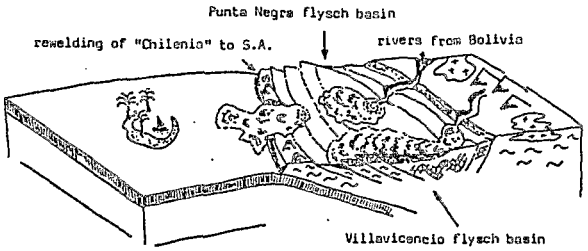
The Devonian sediments display a flysch-like character indicating orogenic activity (folding) in the hinterland and the Precordillera itself (fig. 4 e). This deformation, accompanied by slight metamorphism, mainly in the western Precordillera, seems to be related to crustal compression processes produced by an eastwards dipping subduction zone to the west of the Precordillera basin (v. Gosen 1992). After closure of the whole basin Permocarboniferous sediments of mostly continental character covered many parts of the early Precordillera.

ACKNOWLEDGEMENTS

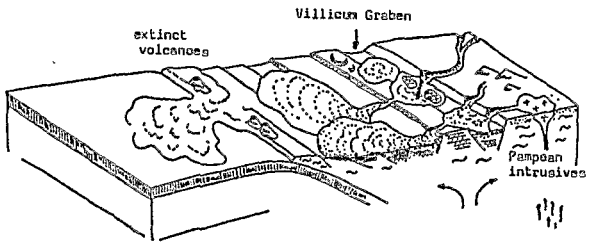
I like to express my thanks to Dr. Osvaldo Bordonaro (now Mendoza) and Dr. Silvio Peralta (San Juan) for their kindly help during fieldwork in September 1988. The Deutsche Forschungsgemeinschaft (DFG) supported field and lab work by a grant (Lo 373/2-1,2).

Fig. 4

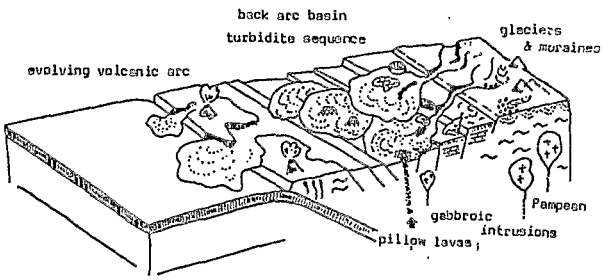
Cartoons displaying the geological evolution of the Precordillera



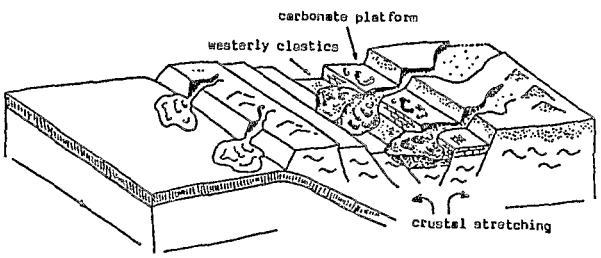
a. Early Cambrian:
initial crustal stretching along the (?) passive continental margin of Gondwana, a continental basement sliver ("Chilenia") is rifting off (see text for further discussion)



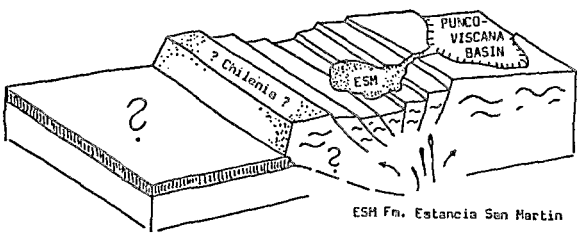
b. Mid Cambrian - Early Ordovican:
formation of a geosynclinal basin with a carbonate platform along the eastern margin an a siliciclastic submarine fan facies to the west; definite indications of subduction in the Pampean Ranges east of the Precordillera



c. Mid Ordovican - Late Ordovician
formation of "oceanic crust" (pillow basalts) in the central Precordillera; drowning of the carbonate platform; overall siliciclastic, partly glacigenic sedimentation; possible formation of an active island arc at the western margin of the Precordillera back arc basin



d. Silurian
submarine fan sedimentation in the western Precordillera basin; formation of graben-like structures along the eastern margin (e.g. Villicum Graben) due to continuous crustal extension



e. Devonian
flysch-like sedimentation related to orogenic closure of the Precordillera back arc basin forced by the rewelding of "Chilenia" to South America

REFERENCES

BACHMANN, G., GRAUERT, B. AND MILLER, H., 1985, Isotopic dating of polymetamorphic metasediments from Northwest Argentina: Zbl. Geol. Paläont. Teil I, 1985 H.9/10, p. 1257-1268.

BACHMANN, G., GRAUERT, B., KRAMM, U., LORK, A. AND MILLER, H., 1987, El magmatismo del cambrico medio/cambrico superior en el basamento del noroeste Argentino: investigaciónes isotópicas y geochronológicas sobre los granitóides de los complechos intrusivos de Santa Rosa de Tastil y Cañani: X Congreso Geologico Argentino, Tucumán 1987, Actas Tomo IV, p. 125-127.

BALDIS, B., BERESI, M., BORDONARO, O. AND VACA, A., 1984, The Argentine Precordillera as a key to Andean Structure: Episodes, 7(3), p. 14-19.

Bhatia, M.R., 1983, Plate tectonics and geochemical composition of sandstones: Journal of Geology, 91, p. 611-627.

CLEMENS, K., KURY, W., LOSKE, W., MANNHEIM, R., NEUGEBAUER, H., MILLER, H. AND TOSELLI, A., 1992, Geodynamische Entwicklung des paläozoischen Gondwana-Randes in West-Argentinien (Präkordillere, Famatina-System): 13. Geowissenschaftliches Lateinamerika-Kolloquium Münster 1992, abstr.

DALLA SALDA, L., CINGOLANI, C. AND VARELA, R., 1992 a, Early Paleozoic orogenic belt of the Andes in southwestern South America: Results of Laurentia-Gondwana collision ?: Geology, 20, p. 617-620.

DALLA SALDA, L.H., DALZIEL, I.W.D., CINGOLANI, C.A. AND VARELA, R., 1992 b, Did the Taconic Appalachians continue into southern South America ?: Geology 1992, Vol. 20/12, p. 1059-1062.

DICKINSON, W.R. AND SUCZEK, C.R., 1979, Plate tectonics and sandstone composition: AAPG, 63(12), p. 2164-2182.

GONZALEZ BONORINO, G. AND GONZALEZ BONORINO, F., 1991, Precordillera de Cuyo y Cordillera Frontal en el Paleozoico temprano: terrenos 'bajo sospecha' de ser autóctonos: Revista Geológica de Chile, Vol. 18/2, p. 97-107.

GOSEN, W. VON, 1992, Paleozoic tectonics in the Precordillera (Argentina): 13. Geowissenschaftliches Lateinamerika-Kolloquium Münster 1992, abstr.

LOSKE, W.P., 1992 a, The West-Argentine Precordillera: a lower Palaeozoic back arc basin ?: in: Conferencia Internacional Paleozico inferior de Ibero-America, Mérida, Abstracts, p. 96-97.

LOSKE, W.P., 1992 b, Sedimentologie, Herkunft und geotektonische Entwicklung paläozoischer Gesteine der Präkordillere West-Argentiniens: Münchner Geol. Hefte, 7, pp. 155.

MANNHEIM, R. AND MILLER, H., 1992, Sistema de Famatina, NW-Argentina: acreción de un arco volcánico en el borde occidental del Gondwana en el paleozoico inferior: in: Conferencia Internacional Paleozoico inferior de Ibero-America, Mérida, Abstracts, p. 102-103.

MCLENNAN, S.M., TAYLOR, S.R., MCCULLOCH, M.T. AND MAYNARD, J.B., 1990, Geochemical and Nd-Sr isotopic composition of deep-sea turbidites: Crustal evolution and plate tectonic associations: Geochim. Cosmochim. Acta, 54, p. 2015-2050.

PEARCE, J.A., 1983, Role of the sub-continental lithosphere in magma genesis at active continental margins, in: Pearce, J.A. and Norry, M.J. eds., Continental basalts and mantle xenoliths, p. 231-249.

RAMOS, V.A., 1988, The tectonics of the Central Andes; 30^0 to 33^0 S latitude: Geological Society of America Special Paper, 218, p. 31-54.

RAMOS, V.A., JORDAN, T.E., ALLMENDINGER, R.W., MPODOZIS, C., KAY, S.M., CORTES, J.M. AND PALMA, M., 1986, Paleozoic terranes of the Central Argentine - Chilean Andes: Tectonics, 5(6), p. 855-880.

RAPELA, C.W., TOSELLI, A., HEAMAN, L. AND SAAVEDRA, J., 1990, Granite plutonism of the Sierras Pampeanas; An inner cordilleran Paleozoic arc in the southern Andes, in Kay, S.M. and Rapela, C.W., eds., Plutonism from Antarctica to Alaska: Geological Society of America Special Paper 241, p. 77-90.