Are the La Pampa Gneisses remnants of the Chilenia basement?

Javier Álvarez*, Constantino Mpodozis*, Antonio García-Casco*, Idael F. Blanco-Quintero* and Diego Morata

1 Departamento de Geología, Fac. de Cs. Físicas y Matemáticas, Universidad de Chile, Plaza Ercilla 803, Santiago, Chile.
2 Antofagasta Minerals, Apoquindo 4001, Santiago, Chile.
3 Departamento de Petrología y Mineralogía, Universidad de Granada, España.
4 Instituto Andaluz de Ciencias de la Tierra (IACT, CSIC-UGR), España.
5 Departamento de Geociencias, Universidad de Los Andes, Bogotá, Colombia.
6 Centro de Excelencia en Geotermia de Los Andes (CEGA), Universidad de Chile, Chile.

* E-mail: javalvar@cec.uchile.cl

Abstract. The La Pampa Gneisses (LPG) form a small outcrop of leucocratic gneisses embedded within the late Paleozoic-Triassic Chollay Batholith to the east of Vallenar (Chile). The LPG was previously considered one of the few preserved remnants of the Chilenia basement (accreted to the Gondwana margin in the Devonian). Zircons collected from these rocks show inherited cores with highly variable U/Pb ages and two principal peak of ca. 301 Ma, interpreted as the age of zircons in the protolith; and a younger peak at ca. 263 Ma, probably record the age of a metamorphic episode, related to a regional Permian intrusion event. Calculated P-T conditions show that peak conditions took place at ca. 780 ºC and 5.3 kbar. These new data indicate that the LPG were emplaced and metamorphosed during the late Paleozoic, attesting that they are not relics of the Chilenia basement.

Keywords: Chilenia, U/Pb, Zircon, Geothermobarometry.

1 Introduction

During most part of the Paleozoic a variety of allochthonous terranes (Pampia, Famatina, Arequipa-Antofalla and Cuyania) were amalgamated to the stable Río de la Plata and Amazonia cratons (Fig. 1). The latest terrane to become part of Gondwana was the hypothetical Chilenia terrane (Ramos et al., 1986; Fig. 1), which accreted to the western margin during the Devonian (ca. 395 Ma; Davis et al., 2000; Willner et al., 2011). However, unlike other terranes such as Pampia or Cuyania (Ramos, 2009; 2010), the outcrops attributed to Chilenia are scarce and there is no direct evidence for its original affiliation. The Guarguaraz Complex, that occur close to Mendoza, Argentina (Fig.1) has been interpreted as an accretionary wedge developed between Chilenia and Cuyania during the Devonian (Willner et al., 2011 and references therein). Chilenia seems to have bounded to the west by late Paleozoic subduction originated after its collision with Gondwana (Hervé, 1988; Fig. 1), which probably include the El Tránsito Metamorphic Complex located in the Frontal Cordillera, east of Vallenar (Ribba et al, 1988; Álvarez et al., 2011).

One of the scarce outcrop attributed to Chilenia is Las Yaretas Gneisses (Keppie and Ramos, 1999). However, López de Azarevich et al. (2009) locate them as part of Cuyania basement.

Figure 1. Map of tectonostratigraphic terranes of Central Chile and Argentina (Ramos, 2009). In black, outcrops of the main metamorphic complexes. TMC: El Tránsito Metamorphic Complex, LPG: La Pampa Gneisses, GC: guarguaraz Complex, LPAC: Late Paleozoic Accretionary Complexes.

Another unit attributed to Chilenia is the Filo Gris Complex (Astini and Cawood, 2009; Fig. 1), in the Frontal Cordillera of La Rioja, Argentina. Finally, the only one outcrop attributed to Chilenia basement in Chile
corresponds to the La Pampa Gneisses (LPG; Ribba et al., 1988; Moscoso et al., 2010). According to Ribba et al. (1988), these rocks form a 2 km in diameter, subcircular enclave within late Paleozoic granitoids of the Chollay Batholith in the El Tránsito valley, east to Vallenar (Fig. 1). The LPG are surrounded by a migmatitic aureole including metamorphic fragments in a tonalite to granodiorite neosome (Ribba et al., 1988) similar to the late Paleozoic granitoids surrounding the metamorphic enclave (Mpodozis and Kay, 1992). The LPG are light colored rocks with alternating biotite-rich and quartz-feldspathic bands. Their mineralogy includes quartz, plagioclase and biotite plus muscovite and also sillimanite and cordierite. Ribba et al. (1988) suggested that they were “probably derived from a granodioritic protolith”. One of the reasons to suggest that the LPG could be part of the basement of Chilenia is a Silurian (415±4 Ma) three point whole rock Rb/Sr isochron age reported by Ribba et al. (1988). Two K/Ar ages (muscovite: 239±10 Ma, biotite: 236±6 Ma) together with a 246±18 Ma Rb/Sr whole rock-muscovite-biotite isochron were considered, by the same authors, as the product of a younger Triassic thermal event.

To check more carefully, the possible affinities of the LPG with the Chilenia basement it is necessary to employ more penetrative geochronological methods including zircon U/Pb dating. In this contribution, we present new zircon U/Pb age data for the LPG and some of the surrounding plutons together with petrological (geothermobarometric and P-T path calculations) data for the LPG in order to evaluate its potential adscription to Chilenia.

2 New data from the La Pampa Gneisses

Geochronology: Figure 2 show the probability density plot of sample JA05, considered to be representative from the LPG. The analyzed sample is a banded gneiss formed by plagioclase, quartz, biotite, muscovite, cordierite and sillimanite. Ages of individual zircon grains extend from the Mesoproterozoic to the Permian. The oldest zircons (Mesoproterozoic, Cambrian, Ordovician and Silurian) are doubtless inherited. The largest populations are late Paleozoic, and include two peaks at 301 (Carboniferous) and 263 Ma (Permian). Carboniferous ages come from zircons with euhedral and prismatic habit that suggest an igneous origin either “in situ” or, if they were detrital zircons, a source very close. Permian ages come instead from the rims of grains with evidence of crystallization, thus showing that would, have been, most likely related to a Permian metamorphic event.

Geothermobarometry: The P-T evolution of LPG sample JA05 was evaluated by means of an isochemical PT projection (pseudosection) using the bulk chemical analysis of the sample, obtained by ICP-OES. Calculations were performed for the KNCFMASHT system using Perple_X software (Connolly, 2005). The pseudosection shows a field formed by sillimanite, biotite, plagioclase, cordierite, garnet, quartz and melt, similar to the peak metamorphic assemblage of the sample. This modelling, and the fact that sillimanite is strongly deformed, whereas quartz and plagioclase are not, suggest that partial melting occurred during prograde metamorphism. The isopleths of observed mineral composition intersect in the stability field of the observed assemblage. Using these data the peak metamorphic conditions are estimated at ca. 780 °C and ca. 5.3 kbar. Considering that the closure temperature in zircon U/Pb system is over 900 °C (Lee et al., 1997), we conclude that Carboniferous (ca. 301 Ma) ages of LPG correspond to the protholith age.
3 U/Pb ages from late Paleozoic and Triassic intrusives

Along with the analysis in the LPG, we analyzed two samples from the Chollay Batholith from localities north and east of the LPG outcrops. The first corresponds to a hornblende-biotite tonalite sample from an large pluton (termed here as La Totora pluton) that intruded the LPG north of the El Tránsito river. This sample (JA01) yield a 266.1±3.5 Ma (Fig. 2) crystallization age, concordant with the age obtained in recrystallized borders within the LPG zircons. The second sample (JA02) corresponds to a coarse grained leucocratic “pink” granites that from large outcrops to the east and were attributed by Mpodozis and Kay (1992) to the Chollay intrusive unit of the Chollay Batholith. This sample has a crystallization age of 247.7±3.4 Ma and is slightly older than another U/Pb age (242.5±1.5 Ma) reported, for the same pluton by Martin et al. (1999), south to the study area. Both ages attest the occurrence of a regional Triassic intrusive. These are older than the K/Ar reported by Ribba et al. (1988) for the LPG that probably correspond to regional colling ages.

4 Discussion and Conclusions

The outcrops of La Pampa Gneisses have been considered as a potential candidate to be the only preserved relict of the Chilenia basement in Chile (Ribba et al., 1988). Nevertheless, the maximum age (ca. 301 Ma) of igneous emplacement indicated by LPG zircon cores, is younger than the time considered as the age of accretion of Chilenia to Gondwana (ca. 395 Ma; Davis et al., 2000). The data presented here rules out the possibility that LPG are remnants of the Chilenia basement. The La Pampa Gneisses were formed after the time of Chilenia collision to Gondwana.

The metamorphic episode can be linked, as shown by the age of zircon rims, to the intrusion of tonalite-granodioritic phases of the Chollay Batholith during the Permian. By contrast, the younger Triassic intrusive event extensively developed to the east, was unable to alter the balance of the mineral phases.

Aknowledgments

This work was supported by Conicyt doctoral thesis and Departamento de Postgrado y Postítulo, Universidad de Chile grants, Fondecyt Project 1080468, Chile and MICINN Project CGL2009-12446, Spain.

References


Martin, M., Clavero, J., Mpodozis, C. 1999. Late Paleozoic to early Jurassic tectonic development of the high Andean Principal Cordillera, El Indio Region, Chile (29-30° S). Journal of South American Earth Sciences 12, 33-49.


