GEOCHRONOLOGIC SYNTHESIS OF THE PIEDRA ALTA TERRANE, URUGUAY.

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INTRODUCTION

The Piedra Alta Terrane located in the Río de la Plata Craton (figure 1), Uruguay, does not show evidences of Neoproterozoic orogenesis (deformation, metamorphism or granite generation). Magmatic rocks of different age, composition and environmental settings predominate in all the terrane (Fernández y Preciozzi, 1974; Bossi y Navarro, 1988; Dalla Salda et al., 1988; Bossi et al., 1993; Preciozzi, 1993).

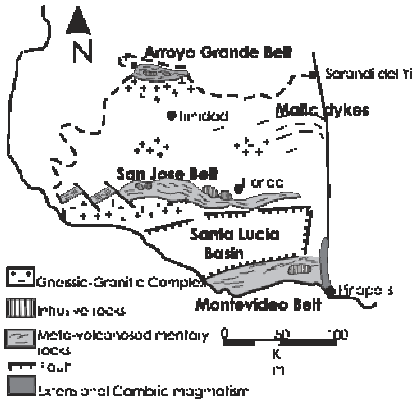

Figure 1. Location map of the Piedra Alta Terrane

The first geochronologic studies performed in the PAT (Piedra Alta Terrane) were done applying Rb-Sr and K-Ar methodologies. Later the studies were increased, basically in the last 5 years, due to the works made by several investigators, together with the data yielded in the framework of the Conicyt 6009 Project "El Cinturón Dom Feliciano y sus Relaciones con el Craton del Río de la Plata y el Terreno Punta del Este – Geología y Geocronología" (Preciozzi & Peel, 2005). It is worth noting that only thirty one whole rock Rb-Sr determinations were available until 1998 (Hart, 1966; Umpierre and Halpern 1971; Cingolani et al., 1990; Preciozzi and Bourne 1992; Cingolani et al., 1997).

These former datings were grouped in three age intervals by Preciozzi et al (1999) of 1.7 - 1.9 Ga (17%); 1,9 -2,2 Ga (64%) and greater to 2.2 Ga (19%). Also, K - Ar cooling ages indicated a range between 1.93 and 2.16 Ga. Besides, it was determined that the extensive cluster of mafic dykes, that represents the last magmatic activity associated to the PAT, has Ar-Ar ages of 1780 ± 30 Ma (Bossi et al., 1993) and U-Pb age of 1790 ± 5Ma (Halls et al., 2001).

Only two ages in the PAT are outside those ranges, the La Paz Granite with a Rb-Sr age of 545 ± 15 Ma (Umpierre & Halpern, 1971) and the Solis Granite with a Pb-Pb age of 584 ± 13 Ma (Oyhantcabal, 2005). Nevertheless, granitoids of these ages have been recognized in the other two great geotectonic domains of Uruguay (Central and Atlantic domains sensu Preciozzi y Peel, 2005; and Masquelin, 2006) as a result of cambrian magmatogenesis.

Within the first period in the geochronology of Uruguay, other bodies were dated like the Cerro Colorado granitoid (Cingolani et al., 1990) yielding a Rb-Sr age (Whole Rock) of 2071 ± 70 Ma. In addition, Cingolani et al. (1997) presented a Rb-Sr isochron for the Isla Mala area, obtaining an age of 2067 ± 201 Ma (Ri = 0.7010) and of 2016 ± 108 Ma (Ri = 0.7002) for the Carreta Quemada area. It is important to notice that in these two last datings the error was very high. Also, the AFE quarry migmatites, next to Suárez town in the departament of Canelones, show Rb-Sr (WR) age of 2233 ± 107 Ma with Ri = 0.7020 and Rb-Sr (WR) age of 2176 ± 146 Ma with Ri = 0.7090 for the deformed granodiorite (Bossi et al, 1993). The only geochronologic data available for the Montevideo Belt (sensu Bossi et al., 1993) was a Rb-Sr age of 1990 ± 32 Ma with Ri = 0.7008 ± 0.0006 corresponding to the Parque Rodó quarries (Cingolani et al., 1997) that could be related to intense deformational phenomena.

Moreover, the first datings conducted in the Arroyo Grande Belt (Preciozzi and Bourne, 1992) presented some differences with respect to other regions within the PAT. For example, in the Marincho Complex, leucogranitic dykes gave a Rb-Sr (WR) age of 1969 ± 25 Ma (Ri = 0.734); the main unit leucogranite yielded a Rb-Sr (WR) age of 2067 ± 24 Ma (Ri = 0.719) and the main granodiorite 2291± 65 Ma, (Ri = 0.714). The last datum according to some authors, should not to be considered. The Sur Granite with an age of 2180 ± 50 Ma (Ri = 0.709) shows consistent values with those defined for the area. Nevertheless, the dating of associated granitic blocks to the Paso del Lugo fault of 2544 ± 38 Ma, Rb-Sr (WR), Ri = 0.7073, could be suggesting the presence of archean crust in the area at that time, completely eroded nowadays.

After 1998, an important amount of geochronologic data is generated, mostly using U-Pb SHRIMP and

conventional methodologies. In 1999, Bossi et al. obtained U-Pb ages of 2074 ± 6 Ma and 2068 ± 12Ma in the Amarelle Quarry (Isla Mala granodiorite in San José Belt). Then, Hartmann et al. (2000) studying the same body obtained an U-Pb SHRIMP age of 2065 ± 9 Ma. According to Hartmann et al., (op. cit.) the region has remained undisturbed after the granodioritic magma crystallization. This age of ca. 2.07 Ga represents an important event of the Transamazonic cycle in Uruguay.
Later, Hartmann et al. (2001) performed a second dating of the Amarelle Quarry obtaining an U-Pb age of 2076 ± 6 Ma. In the same year, Bossi et al. (2001) using U-Pb SHRIMP obtained an age of 2145 ± 21 Ma in a metarhyolite belonging to Paso Severino formation in San José Belt.
From the datings available by Rb-Sr (WR) systematics Preciozzi et al., (1999) obtained a regional isochron of 2094 ± 28 Ma with Ro = 0.70174 ± 0.00009, being interpreted as the age of the metamorphic event that can be recognized in all the PAT. During the years 2001 to 2003, new geochronologic studies were done at the Centro de Pesquisas Geocronológicas, Universidad de Sao Paulo (Brazil), due to the Conicyt 6009 Project. Unlike previous studies, there were applyied U-Pb SHRIMP, conventional and Sm-Nd systematics. The analytical results are presented in table 1 and the concordia and tera diagrams in figure 2.

MODEL AGES

In table 1 are showed the T_{DM} values, the $\varepsilon_{Nd(0)}$ and $\varepsilon_{Nd(TDM)}$ calculated values. The T_{DM} values suggest that the rocks developed in the southern portion of the PAT would not have archean protoliths, being this a clear difference with other regions that constitute the Río de la Plata craton. However, in the north, at the Arroyo Grande area, T_{DM} archean values are obtained in a porfiroblastic hornblendite. The main ranges of T_{DM} values is between 2065.3 to 2565.5 Ma, and of the cristalization ages about 2000 to 2200 Ma, suggesting that the geologic evolution happened in a time interval non greater to 300 Ma between 2.4 - 2.3 Ga (main accretion of its protoliths) and 2.1 - 2.0 Ga (magmatism, metamorphism and deformation).
The $\varepsilon_{Nd(TDM)}$ values calculated for all the samples show positive values between 1.76 to 3.37, pointing out that the rocks were derived from residual solids after magma had been withdrawn earlier being depleted in LILE elements.

FINAL REMARKS

With the available geochronologic data, it can be established a chronology of event attempt:
1) The T_{DM} values and the cristalization ages in the PAT stand for a geologic evolution happened in a time interval of 300 Ma between 2.4 - 2.3 Ga (main accretion of its protoliths) and 2.1 - 2.0 Ga (magmatism, metamorphism and deformation).
2) The PAT represents a juvenile palaeoproterozoic geotectonic unit stable since 1.7 Ga and non affected internally by Neoproterozoic events.
3) The ages around 2200 Ma (San José Belt metamorphites and Montevideo Belt orthogneisses) would point out volcanism in the area. Between 2200 and 2135 Ma would be the crystallization age of metamorphic rocks in the three metamorphic belts.
4) The granitic magma genesis would occur between 2100 to 2053 Ma.
5) A second magmatic event corresponds to a late-orogenic rocks at around 2033 Ma, and melting phenomena that was responsible for migmatitic leucosomes with ages of 2005 Ma.
6) Emplacement of a cluster of mafic dykes around 1,8 to 1,75 Ga. Similar age were obtained in Cerros de San Juan acid metatuff, being unclear its significance.
7) Finally, only two bodies show neoproterozoic – cambrian ages, La Paz and Solís granites.

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RESUMEN

En las Sierras Pampeanas de Córdoba hay dieciséis fajas de deformación dúctil, cuyo significado tectónico permite asignarlas a cuatro grupos. Uno de los cuales, al que pertenece a Faja de Deformación Los Túneles, está integrado por fajas de desenraizamiento postmetamórfico del Orógeno Pampeano cámbrico, de naturaleza inversa, producidas por cizalla general convergente (transpresión), relacionadas con etapas colisionales póstumas del terreno Pampia contra el margen de Gondwana y con la subducción famatiniana.

Nuevos datos radimétricos obtenidos por el método K/Ar en anfíboles y micas permiten acotar mejor la actividad tectónica de la faja, que se habría nucleado después del pico metamórfico M2 (*ca.* 534 Ma), desenraizado el orógeno Cámbrico y exhumándolo hasta el Ordovícico temprano (comienzo de la subducción Famatiniana), cuando es emplazada la granodiorita Charquina (474 Ma). El período de actividad tectónica de la FDLT (*ca*. 64 Ma), coincidiría con el acercamiento del terreno Cuyania al margen gondwánico, antes de su emplazamiento y colisión final en el Ordovícico medio-tardío. Al mismo tiempo, en el ámbito pampeano se estarían produciendo las etapas contraccionales finales de la colisión del terreno Pampia con el margen occidental de Gondwana.

Posteriormente, la FDLT se habría enfriado hasta el Silúrico medio, cuando las Sierras de Córdoba y San Luis continuaron su exhumación pasando por la isoterma de la muscovita. Luego de este enfriamiento generalizado, sobreviene la deformación y magmatismo devónicos que afectaron penetrativamente a las Sierras Pampeanas Orientales.

Sample	**Lithology**	Age U-Pb (Ma)	$\varepsilon_{Nd(0)}$	T_{DM} (Ma)	$\varepsilon_{Nd(TDM)}$
MA-11	Arroyo Grande hornblendite	---------	-8.13	2993.1	1.76
URPR-27	Terruño migmatitic granite	---------	-22.43	2346.4	2.83
URPR-28a	leucosome, migmatite Boca del Rosario	2007 ± 14	-27.23	2276.0	2.96
URPR-28b	melanosome, migmatite Boca del Rosario	---------	-22.63	2415.1	2.70
URPR-29a	migmatitic granite (leucosome)	---------	-37.82	2208.7	3.08
URPR-1	Isla Mala granodiorite	2085.7 ± 11	-20.64	2332.9	2.85
URPR-29b	migmatitic granite (melanosome)	---------	-13.23	2438.2	2.67
URPR-37	Cufré granite	2053 ± 14	-25.07	2218.2	3.06
URPR-51-A	RT/gran.sill.biot.quartzite	---------	-7.43	2442.0	1.79
UPRP-52-A	RT/ porfiritic biot.granodiorite	2011 + 15/-4.9	-29.63	2249.9	3.00
URPR-54	RT/biot.pink granite	---------	-33.16	2293.0	2.92
URPR-60	RT/ Soca	2077.8 ± 7.5	-25.89	2565.5	2.44
URPR-40	San Juan metatuff	1753 +5.7/-4.3			
URPR-44	anfibolic gneiss, San Jose belt	2202 ± 8			
URPR-34	Pajas Blancas porfiritic granite, Montevideo	2158 +24/-23			

Table 1. U-Pb and Sm-Nd analytical results obtained in the Conicyt 6009 Project (Preciozzi & Peel, 2005).

Figura 2.a - Sample URPR 1.

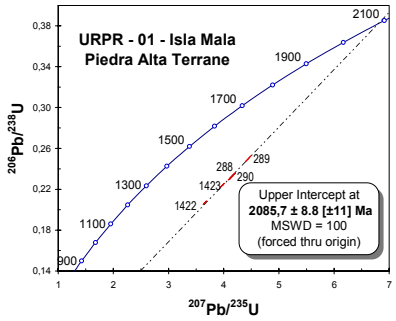

Figura 2.b – Sample URPR-37.

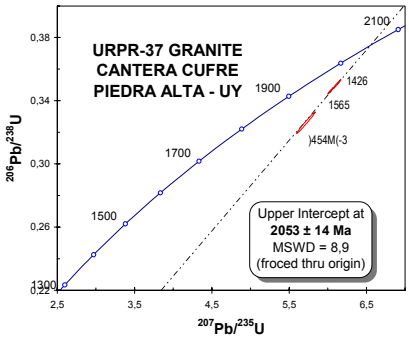

Figura 2.c – Sample URPR-44.

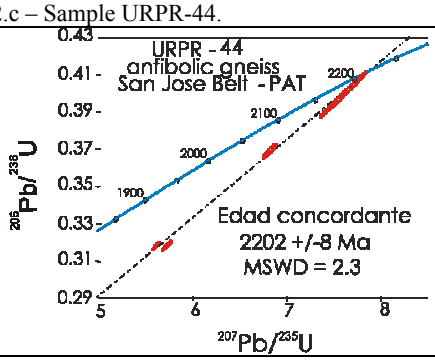

Figura 2.d – Sample URPR-40.

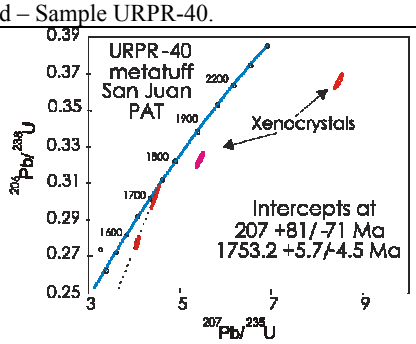

Figura 2.e – Sample URPR-60.

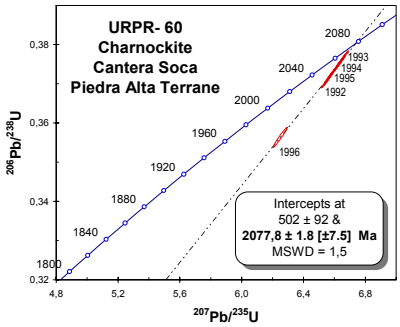

Figura 2.f – Simple URPR-34 (SHRIMP).

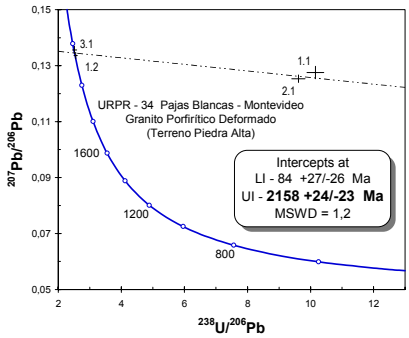

Figura 2.g – Simple URPR-52.

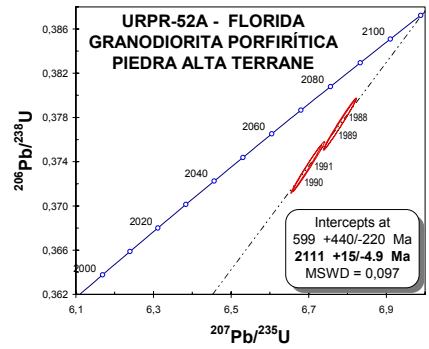

Figura 2.h – Sample URPR-28.

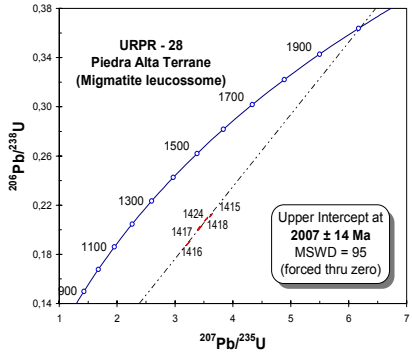

Figure 2. Concordia and Tera diagrams of some samples from the PAT.