RADIOMETRIC DATING OF IGNEOUS ROCKS FROM SIERRAS PAMPEANAS, ARGENTINA

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ABSTRACT In this paper new radiometric dates on igneous rocks (K-Ar method) are given. They confirm the threefold subdivision in the major areas of Sierras Pampeanas, suggested by Linares and La Torre for paleozoic magmatic cycles in the provinces of Córdoba and San Luis; the older cycle during Cambro-Ordovician times, the intermediate during the Devonian, and the younger one during the Carboniferous.

RESUMO Novos dados radiométricos obtidos pelo método K-Ar, permitem que seja reconhecida divisão triplíce no Paleozóico das Sierras Pampeanas da Argentina, correspondente aos ciclos magmáticos datados por Linares e La Torre. O primeiro deles ocorre no Cambro-Ordoviciano e o segundo, no Carbonífero. Entre eles outro ciclo Devoniano também ocorre.

INTRODUCTION During the last twenty-five years, some scientists (Harrington, 1956; González Bonorino, 1950 and others) considered both metamorphic and intrusive rocks outcropping in the whole area of Sierras Pampeanas as Precambrian in age. However, many years before, Rassmuss (1918) and Bonarelli and Pastore (1918), divided without field evidences the magmatic activity in two cycles, one of Precambrian age, the other, Paleozoic (Devonian). This opinion was flung up until radiometric dates re-opened the problem.

Kittl (1965), Linares (1968), Stipanovic and Linares (1969), Linares and La Torre (1969) and Halpern *et al.* (1970) exhibit radiometric dating of some igneous rocks from several localities of Sierras Pampeanas. The results could not establish a Precambrian activity, although the results obtained between 500-550 m.y. (K-Ar method) might suggest that the rocks could be Precambrian in age. Moreover, metamorphic basement dates (Rb-Sr method) given by Halpern *et al.* (1970) offer lower Paleozoic ages, specially reported from the southern hills in Córdoba and San Luis Provinces. Three magmatic cycles were then determined: 1st. between 450-520 m.y.; 2nd. corresponding to 350-380 m.y. and 3rd., the younger, 300-330 m.y. old.

Later on, González (1971) and González *et al.* (1971) determined the chronological position of additional granitic rocks in some distant places of the Sierras Pampeanas, as Sierra de Ancasti, Sierra de Velasco and Cumbres Calchaquies. Dates given by Kittl (1965) for granites of San Luis and by Caelles (1971) for similar rocks in Catamarca are also suggestive.

In more recent times, the present authors analyzed several samples from other localities such as the southwestern hills of the Province of La Rioja (Sierras de Los Llanos, Chepes and Malanzán), the southeastern slope of the Sierra de Aconquija (Province of Tucumán) and so made M. Cabrera (personal communication) in Sierra del Cajón (Province of Catamarca). All the new results confirm the ideas of Linares and La Torre about the Paleozoic magmatic cycles.

RESULTS AND DISCUSSION In Table I the ages of rocks from several localities are listed; the samples dated by the authors are marked with (*). The order of tabulation shown

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gives the values from the youngest to the oldest rocks. In the author's opinion, it is possible to group the results as follows:

- 1) An old magmatic cycle between 540-400 m.y.;
- 2) An intermediate cycle between 395-350 m.y., and
- 3) A younger one between 345-330 m.y.

Table 1 — Radiometric ages of the igneous rocks

Sample	Description and Locality	Method	Mineral	Age in m.y.	Laboratory	Reference
LZ-001	Porphyritic granite, Biale Massé, Cba	Pb/a	zircón	246 ± 25	3	3-4
LZ-019	Granite, Km 83-Pampa de Achala-Cba	Ar/K	biotite	250 ± 10	2	4
LZ-001	Porphyritic granite, Biale Massé, Cba	Ar/K	muscovite	301 ± 10	2	4
LZ-128	Granite — Cantera Giobelli, La Toma, San Luis	Ar/K		303 ± ?	5	4
	Granite — La Toma, San Luis	Ar/K		303 ± ?	5	1
2132	Granite — Rio Arenal, Aconquija, Tuc.	Ar/K	biotite	305 ± 10	1	(*)
LZ-008	Porphyritic granite — Capilla del Monte, Cba	Ar/K	muscovite	307 ± 10	2	4
AC-S13	Granite — San Ignacio — Aconquija, Tuc.	Ar/K	muscovite	310 ± 15	2	(*)
AC-S13	Granite — San Ignacio — Aconquija, Tuc.	Ar/K	biotite	319 ± 10	2	(*)
2132	Granite — Rio Arenal — Aconquija, Tuc.	Ar/K	muscovite	320 ± 9	1	(*)
AC-LP5	Granite — Los Pinos — Aconquija, Tuc.	Ar/K	biotite	321 ± 10	2	(*)
LZ-055	Porphyritic granite — Capilla del Monte, Cba	Sr/Rb	whole rock	325 ± 25	4	4
LZ-001 B	Aplitic granite — Biale Massé, Cba	Ar/K	muscovite	328 ± 15	2	4
LG-S01	Porphyritic granite — Los Gigantes, Cba	Ar/K	muscovite	329 ± 15	2	4
LZ-001	Porphyritic granite — Biale Massé, Cba	Sr/Rb	whole rock	330 ± 25	4	4
LZ-012	Granite — Rio Yuspe, in the way from Tanti to Taninga, Cba	Sr/Rb	whole rock	330 ± 25	4	4
LZ-019	Granite — Pampa de Achala way Cba	Sr/Rb	whole rock	330 ± 25	4	4
LZ-064	Porphyritic granite — A° Las Mojaras, Cba	Sr/Rb	whole rock	330 ± 25	4	4
LZ-066	Granite — Km 72, Pampa de Achala way, Cba	Sr/Rb	whole rock	330 ± 25	4	4
LZ-068	Granite — Km 108 — Pampa de Achala way, Cba	Sr/Rb	whole rock	330 ± 25	4	4
AC(LAJ)2	Granite — Cumbre Las Lajas, S. Aconquija	Ar/K	muscovite	330 ± 10	2	(*)
LZ-014	Porphyritic granite — Characato, Cba	Ar/K	muscovite	331 ± 15	2	4
LZ-032	Granite — La Posta, Pampa de Achala way, Cba	Pb/a	zircon	332 ± 30	3	4
LC-V01	Ore vein — Los Condores, Concarán, San Luis	Ar/K	muscovite	334 ± 10	2	4
121	Granite — Volcán, San Luis	Sr/Rb	whole rock	338 ± 15	2	2
128	Granodiorite — La Totorá, San Luis	Sr/Rb	whole rock	338 ± 15	2	2
AC-LP4	Granite — Los Pinos, Aconquija, Tuc.	Ar/K	muscovite	338 ± 10	2	(*)
VQ(CPB)2	Granite — Campo Pampa Belén — S. Vinquis	Ar/K	biotite	339 ± 10	2	(*)
LZ-020	Granite — Km 20 W from Icho Cruz, Pampa de Achala, Cba	Ar/K	muscovite	345 ± 15	2	4
LP-EC1	Pegmatite — El Criollo, Tanti, Cba	Ar/K	muscovite	350 ± 30	6	4
LP-SJ1	Pegmatite — San José — El Mallín Cba	Ar/K	biotite	352 ± 25	2	4
Z-1	Porphyritic granite — Cuesta de Zapata — Cat.	Ar/K	biotite	355 ± 15	1	(*)
AC-S12	Granite — San Ignacio, Aconquija, Tuc.	Ar/K	muscovite	359 ± 15	2	(*)
LZ-043	Diorite — Las Tunas, Cosquín, Cba	Ar/K	biotite	368 ± 15	2	4
LZ-061	Tonalite — El Diquesite — La Calera, Cba	Ar/K	biotite	370 ± 25	6	4
SC(21)	Granodiorite — Tres Cerritos, S. del Cajón	Ar/K	biotite	373 ± 10	2	(*)
LZ-009	Porphyritic granite — Capilla del Monte, Cba	Pb/a	zircon	373 ± 45	3	4
LN-11	Granite — Tama, Costa del Medio, Los Llanos, La Rioja	Ar/K	biotite	376 ± 9	1	(*)
41	Pegmatite — Cerro Valdivia — San Juan	Ar/K		379 ± ?	7	4
40	Porphyritic granite — Capilla del Monte, Cba	Pb/a		379 ± 40	3	3
LZ-008	Porphyritic granite — Capilla del Monte, Cba	Pb/a	zircon	380 ± 46	3	4
LN-22	Tonalite — Chelco — S. de Chepes, La Rioja	Ar/K	biotite	381 ± 20	1	(*)
BE-1	Granite — Sierra Belén — Cat.	Ar/K	biotite	386 ± 4	1	(*)
AN(AL)2	Granite — El Alto — S. Ancasti	Ar/K	biotite	398 ± 15	2	(*)
LP-C1	Microtonalite — Sierra de Macha, Cba	Ar/K	whole rock	399 ± 6	1	5
LO-2	Granite — Loma Pelada, Cumbres Calchaquies, Tuc.	Ar/K	muscovite	409 ± 12	1	(*)

Table 1 — Radiometric ages of the igneous rocks

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Sample	Description and Locality	Method	Mineral	Age in m.y.	Laboratory	Reference
134	Porphyritic granite — Villa Praga, San Luis	Sr/Rb	whole rock	415 ± 25	4	2
140	Porphyritic granite — Renca, San Luis	Sr/Rb	whole rock	415 ± 25	4	2
141	Granite — Cantera Peña Pintada, San Luis	Sr/Rb	whole rock	415 ± 25	4	2
LN-10	Tonalite — Los Pocitos — S. de Los Llanos, La Rioja	Ar/K	biotite	423 ± 22	1	(*)
VF(SA)7	Granodiorite — San Agustín — S. Valle Fértil	Ar/K	biotite	430 ± 15	2	(*)
LP-33	Microtonalite — S. de Macha, Cba	Ar/K	whole rock	439 ± 21	1	5
LP-32	Microtonalite — S. de Macha, Cba	Ar/K	whole rock	440 ± 21	1	5
LN-21	Granodiorite — Villa Casana, S. de Chepes, La Rioja	Ar/K	biotite	440 ± 7	1	(*)
LN-2	Tonalite — Olpas, S. de Los Llanos, La Rioja	Ar/K	biotite	441 ± 23	1	(*)
V-1	Porphyritic granite — Cuesta de Zapata	Ar/K	biotite	444 ± 6	2	(*)
MAG	Granodiorite — Cuesta de Miranda — S. Famatina	Ar/K	biotite	448 ± 20	(1)	(*)
LZ-005	Diorite — Napa between Charbonier and Ischilín, Cba	Pb/a	zircon	450 ± 50	3	4
LZ-005	Diorite — Napa between Charbonier and Ischilín, Cba	Ar/K	biotite	452 ± 20	2	4
SJ-4	Andesite — S. Ambargasta, S. del Estero	Ar/K	whole rock	452 ± 6	1	6
LN-23	Tonalite — San Antonio, S. de Chepes, La Rioja	Ar/K	biotite	453 ± 24	1	(*)
TV-45	Granite — Mala-Mala, Cumbres Calchaquies, Tuc.	Ar/K	biotite	456 ± 21	1	6
H(LT-1)	Granodiorite — Las Tumanas — San Juan	Ar/K	biotite	456 ± 15	2	(*)
SJ-5	Andesite — S. de Ambargasta, S. del Estero	Ar/K	whole rock	461 ± 22	1	6
SJ-4	Andesite — S. de Ambargasta, S. del Estero	Ar/K	whole rock	461 ± 22	1	6
LU-001	Pegmatite — Sta. Ana, Pringles, Sn Luis	Pb/U I	uraninite	465 ± 15	3	4
44	Porphyritic granite — La Higuera, Cba	Pb/a		465 ± 50	1	3
RS-2	Granite — Rio Sosa, Cumbres Calchaquies, Tuc.	Ar/K	biotite	466 ± 10	1	6
LI-2	Tonalite — La Isabella, Cba	Ar/K	biotite	467 ± 22	1	5
LN-14	Granodiorite — Atilas, Malanzán, La Rioja	Ar/K	biotite	468 ± 12	1	(*)
RS-1	Granite — Rio Sosa, Cumbres Calchaquies, Tuc.	Ar/K	biotite	471 ± 9	1	6
LU-005	Pegmatite — Qda del Tigre, San Javier, Cba	Pb/U Q	uraninite	472 ± 25	3	4
TV-44	Granite — Mala-Mala, Cumbres Calchaquies, Tuc.	Ar/K	biotite	473 ± 22	1	6
LU-004	Pegmatite — Cerro Blanco, San Javier, Cba	Pb/U Q	uraninite	477 ± 25	3	4
TV-39	Granite — Mala-Mala, Cumbres Calchaquies, Cba	Ar/K	biotite	479 ± 9	1	6
SJ-5	Andesite — S. de Ambargasta, S. del Estero	Ar/K	whole rock	479 ± 8	1	5
LU-006	Pegmatite — Angel, San Javier, Cba	Pb/U I	uraninite	480 ± 15	3	4
LU-002	Pegmatite — La Elsa, San Javier, Cba	Pb/U I	uraninite	490 ± 15	3	4
133 D	Turmalinic granite — Villa Praga, San Luis	Sr/Rb		500 ± 20	4	2
137	Granite with garnet — Villa Praga, San Luis	Sr/Rb		500 ± 20	4	2
LZ-004	Porphyritic granite — Ischilín, Cba	Pb/a	zircon	500 ± 50	3	4
AMB-5	Granite — Santa María — S. Ambargasta	Ar/K	biotite	500 ± 15	2	(*)
AMB-2	Granite — Chuña Huasi — S. Ambargasta	Ar/K	biotite	517 ± 15	2	(*)
LZ-054	Granodiorite — Cruz del Eje, Cba	Ar/K	muscovite	520 ± 20	2	4
LU-003	Pegmatite — Las Tapias, Cba	Pb/U I	uraninite	520 ± 20	3	4
G-1	Granite — Guasayán, S. del Estero	Ar/K	biotite	541 ± 8	1	(*)
LI-1	Diorite — La Isabella, S. de Macha, Cba	Ar/K	anfíbol	557 ± 26	1	5

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b) An internal area with the younger rocks: the plutons of Los Pinos and San Ignacio (Province of Tucumán) in the north, and those of La Toma and Los Cóndores (Province of San Luis) in the south; between them, the great batholith of Achala (Province of Córdoba).

c) Two intermediate areas, including the western side of Sierra de Aconquija (Province of Tucumán), Sierras de Belén and Zapata (Province of Catamarca) and a part of Sierra Chica (Province of Córdoba).

CONCLUSIONS 1) According to the radiometric dates made to the present, there is no indication of magmatic activity during Precambrian times in the Sierras Pampeanas.

2) The threefold subdivision suggested by Linares and La Torre (1969) for Paleozoic magmatic cycles is confirmed.

3) The limits referred by these authors can be modified as follows: a) the older cycle: 540-400 m.y.; b) the intermediate one: 395-350 m.y.; c) the younger one: 345-300 m.y.

4) The corresponding magmatic rocks outcrop in three concentric belts, the boundaries of which can not always be well defined by the present lack of additional radiometric ages.

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