$^{40}Ar/^{39}Ar$ DATES IN THE CENTRAL CORDILLERA OF COLOMBIA: EVIDENCE FOR AN UPPER TRIASSIC REGIONAL TECTONOMAGMATIC EVENT

Vinasco, C.J.[1], Cordani, U.G.[1], Vasconcelos, P.[1,2]

[1]Institute of Geosciences, University of São Paulo - Rua do Lago, 562, Cidade Universitária, 05508-900 São Paulo, Brazil; e-mail cesarj@usp.br
[2]University of Queensland, Department of Earth Sciences, Brisbane, Qld, 4072 Australia; e-mail paulo@sol.earthsciences.uq.edu.au

Keywords: $^{40}Ar/^{39}Ar$, Northern Andes, Central Cordillera, Triassic event.

INTRODUCTION

The Coastal, Western, Central and the Eastern Cordilleras constitute four independent mountain ranges in the Northern Andes. The Coastal and Western Cordillera comprises allochthonous oceanic sequences of basic volcanic rocks and marine sediments of Cenozoic and Upper Cretaceous age (Aspden et al., 1987). The so-called Central Cordillera Polymetamorphic Complex (Restrepo and Toussaint, 1982) (Fig. 1), made up the pre-Mesozoic Central Cordillera basement, consists of low through high-grade metamorphic rocks intruded by Meso-Cenozoic batholiths. The Eastern Cordillera is a polydeformed continental mountain range consisting of Precambrian and Paleozoic metamorphic and igneous rocks overlain by Paleozoic to Mesozoic sedimentary covers.

The northern part of the Central Cordillera has been described as a suspect terrain affected by several tectonometamorphic episodes. The most important of them have been always considered those related to the Hercynian orogeny, in Devonian and Carboniferous times, and those occurring at the beginning of the Andean Cycle in the Cretaceous (Restrepo and Toussaint, 1982). A possible Lower Paleozoic and even Precambrian age for the basement of the terrain has also been proposed. Although some indications of a Permo-Triassic event are already available, this period was not considered as of great importance for the geologic evolution of the region. The available radiometric dates in the 200-250 Ma interval, for the Central Cordillera, are as follows:

1. One K-Ar whole rock age for a Granulite of 251±21 Ma. (Restrepo et al, 1991) of the El Retiro group SE of Medellin. However, a K-Ar biotite age of 110±10 Ma. (Toussaint et al., 1978) was obtained for a migmatite rock associated with the same group.

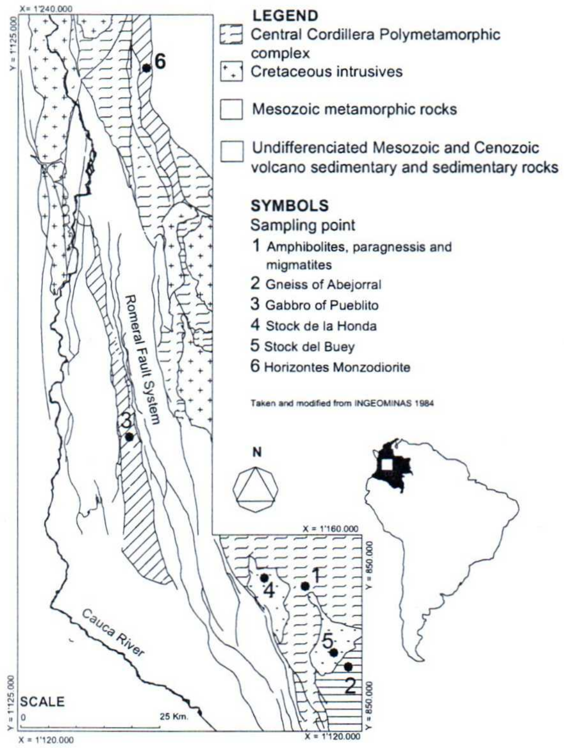

Figure 1. Geological map of study area

2. A Sm/Nd garnet and whole rock age of 226±17 Ma in rocks associated to granulites, SE of Medellin, interpreted as metamorphic ages (Correa and Martins, 2001).

3. K-Ar biotite dates for the Puqui metamorphic complex, occurring north of Medellin, ranging

between 210±11 and 248±10 Ma (Restrepo et al., 1991; Toussaint et al., 1978). However, for the same complex, Rb-Sr whole rock isochrons indicated that the complex may be much older (Restrepo et al., 1991). A metatonalite intruding the Puqui Complex yield K-Ar biotite ages between 211 and 239 Ma (Hall et al., 1972).

4. A K-Ar 215±7 Ma biotite age for the Amagá granite, which is intrusive into low grade metamorphic rocks and has been traditionally interpreted as a post-tectonic intrusion of the Hercynian Cycle (Toussaint, 1995).

5. A K-Ar biotite age of 227±10 Ma for the *stock del Buey* (González, 1980), which intrudes the Paleozoic metamorphic rocks to the south of Medellin.

Moreover, a Triassic event related to the intrusion of the Tres Lagunas batholith at 228 Ma has been described by Litherland et al. (1994) for the Cordillera Real in Ecuador, which is the direct extension of the Central Cordillera of Colombia. According to these authors, during the Triassic, an extensive metamorphic belt affected the mentioned regions, as a response to a megashear associated to anatexis along an ensialic rift basin formed in association with the separation of South America from Laurentia.

We conducted a reconnaissance survey, by the $^{40}Ar/^{39}Ar$ method, on minerals from the terrain of the northern part of the Central Cordillera to investigate the significance of this Triassic tectonomagmatic event. Eight mineral separates, composed of biotite, muscovite, and amphiboles, from two amphibolites, one biotite gneiss, and five magmatic rocks ranging from granodiorite to gabbro were analysed in the newly installed $^{40}Ar/^{39}Ar$ laboratory of the University of São Paulo.

SAMPLING AND EXPERIMENTAL METHODS

The sampling area is located WSW of Medellin, and includes rocks immediately to the east of the Romeral fault system. Additionally, we studied mafic rocks located geographically within the fault system related to the Cauca Ophiolitic Complex. Two amphibolite, one biotite gneiss, one gabbro, one diorite, one monzodiorite, one quartzodiorite and a granodiorite samples were crushed, ultrasoniccated in ethanol, and dried. Ten to fifteen single crystals of hornblende, biotite or muscovite from each sample were picked with metal tweezers, placed in wells in Al-irradiation disks, and irradiated, together with Fish Canyon sanidine fluence monitors, in the IEA-R1 nuclear reactor at IPEN, São Paulo, Brazil. After 2-3 weeks, three grains from each sample were analyzed by the laser incremental heating $^{40}Ar/^{39}Ar$ method at the CPGeo-USP laboratory. Irradiation, analysis, and interpretation procedures follow the methodology presented in Vasconcelos et al. (2001).

RESULTS AND DISCUSSION

METAMORPHIC AGES

Samples CM-45 and CMK 57, from SE of Medellin, are amphibolite rocks interbedded with metasediments (Correa and Martins, 2001). They belong to the El Retiro Group, part of the Central Cordillera Polymetamorphic Complex (Fig. 1). One hornblende grain from sample CMK-45 yields a 231±1 Ma plateau age (Fig. 2), which we interpret as a metamorphic age. The incremental heating results for one hornblende grain from sample CMK-57 yield a plateau-like segment with about 232 Ma age (Fig. 3), also interpreted as a metamorphic age.

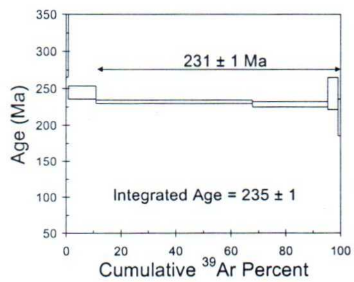

Figure 2. $^{40}Ar/^{39}Ar$ CMK - 45 Amphibole

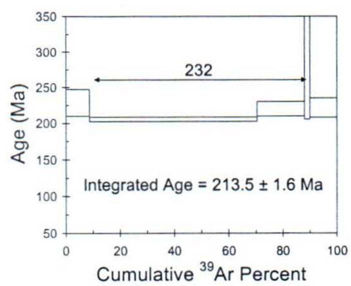

Figure 3. $^{40}Ar/^{39}Ar$ CMK - 57 Amphibole

Sample CJ-32, a medium grade quartzobiotitic gneiss, belongs to the *Intrusivo Gnaissico de Abejorral* (Fig. 1). A 230 Ma $^{40}Ar/^{39}Ar$ plateau-like age for one biotite grain (Fig. 4) is also interpreted to record a metamorphic age because biotite defines the rock foliation. Initial steps in the incremental heating spectrum possibly reflect a re-heating event at about 200 Ma.

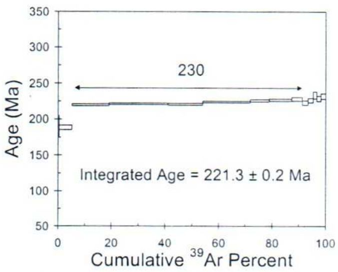

Figure 4. $^{40}Ar/^{39}Ar$ CJ - 32 Biotite

Samples 16 and 21c, an alkaline gabbro and a diorite locally named *Gabro and Diorita de Pueblito* (Fig. 1), are intimately related lithologies. These units have been ascribed to the upper Jurassic-Lower Cretaceous Cauca Ophiolitic Complex, and are hosted within the Romeral fault system, obducted onto the continent during the lower Cretaceous. $^{40}Ar/^{39}Ar$ amphibole plateau ages of 230±3 (not shown) and 224±2 Ma for the gabbro, and 232.6±1.7 and 238.1±1.6 Ma for the diorite (Figs. 5 and 6), are interpreted as metamorphic ages. However a crystallization age is also plausible. The diorite age is slightly higher than the gabbro age, suggesting that the gabbro could represent a late magmatic pulse.

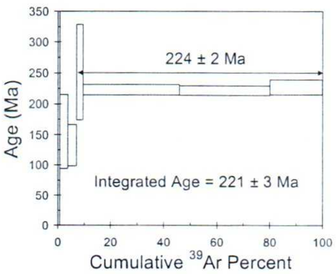

Figure 5. $^{40}Ar/^{39}Ar$ CJ - 16 Amphibole

The $^{40}Ar/^{39}Ar$ results presented here for this mafic sequence suggest that the ophiolitic complex geographically related to Romeral fault system is at least Triassic in age. Models that assume an upper Jurassic-lower Cretaceous age for the ophiolitic complex should be reviewed. Additionally, the Triassic ages obtained imply that these mafic and ultramafic units cannot be part of the Cretaceous Quebradagrande basic volcanic sequence, as previously proposed.

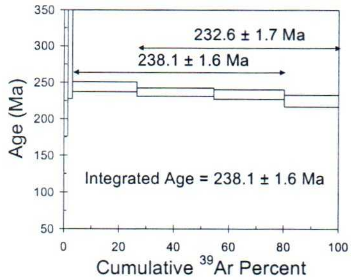

Figure 6. $^{40}Ar/^{39}Ar$ CJ - 21C Amphibole

MAGMATIC AGES

The *stock de la Honda*, sample CJ-24 (Fig. 1), is a quartzodioritic body intrusive in the metamorphic rocks of the ancient Paleozoic metamorphic belt. It is locally foliated by dynamic and protoclastic effects (González, 1980). One biotite grain yields a 218.7±0.3 Ma plateau age (Fig. 7), indistinguishable from the integrated age, which is interpreted as a cooling age related to crystallization.

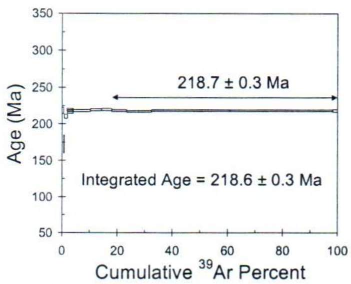

Figure 7. $^{40}Ar/^{39}Ar$ CJ - 24 Biotite

Sample CJ-33, from *El Stock del Buey* (Fig. 1), a cataclastic granodiorite with local mafic faces, yields a disturbed muscovite spectrum. The spectrum displays evidence of argon loss in the initial steps, probably related to a slight alteration or re-heating of the muscovite grains. A 219.3±0.3 Ma plateau age (Fig. 8) is interpreted as a cooling age, reflecting magmatic crystallization. The relative young muscovite and biotite ages obtained for the adamelitic stocks of *El Buey* and *La Honda* suggest that these intrusions are late features in the Triassic thermotectonic event identified in this study. The *stock del Buey* seems to be directly associated to a late deformational phase of the polymetamorphic complex of the Central Cordillera. Its intrusion age dates a deformational event characterized by S1 folding. This deformation event is identifiable by the growth of andalusite crystals parallel to cleavage superimposed on S1 along the contact metamorphic aureoles of the stock (Roldan, 1982).

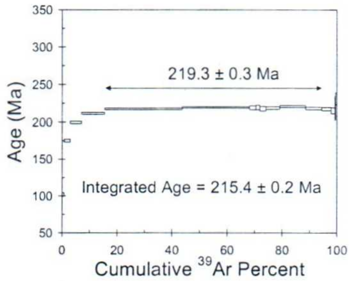

Figure 8. $^{40}Ar/^{39}Ar$ CJ - 33 Muscovite

Sample CJ-12, from the highly deformed Horizontes monzodiorite (Fig. 1), yields very well defined muscovite plateau ages of 207.6±0.3 and 212.3±0.3 Ma (Fig. 9). The plateau ages are indistinguishable from the integrated ages and are interpreted as crystallization ages and not deformation ages because it was obtained a flat and not disturbed $^{40}Ar/^{39}Ar$ spectrum and because of primary character of muscovite crystals.

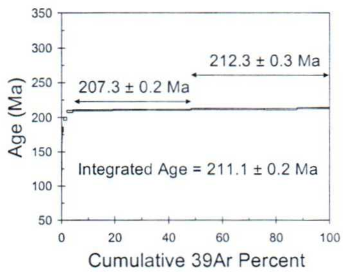

Figure 9. $^{40}Ar/^{39}Ar$ CJ - 12 Muscovite

CONCLUSIONS

$^{40}Ar/^{39}Ar$ ages obtained during the present study indicate an important Triassic event in the northern part of the Central Cordillera of Colombia, Northern Andes. Ages obtained from medium grade quartz biotitic gneisses, pyroxenic gabbros, adamelitic stocks, medium to low pressure amphibolites and diorite-gabbro units clearly mark the importance of this event on this part of the Andean chain. A regional correlation of this Triassic event along the Northern Andes seems to be more plausible with these new $^{40}Ar/^{39}Ar$ results.

ACKNOWLEDGEMENTS

This research was supported by FAPESP. The field work was executed with the cooperation of INGEOMINAS.

REFERENCES

Aspden, J., McCourt, W., Brook, M. 1987. Geometrical control of subduction related magmatism: the Mesozoic Cenozoic plutonic history of Western Colombia. Jour. of the Geol. Soc. London. Vol. 144. P 893-905

Correa, A., Martins, U. 2001. Anfibolitas de la región de Medellín. Tesis de grado. Universidad Nacional de Colombia. 80 p.

González, H. 1980. Geología de las planchas 167 (Sonsón) y 187 (Salamina). Bol. Geol. 23 (1): 174 p.

Hall, R., Alvarez, J., Rico, H. 1972. Geología de parte de los departamentos de Antioquia y Caldas (Subzona IIA) Bol. Geol. 20(1): 1-85.

Litherland, M., Aspden, J., Jemielita, R. 1994. The metamorphic belts of Ecuador. British Geological Survey. 147 p.

Restrepo, J., Toussaint, J., González, H., Cordani, U., Kawashita, K,., Linares, E. Parila, C. 1991. Precisiones geocronológicas sobre el occidente colombiano. Simposio Magmatismo Andino y su marco tectónico. Manizales. Mem. 25 p.

Restrepo, J., Toussaint, J. 1982. Metamorfismos superpuestos en la Cordillera Central de Colombia. V Congreso Latino-Amer. Geol. Argentina. III: 505-512.

Roldan, J. 1982. Contribución al conocimiento tectónico de la Cordillera Central de los Andes Colombianos. VI Congreso Colombiano de Geología.

Toussaint, F. 1995. Evolución geológica de Colombia 2. Triásico- Jurásico. Universidad Nacional de Colombia. Medellín. 94 p.

Toussaint, J., González, H., Restrepo, J., Linares, E. 1978. Edad K/Ar de tres rocas metamórficas del flanco noroccidental de la Cordillera Central. Publ. Esp. Geol. Univ. Nal. Medellín. 14. 7 p.

Vasconcelos, P.M., Onoe, A.T., Kawashita, K., Soares, A.J., Teixeira, W. (2001) 40Ar/39Ar Geochronology at the Instituto de Geociências, USP: Instrumentation, Analytical Procedures, and Calibration. Submitted to *Anais da Academia Brasileira de Ciências*.