

U-Pb ZIRCON AGES AND Nd-Sr ISOTOPES OF THE ALTAVISTA STOCK AND THE SAN DIEGO GABBRO: NEW INSIGHTS ON CRETACEOUS ARC MAGMATISM IN THE COLOMBIAN ANDES

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Keywords: Colombian Andes, arc magmatism, Cretaceous, U-Pb conventional, Nd-Sr isotopes

INTRODUCTION

Mesozoic calc-alkaline plutons intruding high-grade metamorphic basement rocks make up a major part of the Colombian Central Cordillera in the northern Andes. Previous K/Ar and Rb/Sr ages in many of these intrusions were not sufficient to indicate the age of magmatism and relationships between the various plutons.

Amongst such intrusions it is possible to distinguish the Antioquia Batholith, which is the largest Cretaceous granodioritic-tonalitic intrusion of the Central Cordillera, the dioritic to granitic Altavista Stock, and the San Diego gabbro-dioritic intrusion. This study deals with those last two units, which are small intrusive bodies that occur in the vicinities of Medellín.

Previous studies on the Altavista Stock (AVS) and the San Diego Gabbro (SDG) have been carried out by Botero (1963), Restrepo and Toussaint (1984), Rodríguez and Sánchez (1987), Montoya (1987), Preciado and Vásquez (1987), Machado and Salazar (2000) and Ordóñez (2001). Whether or not these intrusions were part of the same magmatic arc remains an unanswered question. Additionally, the sparse geochronological data available from the Altavista Stock and San Diego Gabbro (Restrepo et al., 1991) have pointed out that they are slightly older than the Antioquia Batholith suggesting they could represent a record of the cordilleran Jurassic magmatism.

This study reports the first conventional U-Pb zircon data from the Altavista Stock and the San Diego Gabbro together with new Sr-Nd isotopic results. This study also gathered and re-interpreted former authors isotopic data in order to constrain the crystallization ages of both intrusions.

GEOLOGICAL BACKGROUND

The Altavista Stock and the San Diego Gabbro crop out to the east and west of Medellín, respectively, and are intrude rocks of the Central Cordillera Polymetamorphic Complex (Restrepo and Toussaint, 1982), the Aburrá Ophiolitic Complex, (Correa and Martens, 2000; Correa et al., 2005) and the western portion of the Antioquia Batholith, (Botero, 1963; Ordóñez and Pimentel, 1997), (Fig. 1).

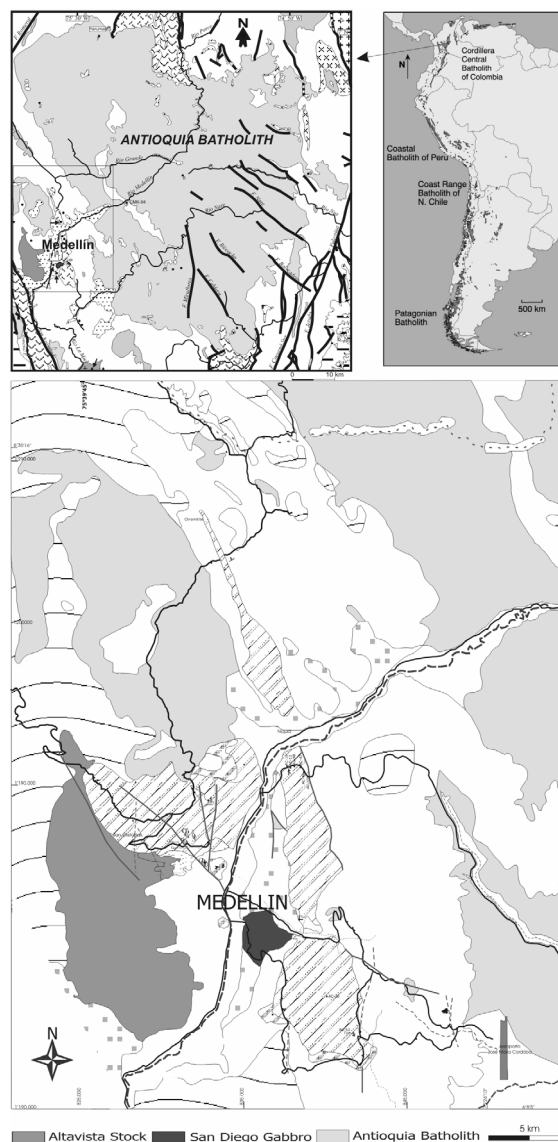


Figure 1. Geological framework of the Northern Sector of the Colombian Central Cordillera with the location of the study area.

THE ALTAVISTA STOCK

This intrusion occupies an area of approximately 83 km² and intrudes the Ancón Schists, Boquerón Amphibolites and the Iguana Gneiss. It exhibits a wide range of textural and compositional varieties. Two main facies can be identified: a felsic facies characterized by granites, granodiorites, monzonites and monzodiorites; and a mafic facies, which is made up of diorites, microdiorites and porphyritic microdiorites (Restrepo and Toussaint, 1984; Rodríguez and Sánchez, 1987; Montoya, 1987; Preciado and Vásquez, 1987).

They are calc-alkaline to alkaline metaluminous to peraluminous rocks. Some authors such as Rodríguez and Sánchez (1987), Montoya (1987), and Preciado and Vásquez (1987) concluded that this intrusion formed from at least two comagmatic pulses. Rodríguez and Montoya (1993) stated that the AVS is a composite pluton bearing a chemical trend compatible with a calc-alkaline mature arc. It shares geological features with a series of plutons such as the Heliconia Diorite, which seem to be structurally controlled by the Romeral Fault (Restrepo and Toussaint, 1984).

Restrepo & Toussaint (1984) stated that the AVS has a Cretaceous age based on Rb-Sr and K-Ar data (96 ± 11 Ma and 77 ± 5 Ma, respectively). Furthermore, research by Restrepo et al. (1991) yielded K-Ar ages of 151 ± 15 and 117 ± 11 Ma, which were interpreted as an overestimate of the intrusion age due to excess argon. On the other hand, Ordoñez (2001) studied Nd and Sr systematics of a mafic rock from the AVS obtaining $\epsilon_{Nd(100Ma)} = +7.37$ and $^{87}Sr/^{86}Sr = 0.70291$, which were interpreted as related to primitive igneous material.

THE SAN DIEGO GABBRO

The SDG is a small gabbro-diorite intrusion which occupies an area of about 6 km². The gabbroic rocks correspond to leuco-gabbros, clinopyroxene-norites, orthopyroxene-norites and minor olivine gabbro-norites. According to Machado and Salazar (2000) the Nd and Sr isotopic data from the SDG can be interpreted as typical of HIMU or PREMA isotopic reservoir.

Restrepo and Toussaint (1984) argued that this intrusion was related to mafic magmatism associated with the Antioquia Batholith. Preliminary mineral chemistry data obtained from an olivine gabbro norite sample indicate that these gabbros are related to an arc-type tectonic setting. (Correa et al., in prep.).

According to Rendón (1999) the SDG intrudes the surrounding gneisses, amphibolites and dunites, however Ordoñez (2001) argued that the contact between gabbro and dunite is tectonic. Restrepo et al. (1991) obtained K-Ar ages of 137 ± 20 and 162 ± 10 Ma, which were interpreted as overestimated, due to the presence of excess Ar.

Whole rock geochemistry data show that dioritic rocks from both AVS and SDG have similar rare earth element patterns, different from those obtained in the gabbros of SDG. It was also observed that AVS granites are enriched in LREE's (Correa et al., in prep.).

SAMPLING AND ANALYSES

Sm-Nd isotopic analyses and ID TIMS U-Pb analyses were carried out at the Geochronology Laboratory of the University of Brasília

U-Pb IDTIMS analyses were performed on zircon aliquots from a diorite and a granite from AVS and a diorite from SDG.

The isotopic data was obtained from two samples from diorites, one from microdiorite and one from granite, which cover the two facies of the AVS. Four gabbro samples have been collected from SDG.

RESULTS

Zircons from an AVS diorite sample yielded a U-Pb concordia age of 96 ± 0.39 Ma (MSWD=1.15), whereas zircons of an AVS granite provided a concordant age of 87 ± 0.53 Ma (MSWD=1.12). On the other hand analysis performed on zircons from a granite sample of SDG yielded a U-Pb concordant age of 94 ± 0.9 Ma (MSWD=0.12).

Nd-Sr systematics on representative AVS samples give $\epsilon_{Nd(96Ma)}$ varying from +7.4 to +9.8 for the mafic facies and $\epsilon_{Nd(87Ma)} = +1.6$ for a sample from the felsic facies. Initial strontium isotopic ratios from AVS's mafic facies ranges from 0.70292 to 0.70456, whereas a sample from the felsic facies gives $^{86}Sr/^{87}Sr = 0.70743$. Analyses of both dioritic and gabbroic facies of SDG produced $\epsilon_{Nd(94Ma)}$ varying from +2.8 to +6.1 and initial strontium isotopic ratios from 0.70326 to 0.70331.

DISCUSSION

The data presented here clearly proves that the Altavista Stock and San Diego Gabbro are indeed Cretaceous intrusions. The data indicate that they are coeval with the intrusion of the Antioquia Batholith (ca. 90-100 Ma), and are not Jurassic or Early Cretaceous as suggested in previous models. The dioritic facies from the AVS and SDG are contemporaneous. The isotopic data from AVS and SDG mafic facies indicate that these rocks represent magmas derived from a strongly depleted mantle, whereas the felsic facies of the AVS represents granite magma originated from mixing between a mafic mantle-derived component and sialic crust-derived component. Based on these data, we conclude that both intrusions are representative of an open magmatic system that remained active during 15 to 20 Ma.

Furthermore, we suggest that the Altavista Stock and the San Diego Gabbro belong to the same magmatic arc, which produced the Antioquia Batholith. In fact, the associated Antioquia Batholith, San Diego Gabbro and Altavista Stock are comparable to the Sierra Nevada Batholith in California and the Coastal Batholith in Peru, which are considered to be composite intrusions related to continental arc magmatism.

ACKNOWLEDGMENTS

This paper is part of the Ana Maria Correa's doctoral thesis, which is being supported by a grant from the Conselho Nacional do Desenvolvimento Científico e Tecnológico (CNPq-Brasil, process 141622/03-2).

The authors wish to thank Milton Alvarez for zircon (Universidad Nacional de Colombia, Medellín) for supplying some of the processed samples.

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RESUMEN

El Stock de Altavista y el Gabro de San Diego son dos plutones pequeños que afloran en el sector norte de la Cordillera Central de los Andes Colombianos, al occidente de la extensa intrusión (~7500 km²) del Cretácico Tardío conocida como Batolito Antioqueño. El Stock de Altavista es un plutón calcoalcalino heterogéneo compuesto de dioritos, microdioritos, monzodioritos, granodioritos y granitos. El gabro de San Diego también es calcoalcalino y consiste de gabros y dioritos.

Fracciones de zircones separadas de un diorito y de un granito del Stock de Altavista arrojaron edades de cristalización U-Pb de 96±0,39 Ma y 87±0,53 Ma respectivamente, mientras que las fracciones de zircones obtenidas de un diorito del Gabro de San Diego dieron una edad de 94 ± 0,9 Ma.

Los valores de $\epsilon_{Nd(96Ma)}$ entre +7,4 y +9,8 para muestras de la facies máfica del Stock de Altavista sugieren que estas rocas se derivaron de un manto fuertemente empobrecido, mientras que el valor de $\epsilon_{Nd(87Ma)} = +1,6$ en una muestra de la facies félsica representa un magma probablemente resultante de la mezcla de un componente máfico derivado del manto con material proveniente de la corteza continental. Los valores de $\epsilon_{Nd(94Ma)}$ de las rocas del Gabro de San Diego varían de +2.8 a +5 y representan material juvenil. Las edades Cretácicas y las características isotópicas demuestran que las dos intrusiones son contemporáneas con el magmatismo que generó el Batolito Antioqueño y sugieren que éstas pueden hacer parte del mismo arco magmático Cretácico. Las variaciones temporales y espaciales observadas en las condiciones magmáticas apuntan para un origen relacionado con diversas fuentes magmáticas e indican que el magmatismo del Cretácico Tardío en la porción norte de los Andes Colombianos no fue tan homogéneo como se pensaba.