Late Miocene garnet-bearing andesites in the Northern Andean Block and their tectonic implications

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Abstract

Garnet-bearing volcanic rocks are extremely rare at convergent margins, with few known occurrences worldwide [ref 1-2]; however, such rocks are common within the late Miocene volcanic rock suite of the Northern Andean block (NAB) along the Central Cordillera, Colombia [ref 3-5]. They have been linked to pre-existing zones of crustal weakness that channeled magmas to the upper crust in a short period of time [ref 5-6]. Here we present new geochronological and petrographic data to constrain the timing and petrogenesis of these unusual rocks. We obtained mineral chemical analyses from 7 porphyritic-andesite samples from the eastern flank of the Central Cordillera and the Cauca-Patia Basin, Colombia. Garnet phenocrysts are almandine in composition, ranging from 23 to 29 wt.% FeO, 6 to 8 wt.% CaO, and 1 to 4 wt.% MnO. In some samples, garnets are homogeneous with no reaction rims and lacking inclusions; however, in other samples, garnets show re-absorption rims and inclusion assemblages similar to the rock matrix (plag, amph, ± bt) as well as rare plagioclase coronas. The high Ca and low Mn contents of the NAB garnet cores are consistent with crystallization at ˜1.2GPa, based on phase equilibrium experiments of [ref 7], while garnet rim assemblages are congruent with a second stage of crystallization at ˜0.8GPa under water-undersaturated conditions. Finally, a pre-eruption dehydration stage is evidenced by the presence of breakdown rims in amphibole crystals. Our new U-Pb in zircon ages reveal that NAB garnet-bearing volcanic rocks formed between 9 and 8 Ma. Taken together, our data suggest a rapid ascent of the NAB magmas associated with the onset of regional volcanism and extension, and possibly the development of the Caldas Tear, a slab window within the Nazca Plate. [1] Green & Ringwood (1968) CMP. [2] Harangi et al. (2001) Journal of Petrology. [3] Orrego (1975) UNAL Colombia. [4] García (1983) UNAL Colombia. [5] Bissig et al. (2017) EG. [6] Weber et al. (2018) SGC (in press). [7] Alonso-Pérez et al. (2006) CMP.

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Introduction

Garnet-bearing volcanic rocks are rare at convergent margins, and few known occurrences have been reported worldwide [1]. However, they are a common feature within the Late Miocene volcanic rock suite of the Northern Andean Block (**NAB**) along the Central Cordillera of Colombia.

Garnets are generally found in porphyritic andesites from the Amagá-Cauca-Patía Basin (**ACPB**).

Our results suggest a rapid ascent of the NAB magmas associated with the development of the Caldas Tear, a possible slab window within the Nazca Plate.

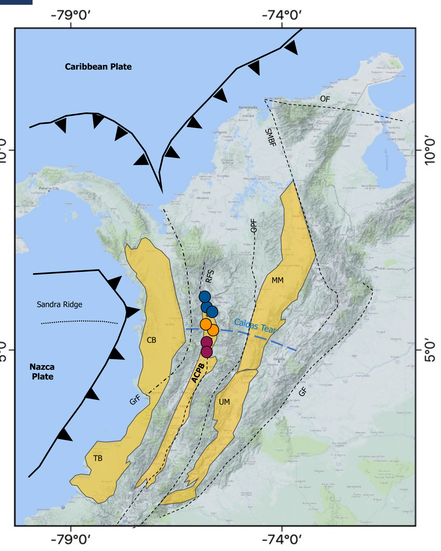


Fig. 1. Geologic setting of northwestern South America. Samples taken in this study. ACPB: Amaga-Cauca-Patia Basin; CB: Choco Basin; MM: Middle Magdalena Valley; GrF: Garrapatas Fault; RFS: Romeral Fault System; OPF: Otu-Pericos Fault; GF: Guicaramo Fault; SMBF: Santa Marta-Bucaramanga Fault; OF: Oca Fault

Motivation question

Is it possible to determine the tectonic scenario underlying the occurrence of garnet-bearing andesites in NAB during the Late Miocene?

Methods

Garnet-bearing andesites were sampled between 1.6˚ N and 6˚ N on the eastern flank of the Central Cordillera and the ACPB (75˚ W).

- Detailed petrographic descriptions.
- Mineral chemical data and transects in garnet phenocrysts (EPMA).
- Zircon U/Pb geochronology, performed by LA-ICP-MS.

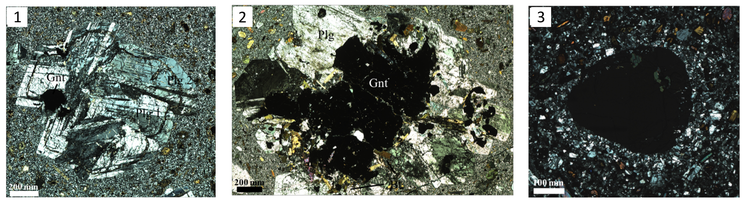
Results

Petrography

Type-1: homogeneous, euhedral to subhedral, no reaction rims and lacking inclusions.

Type-2: slightly zoned, anhedral to subhedral, with reaction rims, and inclusions of plg, hbl and bt.

Type-3: heterogenous, euhedral to subhedral, with reabsorbtion rims and plg coronas.



Results

Mineral chemistry

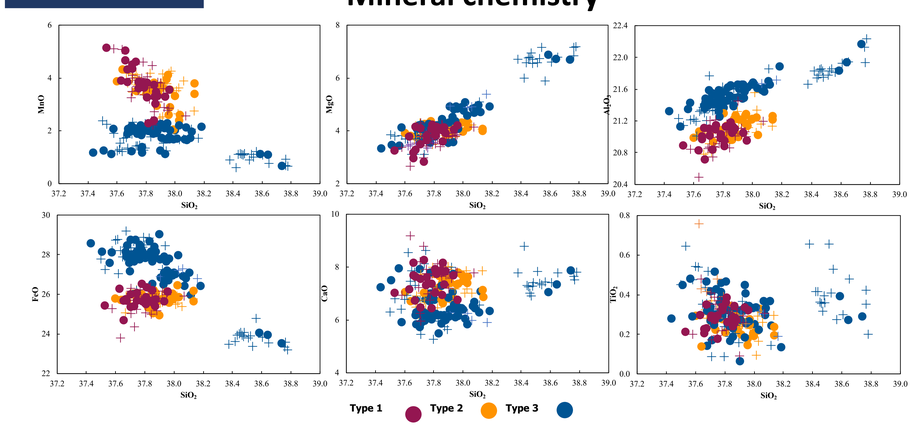


Fig 2. Representative major element analyses of garnets in andesites from the ACPB. Samples are divided according to the defined petrographic types. Circles represent rims and crosses cores of respective garnets

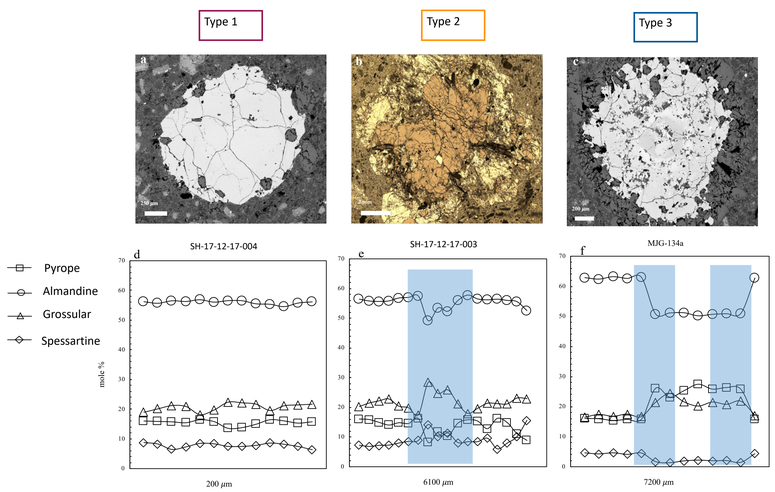
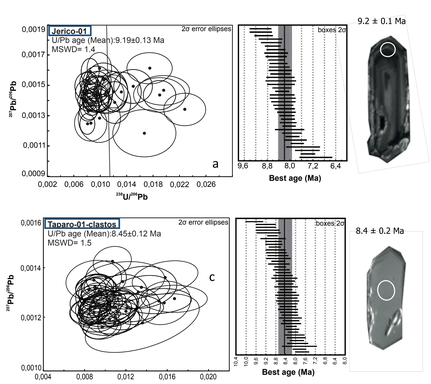


Fig 6. Representative images (a-c) and compositional profiles (d-f) of garnets in andesites from the ACPB. Length of the profile is shown at the bottom of d-f.



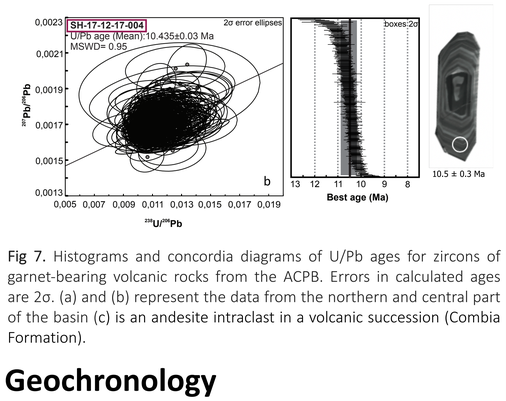


Fig 7. Histograms and concordia diagrams of U/Pb ages for zircons of garnet-bearing volcanic rocks from the ACPB. Errors in calculated ages are 2σ. (a) and (b) represent the data from the northern and central part of the basin (c) is an andesite intraclast in a volcanic succession (Combia Formation).

Geochronology

Early Miocene ages (19 to 12 Ma) in samples with type-2 garnets may reflect a first stage of crystallization before the main magmatic crystallization stage (10.4 Ma), which implies a tectonic connection with the southern garnet-bearing samples dated at this same age interval.

Discussion

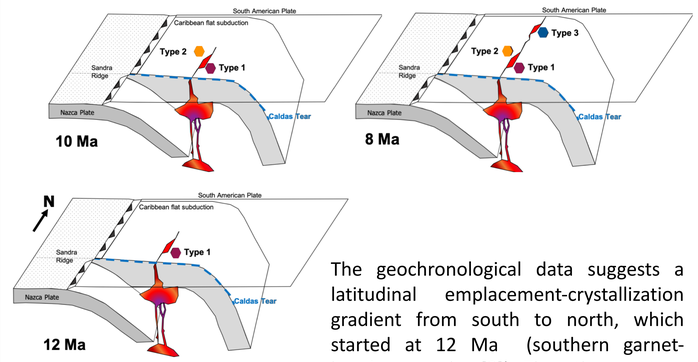


Fig 8. Proposed temporal and spatial model for the emplacement of the garnet-bearing andesites in the ACPB.

The geochronological data suggests a latitudinal emplacement-crystallization gradient from south to north, which started at 12 Ma (southern garnet-bearing samples [3]). Then the aperture of the basin continued to the north at 10 Ma, and finally the last extensional event in the basin occurred at the current Combia Formation location during the Tortonian (~8 Ma).

We propose that during the Late Miocene, the NAB had a dynamic and rapidly evolving tectonic environment -extension following subduction- which propitiated an opportunity for transient extensional conditions to transport materials originated in the lower crust.

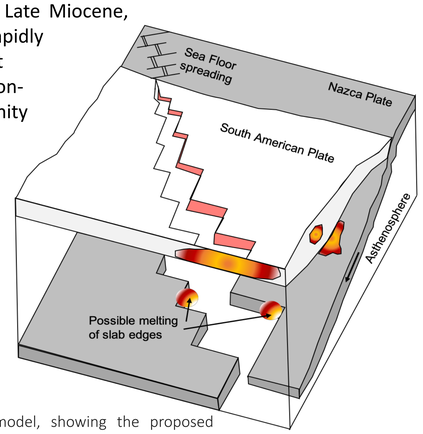


Fig 9. Ridge-subduction model, showing the proposed arrangement of a slab possible window due to a slab tear [8].

Future research

Integration of amphibole mineral chemistry to constrain the pressure-temperature conditions through Al in hornblendes.

References

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