Coronitic metagabbros from the Sobrado Unit (Órdenes Complex, NW Iberian Massif). II: Thermobarometry and P-T path

Metagabros coroníticos de la Unidad de Sobrado (Complejo de Órdenes, NW del Macizo Ibérico). II: Termobarometría y trayectoria P-T

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ABSTRACT

Three types of corona textures developed in metagabbros of the Sobrado Unit. Detailed thermobarometry, carried out in groups II and III coronas, together with inferred P-T conditions for group I coronas, show that the corona textures were generated during a drastic and virtually isothermal increase in pressure. Highest P-T conditions, registered in group III coronas, reached 660-770 °C and 13-17 kbar. Subduction of a relatively thin slice of arc-related crust below a mantle wedge, either with an intact thermal structure or heated and thermally softened in a relatively inner part of a volcanic arc, is suggested as the probable dynamic setting to explain the P-T path found in the coronitic metagabbros.

RESUMEN

Tres tipos de coronas se han desarrollado en los metagabros de la Unidad de Sobrado. La termobarometría detallada obtenida en las paragénesis minerales de las coronas de los grupos II y III, junto con las condiciones P-T inferidas para las coronas del grupo I, indican que las texturas coroníticas fueron generadas durante una presurización drástica y virtualmente isotérmica. Las condiciones P-T más extremas se registraron en las coronas del grupo III, y alcanzaron 660-770 °C y 13-17 kbar. El contexto dinámico más compatible con la trayectoria P-T encontrada en los metagabros coroníticos, incluiría la subducción de una escama relativamente delgada de una corteza de tipo arco. La subducción tendría lugar bajo una cuña de manto con una estructura termal intacta, o previamente calentada en un sector relativamente interno de un arco volcánico.

Key words: *Coronitic metagabbros, corona thermobarometry, P-T path, Órdenes Complex, NW Iberian Massif.*

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Introduction

Three groups of coronas have been distinguished in the coronitic metagabbros of the Sobrado tectonic window: I) Amp+Opx; II) (Amp) +(Cpx) +Opx +Grt; III) (Amp) + Cpx + Opx + Grt (subordinate phases in brackets). The mineral assemblages of these three groups of corona textures, as well as their chemical characteristics have been described in a previous contribution (Martínez Catalán and Arenas, this volume).

The formation of orthopyroxene and pargasite in olivine domains is typical of early stages of metamorphic transformation of gabbro, in the presence of fluid (Rivers and Mengel, 1988). Clinopyroxene-garnet coronas around ferromagnesian domains and kyanite inclusions in plagioclase are typical of incomplete transformation of Mg-Al gabbro under high-pressure metamorphic conditions, due to limited diffusion of elements between the plagioclase and the ferromagnesian textural domains (Indares, 1993; Indares and Rivers, 1995). In the context of the upper slice of the Sobrado Unit, the presence of high-pressure granoblastic granulites and the low Na-contents of clinopyroxene in the coronites indicate that the later represent arrested stages during transformation to granulite. Different stages in the prograde metamorphic evolution are preserved in the three groups of coronas, which recorded P-T conditions increasing from group I to group III. On the other hand, the absence of textures related to subsequent cooling and/or decompression suggest that the coronites did not record any of these stages of the metamorphic evolution. In that respect it should be mentioned that high-grade coronitic metagabbros commonly display secondary plagioclase collars between clinopyroxene and garnet coronas, interpreted to have formed during decompression at the initial stages of unloading (Indares, 1993). Such textures may develop during isothermal decompression, or under a thermal relaxation regime if peak temperatures postdated peak pressures. The absence of plagioclase collars from group III samples, that display the most advanced

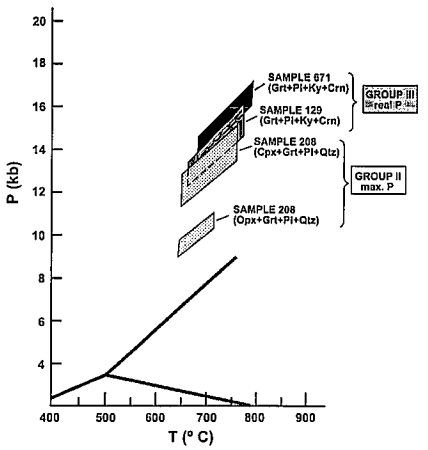

Fig. 1.- P-T diagram showing thermobarometric data for the mineral assemblages of coronas of groups II and III. Stability of the Al_2SiO_5 polymorphs according to Holdaway (1971).

Fig. 1.- Diagrama P-T con datos termobarométricos para las paragénesis minerales de las coronas de los grupos II y III. Límites de estabilidad para los polimorfos de Al_2SiO_5 según Holdaway (1971).

stages of metamorphic transformation, is therefore compatible with simultaneous achievement of maximum P-T conditions. Thence, the prograde metamorphic evolution inferable from group I to group III coronas is compatible with a simple P-T path, connected with the burial of the unit including the metagabbros.

Thermobarometry and P-T path

T determinations may be obtained by application of Cpx-Grt thermometry and Opx-Grt thermometry (group II only) to adjacent garnet and pyroxene rims. For estimations of pressures, no appropiate equilibria can be written for group II samples. However, upper P limits may be calculated by using equilibria with a missing phase. Given the coexistence of Opx-Grt-Pl and Cpx-Grt-Pl in the outer rims of the ferromagnesian domains, the following reactions can be used: 1) 3An+3Di=2Grs+Prp+3Qtz (Cpx-Grt-Pl); and 2) 3An+3En=Grs+2Prp+3Qtz (Opx-Grt-Pl), with quartz as the missing phase. In group III samples, coexistence between garnet (outer rims of the ferromagnesian domains) and plagioclase with kyanite and corundum, allows calculations of pressures with the equilibrium: 3An+Crn=Grs+3Ky (Grt-Pl-Ky-Crn) (Indares and Rivers, 1995).

Thermobarometry was applied to representative samples by using the TWQ method (Berman, 1991). For all samples, temperatures calculated with TWQ (Cpx-Grt equilibrium) range between 660-770 °C (Fig. 1). The *c.* 100 °C spread of the T values is attributed to variations in the estimated Fe^{3+}/Fe^{tot} ratio of the clinopyroxene analysis (charge balance method). In contrast, T calculated by the Opx-Grt equilibria cover a narrower range, between 670-745 °C (Fig. 1). Orthopyroxene has more Fe that clinopyroxene, therefore variations in Fe^{3+}/Fe^{tot} have less effect on calculated temperatures. For the estimated T range, pressures calculated with Grs-Pl-Ky-Crn equilibrium range between 13-17 kbar (Fig. 1). Maximum pressures calculated in group II coronas range between 12-15 kbar (Cpx-Grt-Pl-Qtz barometry; Fig. 1) and 9.5-11 kbar (Opx-Grt-Pl-Qtz barometry; Fig. 1).

An important problem for the deduction of the P-T path followed by the metagabbros arises from the impossibility of precise P-T determinations in the garnet-free mineral assemblages of group I coronas. Nevertheless, though there are limited experimental information relative to the stability of pyroxenes in metabasites, this clearly show that development of Opx in these compositions is only possible in high-T conditions, exclusively inside the granulite facies (Spear, 1981). Thence, this is the more probable T range for group I coronas. Additionally, in relation to the significant P range of group I coronas, though highly imprecise, it should be located below the baric range (maximum) calculated for group II coronas. This lower P range (consistent with the absence of garnet in group I coronas and with their lower recrystallization grade in relation to group II coronas), is also compatible with the available experimental data. These data clearly show that the development of garnet-free mineral assemblages with Opx+Cpx in metabasites, though very dependent of protolith composition, is possible in general below 8 kbar (Green and Ringwood, 1967; see Fig. 2).

Discussion

Though mineral assemblages characteristics of group I coronas are not significant for precise P-T determinations, and in spite of the maximum character of P determinations obtained in group II coronas, data presented in this contribution strongly suggest that the three corona groups define a prograde P-T path for the Sobrado metagabbros (Fig. 2). This path

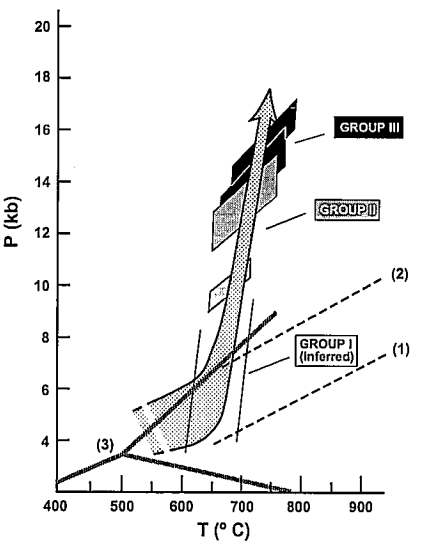

Fig. 2.- P-T path suggested for the coronitic metagabbros of the Sobrado Unit. P-T conditions for the development of group I, II and III coronas are also shown, together with lower (1) and upper (2) conditions for the beginning of garnet stability in mafic granulites (after Ringwood and Green, 1966 and Green and Ringwood, 1967). Stability of the Al_2SiO_5 polymorphs (3) after (Holdaway, 1971).

Fig. 2.- Trayectoria P-T que han seguido los metagabros coroníticos de la Unidad de Sobrado. También se muestran las condiciones P-T estimadas para la formación de las texturas coroníticas de los grupos I, II y III, junto con las condiciones inferiores (1) y superiores (2) para el comienzo de la estabilidad del granate en las granulitas máficas (según Ringwood y Green, 1966 y Green y Ringwood, 1967). Límites de estabilidad de los polimorfos de Al_2SiO_5 (3) según Holdaway (1971).

explains the transition from group I to group III coronas through a drastic increase in pressures almost isothermal, which operated at high-T, in the low-T range of the granulite facies (Fig. 2). This prograde P-T path accounts for the ensemble of textural, mineralogical ang chemical characteristics of the coronas, and it is considered as significant for the early metamorphic evolution of the HP-HT unit of the Sobrado Window. This prograde evolution advanced in the lower parts of the unit, through the upper baric range of the granulite facies up to the eclogite facies.

The research work developed in the coronitic metagabbros of the Sobrado Unit clearly shows that, though difficult to elucidate, still is possible to use the complex reactional history of the corona

textures to reconstruct a part of the early metamorphic evolution of the HP-HT units. Probably one of the more interesting aspects of this contribution is the very early character of the studied metamorphic evolution, which is the cause of its very occasional preservation. In this way, our research suggest, and this is probably the more important conclusion of this paper, that the study of the complex metamorphic reactions characteristic of the coronitic metagabbros, together with the deduction (at least partially) of the P-T conditions for their development, represent an important tool to elucidate early (and generally lost) parts of the orogenic evolution.

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