Lithos 162–163 (2013) 1–13

Contents lists available at SciVerse ScienceDirect

Lithos

journal homepage: www.elsevier.com/locate/lithos

Paragonite in marbles from the Tauern Window, Austria: Compositional and thermobaric controls

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ARTICLE INFO

Article history:
Received 28 August 2012
Accepted 20 December 2012
Available online 4 January 2013

Keywords:
Paragonite
Pseudosection
Fluorine
Limestone
Dolostone
Sonnblick dome

ABSTRACT

Paragonite coexists with phengite, chlorite, zoisite, tremolite and quartz in dolomitic marbles from near Döllach in the Sonnblick area of the SE Tauern Window, Austria, prompting an investigation into the petrogenetic significance of paragonite in carbonate rocks.

Thermodynamic calculations on pure-end-member reactions indicate that the assemblages paragonite + $CaCO_3$ + quartz and paragonite + dolomite + quartz are stable over wide ranges of $X(CO_2)$ and have *P–T* stability fields almost as wide as that of paragonite + quartz. *P–T* pseudosection calculations spanning 0.35–1.4 GPa and 400–590 °C in the model system Na_2O–CaO–K_2O–FeO–MgO–Al_2O_3–SiO_2–TiO_2–H_2O–CO_2 yield wide fields for paragonite-bearing assemblages in the Döllach paragonite-marbles at low $X(CO_2)$. The bulk compositions of these rocks are characterised by high values of molar Na/(Na + K) and Al/(Na + K) and these parameters are influential in stabilising paragonite-bearing assemblages in marbles. A large proportion of published limestone and dolostone whole-rock compositions would be capable of supporting paragonite at *P–T* conditions within the greenschist, blueschist or epidote–amphibolite facies. Paragonite is probably much more common in low- and medium-grade marbles than the rarity of reports of its occurrence suggest.

Apart from zoisite, the hydrous silicates in the Döllach marbles are characterised by modest fluorine contents, with X_F values of coexisting minerals decreasing in the order Tr > Phe > Pa ≈ Chl.

Calcite–dolomite thermometry and pseudosection calculations indicate peak-metamorphic conditions for the Döllach marbles of $T = 510 \pm 20$ °C, $P > 0.77$ GPa and $X(CO_2) < 0.065$. The *P–T* data agree with previous estimates for the area.

1. Introduction

The dioctahedral mica paragonite is not normally considered a typical mineral of metamorphosed carbonate rocks. Its characteristic occurrence is as a minor phase in metabasites of low grade (e.g. Jiang and Peacor, 1993; Pe-Piper, 1985), amphibolite facies (e.g. Laird and Albee, 1981), blueschist facies (e.g. Ahn et al., 1985; Makanjuola and Howie, 1972), and eclogite facies (e.g. Fotoohi Rad et al., 2005; Giorgetti et al., 2000; Holland, 1979; Okay, 1995) and in aluminous pelites of subgreenschist facies (e.g. Frey, 1969; Li et al., 1994; Merriman and Roberts, 1985), greenschist facies (e.g. Höck, 1974; Katagas and Baltatzis, 1980), amphibolite facies (e.g. Baltatzis and Wood, 1977; Droop, 1981, 1985; Grambling, 1984; Henley, 1970), blueschist facies (e.g. Mposkos and Perdikatzis, 1981) and eclogite facies (e.g. Konopasek, 2001). It also occurs in eclogite-facies metagranitoids (e.g. Koons et al., 1987; Schliestedt and Okrusch, 1988) and amphibolite-facies calc-pelites (e.g. Ackermand and Morteani, 1973). In contrast, reports of paragonite in marbles are rare: Castelli (1991) documented paragonite as a retrograde mineral in 1.5 GPa eclogite-facies marbles from the Sesia–Lanzo Zone, W. Alps. Peak-metamorphic paragonite has been reported from 0.95 GPa marbles in the Nevado–Filabride complex, SE Spain (Sánchez-Vizcaíno et al., 1997) and 1.5–1.6 GPa marbles from Syros (Schumacher et al., 2008). Paragonite also occurs in evaporitic ruby-bearing marbles in N Pakistan (Garnier et al., 2004) and has also been noted in a survey of accessory minerals in circum-Mediterranean marbles (Capedri et al., 2004). A feature shared by the occurrences for which metamorphic conditions have been estimated is a relatively high pressure, begging the question of whether paragonite is only stable in carbonate rocks at high pressure and thus whether such assemblages have barometric significance.

In this paper, this question is addressed with reference to an occurrence of paragonite marble in the Sonnblick area in the SE Tauern Window, Austria. This is an area dominated by rocks that have undergone Alpine greenschist- to amphibolite-facies metamorphism at modest peak-metamorphic pressures of 0.6–0.7 GPa (Droop, 1985; Hoinkes et al., 1999) but also contains rocks that preserve relict eo-Alpine high-P/T mineral assemblages (Dachs and Proyer, 2001; Hoinkes et al., 1999). The peak-metamorphic conditions of the marbles and the dependence of paragonite stability on bulk-rock composition will be explored using THERMOCALC (Powell and Holland, 1988). It will be shown that bulk chemistry has a major control on paragonite stability

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0024-4937/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.lithos.2012.12.013

in marbles and that paragonite + carbonate assemblages do not have special barometric significance.

2. Geological context

The paragonite-bearing marbles described in this paper form part of the Mesozoic 'Peripheral Schieferhülle' cover sequence in the SE Tauern Window, Austria. They crop out in a 30 m thick layer which is well exposed on the SE flank of Stanziwurten, *ca.* 2.6 km NE of the town of Döllach, at longitude 12° 55′ 00.00″ east and latitude 46° 59′ 34.47″ north. The unit is described by Exner and Prey (1964) who ascribe it to the Seidlwinkl Series, an epicontinental sequence of presumed Triassic depositional age. It forms part of the Rote Wand–Modereck Nappe and lies above Gneiss Lamella 4, the uppermost of the allochthonous basement 'gneiss-lamellae' overlying the SW flank of the Sonnblick Dome basement massif (Fig. 1).

The Peripheral Schieferhülle rocks of the Sonnblick area underwent complex polyphase deformation during the Tertiary as a result of continental collision between Adria and northern Europe (e.g. Handy et al., 2010). An early phase of imbrication, foliation formation and folding (designated D_1), interpreted as the result of top-to-N nappe stacking, was followed by asymmetric folding resulting from top-to-NW shearing (D_2), the latter coinciding with the late-prograde stage of Alpine metamorphism (Droop, 1981; Kurz and Neubauer, 1996). Later retrogressive shear zones and crenulations, interpreted as the result of oblique shortening associated with amplification of the Sonnblick Dome, were followed by brittle structures related to extensional unroofing (Kurz and Neubauer, 1996).

The Alpine metamorphism in the SE Tauern Window was of broadly Barrovian type (Droop (1981, 1985), and the rocks of the Sonnblick Dome area are of albite–epidote–amphibolite facies (Droop, 1985). AFM-mineral assemblages in pelitic schists on the SE side of the

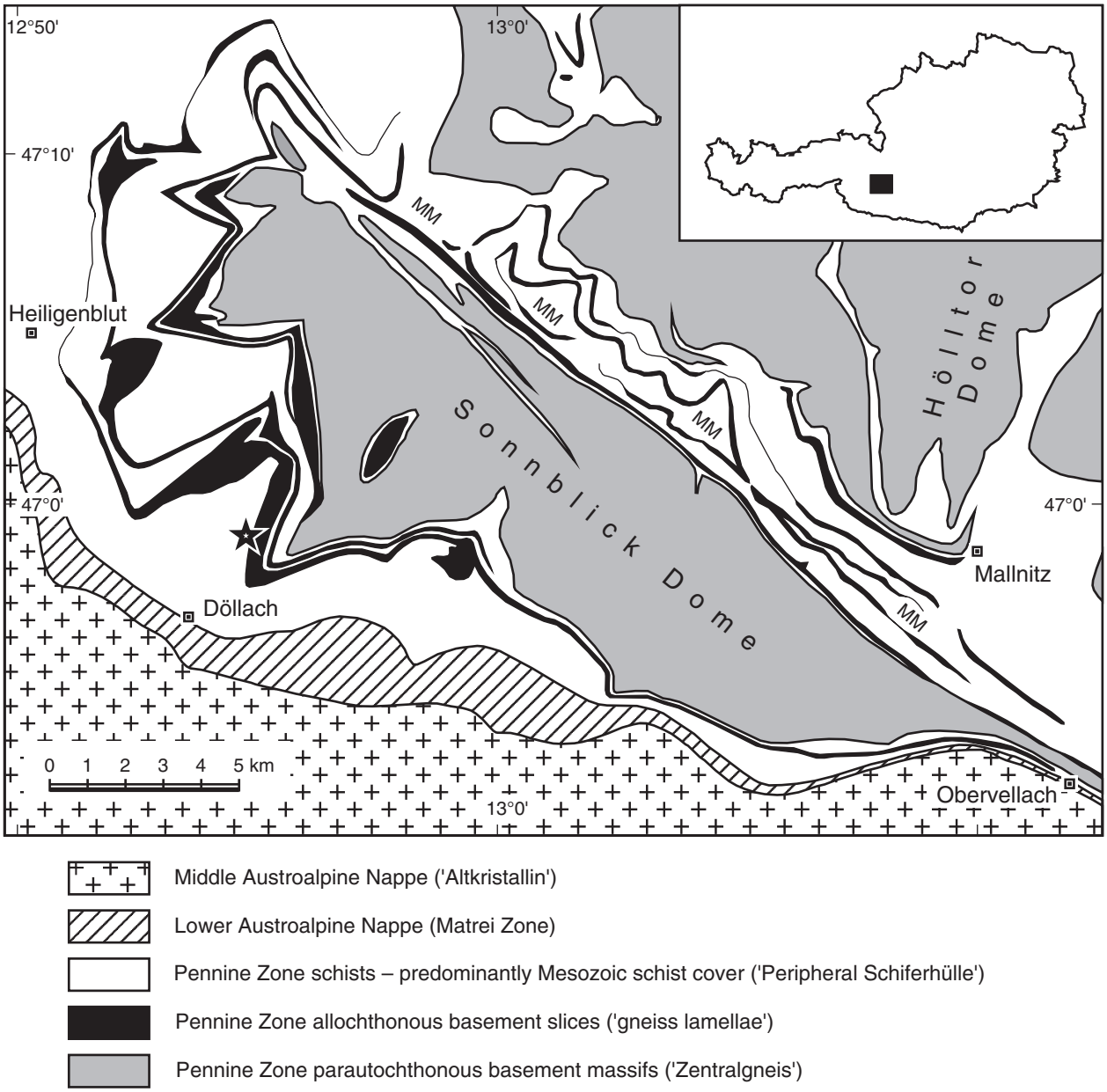

Fig. 1. Tectonic map of the south-east Tauern Window, Austria, in the vicinity of the Sonnblick Dome (from Exner and Prey, 1964). Star: locality of the paragonite marble. MM: Mallnitzer Mulde synform. Inset: location of the map within Austria.