Comment to "Chloritoid composition and formation in the eastern Central Alps : a comparison between Penninic and Helvetic occurrences" by M. Rahn, M. Steinmann and M. Frey

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Comment

Comment to "Chloritoid composition and formation in the eastern Central Alps: a comparison between Penninic and Helvetic occurrences" by M. Rahn, M. Steinmann and M. Frey

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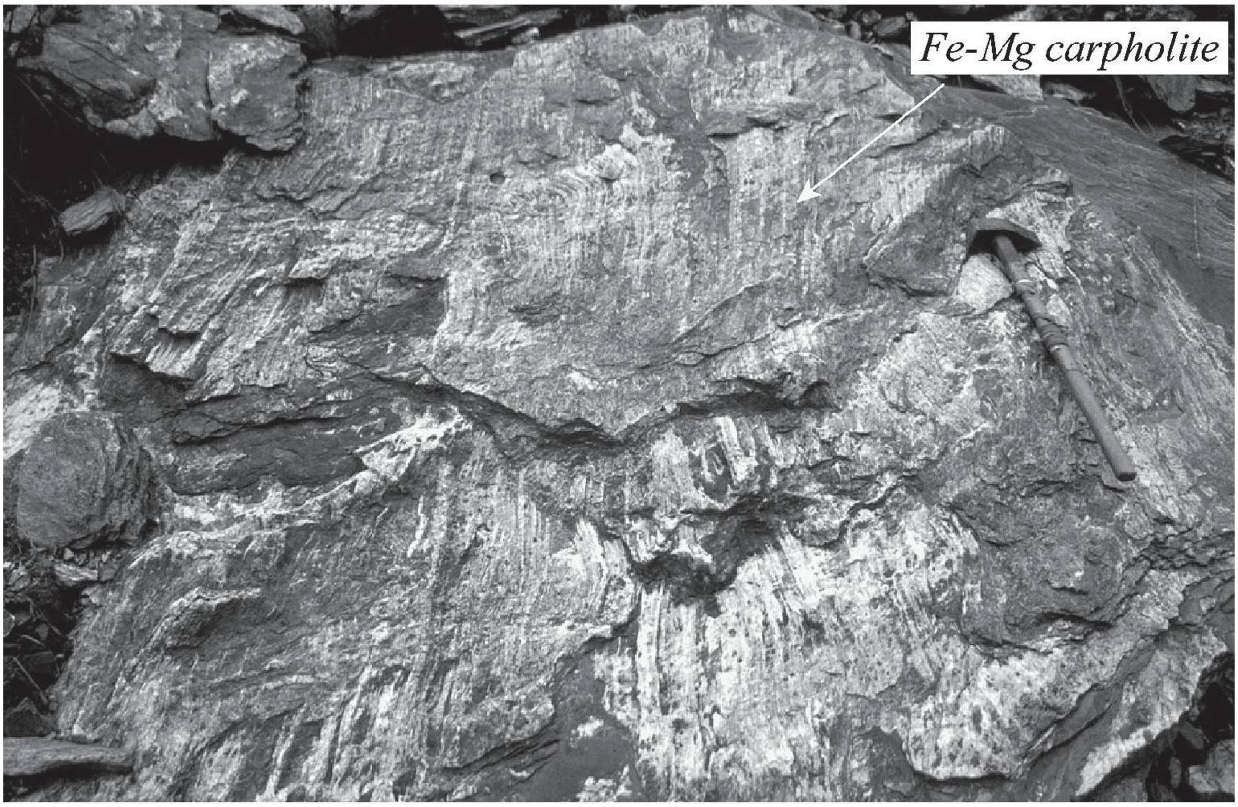

Fig. 1 Mg–Fe carpholite fibers occurring in Val Glong (hammer for scale).

The article by Rahn et al. (2002) gives a good review of the occurrences of chloritoid in the western Grisons north of the Penninic crystalline nappes. The formation of chloritoid is discussed for various bulk compositions. The authors assumed that chloritoid formed by the reaction muscovite + chlorite = chloritoid + celadonite + quartz, disregarding the reaction Fe–Mg carpholite = chloritoid + quartz + H_2O because they did not find Fe–Mg carpholite in the Bündnerschiefer. However, their conclusion that chloritoid in North Penninic Bündnerschiefer is not related to the breakdown of Pre-Lepontine high pressure low temperature mineral assemblages containing Fe–Mg carpholite is not justified.

Based on classic studies (e.g. Niggli and Niggli, 1965; Hunziker et al., 1992; Frey and Ferreiro-Mählmann, 1999), it is well established throughout the Alps, that the sediments of the Helvetic domain, unlike the Penninic metasediments, had escaped high-pressure metamorphism. Therefore, a comparison of the mineral chemistry of chloritoid from Penninic and Helvetic domain must not be used to conclude that chloritoid from Penninic realms cannot stem from the breakdown of the high-pressure phase Fe–Mg-carpholite.

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The aim of this comment is to clarify obscure aspects found in Rahn et al. (2002) which we consider fundamental to understand the observed phase relations in metapelites as well as the metamorphic evolution of the Central Alps.

Recognition and occurrences of chloritoid

Rahn et al. (2002) claim that “chloritoid was not visible in any chloritoid bearing specimens”, while we and many petrographers before us have indeed recognized this mineral in the field. As clearly stated in Oberhänsli et al. (1995), chloritoid at Piz Beverin in the Tomül unit (studied by Rahn et al., 2002) appears outside the mineral zone boundary depicted for Fe–Mg chloritoid associated with carpholite. Martin Frey, who confirmed that no Fe–Mg carpholite has been found at Piz Beverin, had indicated this chloritoid locality to us. In Val Safien, Val Lumnez, Valser Tal and Val Glong Fe–Mg carpholite is macroscopically visible.

For the Helvetic domain (Kunkels Pass), Frey and Wieland (1975) reported that chloritoid occurs in association with phengite, paragonite, albite and quartz, while Oberhänsli et al. (1995) described occurrences of chloritoid associated with phengite, chlorite, Fe–Mg carpholite and quartz in the western Grisons (Val Safien; e.g. 741.05/165.99). Furthermore, up to now Mg-carpholite but no chloritoid has been found in the Engadine window (Goffé and Oberhänsli, 1992; Bousquet et al., 1998). Comparisons of data from the Engadine window, where no chloritoid has been described, and the western Grisons must take into account the known differences in mineral compositions. In the Engadine window, Mg-carpholite (X_{Mg}=0.7) is stable, while in the western Grisons only Fe–Mg carpholite (X_{Mg}=0.4) occurs in association with chloritoid (Bousquet et al., 2002).

P–T estimates

Rahn et al. (2002) question pressure estimates for the western Grisons given by Oberhänsli et al. (1995). They argue that phengite contains a high illite component, and thus the estimates are erro-

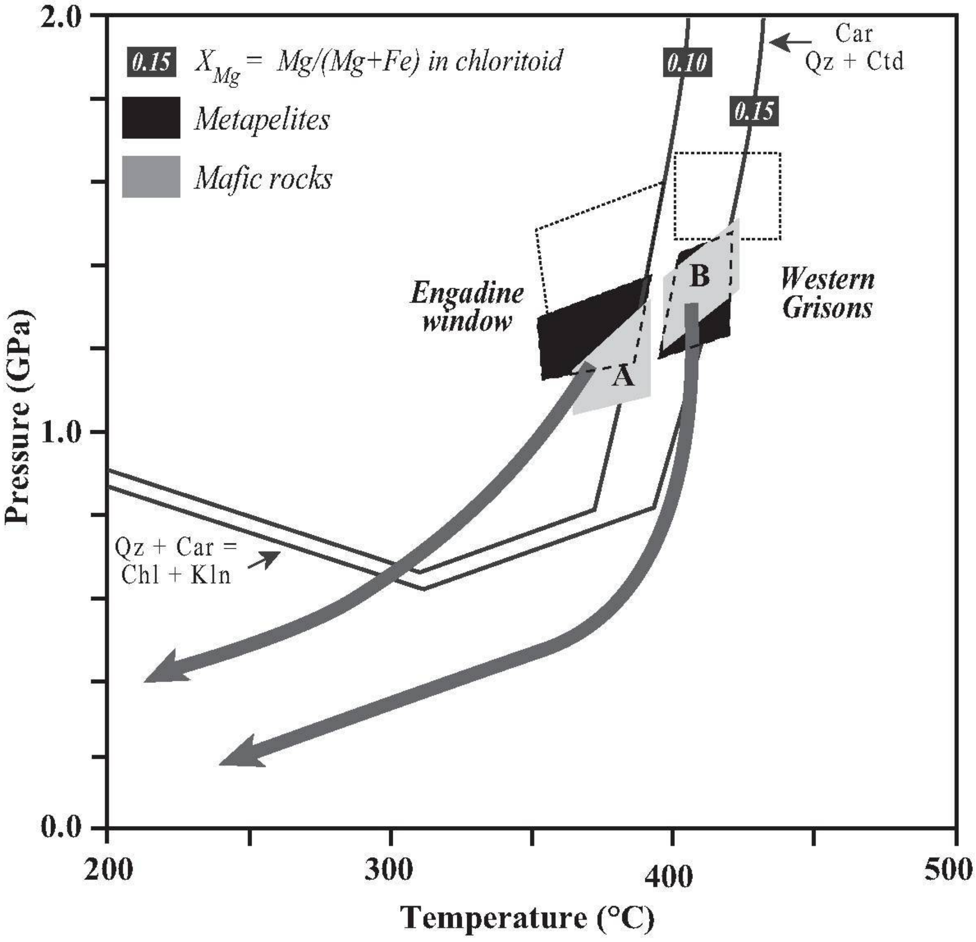
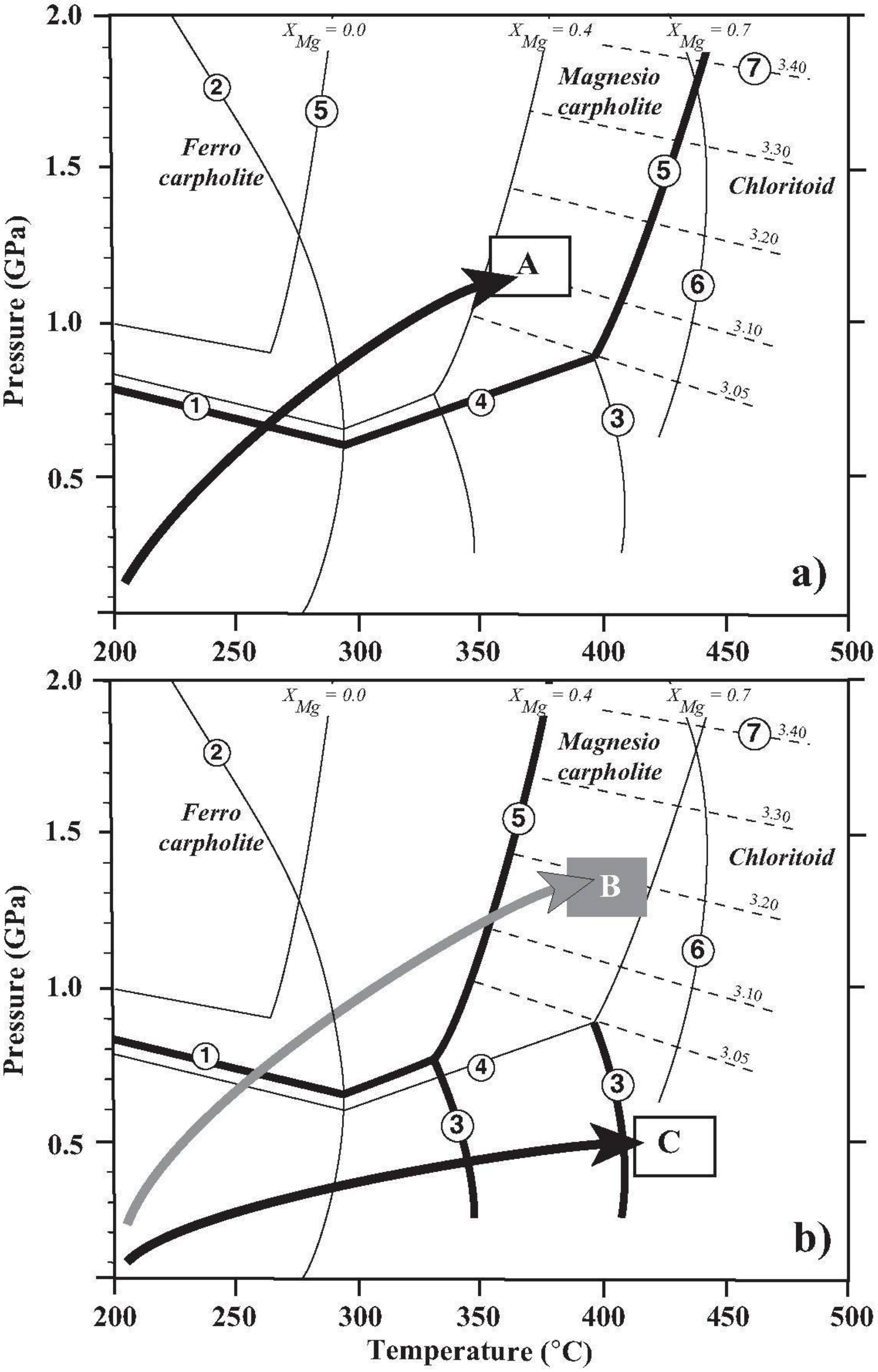


Fig. 2 Summary of P–T conditions and P–T paths estimated (Bousquet et al., 2002) for the North Penninic Bündnerschiefer of the Engadine window (A) and the western Grisons (B). P–T conditions for the metasediments (black boxes) and the metabasites (Grey boxes) are in good agreement. Dashed boxes refer to earlier estimates (Oberhänsli et al., 1995) obtained for the metasediments ignoring the illite component in the phengites. Consideration of the illite component in phengite lowers the pressures by only 0.2 GPa (see discussion in Bousquet et al., 2002).



1: Chl + 4Kln = Qz + 5Car + 2W
2: 2Qz + Kln = Prl + W
3: 4Prl + Chl = 5Ctd + 14Qz + 3W
4: 5Car + 9Qz = 4Prl + Chl + 2W
5: Car = Qz + Ctd + W
6: Prl = Ky + 3Qz + W
7: 2Ms + Chl + 2Qz = 3Ctd + 2ACel + W

Fig. 3 Petrogenetic grid for metapelites showing the major reactions described in this note for appearance of chloritoid (after Vidal et al., 1992). Depending on the P–T path followed and the bulk composition of the rocks, different mineral assemblages are stable. A—Engadine window; B—western Grisons; C—Helvetic nappes (for explanation see text). Car—carpholite, ACel—alumino-celadonite, Chl—chlorite, Ctd—Chloritoid, Kln—kaolinite, Ky—kyanite, Ms—muscovite, Prl—pyrophyllite, Qz—quartz, W—water. Dashed isopleths indicate Si-contents (Si p.f.u.) in white mica. X_{Mg} refers to Mg/(Mg+Fe) in carpholite.

neous. This was recognised and accounted for by Bousquet et al. (2002), where we showed that this effect, at such low temperature conditions, diminishes the pressure values for these rocks by 0.2 GPa compared to the previous estimates. Even so, 1.2–1.3 GPa (corrected down from 1.4–1.5 GPa) at 400 °C still documents low-temperature high-pressure conditions. We also showed (Fig. 2) that these estimates match closely those from mafic rocks containing glaucophane (Vals) and ferroglaucophane (Engadine window).

P–T paths and the appearance of chloritoid

Depending on the P–T path, chloritoid, chloritoid + Fe–Mg carpholite, or only Fe–Mg carpholite can be produced in different tectonic units that occur in close juxtaposition. Figure 3 clearly shows the various P–T paths leading to different mineral assemblages in the different tectonic units. Path A shows conditions for the Engadine window, where the bulk rock composition is Mg-rich, and only Mg-carpholite appears (X_{Mg}=0.7); therefore the P–T path never crossed reaction (5) that would form chloritoid. Path B pertains to assemblages observed in the western Grisons, the bulk rock composition of which is less Mg-rich than in the Engadine window. This led to the formation of Fe–Mg carpholite (X_{Mg}=0.4), and the pertinent P–T path did cross reaction (5), forming chloritoid for such compositions. Finally, path C shows the conditions for carbonaceous samples from the Helvetic nappe. There, chloritoid formed by breakdown of pyrophyllite (reaction 3 in Fig. 3) (Frey and Wieland, 1975).

Rahn et al. (2002) favor the reaction muscovite + chlorite = chloritoid + celadonite + quartz + H_2O for the appearance of chloritoid. Mass balance among these phases requires a correction to: 2 muscovite + chlorite + 2 quartz = 3 chloritoid + 2 celadonite + 1 H_2O. While this equilibrium is written among pure end members, natural chloritoid produced involves considerable phengite component (Tschermak substitution). Relative to the stoichiometric phase equilibria shown, this shift implies a pressure increase of about 0.1 GPa for the carpholite forming reaction.

Conclusion

Detailed fieldwork and consideration of various mineral assemblages allows us to distinguish and explain subtle differences in the geodynamic evolution of the “Bündnerschiefer” units in the Grisons. Recognising minerals in the field is crucial for a petrographers work. An excellent example is the recognition of Fe–Mg carpholite (Goffé et al., 1973) that has changed the models of geodynamic evolution of many mountain belts (e.g. Bousquet et al., 2002).

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