The critical factor in any potential metamorphic model is the behavior of biotite - by far the most significant carrier of HFS elements and rare alkalis in metamorphic lithologies. Melting scenarios involving the bulk of biotite but conserving (at least most of) plagioclase + quartz do not seem petrochemically feasible; melting of biotite takes place in high-% anatexis which prevents substantial accumulation of lithophile rare elements. A recent experiment by ICENHOWER & LONDON generated low-% melt enriched in rare elements by recrystallization of biotite, but in a H_2O-oversaturated environment which does not seem to be geologically realistic in prograde metamorphism. Thus the concept of direct metamorphic derivation of rare-element pegmatites is so far not supported by any feasible mechanism.

THE AGE OF THE ÖTZTAL-MIGMATITES - STILL A MATTER OF DEBATE

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The Ötztal basement exhibits several migmatite bodies, formed in situ from biotite-plagioclase-gneisses and biotite-schists (Winnebach near Längenfeld/Ötztal; Verpeil near Feichten/Kaunertal; Nauderer Gaisloch E of Reschenpaß). So far, geochronological studies have only revealed minimum ages for the migmatisation. The genetic relation between migmatites and the intrusion of surrounding magmatites is not yet proved. Rb/Sr-mineral-dating shows "Caledonian" to "Alpine" model ages depending on the post-anatectic metamorphic overprint.

The minimum age for the anatexis in the Winnebach-migmatite is defined by a muscovite age of 461 ± 8 Ma. The migmatites of the Reschenpaß area are crosscut by pegmatites for which an age of 472 ± 26 Ma is reported (Rb/Sr whole rock data, SCHWEIGL, 1993).

All before mentioned migmatites are in direct contact or in the nearest vicinity of metagranitoids. Thus, the heat source for the migmatisation of the paragneisses could be suspected in these magmatites. The age of migmatisation would then correlate with the intrusion ages of these rocks. The intrusion age of the Alpeiner granite E and W of the Winnebach-migmatite is still not known. The metagranitoids surrounding the Feichten-migmatite (Kaunertal) are believed to have intruded around 481 ± 7 Ma (Pb/Pb zircon evaporation age, HOINKES et al., 1994), although some of the zircons yield older ages of ~ 530 Ma (pers. comm. U. KLÖTZLI). The not well defined intrusion age of the Klopair-tonalite (Nauderer Gaisloch, Reschenpaß) is around 520 Ma (SCHWEIGL, 1993). None of these intrusion ages is without debate and/or backed up with other geochronological methods. Additionally, no direct field evidence is found proving the direct connection between magmatites and migmatites.

Rb/Sr-whole-rock-measurements from the Winnebach-migmatite show that the in situ migmatisation has not lead to a complete homogenisation of the Sr-isotopes.

During later events the migmatites (Winnebach and Nauderer Gaisloch) behaved as rigid bodies only weakly or completely undeformed by the structural overprint affecting their surroundings. The varying intensity of deformation within the migmatite-bodies has accentuated the differences of the isotopy of Sr, prohibiting a large scale post-anatectic isotopic homogenisation.

Probably Alpine serizitisation is only locally found. The rejuvenation of the isotope systems due to the general increase in the metamorphic grade of the Alpine metamorphism from NW to SE (THÖNI, 1981; HOINKES et al., 1991) is disturbed on a small scale depending on the amount of tectonic overprint and serizitisation. The Rb/Sr-model ages from white mica in the Winnebach area vary from 461 ± 8 Ma (measured in homogeneous, not serizitisised neosom) to 293 ± 4 Ma (measured in inhomogeneous neosoms with pre-anatectic layering and post-anatectic weak schistosity). The Rb/Sr-model ages of biotites are between 314 ± 6 Ma and 99.2 ± 2 Ma.

The Gaislehn-granitegneiss located SE of the Winnebach-migmatite shows beside small biotite-schist-rafts on its borders a penetrative schistosity affecting a homogeneous matrix. In this area the Rb/Sr-system of white mica was resetted during the variscan metamorphism. The white mica yields an isochron age of 317 ± 9 Ma, the biotite is rejuvenated to Alpine data of 95.5 ± 2 Ma.

Migmatites forming from paragneisses are especially unsuitable for dating with the Rb/Sr-method because of their primary inhomogenities and post-anatectic behavior during metamorphic overprints. Thus neither precise formation ages nor metamorphic ages can be deduced. Consequently "Variscan" white mica ages from the migmatite areas have to be interpreted as mixing ages and are therefore geologically meaningless.

As long as no real migmatisation ages are known, the age values found don't provide any information about the intensity of the post-anatectic metamorphic overprints. For instance, the white mica Rb/Sr age of 293 ± 4 Ma measured in inhomogeneous neosoms of the Winnebach migmatite could be interpreted as a real Variscan cooling age, as a late Variscan rejuvenation of a Caledonian cooling age or a Alpine rejuvenation of a Variscan or Caledonian cooling age.

In order to establish precise formation ages for the Ötztal migmatites, conventional single zircon U/Pb and single zircon evaporation Pb/Pb dating is currently in work. Using these methods, the drawback of the Rb/Sr method should be overcome, thus providing very important new information about the history of the Ötztal basement.

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THE ANNITE - PHLOGOPITE JOIN: AN IDEAL SOLUTION?

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Existing Fe - Mg partitioning data between garnet and biotite (FERRY & SPEAR, 1978, and PERCHUK & LAVRENT'EVA, 1983) have been reanalyzed based on revised standard-state properties of annite, as extracted by DACHS (1994) from hydrogen-sensor data of the redox reaction annite = sanidine + magnetite + H_2. Because annite standard-state properties could be taken from this independent source, the partitioning data of FERRY & SPEAR (1978) and PERCHUK & LAVRENT' EVA (1983) were solely used to constrain the Fe - Mg mixing in biotite, an advantage compared to previous determinations.

The data processing was done by fitting the partitioning data isothermally to an assymetric Margules equation, taking into account the Al^{VI} content of biotite in the experiments of PERCHUK & LAVRENT'EVA (1983), as given by ARANOVICH et al. (1988). The interaction parameters ($W_{G,i}$) obtained (Table 1) are positive in sign for $W_{G,AnnPhl}$ (ranging between ~3 and ~18 kJ/mol, one-site basis) and negative for $W_{G,PhlAnn}$ (ranging between ~-12 and ~-25 kJ/mol, one-site basis). The annite - phlogopite binary therefore appears as an assymetric solution with negative deviation from ideality for the annite component ($\gamma_{Ann}^{Bt} < 1$), except at Mg-rich compositions. Plotted against temperature, there is no clear temperature dependence visible in the W_G's, but a considerable scatter reflecting inconsistencies in the underlying partitioning data at different temperatures. Using the W_G's as given in Table 1, the experimental temperatures can be reproduced with an average precision of 19° C.

The deduced mixing behavior of Fe - Mg biotites can be tested against constraints coming from equilibrium data of WONES & EUGSTER (1965). They studied the displacement of the endmember reaction annite = sanidine + magnetite + H_2 due to the incorporation of Mg into biotite. Combined with the results of DACHS (1994) on the same equilibrium, the activity of the annite component in the reversed experiments of WONES & EUGSTER (1965) was estimated and a similar behavior was found as derived above from the partitioning data ($\gamma_{Ann}^{Bt} < 1$).
Volume - composition relationships along the annite - phlogopite join (REDHAMMER, et al., in prep.) exhibit negative excess volumes showing the same assymetric trend as following from the W_G's, with a maximum at $X_{Ann} = 0.7$. The fitted Margules volume parameters are (three-site basis): $W_{V,AnnPhl} = 0.018 \pm 0.016$ J/(bar.mol) and $W_{V,PhlAnn} = -0.391 \pm 0.025$ J/(bar.mol).