Late to post-variscan tectonometamorphic evolution of the KTB rock suite Depth dependant variation of fault and vein- mineralisations

G. Zulauf, Geol.-Paläont. Institut
Universität Frankfurt a.M.
H. de Wall, KTB-Feldlabor
Windischeschenbach

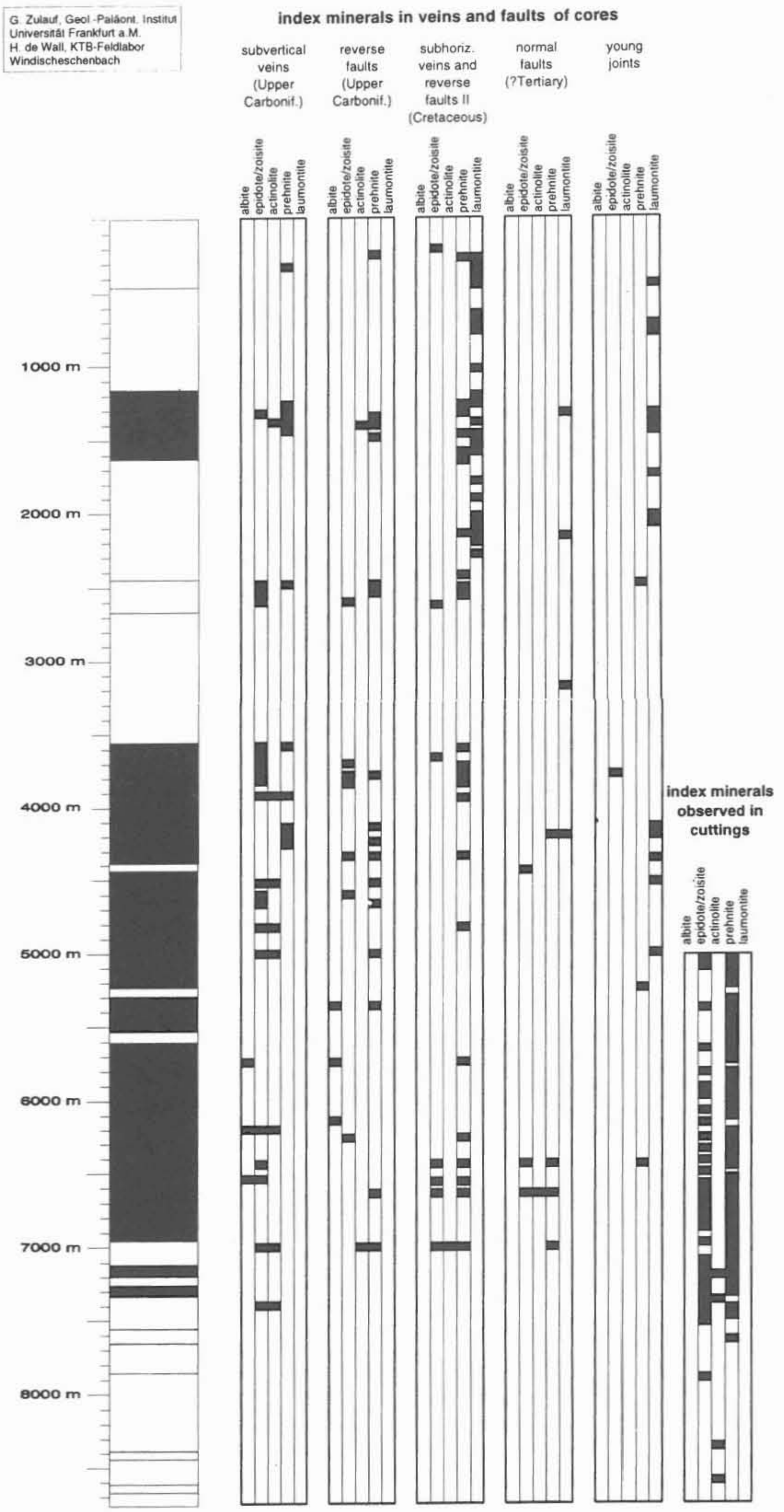

Fig. 1 metabasite paragneiss hornblendegneiss variegated series

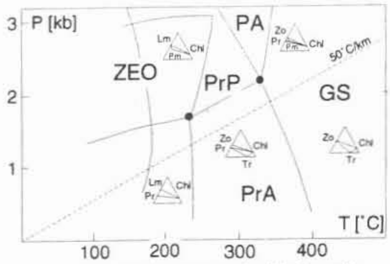

Fig. 2: P-T diagram showing a petrogenetic grid for low-grade metamorphic facies in the basaltic system (after LIOU et al. 1987): Chl = chlorite, Lm = laumontite, Pm = pumpellyite, Pr = prehnite, Tr = tremolite, Zo = zoisite; GS = greenschist facies, PA = pumpellyite-actinolite facies, PrA = prehnite-actinolite facies, PrP = prehnite-pumpellyite facies, ZEO = zeolite facies.

Late to post-Variscan brittle faults and veins are the most striking deformation structures drilled so far by KTB. Synkinematic mineralization, found within these structures, yields important clues for deriving the P-T conditions during the brittle deformation events. Moreover, by pursuing the mineralization with depth, potential depth-dependent gradients and fault-related discontinuities of the lithological profile might be revealed.

The following sequence of late to post-Variscan deformation structures has been derived (ZULAUF 1992): 1) Upper Carboniferous subvertical veins, 2) Upper Carboniferous reverse faults, graphite-enriched in gneisses, 3) Cretaceous reverse faults and subhorizontal tension gashes, 4) ?Tertiary normal faults, 5) Young joints.

Only the index minerals (laumontite, prehnite, epidote/zoisite, and actinolite; LIOU et al. 1987) have been depicted in Fig. 1. Apart from these, K-feldspar, calcite, quartz, chlorite, and sericite are common constituents of veins and faults. Graphite is restricted to the oldest generation of reverse faults of gneisses.

The kind of index minerals depends on both the depth and the age of the structures. With increasing age and depth, the following sequence occurs: laumontite, prehnite, epidote/zoisite, actinolite, albite (Fig. 1). Several metamorphic facies transitions can be derived by considering the mineralizations observed. Between 4000 and 5000 m, prehnite ceases more and more within the **Upper Carboniferous subvertical veins** indicating the transition from the prehnite-actinolite to the greenschist facies (Fig. 2).

Within the **Upper Carboniferous reverse faults** prehnite, epidote and actinolite indicate metamorphic conditions of the prehnite-actinolite facies until at least 7000 m depth.

The **Cretaceous compressional structures** (reverse faults and subhorizontal veins) developed under low-P/high-T zeolite-facies conditions until ca. 2500 m. The latter is indicated by the presence of laumontite and prehnite. From 2500 m to at least 7000 m prehnite, actinolite, and epidote refer to metamorphic conditions of the prehnite-actinolite facies.

The **?Tertiary nomal faults** are less abundant than the structures mentioned previously. Thus the data density is relatively low. However, there is a clear trend from the zeolite-facies in the upper part to the prehnite-actinolite facies in the lower part. Laumontite is present until ca. 4500 m.

Within the **young joints** laumontite reaches up to at least 5000 m indicating zeolite-facies conditions until this depth. Moreover, BORCHARDT & EMMERMANN (1993) describe laumontite at 6242 m which probably refers to the youngest joints. Below this depth laumontite is completely absent.

One finding of pumpellyite, together with prehnite, laumontite, and calcite, at 5012 m (BORCHARDT & EMMERMANN 1993) is likely to indicate a lower heat flow during the formation of the young joints. All the other structures should have formed under elevated heat flows (> 40 C/km) as is indicated by the metamorphic conditions of the prehnite-actinolite and the low-P/high-T zeolite facies (Fig. 2).

It has to be emphasized that the prehnite-actinolite facies is restricted to a small pressure (depth) interval only. Assuming a geothermal gradient of 50 C/km, it should occur at pressures between ca. 1,3 and ca. 2,0 kbar (LIOU et al. 1987; Fig. 2) corresponding to a depth interval of ca. 2500 m. This small interval is not in accordance with our observations. Regarding the Upper Carboniferous reverse faults, the prehnite-actinolite facies covers at least 7000 m depth. This is also confirmed by the quartz fabrics of the graphitic reverse faults, which represent the brittle-ductile transition regime (see part B, DUYSTER & ZULAUF, this volume). Consequently, the crust must have been dramatically thickened in post Variscan time. The most appropriate thickening event is further discussed in Part C (ZULAUF et al., this volume).

Prehnite was found continuously until ca. 7250 m and sporadically until 7610 m. Below the latter depth, prehnite is completely absent, although metabasites (which are suitable for prehnite formation) are intercalated within the gneisses. Thus, the stability field of prehnite was obviously overstepped below ca. 7610 m, and every structure mentioned above should have developed under greenschist facies conditions.

References:

BORCHARDT, R. & EMMERMANN, R. (1993): KTB Report, 93-2: 481-487. LIOU, J.G. et al. (1987) in FREY, M. [ed.], Low temperature metamorphism, p. 59-113; New York (Chapman & Hall). ZULAUF, G. (1992): Tectonophysics, 202: 1-21.

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