central parts of the body. The coarse-grained unit and particularly the saccharoidal albite unit show a distinct foliation and, locally, a lineation of beryl-aquamarine crystals.

Chemical composition of muscovite-phengite is characterized by high Fe and Mg contents, which are fixed throughout the pegmatite crystallization. There is a distinct increase of F content and slight increase of Rb, Mn, Na in muscovite-phengite from the coarse-grained unit to blocky Kfs + Qtz unit, and to the saccharoidal albite unit. A quite similar pattern was recorded in schorl, with F increasing from the coarse-grained unit through saccharoidal albite to schorl with increased amount of olenite and elbaite components in the blocky Kfs + Qtz unit. Garnet (spessartine-almandine) is mostly zoned with Mn-depleted, Fe-enriched rims; however, compositions of garnet cores display similar Mn-contents in the coarse-grained unit, graphic pegmatite and blocky Kfs + Qtz unit and increased Mn in the cleavelandite unit. Garnet from saccharoidal albite is almost homogeneous and fairly Mn-depleted. Apatite shows increased F from the coarse-grained unit through graphic pegmatite, blocky Kfs + Qtz unit to the cleavelandite unit. Composition of beryl seems to be similar in all pegmatite units.

Significant increasing of F in mica, tourmaline and apatite throughout the pegmatite crystallization is the most typical feature of this pegmatite, whereas evolution of Mn/Fe ratio in garnet and tourmaline is quite insignificant. Also recorded were weak increases of K/Rb and K/Cs ratios as well as a very low Li-content ($\leq$1150 ppm Li) in mica and Rb and Cs in K-feldspar.

Niobium-tantalum oxide minerals represent typical accessory minerals in almost all pegmatite units, but they are absent in the saccharoidal albite unit. They display extreme fractionation of Ta from Nb from ferrocolumbite to manganocolumbite with Ta/(Ta+Nb) (at.) = 0. 06-0. 35, Mn/(Mn+Fe) = 0.35-0.64 in the coarse-grained unit; through manganocolumbite to manganotantalite characterized by Ta/(Ta+Nb) = 0.46-0.83, Mn/(Mn+Fe) = 0.66-0.90 in the graphic and blocky units; to manganotantalite with Ta/(Ta+Nb) = 0. 73-0. 97, Mn/(Mn+Fe) = 0. 75-0. 90 and ferrotapiolite with Ta/(Ta+Nb) = 0.96-0.98, Mn/(Mn+Fe) = 0.22-0.35 in the cleavelandite unit. Compositionaly variable pyrochlore-microlite replaced columbite-tantalite in all textural-paragenetic units, and its Ta/(Ta+Nb) ratio is mostly equal to that of precursor.

The extreme evolution of Ta/Nb ratios in the manganotantalite-ferrotapiolite pair approaches a level comparable with that from highly evolved complex Li-rich pegmatites. The insignificant fractionation of muscovite, K-feldspar, garnet, beryl, tourmaline in the terms of K/Rb, K/Cs and Mn/Fe ratios as well as the very low Li, Rb and Cs contents in mica and K-feldspar are in a conspicious contrast. However, there is a distinct positive relationship between the Ta/(Ta+Nb) ratio of Nb, Ta-oxide minerals and the F-content in apatite, mica, and tourmaline from the same textural-paragenetic unit. The increasing μHF in the parent medium also indicated by the presence of topaz, triplite, microlite and euclase seems to have been the crucial factor which promoted the increase in Ta/(Ta+Nb). The extreme enrichment of the ferromanganoan minerals in Mn, which precedes enrichment in Ta in the lepidolite pegmatites (high μKF), is not observed here.

HIGH, MEDIUM AND LOW PRESSURE METAMORPHIC ROCKS: EYEWITNESSES TO THE VARISCAN DISTURBANCE IN THE BOHEMIAN MASSIF

P.J. O'BRIEN

Bayerisches Geoinstitut, Universität Bayreuth, Postfach 10 12 51, D-95440 Bayreuth, Federal Republic of Germany

Metamorphic rocks provide a fundamental insight into the past thermal structure as well as tectonic behaviour of the earth. Mountain building episodes seriously disturb the thermal structure of the lithosphere by juxtaposing rock units of different ambient temperatures and it is during the drive to eradicate these perturbations that metamorphic transformations take place. The metamorphic rocks thus formed are therefore the eyewitnesses to the disturbance. Our task is to 'interview' the rocks, by various geological means, and try to decipher the encoded mineralogical, chemical and structural record in terms of temperature, pressure, stress and material transport variations over time. The job is made difficult by the fact that the studied rocks have generally made their way to the surface and thus may have 'forgotten' what happened at depth i.e. they have recrystallised at lower pressure. Likewise, during complex polyphase (different events separated by a long time period) or multiphase (different stages during the same orogenic episode) evolutions a rock body may only 'remember' the high-lights (e.g. thermal peaks) and 'forget' what happened between these times or may even 'overlook' an event completely. However, although our witnesses may have poor eyesight or bad memories they always tell the truth and it is up to us to interpret these facts.

Exposed within the environs of the Bohemian Massif are a wide variety of metamorphic rocks of different bulk composition (pelitic, calcareous, granitic, mafic, ultramafic) that exhibit different styles of metamorphism (regional, contact) and that suffered fundamentally different pressures and temperatures. Best known are rocks that underwent the low pressure – high temperature episode during the Carboniferous i.e. the characteristic cordierite–sillimanite paragneisses and associated migmatites. Closely related is the contact metamorphism – at similar shallow (i.e. low pressure) crustal levels – developed around the numerous granite plutons that shortly postdate the regional event. Although evidence exists for an earlier higher pressure stage in the paragneisses (staurolite, kyanite, garnet) it is as yet by no means certain that the earlier event belongs to the same orogenic cycle. If the higher pressure stage was much older (e.g. Cadomian) the important implication is that the younger metamorphism could represent an isobaric heating event rather than a decompression event i.e. the P–T–t path constructed by joining together the two calculable P–T boxes would not represent the true path taken.

The source of heat for such large scale high temperature metamorphism and melting is a major area of contention. Models of the thermal evolution of the crust during tectonic thickening followed by erosion do not generally predict major HP–LT metamorphism. However, with a different starting point such as thrusting of thinned crust with young sedimentary basins, high temperatures can be generated and major melting would be likely (cf. Brown & Treloar 1991 Terra Abs 3 p. 87).

Of smaller areal extent, but no less important in terms of our understanding of the Variscan orogeny, are the numerous bodies of rocks preserving high pressure assemblages such as granulites, eclogites and garnet peridotites. Calculated pressures for these rocks imply a burial to depths equivalent to two or three times the thickness of the normal crust. Most geologists agree that some kind of crustal imbrication, probably preceeded by subduction of oceanic and/or thinned continental crust, was the cause of thickening but the rate and mechanism of exhumation of the deeply buried rocks is still a contentious issue. Simple erosion of the thickened crustal pile would yield a considerable volume of sedimentary rocks: such deposits are apparently missing. Extension models are currently in vogue to explain the exhumation of high pressure rocks in other orogenic belts. Clearly this mechanism can not operate alone as in many places in the Bohemian Massif the rock units with high pressure relics sit above lower grade units.

An important feature not to be overlooked in the units with high pressure relics is the fact that the rocks within a single body have generally experienced different pressure peaks i.e. the high pressure units are themselves composite bodies compiled by multiple stages of intracrustal thrusting. For example the acid granulites in Saxony, North and South Bohemia, Moravia and Lower Austria yield maximum pressures in the range 12–16 kbar whereas associated peridotites and their enclosed garnet–clinopyroxene rocks generally experienced pressures above 20 kbar with an obvious overprint at lower pressures. Most rocks in these high pressure units also show clear evidence for medium pressure granulite facies (6–8 kbar) and amphibolite facies overprints thus making recognition of the earlier history difficult.

Eclogites of tholeiitic composition and with quartz, kyanite, zoisite, phengite and amphibole as accessories are another important tectonometamorphic indicator in the Bohemian Massif. They clearly do not belong to the granulite–garnet peridotite association and may instead represent some kind of meta–ophiolite unit. Multiple partial re–equilibrations in these rocks, sometimes at higher temperatures than the initial eclogite facies stage, led to the development of new phases such as orthopyroxene, spinel, olivine and sapphirine. It is not uncommon to find evidence for three or four different metamorphic stages in the same thin section. In undeformed rock bodies the partial transformations can often be traced to the influx of fluids into the samples even where no hydrous phase is formed. It is perhaps then the exclusion of catalysing fluids from the rocks that allows them to reach shallow crustal levels relatively unaffected by what are, from the partial reactions seen, relatively high metamorphic temperatures. However, the preservation of sharp compositional boundaries in phases such as garnet indicates only limited exposure to high temperatures regardless of fluid presence. Once again this points to a more complex thermal history perhaps with multiple thermal spikes as would be expected within a thrust stack where polyphase out–of–sequence thrusting occurred.

The age of the high pressure metamorphism is another area of dispute. Eclogites with relatively low temperature overprints yield Devonian to Silurian ages for peak metamorphism and were probably already at amphibolite facies conditions by Late Devonian times. In contrast, Lower Carboniferous ages are common from within the acid granulite/peridotite units. Temperatures were high for a significant proportion of the uplift history of these rocks and it may be that the ages are not those of the high pressure metamorphism. This aspect of BohemianMassif geology is currently actively under investigation and we may be in for a few surprises if the remarkably young ages derived for Alpine high pressure rocks are anything to go by.

TOPAZ BEARING QUARTZITES AT THE CONTACT WITH GRANITOID ORTHOGNEISSES NEAR ZDOBNICE IN THE ORLICKÉ HORY (LUGICUM, BOHEMIAN MASSIF)

M. OPLETAL[1] - A. SOKOL[2]

[1] *Czech Geol. Survey, Klárov 3, 11821 Praha 1, Czech Republic*

[2] *Loretánské nám. 2, 11800 Praha 1, Czech Republic*

Variscan tin mineralization is very well documented from the Saxothuringian zone – in the Krušné hory. However, cassiterite, scheelite and topaz mineralization of pre–Variscan age is also reported in crystalline rocks of the Lugicum (Michniewicz, et al. 1991). These mineralization follows contacts between orthogeniss and country rocks and is considered to be Caledonian (Borkowska et al. 1990) or more precisely early Caledonian as deduced from the $^{207}Pb/^{206}Pb$ age of 507±10 Ma – 503±4 Ma (Kröner, Jaeckel and Opletal – this volume).

Topaz–bearing quartzites were recently discovered by field geochemical prospection near Zdobnice in the Orlické hory at the top of mountain crest (910 m). Granitoid orthogneiss is in a overturned position above quartzites and mica schists.

Muscovite quartzite is fine grained, distinctly foliated with lepidogranoblastic texture. Hypidiomorphic topaz 0.X—2.6 mm in size was affected by two tectonometamorphic phases recorded by two cleavage systems and recrystallization. Crystals of topaz were coroded by quartz (silicification effect), partly replaced by muscovite during the first phase and crushed during the second one.

The dated granitoid orthogneiss with lepidogranoblastic texture represents metamorphosed granite contact metamorphic effect of which can still be seen in country micaschist and marbles (sulphide – scheelite – cassiterite contact mineralization).

With a view of these fact the discovery of primary topaz in muscovite quartzite at the contact with granitoid orthogneiss proofs the existence of the end of early Caledonian (or terminal Cadomian) magmatic event cca 500 Ma old and contact pneumatolitic metallogenic activity in the eastern part of Lugicum.

SILURIAN (WENLOCKIAN) SPOROMORPH IN SOUTH BOHEMIAN MOLDANUBICUM

B. PACLTOVÁ

Department of Paleontology, Charles University, 128 43 Praha 2, Albertov 6, Czech Republic

In strongly metamorphosed graphitic limestones from the locality "U vápenky" quarry at the southern periphery of Český Krumlov, further well definable Cryptospores, sculptured miospores together with nethromorphic acritarchs (*Deunffia, Domasia sp. div., Veryhachium sp., Leiofusa sp. div.) Leiosphaeridium sp. div., Tasmanites, Glaeocapsomorpha prisca,* organic–walled tubes and cuticles were discovered.

According to Burgess and Richardson (1991) the appearance of sculpture on hilate cryptospores and trilete miospores is an event of biostratigraphical, biological and evolutionary significance, which is useful for interregional stratigraphical correlation. The sculptured sporomorphs appeared first in the late Wenlockian Cyrtograptus lungreni Biozone of the type area in Shropshire. This assemblage characterized inshore facies. According to Dr. P.Dufka (personal communication), some of the sporomorphs stated above (e.g. trilete miospore Type 1, Burgess & Richardson) have been newly described from the Wenlockian of the Barrandian area (Dufka in press).