Summary

I. Comparison of the Krušné hory-Smrčiny and Cornubian batholiths

COMPARABLE FEATURES

Shape and form of batholiths

Both batholiths have similar dimensions (length about 200 km; width varies from 20 to 40km). The steep sides and flat roofs of the plutons are other significant common feature in both batholiths.

Post - emplacement wrench faulting

NW-SE trending wrench faults dislocating the granite plutons are common in both batholiths.

Presence of granite porphyries

In both batholiths, granite porphyries with similar petrographic features occur, but there is a difference in their ages of emplacement relative to the granites. In the Krušné hory Mts., granite porphyries are older than youngest pulse of granite intrusion, whereas in the Cornubian batholith, granite porphyries are intruded into the younger granites.

Granite typology

Granite types in both the batholiths vary from monzogranite to syenogranite, except for G1, which is granodiorite and monzogranite. G1 granites are absent in the Cornubian batholith.

Geochemistry of granites

The granites within their groups in both batholiths have similar alumina balances, alkali ratios, alkali/ calcium ratios, dark mineral constituents, normative feldspars, and trace element distributions, apart from the G3 granites which differ with respect of the Ba, Sr, Zr, and Mg/Fe ratios. An explanation for the difference in the G3 granites is discussed later separately (see contamination in G3).

Degree of differentiation in granites

Granites of the same group in both batholiths show remarkably similar degrees of differentiation.

Tectonic discriminations of granites

Several schemes for tectonic discrimination of the granites suggest similar tectonic settings for similar granite groups (syn-collisional and/or post orogenic).

Approximate age of emplacement

Available radiometric dates for the emplacement of the granites indicate simultaneous emplacement of the same granite types in both batholiths.

$^{87}Sr/^{86}Sr$ ratio

The initial $^{87}Sr/^{86}Sr$ ratio in granites of similar typology in both batholiths are similar. In general, the initial Sr isotope ratio is high in both the batholiths, except for some younger granites in the northeastern part of the Krušné hory Mts. (Table 6).

Physical conditions of magmatism

Pressure and temperature conditions estimated for the formation (700-900 ^{0}C & 8kb P) and emplacement of granites (600-700 ^{0}C & 2-2.5 kb P) in both batholiths are similar.

Association of ore mineralization to the granites

Granites in both batholiths indicate similar types of associated mineral deposits (Sn ± W, Cu, Mo). The similarities in the mineralization include the modes of occurrence, and qualitative ore mineral associations, but there are some contrasts in the physical relations of the deposits to the granites, and in the order of abundance of the ore minerals.

Heat flow and heat production

There are significant differences in the surface heat flow and heat production of the granites in these batholiths. The Cornubian province has a higher heat flow and heat production than the Krušné hory-Smrčiny Mts. province. But there is also a difference of at least 500m in the altitude of the provinces. Many authors have a vertical uplift of the Krušné hory mountains prior to Tertiary volcanism. Therefore, the interaction of ground water with the granites (in micro and macro fractures) might have been great in the Krušné hory-Smrčiny Mts. than in Cornubian rocks. Myslil (p.c.) assumes that due to a high ground water migration through the granites, mainly via fracture flow and rock matrix diffusion, the heat production of granites in the Krušné hory batholith might have been reduced. Similar observations were made by Guthrie (1991) in Australia. This may indicates that there is a similar initial heat production in the granites of both provinces.

CONTRASTING FEATURES

Position of the batholiths in the tectonic frame of Hercynian Europe is a puzzle. Why granites having remarkably similar features lie in the different tectonic zones (e.i. Rhenohercynian zone and Saxothuringian zone) within a single orogenic belt (Hercynian fold belt)? An explanation may be that during regional tectonic evolution different orientations of compressional and extensional sub-crustal forces may occur during the collision of two plates. Probably, because of "change in the orientation of the layering relative to the axes of the incremental strain ellipsoid" or "subjection to a constructive type of two dimensional stress" (Ramsay, 1967). With the result the position of upper crustal lithostratigraphic column can be shifted.

Regional structures

Both batholiths are located in different regional structural frameworks. The Krušné hory-Smrčiny batholith is confined to an antiform and it seems that emplacement of granites followed structural weak zone 'axial plane of the anticline', whereas, the Cornubian batholith is intruded in a highly folded and faulted synform in SW England. The emplacement of the Cornubian batholith does not seem to follow a particular regional structure as is the case in the Krušné hory-Smrčiny batholith. This is perhaps due to different style of deformation in these provinces.

Volcanism

In SW England, erupted acid volcanics are not preserved directly above the granite bodies, whereas in certain parts of the Krušné hory Mts. volcanic rocks are well preserved (Teplice caldron). This may be due to relatively more uniform uplifting and/or erosion in SW England than in the Krušné hory Mts.

amount and dimensions. However, the distribution site of tourmaline differs from pluton to pluton. For example, in both the Vaikrita and Cornubian leucogranites, tourmaline is abundant within the granite body, whereas, in the Krušné hory-Smrčiny batholith tourmaline is confined to the contact zone.

Associated mineralization

The Hercynian leucogranites are well known for their associated Sn-W mineralization, whereas, no such mineralization is known at present in the Himalayan leucogranites. This is another unsolved problem.

Space form of the batholiths

The space form of the Hercynian granite bodies (SW England and NW Bohemia) is clear owing to extensive geophysical and drilling prospecting for the associated Sn-W mineralization. The space form of the granite batholiths in Himalayas has not been studied (due to unknown economic significance, politically disputed terrain, thick snow and ice cover, and difficult accessibility of the area). However, according to present knowledge, the granites are capped by metasedimentary rocks in the Vaikrita thrust sheet of the central Himalayas. This compares them with the Hercynian leucogranites, as their roofs is close to the present erosion level.

Tectonic settings

The tectonic settings of the leucogranites differ from batholith to batholith. In NW Bohemia, leucogranites are associated with the deep vertical faults, in Cornwall setting is uncertain, and in the Vaikrita Thrust Sheet, they lie above the Main Central Thrust.

Initial Sr isotope ratio

The higher $^{87}Sr/^{86}Sr$ ratio in the Hercynian leucogranites implies a crustal origin for the granites, or crustal contamination. Crustal source for Himalayan leucogranites is not fully favoured by the $^{87}Sr/^{86}Sr$ ratio.

Rare earth elements

The REE patterns of the Himalayan and Hercynian leucogranites show slight differences. The Hercynian leucogranites have remarkably high negative Eu anomalies (Eu/Sm=.05-.13), whereas, the Himalayan leucogranites have low or no significant negative Eu anomalies (Eu/Sm=.17-.34). The only available REE data for the Manaslu leucogranite show a sharp negative Eu anomaly (Vidal et al., 1982). The range of Eu/Sm ratio differs in the Himalayan and Hercynian leucogranites, but the ratio, in general, does not exceed a "moderate" to "negative" Eu anomaly (Eu/Sm=.20-.36 after Henderson, 1984). The LREE/HREE ratios in the Hercynian and Himalayan leucogranites also differs [e.g. (La/Lu)cn= 8-18 in the Hercynian leucogranites and (la/Lu) = 3-9 in the Himalayan leucogranites]. However, the complete variation of LREE/HREE ratio in all the leucogranites considered here is also in the range of a moderate Eu negative anomaly (Henderson, 1984). It is interesting, that the Vaikrita leucogranites, which are comparable to the Hercynian leucogranites in most geochemical and petrographical aspects, differ with respect to the Eu anomaly. The overall REE abundance is relatively low compared with normal granites and indicates a consistent pattern that points to fractional crystallization. This is a common observation in the worldwide leucogranites of whatever age. The strong negative Eu anomalies in the Hercynian leucogranites supports other geochemical observations which indicate that they underwent greater fractionation than the Himalayan leucogranites.

Origin of leucogranites

The Vaikrita leucogranites are structurally located above the Main Central Thrust (MCT). The low $^{143}Nd/^{144}Nd$ and high $^{87}Sr/^{86}Sr$ (.745) ratios indicate that the granitic magma developed by anatectic melting of crustal rocks. Such conclusions have been drawn by many authors working on Himalayan leucogranites. Generally, the Vaikrita leucogranites are said to be geochemically related to the genesis of the Vaikrita thrust sheet (Le Fort, 1981, Vidal et al., 1982, Cuney et al., 1984; Deniel et al., 1985), which was brought up from deeper level and thrust southward along MCT. The subsequent dehydration and decarbonation of these sediments released a large amount of fluid, which fluxed the overlaying gneisses and gave rise to wet melting. In this model, it would appear that the heat source required to produce the leucogranite melt is uncertain. Stern et al. (1989) suggested that the Indian continental crust was preheated, and, that the heat might have been supplied from the hot asthenosphere, which replaced the continental lithosphere.

The origin of Hercynian leucogranites can also be compared with this model. It is important to consider the idea that the Vaikrita leucogranites were formed during crustal thickening (60-70 km), whereas such crustal thickening in the Hercynian leucogranite provinces is not evident. Therefore, the crustally derived leucogranites in Hercynian Europe, have probably been supplied not only by heat, but also by some material from the mantle. This supply of heat and material from mantle to the similar leucogranites in the Vaikrita thrust sheet might not have been achieved by crustal thickening. As a result, the leucogranites in the Himalayas are neither metasomatised nor mineralized as are the Hercynian leucogranites.

IV. Comparison of the Almora granites and the Hercynian Older Granite

The syntectonic and synmetamorphic Almora Granite, in the Lesser Himalayas shows close geochemical and petrographical affinity with the Hercynian older granites. Apart from similar geochemical and petrographical features, there are many other features common in both of these granites, e.g. the relics of metamorphic minerals and xenoliths of metasedimentary rocks.

The alumina balance [Al-(Na+K+2Ca)], alkali/calcium ratio [(Na+K)/Ca], ferro-magnesium ratio [Mg/(Mg+Fe)], dark mineral constituting elements (Fe+Mg+Ti), free quartz [Si/3-(Na+K+2/3Ca)], alkali ratio [K/(Na+K)], trace element distribution, initial Sr isotope ratio, REE distribution are fully comparable features in these granites. Geochemically, only the degree of fractionation as understood by negative Eu anomaly provides a contrast. Perhaps, as the source of the Hercynian older granites is not exposed, the magma might have been transported for some distance, which would allow greater fractionation of the Hercynian older granites than in the "in situ" Almora granites.

It follows from this comparison between the Almora and Hercynian older granites that because the source rock of the former can be shown to have been pelitic schist, the latter must have been also derived from a similar source material.