I-TYPE GRANITOIDS AS INDICATORS OF A LATE PALEOZOIC CONVERGENT OCEAN/CONTINENT MARGIN ALONG THE SOUTHERN FLANK OF THE CENTRAL EUROPEAN VARISCAN OROGEN

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The roughly easterly trending Variscan orogenic belt of Central Europe evolved in connection with the Paleozoic convergence of the megacontinents Gondwana in the south and Laurentia - Fennosarmatia (Laurasia) in the north and was consolidated in the Late Paleozoic. Unresolved questions center around the plate tectonic framework in the Variscan realm and where subduction zones were located (ZIEGLER 1986, MATTE 1986, NEUGEBAUER 1988, EISBACHER et al. 1989, FRANKE 1989, FRISCH & NEUBAUER 1989).

The objective of our study is to test, if the chemical characteristics of the voluminous Carboniferous to Permian Variscan plutonism allow to deduce a distinct plate tectonic environment towards the end of the Variscan orogeny. The study is based on the assumption that distinct tectonic regimes are likely to produce chemically distinct types of plutonic suites (PITCHER 1983, PEARCE et al. 1984). Main subject of our investigation are the numerous Late Paleozoic granitoid plutons that occur in the Alps, but are part of the southern portion of the Variscan orogen (Fig. 1).

Chemical data for these intra-Alpine Variscan plutons show several features in common with the "Cordilleran I-type plutons" of PITCHER (1983), e.g. a broad compositional spectrum from tonalitic to granitic, generally high Na_2O contents and low $Al_2O_3/CaO+Na_2O+K_2O$ ratios. This is surprising, because the late stage plutonic event of the Variscan orogeny has commonly been related to a collisional environment and not to subduction (ZIEGLER 1986, MATTE 1986, FRANKE 1989).

However, examples of "Cordilleran I-type plutons" with associated tonalite (or diorite), granodiorite and granite can be found over a distance of more than 1000 km from the Western Alps (e.g. Dora Maira, Dent Blanche, Mont Blanc, Monte Rosa pluton) to the Southern Alps (e.g. Cima d'Asta) into the Eastern Alps (e.g. Zillertal-Venediger, Hochalm, Seckau-Bösenstein pluton). Similar compositional characteristics have been also found in the Modra and Bratislava Massif of the Carpathians (for data see references in Fig. 1).

The predominantly granodioritic-tonalitic intra-Alpine Variscan plutons contrast with a contemporaneous plutonic zone of granites, which extends to the north of the Alps in the Moldanubian section of the Variscan orogen. These Moldanubian Variscan granites display significantly higher K_2O/Na_2O ratios than the intra-Alpine Variscan granitoids (Fig 2).

A second important difference are the generally negative εNd initial ratios of the Moldanubian S- and I-type plutons, which indicate a dominant role of old crustal sources. The values contrast with the less negative, partly even positive εNd initials of the intra-Alpine Variscan granitoids (Fig. 3). The latter plutons have covariations of Sr and εNd initial ratios, which indicate an involvement of both sources with mantle-isotopic composition and ancient crustal sources. Similar patterns have been found in the continental margin batholiths of California (DE PAOLO 1981).

The regional duality of Variscan plutonism resembles the modern plutonic configuration along active circum-Pacific continental margins with outer coastal batholiths of the "Cordilleran I-type" and inner K2O-enriched granitoid belts. The observed distribution of Variscan granitoid types in central Europa might therefore be taken as an indicator of a Late Paleozoic convergent ocean/continent plate boundary along the southern flank of the Variscan belt.

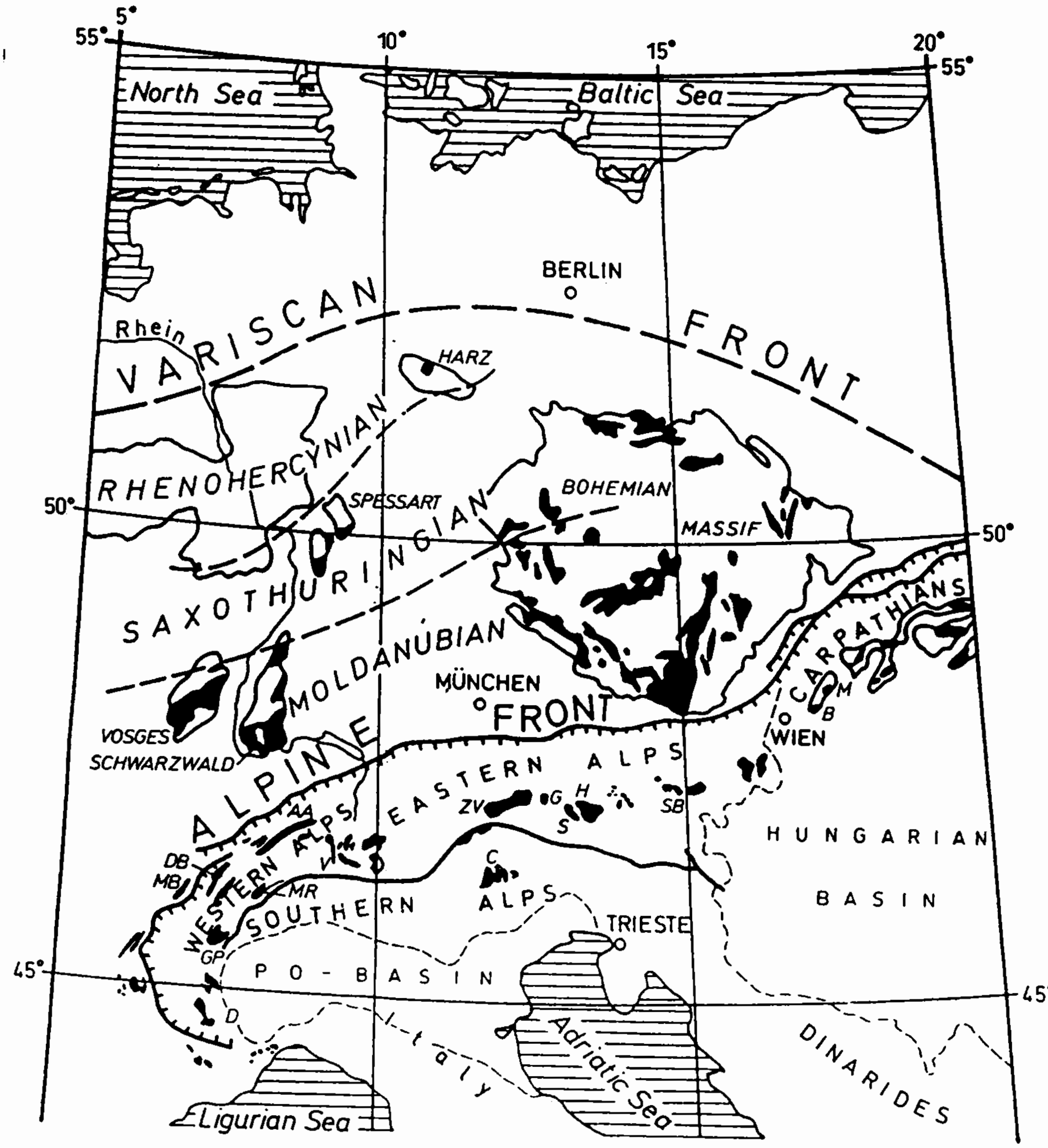
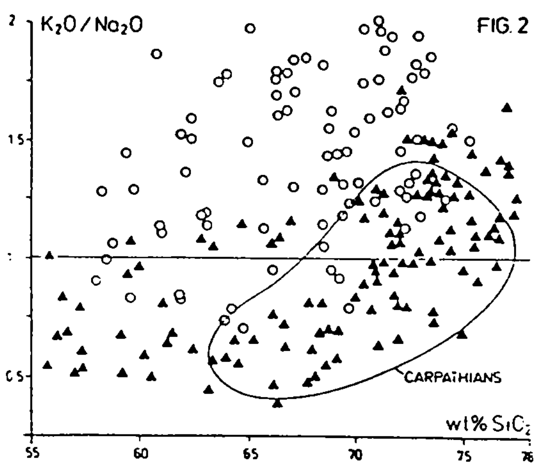


Fig. 1: Distribution of Late Paleozoic granitoid rocks (black) in Central Europe according to the Geological World Atlas (CHOUBERT & FAURE-MURET, 1980) and BARGOSSI et al. (1979).

Abbreviations of names of studied putonic units in the Alps and Carpathians: AA=Aar (data source: SCHALTEGGER 1989); B=Bratislava, M=Modra (CAMBEL & VILINOVIC 1987); C=Cima d'Asta (D'AMICO et al. 1987); D=Dora Maira, GP=Gran Paradiso, MR=Monte Rosa, V=Val Savaranche (BARGOSSI et al. 1979); MB=Mont Blanc (BUSSY et al. 1989, MARRO 1988); G=Granatspitz, H=Hochalm, S=Sonnblick, SB=Seckau-Bösenstein, ZV=Zillertal-Venediger (FINGER & STEYRER 1988 and unpubl.)

According to the yet available geological and paleomagnetic evidence (see review in NEUGEBAUER 1988) it appears, nevertheless, also likely that Gondwana and Laurasia were linked when the voluminous Late Variscan plutonism occurred and that the Early Variscan oceans, which separated the continents, were already closed. We suspect that this is the reason why most investigators have, so far, not correlated the final putonic event of the Variscan orogeny to subduction, but to an intracontinental post-collisional uplift setting. However, the extended intra-Alpine Variscan I-type granitoid belt is not typical for an intra-continental collision regime, especially when the Himalayan and Alpine analogues are considered (compare e.g. PITCHER 1983, HARRIS et al. 1984). Atypical for a thickened collisional crust seems also the extremely high-heat flow during the late stage of the Variscan orogeny, which caused widespead LP metamorphism and anatexis in the Moldanubian unit (BLÜMEL 1986).

On the other hand, the combination of plutonism and high heat flow is again a very characteristic signature of modern active continental margins. Therefore, it appears the more plausible for the Variscan orogen that a Late Paleozoic Cordilleran type tectonic setting with an southerly, northward descending oceanic plate existed. Paleomagnetic data (SCOTESE 1984) do not rule out the existence of such a large Carboniferous oceanic plate on the southeast of the Variscan belt (Fig. 4). This "Paleotethys ocean", however, seems to have formed first in the course of a "post-collisional" Carboniferous westward removal of the Gondwana continent relative to the Variscan fold belt. We speculate that this westdrift of Gondwana changed the orogenic situation in Central Europe from collisional and widely intracontinental in "Mid Variscan", i.e. Late Devonian to Early Carboniferous times to a "Late Variscan" Cordilleran type plate configuration, which allowed a north(west)ward subduction of oceanic crust under the Variscan belt in front of Laurasia (Fig. 4). This new concept has the advantage to explain both the earlier Alpinotype collision features (HP-metamorphism; nappe tectonics - MATTE 1986) and the late stage Cordilleran type features of the Variscan orogeny.



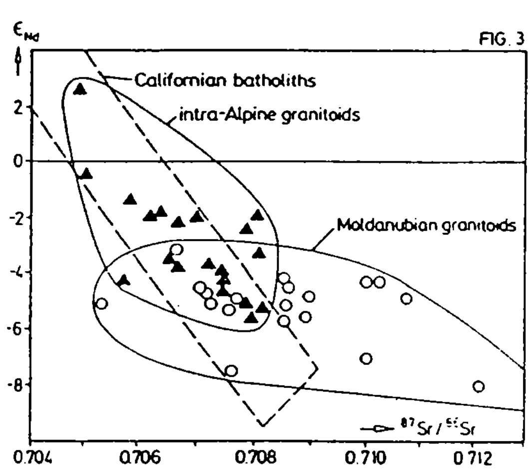


Fig. 2: K2O/Na2O vs SiO2 diagram with plots of intra-Alpine (black triangles) and Moldanubian Variscan granitoids (open circles). Data source for the Alps and Carpathians see Fig. 1, for Moldanubian granitoids: EMMERMANN (1977), LIEW et al. (1989), FINGER et al. (1988), FINGER (1984) and unpubl.

Fig. 3: Sr 87/86 vs εNd model initial ratios of intra-Alpine (v.QUADT, unpubl.) and Moldanubian Variscan granitoids (LIEW et al. 1989, LIEW & HOFMANN 1988). Field of the California batholiths according to DE PAOLO (1981), Symbols as in Fig. 2.

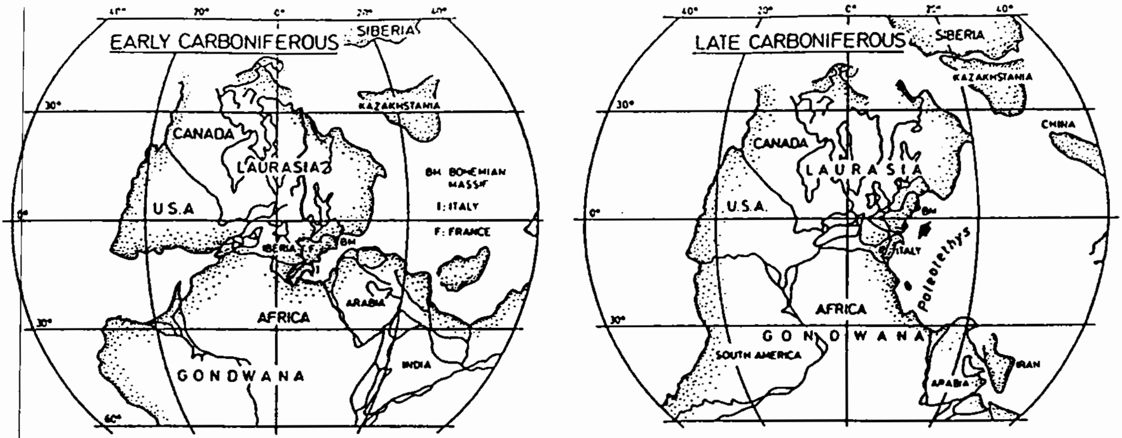


Fig. 4: Paleogeographic base maps for the Early and the Late Carboniferous according to SCOTESE (1984). We believe that the Paleotethys ocean was subducted in Late Carboniferous times below the Variscan fold belt, which lies in front of the northern Laurasian craton. Note, however, that this plate configuration probably formed first in the course of the Carboniferous westdrift of Gondwana relative to Central Europe. The map for the Early Carboniferous suggests a more or less intracontinental environment of the Variscan fold belt between Gondwana and Laurasia.

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