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Some Aspects of Mineral Deposits Formation and the Metallogeny of Central Europe

By LUDWIG BAUMANN*)

With 7 figures and 1 table

Schlüsselwörter

Mitteleuropa
DDR
prävariszische Metallogenese
variszische Metallogenese
postvariszische Metallogenese
Magmatismus
Tektonik
postvariszische Platten
Taphrogenese
Mesozoikum

Summary

As a result of recent research work carried out on deposits mainly in the GDR, the view regarding the uniformity of the magmatic deposits of Central Europe, held until the midsixties, can no longer be maintained. Based upon the metallogenetic – minerogenetic development a pre-Variscan epoch (Proterozoic-Ordovician), a Variscan epoch (Silurian-Lower Permian) and a post-Variscan epoch (Upper Permian-Cenozoic) can be distinguished. Each of these epochs has characteristic features of its own in regards to tectonics, inherent magmatism, sedimentation and – caused by these – deposit formations. Some topical questions connected with this are treated, which are of importance for deposit location forecasting in Central Europe:

– Character of the pre-Variscan types of deposits
– Genetic problems of Variscan sialic deposit formation
– Deposits of platform activation due to post-Variscan platform magmatism.

From the metallogenetic regional analysis follows the conclusion that the post-Variscan deposits of Central Europe are associated with an alkalinely differentiated intrusive magmatism that developed during the Mesozoic in connection with taphrogenic tectonics. Deposits have mainly formed in the areas of intersection of the taphrogenic structures (NNE-SSW) with Mesozoic germanotype faults (NW-SE).

1. Introduction

Discovery, exploitation and utilization of mineral raw materials will take place in the future under ever increasingly difficult conditions of exploring and development. The solution to these tasks will require greater demands on corresponding preliminary scientific work in the fields of economic geology and metallogeny-minerogeny. In the following several topical problems concerning deposits research are considered which are of great impor-

*) Athor's address: Dr. L. BAUMANN, Bergakademie Freiberg, Straße der Freiheit 78, DDR – 92 Freiberg.

tance in metallogenetic – minerogenetic analysis and in forecasting deposits locations in Central Europe. The results are also of interest for the deposits provinces of the Alps.

These problems are:

– the existence and character of mineralizations in the *pre-Variscan* basement complex

– genetic problems of *Variscan* sialic deposit formation

– deposits of *post-Variscan* platform activation.

The formation of deposits in a region is determined by the geotectonic, petrological and lithofacies development. Their characterization and time-space delimitation constitute the basis of the regional division of a definite area. For Central Europe mainly three large different developmental epochs can be distinguished:

1. a pre-Variscan epoch (from Proterozoic to Ordovician) with predominant geosynclinal development (femic-sialic type after V. I. SMIRNOV 1970),

2. a Variscan epoch (from Silurian to Lower Permian) with a nated with three corresponding metallogenetic epochs or cycles of mineralization. These show, in parts, the same element composition (metallogenetic heredity; in parts they also reveal specific element concentrations (Table 1).

Table 1: **The most important ore deposit-forming elements of the three metallogenetic epochs of Central Europe**

Epoch	Ore deposit forming elements
Post-Variscan (Mesozoic-Cenozoic)	Fe, Mn; F, Ba, Ca, Mg; Pb, Zn, Cu; Bi, Co, Ni, Ag, (U); Hg, As, Sb; (Sn), (SE)
Variscan (Young-Paleozoic)	Fe, Mn, Ba; Sn, W, Mo, Bi, Li, F; (Au), Zn, Cu, Pb; U; Sb, As, Ag
Pre-Variscan (upper Proterozoic-Cambrian)	Fe; Cu, Zn, (Pb), Sn

2. Pre-Variscan Mineralizations

Within the metamorphous pre-Variscan basement complex of the GDR several rock series with especially characteristic lithofacies can be distinguished (LORENZ and HORTH 1964, 1967):

– the Pressnitz series (= late Proterozoic stage of the Precambrian complex), which is an equivalent of the spilitic and post-spilitic series of Bohemia/CSSR;

– the Keilberg, Joachimsthal and Frauenbach series (= Cambro-Ordovician complex).

These series are characterized by heterogeneous litho-suites of the geosynclinal type (psammitic-pelitic facies with conglomerate inclusions as well as carbonate and lyditic-sapropelitic rock closely associated with basic and acid effusive magmatites). The geological-lithofacial nature of these rock series requires the assumption of at least two pre-Variscan geosynclinal developments (assyntic and Caledonian: SCHMIDT and LÄCHELT 1974; BAUMANN and TISCHENDORF et al. 1976). An exact delimitation of these partial developments from each other and from the younger Variscan epoch is extraordinarily difficult because of the different rock metamorphosis cutting the temporal bed boundaries.

Numerous stratiform ore occurrences are associated with some metamorphously superimposed rock series (amphibolites, chlorite schist, porphyroids, layered red gneisses, metagraywackes, quartzites, calcareous dolomites, two-mica gneisses). The mineralizations are stratigraphically and facially bound to the lithologically heterogeneous, volcanogenic-

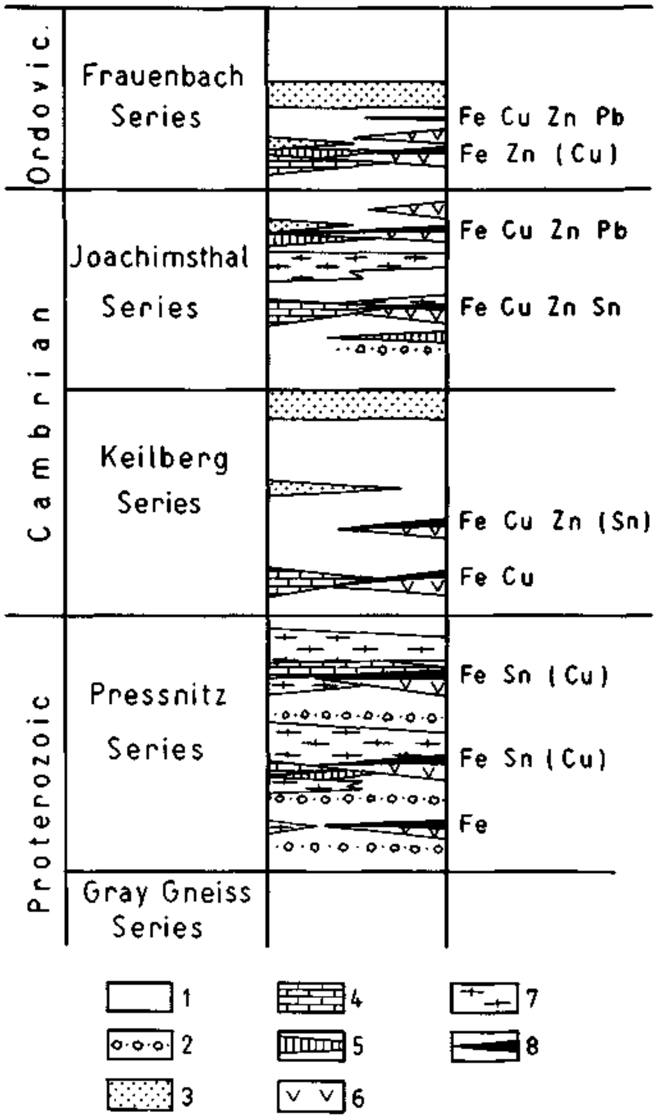


Fig. 1: Stratiform mineralizations in the pre-Variscan basement complex of the Erzgebirge (schematic, in part after WEINHOLD 1977).
1 – two-mica gneiss, mica slate; 2 – metagraywacke, metaconglomerate; 3 – quartzite; 4 – limestune marble, dolomite; 5 – metalydite, metasapropelite; 6 – metabasite (amphibolite, green schist); 7 – metaporphyroids (red gneiss); 8 – Stratiform mineralizations.

sedimentary rock "classic" geosynclinal-orogene development (sialic-femic type after V. I. SMIRNOV 1970),

3. a post-Variscan epoch (from Upper Permian to Cenozoic) with predominant platform development.

Each of these three epochs has its own characteristic features in regards to tectonics, inherent magmatism, sedimentation, metamorphosis and – caused by these – the formation of deposits. The recognition of three epochs of deposit formation in Central Europe, however, is not yet very old. Up to about fifteen years ago the view predominated that in Central Europe endogenous deposit-forming processes have become effective only in one metallogenetic epoch and – except the deposits of the basic geosynclinal magmatism of the Lahn-Dill type – all morphologic-genetic types of deposits (veins, beds, impregnations and metasomatites in the most varying rocks and geological horizons) have to be attributed to deep-seated ore-bearing granite bodies of Variscan age. Nor until the early 1960's – promoted among others, by research work carried aut at the Mining Academy of Freiberg – the view gradually did begin to prevail that besides the "classic" Variscan formation of deposits there was also a younger post-Variscan (alpidic) phase of mineralization (BAUMANN 1963, 1965a, 1967; WERNER 1966; BORCHERT 1967; RÖSLER 1967; BAUMANN and RÖSLER 1967 et al). Furthermore, based upon new exposures and new studies of stratiform mineralizations and skarn deposits in the crystalline basement rocks of the Erzgebirge, the existence of an older, pre-Variscan phase of mineralization was proven (BAUMANN 1965b; LANGE 1962, 1965; WEINHOLD 1974, 1977).

Based upon these new research results, the three named geological developmental epochs in Central Europe can be coordiformations and thus are obviously of a stratigenic nature. Within both the Upper-Proterozoic Pressnitz series and the Cambrian-Ordovician series several ore-bearing horizons can be distinguished (Fig. 1) Here, as regards to the ore element association increasingly more complex composition can be proved from the older to the younger series (Proterozoic Pressnitz series with Fe, Sn, Cu: Magnetite and pyrite-cassiterite deposit of Prisecnice-Medenec/CSSR, "felsite horizon" of Halsbrücke near Freiberg/GDR, Boden-Hassberg range near Niederschmiedeberg/GDR-CSSR, Nové Mesto-Gierczyn in the Iser Mountains/CSSR-Poland, Kovary in the Giant Montains/Poland; Cambro-Ordovician series with Fe, Cu, Sn, Zn, Pb: Breitenbrunn, Schwarzenberg, Elterlein, Geyer in the GDR, Johanngeorgenstadt-Zlaty Kopec and Klingenthal-Kraslice/GDR-CSSR as well as presumably Sparneck/GFR, Bayerland near Waldsassen and Bodenmais/GFR. Further similar pre-Variscan geosynclinal mineralizations can be assumed to exist also in other basement-rock complexes (e. g. Chvaletice and Staré Ransko in the Bohemian Massif/CSSR).

The mainly impregnative-schlieric to compactly layered mineralizations attains thicknesses of several meters and often extends regionally several kilometers. The most important ore minerals are magnetite, hematite, pyrite, marcasite, pyrrhotine, cassiterite (partly as wood tin, partly as recrystallized needle tin), chalcopyrite, sphalerite and galena. Bedding and depositional fabrics as well as diagenetic to postdiagenetic folding structures in the ore deposits highly indicate a genetic interpretation of the above as primary-syngenetic formations within the volcanogenic-sedimentary rock series (Figs. 2 and 3: BAUMANN 1965b; WEINHOLD 1977; BAUMANN and TISCHENDORF 1974 and 1978). In the last years special attention was aroused by the cassiterite mineralization of these series. The concentric-shelly wood tin aggregates in a chloritic-silicate matrix point to a primarily colloidal (submarine) precipitate (Fig. 4). Further, these pre-Variscan cassiterite formations, as compared with the "classic" cassiterite mineralizations confined to Variscan granites, reveal distinct differences in their paragenesis, concentrations of trace elements (contents of Ta, Nb, Sc, Ti, Zr,

Fig. 2: Layered compact ore consisting of pyrite (white), melnikovite and marcasite (light grey), rhythmically alternating with cassiterite (dark grey) as well as quartz-chlorite schist (black; partly with boudinage formations). The layered structure points to light folding. – "Felsite horizon" of Halsbrücke (Pressnitz series), ore horizon II, 350 m level, scale 1 : (from WEINHOLD 1977).

Bi, Li, and Ga ten times lower) and in their oxygen isotope composition (lower δ^{18} O-values, mostly below 4‰ → mixture with ocean water!).

So the exclusive connection of endogenous tin concentrations to acid (Variscan) magmatites assumed so far cannot be maintained any longer. Because of their pre-Variscan age the ore beds were subjected to manifold geological influences and metamorphic changes (regional and contact-metamorphic processes of recrystallization, rearrangement and mobilization with partly Variscan, post-granitic superimpositions), leading to the metamorphic to

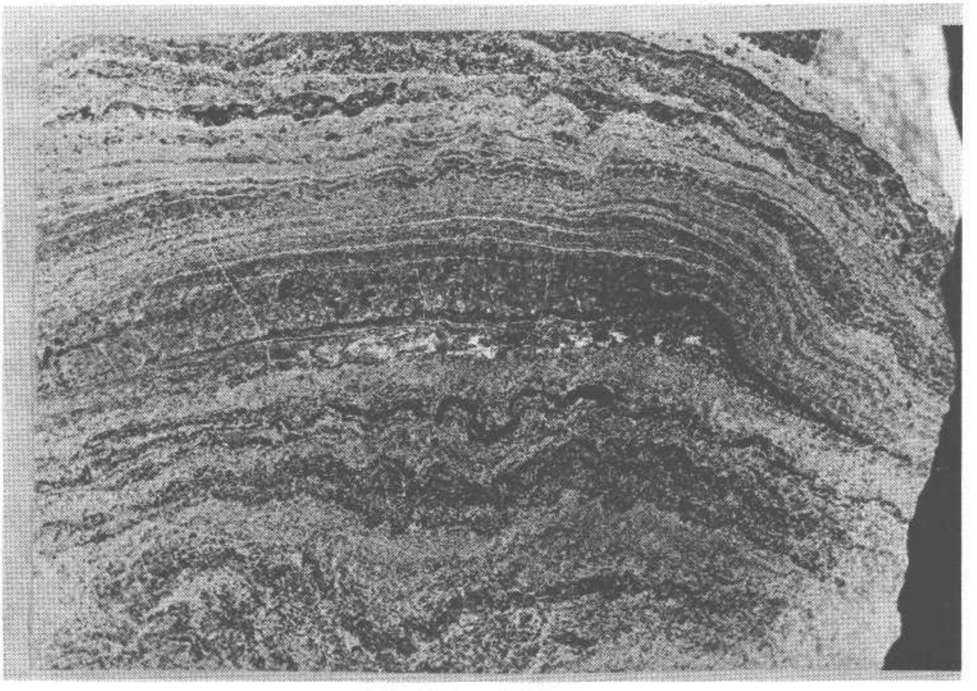


Fig. 3: Excellent finely folded layered structures of magmatite and hematite in amphibolite schist. – Fischerzeche near Přisečnice/CSSR (Pressnitz series). Scale 1 : 1 (from WEINHOLD 1977).

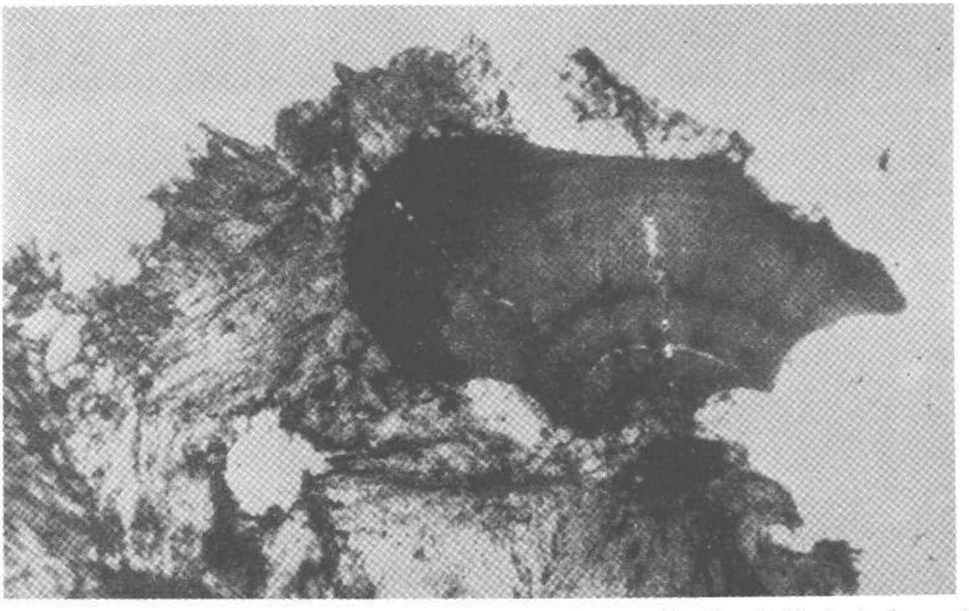


Fig. 4: Relics of primarily colloidally formed wood tin with recrystallized cassiterite in the form of fine needles (different shades of grey) included in a chloritic matrix (white). – "Felsite horizon" of Halsbrücke (Pressnitz series), ore horizon I. Microsection 50 : 1, 1 Nic. – from BAUMANN 1965b).

partly epigenetic fabrics predominating at present. The pre-Variscan ore beds existing today are thus the result of a polygenetic development extending over a long period of time.

Concerning the stratiform tin mineralizations in the Erzgebirge it may be mentioned that in the last decade basement rock investigations have led to surprisingly similar results in many countries outside of Central Europe. A large number of stratiform sulphide deposits of the "metamorphic kies – ore bed" type, which are very common in the Precambrian rock series of the ancient continents, also reveal, according to recent investigations, increased contents of Sn. Thus, cassiterite mineralizations, e. g. in the stratiform polymetallic ore deposits of Kidd Creek, South Bay and Sullivan in Canada, occur with contents up to 0.3 per cent of Sn (MULLIGAN 1974). Cassiterite could also be found in Grängesberg (magmatite-hematite beds) and Boliden/Sweden, in Renison Bell/Tasmania (MAUCHER 1974), in Pitkäranta/Carelian SSR, as well as in similar ore beds of the Caucasus, in the Baikal region, southern Ural and in the Kolyma district/USSR (SMIRNOV 1970). Recently Sn contents up to 1 per cent became known for the Lower-Cambrian volcanogenic-sedimentary sulphide deposit Takyrnoe in the Balkash region/Kasakh SSR (cassiterite and stannite intimately associated with other sulphides; MIROZHNICHENKO et al 1976). All these deposits possess specific characteristic features (lithofacies, morphology, structure, paragenetic and geochemical composition), by which they differ considerably from the tin mineralization types known so far. They have to be classified as a genetically independent type of deposit.

3. Some Genetic Problems of the Variscan Sialic Formation of Deposits

In the investigation of the deposits of the Variscan orogenetic areas it is often found that formations geochemically specialized for certain elements occur besides correspondingly specialized older and younger rock formations. Deposit provinces, where concentrations of similar elements are repeated in various geological epochs, must be considered from the viewpoint of metallogenetic heredity (ROUTHIER 1971). The elements repeatedly ocurring in certain concentrations in the deposits are typochemical for the given regional unit. In the Erzgebirge, e. g., such a typochemical element is tin (Sn), which, according to recent research work, occurred several times in workable concentrations from the Precambrian (volcanogenic-sedimentary series) through the Paleozoic (Variscan granites) to the Cenozoic (alluvial placers) (BAUMANN 1970; BAUMANN and TISCHENDORF 1974, 1978). The same applies obviously also to Fe, Cu, Zn, U and Ag (Fig. 1). It is an eminent task of metallogenetic investigations to explain the systematic connections within such geochemical provinces for the deposit areas of Central Europe and the alpidic orogenetic areas. The knowledge of such relationships is of very great importance for the forecasting of deposit locations and for the ensuing search and exploration.

Recently in this connection this view has become more widespread which rejects an active, element-supplying function of the granite intrusions as source of material in the formation of deposits (KITTL 1960; TUGARINOV 1963, 1967; SUDOVIKOV 1965; BARSUKOV 1971; BELEVTSEV 1972). TUGARINOV especially maintains the view that granitic magmatism plays solely the part of a mobilisator and stimulator for metamorphogenic-hydrothermal solutions, the solution constituents themselves being derived from the surrounding metamorphosed rock formations. Observations show that with increasing degree of metamorphism in the rocks the contents of some elements will decrease considerably, and this process in connected with the transition of the elements into the metamorphogenic-hydrothermal solutions. The intrusive process is assumed to play only the passive role of heating, by which the regional metasomatism of the surrounding rocks is activated (BOYLE 1970; BELEVTSEV 1972, 1974 et al). The mobilization of metasomatic and veined hydrothermal mineralizations from older syngenetic ore horizons within the contact range of younger intrusions has recently also been described by PUTZER (1976) for the Andes of South America.

An intermediate attitude regarding this question is adopted by BARSUKOV in his much discussed theory of mobilization. As is known, he begins with the assumption that rock-forming minerals of the granitoids carry and concentrate many ore elements which enter the minerals during their crystallization from the magmatic melt (e. g. Pb in orthoclase; B und W in plagioclase; Sn, Zn, Ta, Nb, Cu and others in biotite and hornblendes)[1]). These elements can then be dissolved, mobilized and again concentrated by postmagmatic solutions. This process was thoroughly investigated and proven, particularly for Sn (BARSUKOV 1957, 1971). According to this, the mobilization of Sn from the crystal lattices of the Sn-concentrating minerals (biotite, hornblende) takes place during their postmagmatic change to other minerals (muscovite, chlorite), for which an isomorphous substitution of Sn is no longer possible. Obviously, this mechanism is characteristic not only of Sn, but also for a number of other ore elements. It is known from the literature that the postamagmatic changes of the granites in a number of cases led to the mobilization of W, Mo, Cu, Zn and others. The mechanism described, however, is probably characteristic only of those elements for which the occurrence of so-called "metallogenetically specialized" magmatites is typical.

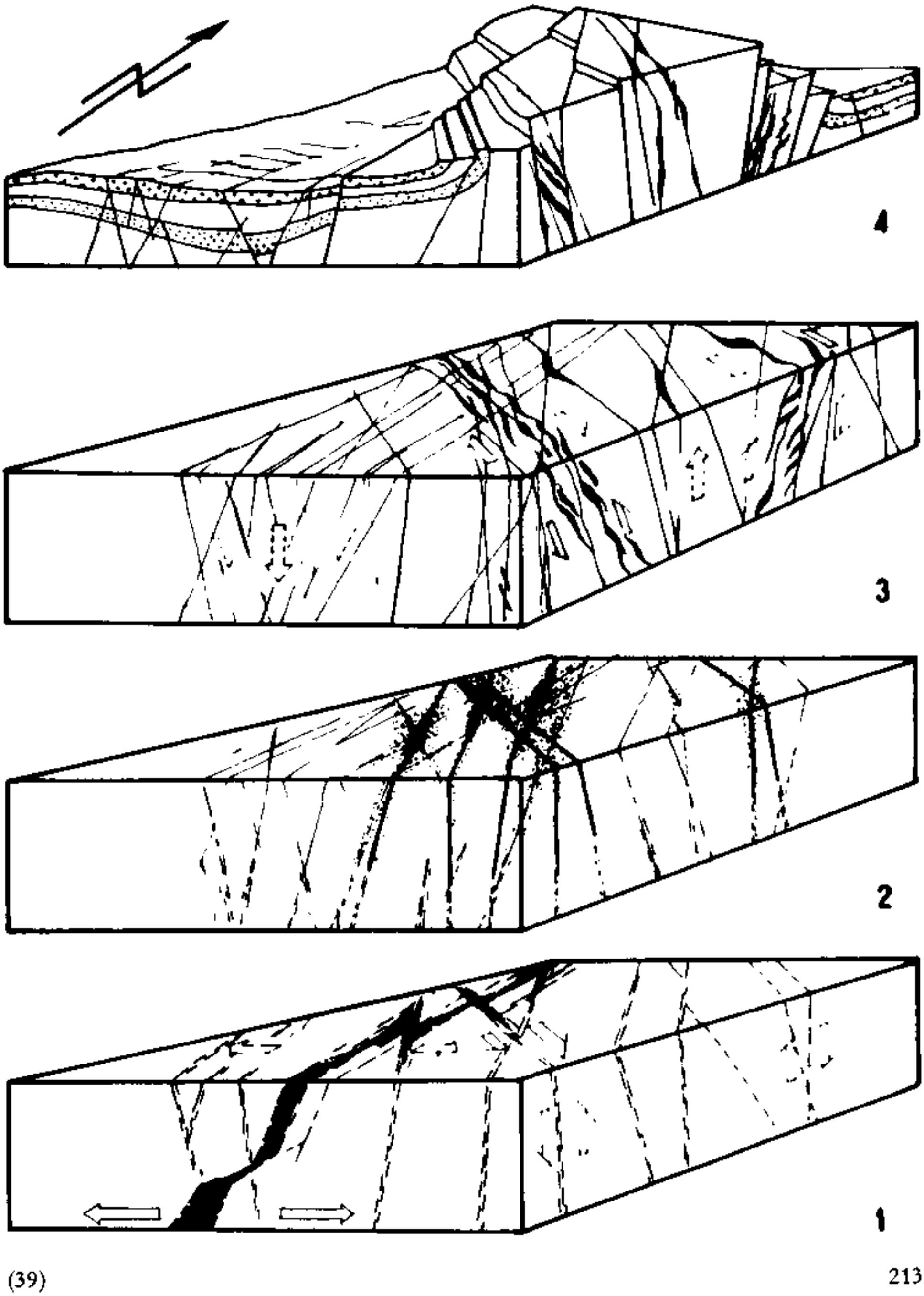
For the Erzgebirge the assumption suggests itself that there is a metallogenetic connection between the pre-Variscan mineralizations and the tin deposits occurring as a consequence of younger Variscan granites. A regeneration of the Variscan tin deposits of the Erzgebirge from the pre-Variscan tin-bearing rock formations would make intelligible the regional specialization of tin as a typochemical element for this area. This would also explain, why the granites of other basement complexes of Central Europe (e. g. the Sudetes, Hartz, Thuringia, Spessart, Black Forest, Vosges) are not Sn-specialized and thus have not led to the formation of postmagmatic tin deposits.

4. Deposits of the Post-Variscan Platform Activation

In extra-Alpine Central Europe the post-Variscan epoch is determined by the Mesozoic-Cenozoic platform development (Upper Permian-Quarternary), which is characterized by movements of uplift and subsidence – due to marked germanotype fault-block

[1]) For the ores to become concentrated in the easily volatized phase in a sufficient amount after saturation of the rock-forming minerals, it would be necessary for the level of their contents in the magmatic melt to be considerably above the "isomorphous volume" of the rock-forming minerals. For single elements, whose metamorphism with petrogenic elements is most limited (U, Th and others), this assumption is possible. For most ore elements, however, such high element concentrations would be required in the melt that this would be most improbable.

Fig. 5: The taphrogenic and Mesozoic germanotype fault structures and their inherent magmatism (from BAUMANN and WEBER 1976).
1 – graben marginal faults (extension structures of taphrogenic kinematics); 2 – zones of upfaulting and overthrusting of germanotype fracture tectonics; 3 – deep general fault structures; 4 – salt structures (for marking hidden block boundaries); 5 – Magmatic phenomena of the trachyt basalt formation (Permian, Triassic): a) – small intrusions, subvolcanoes, pipes; b) – with pronounced fenetization; 6–8 – Surface formations of the effusive platform magmatism (from Oligocene to Pleistocene): 6a – volcanic rocks; b – mainly tuffs; c – hidden areas of volcanic rocks; 7 – cryptoexplosion: a – pipes; b – bulgings over the explosion foci; 8a – carbonatite (Kaiserstuhl); b – essexite intrusions in main volcanic rock centres of the Egertal graben; 9 – line of pre-Zechstein outcrop.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tectonics – as well as the deposition of platform sediments. The large-scale crust kinematics initiated as early as the Permian is characterized by two basic types of movement (Fig. 5; WEBER 1975; BAUMANN and WEBER 1976):

– Taphrogenic kinematics on submeridional faults (mainly NNE-SSW)

– Vertical block movements, mainly on NW-SE faults (Mesozoic fault-block tectonics).

In regards to intensity and effects of both types of movement, there are temporal and regional differences within Central Europe (WEBER 1975).

The *taphrogenic* movement is characterized by a mainly W–E extension of the crust and upper mantle and leads first of all to an enlargement of NNE–SSW structures and, among other things, to a repeated working out of the Mediterranean Mjösen zone (continental rift zone after MILANOVSKI 1972 or subplate boundary in the sense of ILLIES 1972). The development of this taphrogenic main structure (NNE-SSW uparching zone with graben faulting) has been subjected to temporal and spatial changes from the Zechstein to the present time according to magmatic activities in the upper mantle or in the subcrustal boundary range. This diapiric hypomagmatism of a presumable alkali-ultrabasite formation is supported geophysically (ANSORGE et al 1970; LAUBSCHER 1970; LAUTERBACH 1962) as well as petrologically and paleotectonically (ILLIES 1972; WEBER 1974). A largely analogous behaviour may be assumed for the zone of the recent Egertal graben (Ohre graben; KOPECKY 1971), which was formed under the influence of the general W–E crust extension over transform faults (WILSON 1965) of the taphrogenic main zone. In the taphrogenic structures simatic magmatism is exposed in the form of contaminated intrusives and extrusives of the trachybasalt formation (basalt-andesite-rhyolite rocks in Upper Permian-Lower Triassic), as well as by extrusives of the trappean rock formation (alkali basalt, phonolite rocks in the Tertiary). In Central Europe the intrusive branch is still widely unknown. Besides the above-mentioned results of geophysical measurements indirect indications are provided by inclusions and differentiated melts within Tertiary volcanism as well as by taphrogenic kinematics (Fig. 6).

In contrast to the largely autarkic taphrogenesis, the *Mesozoic fault-block tectonics* (in the narrover sense), beginning in the Lias (old Cimmerian) and culminating in the Upper Cretaceous, can be regarded in a simplified way as a result of the unstable block field of the Central European platform in the mobile alpidic geosynclinal area. It is determined by differentiated vertical displacements of predominantly WNW-ESE ridge blocks inducing in the overburden secondary movements on WNW-ESE, NW–SE and NNW–SSE block boundaries. Space-creating mechanisms for opening large and deep fissures are lacking. Therefore, no extensive magmatic activities are bound to these structures.

From these considerations it can be deduced that the structures and processes of taphrogenic kinematics in post-Variscan Central Europe are the most important controlling factors of a simatic magmatism this can be proven in its extrusive form and as hypomagmatism can be compared with the magmatic formations of the platform areas after STARITSKI (1973) (BAUMANN and TISCHENDORF 1976).

Numerous deposits in extra-Alpine Central Europe can be related with tectonic-magmatic activation (in the sense of ŠČEGLOV 1968) which are characterized mainly by Fe, Mn, F,

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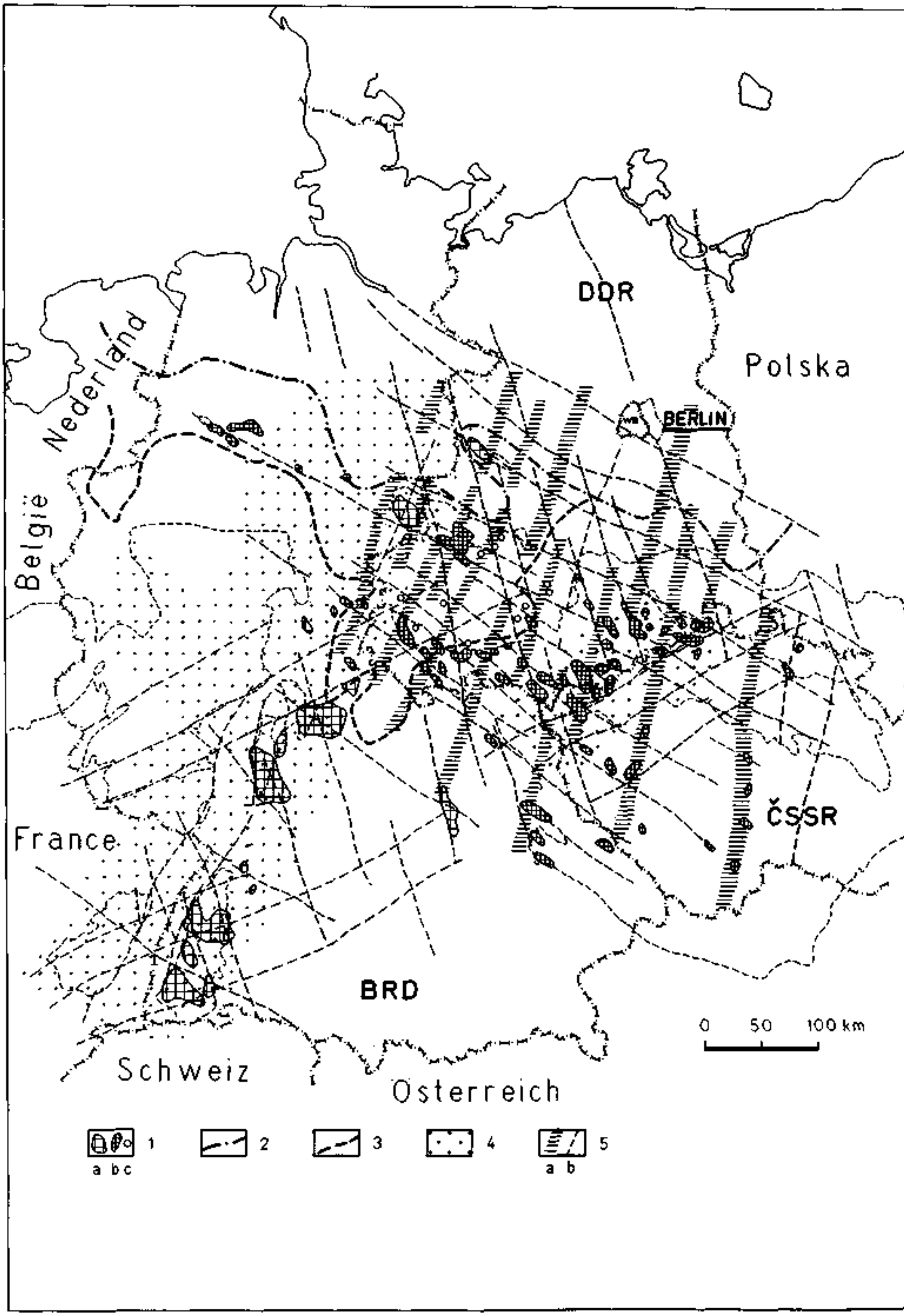
Fig. 6: Schematic representation of the minerogenetic function of germanotype fault structures within the Central European platform (exemplified by the Thuringian Forest; from BAUMANN, LEEDER and WEBER 1975).

1 – Magma-controlling structures (NNE-SSW expansion structures); 2 – structures of solution ascent and solution distribution (areas of intersection of NNE-SSW structures with NNW-SSE and NW-SE-structures); 3 and 4 – mineral precipitation structures (NW-SE structures and inherent feather structures).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Ba, Ca, Mg, partly by polymetals, Co, Ni, Ag, Sb, Hg as well as the trace elements Sr, Ge, Nb, Ta and rare earths.

Based on paragenetic composition, the following groups of mineralizations can be distinguished (BAUMANN, LEEDER 1969, 1974):

– Fe–Mn mineralizations with hematite or siderite, oxides or carbonates of Mn, barite, quartz and others ("eba-formation" type of the Erzgebirge): Erzgebirge, Hartz, Thuringian Forest (GDR); Sudetes (Poland and CSSR); Spessart, Odenwald, Sauerland, Richelsdorf Mountains, Black Forest (GFR)

– Polymetallic F-Ba mineralizations with galena, sphalerite, pyrite, chalcopyrite, fluorite, barite, quartz, carbonates and others (fba-formation type of Freiberg-Halsbrücke): Erzgebirge (GED); Hartz (GDR and GFR); Bohemian Massiv (CSSR); N-Sudetes (Poland); Upper Palatinate, Black Forest, Rhenish Slate Mountains (Sauerland, Ruhr Territory) (GFR)

– Pure F-mineralizations (in veins and as stratiform formations): Thuringian Forest, Hartz, Vogtland (GDR); Sudetes (CSSR); Upper Palatinate, Black Forest (GFR); northern border of the Alps

– Quartz-F-Ba veins with Co-Ni-Fe arsenides as well as sulphide, Ag and U mineralizations ("BiCoNiAg-formation" type): Erzgebirge (GDR and CSSR), Mansfeld Ridge (GDR); Hartz, Richelsdorf Mountains, Upper Palatinate, Black Forest (GRF) and others

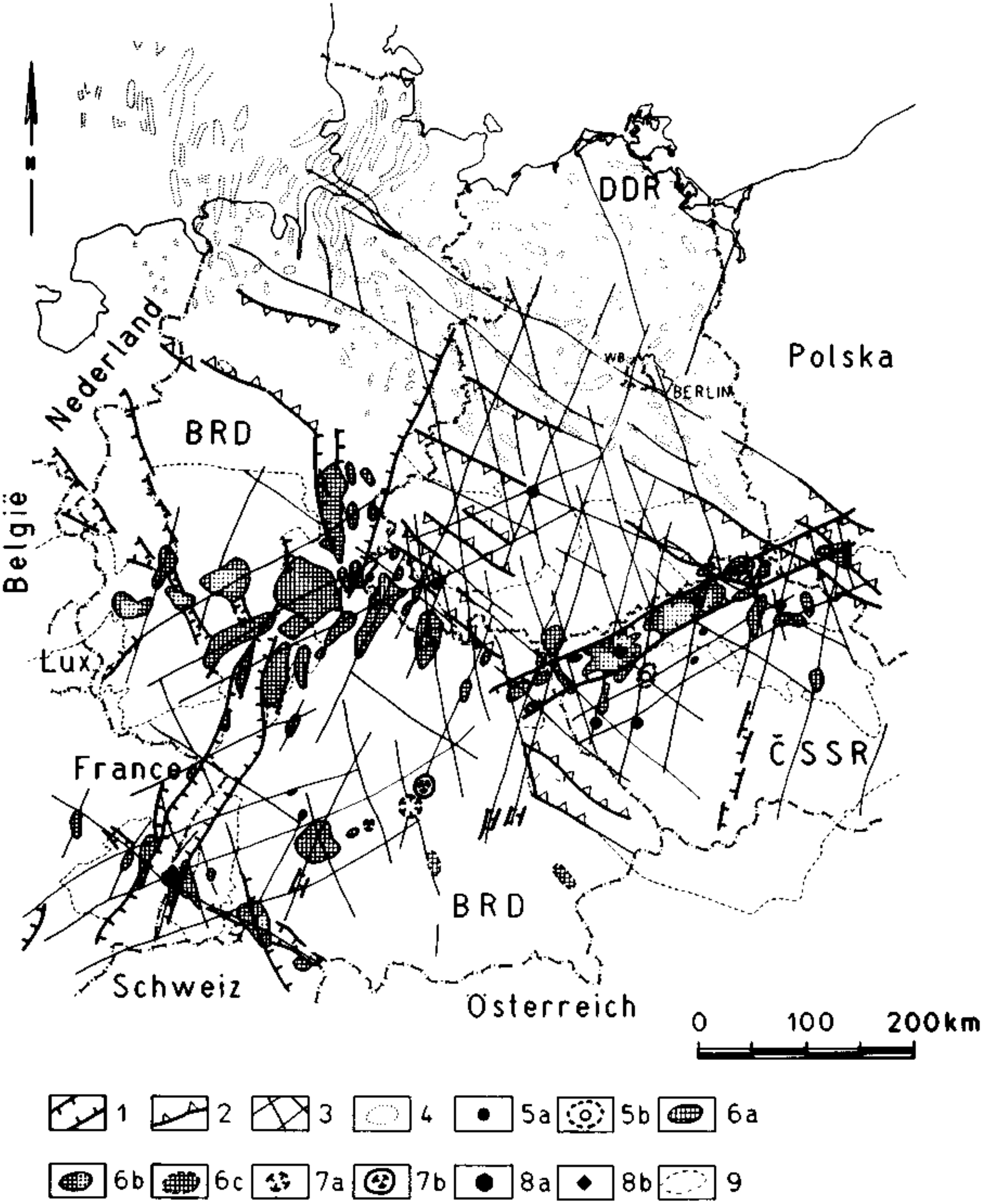
– Younger (Tertiary) mineralizations, partly with Fe-Mn oxides, partly with fluorite, barite, celestine, quartz or calcite: Erzgebirge (GDR and CSSR), Thuringian Forest (GDR), Hartz (GDR and GFR); Bohemian Massif (CSSR), Upper Palatinate, Bavarian Forest, Black Forst, Brahm Massif (GFR).

Because of a certain temporal-tectonic connection, parallel material development within the Alpine area might be expected where different geotectonic situations (Central European platform area – alpidic geosynclinal orogenetic area) might cause a predominance of different structural forms (BAUMANN and LEEDER 1974).

The genetic independence of the post-Variscan cycle of mineralization can be regarded as largely confirmed for Central Europe on the Basis of exhaustive paragenetic-geochemical, paleotectonic, paleomagnetic and isotope-geochemical investigations (BAUMANN and RÖSLER 1967, further original literature there) as well as the numerous metallo genetic regional analyses (BAUMANN 1965a, 1967; WERNER 1966; BORCHERT 1967; SATTRAN and ČADEK 1967; CHRT et al. 1968; BAUMANN and WERNER 1968; BAUMANN and LEEDER 1969, 1974; SCHRÖDER 1971; TEUSCHER and WEINELT 1972; BAUMANN, LEEDER and WEBER 1975; BAUMANN et al. 1976 etc.).

In the formation and spatial distribution of these deposits, kinematics, structures of taphrogenic tectonics and Mesozoic fault-block tectonics are closely interlocked. In this respect, particularly susceptible are the areas of intersection of the taphrogenic NNE uplift and fault zones with the Mesozoic NNW and NW disturbances. While the former, because

Fig. 7: Post-Variscan fluorite-baryte mineralizations and their relations to the regional fault structures of the area of the Central European platform (from BAUMANN, LEEDER and WEBER 1975).
1 – areas with post-Variscan fluorite-baryte mineralization (without considering the Rhenish Mass and the western Upper Rhine area); a – deposit regions and mineralizations (schematically delimited); b – deposit regions (delimited more detailedly); c – mineralizations found by drilling (hidden occurrences); 2 – southern boundary of the area with intensive halokinesis; 3 – southern boundary of the occurrence of the Werra salt formation; 4 – presumed deep-crustal intermediate focus proved geophysically (presumably with rocks of the ultrabasite-alkali rock formation); 5 – deep fault structures: a – large NNE-SSW fault zones; b – other regional fault zones.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of their great extent in depth and extension kinematics, are of special importance for the ascent of magmas and fluids and their differentiation (= magma-controlling), the latter structures perform mainly the function of hydrothermal material distribution and material fixation (= deposit-controlling – Fig. 6).

From this follows the general conclusion that all areas of intersection of taphrogenic NNE structures with the NNW and NW structures of the Mesozoic fault-block tectonics are promising for post-Variscan deposit formation. This general regularity is limited by the negative influence of certain specific rock series of the Mesozoic-Cenozoic platform overburden (e. g. sealing-up by plastic clay sediments of salt cover; high permeability due to porous rocks; increased solubility by hydrogeological influences etd. – Fig. 7).

Taking into consideration the various deposit-controlling factors in the crystalline basement complex, mainly epigenetic types of deposits are developed. To these belong first of all the vein deposits in the Erzgebirge, Thuringian Forest, Hartz, Sudetes, Bohemian Massiv, Spessart, Odenwald, Black Forest, Vosges etc. In the mostly metamorphically superimoposed country rocks metasomatic replacement (skarn type; e. g. Breitenbrunn/Erzgebirge) or impregnations (in quartzites) took place only on a small scale. It is only in the less stressed Permian-Carboniferous sandstones of the Variscan molasse formation and in the fissured effusive rocks that impregnations on a larger scale are to be expected (e. g. in the porphyries near Ilmenau/Thuringia, Halle/GDR, Teplice CSSR).

In the post-Variscan platform formations vein deposits are less common because of the tectonically less favourable country rock; there are, however, more favourable possibilities for impregnation and replacement (e. g. in the Rottliegende of the Schmidgaden basin/Upper Palatinate, the Zechstein limestone near Leutnitz/Thuringian Forest, the Bunter of the Bram Massif/GFR, the Muschelkalk of Upper Silesia/Poland, the Cretaceous sandstone etc.). Further, besides the epigenetic structural types, the formation of syngenetic (submarine-hydrothermal) deposits is possible due to the geotectonic situation. Indications of such mineralization (with F, Ba and partly polymetals) have been confirmed so far in the Zechstein carbonates (Caaschwitz/Thuringia), the Bunter (Bram Massif/GFR), the Muschelkalk (Upper Silesia/Poland), the red marls (Hildburghausen/Thuringia) and the Cretaceous sandstone or Cretaceous marl (Egge Mountains).

Summarizing we see that post-Variscan platform magmatism is not a sterile process as was often assumed in the past decades, particularly for Central Europe (STILLE, SCHNEIDERHÖHN et al.), but that in certain geological-tectonic conditions it can be connected with considerable magma-differentiating and depositforming processes.

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