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## IS THE NOTION OF CALEDONIAN OROGENY APPROPRIATE TO BE APPLIED IN THE SUDETES?

### THE LONG-LASTING CONTROVERSY

Controversies and radical changes of opinions concerning the role of Caledonian versus Variscan (Hercynian) orogeny have repeatedly occurred for many decades among the geologists studying the Sudetes and their surroundings. Since the end of the 19th century a major role in shaping the structure of the Sudetic Palaeozoic complexes was ascribed to Carboniferous diastrophism called Variscan or Hercynian (e.g. E. Suess 1888, F.E. Suess 1926, Kossmat 1927). During the 1920's a hypothesis assuming a significant influence of the pre-Late Devonian, Caledonian orogeny with only little Variscan reworking was put forward by Bederke (1924), whose ideas soon attracted many adherents in the 1940's 50's and 60's. Subsequently, due to new research findings, this hypothesis became gradually rejected in the 1970's and 1980's with an emerging consensus that the tectonic fabric of the Sudetes had been produced mainly by Late Devonian and Carboniferous Variscan tectonothermal activity, locally involving and affecting Neoproterozoic to Early Palaeozoic elements. However, Ordovician to Late Devonian/Early Carboniferous successions, showing uninterrupted basinal sedimentation were still reported to be juxtaposed with metamorphic complexes overlain unconformably by non-metamorphosed Upper Devonian strata. These relationships supported the idea of some Caledonian influence in the Sudetes (e.g. Don 1984).

### NEW CALEDONIAN MODEL

Rather unexpectedly, Oliver et al. (1993) and Johnston et al. (1994) on the basis of newly acquired data, including new U-Pb age determinations, re-interpreted the Palaeozoic geology of the Sudetes and of SW Poland in favour of a dominant Caledonian deformation, re-defining the Sudetes as the "Metamorphic Polish Caledonides and, in practice, excluding this area from the central European Variscan belt. Similar opinions, assuming Caledonian accretion, followed by Variscan reworking were soon expressed by some other workers.

In the 'new Caledonian model' of Oliver et al. (1993) and Johnston et al. (1994) the main evidence in support of a Caledonian orogeny in the Sudetes are: (1) a regional pre-Upper Devonian unconformity, (2) Ordovician magmatism interpreted

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to indicate subduction and collision, (3) structural data from “key localities”, and (4) new, Early Palaeozoic radiometric ages. Oliver, Johnston et al. maintain that faunal and palaeomagnetic data indicated that the Tornquist sea, the SE branch of the Early Palaeozoic Iapetus ocean, which once separated Baltica from Gondwana, narrowed to less than 1000 km in width during the Late Ordovician and subsequently closed, producing a tectonic suture in the Sudetes, along which geologically contrasting Early Palaeozoic terranes had accreted into a Caledonian collage covering the area of SW Poland and northern Czechia. These terranes are believed to include Ordovician and Silurian batholith fragments, whereas the suture zone is interpreted to occur mainly along the Intra-Sudetic fault, being the continental-scale sinistral shear zone, periodically active from Middle Ordovician to Triassic times.

This interpretation became a matter of controversy (e.g. Żelaźniewicz, Franke 1994; Aleksandrowski 1994). In a comprehensive paper by Aleksandrowski et al. (2000) critical assessment has been given of evidence produced by supporters of the influence of the Caledonian orogeny in the Sudetes. It has been shown that the regional pre-Late Devonian unconformity does not exist in most Sudetic structural units, except in the Central Sudetes, where it is the result of Eo-Variscan, convergence of Armorican and Avalonian crustal fragments, but not of Caledonian continental collision (see also Aleksandrowski, Mazur 2002). The intense manifestations of Late Cambrian/Early Ordovician magmatism, resulted rather from the continental rifting leading to subsequent ocean opening (Furnes et al. 1994). The ca 500 Ma U-Pb ages abundant in the Sudetic crystalline complexes are protolith, intrusion ages and do not correspond to a Caledonian deformation. The other arguments of Oliver and Johnston et al. were also critically discussed and dismissed as pieces of evidence in support of a supposed Ordovician to Early Devonian orogeny in the Sudetes. However, even if a record of a collision-related deformation and magmatism/metamorphism of early to mid-Palaeozoic age were found in the Sudetes, it could not have been considered as evidence for the Caledonian orogeny.

#### WHAT IS CALEDONIAN AND WHAT IS VARISCAN?

The most important reason for the so often encountered confusion and controversy regarding the tectonic interpretation of the Sudetes seems to stem from the current dichotomy in usage of the terms ‘Caledonian’ and ‘Variscan’, based on misunderstanding the implications the plate tectonics brought to geology. A dual perspective on orogeny continues to influence present-day geological thinking - an inheritance of the old controversies between catastrophists and uniformitarianists and, later, fixists or oscillationists and mobilists (see comprehensive discussion in Sengör 1990). The ideas of Kober (1921) and Stille (1924), assuming strict episodicity of world-wide contemporaneous orogenic phases and cycles, though incompatible with plate tectonic principles, can still be recognized in, for

example, the tendency to refer to 'Caledonian deformation' in a temporal sense, instead of speaking about 'Early Palaeozoic deformation', irrespective of whether the deformed area lies in northern or central Europe, or, for example, in central Asia. Similarly, the 'Variscan' is often understood as Late Devonian through Carboniferous to Early Permian tectonic activity. However, it has long been known that orogenic "paroxysms are neither synchronous nor world-wide", and also that, in a given province, "orogeny frequently lasts continuously through a number of epochs or periods" (Krejci-Graf 1950). The plate tectonic theory explained this as reflecting commonly long-lasting processes of subduction-related convergence of crustal blocks and to irregular shapes of their convergent margins, which collided at different times in different places. Therefore, in our opinion, accepting the plate tectonic paradigm should logically result in giving up such 'chronostratigraphic' usage of the term 'Caledonian', to denote every Early Palaeozoic tectonic activity irrespective of its (palaeo)geographical location. Thus, using the plate tectonic understanding of orogeny as representing the entirety of convergent margin processes (Sengör 1990), a useful criterion to distinguish between the Caledonian and Variscan (Hercynian) orogenic belts seems to be the provenance of given areas with respect to the oceanic basins whose closure produced these belts and to the adjoining continental margins. According to recent plate tectonic reconstructions, the Caledonian orogenic belt is that developed due to Early Palaeozoic to Early Devonian closure of the Iapetus and Tornquist Oceans between Baltica, Laurentia and Avalonia. The Variscan belt, on the other hand, originated from closure of the Rheic Ocean between Avalonia and Armorica, mostly accomplished by Mid-Devonian times and followed by Late Devonian - Early Carboniferous collision of the Avalonian/Armorican assemblage with Africa, resulting from consumption of the inferred Massif Central - Moldanubian Ocean. This scenario provides us with criteria more appropriate in a plate tectonic framework to distinguish between the Caledonian and Variscan orogenic belts than those relying solely on the timing of tectonothermal events. Consequently, the 'Caledonian' and 'Variscan' orogenies should preferably be understood as diastrophic, magmatic and metamorphic processes leading to the formation of the Caledonian and Variscan orogenic belts, respectively (Aleksandrowski et al. 2000). Identical views have recently been expressed by McKerrow et al. (2000), who stress the necessity of defining orogenies and orogens in spatial and not temporal terms, in a context of particular closing oceanic basins and their margins. They also suggest re-defining the notion of the Caledonian orogeny so as it could not be applied to e.g. areas within the Variscan belt, such as the Sudetes.

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