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THE NIEMCZA ZONE AND THE KAMIENIEC ZĄBKOWICKI-STRZELIN BELT, WESTERN SUDETES: ONE PERSPECTIVE

Abstract: Some possible connections between small-scale mineralization, tourmaline schist, coticule related lithologies, serpentinisation, aluminous rocks, metamorphism and granitoid genesis are explored. All may have been, in one partial way or another, linked to hydrothermal circulation in ocean crust during late Silurian - Lower Devonian times - derivatives of the interplay of volcanic exhalation and detrital deposition on a basin margin at about that time.

Keywords: Polish Sudetes, Niemcza Zone, Kamieniec Zabkowicki-Strzelin Belt, coticule, tourmalinite, mineralisation, Sr-isotopes, serpentinisation, granitoids.

INTRODUCTION

The Niemcza Zone (NZ) and the Kamieniec Ząbkowicki-Strzelin Belt (KZSB) are parts of the Western Sudetes at the eastern end of the Variscides in Poland. The NZ is a north-trending belt of metagreywackes bordering the eastern side of the Góry Sowie Block (Fig. 1). The KZSB which, in turn, bounds the NZ to the east, comprisies two tectono-stratigraphic units of mica schists separated by a major fault or thrust zone (see regional review of Franke, Żelaźniewicz 2000).

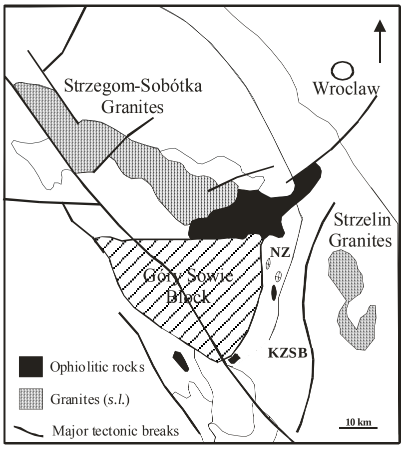

Fig. 1. A outline sketch of the locations of the Góry Sowie Block, the Niemcza Zone (NZ), the Kamieniec Ząbkowicki-Strzelin Belt (KZSB) and outcrops of the Sudetic ophiolite.

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In the Niemcza Zone, small bodies of syntectonic granodiorite intruded at about 340-330 Ma (Oliver et al. 1993, Steltenpohl et al. 1993). A small serpentinite mass within the NZ metagreywackes at Szklary is a fragment of the Sudetic Ophiolite exposed in major outcrops of mafic and ultramafic rocks at the NE margin of the Góry Sowie Block, and in lesser exposures on its margins to the south (Fig. 1). In the KZSB, one of the two tectono-stratigraphic units contains eclogites and HP metamorphic rocks (Novak 1998). The second, eastern, unit contains neither.

This contribution is an attempt to apply insights gained in the Caledonides of Ireland and elsewhere to this eastern part of the Western Sudetes – an area of some structural complexity (see, *e.g.*, Mazur, Puziewicz 1995). The exploration of potential links between some disparate field, mineralogical and isotope elements of the known geology there may provide the beginnings of a different and hopefully provocative perspective on the complex structure of the region.

SERPENTINISATION AND COTICULE HORIZONS

By dating hydrothermal zircon in the blackwall of a plagiogranitic rodingite, Dubinska et al. (2003) established a c.400 Ma age for the early serpentinisation of metagabbro from the Sudetic Ophiolite. The zircon crystallized from hydrothermal fluids moving through what was probably early-Devonian ocean crust. As they moved, these fluids would clearly have scavenged metals and other elements from crustal basalts and gabbros before eventually ejecting them on to the sea floor. In a wide ocean, most of the exhaled metals would have come to reside in proximal sea-floor settings close to vents, some in distal, diluted correlatives near continental margins. Boron would have been significantly involved - serpentinite is a boron sink and boron is adsorbed, with other elements, by clays from seawater (see *e.g.*, Slack 1996). Schist tourmaline enrichments can reflect earlier boron adsorption.

Exhalative manganese precipitated as oxide in a shallow continental shelf or slope setting, will adsorb metals even as, contemporaneously, detrital clays adsorb seawater boron. In clastic sequences, the oceanic metals and the boron mostly remain, not surprisingly, diluted and unnoticed. However, stratabound metalliferous horizons associated with thin layers of manganese-garnet quartzite (coticule) and tourmalinite intercalated within these sequences, and extending over very great lateral distances, clearly indicate that, on occasion and for whatever reason, dilution is minimized. The extended lateral continuity makes coticule a superb stratigraphic marker. It can, in places, be followed unbroken for hundreds of kilometers. As a consequence, coticule-bearing sequences potentially match the long-range correlation value of a volcanic tuff. Fossils are, unfortunately, rare.

Extended coticule-tourmalinite intervals inter-bedded with detrital shelf-slope sediments suggest young spreading systems – narrow ensialic basins venting to the surface for the first time, or arc-related basins opening during subduction. Initial venting would be associated with accelerated circulation in the basic rocks below. Before, any sediment above would have been a barrier subject to increasing heat flow, progressive thinning, metamorphism, metasomatic soaking (an aid to later granite melt formation?) and submarine weathering. Afterwards, circulation would diminish with the introduction of cold seawater.

Coticule-tourmalinite packages of regional extent seem to occur once only in the sedimentary record of many fossil oceans and basins; to the writer's knowledge, no more than one has been mapped in any. It does seem that major exhalation is either confined to a short initial spurt or, alternatively and perhaps more likely, elements exhaled at a constant rate rapidly become increasingly diluted in a widening basin. Either way, dating a serpentinite may be to date metalliferous Mn and B-enriched horizons even where deposited in a detrital context.

Tourmalinite and coticule are often missed on outcrop. The former has been often recorded as amphibolite and the latter passed over as ordinary quartzite; the garnets in what are usually thin layers are minute. Some associated beds may be essentially monomineralic, e.g., albitite (and albite schist) and epidote-rich rock (epicule). Chloritoid (ottrelite) is important in some coticule varieties (Lamens et al. 1986). Gahnite, rutile and Cr-mica are regularly noted. Successive thin laminae of very different mineralogy, *e.g.*, replicating layers of aluminium silicate, coticule and/or tourmalinite, suggest periodic, rhythmic changes in the exhalative input.

Cherts, clays and tuffs have long been suggested as coticule precursors (e.g., Brindley 1954, Kramm 1976). Some, *e.g.*, the type rocks in the Belgian Ardennes, are replaced Mn-carbonate beds (Lamens et al. 1986). Importantly, in the present context, coticule is associated with many ophiolites (*e.g.*, Cook, Halls 1990) and it is no accident that lumps of gabbro, serpentinite, etc. - ophiolitic- and ocean-floor debris - characterise many coticule-hosting sequences.

Associated metapelites are typically very rich in aluminium silicates. These may constitute ores. Individual aluminium silicates may typify individual layers. Within-bed constancy, e.g., of zoned-garnet Mn compositions, and between-bed variation may preserve the original compositional pattern of bedding on the finest of scales (see Stanton, Williams 1978). Low greenschist-facies rocks hosting coticule are, in many instances, so spotted with porphyroblasts of, *e.g.*, chaiastolite, cordierite and chloritoid (*e.g.*, Theunissen 1970, Lamens et al. 1986) that they may superficially appear to be out of context in a low-grade metamorphic setting.

World-wide, coticule is spatially associated with metals, *e.g.*, Pb, Zn, Cu, Au, Ag, W, Sn, *etc.* (*e.g.*, Spry 1990, McArdle, Kennan 1992, Gardiner,Venugopal 1992). These occur in horizons that are also rich in potentially influential fluxes, e.g., boron (reflected in the dravitic tourmaline), lithium (Li-micas and spodumene pegmatites), fluorine and phosphorous (fluor apatite). Though no coticule is known there, the sulphide-tin mineralisation in the Kamienica schist belt north of the Karkonosze Granite may be related (Kennan – in press).

THE POSSIBLE ROLE OF COTICULE ROCKS IN THE NZ-KZSB

Exhalative mineralization in the KZSB has been recognized long since. Dziedzicowa (1966) and Dziedzicowa, Chowaniec (1974) described the occurrence of polymetallic sulphides in finely banded, silica-rich metatuffs defining a single uninterrupted horizon at least 20 km long, though only 40 m thick. Within the metatuffs, the sulphides occur in a single bed that extends along strike for some 5 km. Mica schists (2 m), with intercalated metabentonite lying on top, pass up into aluminous staurolite-garnet schists with albite porphyroblasts (Dziedzicowa 1973). These schists are notably enriched in dravitic tourmaline. Dziedzicowa, Chowaniec (1974) appreciated that submarine volcanism was a possible source for the original boron and suggested an exhalation origin for the sulphides. They noted no coticule though it is only in coticule-related rocks that the speaker has seen platy ‘flattened’ garnets that might compare with those illustrated by Dziedzicowa, Chowaniec (1974, Plate 10).

Coticule does occur in the KZSB. Though not named, typical coticule has been described and illustrated by Nowak (1998, p.12 and Fig. 9). In the vicinity of Kamieniec Ząbkowicki, thin, bedding-parallel layers rich in small Mn-rich garnets occur in mica schists that also enclose lenses of eclogite. It would be exceptional if this coticule occurrence was to prove unique and for other examples, and mineralization, not to be found on essentially the same horizon elsewhere along strike. Złoty Stok and its environs come easily to mind.

The abundance and layered distribution of aluminium silicates in the KZSB mica schists described by Novak (1998) invites comparison with coticule-bearing sequences elsewhere. Even the presence of layers and lenses of pegmatite (*opus cit.* p.6) reminds that coticule-hosting horizons are, in many instances, characterised by an abundance of quartz-segregations and quartzo-feldspathic lenses – a likely consequence of flux enrichment. Because they seem preconditioned to melt, and because of they are typically thinly-bedded, these same horisons may act to focus shearing. This may be significant in the NZ-KZSB area.

Dubinska et al. (2004) suggest that serpentinisation of the Sudetic mantle peridotites started near an oceanic ridge in the early Devonian. If that is so, and the context of an initial-venting, narrow-basin model is valid, the occurrence of an exhalative coticule-tourmalinite package in the KZSB, suggests that the latter is part of a Lower Devonian sequence. The peridotites have been dated at c.420 Ma by Oliver et al. (1993) and at 397-412 Ma by Brueckner et al. (1996). These dates, combined with the fact that the KZSB coticule horizon containing lumps of eclogite etc. is not far removed from large ophioite outcrops, may broadly support the stratigraphic conclusion – especially and in the light of the general observation that ophiolitic rocks tend to be young (<10 Ma) when they interact with or obduct on to continental margins. Any suggestion that some KZSB rocks might be Lower Devonian is not new (see Franke, Żelaźniewicz 2000, p.72) but the line of argument may be novel. In the KZSB and beyond, coticule may offer an additional key to long-range stratigraphic correlation.

THE NZ GRANITOIDS

The NZ granitoids are Carboniferous (‘Variscan’) intrusions. As Lorenc (1998) noted, Rb-Sr whole-rock data for these rocks define a scattered array - an errorchron that suggests (but no more) a c.430 Ma age. The data are simply too few, and the granite Rb-Sr range too narrow, to give any hope of precision. However, the NZ data are clearly anomalous when compared to the whole-rock Carboniferous-granite Rb-Sr data for the western Sudetes as a whole (Kennan et al. 1999, Kennan, Lorenc 2003). Even when plotted against the similar tonalite and quartz diorite data from Strzelin (Oberc-Dziedzic et al. 1996), a subtle but clear local difference emerges (Fig. 2). The Niemcza granitoids, though undoubtedly Carboniferous, carry an apparently older Sr-isotope record.

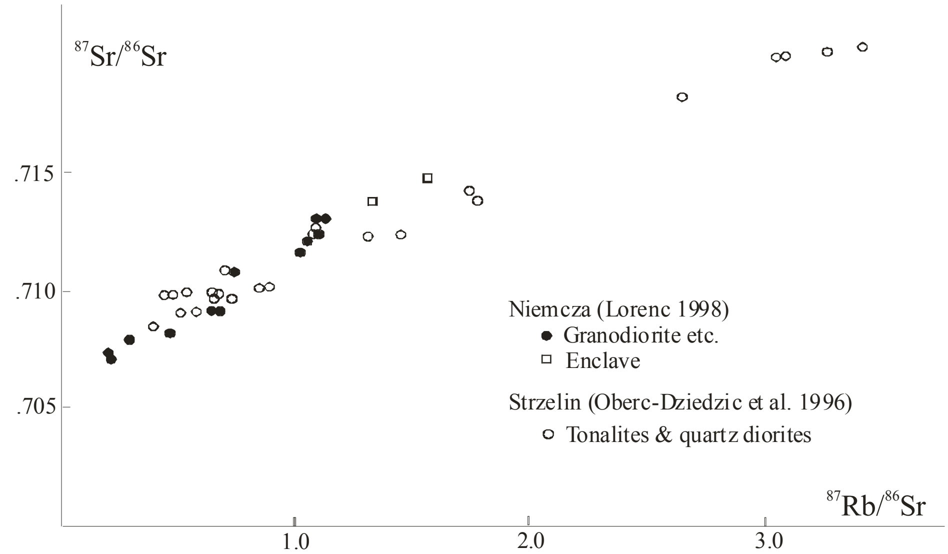

Fig. 2. Isotope arrays from the granitoids of the Niemcza Zone (Lorenc 1998) and from quartz diorites, tonalities and some granites from Strzelin (Oberc-Dziedzic et al. 1996). In the case of Strzelin, data continue the trend to the right.

Rb-Sr whole-rock data from proven c. 400 Ma intrusions emplaced into an Ordovician-Silurian accretionary prism crossing Ireland and the Southern Uplands of Scotland and some emplaced into older envelopes, reveal a similar pattern (Fig. 3; see also Todd et al. 1991, Fig. 7; Kennan 1997). For some individual intrusions, samples with $^{87}Rb/^{86}Sr$ < c.1.5, give perfect isochrons supporting ages that are much too old to be intrusion ages. In some instances where there is stratigraphic control, these 470-480 Ma 'ages' are not far removed from the age of the oldest host rocks intruded. These 'ages' also compare with, or are a little older than, U-Pb isotopic ages determined for major basic and ultrabasic intrusions and ophiolitic remnants in the Caledonides and with some fossil-constrained, lowermost Ordovician, coticule-bearing horizons.

Could it be that in both the Irish Caledonides and in the western Sudetes, the isotope ages of basic intrusions and ophiolite remnants, false 'older' Rb-Sr whole-rock ages of young granite intrusions and the stratigraphic ages of coticule-bearing horizons, might converge to construct a common model? Perhaps, but any conclusion without further reliable field and age data would be speculative. Though the suggestion is there, the Niemcza-granitoid data also fall within the overlap of the regional Rb-Sr isotope trends outlined by Kennan, Lorenc (2003) for the gneisses and granites of the western Sudetes. The question as to whether the

Niemcza-granitoids carry a Cambro-Ordovician or a c.420 Ma inheritance remains open – though comparison with the Irish granites (Fig. 3) may favour the latter.

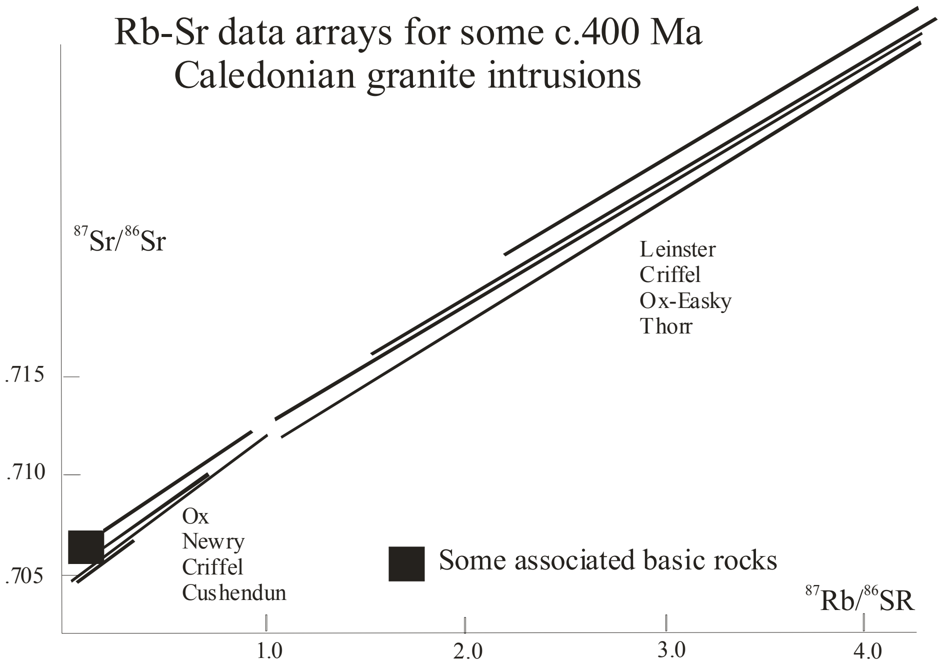

Fig. 3. Some typical Rb-Sr isotope arrays from a number of Caledonides granite (*sensu lato*) intrusions as named – for comparison with Figure 2. The arrays are based on data from: Ox Mtns - Pankhurst et al. (1976), Long et al. (1984); Leinster - O'Connor, Brück (1978); Criffel – Stephens, Halliday 1980; Cushleake – Harrison, Wilson (1978); Newry - Ian Meighan (personal communication). Line extensions to include single isolated points are, in some cases, omitted for clarity.

Large samples of some low Rb/Sr granites clearly do not see the Sr-isotope homogenization presumed to occur during granite intrusion and crystallization (Fig. 3). What if these samples fail to see any re-equilibration occurring during granite genesis? Low-Rb/Sr sample suites (Pankhurst et al. 1976; Max et al. 1976 from different 'across-strike' parts of one intrusion in Ireland both support similar isochron ages that are, as crystallization ages, too old. Recurring relatively steep linear Rb-Sr isotope arrays, described variously as due to 'mixing', 'inheritance' or as 'meaningless', require a consistent explanation. In the NZ, large samples from a single quarry, collected on a notional horizon parallel to the regional strike, might provide a less-scattered errorchron, perhaps even an isochron, for the NZ granodiorites. Any age suggested might well not be an intrusion or crystallisation age - but might be the age of the granodiorite source rocks. Even the limited available Rb-Sr data for the Niemcza granodiorites hint that the age of their source may not be much older than the stratigraphic age of the rocks they intrude.

SOME CONCLUDING REMARKS

(a) Coticule is potentially an important lithostratigraphic marker in the Kamieniec Ząbkowicki-Strzelin Belt – and, most likely, far beyond.

(b) (b) Serpentinisation and the deposition of metals and of Mn- and B-rich sediments may be coeval reflections of KZSB ocean-floor hydrothermal activity.

(c) (c) The age of the NZ-granitoid source rocks may be open to estimation using whole-rock Rb-Sr isotope methods.

(d) (d) The rhythm of oceanic exhalation, subtly affecting rock chemistry layer by layer, may have coloured the metamorphism of some KZSB rocks.

(e) (e) The source polarity of coticule-bearing, exhalation-influenced sequences on a basin edge makes bedding/layering a crucial factor in any sampling strategy.

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