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GEOSITES

The Isentobel in Central Switzerland: remnants of the Penninic ocean and a source of inspiration for Gustav Steinmann's idea of young ophiolites

The Isentobel (or Eisentobel, i.e. "the iron gully"), a small ravine located on the northern slope of the Central Swiss Alps some 50 km ESE of Zurich, exhibits instructive outcrops of ophiolites from the South-Penninic Arosa Zone. It is part of the famous klippen (tectonic outliers) zone of Iberg where Middle Penninic to Austroalpine nappe fragments (relics of the ancient Alpine Tethys ocean and continental microplates) are stacked on top of the Helvetic nappes, Europe's ancient southern passive margin (Trümpy 2006). Apart from its isolated position, constituting also the westernmost occurrence of Austroalpine nappes, the Iberg klippen with their ophiolite outcrops (e.g. along an eastern tributary of the Isentobel; 47°00′32″/8°45′23″) are also of historic interest. Historical evidence suggests that it was here that the German geologist Gustav Steinmann (1856–1929) first saw all three members of the ophiolite rock suite later named after him as the "Steinmann trinity", i.e. the association of serpentinites, basalts, and radiolarites. He wrote: "There [the Iberg area] the most conspicuous rocks of this facies zone [the "Rhätic Nappe" sensu Steinmann, today an obsolete term more or less corresponding to the Arosa Zone] occur in locally great abundance. There are on the one hand serpentinite, ophicalcite, spilite, diabase porphyry, variolite, and gabbro which are found exclusively between the Roggenstock and the Schijen mountains in the Laucheren-Mördergruebi area [the catchment area of the Isentobel], and, on the other hand, closely associated with the former rocks and nowhere else reappearing, radiolarites and reddish-brown deep sea clays" (Steinmann 1905, p. 20/21, freely translated by the author with the spelling of localities changed to present-day practice). The Arosa Zone of the Iberg area, Steinmann's "Rhätic Nappe", represents the western continuation of the Arosa Zone and the Platta Nappe of eastern Switzerland which both constitute relics of the Piemont-Ligurian ocean once dividing Eurasia from the Adriatic plate (Weissert and Bernoulli 1985; Bernoulli et al. 2003). However, contrary to these latter examples, serpentinites do not play a prominent role in the Iberg ophiolites (even though they do occur in isolated outcrops directly in, supposedly tectonic, contact with both metabasalts and radiolarites, see Trümpy 2006, Fig. 14) and they are dominated by metabasaltic rocks and their sedimentary cover (Dietrich 2006). Figure 1 displays a metabasalt block from the Isentobel mixed with reddish micrite. As reported by his American PhD student Edmund C. Quereau (1893, p. III & 96), it was Steinmann himself, together with another German geologist (Ernst Wilhelm Benecke), who first noticed such rocks in the Iberg area in the years 1889 and 1890. The red colour and the fine equigranular crystalline texture of these limestones led Steinmann and Quereau believe that they had been there before the basalt and that lava had invaded these deep-sea deposits and overprinted them metamorphically. One might even speculate that it was because of these peculiar rocks (somewhat resembling ophicalcites, i.e. limestone/serpentinite mixtures, Weissert and Bernoulli 1985, which in fact had been explicitly referred to by Steinmann himself, as shown by the quotation above) that Steinmann was led to his erroneous but nevertheless life-long believe that ophiolites are intrusives much younger than their sedimentary envelopes (Bernoulli et al. 2003). The idea of the intrusive nature of the Iberg metabasalts has still been maintained as late as the mid-1960s (Gansser in Trümpy 1967) which was completely in agreement with then accepted thoughts on ophiolites (see e.g. Aubouin 1965). However, a closer look at the ophiolite blocks in the Isentobel reveals that the reddish micrites are indeed later infills invading cracks in the pre-existing basalts. Figure 2 shows an instructive example of a zig-zag-shaped fracture with a displacement of some 10 mm which once must have been a void space that became subsequently filled by sedimentary carbonate. The same inference is suggested by the microscopic structure showing clearly that the cracks and their fill postdate the basaltic host rock as they cut sharply the magmatic fabric of the latter (for petrographic and geochemical details on the metabasalts the reader is referred to Dietrich 2006). It can only be speculated as to the cause of these fractures: whereas some might be of early tectonic origin, others might perhaps represent cooling fractures.

Seen from a broader and more recent perspective, the Iberg ophiolites likely represent the isolated and tectonically dismembered relics of a once much more extended and very complex ophiolite body. Research in other parts of the Alps has led already shortly after the plate tectonics revolution to the recognition that alpine ophiolites do not fit into the Penrose-type layer-cake model of oceanic lithosphere (Trümpy 1975, see; Letsch 2015 for a historical discussion). The Alpine Tethys Ocean has most likely been a magma-poor basin underlain by hyper-extended continental crust and exhumed lithospheric mantle (e.g. Bernoulli et al. 2003, or Masini et al. 2013) with perhaps no or only restricted formation of new oceanic lithosphere. The Iberg

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Fig. 1 Thoroughly fractured metabasalt block with the fractures filled by a later sedimentary carbonate infill and subordinate diagenetic calcite veins. Some of the metabasalt zones resemble cross sections through basalt pillows and the carbonate might partially represent inter-pillow fills

Fig. 2 Sharp fracture in metabasalt filled with reddish micrite. Thinking away the micrite fill, the fracture could easily be closed again in a jigsaw-fashion thus clearly demonstrating that the micrite postdates the basalt

ophiolites, with their MORB geochemical signatures (Dietrich 2006) and the lack of extensional allochthons of continental upper crust typical for parts of the Platta Nappe and the Arosa Zone in southeastern Switzerland (Manatschal and Nievergelt 1997) might be derived from a more distal part of the hyper-extended Adriatic northern margin as these former ophiolites (as suggested by Trümpy 2006). Be that as it may, still today, some 125 years after Steinmann first visited the Isentobel, the ophiolite blocks lying around in this otherwise rather unspectacular small ravine are silent monuments recalling the prophetic views and deep insights of a great geologist.

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