

Spatial distribution of textural and compositional variations of MORB in the Arosa-Zone

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Slices of the crust of the Piémontaise (Penninic) ocean are today exposed along the alpine suture zone from southern Italy along the northern Apennine and western Alps as far north as southern Germany. Its northernmost extension is known as Arosa-Zone and is exposed as a 10m to a few 100m wide seam along the northwestern base of the Austroalpine Nappes from Graubuenden in the south through the Rätikon and the Walsertal into the Allgaeu in SW Bavaria.

Aside from fragments of sedimentary sections of the austroalpine nappes, tectonic slices of the Piémontaise oceanic crust and ultramafic fragments (serpentinites, ophicalcites) of the late Paleozoic subcontinental lithospheric mantle occur within the Arosa-Zone, both often with their original sediment coverage of Upper Jurassic red deep sea pelites and/or Lower Cretaceous Aptychen limestone. However, as some basalts are directly covered by reddish to grey limestones in Aptychen-facies of Lower Cretaceous age the emplacement of the pillow basalts may be asynchronous. New field observations support that the basalts from Hindelang to Liechtenstein occur as sediment-free "pillow supported" successions. On the contrary, the sequences in the eastern Rätikon and at Arosa exhibit sediment supported emplacement with spherulitic skins as thick as 4cm as well as peperitic textures of magma spheres and lumps embedded in greenish-grey pelites. As already Heugel (1982) pointed out, these textures are not bubble fillings, as is still widely assumed, but rather unequivocal prove for the effusive emplacement into wet sediments. These textural differences suggest that the former basalts erupted in a (distal ?) oceanic environment while the latter magmas erupted in a sediment dominated environment, possibly closer to the continent.

The basalts sampled from the Hörnli at Arosa in the south to the Rothplattenbach at Hindelang in the north preferentially occur as pillowed ol-plag-phyric tholeiitic magmas which are chloritized due to hydrothermal ocean floor alteration. Only spinell phases and relics of clinopyroxenes are usually preserved in primary composition, primary plagioclase being almost absent. While exhibiting alpine metamorphic overprint under eclogite facies conditions in the Western Alps only sub-greenschist facies (very low-grade) conditions were reached in the Arosa-Zone. The northward decreasing alpine metamorphic overprint is indicated by the basalts around Arosa still exhibiting dominantly greenish colors associated with low variation of mobile elements (e.g. Sr 50-300ppm, Ba < 100ppm); progressive reddening and increased element mobility (e.g. Sr 20-1600ppm, Ba 20-300ppm) characterizes the oxidative retrograde alteration of basalts northward.

The basalts can be distinguished into three groups by their different REE patterns:

	(La/Ce) _N	(La/Yb) _N	(Sm/Yb) _N	Eu-anomaly
"N"-MORB	< 1 (0,94-0,96)	< 1 (0,87-0,93)	< 1 (0,93-0,95)	positive
T-MORB type I	< 1 (0,80-0,95)	>/< 1 (0,77-1,1)	> 1 (1,1-1,3)	negative
T-MORB type II	< 1 (0,86-0,87)	> 1 (1,2-1,4)	> 1 (1,3-1,5)	positive

(REE/REE)_N = C1-chondrite normalized ratios

The REE patterns indicate that all magmas were derived from a LREE depleted source that was secondarily enriched to different degrees. The “**N**”-**MORB** are thus only still “normal” by definition, however, their only low degree of LREE depletion indicates a composition as that of the recent Mohn’s or Knipovich Ridge segments in the NE Atlantic. They could genetically be linked to the **T-MORB type I**, which would be derived from comparably higher degrees of melting (supported by a positive Eu-anomaly). The **T-MORB type II** are the most LREE/HREE enriched, being **almost E-MORB** with an early melting history in the garnet stability field being indicated by the comparably lower HREE contents, however, still exhibiting La-depletion. In this they are comparable to the recent Reykjanes Ridge rocks.

The “**N**”-**MORB** are restricted to the eastern Rätikon within the suture zone overlying the Suzfluh nappe and underlying the “Altkristallin” nappe of the Austroalpine. From Liechtenstein to the Allgaeu (extended Walsertal-Zone), only the **T-MORB type I** basalts occur underlying the nappes of Hauptdolomit and associated early Mesozoic units. The **T-MORB type II** magmas are restricted to the Arosa area.

The least variation in incompatible elements is shown by the “**N**”-**MORB** basalts in the eastern Rätikon (e.g. Y 22-27ppm, Zr 80-120ppm). However, the basalts in the eastern Rätikon and around Arosa show a wide variation of compatible elements (e.g. Ni 70-300ppm) while it is low in the **T-MORB type I** in the Walsertal-Zone (e.g. Ni 70-140ppm). Judged on actualistic grounds, this less variable degree of differentiation in the northern basalts may indicate buffering by larger magma systems due to higher spreading rates.

Two types of basalts are supposed to occur in the southern extension of the Arosa-Zone, the Platta Nappe, where **E-MORB** ($[La/Ce]_N > 1$) are associated with the Upper Serpentinite Tectonic Unit and **T-MORB** with the Lower Serpentinite Tectonic Unit (Desmurs et al. 2002). For the latter an U/Pb age of 160 Ma was determined for zircon in a gabbro (Schaltegger et al. 2002). While the suboceanic asthenospheric mantle is isotopically indicated as source of the **T-MORB**, the subcontinental lithospheric mantle is assumed for the **E-MORB** for lack of data (Schaltegger et al. 2002). Whether their emplacement occurred synchronously or these differences possibly indicate sequential stages during development of the Piémontaise ocean (Manatschal et al. 2003) has to be clarified on the base of upcoming data.

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