GEOLOGIC AND GEOCHEMICAL CHARACTERISTICS OF BASIC VOLCANITE-HOSTED LATERITIC BAUXITE OCCURRENCE IN UCKARDESLER-HATIBINAGIL HILL (ISPARTA-TURKEY)

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Uckardesler-Hatibinagil Hill bauxite occurrence is cropped out in NE of Dedecam (Sarkikaraagac-Isparta), situated at the top of the Islikayatepe volcanite and shows autochthonous bauxite character. Thickness of profile, represented by basic volcanite, partly weathered volcanite (saprolite) and bauxite levels, is 120 meters. Two different bauxite levels that are observed in this lateritic profile, contain average 43.55 % Al_2O_3, 27.0 % Fe_2O_3, 4.79 % TiO_2, and 11.36 % SiO_2. Main mineralogical compositions of bauxites are represented by diaspore, hematite, bohmite, kaolinite, saponite, nontronite and anatase. Total rare earth element (REE) of bauxites is 71.8 ppm. Ce is the most abundant element in REE with an average 26.7 ppm and it is followed by La (21.04 ppm) and Nd (12.2 ppm). Light rare earth elements (LREE; La-Sm) (65.72 ppm) were enriched 12 times as much as heavy rare earth elements (HREE; Gd-Lu) (5.43 ppm). Chondrite-normalized REE values for the bauxites are $(La/Lu)_N =$ 16.49, $(Gd/Yb)_N = 1.85$, $(La/Sm)_N = 6.01$, $(La/Yb)_N = 19.11$, $Eu/Eu* = 1.15$ and $Ce/Ce* = 0.63$; basalt-normalized REE values for the bauxites are $(La/Lu)_N = 4.26$, $(Gd/Yb)_N = 1.0$, $(La/Sm)_N = 3.31$, $(La/Yb)_N = 4.78$, $Eu/Eu* = 1.07$, $Ce/Ce* = 0.65$. Negative Ce anomaly suggests that bauxite is formed under the oxidation condition and derived from basic volcanites. The REE contents of lateritic bauxites are 14 times higher than those of the chondrites, 9 times those of the world, 6 times those of the primitive mantle and 5 times those of the peridotites.

ON THE PROBLEM OF COMPOSITIONAL ZONATION IN MAFIC DYKES OF THE ÅLAND-ÅBOLAND DYKE SWARM, KESTIÖ ISLAND, SW FINLAND

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One remarkable feature of mafic-ultramafic intrusions and related ore deposits is the occurrence of marginal zones in which mineral crystallization sequences and compositional trends are distinctly opposite to that predicted by phase equilibria diagrams. Such marginal zones are commonly characterized by a decrease in the number of crystallizing phases in progressively formed rocks while minerals become gradually more primitive inwards from intrusive contacts. Examples include marginal reversals in mafic sills and layered intrusions, reverse concentric zonation in Alaska-type complexes, D-shaped compositional profiles in komatiitic lava flows, reverse internal zonation in massive sulphide bodies and iron oxide ores, etc. Such marginal zones are almost universally developed in magmatic bodies irrespective of their age, geographical location, size, form, and even composition of parental magmas, strongly indicating that some fundamental process or processes are involved in their genesis [14].

In attempts to resolve this puzzle, igneous petrologists have suggested about ten different hypotheses which we have recently reviewed [12, 13, 14]. Among them are magma supercooling [17], contamination of magma by country rocks [23], successive emplacement of magma that becomes increasingly more primitive with time [18], crystal settling of intratelluric phenocrysts or newly grown crystals in the chamber [1], intrusion of successively more primitive batches of magma carrying progressively more phenocrysts [15], flow differentiation during intrusion of olivine or orthopyroxene phenocryst-laden magma [7, 16], crystallization from compositionally stratified magma in the chamber [24], reaction of cumulus minerals with an intercumulus melt increasing in amount towards the base

[20], shrinkage-induced redistribution of intercumulus melt from the cumulate pile towards the intrusive contacts [2, 3, 19] Soret effect [10, 12, 13, 21], and thermal migration [8, 9].
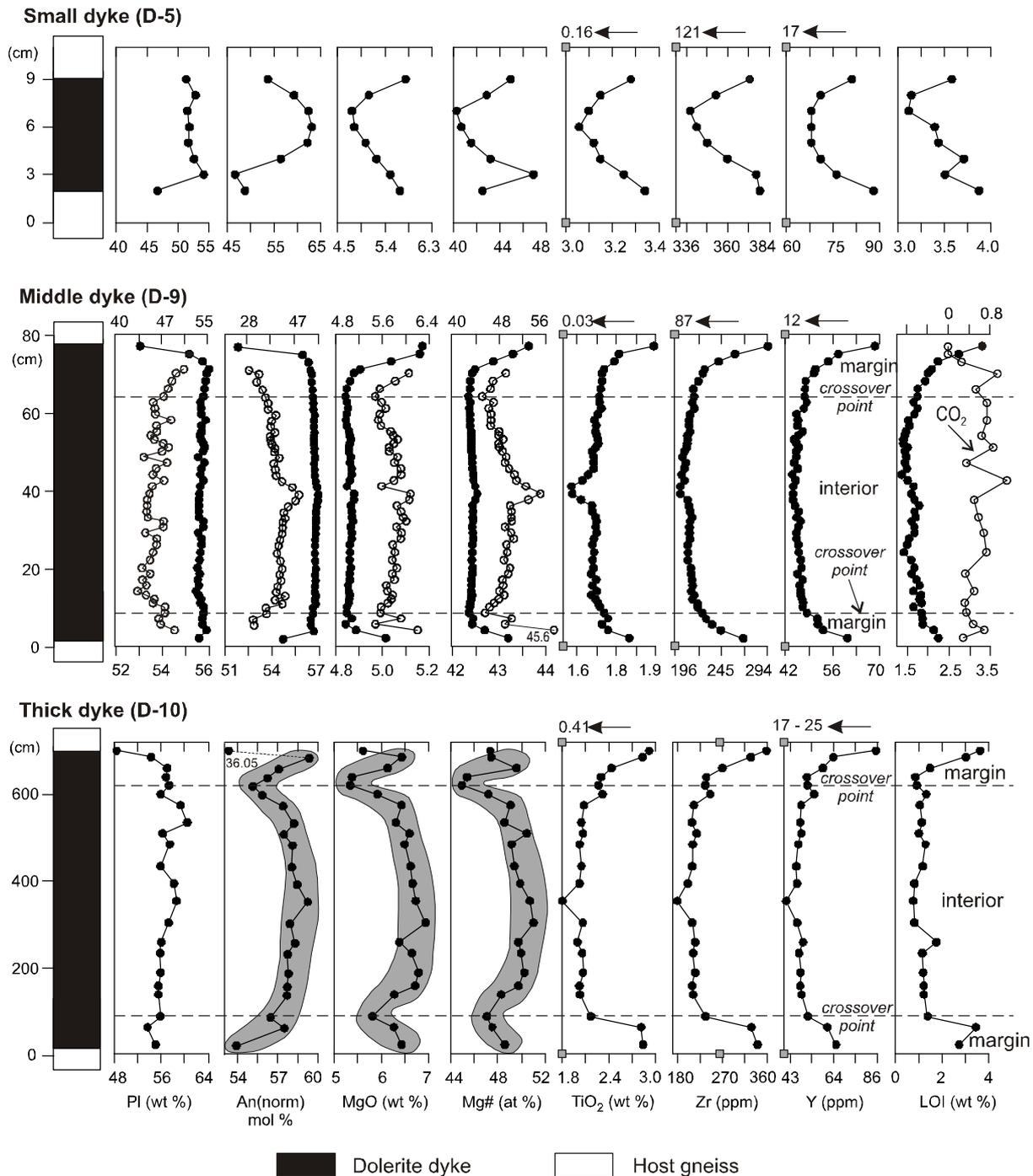

Fig. 1. Compositional variations across small, middle and thick dolerite dykes of the Åland-Åboland dyke swarm (Kestiö Island, SW Finland).

Note that for illustrative purposes, the variations in Pl, An(norm), MgO and Mg# across a central portion of middle dyke are shown separately using a different scale on the upper horizontal axis. Variations in CO_2 are also shown on the last column with a scale indicated on the upper horizontal axis. In small dyke orthoclase component is added to normative Pl. Distance is shown from north-western contact of dykes. Compositional points for host gneisses are indicated by open circles and arrows on horizontal axes. $Mg\#=100*Mg/(Mg+Fe_{total})$; $An(norm)=100*An/(An+Ab)$; LOI – loss on ignition.

Our detailed study of compositional variations across mafic dykes of Kestiö Island, SW Finland resulted in a discovery of spectacular internal zonation in small mafic dykes.

In complex magmatic bodies, such as large layered intrusions, to make a safe choice between the above processes is extremely difficult because of the great diversity of natural processes that may be potentially involved in the origin of marginal reversals. As a way out we suggest therefore turning to relatively simple objects, such as small mafic dykes that also commonly reveal marginal reversals, but in which most complicating factors can be eliminated, significantly narrowing the above list of physico-chemical processes. Observational studies of such simple objects are akin to controlled experiments in which complicating factors are eliminated by manipulating experimental conditions. As an illustration, such processes as crystal settling, magma stratification and infiltration metasomatism are extremely unlikely to be significant in small dykes. Also, depending on the presence or absence of intratelluric phenocrysts, the role of flow differentiation during intrusion can be easily assessed. Detailed compositional profiles across dykes and their adjacent rocks may also give a clear answer as to the role of *in situ* contamination by country rocks. There is then a chance to end up with one or two processes that could be responsible for marginal reversals in small mafic dykes.

We have studied whole-rock major and trace elements as well as mineral compositions across seven mafic dykes of the Åland-Åboland dyke swarm, Kestiö Island, SW Finland [6 11, 22]. This swarm was chosen because it contains a high proportion of relatively fresh and phenocryst-poor dykes that are well exposed on coastal outcrops of numerous islands of the Åland-Åboland Archipelago of the Baltic Sea. The three most representative dykes of different size (small dyke D-5, 7 cm; middle dyke D-9, 75 cm; and thick dyke D-10, 675 cm) are presented here. Detailed sampling across these dykes has revealed an internal zonation of an anomalous nature [4, 5]. The small, almost glassy dyke exhibits a systematic inward decrease in whole-rock MgO and Mg# (indicating a normal fractionation trend) together with a simultaneous increase in normative An and decrease in whole-rock Zr, Y, TiO_2 (indicating a reverse fractionation trend). The middle dyke shows similar compositional trends across its narrow margins, but in the more crystalline interior whole-rock MgO and Mg# gradually but steadily increase inwards. As a result normal and reverse fractionation trends of the margins grade to exclusively reverse fractionation trends of the interior. The thick, almost totally crystalline dyke exhibits an internal zonation similar to that of the middle dyke, with fractionation trends becoming only much more pronounced in the centre of the dyke. The almost glassy nature of small dyke suggests that its anomalous compositional zonation most likely resulted from temporal changes in the composition of magma as it formed the dyke. The mechanism(s) responsible for such systematic changes in composition of inflowing magma remains, however, unknown. The margins of middle and thick dyke form in a similar way whereas their interiors formed by *in situ* cumulate growth against dyke sidewalls. This process resulted in a gradual inward increase in the proportion of cumulus phases owing to magma crystallization in progressively less supercooled conditions with increasing distance from cold country rocks. The compositional zonation of these dolerite dykes is thus produced by two independently operating mechanisms: successive changes in composition of inflowing magma (*an external liquid-state process*) and an *in situ* cumulate growth on dyke sidewalls (*an internal crystal-liquid process*). Based on the relatively minor development of internal zonation in interiors of middle and thick dykes, the former mechanism appears to be several times more effective in causing magma differentiation than the latter. It remains to be determined whether these two processes are a general reason for the formation of marginal reversals in mafic-ultramafic dykes, sills and large layered intrusions.

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SULFUR-ISOTOPE VARIATION IN VOLCANIC-ASSOCIATED MASSIVE SULFIDES OF THE NORTHERN APENNINE OPHIOLITES (ITALY)

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GEOLOGICAL SETTING

Mesozoic ophiolites exposed in the western Alps and the Northern Apennine of Italy (Fig.1) are fragments of the sub-oceanic lithosphere that floored a marginal basin formed by divergence of the European and the Adriatic plates in the western of the Jurassic Tethys [1]. The ophiolites contain several Fe-Cu-Zn sulfide deposits of the Volcanic-Massive-Sulfide type, originated by hydrothermal processes related with sub-oceanic basaltic volcanism that accompanied the ocean opening [2, 3, 4, 5]. Ophiolites