

GEOCHEMISTRY AND EVOLUTION OF THE ULTRABASIC BLUE HILLS INTRUSIVE COMPLEX (NAMIBIA)

KURSZLAUKIS, S.¹, FRANZ, L.², BREY, G.³ & SMITH, C.B.⁴

1: Institut für Geologie, Pleicherwall 1, 97070 Würzburg, Germany

2: Geoforschungszentrum Potsdam, Telegrafenberg A17, 14473 Potsdam, Germany

3: Institut für Geochemie, J.-W. Goethe Universität, Senckenberganlage 28, 60054 Frankfurt, Germany

4: Bernard Price Institute of Geophysical Research, University of the Witwatersrand, Private Bag 3, Johannesburg, South Africa

The Blue Hills Intrusive Complex (Janse, 1971; Spriggs, 1988; Kurszlaukis, 1994; Kurszlaukis *et al.*, in prep.) is part of the Gibeon Kimberlite Province in southern Namibia and is located about 5 km south of the Gross Brukkaros Mountain. Gross Brukkaros is surrounded by a number of magnesio- and silicocarbonatitic dykes and vents (Janse, 1969; Kurszlaukis, 1994), and the Blue Hills are located within the range of these volcanic rocks.

The Blue Hills form an ovally elongated, laccolithic body with a maximum length of 800 m and a thickness of about 50 m within contact metamorphosed shales and quartzites of the Precambrian to Cambrian Nama Group. Judging from the surrounding geology, the maximum intrusion depth of the laccolith did not exceed 400 m.

Six different types of magmatic rocks were distinguished from their mineralogical and chemical composition. Four of these six types are highly undersaturated silicate rocks forming a fractionation trend towards increasing carbonate contents. A late carbonatite, probably derived by liquid immiscibility, and a pegmatite - both with very low REE patterns - are the vaining expressions of the Blue Hills magmatism.

Our age determinations yield an age of 75.1 \pm 0.5 Ma (isochrone) (Kurszlaukis 1994, Kurszlaukis & Smith, *in prep.*) for the pegmatite. This is consistent with the results of Spriggs (1988) on the monticellite picrite.

The magmatic rocks may be characterised as follows: The base of the Blue Hills is formed by a layer of **monticellite-picrite (MP)** with a thickness of 20 m. This rock consists of olivine phenocrysts in a matrix of mostly monticellite and subordinate phlogopite, carbonate, magnetite, and perovskite. The MP is overlain by an up to 45 m thick, strongly altered **mica-olivine-carbonatite (MOC)**. Compared to MP carbonate and phlogopite are increased while monticellite is absent. In the upper portions pillow-like structures of MP within MOC can be observed. In the southern part of the Blue Hills, a discrete body of **phlogopite-carbonate-picrite (PCP)** is located within the MOC. It consists of olivine and phlogopite phenocrysts in a groundmass of carbonate, perovskite, and magnetite. In addition to these main intrusive bodies, several **phlogopite-carbonate-sills (PCS)** occur.

Carbonatite sills and dykes (C) also occur, the latter cutting through all other magmatic bodies. The carbonatites mainly consist of carbonate and to a lesser amount of phlogopite and apatite. Most remarkable is the presence of a small **carbonate-phlogopite-apatite-pegmatite (P)**, which forms veins with thicknesses up to 25 cm in the host rock.

Although different in their modal mineral content, the MP, MOC, PCP and PCS are remarkably similar in their trace element abundances. Their main differences mostly lie in their variable contents of the volatiles H₂O and CO₂. MgO/CaO ratios are 1-1.3 (Fig. 1) which indicates melting in the dolomite stability field at a depth of 80-100 km (Brey, 1978).

Spinel-olivine geothermometry points to temperatures of 1100-1250°C for the parental PCP.

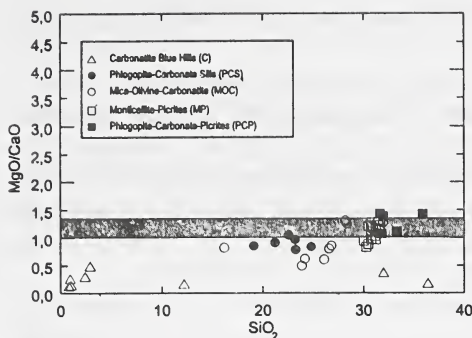


Fig. 1 (left): MgO/CaO vs. SiO₂. The MgO/CaO ratio ranging between 1 and 1.3 for the Blue Hills silicate rocks indicates melting in the dolomite stability field.

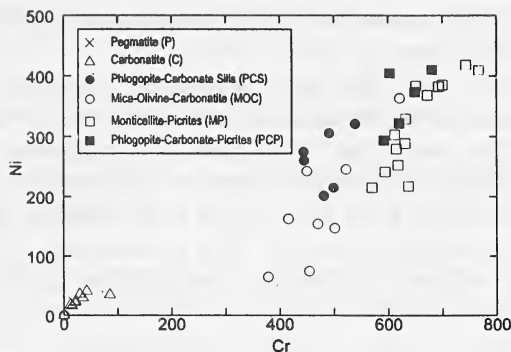


Fig. 2 (right): Ni vs. Cr. The relatively low amounts of highly compatible elements in the MOC and PCS compared to the MP and PCP distinctly point to differentiation processes.

Ni shows a positive correlation with Cr (Fig. 2) indicating fractionation of olivine and spinel. MP and PCP appear to be the most primitive compositions. The gap between the silicate and the carbonate rocks may indicate liquid immiscibility.

This assumption is supported by Fig. 3, where the compositions plot on either side of the liquid immiscibility gap as determined by Kjarsgaard & Hamilton (1989) at pressures > 5 kb. In the contrary a continuous trend from silicate-rich to carbonate-rich melts is found in the adjacent Gross Brukkaros volcanics.

Sample BH-35, a "Monticellite Picrite" (MP) shows a REE pattern similar to kimberlites and olivine melilitites consistent with a low degree of partial melting. Abundant perovskite in the groundmass of this rock is the most important host mineral for REE.

Usually carbonatites contain the highest amounts of REE and also the highest (La/Lu)_{cn} ratios. Samples BH-54 and BH-58b are derived from two different carbonatite sills, however, have a relatively flat REE pattern with much lower LREE and higher HREE compared to MP.

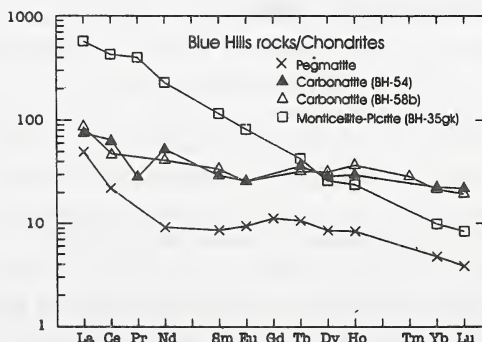
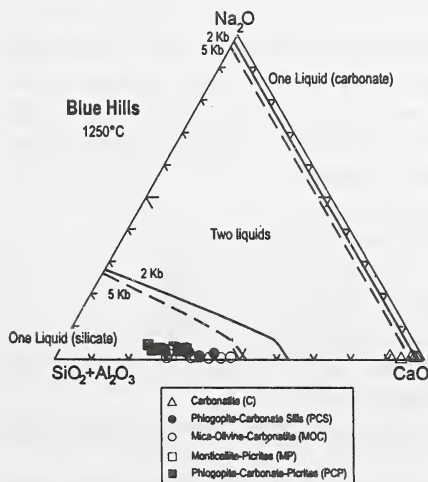


Fig. 3 (left): Major oxide liquid immiscibility diagram for 1250°C (Kjarsgaard & Hamilton, 1989). The solid lines mark the silicate and carbonate limbs at 2 and 5 kb pressure. Note the distinct miscibility gap between the silicate and the carbonate rocks.

Fig. 4 (right): The Blue Hills magmatites normalized to chondritic composition.

The strong depletion of LREEs is the result of perovskite fractionation, the main host mineral for LREEs (Jones & Wyllie, 1984).

The Blue Hills late stage pegmatite surprisingly shows the lowest overall REE pattern. Abundance levels are about 10 times of chondritic values (Nakamura, 1974) and thus are much lower than that of the carbonatites. The pegmatite consists of apatite (42 %), phlogopite (34 %), carbonate (21 %), and magnetite. These main constituents could serve as hosts for La and Ce. The bulge of the REE pattern at the MREEs (Gd and Tb) strongly resembles to the REE pattern occurring in apatite. This is according to the high amount of F⁻ (5.7 wt.%) in the apatites, which is a preferred complexing ion for REEs.

Literature:

- Brey, G. (1978): Origin of olivine melilitites - chemical and experimental constraints.- J. Volcanol. Geotherm. Res., **3**, 61-88.
- Janse, A.J.A. (1969): Gross Brukkaros, a probable carbonatite volcano in the Nama Plateau of South-West Africa.- Geological Society of America Bulletin, **80**, 573-586.
- Janse, A.J.A. (1971): Monitcellite bearing porphyritic peridotite from Gross Brukkaros, S.W.A.- Trans. geol. Soc. S. Afr., **74**, 45-56.
- Jones, A.P. & Wyllie, P.J. (1984): Minor elements in perovskite from kimberlites and distribution of the rare earth elements: an electron microprobe study.- Earth Planet. Sci. Lett., **69**, 128-140.
- Kjarsgaard, B.A. and Hamilton, D.L. 1989. The genesis of carbonatites by immiscibility.- In: Bell, K. (Ed) Carbonatites. Genesis and Evolution. Unwin Hyman, London, 388-404.
- Kurszlaukis, S. (1994): Geology and geochemistry of the carbonatitic Gross Brukkaros Volcanic Field and the ultrabasic Blue Hills Intrusive Complex, southern Namibia.- Ph.D. thesis, Univ. Würzburg, 292 pp.
- Kurszlaukis, S., Franz, L., Brey, G. & Smith, C.B. (in prep.): Geochemistry and evolution of the ultrabasic Blue Hills Intrusive Complex (Namibia).
- Kurszlaukis, S. & Smith, C.B. *in prep.* New isotope data on carbonatites from the Gross Brukkaros Volcanic Field and the ultrabasic Blue Hills Intrusive Complex.
- Nakamura, N (1974): Determination of REE, Ba, Fe, Mg, Na and K in carbonaceous and ordinary chondrites.- Geochim. Cosmochim. Acta, **38**, 757-775.
- Spriggs, A.J. (1988): An isotopic and geochemical study of kimberlites and associated alkaline rocks from Namibia.- PhD. thesis Univ. Leeds.