VOLCANOLOGY OF THE DIATREME-RICH CARBONATITIC GROSS BRUKKAROS VOLCANIC FIELD AND OF THE NEAR-BY GIBEON KIMBERLITE PROVINCE, NAMIBIA.

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The enigmatic carbonatitic Gross Brukkaros volcanic field and the Gibeon kimberlite volcanic field in southern Namibia, both intensively discussed during the First International Kimberlite Conference in 1973, have been restudied in detail since 1991 with the following results:

Gross Brukkaros is a volcano shaped inselberg in southern Nami-bia with a basal diameter of 7 km and a height of 600 m above the surrounding Nama plain. From a structural and morphological point of view Gross Brukkaros forms a ring-shaped ridge 3 km in diameter surrounding an intramontane basin and located in the centre of a ringshaped antiform (4.5 km in diameter at its crest). At the present erosional surface the ring-shaped antiform has a diameter of 10 km of updomed rocks and exposes Cambrian Nama quartzites and shales of the Fish River Subgroup. At the southern and eastern outer margin of the ring-shaped ridge 7 large newly discovered blocks of Dwyka sediments from the basal Karoo have escaped erosion and unconformably overly the Cambrian shales. The Cambrian and Karoo sediments of the inner limb of the antiform are unconformably overlain by up to 250 m of silicified sediments. These sediments form the outer escarpment and inner slope of the Gross Brukkaros ridge. They consist of reworked pyroclastic and country rocks. These sediments were deposited in a depocenter originally larger than the present-day area of outcrop and consist of debris flows, mudflows, and braided fluviatile and lacustrine deposits. The latter contain many turbidite beds and plant fossils which in all probability are of Upper Cretaceous age. A high proportion of dolerite detritus, occurring as lithic clasts and as individual mineral grains (plagioclase and clinopyroxene), as well as rounded, monocrystalline quartz grains were observed in the Brukkaros sediments.This clearly indicates that in Upper Cretaceous time the Karoo sediments in the Brukkaros area not only contained one or several extensive dolerite sills but were already overlain by unconsolidated aeolian Kalahari sediments. Aeolian Kalahari sediments provide the only likely source for these highly mature quartz grains. The lake beds and fluviatile beds in the Brukkaros sediments prove - and this is of paleohydrogeological relevance in respect to the formation of the many diatremes in the vicinity - that there existed sufficient groundwater at near-surface levels and that surface water flow occured. Synsedimentary faulting (with downthrow dowards the center of Gross Brukkaros) and dips of the Brukkaros sedimentary sequence up to 30^o, locally up to vertical, imply that the depocenter subsided over an extended period of time.

Surrounding the central area of Gross Brukkaros there exist in excess of 100 carbonatite dykes and 74 carbonatite diatremes. The updoming of the Cambrian and younger sediments as well as emplacement of these subvolcanic feeder structures are assumed to have been caused by a laccolithic intrusion which through these feeders resulted in carbonatite volcanism - ?lava flows, ?scoria cones and maars. A great proportion of basement xenoliths in the dykes and diatremes clearly points to a laccolith intrusion level largely within the uppermost basement (Nama/ basement boundary at 1 km depth). Growth of the laccolith in several phases resulted in dykes mostly radial to the northwestern margin of Gross Brukkaros, at the intersection with the southwestern area of the so-called Balcony, an intensively blockfaulted area. The dykes extend up to 13 km away from Gross Brukkaros. Most of them are up to 0.5 m in width, a few reach 2.2 m. Vesicles in a few dykes prove exsolution of volatile phases and synchronous quenching to allow preservation. The dykes consist of either silicocarbonatite (Mg-rich) or magnesiocarbonatite, in one instance, relatively close to the Brukkaros ridge, of calciocarbonatite. Carbonatite ash grains and lapilli of the two main types occur, of course, also in the carbonatite diatremes. In addition, there occur redeposited magnesio- and calciocarbonatite lapilli, locally forming up to 70% of the sedimentary rocks, in the Brukkaros sediments. Obviously, this indicates that the reservoir contained different batches of carbonatite magma and may have been layered. The high proportion of calciocarbonatite lapilli in the Brukkaros sediments and the single calciocarbonatite dyke rather close to Gross Brukkaros suggest that the calciocarbonatite magma batch was located near the top and central part of the magma reservoir. In addition it is suggested that calciocarbonatite diatremes were located above the central area of the laccolith, but below the depocenter and they were active prior to deposition of those Brukkaros sediments which are exposed at present.

The 74 carbonatite diatremes surrounding Gross Brukkaros are from a few m (from root zone sizes) up to 200 m in diameter, i.e. the larger ones consist of complex diatreme structures with a multitude of facies. In many instances the diatremes are located on and thus cut a genetically associated dyke ("precursor dyke"). Xenoliths of diverse sizes in the diatremes prove a former upward extension of the diatremes from Nama through Karoo sediments, one or several Karoo dolerite sills, and through unconsolidated Kalahari sediments. They are cut by the present erosion surface between about 200 - 600 m below the original Kalahari surface. which must have been at or above the top level of Gross Brukkaros. The high ratio of country rock clasts to juvenile carbonatite clasts suggests maars as the volcano type cut into the Kalahari sediments and ?Karoo rocks and surrounded by respective tephra rims and beds. Erosion of these ejecta and their redeposition in the Brukkaros depocenter resulted in a large carbonatite fraction and very angular sedimentary clasts (explosively fragmented inside the diatremes) within the Brukkaros sediments. Lack of vesicles within the carbonatite ash grains, lapilli and bombs - many of which are spherical pyroclasts because of action of surface tension - and the paleohydrogeological environment strongly support a phreatomagmatic origin of the carbonatite diatremes. A number of diatremes were finally intruded by carbonatite dikes and plugs.

Due to continued eruption from the radial dykes (lavas?, scoria?) and from the diatremes which must have ejected typical maar tephra a growing mass deficiency evolved in the laccolithic magma reservoir and the overlying roof rocks subsided over an extended period of time resulting in a sagging caldera and consequently in the depocenter and its fill. The Brukkaros sediments, representing this caldera fill, suffered postdepositional strong metasomatic-hydrothermal alteration (fenitization) implying the existence of a hot reservoir still at this stage of the evolution of Gross Brukkaros.

The nearby Tertiary Gibeon Kimberlite Province diatremes also evolved from and cut kimberlite dykes up to 2 m thick and 500 m long. The kimberlite diatremes penetrated Nama and Karoo sediments as well as Karoo lava flows (in the North) or dolerite sills (in the South) as indicated by blocks of enclosed and subsided countryrocks. Spherical nonvesicular lapilli and the same paleohydrogeological environment during the Upper Cretaceous to ?lowermost Tertiary as at Brukkaros also advocate strongly for a phreatomagmatic origin of these diatremes. In a few diatremes there occur late intrusive kimberlite plugs which may have extended into kimberlite lava lakes, lava flows, or scoria cones and scoria beds on respectively outside the floor of the kimberlite maars. Uplift of a few m wide collar of the surrounding country rocks at each kimberlite diatreme suggests swelling of the kimberlite diatreme rocks and upward drag along the diatreme walls due to posteruptive hydration of the kimberlite fraction of the permeable diatreme fill.

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