KALKKOP CRATER, EASTERN CAPE - A NEW IMPACT CRATER IN SOUTH AFRICA;

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Reimold et al. [1] suggested that the 640 m diameter Kalkkop crater, at 32°43'S/24°34'E in the Eastern Cape Province (South Africa), could possibly be of impact origin. This idea was based on the circularity of this structure, its regional uniqueness, lack of recent igneous activity in the region, and petrographic characteristics of drillcore [2,3], indicating that the central core is not underlain by a salt dome and is partially filled with a breccia layer of a thickness which would agree with the dimensions expected for an impact structure of this size. Unfortunately the old drillcore was no longer available for study, and in the absence of surface exposures only drilling could provide the evidence needed to solve the problem of the origin of Kalkkop. For this reason and to study the crater fill from a paleoenviromental point of view, the S. African Geological Survey decided to sponsor a new research drilling project at the Kalkkop site. We are now able to present first petrographic and isotopic results from Kalkkop drillcore studies confirming, without doubt, that this crater is of impact origin.

The Kalkkop drilling project was to comprise a vertical borehole into the center and a second, steeply inclined borehole from outside of the rim towards the crater base. To date, the central borehole has been sunk to a depth of 151.8 m, where drilling was temporarily suspended. However, it is known from [2] that the fractured/breciated basement will only be reached at ca. 213 m depth. The stratigraphic record obtained so far consists of 95.3 m of breccia, with a cm-thick laminated limestone on a cm-wide debris flow that is underlain by breccia. This breccia (Fig. 1) appears very similar to suevite from other impact structures. Fresh melt or glass particles have not been found yet, but the whole breccia layer is strongly deformed, with the rock characteristics as altered, fluidal or glassy particles were repeatedly observed in thin sections. It is therefore justified to apply the term suevite to the Kalkkop breccia. The three examples of Kalkkop breccia shown in Fig. 1 show strong differences in clast population and texture on a mm-scale. Clasts are either shale or sandstone, derived from the Beaufort Group (Lower Beaufort Sequence). Below ca. 140 m, clast sizes increase to >1 m. Several strongly fractured shale clasts broke on gentle prodding to reveal shatter cone-like fractures (Fig. 2a,b) with apices pointing in many different directions with regard to the orientation of the borehole. It is believed that these fractures are the result of interference of the strong cleavage/lamination of the shale with cratering-induced microjoints.

A visit to Kalkkop revealed that the structure is raised a few m above the surrounding Beaufort sandstone plains, because the limestone crater fill is capped by a very resistant calcrete layer. Exploration trenches dug close to the rim and limited outcrop along the crater rim indicate shallow (4-20 m) inward dipping microjoints (Fig. 3a,b). Where limestone and sandstone can be studied in contact, the sandstone stands vertical. It is strongly deformed by narrow-spaced, vertical, radial joints (Fig. 3c). A few m from this locality, the sandstone dips at 10° towards the crater center and is possibly overturned.

Numerous quartz grains with planar deformation features (PDFs) in up to 6 orientations per grain were detected. In addition, partially isotropic quartz grains, frequently with relics of densely spaced PDFs, and a few alkali feldspar grains with PDFs were observed. The total amount of probable melt breccia and glass fragments is estimated at <1% of the total breccia volume. However, the much larger Ries crater does not contain much melt breccia either, and it was argued that this could be caused by sedimentary targets. At the top of the breccia layer a series of mm-thick gritty layers were found and interpreted as debris off the crater rim. However, the lowest one contains a high amount of sulfide droplets and many shocked grains and could represent a fallout layer.

Negative thermal ionization mass spectrometry was used to measure the concentrations and isotopic abundances of Os, Re, and Ir in selected samples of Kalkkop sandstone, shale, and suevite. The 187Os/188Os ratios as a new powerful tool to detect the presence of a meteoritic component in impact melts, even at very low abundances [4]. Koeberl and Shirey [5], for example, found that the sandstone has Os and Re abundances of 0.019 ppb and 0.033 ppb, respectively, a 187Os/188Os ratio of 7.65 and a 187Re/188Os ratio of 1.79. The shale yielded Os and Re abundances of 0.027 and 0.090 ppb, and 187Os/188Os and 187Re/188Os ratios of 7.62 and 1.79, respectively. These values are fairly typical for old crustal rocks. The suevite, however, showed Os and Re abundances of 0.189 and 0.062 ppb, and 187Os/188Os and 187Re/188Os ratios of 1.79 and 16.1. The low 187Os/188Os ratio, in comparison with the high, crustal target rock ratios,
is unambiguous proof of a meteoritic component in the suevite. This component is also supported by the 7-10 times higher Os content in the suevite, compared to target rocks. In conclusion, petrographic and isotopic studies have provided unequivocal proof of an impact origin for the Kalkkop crater.

Acknowledgements: The support of the Director of the Geological Survey of South Africa is gratefully acknowledged. C.K. and S.B.S. are supported from the Austrian FWF Project No. P9026-GEO and the NSF Project EAR-9218847.