'MELT' BRECCIAS FROM ROTER KAMM IMPACT CRATER, NAMIBIA

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SUMMARY: Fragments of 'melt' breccia recovered from the rim of Roter Kamm Crater resemble genuine melt bombs associated with other impact craters (e.g. Ries Crater). Smooth flow-like textures, folds, and ablation-like surfaces of these rocks suggest they are ejected melts. All of the melt-like rock samples examined in this study are products of autochthonous (in-situ) brecciation of carbonaceous slates or phyllites in which layered sedimentary textures are commonly preserved. A pre-impact metamorphic event (presumably during the Damaran Orogeny, ca. 600 Ma) resulted in re-alignment of minerals in the parent rocks. These breccias are interpreted as products of localized breakup of parent rock with limited clast transport. Textures have been significantly altered by fluids derived from a post-impact, circulating hydrothermal system. The present form of the fragments is largely the result of wind erosion and sand abrasion.

DISCUSSION: Roter Kamm is a 2.5 km diameter crater located in the southern Namib Desert, Namibia at 27° 46' S and 16° 18' E [1, 2, 3, 4, 5]. Sand covers much of the crater, but exposures are common along the rim. Detailed accounts of the crater geology have been published by Reimold and Miller [4, 5]. The impact, which excavated Precambrian granitic-granodioritic orthogneisses of the 1200-900 Ma Namaqualand Metamorphic Complex, has been dated at 3.7 +/- 0.3 Ma [6]. Minor exposures of Gariep carbonates occur 1 km south of the crater.

The 'melt' breccias occur as loose fragments and blocks in a radially oriented swath along the northern crater rim. They are the only crater-related materials with features suggestive of aerodynamic transport. Aerodynamic-like sculpting and flow-like surfaces (Fig. 1) prompted use of the terms "melt breccias" and "melt bombs" for these rocks [4, 5, 6, 7]. Koeberl et al. [6] and Reimold et al. [8] refer to them as "schistose melt breccias", based on a presumed metapelite source. The original interpretation of these rocks as impact ejecta was reinforced by identification of glass and of diaplectic quartz in sample URK-41 [5, 6, 9, 10]. This sample is a vesicular impact melt breccia with composition that indicates contributions from several parent lithologies, including basement granite. We examined 'melt' breccias, collected from the northern crater rim, in an attempt to determine whether these samples are true impact melts and to reconcile their textures, mineral assemblages, and compositions with possible parent lithologies. None of the 'melt' breccia samples we have examined show evidence of glass or of melt textures. To date, sample URK-41 is the only true melt breccia described from Roter Kamm crater.

Bulk analysis of breccia samples yields a very narrow spectrum of major, minor, and trace element compositions. All samples we examined apparently derive from a single, fairly homogenous parent rock. The compositional data exclude any significant Namaqualand basement component in these breccias. In contrast to sample URK-41, these breccias show no shock metamorphic effects. The samples are all breccias with angular clasts of very fine-grained, largely opaque material that mineralogically is almost entirely quartz plus muscovite and small amounts of carbon, with minor chlorite in some samples. Irregular, discontinuous non-opaque layers, interpreted as relict sedimentary layering, are cut by networks of quartz and quartz-muscovite veinlets (Fig. 2). Foliation in the muscovite is oblique to the layering and is interpreted as a metamorphic texture probably associated with the Damaran Orogeny.

Source rock for these breccias was a fine-grained sediment, probably belonging to the Gariep Group, that had undergone low grade regional metamorphism before impact. Absence of shock effects suggests that these breccias are late-stage products of the crater-forming process (i.e. during crater readjustment). Breccia clasts display sintered textures and quartz overgrowths similar to those in breccia veins and dykes described by Degenhardt et al. [11], but there is no evidence of significant cataclasis. The brecciation produced large (> mm-sized), angular clasts that formed by localized disruption of the parent rock with limited clast transport (Fig. 3). Breccia textures have been modified by extensive emplacement of secondary quartz in a variety of forms, and of sericite.

CONCLUSIONS: For the formation of the Roter Kamm breccias examined in this study, we favor a sequence that began with a layered carbon-bearing siliceous shale which underwent low-grade metamorphism. This transformation involved metamorphic re-alignment of original sedimentary textures and transformation of the rock to slate or fine-grained phyllite. The breccias formed in-situ during the re-adjustment phase of the crater-forming process and did not experience appreciable cataclasis, comminution, or frictional melting. A circulating hydrothermal system generated from impact-derived heat, such as proposed by Koeberl et al. [12], served to alter the newly formed breccias. Gradual erosion along the crater rim uncovered portions of the breccia layer, exposing them to wind erosion and sand abrasion. We interpret the present 'fluidal' forms of the Roter Kamm 'melt' breccias to be the result of this erosion and weathering, rather than impact melting.

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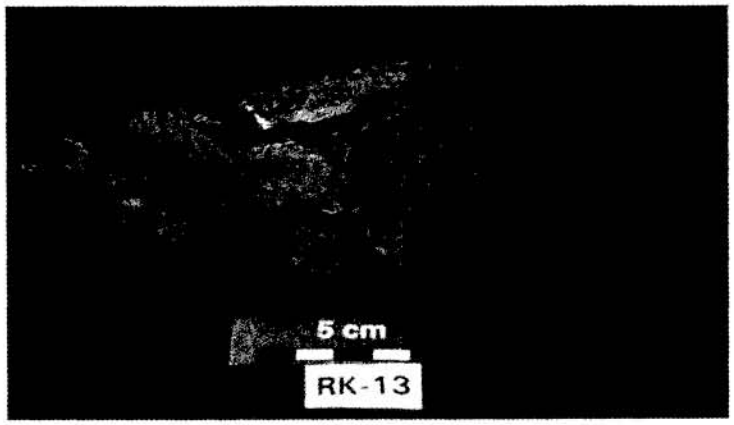

Figure 1. 'Melt' breccia RK-13 from Roter Kamm Crater. Note 'fluidal' surface.

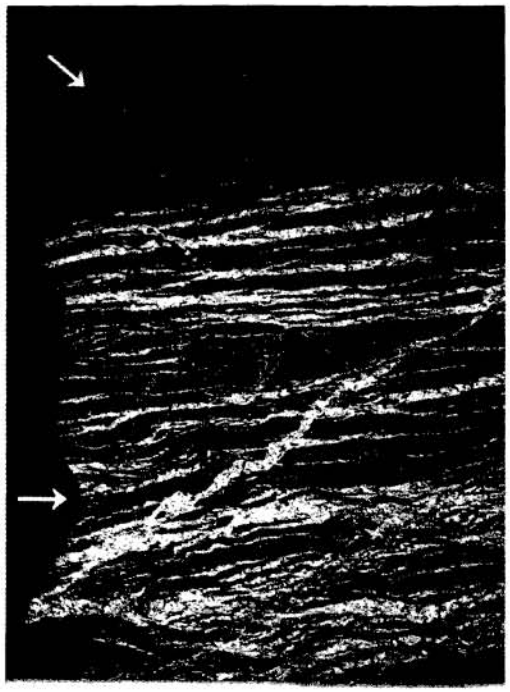

Figure 2. Photomicrograph of Roter Kamm breccia RK-6, showing layering and quartz veins. Left and top margins (arrows) show truncation of layers by the original breccia surface. Crossed nicols; width of field 2.4 cm.

Figure 3. Photomicrograph of Roter Kamm breccia MZRK-6. Width of field 2.2 cm.