

**MAGNETIC INVESTIGATIONS OF BRECCIA VEINS AND BASEMENT ROCKS FROM ROTER KAMM CRATER AND SURROUNDING REGION, NAMIBIA.** D. Rajmon<sup>1</sup>, S. A. Hall<sup>1</sup>, A. M. Reid<sup>1</sup>, R. McG. Miller<sup>2</sup>, D.J. Robertson<sup>3</sup>, <sup>1</sup>Department of Geosciences, University of Houston, Houston, Texas 77204-5007, USA, [drajmon@yahoo.com](mailto:drajmon@yahoo.com); <sup>2</sup>Consulting Geologist, PO Box 11222, Windhoek, Namibia; <sup>3</sup>Physics Department, University of Namibia, Windhoek, Namibia.

**Introduction:** Earlier investigation of  $^{40}\text{Ar}/^{39}\text{Ar}$  isotopic system of breccia veins and basement rocks from  $3.7 \pm 0.3$  m.y. old [1] Roter Kamm crater revealed no influence of frictional heating on the veins and indicated that the highest temperatures both veins and basement rocks experienced as a result of the impact event were 230-290 °C and were induced by shock heating [2]. This investigation did not include samples unaffected by the impact, which could provide information whether all of the observed Ar loss from the crater samples is due to impact or some of it is a regional signature. Thus the established temperature range is an upper limit only.

Preliminary paleomagnetic analysis of an unoriented core from the breccia vein yielded excellent data with two populations of grains, each holding magnetization with a distinct orientation. Under the assumption that the magnetizations were acquired during thermal events, comparison of paleomagnetic data for the breccia and host rocks from the crater and for country rocks outside the crater could provide an independent test of our temperature estimates derived from the Ar data. If space orientations of isolated magnetic components were known, they could be related to Africa's apparent polar wander path (APWP) and thus test whether the breccia is temporally related to the impact event or to earlier periods of magmatic and metamorphic activity indicated at 900-1200, ~670, ~470 [3] and ~300 Ma [2].

**Analytical techniques:** Selected field oriented samples of vein and host rock material were drilled and cut to obtain thin sections for petrographic description and cores 2.5 cm in diameter for magnetic

analyses. Two cores for magnetic analyses were obtained from each sample. The sample RK115 containing 1-cm-wide breccia vein provided two cores of the host rock and two cores with the vein. One set of cores was subjected to a stepwise demagnetization by an alternating field (AF) with intensity within 0.5-100 mT. The other set of cores was thermally (TH) demagnetized within 50-650 °C. The magnetic susceptibility (MS) was monitored throughout the thermal demagnetization experiment in order to check for any changes in mineral assemblage produced while heating. All cores were measured for anisotropy of magnetic susceptibility (AMS). AMS measurements were performed after the AF but before the TH demagnetizations.

**Samples:** Nine hand samples were selected for the study representing rocks from the crater rim, with and without breccia veins, and rocks located ~120 km north and east of the crater. One sample without breccia was located just outside the crater. All samples are granites or weakly foliated granitic gneisses. They primarily consist of microcline, quartz and plagioclase in roughly equal proportions or in the order of decreasing volume, respectively. Biotite is present in smaller amounts. Most of the rocks contain some accessory minerals such as zircon, allanite, epidote and garnet. Alteration products include sericite, epidote and carbonate.

Samples RK111, RK112 and RK115 contain narrow veinlets or 1-5 cm veins of the breccia. The veins are filled with the same material as the host rock but comminuted to a range of grain sizes from several  $\mu\text{m}$  to 5-mm fragments of the host rock. The finest quartz grains of the vein locally display granoblastic texture suggestive of partial recrystallization. The finest biotite grains in these veinlets often appear recrystallized. We have not observed any PDFs in quartz or any other shock indicators.

**Results:** The suite of newly collected rocks from Roter Kamm possesses a natural remanent magnetization (NRM) in the range of  $7.2 \times 10^{-8}$  –  $8.6 \times 10^{-5}$   $\text{Am}^2\text{kg}^{-1}$  with an average of  $6 \times 10^{-6}$   $\text{Am}^2\text{kg}^{-1}$ . These values are similar to common NRM of granite, gneiss

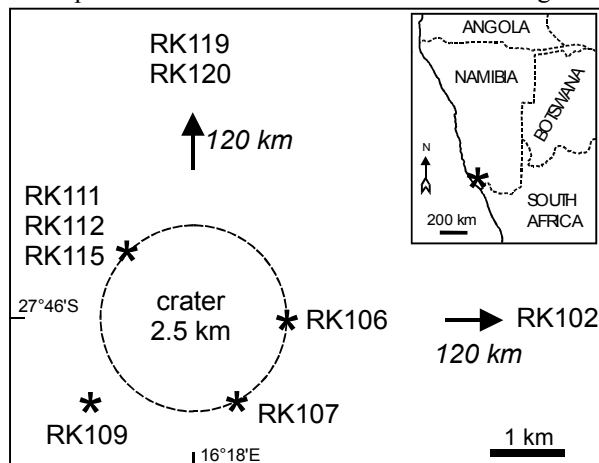


Figure 1 Locations of Roter Kamm crater and studied samples.

or diorite ( $10^{-6}$ ,  $5 \times 10^{-6}$  and  $10^{-5}$   $\text{Am}^2\text{kg}^{-1}$ , respectively [4]). Although the samples with breccia tend to display magnetizations within the lower values of the range, there is no clear distinction with respect to the samples without a breccia. In contrast, the pure breccia core of the previously studied sample RK-SR carried the strongest magnetization of all samples.

The thermal demagnetization patterns vary from sample to sample in both intensity and orientation. Thermal demagnetization curves typically show ranges of unblocking temperatures beginning at 100-300 °C and ending at 550-600 °C. The decrease of magnetization intensity with progressive demagnetization varies for most of the samples with locally smaller or greater slopes in intensity-vs.-temperature or alternating field plots. Such a pattern suggests the presence of more than one grain population with different unblocking temperatures.

Alternating field (AF) removed most of the remanent magnetization within 2.5-15 mT for most of the samples. RK111 (with veinlets) also lost a majority of its magnetization between 2.5-15 mT but retained ~25 % of magnetization throughout the experiment. The cores from RK115 (with 1-cm vein or veinlets) display a complicated demagnetization pattern with increase in magnetization intensity within 0.5-1 (2.5) mT, decrease within 2.5-15 mT, increase within 15-20 mT, decrease within 20-40 mT and increase within 40-80 mT. This oscillation pattern corresponds to sharp changes in magnetization vector orientation. RK-119 (far from the crater) lost its magnetization linearly with the increasing AF intensity throughout the applied AF range, which is different from all other samples.

All breccia-bearing samples had a specific magnetic susceptibility  $\sim 1 \times 10^{-8}$   $\text{m}^3\text{kg}^{-1}$  whereas all other samples had  $\sim 5 \times 10^{-8}$  –  $1.5 \times 10^{-7}$   $\text{m}^3\text{kg}^{-1}$ . These values are similar to common susceptibilities of granite or gneiss ( $2 \times 10^{-7}$ ,  $5 \times 10^{-8}$   $\text{m}^3\text{kg}^{-1}$ , respectively [4]). Magnetic susceptibility typically remained constant during the TH demagnetization experiments with minor increases around 600 °C corresponding to onset of or continued erratic remanent magnetization orientations.

Results of demagnetization experiments suggest that the major magnetic carriers in the studied samples are magnetite and hematite.

Principal component analysis of the thermal demagnetization and alternating field demagnetization data yielded a number of different characteristic remanent magnetization (ChRM) components. Orientations of the AF demagnetization data are generally more stable than those of the TH demagnetization data. Orientations of the TH data for the cores without the breccia tend to be more stable than orientations for the cores containing the breccia.

Such a correlation does not exist in the AF data set. There is also poor to no correlation between sample location (outside or inside the crater) and the quality and orientations of AF/TH principal components.

Calculated poles for each principal component fall on or close to the APWP for Kalahari and Congo cratons between ~1.1 and ~0.5 Ga [5]. The poles tend to cluster close to where Kalahari paleopole was located at ~1.1-0.9, ~0.7, ~0.6 and ~0.5 Ga, which closely correspond to the ages of igneous and metamorphic events in the region [3]. Several good quality components have poles, which fall outside of the Kalahari APWP for ~1-0.8 Ga. This could be explained by a rotation of the target rock blocks during crater formation or by an uncertainty in APWPs constructed by various authors. The African APWP for 0.5 Ga to present [6; 7] lies far from most of calculated component poles except where the Phanerozoic APWP overlaps with the Proterozoic APWP.

AMS data tend to show stronger anisotropy for samples containing breccia veins than for other samples. This characteristic of cores from breccia bearing samples as a group appears significant even though the calculated degrees of anisotropy for these cores are associated with large uncertainties. The samples without breccia display much smaller uncertainties in data.

Most of the cores display oblate AMS ellipsoids. AMS ellipsoids for the breccia-bearing samples tend to be less defined than for samples without the breccia.

**Conclusions:** Results of demagnetization experiments suggest that the major magnetic carriers in the studied samples are magnetite and hematite. Essentially all isolated NRM components can be best related to the Kalahari APWP for ~1.1-0.9, ~0.7-0.6 and ~0.5 Ga. There is no evidence for re-magnetization of the Roter Kamm samples at ~300 Ma or during the impact at 3.7 Ma. The AMS experiment demonstrated that the formation of the vein breccias led to a decreased magnetic susceptibility, increased anisotropy of magnetic susceptibility and disruption of the regional AMS pattern.

**References:** [1] Hartung J. B. et al. (1991) *Meteoritics*, 26 (Suppl.), A342-A343. [2] Rajmon D. et al. (2003) *paper submitted to Meteoritics and Planetary Science*. [3] Koeberl C. et al. (1993) *Meteoritics*, 28, 204-212. [4] Thompson R. and Oldfield F. (1986) Allen & Unwin, London, UK. [5] McWilliams M. O. and Kröner A. (1981) *J. Geophys. Res.*, 86(B6), 5147-5162. [6] McElhinny M. W. and McFadden P. L. (2000) Academic Press, San Diego, California, USA. [7] Besse J. and Courtillot V. (2002) *J. Geophys. Res.*, 107(B11), EPM 6-1 - 6-31.