New evidence for impact-induced hydrothermal activity in the Miocene Ries impact crater, Germany

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I. Impact-induced hydrothermal activity

Post-impact hydrothermal activity has been reported from a number of terrestrial impact craters, from large impact structures 200-250 km in diameter to smaller craters only 1.8 km in diameter. Nonetheless, hydrothermal activity in the 24 km-sized Ries Impact Crater (Fig. 1), one of the best investigated impact structures on Earth, has poorly been constrained. To date, mineralogical investigations point to a restriction of hydrothermal activity to the impact-melt bearing breccia, specifically the crater-fill suevite (Ohsinski 2005). The formation of hydrous clay minerals in the fallout suevite, previously assigned to hydrothermal alteration (Newsom et al. 1986), however, can alternatively be explained by late meteoric diagenesis (Muttik et al. 2008).

The impact crater Nördlinger Ries is located 110 km NW of Munich. 40Ar-39Ar data indicate an age of 15 Ma for the impact event (Staudacher et al. 1982), which is in accordance with U/Pb single zircon dating of volcanic tufts bracketing the "Brockhorizon" (Rocholl et al. 2011). The age of 15 Ma for the impact event (Staudacher et al. 1982), which is in accordance with U/Pb single zircon dating of volcanic tufts bracketing the "Brockhorizon" (Rocholl et al. 2011). The single zircon dating of volcanic tufts bracketing the "Brockhorizon" (Rocholl et al. 2011).

II. Geological setting

The Erbisberg mound is located 1.1 km SE of Nördlingen and surpasses the surrounding plain of the central crater by 5-10 m (Fig. 2). It consists of a central travertine core overlying a 5 m thick tuffaceous unit. The mound is characterized by a central travertine core overlying a 5 m thick tuffaceous unit. The mound is characterized by a central travertine core overlying a 5 m thick tuffaceous unit. The mound is characterized by a central travertine core overlying a 5 m thick tuffaceous unit.

In addition, a drill core was recovered in May 2011 by the Bavarian Environmental Agency (Fig. 2A). In June 2006, the construction of a biogas plant was associated with digging of a pipeline trench, which exposed a section of marginal travertine mound parts (Fig. 2B). In addition, a drill core was recovered in May 2011 by the Bavarian Environmental Agency (Fig. 2A).

IV. Strontium isotope stratigraphy

The isotope stratigraphic position of the travertine mound, as indicated by 87Sr/86Sr values of mound margin carbonates with lacustrine components, suggests that the mound was active during deposition of the laminite unit of the basal succession, i.e., at least several thousands of years after the impact event (Fig. 5).

Fig. 1. Structural subdivision of the Ries impact crater and location of the travertine mound Erbisberg.

Fig. 2A. The Erbisberg travertine mound southeast of Nördlingen. Overview showing the positions of the investigated pipeline trench and the new drilling.

Fig. 2B. Section view of the trench with distribution of streamer carbonates and "non-skeletal" stromatolites (i.e., cement crust stromatolites, vesicular-clotted stromatolites).

Fig. 3A. Streamer carbonate of the Erbisberg.

B. Streamer carbonate of a present-day thermal spring near Viterbo, Italy.

C. Cement crust stromatolite showing serrated laminae due to angular crystal traces, Erbisberg.


IV. REE patterns

With respect to REE patterns, cement crust stromatolites show flat patterns, while streamer carbonates either were enriched in HREE due to diagenetic dissolution and reprecipitation, or exhibited flat REE patterns with a minor positive Eu anomaly. A post-impact calcite vein from brecciated gneiss of the subsurface crater floor finally revealed a flat REE pattern with a clear positive Eu-anomaly, considered to indicate hydrothermal remobilisation of Euβ from plagioclase (Fig. 4).

Fig. 4. Rare Earth Element patterns of the Erbisberg carbonates and reference samples from the Ries crater basin.

V. Conclusions

(1) Carbonates almost identical to streamer carbonates of present-day thermal springs suggest that the Erbisberg mounds was formed by hydrothermal activity.

(2) Facies analysis indicates that this mound was formed at an subaerial spring site close to the lake shore.

(3) REE patterns with a positive Eu-anomaly, as detected in a subsurface calcite vein and a streamer carbonate sample, indicate an interaction of hydrothermal fluids with plagioclase from crystalline basement rocks.

(4) The stratigraphic position of the mound, as indicated by 87Sr/86Sr values of adjacent lacustrine carbonates, suggests that post-impact hydrothermal activity in the Ries basin was much longer than previously assumed.

References