

**WHAT DO WE KNOW ABOUT THE DURATION OF POST-IMPACT HYDROTHERMAL ACTIVITY?**

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**Introduction:** Robust constraints on the timescales over which post-impact hydrothermal systems remained active are crucial for assessing the potential of these environments for habitability. However, the lifetimes of impact-induced hydrothermal systems are poorly constrained, with durations in only a few structures having been quantified by geochronological measurements [e.g., 1–3], and most of the quoted durations originating in numerical simulations [e.g., 4,5] or calculations involving cooling of impact melt rocks [e.g., 6,7]. However, these calculations typically fail to account for heat from deep rocks that were uplifted during crater formation, and the effects of fluid circulation due to heterogeneous permeability. Permeability has repeatedly been found to be one of the key properties affecting the longevity of hydrothermal activity [4,5], yet it is often one of the most poorly constrained parameters for input into simulations.

Radioisotopic age determinations have characterized the duration of only a few hydrothermal systems [1,2,6], and these measurements often disagree with modelled durations. For example, the Lappajärvi (23 km diameter) and Chicxulub (200 km diameter) impact structures yielded order of magnitude differences in the measured versus calculated durations [1,2,6]. At Lappajärvi, combined <sup>40</sup>Ar/<sup>39</sup>Ar and U-Pb ages have indicated that hydrothermal activity lasted approximately 1 million years, substantially longer than the thousands to tens of thousands of years predicted by calculations at similarly sized impact structures [7,8]. Likewise at the Ries impact structure (24 km diameter), hydrothermal activity appears to have lasted at least 250 kyrs [9]. The Sudbury impact structure (~250 km diameter) is the site of the most extensive hydrothermal alteration in a terrestrial impact structure [5]. Zircon U-Pb ages indicated a maximum duration of conductive cooling of the Sudbury igneous complex of 1 million years [6], but the hydrothermal system is considered to have cooled much faster, over just tens to thousands of years, due to fluid convection. Numerical simulations at Sudbury by Abramov and Kring [5] suggested that the hydrothermal system could have remained active for hundreds of thousands to several million years depending on permeability of the host rock. Simulations at Chicxulub yielded similar results (~1.5 to 2.3 Myr), again with a substantial dependence on permeability of the host rocks [4]. Whereas more recent simulations have demonstrated that hydrothermal activity at Chicxulub may have lasted up to 6 Myrs [10]. The results of these simulations are supported by <sup>40</sup>Ar/<sup>39</sup>Ar geochronology that indicates hydrothermal fluid flow at Chicxulub continued for at least 6 Myr post-impact [10, 11], up to three times longer than the ~2 Myr estimate from previous numerical simulations [4].

These results indicate that we may have been significantly underestimating the window of habitability created by impact events, and certainly demonstrate that there is significant room for improvement in our understanding of impact-generated hydrothermal systems.

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