DISTRIBUTION AND ORIGIN OF MAFIC IMPACT EJECTA FROM THE LOCKNE CRATER, SWEDEN

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Introduction: The Lockne crater formed ca. 455 million years ago in a target composed of a crystalline Proterozoic basement, overlain by early Palaeozoic sedimentary rocks, and seawater. The inner crater has a diameter of ca. 7 km, with an up to 2.5 km wide brim of ejected, crushed crystalline basement spread around it [1]. Large ejecta blocks within this rim range from a few meters to ca. 100 m in diameter are found as far 15 km from the edge of the crater. The largest ejecta blocks have created smaller, secondary craters around Lockne with diameters of 100-200 m (i.e. Målingen, Karsåtjärnen, and Kloxåsen) [2]. The field distribution of the Kloxåsen ejecta blocks is unknown but determining their relation to the rest of the impact structure is important for a fuller understanding of the formation of Lockne and other similarly sized craters in mixed (crystalline and sedimentary) targets. Here, we have mapped the distribution of ejecta around Kloxåsen. As the chemical and mineralogical composition of the Kloxåsen ejecta blocks is unknown we have also carried out a mineralogical and chemical analysis of this material to establish the source rock of the mafic ejecta blocks, to characterise the extent of hydrothermal alteration, and to determine the levels of shock in the ejecta.

Results and discussion: Mapping of the Kloxåsen area showed that the mafic ejecta breccia is much more widely distributed than previously thought, although the granitic breccia dominates. Optical petrography, SEM-EDS, and Raman spectroscopy revealed extensive and curious hydrothermal alteration in the mafic clasts. Olivine has been completely replaced by serpentine and chlorite that in turn are wholly or partly replaced by calcite (and translucent sphalerite). This strongly depletes the clasts in Fe and Mg, and enriches them in Ca. Titanaugite has been replaced by quartz, chlorite, calcite, and anatase, although unaffected titanaugite grains still occur. Some biotites appear “split open” and are replaced by quartz and anatase, but no kinkbanding has been observed. Titanaugite affected by mechanical twinning suggests shock pressure of at least 5 GPa [3]. Fluid-inclusion analysis in calcite revealed that the hydrothermal system in Kloxåsen is the same as in the rest of the crater [2]. Sector-zoned titanaugite oikocrysts, which are only known to occur in CSDG (Central Scandinavian Dolerite Group) rocks [4], and whole-rock geochemistry conducted in this study, strongly suggest the Åsby dolerite as a protolith for the observed mafic impact ejecta at Kloxåsen.

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