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Resurge deposits supporting a marine target of the Early Cambrian Vakkejokk impact, north Sweden

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Abstract

The 520 Ma Vakkejokk Breccia, Sweden, likely is a proximal ejecta layer from an impact in a marine environment. Three short core drillings give evidence for resurge deposits supporting a marine target.

1. Introduction and aim of study

The ⩽27m thick Vakkejokk Breccia (VB) is semi-continuously exposed for a stretch of about 7km. Recent studies, including the discovery of planar deformation features in quartz (PDF) suggest the breccia to be impact related [1]. The VB is intercalated in a shallow marine succession that was deposited after the peneplanized Precambrian basement was transgressed in the Early Cambrian. The autochthonous sequence begins with the ~5m thick, transgressive, Lower Sandstone member, followed by the ~20m thick Lower Siltstone member (It is this unit that in the study area is partially replaced by the VB), which is in turn abruptly overlain by the 15-25m thick Red and Green Siltstone member. All together this suggests a marine target setting for the inferred impact. Based on sequence stratigraphical reasoning the VB is correlated to an absolute age of ≈520Ma [1]. The crater is estimated to be 2-3km wide, and most likely located below nearby Caledonian overthrusts [1].

The lower part of the VB is characterized by highly disturbed sandstone and siltstone blocks intermingled with clasts deriving from the Precambrian basement, some of decameter dimensions. This sub-unit is referred to as the 'lower polymict breccia' (LPB), and is suggested to have formed by ballistic bombardment of the sedimentary strata surrounding the crater by crystalline basement ejecta [1]. Overlying the LPB with a usually rapid transition is a polymict breccia, most commonly meter-thick and often graded. It occurs as both matrix-supported (most commonly a green, but also red-brown, silt), and as clast-supported, often in the upper half. Grading is obvious in the clast-supported variety, but occurs in the matrix-supported part as well, and thus this subunit is called 'graded polymict breccia' (GPB) [1]. It is at some sites overlain by an up to a few dm thick bed of quartzitic sand ('top sandstone', TS). It is from the GPB and TS that grains of shocked quartz have been retrieved [1]. These sub-units are suggested to have formed by marine resurge carrying ejecta and rip-up material back towards the crater. Locally the TS seems to be replaced by a mostly matrix-supported conglomerate that is suggested to originate from later slumps associated with degradation of the crater rim [1].

It is known from marine-target craters such as Lockne, Tvären, and Chesapeake Bay that the resurge deposits are essential for disentangling the marine cratering process and estimating target water depth [e.g., 2, 3]. Nevertheless, in the usually weathered exposures of the VB it is not always easy to see the sedimentological relations between the putative resurge deposits and underlying para-autochthonous breccia, notably whether there are gradual transitions, or erosive boundaries. This is more readily investigated in drill-cores.

2. Methods

Based on the previous mapping by Ormö et al. [1] three drill sites were selected that display a succession of TS and GPB overlying the para-authochtonous LPB. The first core, Vakk-CH1, was retrieved at N68° 22.259', E19° 14.132'. The other two cores, Vakk-CH2A&B, were drilled a further 100m to the west and only 1.5m apart at N68° 22.269', E19° 14.013' (Fig. 1). The cores were cut into halves. One half was polished to allow detailed visual logging and high-res photos. A first granulometric log was made by applying the line-logging technique given by Ormö et al. [2, 3] in which clast lithology and size (⩾ 5mm) was determined.

Figure 1. Drilling of Vakk-CH2B with a HILTI DD-200 (52mm drill crown)

As the short cores do not allow the statistical treatment of clast granulometry per meter, the line-logging results are seen as indicative, but also as a guide for the statistically more relevant logging carried out with the software JMicroVision v1.2.7. Here, a preset box of $20cm^2$ was systematically moved along the core photos. The box area is chosen so that to obtain an amount of clasts similar to that of published line-logs [i.e., 3]. The box width is set to fill up the width of the core with some margin. In case the core is very uneven in shape the box shape is adapted to the core maintaining the $20cm^2$ surface area (In this study at only one location). The maximum length of the box is limited to locations with rapid changes in the sediment; The data is plotted at the depth of the center of the box (i.e., the shorter the box the narrower the data point spacing). Every clast $\geqslant$5mm inside the box is determined for size (visible length axis) and lithology. The exterior of the box is considered unknown, thus only the visible part of clasts crossing the perimeter of the box is measured. The outline of each clast is hand drawn allowing the percentage of matrix to be calculated by subtracting the total area of the clasts from the box area. Clast sizes are given as mean $-\Phi$ values per box (here called φ), and sorting is determined by the standard deviation (σ) of this value [cf. 2, 3].

3. Results and discussion

The three cores Vakk_CH1 (135cm), CH2A (85cm), and CH2B (135cm) show similar trends and due to limited space we here only describe Vakk_CH1; Notable is how: 1) There is an approximately 40cm thick graded arenite that has a gradual, although rapid, downwards transition to a clast supported breccia. This has a likewise gradual transition into a matrix-supported breccia towards the end of the core. 2) Siltstone clasts are generally larger than granite clasts at the same depth (i.e., transport energy in suspension), possibly as a result of their shape. 3) The clast-supported part is dominated by another variety of granite than the matrix-supported part. 4) The number of clasts is (logically) the highest in the clast-supported part. 5) Clast size varies greatly below 112cm depth. Above that level there is a slight fining-up trend, as well as a higher amount of crystalline (basement) clasts. 6) Sorting is improving upwards, indicating waning resurge flow [cf. 2, 3]. 7) Crystalline clasts dominate (especially above 112cm), but are upwards more and more replaced by (more easily transported?) siltstone clasts.

4. Conclusions

Although the data set is limited it shows systematic trends that we find support the model by Ormö et al. [2017] of a resurge of water and ejecta separated in an overriding hyperconcentrated suspension flow that drives a traction flow of ejecta and rip-up material from the underlying ballistic ejecta (LPB) (Fig. 2).

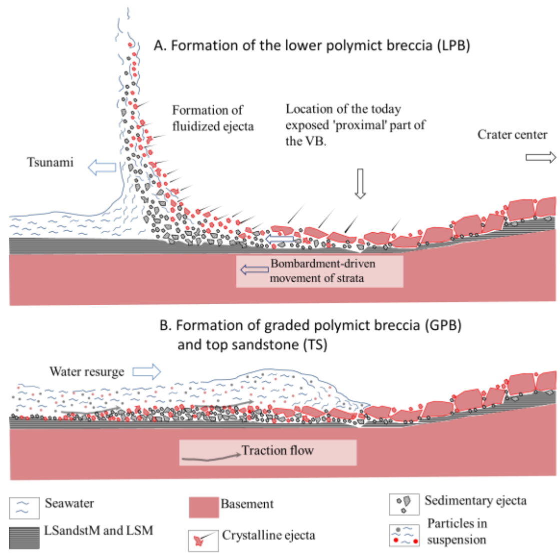

Figure 2. Model of formation of the VB with the para-autochthonous LPB and the subsequent resurge deposits GPB and TS. Modified from [1].

References

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