EVIDENCE FOR AN EARLY CAMBRIAN PROXIMAL IMPACT EJECTA LAYER IN THE NORTH-SWEDISH CALEDONIDES. J. Ormö[1], A. T. Nielsen[2], and C. Alwmark[3], [1]Centro de Astrobiologia (INTA-CSIC), ES-28850 Torrejon de Ardoz, Spain (ormoj@cab.inta-csic.es), [2]University of Copenhagen, Natural History Museum of Denmark, DK-1350 Copenhagen, Denmark. [3]Dept. of Geology, Lund University, SE-22362 Lund, Sweden.

Introduction and aim of study: Relatively shallow marine successions of Early Cambrian age are preserved at many places along the Caledonian Mountain chain in Sweden and Norway. In the Torneträsk area, northern Sweden, the local Lower Cambrian deposits, up to about 100 m thick, are assigned to the Torneträsk and Grammajukku Formations [1, 2]. The Torneträsk Fm rests unconformably on the basement and comprises a number of sand- and siltstone dominated members signaling changes in sea level during deposition. In this part of the sequence an enigmatic occurrence of a mostly 2-4 m thick, crystalline-rich, polymict breccia, the Vakkejokk Breccia (VB), has long attracted the attention of geologists working in the area [1, 3, 4]. The breccia occupies a stratigraphic position between the 'Lower Siltstone mbr' (LSM) and the 'Red and Green Siltstone mbr' (RGSM) of the Torneträsk Fm. The lower boundary is erosive and locally the breccia even rests directly on the basement. The VB contains a mixture of clasts of Lower Cambrian sediments as well as the crystalline basement. The clast size varies from gravel to boulders and some of the larger basement blocks exceed 100 m in length although being less than 10 m thick, but even basements rafts > 200 m long have been reported [4].

The VB has been reported from a series of exposures on the northern side of Lake Torneträsk, where it is semi-continuously exposed between the Vakkejokk and Tjäurajokk rivers, i.e. for a stretch of about 7 km [1, 4]. It can be traced further eastwards in disjunct river sections for another c. 7 km [cf. 1]. Thin conglomerates in the same stratigraphic position occur also south of Lake Torneträsk, e.g., at Luopakte, possibly representing an equivalent to the VB [1, 4], but may just as well be normal sedimentary conglomerates, marking a sequence boundary [cf. 2].

The breccia has previously been interpreted as a tillite or being fault-related [see summary by 1, 2]. However, the latter authors found the previous explanations unsatisfactory due to the rather local distribution and in particular the occurrence of the very large basement boulders and suggested the breccia to be impact related. This re-interpretation sparked the new investigations reported here.

Methods: The study area was visited by Ormö and Nielsen during a one week field campaign in the summer of 2012 in order to study field relations of the VB and to collect samples that potentially could provide evidence of shock diagnostic for impact. Thin sections of VB samples obtained during the 2012 field campaign were studied by Alwmark using a Leitz 5-axes universal stage [5] mounted on an optical microscope in search of planar deformation features (PDFs) in quartz grains. The crystallographic orientations of identified PDFs were determined according to techniques described in [6, 7].

Results and discussion: Shock metamorphic features, in the form of PDFs, have been found in six quartz grains from one of the breccia samples (Fig. 1). Of the six shocked grains, four display a single set of PDFs, all oriented parallel to the basal plane *c* (0001). Two grains contain two sets; one set oriented along (0001) and one parallel to crystallographic plane ω $\{10\bar{1}3\}$.

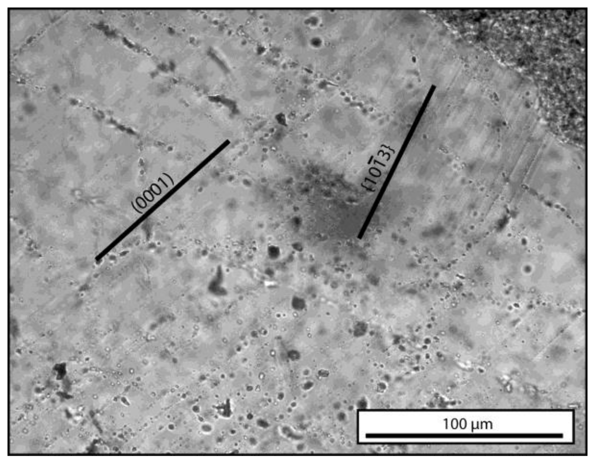

Figure 1. Thin section photomicrograph of part of a shocked quartz grain displaying two PDF sets: one oriented along the basal plane and one with $\{10\bar{1}3\}$ equivalent orientation (uncrossed polars).

Our examination of the VB along the Mount Vaivvancohkka section confirmed that the thickness (<20 m) as well as clast size (tens of m) is at the greatest in the central parts of the exposure. Here, clast supported VB rests on deformed shale and sandstone strata of the LSM and even directly on the peneplain. Towards the east, the breccia rapidly decreases in thickness to just a couple of meters that is maintained for a few kilometers. Here it is still clast supported, but with clast sizes <1m, and commonly rests on relatively less deformed LSM. The thickness of the VB layer then drops to about 30-50 cm at the Tjäurajokk exposure where it shows clast sizes <15 cm and is mainly matrix supported with a conspicuous green, silty matrix. This silt gradually transforms upwards into the several meters thick green siltstones of RGSM. Likewise, in the westernmost parts of the section, i.e. near Vakkejokk, the breccia rests on a relatively well-preserved LSM as well as being matrix supported with the same green, silty matrix as at Tjäurajokk. Also here the silt gradually transforms upwards into the overlying green siltstones of RGSM. Although green silt also occur in the LCM, the gradual transition from green matrix to the overlying green siltstones of the RGSM may indicate a formation (ejecta emplacement) during the very early deposition of this unit. The VB layer is here about 4-7 m thick and the crystalline clasts are noticeably rounded and with dimensions of up to a couple of meters.

The clast size distribution, the stratigraphic position (i.e. erosion of the substrate) as well as variation in matrix content suggest that the central parts of the VB exposure along Mount Vaivvancohkka are most proximal to the crater (Fig. 2). The location of the VB within the autochthonous sequence raises hopes that the crater has avoided tectonic deformation. It must be located either within Lake Torneträsk or below the Mount Vaivvancohkka just north of the breccia exposure. As the Lake Torneträsk is mainly a consequence of Pleistocene glacial erosion, the much older (Early Cambrian) impact will, of course, not be the cause for the lake´s current geomorphology. Glacial erosion would, however, have removed much of the crater´s upper parts (the lake level is about a hundred meters below the breccia layer). We have so far not seen anything in the bathymetry or shape of the lake that would indicate the presence of an impact crater at the inferred location. On the other hand, the Mount Vaivvancohkka forms part of a Caledonian overthrust nappe whose movement has occurred mainly along the weak, relatively low friction sediments of the Alum Shale and Grammajukku Formations. In that case, the crater in the basement may be very well preserved, as indicated by the exposed ejecta layer. Indeed, as c. 100 My have passed between the formation of the crater and the emplacement of the nappe there is good chances that the crater may contain a very interesting post-impact succession, maybe even including an expanded Early/Mid Cambrian boundary succession. Judging from the extent of the exposed ejecta layer and the dimensions of the seemingly most proximal fragments (i.e. parts of overturned flap), it is reasonable to estimate that the crater may be approximately 2-4 kilometers wide. For comparison, the 7 km wide Lockne crater in central Sweden has a couple of kilometers wide preserved ejecta blanket that in its most proximal parts (i.e. at the outer flank of the overturned flap) is approximately 30 m thick [e.g., 8].

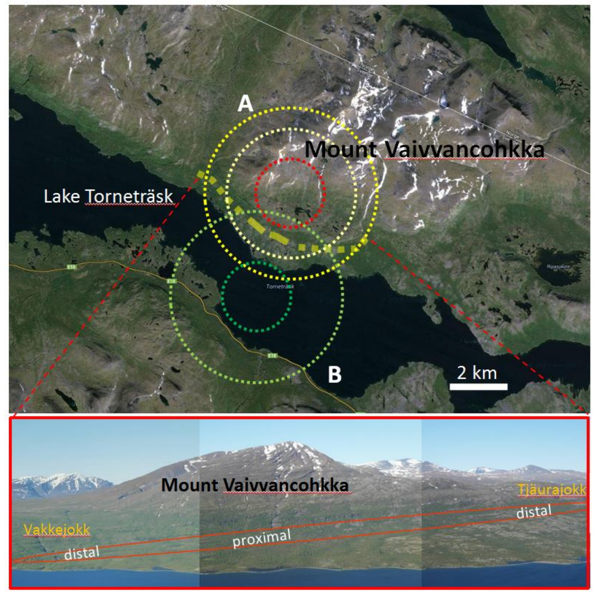

Fig. 2. Location of the Vakkejokk Breccia section (fat yellow stippled line) and inferred location of the putative crater (alternatively red or green circles). Option A is favored as it makes it easier to put a crater more proximal to the mega-clast part of the breccia in the center of the exposed section, and that it accommodates most of the exposure within a hypothetical ejecta layer without having to increase the crater size. Option A has an additional concentric circle representing the border between proximal, clast supported breccia, and more distal, commonly matrix (mud) supported breccia.

References:

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