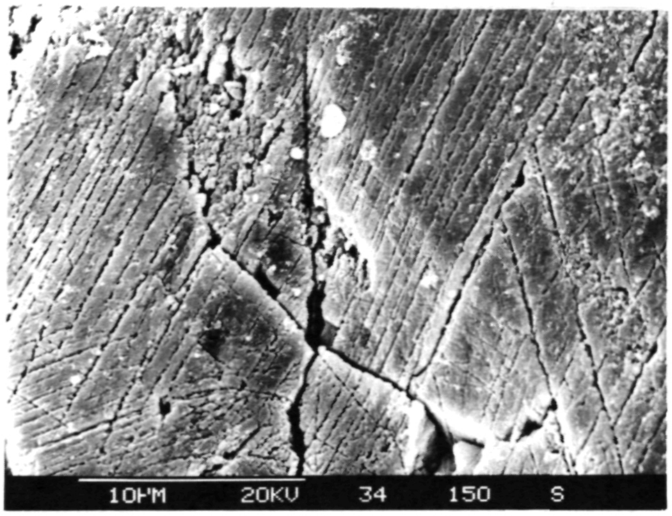

Fig. 1. PDF (4 sets).

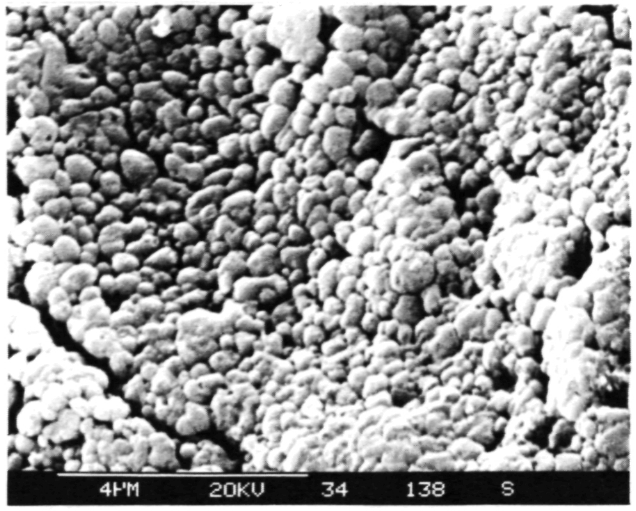

Fig. 2. Granular texture.

subjected to an alkaline etch [3]. We dissolved samples of both the Gray and Black Members of the Onaping with acids to free the contained zircons, which were then etched in alkaline solutions to reveal any PDF. These samples were collected from outcrops of the Onaping along Highway 144 south of Levack and west of the High Falls on the Onaping River. In the process of separating the zircons, we also recovered other resistant trace minerals indicative of target rock lithologies. These include tourmaline, garnet, kyanite, rutile, staurolite, chromite, pyrite, and pyrrhotite.

Many of the etched zircons from both the Gray and Black Members display PDF when viewed in an SEM. Figure 1 shows an area of a shocked zircon from the Black Member that displays at least four sets of PDF. These shock lamellae in zircon are much narrower than those in quartz and do not etch as deeply, probably because they contain less glass within them. Precession X-ray photos of zircons from K/T ejecta with PDF show extreme broadening and streaking (asterism) of diffraction maxima, confirming that they have been highly shocked [3].

Krogh et al. [4] reported zircons from the Onaping Formation at Sudbury that show linear, crystallographically oriented fracturing. They ascribed these features to shock caused by impact, and this conclusion is supported by U-Pb data. The discordance of these zircons is crudely proportional to the amount of fracturing they display, caused by the Sudbury event dated from a lower intercept age of ~1836 Ma. We have also observed both linear and irregular fractures in our Onaping zircons, but the finer-scale PDF probably indicate a significantly higher level of shock than do these coarse, open features.

In addition to fractures and PDF, Onaping zircons also show another type of textural feature that indicates exposure to a high level of shock. We have called this texture, first noted in zircons from K/T ejecta [3], "granular" or polycrystalline (Fig. 2). Often, zircons displaying this texture are idiomorphic with some of the original crystal surfaces still visible. This indicates that the zircons have not melted, but instead have been recrystallized due to shock. Thus, these granular zircon grains can be considered to be diaplectic—that is, shock-converted by solid-state transformation into polycrystalline zircon below their fusion temperature. On the other hand, zircons also can be melted by impacts, as shown by fused grains partially or completely converted to baddeleyite in high-temperature impact glasses [5]. The granular zircons in K/T ejecta and from the Onaping show no phase or compositional changes by X-ray analyses, in either diffraction or energy-dispersive modes. This is another indication that their texture is due to solid-state transformation induced by shock, and not thermal melting.

It is instructive that these granular-textured zircons have been found only in ejected material, and not in shocked, *in situ* target rocks around craters. However, zircons bearing impact-generated PDF have been identified from three types of sites and materials: K/T distal ejecta, Sudbury fall-back ejecta (Onaping), and Manicouagan target rocks. More importantly, PDF and granular textures have never been seen in volcanic zircons. Therefore, zircons can provide corroborating evidence of impact-generated shock; this discovery could prove very useful in evaluating the metamorphic histories of quartz-poor lunar rocks and meteorites.

Acknowledgments: We thank B. Dressler for guiding one of us (BFB) to the "type" locality of the Onaping. T. Krogh provided the Manicouagan zircons, and E. Foord performed the X-ray analyses.

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SUEVITE SUPERPOSITION ON THE BUNTE BRECCIA IN NÖRDLINGER RIES/GERMANY: NEW FINDINGS ON THE TRANSPORT MECHANISM OF IMPACTITES. D. Bringemeier, Marie-Hedwig-Str. 15, W-3392 Clausthal-Z., Germany.

Research undertaken in the last decades in Nördlinger Ries, Germany, has repeatedly emphasized the sharp contact between Bunte breccia and suevite. However, extensive investigations into this layer boundary have not yet been possible due to insufficient outcrop ratios.

New outcrops enabled an in-depth investigation into the superposition of suevite on the Bunte breccia, which is assigned a key role in interpreting the transport mechanisms of ejecta of large impact.

In two quarries lying several kilometers east and south-southwest of the crater (Otting, Aufhausen/Seelbronn), the contact between the suevite and Bunte breccia was recorded in detailed sections on outcrops of over 50 m in length.

It was possible to confirm studies made in the 1960s by Wagner [1] that suggested a division of the suevite into main suevite, rich in pancake bombs (also called "flädle"), and a relatively well-sorted, thin-base suevite consisting of fine gravel. A semiquantitative analysis of the just slightly consolidated base suevite revealed the main constituent to be "fresh," bubble-abundant, albeit sometimes bubble-deficient, angular glasses. Secondary crystalline and sedimentary rock clasts and very rarely "flädle" were detected. Significant to the transport mechanism of the base suevite is its content of Bunte breccia fragments and the discovery of shell fragments. Between the base suevite and the Bunte breccia is a crystalline breccia of ca. 0.1 m in thickness that is separated from the Bunte breccia by a sharp boundary. In some areas a transition bed is visible between the crystalline breccia and the base suevite. This transition bed indicates an erosive reworking of crystalline breccia by the base suevite. In one of the sections (Aufhausen/Seelbronn) the base suevite was not observed, as the main suevite lay either on the crystalline breccia or directly on the Bunte breccia. The crystalline breccia is highly altered and in the transition to main suevite contains disintegrated glasses.

In both sections structures were established that can be explained only by an erosive reworking of the subsoil caused by a shifting viscous suevite flow. Particulary on the flanks of the hummocks of Bunte breccia, lying several meters higher, the layers below the main suevite have been plained, compressed, and mixed by the suevite flow. In the Aufhausen/Seelbronn section hook-shaped, decimeter-sized, fingerlike compressions of Bunte breccia and crystalline breccia project into the main suevite. A clear erosive discordance between the main suevite and the base suevite is visible in the Otting section.

Reference: [1] Wagner G. H. (1965) *Jh. Geol. Landesamt Baden-Württemberg, Vol. 7,* 199–222.

SUDBURY PROJECT (UNIVERSITY OF MÜNSTER–ONTARIO GEOLOGICAL SURVEY): (7) Sr-Nd IN HETEROLITHIC BRECCIAS AND GABBROIC DIKES. D. Buhl[1], A. Deutsch[2], R. Lakomy[2], P. Brockmeyer[2], and B. Dressler[3], [1]Inst. f. Geologie, RU Bochum, Postfach 10 21 48, D-4630 Bochum 1, Germany, [2]Inst. f. Planetologie, Univ. Münster, Wilhelm-Klemm-Str. 10, D-4400 Münster, Germany, [3]Ontario Geological Survey, 77 Grenville Street, Toronto, Ontario M7A 1W4, Canada.

One major objective of our Sudbury project [1–6] was to define origin and age of the huge breccia units below and above the Sudbury Igneous Complex (SIC), i.e., the Footwall Breccia (FB) and the Onaping Formation, which caps the SIC. For the terminology used here we refer to the companion abstracts in this volume [1,3]; petrographic descriptions of the FB and of the Onaping breccias are found in [3,5,7–10].

The heterolithic FB, which is up to 150 m thick, represents a part of the uplifted crater floor [7,8]. It contains subrounded fragments up to several meters in size and lithic fragments with shock features (>10 GPa) embedded into a fine- to medium-grained matrix [8,9]. ε_{Nd}-ε_{Sr} relationships point to almost exclusively parautochthonous precursor lithologies (see Fig. 1 in [3]). The different textures of the matrix reflect the metamorphic history of the breccia layer: Thermal annealing by the overlying hot impact melt sheet (SIC) at temperatures >1000°C resulted in melting of the fine crushed material, followed by an episode of metasomatic K-feldspar growth and, finally, formation of low-grade minerals such as actinolite and chlorite. Figures 1 and 2 show that the Rb-Sr method on thin slabs and mineral fractions clearly can separate these events, whereas the Sm-Nd system apparently did not respond to either the thermal or the "late" metamorphic episode [7,8]. This is due to the fact that the highly refractory accessory phases that are the main REE carriers survived the melting in part [10].

Isotope relationships in the Onaping breccias (Gray and Green Member) are much more complex ([10–14]; compare also Fig. 1 in [3]). All attempts to date the breccia formation failed: Zircons are entirely derived from country rocks and lack the pronounced Pb loss caused by the heat of the slowly cooling impact melt sheet (SIC), which is documented in the crater basement [15]. Rb-Sr techniques using either lithic fragments of different shock stages [12], carefully separated, now recrystallized melt particles and melt matrices or the thin slab method [13,14] just set time limits for the apparently pervasive alkali mobility in these suevitic breccias. The data array

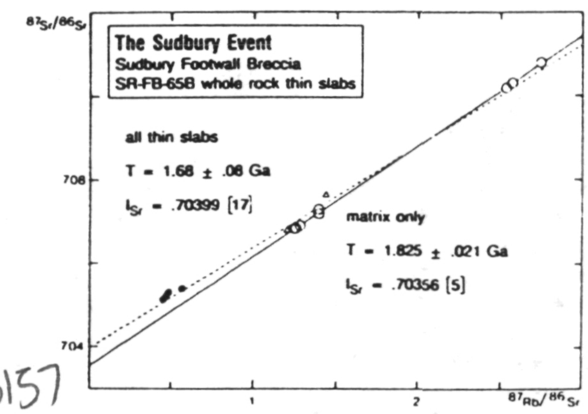

Fig. 1. Rb-Sr isochron diagram for thin slabs of the Footwall Breccia (north of Stathcona mine, Levack Township, North Range). Thin slabs of the quartzdioritic (= melt) matrix yield the age of the impact.

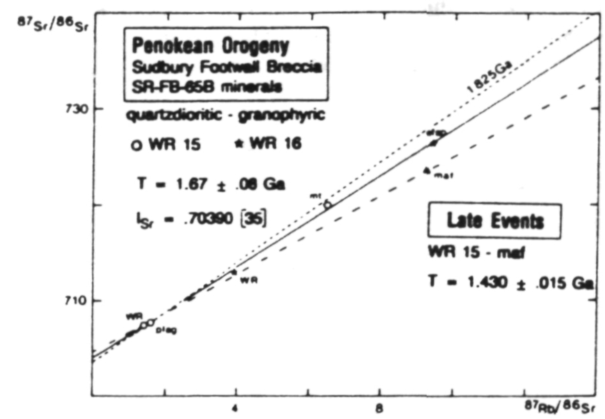

Fig. 2. Same samples as in Fig. 1. K-spar-rich granophyric matrix date a metasomatic episode; mineral fractions define a late, low-grade event.