THE NEWPORTE IMPACT STRUCTURE, NORTH DAKOTA: SHOCK METAMORPHISM IN BRECCIAS. Christian Koeberl[1], Wolf Uwe Reimold[2], and Dion Brandt[2]. [1]*Institute of Geochemistry, University of Vienna, UZA II, A-1090 Vienna, Austria (a8631dab@vm.univie.ac.at);* [2]*Department of Geology, University of the Witwatersrand, P.O. Wits, Johannesburg 2050, South Africa (065wur@cosmos.wits.ac.za).*

Introduction and Summary. The 3-km-diameter Newporte structure is situated about 2 km south of the U.S.-Canada border in North Dakota. It is covered with about 3 km of rock formations and has first been studied in the course of hydrocarbon exploration in the late 1970s, when it was found to contain significant oil reserves. The structure is situated in Precambrian crystalline bedrocks, which are highly fractured and brecciated. Detailed petrographic and geochemical studies of rock samples from three drill holes show the presence of three types of breccias, a mainly granite-derived breccia, a mainly metasediment-derived breccia, and a mixed breccia type. Quartz grains (as well as a few rare feldspar grains) from all three breccia types show planar deformation features (PDFs) with up to five sets per grain. Orientation measurements show predominantly {10$\bar{1}$3} (ω) orientations, which are characteristic of shock metamorphism. These observations confirm the impact origin of the Newporte structure.

Geological Setting. The Newporte structure is almost circular and has a diameter of about 3 km. It is located about 2 km south of the U.S.-Canada border in Renville County, North Dakota (Fig. 1), at 48° 58' N and 101° 58' W. The petroliferous subsurface structure is somewhat similar to the Ames (Oklahoma) or Red Wing Creek (North Dakota) impact structures. Newporte has been explored through oil drilling since 1977. A first test well (October 1977) yielded oil, which led to further drilling. In connection with the hydrocarbon exploration, some geological and geophysical work was performed (see Clement and Mayhew [1]). The seismic studies, in conjunction with data from the drill cores, showed that the structure has a bowl shape with a raised rim (Fig. 2). Clement and Mayhew [1] also noted that during the drilling highly fractured and brecciated granitic and gneissic Precambrian rocks were encountered. This early study did not reach any conclusions regarding the origin of the structure. Recently, a geological and geophysical study, and a petrographical investigation of drill core samples, was performed by Gerlach [2] (see also Gerlach et al. [3]). These authors suggested an impact origin for the Newporte structure based on the presence of shocked quartz and kinked biotite. This was confirmed in a petrographical and geochemical study by Koeberl and Reimold [4], who found abundant evidence for shock metamorphism.

Petrography of Newporte samples. Eighteen bulk rock samples from boreholes Duerre 43-5, Mott 14-34, and Wisdahl 23-10, located along the rim of the Newporte structure were studied by petrographic and chemical analysis. Polished thin sections were prepared from representative matrix areas as well as from distinctive clasts. Optical microscopic studies were carried out on 28 subsamples, of which about 45 sections were prepared. All breccia samples are fragmental breccias - no evidence of melting was found. The most important clast types recognized are granitoids (granitic to granodioritic, with a small dioritic component), a biotite-schist, sandstone, and a very fine-grained shale. It is possible that the shale component represents a subordinate component of the sandstone formation, as lensoid inclusions of shale or chert are frequently observed in sandstone samples, and intercalated bands of chert, sandstone, and shale occur in others. The sample collection contains three breccia types: (1) a variety that is only composed of granitoid-derived material; (2) a variety that is derived from metasedimentary precursor rocks, dominated by the sandstone component; and (3) a mixed breccia that consists predominantly of granitoid-derived clasts, but also contains an (estimated) up to 15 vol% metasedimentary component. Breccia types 2 and 3 are, in our sample collection, restricted to drill core Duerre 43-5, from 2880.4 to 2882.7 m (9450.2 - 9457.5 ft) depth. All breccia samples are characterized by highly angular clasts that generally are devoid of significant intragranular deformation (e.g., fracturing is limited). In a number of quartz clasts from all three breccia types, *bona fide* PDFs were recognized. The number of quartz grains with PDFs per thin section rarely exceeds 3, with exception of the metasedimentary and mixed breccia samples, where individual samples revealed up to 6 grains per section. Most shocked quartz grains have only one set of PDFs (Fig. 3), but a few grains with up to 5 differently oriented sets were recognized (Fig. 4). Two samples with a few grains of shocked K-feldspar were observed. Crystallographic orientations of the PDFs were measured using a universal stage, showing predominantly {10$\bar{1}$3} (ω) orientations, which is characteristic of shock metamorphism. Our results confirm that Newporte is an impact structure.

Acknowledgements: Supported by the Austrian FWF, Project P08794-GEO, to CK.

References: [1] Clement, J.H., and Mayhew, T.E. (1979) Oil and Gas Journal 77(26), 165-172. [2] Gerlach, T., M.Sc. thesis, 1994, Univ. North Dakota, Grand Forks. [3] Gerlach, T. R., Forsman, N.F., and Anderson, N.L. (1994) GSA Abstr. w. Progr. 26(7), A-425. [4] Koeberl, C., and Reimold, W.U. (1994) GSA Abstr. w. Progr. 26(7), A-425.

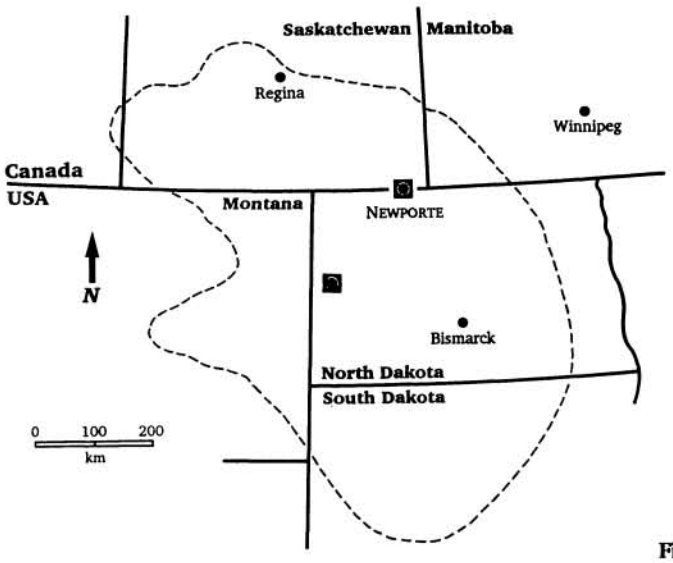

Fig. 1. Location of the Newporte structure. The second square symbol marks the Red Wing Creek structure. The dashed line indicates the extension of the Williston Basin.

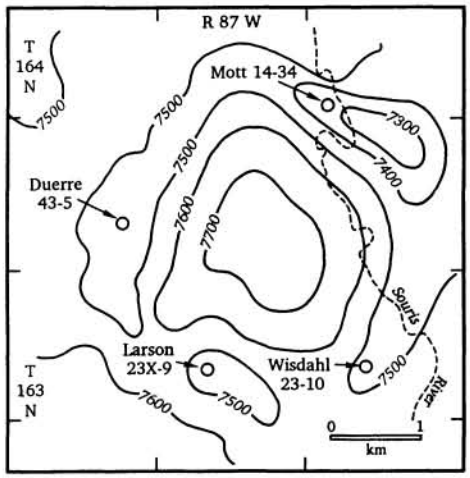

Fig. 2. Structural map marking the top of the Middle Ordovician Winnipeg Group, as obtained from geophysical studies (after [1]). The locations of the three cores, from which samples were studied, are indicated. Depth in ft.

Fig. 3. One set of fluid inclusion decorated PDFs in quartz; breccia, 2880.4 m depth (Duerre 43-5 core). Width: 235 μm.

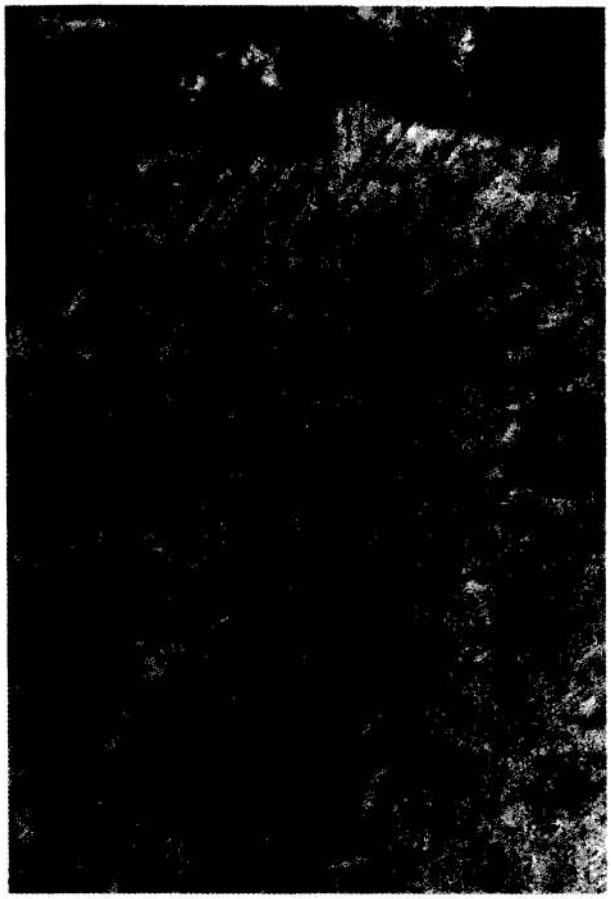

Fig. 4. Three sets of PDFs in quartz; in granite clast from breccia; 2880.4 m depth (Duerre 43-5 core). Width: 355 μm.