

are observed and they occur exclusively as xenoliths. None of the bronzite grains are in equilibrium with the granophyre melt.

Two major types of granophyre are observed: (1) fine-grained, clast-rich dikes, confined to the central core of the structure that are dominated by a spherulitic texture and textural heterogeneity occur over distances ranging from millimeters to tens of meters produced by four spherulitic subtypes and an ophitic subtype texture; and (2) medium- to fine-grained clast-rich granophyre core-collar dikes dominated by hypidiomorphic textures [11]. Grain size of the granophyre matrix minerals ranges up to 5 mm. The mineralogy of all dikes is similar with the exception of the higher modal abundance of biotite in the core dikes relative to the core-collar dikes. The spherulitic texture with skeletal crystal morphologies observed in the core dikes is indicative of extreme undercooling conditions [12], while increased textural homogeneity characterizing the core-collar granophyre dikes indicates more uniform and slower cooling histories.

Numerous monomineralic and lithic fragments, up to 80 cm long, compose up to 20% of the rock volume [11]. All the major country rocks are represented as inclusions in every dike examined. Granite, gneiss, and quartzite are the most abundant, mafic rock fragments and metasediments other than quartzite are less abundant, and shale inclusions are rare [10,11]. These abundant inclusions show intense recrystallization, reactions with the granophyre melt, and melting. Rare shock features are observed in quartz grains and are restricted to remnants of decorated planar elements occurring as one set parallel to the c axis of individual quartz grains.

Chemistry: Chemical homogeneity, on a regional scale, is a major characteristic of the granophyre dikes of the Vredefort structure. Homogenization was achieved early in the melt's history and was maintained as the melt intruded the fractured country rocks where it underwent cooling and crystallization under relatively undisturbed conditions.

Although no gross differences in major- and most trace-element compositions were detected that could be ascribed to regional position within the structure, minor chemical variations are present. The granophyre dikes of the central core have higher SiO_2 , TiO_2 , Al_2O_3 , and K_2O contents than the core-collar dike, while core-collar dikes have higher $\text{FeO} + \text{Fe}_2\text{O}_3$, MgO , CaO , and Na_2O contents. These differences are thought to be due to differences in the composition and amount of local materials assimilated. Although the granophyre melt is weakly differentiated, this is a minor factor in the evolution of the granophyre melt and differential assimilation is the major cause of the chemical variability observed.

Discussion: Metasediments and shale inclusions, from lithologies occurring within units stratigraphically higher than the present emplacement level of the granophyre dikes, are regionally distributed within all these dikes. This observation is hard to reconcile with the processes involved in the intrusion of a magma from the mantle or upper crust and indicates that the granophyre melt must have been efficiently and dynamically mixed before being injected into major fractures. Highly heterogeneous clast populations from widely different stratigraphic levels, a complex thermal history, and injection of melt/clast mixtures into dikes are in agreement with processes related to impact melt formation. The first report of rare shock features in xenolithic quartz grains supports the melt origin by impact. Two reasons explain why shock planar features, observed in the source rocks [13], are rarely seen in inclusions of the granophyre: (1) they have been annealed [13,14] and (2) shocked fragments are preferentially assimilated in the melt because they attained a higher temperature during the initial shock event [15,16].

Conclusions: The matrix textures, the variable thermal effects in the inclusions, and the chemical variations presented for the granophyre dikes of Vredefort are compatible with an impact melt [15,16]. Our observations and results indicate that the granophyre dikes best represent remnants of an impact melt that intruded fractures of the transient crater floor of Vredefort. We thus favor the Vredefort structure as a deeply eroded multiring impact basin.

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A COMPARISON OF THE CHEMISTRY OF PSEUDOTACHYLITE BRECCIAS IN THE ARCHEAN LEVACK GNEISSES OF THE SUDBURY STRUCTURE, ONTARIO.
Lucy M. Thompson and John G. Spray, Department of Geology, University of New Brunswick, Fredericton, New Brunswick, Canada.

NW 841857

The Archean Levack Gneisses of the North Range host millimeter-thick veins and centimeter-thick lenses of pseudotachylite, as well as substantially larger meter-wide, dykelike bodies of pseudotachylitic "breccia." The "breccia" occurs up to several tens of kilometers away from the Sudbury Igneous Complex and is commonly sited within or near joints and other natural weaknesses such as bedding, dyke contacts, and lithological boundaries.

The larger "breccia" dykes comprise a generally dark matrix containing rounded to subrounded and occasionally angular rock fragments derived predominantly from Levack Gneiss. The matrix may exhibit flow features and typically appears aphanitic, although in certain exposures it possesses a fine-grained crystalline texture. The "breccia" fragments can be as large as 2-3 m in their long dimension and are typically chaotically arranged within the matrix, showing evidence of both rotation and internal fracturing. More exotic rock fragments, such as amphibolite, also occur and these appear to have been transported for some distance (i.e., at least tens of meters). The origin of the so-called Sudbury Breccias is a subject of controversy, but is generally believed to be related to the 1.85-Ga Sudbury event. Field evidence indicates that they are fault-related and frictionally induced and are therefore not the direct products of shock melting.

Selected samples of bulk Sudbury Breccia and Sudbury Breccia matrices have been chemically analyzed and compared to existing data on the Levack Gneisses and Sudbury Breccia. The matrices are apparently enriched in Fe and, to a lesser extent, Mg, Ti, and Ca compared to the wallrocks and the majority of clasts. This enrichment can be partly explained by the preferential cataclasis and/or frictional melting of hydrous ferromagnesian wallrock minerals, but also appears to require contamination by more basic exotic

lithologies. This suggests that certain components of pseudotachylitic Sudbury Breccia have undergone significant transport (kilometers) during their formation.

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⁴⁰Ar-³⁹Ar AGES OF THE LARGE IMPACT STRUCTURES KARA AND MANICOUAGAN AND THEIR RELEVANCE TO THE CRETACEOUS-TERTIARY AND THE TRIASSIC-JURASSIC BOUNDARY. M. Triloff and E. K. Jessberger, Max-Planck-Institut für Kernphysik, P.O. Box 103980, W-6900 Heidelberg, Germany.

MN009162

Since the discovery of the Ir enrichment in Cretaceous-Tertiary boundary clays in 1980 by [1] the effects of a 10-km asteroid impacting on the Earth 65 Ma ago are discussed as the possible reason for the mass extinction— including the extinction of the dinosaurs—at the end of the Cretaceous. But up to now no crater of this age that is large enough (ca. 200 km in diameter) has been found. The Manson Crater in north America is 65 Ma old [2], but too small—only 35 km in diameter. A recently discovered candidate is the Chicxulub structure in Yucatan, Mexico, but intensive investigations have to be done to identify it as the K-T impact crater. Petrographic signs at the K-T boundary seem to point to an impact into the oceans as well as onto the continental crust; multiple impacts were considered [3].

Another candidate is the Kara Crater in northern Siberia. Kolesnikov et al. [4] determined a K-Ar isochron of 65.6 ± 0.5 Ma, indistinguishable from the age of the K-T boundary and interpreted

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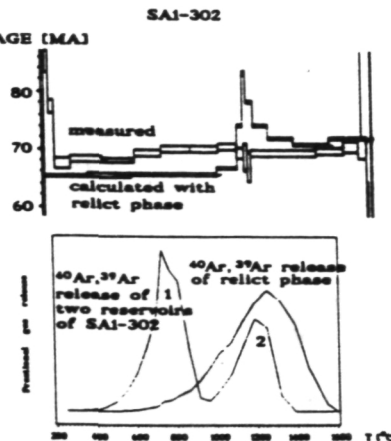


Fig. 2.

this as confirmation of earlier proposals that the Kara bolide would have been at least one of the K-T impactors. Koberl et al. [5] determined ⁴⁰Ar-³⁹Ar ages ranging from 70 to 82 Ma and suggested an association to the Campanian-Maastrichtian boundary, another important extinction horizon 73 Ma ago.

We dated four impact melts, KA2-306, KA2-305, SA1-302, and AN9-182. All spectra show well-defined plateaus. They are shown with a strong extended age scale (Figs. 1 and 2). Our ages range from 69.3 to 71.7 Ma, and it is clearly visible that our data suggest neither an association with the Cretaceous-Tertiary nor the Campanian-Maastrichtian boundary. Errors are given as 1σ errors computed of the deviation of the plateau fractions. The systematic error induced by the NL25 hornblende standard is 0.6 Ma. It may be argued that our ages—old in comparison to the K-T boundary—could be caused by relict target rocks incorporated in the melt. At the first sight this seems to be possible: If only 1% of the sample's potassium is located in a relict phase of paleozoic age of 500 Ma, this is enough to lift the sample's K-Ar age from 65 Ma to 70.5 Ma. We consider SA1-302 to test whether the age pattern would then still show a plateau or if the relict phase would be recognizable. The degassing pattern shows two distinct reservoirs. We calculated the diffusion parameters, activation energy Q and frequency factor D₀, by Arrhenius plots for each reservoir and simulated the gas release by two phases having different diffusion parameters. We assumed an age of 65 Ma for the two phases and added an arbitrarily chosen relict phase having

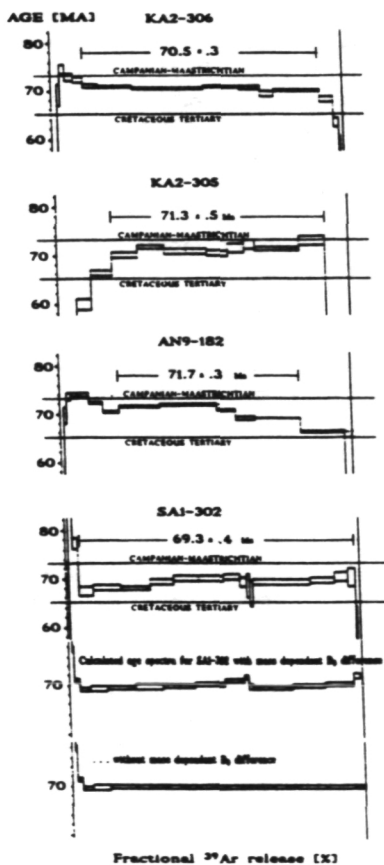


Fig. 1.

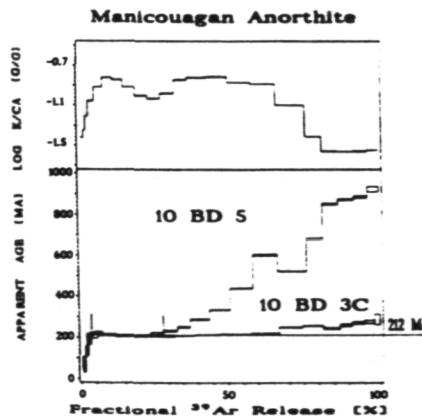


Fig. 3.