inferred to have produced shocked materials found in the upper layer of some K/T boundary deposits, mainly because its radiometric age (66 m.y.) is compatible. Short, in 1966 [1], was the first to show that Manson is an impact crater through analysis of 22 samples from a 1553 drillhole (2-A). These samples have now been studied in detail, with these key results: (1) The lithology of clasts within 2-A is dominantly granitic. (2) Most quartz is strongly shocked (many planar deformation features, PDFs) and shows a pervasive alteration (clay minerals; iron stain). (3) A unique texture (single crystals broken into hundreds of small fragments (polycrystalline)) occurs in some heavily shocked quartz. (4) Feldspars display a wide range of shock features from multiple PDFs to incipient melting (internal flow) and extensive recrystallization. Table 1 summarizes the major shock features arranged in stages of progressive shock metamorphism for the three principal minerals: quartz, feldspar, and biotite.

The predominant mode of PDF occurrence in quartz within leucocratic clasts, and in most quartz fragments in matrix material, is marked by light, orange-brown to grayish brown in plane transmitted light, and a deeper reddish brown, with reduced birefringence, cross-polarized light. At high magnification, the alteration consists of tiny specks of unknown identity that often obscure but do not destroy the sets of PDFs. The effect under the microscope sometimes resembles the "texture" of toasted bread. This hallmark of Manson shocked quartz is rarely seen in shocked quartz from other impact structures (occasional in materials examined by NMS from West Hawk Lake and Steen River in Canada). Sharpn et al. [2] describe similar quartz in their examination of Manson materials, stating the origin of this alteration to be due to in-crate postimpact hydrothermal alteration; if so, such a condition would not be diagnostic of shocked quartz grains in K/T deposits and is therefore not a criterion for relating these deposits to the Manson event. Single (larger) crystals of "toasted" quartz contain an average of 5.5 sets of PDFs whose principal crystallographic orientation is π1012 (01013 is second most common). Much less frequent in clasts and matrix grains are untoasted but decorated PDFs in quartz, with ε2 predominant in the average 2.2 sets per grain.

In some strongly shocked leucogranites, and in occasional matrix fragments, single crystals have been broken into numerous small (100 μm) interlocking quartz grains (toasted), containing an average of only 1.4 PDF sets, in which ε2 is prevalent. These sets do not cross individual microcrack boundaries and orientations vary between grains. This highly distinctive texture, which we interpret as shock-induced shattering of single crystals accompanied by rotations, may be unique to Manson. A similar texture has been described by Schrerr et al. [3] in Vredefort Central Core granites, but in those quartzes the PDFs pass across grain boundaries. In highly shocked Manson quartz, recrystallization may completely remove PDFs and the toasted effect is absent.

Manson feldspars show a range of PDFs, some resembling those in quartz, others arranged on echelon in alternating albite twins, others concentrated in deformation bands. Feldspars may partially isotropize or display internal flow banding in thomastocphic crystals or may be recrystallized. Biotite responds by interate kinking progressing through nearly complete decomposition. Undeformed glass is rare in 2-A.

In 1991–1992, the U.S. Geological Survey drilled 12 holes to depths under 380 m along a zone from crater center to assumed rim. Hole M-1 lies about 4 km northeast of 2-A within the central peak (probably a ring). Materials in the upper 100 m of are mainly shales and some carbonates that show indicative shock effects except for occasional melting. Crystalline clasts below the sedimentary materials have proportionately less leucogranites and more dioritic and amphibolitic clasts. The variety and characteristics of shock effects in these rocks are often notably different from those in crystalline 2-A clasts.


EVIDENCE FOR EXTREMELY-HIGH-TEMPERATURE MELTING IN THE SOLAR NEBULA FROM A CaAl₂O₄-BEARING SPHENE FROM MUNCHISON. S. B. Srinivasan, L. Grossman,1,2 A. M. Davis,2 J. R. Beckett,3 and L. Chamberlain2, 1Department of Geophysical Sciences, University of Chicago, Chicago, IL, 60637, USA, 2Enrico Fermi Institute, University of Chicago, Chicago IL, 60637, USA, 3Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena CA 91125, USA.

We have recovered a unique refractory spherule (86) from the Murchison C2 chondrite. Approximately 140 μm in diameter, it is concentrically zoned, with an outer rim sequence, from outermost to innermost, of aluminous diopside (10 μm thick), andesite (3 μm), and melilite (3 μm). Inside the melilite layer is a 7-μm-thick, nearly pure (except for a single, diverging-inward spray of hibonite crystals) layer of spinel. Inward from this layer is a 22-μm-wide zone of hibonite (~5.5 wt% TiO₂) plus spinel, in which hibonite laths, 1–4 μm across and up to 10 μm wide, are predominantly radially oriented and enclosed in spinel. Inward from this zone, presumably at the
CROSS-SECTION MEASUREMENTS FROM 40 TO 450 MeV FOR THE PRODUCTION OF 14C FROM SILICON AND OXYGEN: BETTER ESTIMATES FOR COSMOGENIC PRODUCTION RATES. J. M. Sierksa, A. J. T. Jullb, A. Bevendiag, A. M. Koehlerc, C. Casteneda, J. Vincent, D. J. Donalduc, P. A. J. Englerd, C. Gams, J. Young, and R. C. Reddy. 1Harvard Cyclotron Laboratory, Harvard University, Cambridge MA 02138, USA. 2NSF-Arizona AMS Facility, University of Arizona, Tucson AZ 85721, USA. 3Department of Chemistry, San Jose State University, San Jose CA 95221, USA. 4Carnegie Nuclear Laboratory, University of California, Davis CA 95616, USA. 5Department of Physics, California State University, Chico CA 95929, USA. 6TRIUMF, 4004 Westminster Mall, Vancouver BC V6T 2A3, Canada. 7Space Science and Technology Division, Los Alamos National Laboratory, Los Alamos NM 87545, USA.

Cosmogenic nuclides in extraterrestrial materials allow studies to be made of the solar cosmic ray (SCR) flux over time periods in the past [1], the constancy of the galactic cosmic ray flux, and even the sample’s recent history. To interpret such measurements, especially for SCR-produced nuclides, it is essential that the cross sections for the reactions of all cosmic ray particles with each constituent of the sample be very well known. Approximately 98% of SCR particles are protons and their interactions are the major source of cosmogenic nuclides in the surface layers of extraterrestrial materials. Utilizing the development of accelerator mass spectrometry (AMS), few of the needed cross sections were known well enough to be used with confidence. Now, using thin-target irradiations and the improved sensitivity of AMS, good cross-section measurements for the production of these cosmogenic isotopes can be made.

Preliminary cross-section measurements for 14O(p,3p)12C and 28Si(p,x)27Al are made at the Harvard Cyclotron Laboratory (HCL) using SiO2 and Si targets that have been reported for the proton energy range 65–100 MeV [2]. They confirm earlier data for the (p,3p)14O cross section and are the only measurements for the (p,x)27Al cross section. New measurements made at the cyclotron at the University of California at Davis for proton energies from 43 MeV to 67.5 MeV and at TRIUMF for proton energies from 200 to 450 MeV have extended the energy range over which these cross sections are well known, including the important region near the threshold of the excitation function. In all cases, targets of SiO2 and Si were irradiated in thin-target conditions that kept the energy loss in a single target to <2 MeV. The total energy lost in the entire target stack for the Davis irradiations was <8 MeV, for the TRIUMF irradiations ≤1 MeV, and at HCL ranged from <5 MeV at 160 MeV to <10 MeV at 65 MeV. Thus both the secondary neutron production within the target stack and loss of protons due to scattering were minimized. The proton fluence was determined using Faraday cups and the 28Si(p,x)27Al reaction measured in Al monitor foils. All the samples were analyzed for 14C at Arizona using well-known methods [3,4].

Details of these measurements and new values of the 14C production cross sections will be presented in the context of their importance to lunar sample and meteorite studies. These measurements represent the first data available for Si, SiO2, Al, Mg, and C targets that have already been irradiated at some proton energies. These targets will be analyzed for 14C, 10Be, 30Al, 9Be, 26Na, and the noble gases, while additional relevant target materials will be