EFFECTS OF METEOROID SHAPE ON COSMOGENIC NUCLIDE PRODUCTION

T. H. Prettyman[1] J. S. Hendricks,[2] and R. C. Reedy[1]. [1]Planetary Science Institute. E-mail: prettyman@psi.edu. [2]Techsource, Inc., Los Alamos New Mexico.

Meteoroids are steadily bombarded by cosmic rays as they travel through space. These high-energy ions undergo nuclear reactions within the meteoroid to produce stable and radioactive nuclides (e.g. ^{3}He, ^{21}Ne, ^{22}Ne, ^{10}Be, ^{14}C, ^{26}Al, ^{36}Cl, ^{41}Ca, ^{60}Fe). Cosmogenic nuclides provide constraints on the exposure history of meteoritic materials. If the pre-atmospheric size of the meteoroid is known, then cosmogenic nuclides also provide constraints on the meteoroid's macroporosity. For example, the porosity of 2008 TC3, whose pre-atmospheric shape was determined from photometric data (2.4- × 3.6- × 6.6-m axes) [1], was estimated from measurements of the concentrations and production rates of ^{10}Be, ^{26}Al, and ^{36}Cl in fragments of the Almahata Sitta meteorite [2].

Analytic uncertainties include the geometry and density of the meteoroid (shielding) and the complexity of the exposure history. Radiation transport codes are used to determine the systematic variation of cosmogenic radionuclide production as a function of meteoroid size and composition (e.g. [3]). These codes model the shower of hadrons produced by cosmic ray interactions with the meteoroid. Cosmogenic nuclide production is dominated by neutrons and protons. Consequently, a radiation transport code is often used to determine the flux of neutrons and protons within the meteoroid, and production rates are separately calculated from tabulated cross sections (e.g. [4]).

Until recently, production calculations have only considered spherical geometry; whereas, meteoroids are usually irregularly shaped [e.g. 5]. Shape can affect shielding, depending on the size (mass) of the meteoroid. For example, we studied shape systematics of cosmogenic radionuclide production in Knyahinya (~1 m diameter) [6]. The meteoroid was modeled as a tri-axial ellipsoid. We found that the depth profile for ^{26}Al was sensitive to the oblateness of the meteoroid, due to neutron leakage effects.

The purpose of this study is to determine the effects of shape on nuclide production, supplementing existing data tables for spherical meteoroids (e.g. [3]). Parameters include the ellipsoid semi-major axes, bulk density, and composition. Information on the diversity of small-body shapes is provided by an ever growing database of shape models determined from photometric and radar observations of asteroids (e.g. [7,8]). To utilize this resource, we implemented a polygonal shape model for irregular surfaces in the general purpose radiation transport code MCNPX. This capability allows us to explicitly model complex shapes of meteoroids, such as 2008 TC3 [1]. Results of our study, including an assessment of shape effects for 2008 TC3, are presented.

References: [1] Scheirich P. et al. 2010. *Meteoritics & Planetary Science* 45(10-11), pp. 1804-1811. [2] Welten K. C. et al. 2010. *Meteoritics & Planetary Science* 45(10–11), pp. 1728–1742. [3] Leya I. and J. Masarik 2009. *Meteoritics & Planetary Science* 44(7), pp. 1061–1086. [4] Masarik J. and R. C. Reedy (1994). *Geochim. Cosmochim. Acta.* 58, pp. 5307-5317 [5] Muinonen K. and J. S. V. Lagerros 1998. *Astron. Astrophys*. 333, pp. 753-761 [6] Prettyman, T. H. and R. C. Reedy (2012) *Asteroids, Comets, Meteors* Abstract #6459. [7] Durech J. et al. (2010). *Astronomy & Astrophysics* 513, A46. [8] NASA Planetary Data System Small Bodies Node.