Reconstructing the chronology of Supernova events: Determining major variations in the history of the cosmic-ray flux incident on the Earth's surface by measuring the concentration of ^{22}Ne in halite

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The goal of this project is to measure the inventory of stable ^{22}Ne atoms preserved in the mineral lattice of halite in deposits of rock salt of sequential geologic ages, and to use that inventory to measure variations in the cosmic-ray flux to reconstruct the history of supernova events in our part of the Milky Way Galaxy.

A supernova is a stellar-explosion event that emits a burst of radiation that may briefly exceed the output from an entire galaxy. The explosion drives a shock wave, carrying much of the mass of the original star, through the adjacent stellar medium. That radiation includes many protons, some of which decay into highly energetic muons that can penetrate the atmosphere of Earth to reach the solid surface. A muon incident on an atom of ^{23}Na may convert that atom to ^{22}Ne by either of the following reactions:

1. $\mu + {}^{23}Na \rightarrow {}^{22}Ne + P + \mu$ or $\mu + {}^{23}Na \rightarrow {}^{22}Na + N + \mu$ (μ = muon)
   followed by beta decay: ${}^{22}Na \rightarrow {}^{22}Ne + \beta$.
2. $\mu^- + {}^{23}Na \rightarrow {}^{22}Ne + N + \nu_\mu$. ($\nu$ = neutrino)

Bedded rock salt consists almost entirely of the mineral halite (NaCl). Any neon trapped in the halite crystals during formation will be primarily ^{20}Ne, with a ^{22}Ne concentration of 9% or less. Any neon resulting from cosmic-ray interactions with ^{23}Na will be solely ^{22}Ne; therefore, ^{22}Ne atoms in excess of 9% of the total neon will be of cosmogenic origin. Measurement of the ^{22}Ne inventory in halite of a range of geologic ages may enable us to document the systematic growth of ^{22}Ne through geologic time and, thus, establish a chronology of supernovae events in the region of the Milky Way Galaxy nearest to Earth.

The muon flux from a supernova event will be attenuated in direct proportion to the mass of material that overlies a target halite deposit. To adjust the ^{22}Ne inventory to account for that attenuation, we must reconstruct the post-depositional history of accumulation and removal of superjacent sediment for each halite deposit we study. We will do that systematically for each sample by referring to published descriptions of the rock columns younger than the age of the halite, and by various thermochronologic methods - fission-track analysis, (U-Th)/He, vitrinite reflectance, fluid inclusions, and $^{40}Ar/^{39}Ar$ - to approximate the mass of superjacent material that accumulated over each halite deposit, and the duration of that cover.

We have begun to acquire halite samples from deposits of bedded salt from a number of locations: the Michigan Basin (Silurian-Devonian), the Williston Basin (Carboniferous – Jurassic), and the Permian Basin in the USA; the Amadeus Basin (Precambrian – Cambrian) in Australia; and the Salt Ranges (Precambrian) in Pakistan. By reference to detailed stratigraphic columns, both published in the primary literature and maintained in the offices of salt-mining companies, and from interpretation of the results of various thermochronologic analyses, we will reconstruct the post-deposition shielding history for each of those halite samples.