

Search for an ^{60}Fe supernova-produced isotopic signal in marine sediments

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The recent observation of an ^{60}Fe peak in a deep-sea FeMn crust has been interpreted as due to the signature left by the ejecta of a supernova (SN) relatively close to the solar system 2.8 ± 0.4 Myr ago [1]. To confirm this interpretation with better time resolution and more direct flux estimate, we have performed Accelerator Mass Spectrometry (AMS) ^{60}Fe measurements along a dated marine sediment core.

FeMn crusts are authigenic objects. Marine sediments are composed of a larger variety of geochemical phases. Since the iron in the aluminosilicate phase is not equilibrated with the soluble ^{60}Fe in the ocean, its inclusion would lower the $^{60}\text{Fe}/\text{Fe}$ ratio compared to the authigenic fraction. Therefore, we used a chemical procedure to isolate this fraction [2]. The AMS measurements were carried out at the facility of Garching. In order to verify that our chemistry was dissolving the phase containing the ^{60}Fe seen in the crust, we tested it on samples from the same crust. We also observed an $^{60}\text{Fe}/\text{Fe}$ peak, consistent with that found by [1].

The ^{60}Fe signal in the FeMn crust was observed over a depth interval corresponding to 800,000 years [1]. However, we initially assumed that this was due to the inherent time resolution associated with the growth and sampling of the FeMn crust. Assuming a short deposition time e.g. 10,000 years [3], and considering the characteristics of the marine sediment core, we can calculate a $^{60}\text{Fe}/\text{Fe}$ ratio in the authigenic phase of the sediment of 5×10^{-14} .

We performed $^{60}\text{Fe}/\text{Fe}$ measurements along the sediment core from 1.7 to 3.2 Myr. The extension of the original time interval (2.4-3.2 Myr [1]) is from taking into account (i) that ^{10}Be dating has been repeated in the crust, (ii) $t_{1/2}(^{10}\text{Be})$ uncertainty.

We found no evidence for an $^{60}\text{Fe}/\text{Fe}$ peak in the sediment in the time interval 1.7-3.2 Myr, with upper limits at least an order of magnitude lower than the value expected under the above assumptions. We will discuss possible reasons for this result, including the possibility that the deposition time was indeed $\gg 10$ kyr.

References

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The groundwater beneath Hekla volcano, Iceland; A natural analogue for CO_2 sequestration

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The increased concentration of CO_2 in the atmosphere has made it necessary to develop methods to store CO_2 . One of the possibilities for CO_2 storage is by reacting it with basalt and thereby precipitating the CO_2 as calcite (CaCO_3). A pilot project is being performed in Iceland by Reykjavik Energy, University of Iceland, Columbia University and University of Toulouse.

The Hekla volcano is one of Europe's most active volcanoes (e.g. Flaathen and Gislason, 2007) and its magma chamber degasses even under quiet periods where the main emitted gases are CO_2 , HF and SO_2 . These are some of the same gases emitted from geothermal power plants and aluminum smelters in Iceland. This makes Hekla volcano a very good natural analogue to CO_2 sequestration in basalt.

The lava fields surrounding the volcano host a large ground water body. Water samples from its springs have been collected periodically for 20 years. Analysis and modelling of this water can tell us what may happen when CO_2 is being injected into basalt.

The gases emitted from the magma chamber make the ground water acidic. The acidity enhances the dissolution rate of the basalt releasing elements like Ca into the ground water. These reactions consume protons and the increase in concentration of elements in the ground water together with increase in pH leads to the precipitation of secondary minerals like calcite.

Modelling performed by the PHREEQC 2.11 computer code (Parkhurst and Appelo, 1999) shows that calcite goes from being undersaturated to almost saturated with increase in pH.

At the early state of dissolution of the basalt, at low pH, the concentration of toxic metals like Cr and Pb in the ground water might be high. The pH of the groundwaters in the vicinity of Mt. Hekla range from about 7 to 9. The concentration of toxic metals is very low in these waters (nmole/kg) which is also the case for Fe. Modelling shows that Fe-hydroxides are supersaturated in the groundwaters and the precipitation of this phase might scavenge the toxic metals.

References

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