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Geomagnetic Reversals, Polar Ice and Cosmic Spherules: Some Recent Measurements with a Small Dedicated Accelerator Mass-Spectrometry Facility [Abstract Only and Discussion]

G. M. Raisbeck, F. Yiou, G. Turner, W. Kutschera, W. Henning, D. S. Donahue and L. Brown

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Geomagnetic reversals, polar ice and cosmic spherules: some recent measurements with a small dedicated accelerator mass-spectrometry facility

[Abstract only]

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We have developed techniques for measuring the cosmogenic isotopes ^{10}Be (half-life 1.5 Ma) and ^{26}Al (716 ka) by using a small (*ca.* 2.2 MV) dedicated accelerator mass spectrometer facility. Three recent applications of such measurements are as follows.

1. ^{10}Be has been measured in marine-sediment cores at levels corresponding to three recent geomagnetic reversals. We observe an increase in ^{10}Be production at each of these times. The results give information on the form and length of the geomagnetic intensity changes during a reversal, and the level at which magnetic remanence is acquired in the sediments.

2. ^{10}Be has been measured over a 2083 m ice core, corresponding to the last climatic cycle, recovered from Vostok, Antarctica. The results suggest that the precipitation rate during the last Ice Age was about half of its present rate. There are also some indications of fairly rapid ^{10}Be production changes.

3. ^{10}Be and ^{26}Al have been measured in 'cosmic spherules' (small round objects, *ca.* 500 μm diameter) recovered in deep-sea sediments and in melt lakes on Greenland ice. The results confirm an extraterrestrial origin for such objects, as well as indicating that the parent bodies of most of them were irradiated in space as small (less than 1 cm) objects. These spherules thus very probably represent cometary debris.

Discussion

G. Turner (*University of Sheffield, Sheffield, U.K.*). Could Dr Raisbeck say something about the extent to which the activities are saturated? What is the age of those spherules?

G. M. Raisbeck. I did not mention that only the ^{10}Be production is sufficiently constant with depth that one can estimate reasonably the saturation activity. Therefore, the ^{10}Be activity that one finds can be used to estimate the length of irradiation time. What we have found is different from normal meteoritic material, which is why we think that they are not meteorites. Of course most meteorites are totally saturated in ^{10}Be and ^{26}Al. We find that lifetimes for these particles are from 10^5 to about 10^6 years generally; this is considerably less than saturated meteorites. These exposure times have large uncertainties because no one has yet determined the saturation activity in the small bodies. We know the saturation activity in meteorites but not in small bodies.

W. Kutschera (*Argonne National Laboratory, Illinois, U.S.A.*). I do not understand how these spherules would survive if they are primary objects entering the atmosphere.

G. M. Raisbeck. A lot of people were surprised at that too. Text books say that particles of 1 mm do not survive on entering the atmosphere, but this clearly depends on how they enter it. If they enter the atmosphere at a sufficiently low angle their survival probability is increased.

W. Henning. Can Dr Raisbeck say what is the chemical composition of the spherule? What is the absolute concentration of other radioisotopes?

G. M. Raisbeck. There are two types of spherules. Most of these objects are chrondritic in composition. There were also iron spherules that are shiny and represent less than 1 % of the Greenland sample.

W. Kutschera. What is the absolute concentration in atoms per milligram?

G. M. Raisbeck. The absolute concentration is 3×10^9–3×10^{10} atoms of ^{10}Be per gram. Samples typically contain *ca.* 10^6 atoms of ^{10}Be, so we are pushing the AMS technique in most of these cases.

D. S. Donahue (*University of Arizona, Arizona, U.S.A.*). Are these spherules from the surface of the sediment or are they from down below?

G. M. Raisbeck. They are from the surface. About one is obtained out of every kilogram of sediment, so one cannot do the depth dependence unless one has a big core and a lot of patience. The ones we have studied have been removed with a magnet.

D. S. Donahue. Does the fact that they are on the surface mean that they got there fairly recently?

G. M. Raisbeck. Well, the surface means 10–20 cm of sediment; this could represent a few tens of thousands of years. In other words, they could have been there for several thousands of years. Another advantage of the Greenland spherules is that there is some hope that by looking at ice with known ages, which one can obtain by flow models, one could have perhaps information on flux as a function of time also.

L. Brown. Has Dr Raisbeck interpreted the shift between the magnetic data and the ^{10}Be data as a residence time in the ocean?

G. M. Raisbeck. No, although some people would. There have been suggestions for residence times of 3000–4000 years in the ocean, giving a part of this shift but not the whole shift. We think the residence time is closer to 500 years. One way of checking this would be doing several sites that have different sedimentation rates, and of course if it were a residence-time effect then one would see differences, whereas if it really is an offset due to palaeomagnetism then it should be roughly the same. It may also depend on the type of material in the sample.