^{26}Al AND ^{10}Be IN DEEP SEA STONY SPHERULES ; EVIDENCE FOR SMALL PARENT BODIES. G.M. Raisbeck, F. Yiou, Laboratoire René Bernas, 91406 Orsay France, J. Klein, R. Middleton, Physics Dept., U. of Pennsylvania, Philadelphia, Pa. 19104. Y. Yamakoshi, Institute for Cosmic Ray Research, Tokyo 188, Japan. D.E. Brownlee, Dept. of Astronomy, U. Of Washington, Seattle, Wash. 98195.

"Cosmic spherules" collected in deep sea sediments are of interest because they may represent forms of solar system matter not readily available by any other means (1). In addition they can possibly give a record of the input of this matter onto the earth in the past. Until very recently the identification of these spherules as extraterrestrial has been on the basis of chemical composition and petrology. An independent and more definitive characterization would be the presence of cosmic ray produced nuclides in the spherules. In addition to identification, these cosmogenic nuclides also carry potential information on the irradiation age and size of the body in which they were formed. Pioneering work in this area has been done by Nishiizumi and his colleagues who have applied a very sensitive nuclear transformation technique for the measurement of ^{53}Mn ($t_{1/2}$ = 3.7 My) (2,3,4). Nishiizumi (3,4) has used his ^{53}Mn results to argue that cosmic stony spherules are ablation products of large (1-100 Kg) chondritic meteorites. The technique of accelerator mass spectrometry permits the detection of very small quantities of several other long lived cosmogenic nuclides, in particular ^{10}Be (1.5 My) and ^{26}Al (0.72 My). The advantage of this pair is that ^{10}Be is made primarily from high energy galactic cosmic rays, while ^{26}Al can also be abundantly produced in Si (but only over a few cm of matter) by low energy solar cosmic rays. Thus the ratio of the concentrations of these two isotopes can give information on the size of the parent bodies of cosmic spherules. We have previously given a preliminary result for the concentration of ^{10}Be and ^{26}Al in Fe type spherules (5). We present here our first results on "stone" type spherules. The spherules were collected either directly from the ocean floor by the "cosmic muck rake"(B-1 - Brownlee) or by magnetic and hand sorting from dredged sediments (Y-2,Y-5 - Yamakoshi). The spherules were chemically processed at Orsay, and ^{10}Be and ^{26}Al were measured on the U. of Pennsylvania tandem accelerator, using techniques outlined elsewhere (6,7). Studies on other specimens from the same sample collections indicate that the spherules have compositions similar to carbonaceous or ordinary chondrites. (There is, however, some evidence (Yamakoshi, unpublished work) that spheres from the region of sample Y-2 may have Al concentrations as large as 3-5%. Verification of this is important, since Al is an important progenitor of ^{26}Al).

A summary of our preliminary results is given in Table 1. The uncertainties on the ^{26}Al and ^{10}Be measurements are estimated to be ~ 15%. Since a significant fraction of the Al in these spherules resides in a glass phase, and it is known that this glass phase is etched away by seawater, the ^{26}Al concentrations should be taken as lower limits. To check this we measured Al in samples B-1 and Y-5. The values found, 1.12% and 0.58% respectively, indicate that in these cases little - certainly less than half - of the Al has been lost. A similar question also exists for ^{10}Be, although we presently have no information on what fraction of the Be may be lost. We have also included in Table I observed saturation values of ^{26}Al and ^{10}Be in carbonaceous and ordinary chondrites.

The main points to note in Table I are -1- the concentrations of both nuclides are variable ; -2- in two of the three samples, both the absolute concentration of ^{26}Al and, more dramatically, the ^{26}Al/^{10}Be ratio, are larger than in saturated chondritic meteorites. Possible explanations that come to mind for the first point are (i) the variations come from even larger variations in individual spherules ; (ii) variable losses of ^{26}Al and ^{10}Be due to etching ; (iii) differences in the parent bodies giving rise to the spherules at different locations. This last explanation would be quite surprising since one might imagine that the spherules from each location in the ocean would average over many thousands of individual incoming bodies. The only plausible way we can see to explain the second point is by a significant production of ^{26}Al by low energy solar flare particles. (Although preferential removal of ^{10}Be by etching compared to ^{26}Al could increase the ^{26}Al/^{10}Be ratio, it is hard to see how it could increase the ^{26}Al above the saturation value). Solar flare production could arise either on the surface of a large parent body, or if the parent body itself was of the order of a few centimeters in size. While we cannot yet totally exclude the former, both the low ^{10}Be, and the low ^{53}Mn concentrations observed by Nishiizumi (3,4) would seem to argue against surface production. We thus suggest that the most probable explanation for our results is that the spherules in samples Y-2 and B-1 are ablation products from parent bodies of the order of a centimeter in diameter. (If the spherules were actually irradiated in space as such, as proposed by Parkin et al. (8), the expected saturation activity of ^{26}Al would be $\sim 10^3$ dpm/kg. Our results appear to exclude such a possibility). In the above scenario, the reason for the low ^{53}Mn activities observed by Nishiizumi in similar spherules might be that the parent bodies have not been irradiated to saturation. For example, a 0.7 million year irradiation time, which would bring ^{26}Al to $\sim$ 50% of its saturation activity, would bring ^{10}Be and ^{53}Mn to only $\sim$ 28% and 12% of theirs, respectively.

It is clear that these conclusions must remain very tentative until further experiments are carried out. In particular, it is now desirable to carry out measurements of ^{26}Al and ^{10}Be (and ^{53}Mn if possible) on the same <u>individual</u> spherules which have previously been characterized chemically and petrologically as well as for glass loss. Measurements for ^{26}Al and ^{10}Be on individual particles as small as 100 μg are now within the capabilities of the accelerator mass spectrometry technique.

Table 1

Sample	N$_o$ of spherules (diameters)	Location (depth)	total wgt (mg)	^{26}Al 10^9 atoms/g (dpm/kg)	^{10}Be 10^9 atoms/g (dpm/kg)	^{26}Al/^{10}Be atom/atom
Y-2	?	11°S, 146°W (4912 m)	1.40	69.4 (128)	10.4 (9.1)	6.67
Y-5	14 (315-450μ)	"near Hawaii"* (4500 m)	0.98	36.3 (67)	29.2 (25.7)	1.24
B-1	11 (430-550μ)	1000km east of Hawaii (5000 m)	1.78	46.0 (85)	5.60 (4.93)	8.21
Saturated chondritic meteorites (9,10)				(40-65)	(~20)	1-1.5

* These spherules were recovered during a commercial mining survey and the exact location is not available to us.

<u>References</u> : (1) Brownlee, D.E. (1981) In The Sea, Vol 7, J. Wiley γ Sons, 733-762. (2) Nishiizumi, K. and Brownlee, D.E. (1979) Proc. 16th Int. Cosmic Ray Conf., 2, 288-291. (3) Nishiizumi, K. and Arnold, J.R. (1982) Lunar and Planet. Sci. XIII 594-595. (4) Nishiizumi, K. (1982) (preprint). (5) Raisbeck, G.M. et al. (1982) 45th Meteoritical Society Meeting (abstract). (6) Klein, J. et al. (1982) Nucl. Inst. Meth. 193, 601-616. (7) Raisbeck, G.M. et al. (1983) Nature, (in press). (8) Parkin, D.W. et al. (1977) Nature 266, 515-517. (9) Heymann, D. and Anders, E. (1967) Geochim. Cosmochim. Acta. 31, 1793-1809. (10) Moniot, R.K. et al. (1982) Lunar and Planet. Sci. XIII 536-537.