^{36}Cl - A POTENTIAL DATING TOOL

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The need for an isotopic tool capable of extending our ability to date fossil organic materials beyond the 50,000-yr range of ^{14}C has been recognized for some time. Chlorine-36, a cosmogenic nuclide with a half-life of 300,000 yr, appears to be eminently suited to this role. It exchanges readily with stable chloride, which is present in ppm quantities in most living materials, and can be measured accurately at extremely low levels by accelerator mass spectrometry.

Dating is most commonly performed on fossil remains of organic material, some of the more common being wood, pollen, seeds, peats, and small organic lenses located in strata composed of mainly inorganic detritus. Largely inorganic materials such as bones and teeth are also sometimes suitable for dating. In order to demonstrate the applicability of ^{36}Cl to paleodating, it is necessary to prove both the maintenance of a unique signal for this isotope in any given growing season, and the retention of that signal during burial and diagenesis.

Using AMS techniques to measure ^{36}Cl/Cl, we have shown that good agreement exists between this ratio in plant leaves and seeds and that in the soil pore water utilized by the plant, suggestive of long-term equilibrium between seed and precipitation values. We subsequently identified the large pulse of ^{36}Cl injected into the stratosphere during atmospheric weapons testing, recorded in conifer seeds grown in the 1950s, and hence providing verification of the uniqueness of the annual input signal.

In order to prove that this signal is retained over long time frames, we have made some preliminary measurements of ^{36}Cl and stable chloride in peats and organic-rich sediments. The non water-leachable chloride component of a "modern" peat (^{14}C "age"? 6000 yr BP) has a ^{36}Cl/Cl component similar to those we have measured in pre-1950 seeds and other vegetative materials grown early in this century. ^{36}Cl/Cl measurements in older organic-rich sediments previously dated by optical dating methods, and some measurements in mastodon teeth, are in progress.

A NEW INTERPRETATION OF THE DISTRIBUTION OF BOMB-PRODUCED CHLORINE-36 IN THE ENVIRONMENT, WITH SPECIAL REFERENCE TO THE LAURENTIAN GREAT LAKES

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In the early days of AMS, ^{36}Cl was thought to be an ideal hydrological tracer. For old waters, except in rare cases, *e.g.*, the Great Artesian Basin in Australia (Bentley *et al.* 1986), this hope proved vain. The difficulties were proved to be the result of ^{36}Cl production by other than cosmological means—in particular, production in surface rocks by cosmic ray neutrons, and production by fission neutrons in the aquifer. Nevertheless, it was still believed that chlorine in the hydrological environment existed primarily in the ionic form, Cl^-, and was "conservative", that is, it moved with the water at the same rate, and hence for waters younger than *ca.* 50 yr, the bomb-produced pulse of ^{36}Cl would still be useful as a tracer. However, vastly improved information on Cl behavior in vegetation, litter and surface soils (Milton *et al.* 1995) brings the "conservative" assumption into question. Strong

support for this new interpretation comes from the previous knowledge that Cl in the atmosphere is found largely in organic compounds (Rahn *et al.* 1976).

It is now clear that Cl is recycled by vegetation, and furthermore is held up for considerable periods in the ground waters of at least some of the seasonal wetlands that cover a large fraction of the Canadian Shield, and in particular, the drainage basin of Lake Superior. This new knowledge is used to improve our understanding of the concentrations, previously considered anomalous, of ^{36}Cl in the Great Lakes (Milton *et al.* 1994), and may be able to throw some light on the very large variation in the measured amounts of bomb-produced ^{36}Cl at different geographic locations. It is also pertinent to the movement of the many chlorine-containing pollutants in the biosphere.

References

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COSMOGENIC RADIONUCLIDE CONTENTS OF ANTARCTIC METEORITES FROM ALLAN HILLS HAVING HIGH NATURAL THERMOLUMINESCENCE

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We analyzed a group of 15 H_4-H_6 chondrites recovered from the Main Allan Hills blue ice field of Antarctica. Previous studies indicate these chondrites exhibit high TL level (>100 krad) unusual by most meteorite standards (Benoit and Sears 1993). ^{14}C analysis of two meteorites reveal terrestrial ages ≤2300 yr (Benoit and Sears 1993). At Purdue's PRIME lab facility, we determined ^{10}Be, ^{26}Al, and ^{36}Cl activities that range from 15.4 ± 0.40 to 18.4 ± 0.35 dpm kg^{-1} meteorite, 38.1 ± 1.18 to 58.0 ± 2.14 dpm kg^{-1} meteorite and 18.4 ± 0.61 to 23.9 ± 0.60 dpm kg^{-1} metal, respectively. An unusual three-isotope plot of $^{10}Be/^{26}Al$ *vs.* $^{36}Cl/^{26}Al$ illustrates a highly significant positive linear correlation with a 0.906 coefficient, corresponding to a p-value $<<0.001$. These results demonstrate a relationship between natural TL and cosmogenic isotope abundance for at least one suite of samples. These two parameters may be simultaneously used to determine the irradiation and orbital history these meteorites have experienced (Benoit and Sears 1991).

The high TL correlation differs markedly from that involving Antarctic meteorites previously analyzed at Purdue (Michlovich 1994). Sampling plays an important role when comparing these two populations. While the earlier sampling involved 43 H-chondrites for which volatile trace elements had been determined by RNAA, our sample selection was based strictly on TL levels. Previously analyzed H-chondrites were randomly selected to minimize both pairing and weathering for RNAA purposes. On a three-isotope plot, prior data yield a correlation coefficient of 0.388, only a weak correlation. These results require a correction due to long terrestrial ages, increasing the correlation coefficient to 0.544, still significantly lower than that of the high TL suite.