The Enigma of the Ubiquity of ^{14}C in Organic Samples Older Than 100 ka

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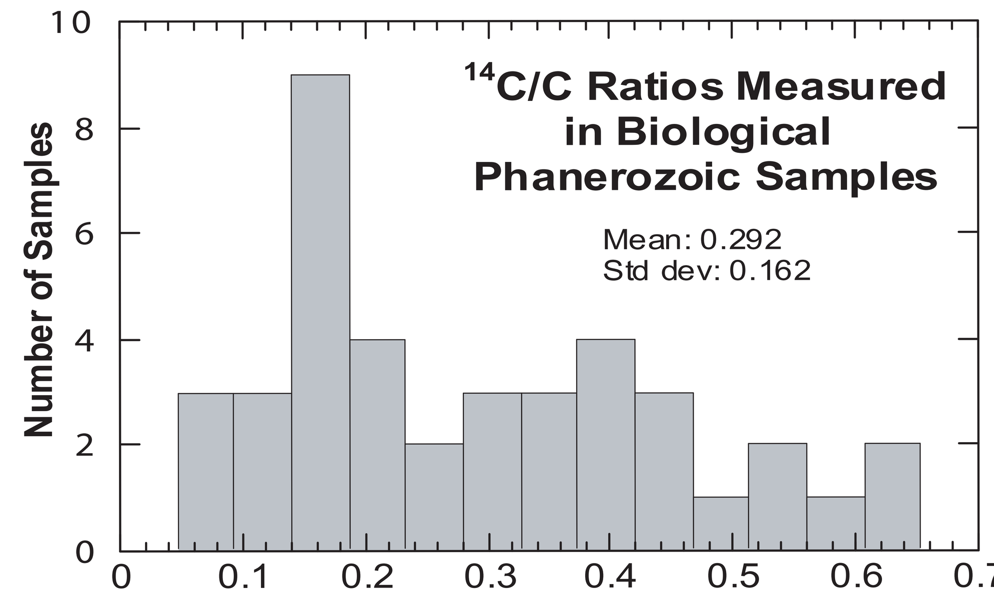
ABSTRACT

Given the 5730 year ^{14}C half-life, organic materials older than 200,000 years (35 half-lives), should contain absolutely no detectable ^{14}C. (One gram of modern carbon contains about 6 x 10^{10} ^{14}C atoms, and 35 half-lives of decay reduces that number by a factor of 3 x 10^{-11}.) An astonishing discovery made over the past twenty years is that, almost without exception, when tested by highly sensitive accelerator mass spectrometer (AMS) methods, organic samples from every portion of the Phanerozoic record display ^{14}C/C ratios far above the AMS detection threshold of 0.001 percent modern carbon (pmc). ^{14}C/C ratios from all but the youngest Phanerozoic samples appear to be clustered in the range 0.1-0.5 pmc, corresponding to ^{14}C ages of 44,000-57,000 years, regardless of geological 'age.' An inference that can be drawn from these observations is that all but the very youngest Phanerozoic organic material was fossilized less than 70,000 years ago. When one accounts for the significant amount of biomass involved, the AMS measurements are consistent with the time scale from historical accounts of a global cataclysm that destroyed most of the air-breathing life on the planet only a few millennia into the past.

Table 1. AMS measurements on samples conventionally deemed ^{14}C 'dead'. These measurements were performed in various laboratories around the world and reported mostly in the journals *Radiocarbon* and *Nuclear Instruments and Methods in Physics Research B*.

	^{14}C/C (pmc) (±1 S.D.)	Material	Reference
1	0.71±?	Marble	Aerts-Bijma et al. [1997]
2	0.65±0.04	Shell	Beukens [1990]
3	0.61±0.12	Foraminifera	Arnold et al. [1987]
4	0.60±0.04	Commercial graphite	Schmidt et al. [1987]
5	0.58±0.09	Foraminifera (Pyrgo)	Nadeau et al. [2001]
6	0.54±0.04	Calcite	Beukens [1990]
7	0.52±0.20	Shell (Spisula)	Nadeau et al. [2001]
8	0.52±0.04	Whale bone	Jull et al. [1986]
9	0.51±0.08	Marble	Gulliksen & Thomsen [1992]
10	0.50±0.10	Wood	Gillespie & Hedges [1984]
11	0.46±0.03	Wood	Beukens [1990]
12	0.46±0.03	Wood	Vogel et al. [1987]
13	0.44±0.13	Anthracite	Vogel et al. [1987]
14	0.42±0.03	Anthracite	Grootes et al. [1986]
15	0.40±0.08	Foraminifera	Schleicher et al. [1998]
16	0.40±0.07	Shell (Turitella)	Nadeau et al. [2001]
17	0.38±0.05	Wood (charred)	Snelling [1997]
18	0.36±0.03	Anthracite	Beukens et al. [1992]
19	0.35±0.03	Shell (Varicorbula)	Nadeau et al. [2001]
20	0.34±0.04	Wood	Beukens et al. [1992]
21	0.34±0.11	Recycled graphite	Arnold et al. [1987]
22	0.32±0.06	Foraminifera	Gulliksen & Thomsen [1992]
23	0.30±?	Coke	Terrasi et al. [1990]
24	0.30±?	Coal	Schleicher et al. [1998]
25	0.26±0.02	Marble	Schmidt et al. [1987]
26	0.23±0.06	Carbon powder	McNichol et al. [1995]
27	0.23±0.04	Foraminifera (mixed)	Nadeau et al. [2001]
28	0.21±0.02	Fossil wood	Beukens [1990]
29	0.21±0.02	Marble	Schmidt et al. [1987]
30	0.21±0.06	CO2	Grootes et al. [1986]
31	0.20-0.35 (range)	Anthracite	Aerts-Bijma et al. [1997]
32	0.20±0.04	Shell (Ostrea)	Nadeau et al. [2001]
33	0.20±0.04	Shell (Pecten)	Nadeau et al. [2001]
34	0.20±0.10*	Calcite	Donahue et al. [1997]
35	0.20±0.06	Carbon powder	McNichol et al. [1995]
36	0.18±0.05 (range?)	Marble	Van der Borg et al. [1997]
37	0.18±0.03	Whale bone	Gulliksen & Thomsen [1992]
38	0.18±0.03	Calcite	Gulliksen & Thomsen [1992]
39	0.18±0.01*	Anthracite	Nelson et al. [1986]
40	0.18±?	Recycled graphite	Van der Borg et al. [1997]
41	0.17±0.03	Natural gas	Gulliksen & Thomsen [1992]
42	0.17±0.01	Foraminifera	Schleicher et al. [1998]
43	0.162±?	Wood	Kirner et al. [1997]
44	0.16±0.03	Wood	Gulliksen & Thomsen [1992]
45	0.154±?*	Anthracite	Schmidt et al. [1987]
46	0.152±0.025	Wood	Beukens [1990]
47	0.142±0.023	Anthracite	Vogel et al. [1987]
48	0.142±0.028	CaC2 from coal	Gurfinkel [1987]
49	0.140±0.020	Marble	Schleicher et al. [1998]
50	0.130±0.030	Shell (Mytilus)	Nadeau et al. [2001]
51	0.130±0.009	Graphite	Gurfinkel [1987]
52	0.128±0.056	Graphite	Vogel et al. [1987]
53	0.125±0.060	Calcite	Vogel et al. [1987]
54	0.120±0.030	Foraminifera	Nadeau et al. [2001]
55	0.112±0.057	Bituminous coal	Kitagawa et al. [1993]
56	0.10 ±0.01	Graphite (NBS)	Donahue et al. [1997]
57	0.10 ±0.05	Petroleum	Gillespie & Hedges [1984]
58	0.098±0.009	Marble	Schleicher et al. [1998]
59	0.092±0.006	Wood	Kirner et al. [1995]
60	0.09-0.18 (range)	Graphite	Aerts-Bijma et al. [1997]
61	0.09-0.13 (range)	CO2	Aerts-Bijma et al. [1997]
62	0.089±0.017	Graphite	Arnold et al. [1987]
63	0.081±0.019	Anthracite	Beukens [1992]
64	0.08 ±?	Natural Graphite	Donahue et al. [1997]
65	0.080±0.028	Cararra marble	Nadeau et al. [2001]
66	0.077±0.005	Natural Gas	Beukens [1992]
67	0.076±0.009	Marble	Beukens [1992]
68	0.074±0.014	Graphite	Kirner et al. [1995]
69	0.07 ±?	Graphite	Kretschmer et al. [1995]
70	0.068±0.028	Calcite	Nadeau et al. [2001]
71	0.068±0.009	Graphite	Schmidt et al. [1987]
72	0.06-0.11 (range)	Graphite	Nakai et al. [1984]
73	0.056±?	Wood	Kirner et al. [1997]
74	0.05 ±0.01	Carbon	Wild et al. [1998]
75	0.05 ±?	AMS Carbon-12	Schmidt, et al. [1987]
76	0.045±?	Graphite	Grootes et al. [1986]
77	0.04 ±?	Graphite	Aerts-Bijma et al. [1997]
78	0.04 ±0.01	Graphite (Finland)	Bonani et al. [1986]
79	0.04 ±0.02	Graphite	Van der Borg et al. [1997]
80	0.04 ±0.02	Graphite (Ceylon)	Bird et al. [1999]
81	0.036±0.005	Graphite	Schmidt et al. [1987]
82	0.033±0.013	Graphite	Kirner et al. [1995]
83	0.03 ±0.015	Carbon	Schleicher et al. [1998]
84	0.030±0.007	Graphite	Schmidt et al. [1987]
85	0.029±0.006	Graphite	Schmidt et al. [1987]
86	0.029±0.010	Graphite	Schmidt et al. [1987]
87	0.02 ±?	Carbon powder	Pearson et al. [1998]
88	0.019±0.009	Graphite	Nadeau et al. [2001]
89	0.019±0.004	Graphite	Schmidt et al. [1987]
90	0.014±0.010	CaC2	Beukens [1993]

*Lowest value of multiple dates



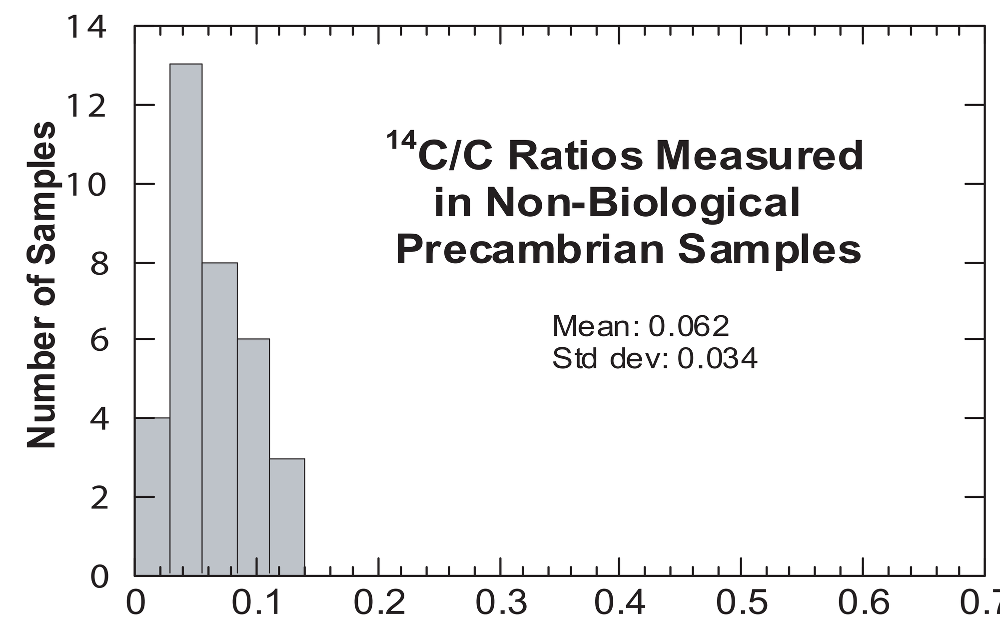


Figure 1. Distribution of ^{14}C values for (a) biogenic samples and (b) non-biogenic samples from Table 1. These samples should contain no detectable ^{14}C according to the standard time scale.

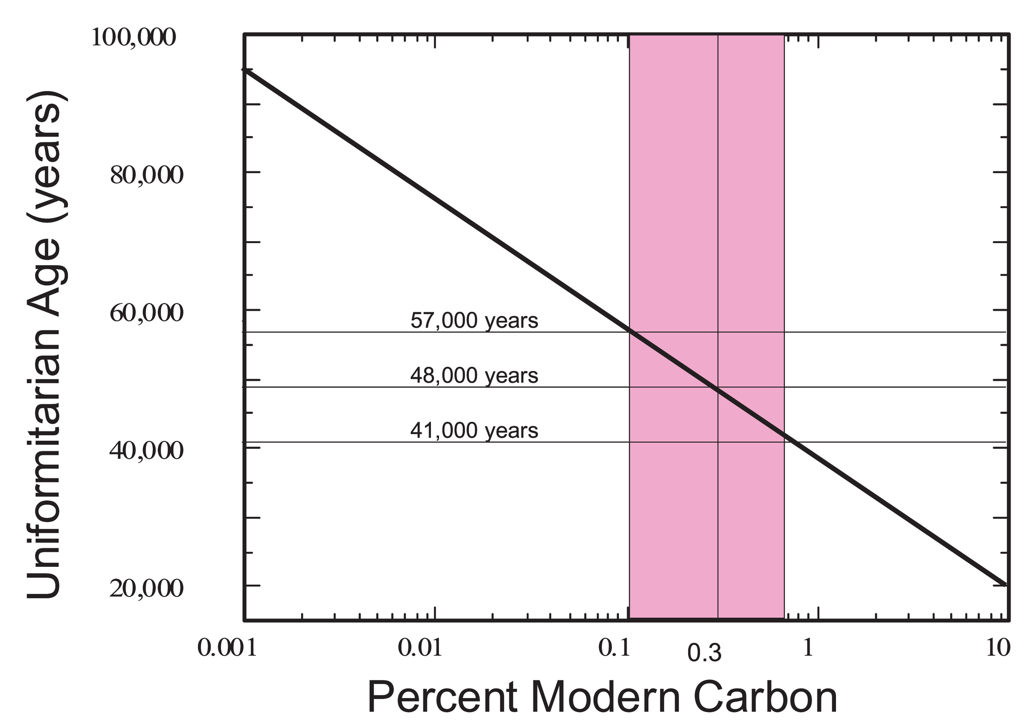


Figure 2. Uniformitarian age as a function of ^{14}C/C ratio in percent modern carbon (pmc). The uniformitarian approach for interpreting the ^{14}C data assumes a constant ^{14}C production rate and a constant biospheric carbon inventory extrapolated into the indefinite past. It does not account for the possibility of a recent global catastrophe that removed a large quantity of carbon from the biospheric inventory. Purple band shows range of values for most '^{14}C dead' biological samples.

Note: The detection limit for the AMS method is about one ^{14}C atom for every 10^{17} ^{12}C atoms, or an absolute ^{14}C/^{12}C ratio of 10^{-17}. Since the modern ^{14}C/^{12}C ratio in living things is about 10^{-12}, the AMS method can measure ratios potentially as low as about 10^{-5} times (0.001%) the modern ratio, or 0.001 pmc.

Given the substantial evidence for levels of ^{14}C hundreds of times the AMS detection threshold in biological materials throughout the Phanerozoic record, our team decided to undertake its own investigation of this phenomenon. We selected ten samples from the U. S. Department of Energy Coal Sample Bank maintained at Penn State University. The coals in this bank are intended to be representative of the economically important coalfields of the United States. The original samples were collected from recently exposed areas of active mines, placed in 30-gallon steel drums with high-density gaskets, and purged with argon.

These large samples were then processed to obtain representative 300 g samples with 0.85 mm particle size (20 mesh), sealed under argon in foil bags and have since been kept in refrigerated storage at 3°C. We selected ten of the 33 coals available with an effort to obtain good representation geographically as well as with respect to depth in the geological record. Our ten samples included three Eocene, three Cretaceous, and four Pennsylvanian coals. We chose one of the foremost AMS laboratories in the world to perform our analyses.

Table 2. Results of AMS ^{14}C analysis of 10 DOE coal samples. These measurements were performed using the laboratory's high precision procedure, with four AMS runs per sample, the results of which were combined as a weighted average and then reduced by 0.077±0.005 pmc to account for a standard background believed to be from sample processing contamination.

Sample	Coal Seam	State	County	Geological Interval	^{14}C/C (pmc)
DECS-1	Bottom	Texas	Freestone	Eocene	0.30±0.03
DECS-11	Beulah	North Dakota	Mercer	Eocene	0.20±0.02
DECS-25	Pust	Montana	Richland	Eocene	0.27±0.02
DECS-15	Lower Sunnyside	Utah	Carbon	Cretaceous	0.35±0.03
DECS-16	Blind Canyon	Utah	Emery	Cretaceous	0.10±0.03
DECS-28	Green	Arizona	Navajo	Cretaceous	0.18±0.02
DECS-18	Kentucky #9	Kentucky	Union	Pennsylvanian	0.46±0.03
DECS-21	Lykens Valley #2	Pennsylvania	Columbia	Pennsylvanian	0.13±0.02
DECS-23	Pittsburgh	Pennsylvania	Washington	Pennsylvanian	0.19±0.02
DECS-24	Illinois #6	Illinois	Macoupin	Pennsylvanian	0.29±0.03

Averaged over geological interval, the AMS determinations yield remarkably similar values of 0.26 pmc for the Eocene, 0.21 pmc for the Cretaceous, and 0.27 pmc for the Pennsylvanian samples.

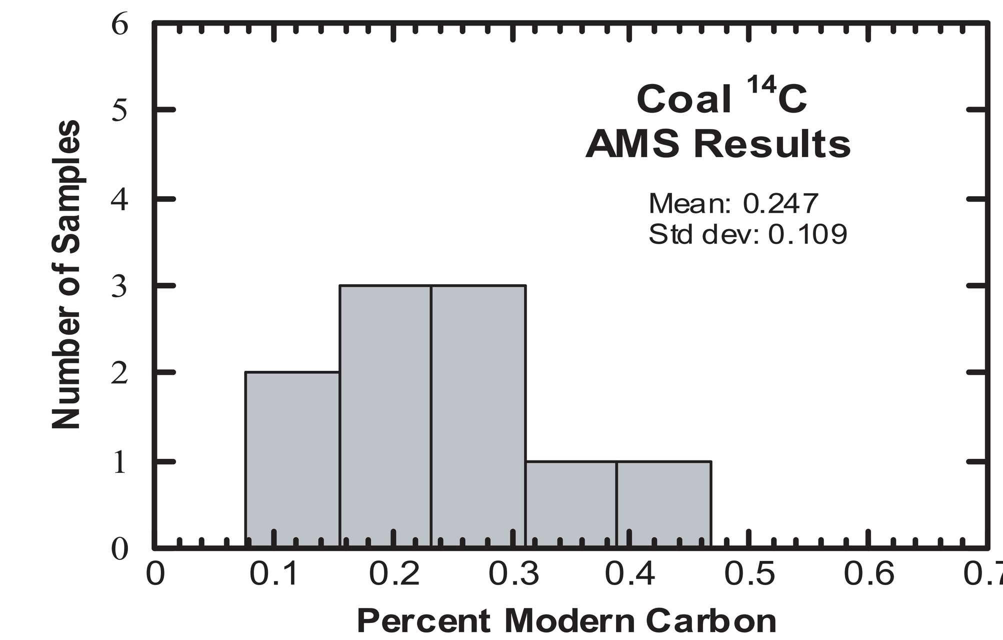


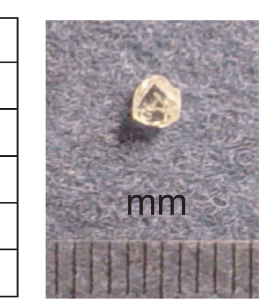
Figure 3. Distribution of ^{14}C values for 10 coal samples from Table 2. These samples should contain no detectable ^{14}C according to the standard time scale. Note the measured ^{14}C levels are a hundred times or more the AMS threshold of 0.001 pmc.

^{14}C Detected in Natural Diamond !

The fact that most of the reported Precambrian inorganic carbon measurements display levels of ^{14}C well above the AMS detection threshold motivated our team to test several samples of natural diamond using the same high precision procedures applied to the coal samples. The results are shown in Table 3 and Figure 4. We obtained a mean value of 0.121 pmc and a standard deviation of 0.021 pmc for our five diamonds.

Table 3. AMS ^{14}C results for five African diamonds. The lab's high precision procedure was applied, but no standard background has been subtracted.

Sample ID	Locality	Country	^{14}C/C (pmc)
Orapa-A	Orapa mine	Botswana	0.138±0.026
Orapa-F	Orapa mine	Botswana	0.105±0.031
Letlhk-1	Letlhakane mine	Botswana	0.120±0.032
Letlhk-3	Letlhakane mine	Botswana	0.146±0.024
Kmbrl-1	Kimberley	South Africa	0.096±0.026



Orapa diamond

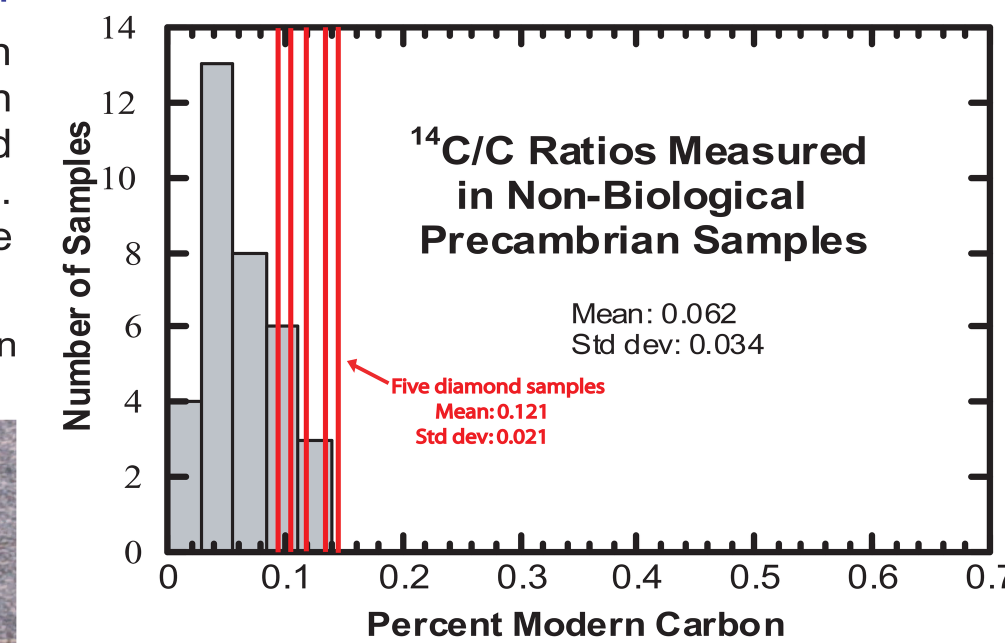


Figure 4. Distribution of ^{14}C values for our five diamonds superimposed on data from Table 1.

CONCLUSIONS

The careful investigations performed by scores of researchers in more than a dozen AMS facilities in several countries over the past twenty years to attempt to identify and eliminate sources of contamination in AMS ^{14}C analyses have, as a by-product, served to establish beyond any reasonable doubt the existence of intrinsic ^{14}C in remains of living organisms from all portions of the Phanerozoic record. Such samples, with 'ages' from 1-500 Ma as determined by other radioisotope methods applied to their geological context, consistently display ^{14}C levels that are far above the AMS machine threshold, reliably reproducible, and typically in the range of 0.1-0.5 pmc. But such levels of intrinsic ^{14}C represent a momentous difficulty for uniformitarianism. A mere 230,000 years corresponds to 40 ^{14}C half-lives. One gram of modern carbon contains 6 x 10^{10} ^{14}C atoms, and 40 half-lives worth of decay reduces that number by a factor of 9 x 10^{-13}. Not a single atom of ^{14}C should remain in a carbon sample of this size after 230,000 years (not to mention one million or 50 million or 250 million years). A glaring (thousand-fold) inconsistency that can no longer be ignored in the scientific world exists between the AMS-determined ^{14}C levels and the corresponding rock ages provided by ^{238}U, ^{87}Rb, and ^{40}K techniques. We believe the most likely explanation for this inconsistency to be the invalidity of uniformitarian assumption of time-invariant decay rates. Other research undertaken by our group supports this conclusion [1, 2, 3, 4]. The fact that ^{14}C is readily detected throughout the Phanerozoic part of the geological record argues the half billion years of time uniformitarians assign to this portion of earth history is likely incorrect. The relatively narrow range of ^{14}C/C ratios further suggests the Phanerozoic organisms may all have been contemporaries and that they perished simultaneously in the not so distant past.

We note there are strong indications that ^{14}C currently exists in environments sealed from biospheric interchange since very early in earth history. In summary, AMS ^{14}C measurements raise nontrivial questions concerning the uniformitarian assumption of the constancy of nuclear decay rates and concerning the standard uniformitarian interpretation of the geological record.

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