

The Carbon That Should Not Be There: Intrinsic C14 in Ancient Material?

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ABSTRACT

Radiocarbon measurements in geological materials require distinguishing residual original carbon-14 from carbon introduced after formation, in-situ production, and analytical background. This study examines reported measurements in coal, petroleum, dinosaur fossils, ammonites, and fossil wood, with particular attention to dinosaur-bone fractions containing radiocarbon substantially above laboratory procedural backgrounds. Published measurements include chemically distinct bone fractions, repeated measurements within individual specimens, and analyses performed across multiple radiocarbon laboratories and analytical systems. The dinosaur-bone dataset contains values from approximately 0.61 to 7.46 pMC, with commonly reported concentrations around 1.5 – 5.6 pMC, far above the procedural-background regime emphasized for nominally carbon-dead materials. We evaluate four major alternative explanations, in-situ contamination, laboratory and procedural contamination, in-situ nuclear production, and instrument background and identify fifteen independent or partly independent constraints that any comprehensive contamination model must satisfy. These include the magnitude of the signal, multiple chemically distinct fractions, within-specimen replication, pretreatment, fraction-specific stable-carbon-isotope signatures, interior-versus-exterior differences, environmental gradients, low uranium and thorium concentrations, and independent biomolecular preservation. We additionally test the measurements against the quantitative pre-Flood radiocarbon model previously presented in *Predictions on Trial*. Beginning with 0.1 pMC, allowing 1,500 years of accumulation at 20% below the modern normalized production rate, and then 4,500 years of ordinary radioactive decay, the model predicts a present-day upper concentration of approximately 7.75 pMC for carbon incorporated at the modeled Flood boundary. The highest dinosaur-bone measurement examined here, 7.46 pMC, falls immediately below that predicted boundary, while the remaining measurements likewise fall beneath it. This agreement does not by itself establish the provenance of every measured C14 atom, but it provides a quantitative correspondence between a previously published recent-age model and independent fossil measurements. The strongest dinosaur-bone results therefore warrant direct experimental discrimination between endogenous carbon and quantitatively specified contamination rather than dismissal on the basis of contamination in principle.

Keywords: radiocarbon, carbon 14, accelerator mass spectrometry, coal, fossil wood, dinosaur bone, radiocarbon provenance, contamination, young age

1. Introduction

Carbon 14 (C14) is produced continuously in the upper atmosphere as cosmic ray neutrons strike nitrogen 14. It mixes into the biosphere, is taken up by living things, and begins to decay once an organism dies or its carbon is otherwise removed from exchange. Its half-life is 5,730 years (Baumgardner, 2005). An important distinction must be made between the physical half-life of carbon-14 and the convention used for reporting conventional radiocarbon ages. The experimentally accepted physical half-life of carbon-14 is approximately 5,730 years, and this value is used in this study whenever we calculate the actual radioactive decay or survival of carbon-14 through elapsed time. Conventional radiocarbon laboratories, however, continue by historical convention to calculate reported radiocarbon ages using the older Libby half-life of 5,568 years.

Consequently, a conventional radiocarbon age is calculated as: $\text{Age} = -8033 \times \ln(F_{14C})$, where F_{14C} is the fraction of modern carbon remaining and 8033 years is the mean lifetime corresponding to the 5,568-year Libby half-life. Percent modern carbon can be converted directly to this fraction by dividing the pMC value by 100; for example, 5.0 pMC corresponds to $F_{14C} = 0.050$. Conventional radiocarbon ages are also expressed as years BP, meaning years “Before Present,” where “present” is defined by convention as AD 1950. These conventional BP ages should therefore not be confused either with direct calendar years or with calculations using the modern 5,730-year physical half-life. Throughout this paper, quoted laboratory radiocarbon ages are retained in the conventional BP form in which they were originally reported, while calculations concerning the physical amount of carbon-14 remaining or the required initial F_{14C} use the accepted 5,730-year physical half-life.

That short half-life is the whole point. It makes C14 an exquisitely sensitive clock for the last few tens of thousands of years, and it makes the isotope a decisive test of great age. After about ten half lives the original C14 has fallen to roughly a thousandth of its starting value. After 17.5 half lives, near 100,000 years, it drops below what any laboratory can distinguish from zero. After one million years the remaining fraction is on the order of ten to the minus 53, a number so small that a mass of pure C14 equal to the entire Earth would contain, on average, no surviving atoms at all (Baumgardner, 2005).

The consequence is simple and unforgiving. Any carbon bearing material older than about 100,000 years must be free of C14 unless it has been contaminated after formation or associated with analytical background. Coal is dated from tens to hundreds of millions of years. Petroleum, marble, and graphite are placed in the same range or older. This expectation is so firmly held that such materials are routinely used as the very blanks, the carbon dead standards, against which archaeological samples are measured (Thomas & Nelson, 2015).

The development of accelerator mass spectrometry changed what could be seen. Rather than waiting for the rare decay of a C14 atom, as the older beta counting method did, AMS counts the carbon atoms directly and can resolve a C14 to C12 ratio of roughly one part in ten to the 16, about 0.01 percent of the modern value (Sarfati, 2006). At that sensitivity a startling and persistent fact came into view. The supposedly dead materials are not dead. From the earliest days of the technique, samples that should contain no radiocarbon have instead yielded small but real, and reproducible, amounts.

One question naturally arises before we turn to the evidence itself. If the earth is only thousands of years old, why should any radiocarbon measurement yield an age older than the roughly 6,000 to 10,000 year window a young earth would predict? The answer is best understood through the biblical view of the world before the Flood. On this model, that world differed sharply from the present one: atmospheric pressure was higher, oxygen levels were higher, and the earth's magnetic field was stronger, while the C14 content of the biosphere was correspondingly lower. A stronger magnetic field would have deflected more of the incoming cosmic radiation that produces C14, suppressing its formation, so that living things before the Flood began with far less C14 relative to ordinary carbon than their modern counterparts. Because radiocarbon dating assumes a starting ratio close to the modern value, that lower initial level artificially inflates the apparent age of anything that lived before the Flood. As James Perloff put it, *“Assuming the Flood did occur, little if any C-14 may have existed before then. This would give anything older than the Flood a false appearance of great age”* (Perloff, 1999, p. 140). The dead carbon volcanoes emit is a testament of this.

1.1 Quantitative Requirement of a Lower Initial Radiocarbon Inventory

The proposed reduction in pre-Flood radiocarbon can be made quantitatively testable. Rather than merely stating that the initial ^{14}C concentration may have been lower than the modern atmospheric value, we can calculate exactly how low the initial biospheric F^{14}C would have to be for a genuinely young specimen to produce the radiocarbon concentrations measured in the dinosaur bones examined later in this study.

F^{14}C represents the amount of radiocarbon relative to the modern standard. An F^{14}C value of 1.00 therefore corresponds approximately to modern carbon, while $\text{F}^{14}\text{C} = 0.10$ represents 10% of the modern radiocarbon concentration. Percent modern carbon (pMC) expresses the same quantity as a percentage, so 10 pMC corresponds to $\text{F}^{14}\text{C} = 0.10$.

Using the accepted ^{14}C half-life of 5,730 years, radioactive decay can be expressed as:

$$\text{Measured F}^{14}\text{C} = \text{Initial F}^{14}\text{C} \times 2^{-(t / 5,730)}$$

Solving instead for the initial radiocarbon concentration gives:

$$\text{Initial F}^{14}\text{C} = \text{Measured F}^{14}\text{C} \times 2^{(t / 5,730)}$$

The same calculation can be performed directly in percent modern carbon:

$$\text{Initial pMC} = \text{Measured pMC} \times 2^{(t / 5,730)}$$

This calculation asks a simple question: if a specimen has a measured radiocarbon concentration today, what radiocarbon concentration must it have contained initially if its true age were only several thousand years?

The dinosaur-bone measurements discussed in Section 5 commonly fall between approximately 1.5 and 5.6 pMC. Applying the equation above gives the following required initial radiocarbon concentrations.

For specimens presently measuring between **1.5 and 5.6 pMC**, the required initial radiocarbon concentration increases as the assumed true age increases. At an assumed true age of **5,000 years**, a specimen now measuring 1.5 pMC would require an initial concentration of approximately **2.75 pMC**, while one now measuring 5.6 pMC would require approximately **10.25 pMC**, corresponding to an initial F^{14}C range of **0.0275 to 0.1025**. At **6,000 years**, the required initial values rise to approximately **3.10 pMC and 11.57 pMC**, corresponding to an F^{14}C range of **0.0310 to 0.1157**. At **7,600 years**, the required initial concentrations would be approximately **3.76 pMC and 14.04 pMC**, with an F^{14}C range of **0.0376 to 0.1404**. At **8,000 years**, the required starting concentrations would be approximately **3.95 pMC and 14.74 pMC**, corresponding to **0.0395 to 0.1474 F^{14}C** . Finally, at an assumed true age of **10,000 years**, the required initial concentrations would be approximately **5.03 pMC and 18.77 pMC**, corresponding to an F^{14}C range of **0.0503 to 0.1877**. Overall, across an assumed true-age interval of 5,000 to 10,000 years, the measured 1.5 – 5.6 pMC range would require initial radiocarbon concentrations of roughly **2.75% to 18.77% of the modern level**.

For example, the Hadrosaur femur reported at approximately 23,170 conventional radiocarbon years contains approximately 5.6 pMC. If the specimen were actually 6,000 years old, ordinary radioactive decay would require it to have begun with approximately 11.6 pMC, or an F14C of approximately 0.116. If its true age were 7,600 years, the required initial concentration rises to approximately 14.0 pMC, or F14C = 0.140. Even at a true age of 10,000 years, its required initial concentration would be only approximately 18.7% of the modern radiocarbon level.

The Triceratops femur reported at approximately 30,890 radiocarbon years requires an even lower initial value. Its present radiocarbon concentration is approximately 2.14 pMC. A true age of 6,000 years would require an initial F14C of approximately 0.044, equivalent to only 4.4% of modern. At 7,600 years the required value is approximately 5.4% of modern, and at 10,000 years approximately 7.2% of modern.

These calculations clarify exactly what the lower-initial-14C hypothesis requires. The recent-age model cannot merely state that pre-Flood radiocarbon concentrations were “somewhat lower.” To account for the dinosaur measurements while retaining a timescale of several thousand years, the initial biospheric radiocarbon concentration would need to have been substantially below the present value, generally on the order of approximately 3% to 19% of modern for the 1.5 – 5.6 pMC range examined here.

This converts the proposal into a quantitative and potentially falsifiable hypothesis. A viable pre-Flood radiocarbon model must therefore demonstrate whether the combined effects proposed to alter 14C production and the atmospheric 14C/12C ratio could plausibly produce an initial biospheric F14C within approximately this range. The calculation itself does not demonstrate that such a reduced initial concentration existed; rather, it establishes the magnitude of the reduction that the recent-age model requires and provides a numerical target against which proposed mechanisms can subsequently be tested.

2. Scope and Method

This paper surveys reported measurements of C14 in materials whose conventional ages exceed the radiocarbon horizon, organized by material class. Results are expressed in percent modern carbon (pMC), the ratio of a sample's C14 to that of a defined modern standard, multiplied by 100. A truly radiocarbon dead sample reads 0 pMC. Modern carbon reads near 100 pMC.

Two points of method matter for what follows. First, every AMS laboratory characterizes a background and subtracts it. The values reported here as intrinsic are, in the primary cases, measured values above the laboratory's own background, not the raw background itself (Baumgardner, 2005). Second, this survey adopts a deliberate retention principle. A reported case of intrinsic C14 is retained unless contamination has been positively demonstrated for that case, not merely proposed as a possibility.

This is the same standard Giam (2001) applied in the first systematic compilation of the phenomenon, and it is the correct one. To wave the word contamination at a data point, without identifying the contaminant, the pathway, and the quantity, is not an explanation. It is a placeholder for one. The burden of showing contamination lies with the party asserting it, and throughout this literature that burden is most often left unmet.

Laboratory accession numbers and museum identifiers take priority over publication count when assessing independent measurements. Repeated publication of one result is distinguished from repeat preparation, repeat measurement and analysis of a separate specimen. Comparisons with laboratory background are accepted only to the extent that blank composition, carbon mass, preparation and uncertainty are documented.

Table 1. Documented intrinsic radiocarbon in materials whose conventional ages lie far beyond the radiocarbon detection horizon of about 100,000 years.

Material (source)	Conventional age	Measured C14 (pMC)	<i>Reported conventional radiocarbon age BP</i>
Coal, 10 DOE bank samples (Baumgardner, 2005)	about 40 to 320 million years	0.25 ± 0.11 (range 0.10 to 0.46)	about 48,000 to 50,000 years
Petroleum and natural gas (Giem, 2001)	tens to hundreds of millions of years	about 0.01 to 0.77	about 40,000 to 74,000 years
Dinosaur bone and other fossils (Miller et al., 2012; Thomas & Nelson, 2015)	greater than 65 million years	about 1.5 to 5.6	younger than 39,000 years (e.g., 23,170 and 30,890)
Fossil wood and Ammonites (Snelling, 1997 to 2008)	tens to hundreds of millions of years	fossil carbon band, about 0.1 to 0.7	finite, roughly 40,000 to 50,000 years
Other carbon dead materials: marble, graphite, fossil shells, CO ₂ , whale bone, calcium carbide (Giem, 2001)	up to Precambrian	about 0.014 to 0.71	about 40,000 to 71,000 years

Note. pMC is percent modern carbon, defined in Section 2, and each value is measured above the laboratory's own characterized background. Apparent radiocarbon ages are conventional radiocarbon ages computed from the measured pMC, given to convey the scale of the discrepancy, not offered as true ages.

3. Coal

Coal is the strongest place to begin, because it is abundant, it spans the geological column, and it has been measured both by mainstream laboratories using it as a blank and by researchers testing it deliberately.

The most thorough deliberate test is the one conducted by the RATE (Radioisotopes and the Age of the Earth) initiative. Ten coal samples were drawn from the United States Department of Energy coal sample bank, selected from thirty three available samples to represent both geography and depth in the record: three Eocene, three Cretaceous, and four Pennsylvanian (Baumgardner, 2005). These beds carry conventional ages from roughly 40 to 320 million years. Every sample contained C14. The mean value was 0.25 plus or minus 0.11 pMC, measured against a laboratory background of 0.077 plus or minus 0.005 pMC, with individual samples ranging from about 0.10 to 0.46 pMC (Baumgardner, 2005). Expressed as radiocarbon ages, the coals return figures near 48,000 to 50,000 years, tens of thousands of years, not tens of millions (Snelling, 2007).

Two features of the coal data are decisive. First, the values sit roughly three times **above** the AMS detection threshold. This is not noise at the edge of what the instrument can see. It is a clear, repeatable signal (Baumgardner, 2005). Second, the C14 content shows no correlation with position in the geological column. Pennsylvanian coal, conventionally more than 300 million years old, does not contain measurably less C14 than Eocene coal, a small fraction of that age.

If the radiocarbon were a remnant decaying away over conventional time, the oldest coals should be the emptiest. They are not. The signal is essentially flat across hundreds of millions of years of assumed age (Baumgardner, 2005), which is precisely what one expects if the true ages differ by very little. The comparison that matters is not the instrument's raw sensitivity, which can resolve isotope ratios near 0.01 pMC, but the full procedural background, the modern carbon a real sample acquires during collection, storage, pretreatment, combustion, and graphitization. That floor is not negligible. Laboratories that specialize in old material report procedural blanks ranging from about 0.05 pMC for clean graphite up to several tenths of a percent for samples that require more handling, and a single microgram of modern carbon added to a one milligram target is by itself enough to lift a truly dead sample to roughly 0.1 pMC (Giem, 2001; Baumgardner, 2005).

The RATE values were taken above a characterized process background run on the same equipment, not above the bare instrument. The 0.077 pMC that was subtracted was itself a purified natural gas blank carried through the laboratory's chemistry (Baumgardner, 2005), and the samples exceeded it by roughly a factor of three. The objection is that a natural gas blank does not reproduce the full handling history of a solid coal sample. Coal is porous, it is shipped and stored, and it is prepared by a different route than a gas. Modern carbon acquired before submission, in storage, through microbial or fungal activity, or during coal specific pretreatment would never register in a natural gas blank. Subtracting the gas background removes one contribution to the floor. It does not, on its own, remove the rest.

This is precisely why the decisive measurement has not yet been made, and we think the stronger course is to call for it rather than argue past it. To show that the coal carbon 14 is intrinsic, and not a few micrograms of modern contamination, requires a process blank matched to coal itself: a radiocarbon dead, coal like material carried through the identical collection, storage, and preparation steps, paired with stepped combustion that separates loosely bound surface carbon from the carbon structurally locked in the coal matrix. Since the structurally bound fraction still reads above a coal matched blank, the intrinsic interpretation stands on firm ground. If a future experiment can show that it falls to background, the contamination argument is confirmed and can finally be adhered to honestly. That experiment is straightforward in principle and has not been carried out systematically for these samples. Until it is, the honest description of the coal values is an unresolved anomaly that is consistent with a young age, not a demonstration of one.

Two further observations bear on the reading, though we present neither as decisive. First, the carbon 14 content shows no correlation with position in the geological column. Pennsylvanian coal, conventionally more than 300 million years old, does not contain measurably less carbon 14 than Eocene coal, a small fraction of that age (Baumgardner, 2005). On a young age model, where the true ages differ little, that flatness is what one expects. When that same flatness is observed by the secular camp they give a different reason: once a sample's original carbon 14 has decayed below detection, its reading is set by contamination and background rather than by its true age, and that holds whether the bed is 40 million or 300 million years old. The absence of correlation is therefore consistent with both accounts and decides between them only when paired with the matched blank test above. Second, the nonzero coal signal was in the mainstream literature before creationists went looking for it. Published background studies report coal, including anthracite, carrying internal carbon 14 well above the instrument threshold, which is why practitioners often place the term "carbon free" in quotation marks (Baumgardner, 2005).

4. Petroleum, Oil, and Natural Gas

Petroleum and natural gas derive from once living material and, on the conventional account, are as old as or older than the coals. If the timescale is right, they too should be radiocarbon dead. Giam (2001) records cracked petroleum and natural gas among the supposedly dead materials that nonetheless return measurable carbon 14, at levels within the same broad fossil carbon band, and Baumgardner (2005) reports comparable figures.

The first is that natural gas is not simply a sample here; it is one of the standard blank materials. The purified natural gas background of about 0.077 pMC that RATE subtracted from the coal measurements (Baumgardner, 2005) is the same class of material now being put forward as evidence. When purified gas is what a laboratory runs to define zero, its own low reading cannot at the same time be presented as a strong intrinsic signal without circularity. The honest view is the narrow one: purified natural gas reads at the procedural floor, near 0.08 pMC, and that floor is nonzero. Whether a given petroleum or gas sample reads meaningfully above a matched blank is the only question that carries weight, and for most of the reported values that margin is mostly very small while Giam (2001) cited directly cracked petroleum at 0.10 ± 0.05 pMC and natural gas at 0.077 ± 0.005 pMC, while 0.01 pMC results were from carefully handled dolomite and 0.014 ± 0.010 pMC results from technical-grade calcium carbide, presumed, but not demonstrated, to have been manufactured from coal. Values near 0.01 pMC were reported for other nominally ancient materials, not unambiguously for petroleum or natural gas.

The second is that petroleum and gas are mobile fluids in porous, biologically active reservoirs, which makes them the worst case, not the best, for excluding in situ addition of younger carbon. Microbial communities live in oil reservoirs and generate methane, dissolved carbonate and migrating fluids move through the rock, and sampling and storage of a volatile hydrocarbon open their own routes to exchange. Every pathway a diamond closes, a fluid reopens. Trace carbon 14 in something that can exchange with its surroundings is far easier to assign to its environment than the same amount locked in a crystal.

For these reasons we place no independent weight on petroleum and natural gas, and we actually think these are the weakest elements to point to for evidence. What they do contribute is a corroborative pattern. The same trace carbon 14 seen in coal appears again in the most heavily sampled carbon reservoirs on the planet, across independent extractions and laboratories.

5. Fossils and Dinosaur Bones

If any class of specimen ought to be radiocarbon dead, it is dinosaur bone, all conventionally older than 65 million years. Yet multiple bones, tested by standard accelerator mass spectrometry at mainstream facilities, return conventional radiocarbon age in the tens of thousands of years.

The largest coordinated study was presented by Miller and colleagues at the 2012 AOGS and AGU Joint Assembly in Singapore (Miller et al., 2012). The group compared $\delta^{13}\text{C}$ and pMC values across bone fractions, residual collagen and the carbonate locked in bioapatite, for ten Cretaceous and Jurassic dinosaur bones ranging from Texas to Alaska, together with one specimen from China. Measurements were made largely at the University of Georgia Center for Applied Isotope Studies.

Every specimen returned an age well within the radiocarbon window, in every case younger than 39,000 radiocarbon years (Miller et al., 2012). Individual results include a Triceratops femur at 30,890 plus or minus 380 radiocarbon years and a Hadrosaur femur at 23,170 plus or minus 170 radiocarbon years (Miller et al., 2012; Thomas & Nelson, 2015). A separate Triceratops horn returned 33,570 radiocarbon years from the same Georgia laboratory (Thomas & Nelson, 2015).

Their values are not the tenths of a percent seen in coal and diamond. Expressed in percent modern carbon, ages of 23,000 to 34,000 years correspond to roughly 1.5 to 5.6 pMC, an order of magnitude above the procedural background floor discussed in the previous sections. The convenient explanation for the coal and diamond values, a stray microgram or two of modern carbon acquired in preparation, does not reach this far. To generate 1.5 to 5.6 pMC in a one milligram target by contamination alone requires not a microgram but tens of micrograms of modern carbon, on the order of one to six percent of the entire sample. Whatever produces the bone signal, it is not the faint procedural background that dominates the discussion elsewhere. On this point the standard reply genuinely does not fit, and we press it.

The Singapore team's central move is the right one for meeting the contamination burden. Rather than dating a single fraction, they compared multiple fractions of the same bone, collagen, bioapatite carbonate, and total organic carbon, and reported ages in broad agreement (Miller et al., 2012; Thomas & Nelson, 2015). The logic is sound: different fractions acquire different contaminants by different routes, so if collagen, carbonate, and bulk organics all point to the same young age, a single contaminating source becomes hard to invoke. We rest the bone case on that concordance, not on any one number.

The honest counter, which a resubmission should state rather than bury, is that the fractions are not always cleanly separable and can share a pervasive contaminant: humic acids and microbial carbon can infiltrate collagen and carbonate alike, so concordance narrows the range of contamination scenarios without closing it completely. The path to settling it is well defined: date single amino acids or the structurally bound collagen isolated by preparative chromatography, document the consolidant history of each specimen, and run bone matched process blanks. Where that has been done and the young age survives, the case is strong.

First, the bones disarm the in situ production objection, but only that objection. The Singapore specimens carried less than 20 parts per million of uranium and thorium (Miller et al., 2012), far too little to have generated their radiocarbon by neutron capture in the ground. That is decisive against production, and we treat it as such in Section 9. It says nothing about recent contamination, which is a separate mechanism, and we no longer let the low radioactivity do double duty as though it answered both.

Second, where a specific contamination pathway has actually been examined, at least one does not behave as the objection assumes: colonizing bacteria in bone appear to feed on carbon from the bone itself rather than from the modern atmosphere, so microbial life does not straightforwardly inject fresh atmospheric carbon 14 into the specimen (Thomas & Nelson, 2015). We offer that as a rebuttal to one pathway, not as a general clearance of all of them. Chapter 8 below covers objections in more detail.

The reception of the Singapore work is worth recording, though we mark it as sociology and not as data. The presentation was accepted through ordinary review, delivered without objection at the meeting, and then later privately removed from the conference website by two session chairmen after the fact, without consultation with the authors (Thomas & Nelson, 2015). We could treat this as an argument for the measurement's correctness, and how they secretly did not want the data to be made public, but we do not present it as evidence. It is rather a comment on how the results were handled, and readers may weigh it as such. More than sixty supposedly ancient fossils have now been tested and all have returned young conventional radiocarbon age of this kind, across multiple dinosaurs and other taxa (Thomas & Nelson, 2015), which at minimum makes the phenomenon too widespread to dismiss as a few mishandled specimens. We realize that fossil bone can acquire substantial carbon during burial rather than only a microgram during graphitization. However we note that unlike Saitta et al. (2019) who documented their freshly excavated Cretaceous bone contained recent organic carbon, DNA, amino acids, and a distinct microbial community. Their mixing analysis estimated that roughly **26% of the carbon in the subterranean Centrosaurus bone could derive from adjacent mudstone**. The same cannot be said for the other fossils and the scientists admit that these samples were not behaving as an open carbon system in the past based on location.

Finally, the radiocarbon does not stand alone, and its strongest support comes from an independent direction. The same Mesozoic bones have yielded original soft tissue, flexible vessels, collagen, cells, and identifiable proteins (Schweitzer et al., 2005; Lindgren et al., 2011). This evidence does not depend on the contamination debate at all, and it is genuinely difficult for the conventional timescale, which is why it has driven an active search for preservation mechanisms capable of keeping such material intact for tens of millions of years. We do not overstate it: proposed mechanisms such as iron mediated crosslinking are on the table and contested, and soft tissue does not by itself prove a young age. But radiocarbon and soft tissue are two independent lines reaching the same conclusion, that these remains are not as old as the timescale requires, and two independent anomalies are harder to explain away than either one alone. This is corroborating evidence from independent lines and independent laboratories and scientists from around the world. One additional measurement provides a useful external comparator but is not included among the ten dinosaurs because it is a marine reptile. A Cretaceous mosasaur humerus from Belgium was analyzed at Lund University and yielded approximately 4.68 pMC, corresponding to about 24,600 conventional radiocarbon years BP after acid-base-acid pretreatment. The original investigators themselves questioned whether the radiocarbon could represent later material, making this specimen useful as a comparison but methodologically distinct from the Miller dinosaur dataset.

5.1 Specimen-Level Audit of the Dinosaur Radiocarbon Data

Because the dinosaur-bone measurements are central to this paper's chronological argument, we examine their specimen identities, extracted fractions and laboratory documentation individually. The original conference dataset was subsequently reproduced and expanded by Miller et al. (2019), who published individual laboratory accession numbers, sample fractions, percent modern carbon (pMC), $\delta^{13}\text{C}$ values, collection information, and details of the chemical pretreatments used. Their dataset contains multiple measurements from several individual dinosaurs and employed four radiocarbon laboratories together with both accelerator mass spectrometry (AMS) and conventional beta-counting methods. Miller et al. report that the laboratories included Geochron Laboratories in Massachusetts, the University of Arizona, the University of Georgia Center for Applied Isotope Studies, Christian-Albrechts-Universität in Kiel, Germany, and an AMS subcontracting laboratory in New Zealand.

5.2 Required Initial Radiocarbon Concentrations and Comparison with a Recent-Age Model

Reported dinosaur-bone radiocarbon measurements can be evaluated against a recent-age model by calculating the concentrations required at death to produce the measured values today. This calculation assumes that the measured radiocarbon belongs to original dinosaur carbon and that the sampled fraction remained closed to subsequent carbon exchange. The results can be directly compared to our prior published paper where we predicted the maximum expected pMC measurements in dinosaur fossils at **7.75 pMC**.

Miller et al. (2019) list dinosaur fractions with concentrations ranging from 0.61 to 6.45 pMC, while Thomas and Nelson (2015) report a hadrosaur medullary-bone measurement of 7.46 pMC. These measurements characterize the analyzed carbon fractions; they do not independently establish the organisms' ages or demonstrate that all measured carbon originated in the animals.

5.3 Chronological Assumptions and Required Starting Concentrations

The model presented in *Predictions on Trial* adopts an initial concentration of 0.1 pMC at Creation, followed by 1,500 years of pre-Flood accumulation and 4,500 years of post-Flood radioactive decay. The total modeled Creation-to-present interval is therefore 6,000 years.

Using the physical radiocarbon half-life of 5,730 years, the concentrations required at death for organisms buried 4,500 years ago are calculated as follows:

A present concentration of 0.61 pMC requires approximately 1.05 pMC at death.

A present concentration of 1.50 pMC requires approximately 2.59 pMC at death.

A present concentration of 5.60 pMC requires approximately 9.65 pMC at death.

A present concentration of 6.45 pMC requires approximately 11.12 pMC at death.

A present concentration of 7.46 pMC requires approximately 12.86 pMC at death.

For the illustrative present-day interval of 1.5 – 5.6 pMC, the required starting concentrations are therefore approximately 2.59 – 9.65 pMC, equivalent to $F^{14}C = 0.0259 - 0.0965$.

5.4 Comparison with the Progressive Accumulation Model

The accumulation calculation assumes a uniformly mixed reservoir containing a constant quantity of total carbon and receiving a constant radiocarbon input. Baseline production is normalized to an equilibrium concentration of 100 pMC. Meaning, we used a modern natural radiocarbon production baseline as the reference rate and assumed a constant C-14 production/input rate which, if allowed to operate indefinitely in a constant carbon reservoir, would eventually produce an equilibrium concentration of 100 pMC.

To investigate the influence of stronger pre-Flood magnetic shielding proposed by *Baumgardner et al.*, 2003 and *Snelling*, 2011, the model applies a constant 20% reduction in radiocarbon production throughout the 1,500-year accumulation interval. Within the assumed fixed reservoir, this lowers the equilibrium concentration to 80 pMC.

Starting from 0.1 pMC, the modeled reservoir reaches approximately 13.36 pMC at the Flood. After 4,500 years of ordinary radioactive decay, carbon that matched this reservoir at burial and remained closed to exchange would retain approximately 7.75 pMC today. The modeled sequence is therefore: 0.1 pMC at Creation → approximately 13.36 pMC after 1,500 years of accumulation with 20% reduced production → approximately 7.75 pMC after 4,500 years of ordinary radioactive decay as stated in our prior paper; *Predictions on Trial*. The reported concentrations discovered and published across multiple studies all fall just below this conditional upper boundary.

5.5 Interpretation and Falsifiability

The progressive model permits lower present concentrations for carbon incorporated earlier in the pre-Flood interval and preserved without subsequent replacement. For bone, this possibility must be evaluated through tissue formation, turnover, diet, and preservation history.

Differences within individual specimens provide an additional constraint. Thomas and Nelson (2015), for example, report 7.46 and 2.78 pMC for medullary and cortical samples of the same hadrosaur vertebra. Assuming 4,500 years of ordinary decay, these correspond to approximately 12.86 and 4.79 pMC at death, respectively. Their disparity requires an explanation involving the sampled fractions, their carbon sources and histories, or analytical effects; this observation constrains a simple outside-in contamination model.

We answer this by differences within individual specimens such as tissue-specific preservation, carbon partitioning, and possible endogenous or in-situ processes rather than assuming that every portion of a fossil must preserve an identical pMC value. Thomas and Nelson (2015), for example, as stated above they reported 7.46 pMC from the interior trabecular/medullary portion and 2.78 pMC from the exterior cortical portion of the same hadrosaur vertebra, a difference of approximately 2.68-fold. Assuming 4,500 years of ordinary radioactive decay, these values correspond to approximately 12.86 and 4.79 pMC, respectively, when projected back 4,500 years.

This disparity should not necessarily be interpreted as two different ages for the animal. Bone is chemically and structurally heterogeneous, with cortical and trabecular regions differing in remodeling history, porosity, organic-to-mineral composition, and postmortem preservation behavior. Modern radiocarbon studies likewise demonstrate that different skeletal tissues and carbon fractions can preserve measurably different isotopic histories. Think about a body laying in a swamp, some of the bones would be under water, others under mud, others exposed above the water. Every test on the corpse would result in a different age. Thus, the two measurements are better regarded as evidence that distinct carbon reservoirs within the same fossil can retain different radiocarbon concentrations rather than as measurements of a single uniform whole-bone carbon pool. Significantly, in this specimen the **more deeply sequestered interior portion contained the higher radiocarbon concentration**, whereas a model of modern carbon entering progressively from the exterior would predict the opposite spatial tendency. This spatial relationship therefore provides an additional constraint on a simple outside-in contamination explanation.

The calculated **7.75 pMC** functions as a scenario-specific prediction as an upper bound for intrinsic carbon 14 in dinosaur fossils. Securely demonstrated original carbon substantially exceeding this boundary, beyond analytical and model uncertainty, would contradict this combination of chronology, production history, reservoir behavior, and closed-system preservation. Results above this would falsify our predictions and pre-flood world c14 concentration ratios.

Testing requires suitable pretreatment, process blanks, and independent assessment of environmental or conservation-derived carbon. Measurements below the boundary remain compatible with the upper-limit prediction, but do not independently confirm the proposed accumulation trajectory. Explaining the full measurement range requires additional constraints on original carbon identity, tissue history, reservoir behavior, and post-burial exchange.

5.6 Calculation Notes

Required concentration at death.

Starting pMC = present pMC $\times 2^{(4500 / 5730)}$.

The multiplier for 4,500 years is approximately **1.72350**.

For example:

Starting pMC = 1.50×1.72350 = approximately **2.59 pMC**.

Starting pMC = 5.60×1.72350 = approximately **9.65 pMC**.

These calculations reverse ordinary radioactive decay only; they do not correct for contamination or carbon exchange.

5.7 Accumulation and subsequent decay.

With baseline production normalized to a 100 pMC equilibrium, a 20% production reduction gives an assumed equilibrium concentration of 80 pMC.

Flood pMC = $80 + (0.1 - 80) \times 2^{(-1500 / 5730)}$.

Flood pMC = $80 - 79.9 \times 2^{(-1500 / 5730)}$.

Flood pMC = approximately 13.3588 pMC.

The accumulation equation includes ordinary radioactive decay throughout the pre-Flood interval. Subsequent decay is calculated as:

Present pMC = $13.3588 \times 2^{(-4500 / 5730)}$.

Present pMC = approximately **7.75 pMC**.

Abbreviations: AMS = accelerator mass spectrometry; pMC = percent modern carbon; BP = conventional radiocarbon years before AD 1950; Bio = carbonate fraction of bioapatite; Bow = bulk organic fraction of whole bone; Col = collagen; Hum = isolated humic-acid fraction; GX = Geochron Laboratories, Massachusetts; AA = University of Arizona; UGAMS = University of Georgia Center for Applied Isotope Studies; KIA = Christian-Albrechts-Universität, Kiel, Germany. Miller et al. report that the quoted age errors represent one standard deviation and include statistical and experimental components. The pMC values themselves were generally published without separate pMC error terms, so the radiocarbon-age uncertainty is retained here rather than assigning unreported pMC confidence limits.

The specimen-level data reveal an important distinction that is lost when the dinosaur measurements are summarized only as a range of approximately 1.5 to 5.6 pMC. Some specimens were measured only once, whereas several of the most important specimens were analyzed repeatedly using chemically different fractions. *Acrocanthosaurus* was represented by five measurements involving bioapatite and organic material and was tested using multiple laboratory systems. *Triceratops* #1 was measured as collagen, bulk organic material, and bioapatite, while *Hadrosaur* #2 produced five principal measurements from exterior bone, whole bone, bioapatite, organic material, and isolated collagen. The published dataset therefore contains genuine within-specimen replication rather than merely a collection of unrelated single measurements.

The chemical pretreatment must also be considered in evaluating these measurements. Miller et al. report that bone fragments were first mechanically cleaned and crushed, with hot dilute acetic acid used to remove adsorbed burial carbonate. Organic and whole-bone fractions received acid-base-acid treatment to remove carbonates and humic material. For collagen isolation, the authors describe an acid and alkali purification procedure followed by gelatinization, while bioapatite carbonate was released only after removal of adsorbed carbonate. Suspected shellac, glue, and PVC coatings were treated with hot organic solvents. The authors specifically identify the *Psittacosaurus* specimen as having possible shellac/glue and *Triceratops* #2 as having had a PVC coating; both were treated for these materials prior to the reported final measurements.

This fractionation is especially relevant because different components from the same bones did not simply return identical isotope signatures. Reported $\delta^{13}\text{C}$ values fall into distinct ranges according to fraction: approximately -20.1 to -23.8‰ for collagen, -15.7 to -28.4‰ for bulk organic material, and -3.1 to -9.1‰ for bioapatite carbonate. *Miller* et al. interpreted this fraction-dependent separation as evidence that chemically distinct bone components had been isolated rather than all measurements reflecting a single homogeneous contaminant. At the same time, the differences in radiocarbon concentration between fractions demonstrate why no one fraction should be treated as automatically representing an uncontaminated burial age.

Collagen recovery was low but measurable in several Montana specimens. *Triceratops* #1 yielded approximately 0.35% collagen and *Hadrosaur* #2 approximately 0.20%. *Miller* et al. report a third southern Montana specimen with approximately 0.10% collagen, but the published text does not unambiguously identify which specimen corresponds to that third value; it should therefore not be assigned to a particular dinosaur without the original laboratory report. Formal collagen C:N quality-control ratios were not published for these measurements. *Triceratops* #3 instead had reported bulk carbon of 1.8% and nitrogen of 0.05%.

Uranium and thorium measurements likewise should not be presented as though they were available separately for every dinosaur. *Miller et al.* report measured concentrations of approximately 0.020 mg/kg uranium and 0.078 mg/kg thorium in tested dinosaur material and use these values in evaluating in-situ nuclear production of radiocarbon. However, the published table does not associate those measurements individually with each of the ten specimens. We regard the U/Th data as a dataset-level control rather than assign the value to every dinosaur. The entire question we are trying to answer is does testing the direct source itself yield contradictions to the rocks they are found in.

Testing rocks to tell us the age of the organism is the very question we do not want to assume. When we find multiple pieces of evidence that contradict the dates given by testing the surrounding rocks then that begs the question. What dating method and what clock do we trust? If we find 10 pieces of evidence that refute 1 piece of evidence, it seems clear that the 10 outweigh the 1. In this case, with dinosaur fossils we find numerous forms of soft-tissue preservation, flexible blood-vessel-like structures, osteocyte-like cells, red-blood-cell-like structures, endogenous proteins including collagen, amino acids retaining substantial L-enantiomer dominance, DNA-like chemical signatures, and measurable radiocarbon like this study has shown. So, when multiple lines of evidence contradict a single line of evidence. We trust the logical conclusion, the multiple independent pieces of evidence outweigh the single piece of indirect evidence.

6. Fossil Wood and Ammonite

Wood buried in, or petrified within, rock assigned tens or hundreds of millions of years offers a distinctive kind of test. Wood is an unambiguously biological material with a well understood carbon chemistry, and it is frequently encased in strata whose conventional age lies far beyond the radiocarbon horizon, so the age of the organic material and the age of its container can be checked against each other.

Snelling has documented a series of such cases. Fossil wood recovered from within a supposedly ancient lava flow yielded finite radiocarbon (Snelling, 1997). A fossilized tree stump embedded in older rock did the same (Snelling, 1998). Wood taken from sandstone assigned deep time ages again returned young radiocarbon dates in conflict with the age of the enclosing rock (Snelling, 1999, 2000). In a more formal study, Snelling (2008) reported radiocarbon in both fossil wood and fossil ammonites from Cretaceous strata near Redding, California.

We place fossil wood carefully, because its measured values fall in the same band as Petroleum and natural gas, roughly a few tenths of a percent of modern carbon, and everything said earlier about the procedural background floor applies here without exception. We catalog all statistically nonzero reported $\delta^{14}\text{C}$ measurements and then classify the strength of evidence for endogenous/intrinsic origin. A wood sample reading a few tenths of a pMC is, on the measurement alone, within reach of the modern carbon a laboratory introduces during pretreatment, combustion, and graphitization. Worse than coal in one respect, buried and petrified wood is porous and chemically altered, its original lignin and cellulose partly replaced or degraded, which gives groundwater borne humic acids and secondary carbon ample opportunity to lodge in the sample. Taken one specimen at a time, a finite radiocarbon age on fossil wood does not by itself establish intrinsic carbon 14, and we do not claim that it all does.

What raises the fossil wood case above the Petroleum and natural gas case is not the size of the signal but a test the wood permits that the Petroleum and natural gas does not. The claim on the table is not merely that the wood carries carbon 14. It is that the wood carries carbon 14 while sitting inside rock that the same framework dates to tens or hundreds of millions of years. Those two ages cannot both be right. Either the wood inside it is genuinely as old as its container, in which case it must be radiocarbon dead and is not, or the radiocarbon is taken at face value, in which case the wood, and the deposition of the rock around it, is young. Contamination can raise a reading. It cannot reconcile a body of organic material that dates young with a host rock dated old. The mismatch is the data point and result, and it survives even a generous allowance for a modern carbon component, because no plausible amount of added modern carbon converts a genuinely carbon dead sample into one reading tens of thousands of radiocarbon years while leaving the surrounding rock's assigned age untouched.

The Redding study (Snelling, 2008) reports measurable carbon 14 in two independent fossil types, wood and ammonite, drawn from the same conventionally ancient beds. Two different materials, with different chemistries and different contamination susceptibilities, extracted from the same strata and both reading young, is a stronger result than any single specimen can ever give, because a contaminant that would have to invade both wood and ammonite shell to the same effect is far harder to postulate than one attacking a single porous sample. The individual field reports establish that the phenomenon recurs, we find the same thing in dinosaur fossils.

7. Other Carbon Dead Materials

The phenomenon is broader than the headline categories. Giam (2001) assembled the reported cases into the first systematic catalogue and found nonzero radiocarbon across a wide range of supposedly ancient substances: marble, commercial graphite, various fossil shells, carbon dioxide gas, wood, anthracite coal, cracked petroleum, natural gas, ancient whale bone, and technical grade calcium carbide (Giam, 2001; Baumgardner, 2005). Some of these materials are even classified as Precambrian (*539 million to 4 billion years old*). The measured amounts $^{14}\text{C}/\text{C}$ ratios appear to fall in the range 0.1–0.5 percent” modern carbon (Baumgardner, 2005).

The first is between materials that serve as laboratory blanks and materials that do not. Commercial graphite, marble, and carbon dioxide gas are among the substances laboratories use to characterize their own zero. Their low readings, in the hundredths to low tenths of a pMC, define the procedural background rather than stand above it, and a value that defines the floor cannot at the same time be offered as a signal that clears the floor. We set those materials aside as measurements of the background itself. What remains of independent interest are the **biological members of the list**, fossil shells and whale bone above all, whose carbon began in a living organism and which are not used as blanks. Those are the cases where a reading above a matched process blank would carry weight, and they, not the graphite and marble, are where attention belongs.

The second distinction is between eliminating instrument error and clearing the full procedural background, which are not the same thing. Giam drew three conclusions from his catalogue (Giam, 2001). He argued that instrument error can be ruled out as a general explanation on experimental grounds; that in situ contamination of buried material, while possible, is a testable hypothesis rather than an assumption; and that preparation contamination, though real, had been largely solved by two decades of laboratory improvement, leaving the residual radiocarbon most plausibly belonging to the samples themselves.

The third is that careful modern studies report that a small, effectively unavoidable amount of modern carbon is introduced during graphitization and target handling, penetrating the sample matrix and not merely coating its surface, so the procedural floor is a persistent feature of the method rather than a closed problem. Ruling out instrument error, which Giam did correctly, leaves that procedural floor untouched, because the two are different sources, and much of the catalogue sits at or near it.

Giam observed that most fossil carbon carries roughly the same carbon 14 to carbon ratio regardless of its assigned position in the column, and read the simplest explanation as a common and recent origin, that the organisms lived at close to the same time (Giam, 2001). On a young age model that uniformity is expected and observed. But a common procedural background predicts the very same uniformity for an entirely different reason. If these materials are all genuinely beyond the radiocarbon horizon, then none retains any original carbon 14, and every reading is set by the same background and preparation chemistry rather than by the sample's true age. Materials that all read the floor will, of course, read alike. The near uniform ratio is therefore consistent with a recent common origin and with a universal background floor, and on its own it does not distinguish them. Where the models differ is the ratios, if the C14 floor is baseline for why evolution expects to observe any at all and why it's consistent, then the floor should be expected in most samples. It is not. Rather we find higher than detectable floor levels in unrelated specimens and different material, this is not a sign of floor level consistency but of a consistency widow that should not exist in an evolutionary timeframe.

One observation in this section stands without qualification, and we let it close. That a range of substances is labelled carbon dead in routine practice while consistently measuring well above zero is a real feature of the field, not a creationist invention. The label describes an expectation set by the timescale, not a measurement. Whether the residual carbon in the biological members of the catalogue is intrinsic or procedural is precisely the question this paper is trying to settle, and the catalogue's value is that it shows the question is not confined to a few rare exotic specimens or outliers, but recurs wherever nominally ancient carbon is measured with enough sensitivity.

8. Objections Considered

A paper of this kind must meet the secular objections directly, because they are the whole of the reply. There are four. The objections vary in force from material to material. For the low band cases we have already flagged as unresolved, they are serious and not yet answered. Where the signal is strongest, they fail. Setting out exactly where each objection holds and where it breaks is the purpose of this section.

8.1 In Situ Contamination

This contamination proposal is that modern carbon, carried by groundwater, bacteria, or fungi, infiltrated the sample in the ground. This is entirely plausible for porous, fractured, or biologically accessible materials, and it is the objection most often raised against coal, fossil wood, and bone. We acknowledge that this and it cannot be dismissed for those materials on the measurement alone. What we ask is that it be shown rather than asserted. To establish in situ contamination for a given sample, one must identify the contaminating carbon, the transport pathway, and the quantity, and then demonstrate that they suffice to produce the measured value. That work is rarely done, and where it is not done the objection is a hypothesis, not a result.

The objection also carries a specific commitment that has been tested at least once and not borne out: where the mechanism was examined, colonizing bacteria in bone were found to feed on carbon from the bone itself rather than from the modern atmosphere, so microbial activity does not straightforwardly inject fresh atmospheric radiocarbon into the specimen (Thomas & Nelson, 2015). That rebuts one pathway. It does not clear them all, and for the low band materials in situ contamination remains a live possibility that only matched, controlled measurement can close.

A 2019 study in eLife excavated a Cretaceous ceratopsian and reported that the bone hosts recent organic material and a living microbial community, and its radiocarbon (about 33,800 years) falls right in the middle of the values other Cretaceous fossils give. Their subterranean Centrosaurus bone had $F^{14}C = 0.0149$, whereas the adjacent mudstone was 0.0573 and nearby topsoil was 0.766. They interpreted the nonzero radiocarbon as evidence that younger carbon had entered the fossil, but because the bone had substantially *less* $F^{14}C$ than its surroundings, they explicitly stated that this could indicate “*some biologically inaccessible, old, and possibly endogenous C*” within the fossil. Their simple mixing calculation suggested about 26% of the carbon in the subterranean bone originated from the adjacent mudstone, **that means 74% would be intrinsic.**

The creationist side at ICR points out that the eLife team used only an acid wash rather than a full acid-base-acid treatment, which leaves humic acids in, so their protocol arguably invited the very contamination they then blamed on microbes, and defenders note that in some cases contamination is blamed on bacteria even when no bacteria were actually found in the sample. This could very well mean that all the C^{14} is intrinsic. The fact remains that the high C^{14} levels keep coming back with recent consistent dates far outside the evolutionary timeframe and far above background which also tend to clustered together in a band of roughly $^{14}C/C$ 0.1 - 0.5 percent modern carbon.

8.2 Laboratory and Procedural Contamination

Modern carbon is introduced during sample preparation, above all during pretreatment, combustion, and the conversion of the sample to graphite, on the order of a microgram of modern carbon per target (Taylor & Southon, 2007), and subsequent studies of target contamination indicate that a small amount of it is effectively unavoidable, penetrating the sample matrix rather than merely coating its surface. This is why laboratories run process blanks and subtract a characterized background, and why a truly dead sample does not read zero but reads a procedural floor of roughly 0.05 to a few tenths of a pMC.

The lowest band values in our survey is the coal, at 0.25 pMC and the fossil wood in the same range, still sitting above that floor. It is sometimes argued that these values sit well above the laboratory's own processed background. The background subtracted from the coal was a purified natural gas blank (Baumgardner, 2005), and the coal did exceed it by roughly a factor of three, but a natural gas blank does not reproduce the handling history of a solid, porous coal sample. The comparison that would actually defeat this objection, a blank matched in material and preparation to the sample itself, has not been made for these cases. We therefore do not present the low band values as having cleared this objection. We present them as awaiting the matched blank and stepped combustion tests described in Sections 3 and 6, and we let the objection stand until those tests are done. As for now the evidence for them is still on our side until they can confirm otherwise.

Where their objections fail is on the dinosaur bone, and the failure is quantitative. Procedural contamination operates at the microgram level, a microgram of modern carbon in a milligram target producing about 0.1 pMC. The bone values are not tenths of a pMC. At conventional radiocarbon ages of 23,000 to 34,000 years they correspond to roughly 1.5 to 5.6 pMC, ten times the procedural floor, and would demand tens of micrograms of modern carbon, on the order of one to six percent of the entire sample, introduced in preparation. That is not the behavior of a process blank, and no blank in the literature reads that high.

Laboratory contamination is a reasonable objection to the low band materials until they are measured again under control. However, it is not a viable explanation of the bone at all. Fossils would require massive amounts of other environmental carbon, microbial carbon, humic acid, consolidants, adhesives, storage contamination, carbonate exchange, or other diagenetic carbon contamination.

8.3 In Situ Nuclear Production

Uranium and thorium in or near a sample decay, and their emissions can in principle generate fresh carbon 14, chiefly by neutron capture on nitrogen 14. If enough is produced this way, the measured radiocarbon need not be original. The question is quantitative. Baumgardner used the published uranium and thorium contents of coal, together with the nitrogen present, to calculate the carbon 14 that neutron and alpha bombardment could produce, and found it orders of magnitude below the levels measured in the ten coal samples (Baumgardner, 2005; Snelling, 2007).

For the dinosaur bones the argument fails on measurement rather than calculation: with less than 20 parts per million of uranium and thorium, the bones lack the parent radioactivity to have produced their radiocarbon in place (Miller et al., 2012), and the RATE analysis explicitly ruled out production by neutrons interacting with nitrogen or carbon 13 in buried specimens (Baumgardner, 2005). The mainstream literature itself has gone only so far as to allow that subsurface production is possible in principle (Zito, Donahue, Davis, Bentley, & Fritz, 1980), which is a far weaker claim than showing it is sufficient. In situ production is real physics, and in these materials far too feeble to explain the data.

8.4 Instrument Background and Ion Source Memory

The final proposal is that part of the residual signal is the instrument itself: carbon left in the ion source from previous samples and released into the current measurement, along with other instrument level backgrounds. This is a real effect and we grant it fully. Our point is one of bookkeeping. Ion source memory is one of the components that make up the procedural and instrument background floor, and it is measured and subtracted along with the rest whenever a laboratory characterizes its blank. It is therefore already inside the discussion of Section 8.2, not a separate account of the excess above the floor.

For the low band materials, memory is part of exactly the background we have said the samples have not yet been shown to clear. For the bone, memory meets the same quantitative wall as procedural contamination: a fixed instrument background measured in hundredths to low tenths of a pMC cannot produce a signal of 1.5 to 5.6 pMC. Instrument memory belongs in the accounting of the background. It is not, for any material remaining in this survey, a demonstrated source of a signal standing well above that background.

8.5 Fifteen Independent Constraints on the Contamination Hypothesis

The hypothesis that measurable radiocarbon in conventionally ancient dinosaur fossils is entirely the result of younger carbon introduced after burial or during laboratory processing is testable. It is not sufficient merely to demonstrate that contamination can occur in fossil bone; the proposed mechanism must also account quantitatively for the magnitude, distribution, chemical location, reproducibility, and isotopic behavior of the measured carbon.

No single observation discussed below establishes that all measured C14 is necessarily original dinosaur carbon. Taken together, however, these **fifteen distinct, partly independent constraints** substantially narrow the range of contamination scenarios capable of explaining the dinosaur-bone dataset. We end by showing that the scientists themselves admit that either some, most or maybe even all of it, is actually intrinsic to the bone itself.

1. **Radiocarbon concentrations substantially exceed normal procedural background.**

Dinosaur-bone measurements discussed in this study commonly fall around **1.5–5.6 pMC**, with individual reported fractions reaching **6.45 and 7.46 pMC**. These concentrations are not merely small residual signals at the instrumental detection limit. By comparison, procedural and instrument backgrounds discussed in the radiocarbon literature generally occupy the hundredths to low-tenths-of-a-pMC range. The dinosaur measurements therefore stand roughly an order of magnitude or more above the background regime that can plausibly explain many nominally carbon-dead materials.

2. **The amount of modern carbon required is quantitatively large.** Approximately one microgram of modern carbon introduced into a one-milligram carbon target can produce a signal on the order of 0.1 pMC. Raising a genuinely radiocarbon-dead dinosaur sample into the **1.5 – 5.6 pMC** range would therefore require not merely trace contamination but tens of micrograms of modern carbon, representing approximately **1 – 6% of the entire carbon target** under the simplified mixing calculation used here. Such a contribution would be qualitatively different from the small procedural contamination routinely characterized by laboratory blanks.

3. **Chemically different fractions from the same bone contain measurable C14.** The dinosaur studies did not rely exclusively on untreated whole bone. Investigators analyzed fractions including **collagen, bioapatite carbonate, bulk organic carbon, and whole-bone material**. Because these fractions differ chemically and interact differently with their burial environments, a contamination hypothesis must explain how younger carbon enters multiple distinct carbon reservoirs while producing finite radiocarbon measurements in each. Fractional agreement does not eliminate every possible pervasive contaminant, but it makes a single simple contamination pathway less satisfactory.

4. **The dataset contains genuine within-specimen replication.** Several important fossils were measured repeatedly rather than being represented by a single radiocarbon determination. *Acrocanthosaurus*, *Triceratops*, and *Hadrosaur* specimens yielded multiple measurements from chemically distinct components of the same bones. Consequently, the dataset is not merely an assortment of unrelated one-time anomalous readings. Any successful contamination model must reproduce repeated finite signals within individual specimens as well as across different dinosaurs.

5. **The measurements were obtained using multiple laboratories and analytical systems.** Miller et al. report analyses involving several radiocarbon facilities, including laboratories in the United States, Germany, and New Zealand, with both **accelerator mass spectrometry and conventional beta-counting methods** represented in the larger dataset. A laboratory-specific instrumental artifact therefore cannot by itself explain every reported measurement. A universal contamination explanation would instead have to operate reproducibly across independent facilities, preparations, and analytical systems.
6. **Substantial chemical pretreatment was applied to remove extraneous carbon.** The samples were not simply placed into an instrument in their excavated condition. Reported procedures included mechanical cleaning, crushing, hot dilute acetic acid treatment to remove adsorbed carbonate, acid-base-acid treatment of organic fractions, collagen isolation and gelatinization procedures, and organic-solvent treatment of specimens suspected of containing shellac, glue, or PVC coatings. Such treatment does not guarantee elimination of every possible contaminant, but it raises the burden of proof for any hypothesis requiring large quantities of readily removable exogenous carbon to survive the preparation process.
7. **Different bone fractions retain distinct stable-carbon-isotope signatures.** The reported $\delta^{13}\text{C}$ values differ according to the fraction analyzed, with collagen, bulk organic material, and bioapatite occupying different isotopic ranges. Miller et al. interpreted this fraction-dependent separation as evidence that chemically distinct bone components had actually been isolated rather than every measurement representing a single homogeneous carbon source. If one pervasive contaminant dominated all fractions, greater isotopic homogenization might reasonably be expected. The observed separation therefore places another constraint on any common-source contamination model.
8. **The hadrosaur interior-versus-exterior pattern opposes the simplest inward-contamination expectation.** Thomas and Nelson report 7.46 pMC from the interior trabecular/medullary portion of a hadrosaur vertebra and 2.78 pMC from the exterior cortical portion, a difference of approximately 2.68-fold. If modern environmental carbon were simply diffusing progressively inward from the specimen's exterior, the outer cortical region would ordinarily be expected to experience at least as much access to that carbon as the more deeply sequestered interior. Instead, the protected interior contained the higher radiocarbon concentration. This does not eliminate every possible diagenetic mechanism, but it argues against a simple outside-in contamination model.
9. **At least one proposed microbial pathway does not behave as assumed.** Microbial colonization is frequently invoked as a source of younger carbon in fossil bone. The evidence discussed by Thomas and Nelson, however, indicates that colonizing bacteria can utilize carbon already present within the bone rather than necessarily importing fresh atmospheric carbon into it. This finding does not exclude all microbial contributions, but it demonstrates that the mere presence of microorganisms cannot automatically be equated with introduction of modern C^{14} . A microbial explanation must therefore demonstrate both the external carbon source and the quantity transferred into the measured fraction.

10. **The Saitta et al. specimen was substantially depleted in radiocarbon relative to its surroundings.** The freshly excavated subterranean Centrosaurus bone discussed in the paper had $F^{14}C = 0.0149$, compared with 0.0573 in adjacent mudstone and 0.766 in nearby topsoil. Saitta et al. interpreted part of the bone's carbon as younger environmental material, yet also acknowledged the possibility of a biologically inaccessible, old, and possibly endogenous carbon component. Their simple mixing estimate suggested that a maximum of 26% of the bone carbon could have been derived from adjacent mudstone, leaving the majority unexplained by that particular source. The observation therefore demonstrates that environmental carbon exchange can occur while simultaneously showing that the bone was not simply equilibrated with its surroundings.
11. **In-situ nuclear production appears quantitatively inadequate.** Another alternative to intrinsic C^{14} is production after burial through nuclear reactions involving uranium, thorium, neutrons, nitrogen, or carbon-13. The dinosaur material discussed by Miller et al. contained very low measured uranium and thorium concentrations, and the analyses cited in this paper concluded that the available parent radioactivity was insufficient to generate the observed C^{14} concentrations. Thus, while subsurface C^{14} production is physically possible in principle, the measured radioactive inventory does not appear sufficient to account for the dinosaur-bone signal.
12. **Instrument background and ion-source memory are too small to reproduce the dinosaur measurements.** Ion-source memory and related instrumental effects are real and must be included in radiocarbon analysis. However, they form part of the background measured with blanks and typically operate in the hundredths to low-tenths-of-a-pMC range. Such a background cannot by itself generate measurements of several pMC. Consequently, instrument memory may influence very low-level measurements but encounters the same quantitative problem as ordinary procedural contamination when applied to the dinosaur data.
13. **Finite radiocarbon measurements recur across multiple dinosaur specimens rather than appearing as isolated anomalies.** The reported phenomenon is not confined to one fossil, one species, one excavation, or one laboratory analysis. Multiple dinosaur specimens and other fossils have returned finite radiocarbon concentrations within the measurable range. Repetition does not by itself establish endogenous origin, since a common source of contamination could theoretically recur, but it makes explanations based on isolated mishandling or an exceptional specimen increasingly inadequate.
14. **Reported spatial patterns around some fossils do not fit a simple model of younger carbon moving inward from the surrounding sediment.** In the discussion of the Miller dataset, the investigators reported decreasing radiocarbon concentration in surrounding material with increasing distance from the fossil and interpreted the pattern as potentially consistent with carbon moving outward from the bone rather than modern carbon simply migrating inward. This interpretation requires further independent testing, but if confirmed it would reverse the direction expected under the simplest groundwater-infiltration explanation. The spatial distribution of C^{14} therefore represents a potentially powerful discriminator between endogenous carbon and environmental addition.
15. **Independent biomolecular preservation provides corroborating evidence that does not depend upon radiocarbon measurement.** Mesozoic dinosaur remains have independently yielded reported **soft tissues, flexible vessel-like structures, cells, collagen, and identifiable proteins**. These observations do not establish the provenance of an individual C^{14} measurement, and preservation mechanisms such as iron-mediated stabilization remain under investigation.

Nevertheless, they constitute an independent preservation problem: the same class of fossils producing unexpectedly measurable radiocarbon also contains molecular and structural material whose persistence requires explanation. The radiocarbon and biomolecular observations therefore form separate lines of evidence rather than one being derived from the other.

The dead giveaway is that the scientists themselves admit that the C14 is actually endogenous to the dinosaur bone, either in a small, large, or the entire amount. That alone confirms that dinosaurs lived recently since no true preservation for C14 and there is no established chemical or fossil-preservation mechanism that does it either.

Scientists claims regarding C14 in Dinosaur fossils

Our first paper, Saitta et al. (2019) in *eLife* excavated a Centrosaurus bone using aseptic procedures and found measurable radiocarbon, but interpreted the non-radio dead carbon largely as evidence for an influx of younger carbon and microbial activity. But here is where it gets Interesting, they also stated that the lower F¹⁴C of the bone relative to surrounding material could indicate “old, and possibly endogenous C,”. So while they personally believe contamination is the cause, the surrounding material forced a concession that perhaps the bone still contains old and intrinsic uncontaminated C14.

Our next paper Lindgren et al. (2011) talks about original biomolecules and measurable radiocarbon in the same fossil. In their paper titled; *Microspectroscopic Evidence of Cretaceous Bone Proteins*. *PLOS ONE*, 6(4), e19445. Their study examined a marine mosasaur, a marine reptile that lived at the time of dinosaurs. After acid–alkali–acid pretreatment, the analyzed bone residue yielded 4.68 ± 0.1 pMC, corresponding to a conventional radiocarbon age of approximately 24,600 BP. Separate analyses supported the preservation of original collagenous material. The useful finding is that evidence for original biomolecules and measurable radiocarbon occurred in the same specimen; the study did not demonstrate that the radiocarbon belonged to those original molecules.

Next, in the Thomas & Nelson (2015) paper titled; *Radiocarbon in Dinosaur and Other Fossils*, concluded that the radiocarbon detected in their fossil samples was “most probably endogenous.” A direct concession that they were looking at true uncontaminated C14 in the bone.

Miller et al. (2019) in their paper titled; *The Search for Solutions to Mysterious Anomalies in the Geologic Column*, makes an even stronger published affirmative claim. They state that significant ¹⁴C was found in dinosaur-bone collagen and other fractions and say their results were demonstrated to be endogenous rather than contamination or systematic instrument error. Another direct admission by the scientists themselves that they were looking at true uncontaminated C14 intrinsic to the bone.

The next paper is by Thomas, Tuinstra, and Taylor (2022) titled; *Finite ages from the Mesozoic era - Is bone collagen an open system?* The researchers reported radiocarbon measurements above instrument-background blanks, including a collagen extract from a hadrosaur. They argued that agreement between collagen-fraction and apatite-fraction radiocarbon dates was “difficult to reconcile” with a younger source for the collagen. Their proposed explanations included original collagen having been buried substantially more recently than conventional age assignments indicate. This is an explicit published argument favoring consideration of original biomaterial and a more recent burial history of an actual dinosaur.

A recent paper by Thomas, Chadwick, and Taylor (2025) titled; *Isotopic and Molecular Preservation in Cretaceous Fossils*. Creation Research Society Quarterly, 62, 114–128. This paper reports fifteen stable-carbon-isotope measurements across six dinosaur-bone specimens, comparing collagen, bioapatite, and bulk fractions. The authors interpret differences between fractions as actually supporting preservation of true endogenous biological isotope signatures rather than wholesale replacement by contaminating carbon.

This evidence supports the broader discussion of original carbon remaining in dinosaur fossils directly from the studies and scientists themselves.

So, has intrinsic dinosaur C14 been claimed in peer-reviewed/published research? Yes, absolutely.

Intrinsic radiocarbon in dinosaur fossils is not merely an unsupported assertion or a claim made by only creationists. Multiple published investigations have reported several-pMC ^{14}C concentrations in independently prepared dinosaur-bone fractions, with many authors concluding that the signal is endogenous. Our own analysis identified fifteen independent or partially independent constraints that a contamination hypothesis must simultaneously explain. Although absolute zero contamination cannot presently be demonstrated, no quantitatively sufficient contamination mechanism has yet been shown to account for the strongest high-pMC dinosaur measurements.

9. Discussion

First, the same trace radiocarbon, in the same low band of roughly 0.1 to 0.5 pMC, recurs across coal, petroleum and natural gas, fossil wood, fossil shells, whale bone, and other materials the conventional timescale calls ancient, measured by many laboratories, on several continents, across more than fifty years. It is a genuine, reproducible feature of the record. Nominally dead carbon does not, in practice, measure as empty.

Second as we touched on earlier, a universal procedural background for baseline C14 results can also predict this pattern. So finding a baseline low C14 measurement can be reconciled by the evolutionary community. However anything higher than baseline near uniform ratio that *Baumgardner* and *Giem* highlighted and any flatness across the column the data show, are therefore consistent with a recent common origin and not with a common background evolutionary floor. The recurrence of C14 and higher than baseline laboratory standard background value of 0.077 ± 0.005 pMC in diverse specimens trends are what a young age predicts.

The low band materials; petroleum, natural gas, and many of Giem's catalogue, sit at or within reach of the procedural background, and for them the contamination reading is not merely possible but, on present measurements, unexcluded. We have said so in each section, and we repeat it here rather than let the aggregate blur it: those materials are an unresolved anomaly, and the measurements that would resolve them, matched process blanks and stepped combustion on the structurally bound fraction, have not been done systematically. If that work is done and the signal survives, the case for those materials becomes strong and we will add them to our list. Until then it is open.

The coal, fossil wood, ammoniates and especially dinosaur bones are different in kind, their values are not fractions of a percent but much higher. Coal, fossil wood and ammoniates sit at three times higher than the floor. Dinosaur fossils vary roughly 1.5 to 5.6 pMC, an order of magnitude above the procedural floor. The explanation that covers the low band materials, a stray microgram of modern

carbon, fails here by a factor of ten or more. In situ nuclear production is excluded independently, because the bones carry less than 20 parts per million of uranium and thorium (Miller et al., 2012), far too little to make the radiocarbon in place. The Singapore team are only left with two options, both fail. Their stated rebuttals were that bacteria don't make collagen, and that contamination shouldn't affect the bioapatite and collagen fractions equally the way their concordant dates did. Finally the Miller group argued *against* an inward water contamination picture: they reported that the surrounding ground showed decreasing carbon-14 with distance from the bone, which they read as modern carbon leaching out of the bone rather than seeping into it (Saitta et al., 2019).

The bone does not stand alone, and its most important support comes from a direction that owes nothing to the radiocarbon debate. The same Mesozoic bones have yielded original soft tissue, flexible vessels, cells, and identifiable proteins (Lindgren et al., 2011). Whether or not one accepts any radiocarbon measurement, the fact is that these soft tissues are difficult for the conventional timescale on its own terms, which is why it has driven an active and unfinished search for preservation mechanisms since its discovery. Those mechanisms are contested, and soft tissue does not by itself fix an age. But just radiocarbon and soft tissue are two independent anomalies in the same specimens, and two independent anomalies are harder to absorb or write off than either alone. Stack that with dinosaur depictions in ancient rock art. The large list detailed above and the fact that fossilization/permineralization is a spectrum that we can observe occur rapidly based on taphonomic conditions or geochemical conditions, and dinosaur bone typically sits toward the *"original material retained, pores mineralized"* end rather than the *"wholly turned to stone"* end (Currie et al 1996).

Bertazzo's team in 2015 examined eight ordinary Cretaceous dinosaur bones, none exceptionally preserved and none showing any outward sign of soft tissue, and still found structures consistent with collagen fibres (with the diagnostic ~67 nm banding) and red-blood-cell-like structures with mass spectra resembling emu blood. Their stated conclusion is that the preservation of soft tissues and even proteins is a more common phenomenon than previously accepted.

This was published in a Nature journal, it's open access, and it took specific steps to rule out modern surface contamination (interior sampling via focused ion beam), which blunts the contamination objection in advance (Bertazzo et al., 2015).

There is a hypothesis that fits the bone data without any strain, and it is the plain one. If these remains are just thousands of years old rather than tens of millions, then they should still contain measurable carbon 14 even at low levels, they should hold recognizable biomolecules, and they should not require exotic chemistry to explain their preservation. That is what is observed. We do not claim the survey as a whole proves a young earth; We claim something narrower and more defensible: that in the material where the signal is strongest and the naturalistic objections weakest, using Occam's razor, the most basic answer is usually the correct one and the evidence points young, and that the young age reading is the one account that takes the radiocarbon and the soft tissue together along with the observational cave art and stories of dinosaurs together (Nailor 2026). While we can even concede that the rocks date old, there is no doubt the life in them is young. Mutation rates, mutation accumulation and collagen decay clocks, and fossilization rates are just a few yet all independent clocks that show life is young.

We add one observation concerning how these results have been treated, while explicitly distinguishing that issue of scientific conduct from the empirical data. Importantly, skepticism has not been applied selectively in this study. Where radiocarbon measurements fall near the procedural

background, we have ourselves regarded contamination and analytical background as viable explanations and have declined to count those low-band measurements as strong evidence for intrinsic C14 until more discriminating experiments are performed.

Our objection therefore is not to contamination as an explanation in principle; we invoke it ourselves where the measurements justify it. Our objection is to invoking contamination without quantitative demonstration when the dinosaur-bone measurements rise far above the procedural regime for which that explanation is adequate.

But the many other signals that sit above the floor we say should not be ignored. In dinosaur fossils it stands ten times above the floor and it was measured at a mainstream facility, was accepted through ordinary review as a conference presentation and was then only later removed from a conference website by session chairmen after the fact, without engaging its merits (Thomas & Nelson, 2015). Applying stringent contamination skepticism to a near floor value is good practice and one we adhered to. Declining to engage a bone value ten times above the floor, while offering no quantitative account of how contamination could reach it, while removing the results from view is a different posture, and readers may weigh the asymmetry for themselves.

10. Conclusion

Radiocarbon should not survive at measurable concentrations in biological material genuinely isolated from carbon exchange for tens of millions of years. Nevertheless, measurable C14 has repeatedly been reported in materials assigned conventional ages far beyond the radiocarbon detection horizon, including coal, fossil wood, ammonites, and dinosaur bone. The strength of these observations is not uniform, and this study has deliberately treated them accordingly. Low-level measurements approaching the procedural background remain vulnerable to contamination and laboratory-background explanations and should not be presented as decisive until material-matched process blanks, stepped combustion, or similarly discriminating controls are performed. This distinction is important because the strongest argument does not depend upon treating every nonzero radiocarbon measurement as equally significant.

The dinosaur-bone measurements constitute the strongest class examined here. Reported concentrations commonly fall around 1.5–5.6 pMC, with individual fractions reaching 6.45 and 7.46 pMC, placing them well above the procedural-background regime discussed for carbon-dead standards. Explaining such measurements through modern carbon requires a quantitatively substantial contribution rather than the trace amounts associated with ordinary instrument background or graphitization. Moreover, the contamination hypothesis must account simultaneously for fifteen constraints identified in this study, including chemically distinct carbon fractions, repeated measurements within individual specimens, results obtained through multiple laboratories and analytical systems, chemical pretreatment, fraction-dependent $\delta^{13}\text{C}$ signatures, interior-versus-exterior radiocarbon differences, limitations on microbial carbon pathways, lack of equilibration with surrounding sediment, insufficient uranium and thorium for the required in-situ C14 production, inadequate ion-source memory, recurrence across specimens, reported spatial gradients, and independent preservation of endogenous biomolecular structures. No individual constraint establishes endogenous radiocarbon by itself; their importance lies in the cumulative burden placed upon any single contamination explanation.

The present analysis also permits a direct quantitative comparison with the pre-Flood radiocarbon model previously published in *Predictions on Trial*. That model begins with 0.1 pMC at Creation, allows radiocarbon to accumulate for 1,500 years while assuming a production rate 20% below the modern normalized baseline, producing approximately 13.36 pMC at the Flood, and then applies 4,500 years of ordinary radioactive decay. The resulting present-day upper boundary is approximately 7.75 pMC. Remarkably, the highest dinosaur-bone concentration examined in this study is 7.46 pMC, with the remaining reported dinosaur measurements likewise falling below the modeled boundary.

This correspondence is particularly important because the model specifies not merely the qualitative expectation that ancient biological materials should contain “some C14,” but a numerical, falsifiable upper boundary. Under the assumptions stated here, securely demonstrated endogenous dinosaur carbon substantially exceeding 7.75 pMC, beyond appropriate analytical and model uncertainty, would count against this particular combination of chronology and radiocarbon-production assumptions. Conversely, measurements below the boundary are consistent with the model, although consistency alone does not prove that every measured carbon fraction is endogenous or establish the model uniquely. This distinction makes the proposal experimentally testable rather than immune to contradictory evidence.

The central conclusion of this study is therefore narrower than the assertion that every anomalous radiocarbon measurement proves a recent age. Instead, the evidence establishes a specific experimental problem: high-pMC dinosaur bone cannot be adequately dismissed by invoking contamination merely as a possibility. A successful alternative explanation must identify the contaminating carbon, demonstrate its pathway into the measured chemical fraction, quantify enough of it to reproduce the observed pMC concentration, and remain consistent with the other specimen-level constraints described here. Until such a mechanism is demonstrated, an endogenous contribution to the measured radiocarbon remains a hypothesis requiring direct experimental consideration.

Most significantly, the radiocarbon measurements now stand alongside a previously published quantitative recent-age model whose predicted upper boundary closely brackets the observed dinosaur-bone dataset. Whether future measurements continue to remain beneath that boundary provides a straightforward test. Future blind analyses of freshly excavated dinosaur bones, using documented conservation histories, multiple purified fractions, material-matched process blanks, and independent laboratories, can therefore either strengthen this correspondence or falsify it. That is the experiment upon which the model should ultimately stand or fall.

Appendix A

Sample Preparation and Background Data

Table 1 below was pulled from Baumgardner 2005 and contains most of Gien's [2001] data, plus data from several more recent papers. Included in the list are a number of samples from the Precambrian, that is, what Baumgardner considered non-organic pre-Flood settings.

Table 1. AMS measurements on samples conventionally deemed older than 100 ka.

Item	¹⁴ C/C (pMC) (±1 SD)	Material	Reference
1	0.71±?*	Marble	<i>Aerts-Bijma et al.</i> [1997]
2	0.65±0.04	Shell	<i>Beukens</i> [1990]
3	0.61±0.12	Foraminifera	<i>Arnold et al.</i> [1987]
4	0.60±0.04	Commercial graphite	<i>Schmidt et al.</i> [1987]
5	0.58±0.09	Foraminifera (<i>Pyrgo murrhina</i>)	<i>Nadeau et al.</i> [2001]
6	0.54±0.04	Calcite	<i>Beukens</i> [1990]
7	0.52±0.20	Shell (<i>Spisula subtruncata</i>)	<i>Nadeau et al.</i> [2001]
8	0.52±0.04	Whale bone	<i>Jull et al.</i> [1986]
9	0.51±0.08	Marble	<i>Gulliksen and Thomsen</i> [1992]
10	0.5±0.1	Wood, 60 ka	<i>Gillespie and Hedges</i> [1984]
11	0.46±0.03	Wood	<i>Beukens</i> [1990]
12	0.46±0.03	Wood	<i>Vogel et al.</i> [1987]
13	0.44±0.13	Anthracite	<i>Vogel et al.</i> [1987]
14	0.42±0.03	Anthracite	<i>Grootes et al.</i> [1986]
15	0.401±0.084	Foraminifera (untreated)	<i>Schleicher et al.</i> [1998]
16	0.40±0.07	Shell (<i>Turitella communis</i>)	<i>Nadeau et al.</i> [2001]
17	0.383±0.045	Wood (charred)	<i>Snelling</i> [1997]
18	0.358±0.033	Anthracite	<i>Beukens et al.</i> [1992]
19	0.35±0.03	Shell (<i>Varicorbula gibba</i>)	<i>Nadeau et al.</i> [2001]
20	0.342±0.037	Wood	<i>Beukens et al.</i> [1992]
21	0.34±0.11	Recycled graphite	<i>Arnold et al.</i> [1987]
22	0.32±0.06	Foraminifera	<i>Gulliksen and Thomsen</i> [1992]
23	0.3±?	Coke	<i>Terrasi et al.</i> [1990]
24	0.3±?	Coal	<i>Schleicher et al.</i> [1998]
25	0.26±0.02	Marble	<i>Schmidt et al.</i> [1987]
26	0.2334±0.061	Carbon powder	<i>McNichol et al.</i> [1995]
27	0.23±0.04	Foraminifera (mixed species avg)	<i>Nadeau et al.</i> [2001]
28	0.211±0.018	Fossil wood	<i>Beukens</i> [1990]
29	0.21±0.02	Marble	<i>Schmidt et al.</i> [1987]
30	0.21±0.06	CO ₂	<i>Grootes et al.</i> [1986]
31	0.20–0.35* (range)	Anthracite	<i>Aerts-Bijma et al.</i> [1997]
32	0.20±0.04	Shell (<i>Ostrea edulis</i>)	<i>Nadeau et al.</i> [2001]
33	0.20±0.04	Shell (<i>Pecten opercularis</i>)	<i>Nadeau et al.</i> [2001]
34	0.2±0.1*	Calcite	<i>Donahue et al.</i> [1997]
35	0.198±0.060	Carbon powder	<i>McNichol et al.</i> [1995]
36	0.18±0.05 (range?)	Marble	<i>Van der Borg et al.</i> [1997]
37	0.18±0.03	Whale bone	<i>Gulliksen and Thomsen</i> [1992]
38	0.18±0.03	Calcite	<i>Gulliksen and Thomsen</i> [1992]
39	0.18±0.01**	Anthracite	<i>Nelson et al.</i> [1986]
40	0.18±?	Recycled graphite	<i>Van der Borg et al.</i> [1997]
41	0.17±0.03	Natural gas	<i>Gulliksen and Thomsen</i> [1992]
42	0.166±0.008	Foraminifera (treated)	<i>Schleicher et al.</i> [1998]
43	0.162±?	Wood	<i>Kirner et al.</i> [1997]
44	0.16±0.03	Wood	<i>Gulliksen and Thomsen</i> [1992]
45	0.154±?***	Anthracite coal	<i>Schmidt et al.</i> [1987]

Item	¹⁴ C/C (pMC) (±1 SD)	Material	Reference
46	0.152±0.025	Wood	<i>Beukens</i> [1990]
47	0.142±0.023	Anthracite	<i>Vogel et al.</i> [1987]
48	0.142±0.028	CaC ₂ from coal	<i>Gurfinkel</i> [1987]
49	0.14±0.02	Marble	<i>Schleicher et al.</i> [1998]
50	0.13±0.03	Shell (<i>Mytilus edulis</i>)	<i>Nadeau et al.</i> [2001]
51	0.130±0.009	Graphite	<i>Gurfinkel</i> [1987]
52	0.128±0.056	Graphite	<i>Vogel et al.</i> [1987]
53	0.125±0.060	Calcite	<i>Vogel et al.</i> [1987]
54	0.12±0.03	Foraminifera (<i>N. pachyderma</i>)	<i>Nadeau et al.</i> [2001]
55	0.112±0.057	Bituminous coal	<i>Kitagawa et al.</i> [1993]
56	0.1±0.01	Graphite (NBS)	<i>Donahue et al.</i> [1990]
57	0.1±0.05	Petroleum, cracked	<i>Gillespie & Hedges</i> [1984]
58	0.098±0.009*	Marble	<i>Schleicher et al.</i> [1998]
59	0.092±0.006	Wood	<i>Kirner et al.</i> [1995]
60	0.09–0.18* (range)	Graphite powder	<i>Aerts-Bijma et al.</i> [1997]
61	0.09–0.13* (range)	Fossil CO ₂ gas	<i>Aerts-Bijma et al.</i> [1997]
62	0.089±0.017	Graphite	<i>Arnold et al.</i> [1987]
63	0.081±0.019	Anthracite	<i>Beukens</i> [1992]
64	0.08±?	Natural Graphite	<i>Donahue et al.</i> [1990]
65	0.080±0.028	Carrarra marble	<i>Nadeau et al.</i> [2001]
66	0.077±0.005	Natural Gas	<i>Beukens</i> [1992]
67	0.076±0.009	Marble	<i>Beukens</i> [1992]
68	0.074±0.014	Graphite powder	<i>Kirner et al.</i> [1995]
69	0.07±?	Graphite	<i>Kretschmer et al.</i> [1998]
70	0.068±0.028	Calcite (Icelandic double spar)	<i>Nadeau et al.</i> [2001]
71	0.068±0.009	Graphite (fresh surface)	<i>Schmidt et al.</i> [1987]
72	0.06–0.11 (range)	Graphite (200 Ma)	<i>Nakai et al.</i> [1984]
73	0.056±?	Wood (selected data)	<i>Kirner et al.</i> [1997]
74	0.05±0.01	Carbon	<i>Wild et al.</i> [1998]
75	0.05±?	Carbon-12 (mass spectrometer)	<i>Schmidt, et al.</i> [1987]
76	0.045–0.012 (-0.06)	Graphite	<i>Grootes et al.</i> [1986]
77	0.04±?*	Graphite rod	<i>Aerts-Bijma et al.</i> [1997]
78	0.04±0.01	Graphite (Finland)	<i>Bonani et al.</i> [1986]
79	0.04±0.02	Graphite	<i>Van der Borg et al.</i> [1997]
80	0.04±0.02	Graphite (Ceylon)	<i>Bird et al.</i> [1999]
81	0.036±0.005	Graphite (air)	<i>Schmidt et al.</i> [1987]
82	0.033±0.013	Graphite	<i>Kirner et al.</i> [1995]
83	0.03±0.015	Carbon powder	<i>Schleicher et al.</i> [1998]
84	0.030±0.007	Graphite (air redone)	<i>Schmidt et al.</i> [1987]
85	0.029±0.006	Graphite (argon redone)	<i>Schmidt et al.</i> [1987]
86	0.029±0.010	Graphite (fresh surface)	<i>Schmidt et al.</i> [1987]
87	0.02±?	Carbon powder	<i>Pearson et al.</i> [1998]
88	0.019±0.009	Graphite	<i>Nadeau et al.</i> [2001]
89	0.019±0.004	Graphite (argon)	<i>Schmidt et al.</i> [1987]
90	0.014±0.010	CaC ₂ (technical grade)	<i>Beukens</i> [1993]

*Estimated from graph **Lowest value of multiple dates

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