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Radiocarbon Ages for Fossil Ammonites and Wood in Cretaceous Strata near Redding, California

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Abstract

Fossil ammonites from lower Cretaceous mudstones in northern California, which are supposedly 112–120 million years old and biostratigraphic index fossils, were sampled along with fossil wood buried with them. Fragments of two fossil ammonite shells and four pieces of fossil wood yielded easily measurable radiocarbon (^{14}C) equivalent to apparent ^{14}C ages of between 36,400±350 and 48,710±930 years for the ammonites, and between 32,780±230 and 42,390±510 years for the wood. Any contamination with modern ^{14}C due to the sample environment and handling was eliminated by the laboratory's severe pre-treatment procedure. Any alleged contamination due to sample combustion or AMS instrument background was more than compensated for by the laboratory background of 0.077 pMC already having been subtracted from the reported results. The ammonite shells could not have been contaminated in the ground by replacement with modern carbonate ^{14}C either, because they yielded almost identical ^{14}C apparent ages as the wood buried and fossilized with them. It was concluded that the measured ^{14}C is in situ radiocarbon intrinsic to the ammonites and wood when they were buried and fossilized. So once past conditions in the atmosphere and biosphere are taken into account, their true ages are consistent with their burial during the Genesis Flood only about 4,300 years ago, when the ocean waters washed sediments and ammonites onto the continents.

Keywords: Fossil ammonites, Fossil wood, Lower Cretaceous, Radiocarbon, Apparent ages, Contamination, Pre-treatment procedure, Laboratory background, In situ radiocarbon, True ages, Genesis Flood

Introduction

Measurable ^{14}C (radiocarbon) has been detected in fossils from the earliest days of radiocarbon dating. In many instances, according to their supposed uniformitarian ages those fossils should be completely ^{14}C-dead, that is, all ^{14}C originally in them should have decayed, so they should not have any ^{14}C left in them.

When these data are put in perspective, their deadly significance to the uniformitarian timescale is readily apparent. ^{14}C has a half-life of 5,730 years. If an organism when it was buried and fossilized contained the level of ^{14}C currently in plants and animals, then after one million years, corresponding to 174.5 ^{14}C half-lives, the fraction of the original ^{14}C remaining would be 3×10^{-53}. However, a mass of ^{14}C equal to the entire mass of the earth (6×10^{24} kg) contains only about 3×10^{50} ^{14}C atoms (Baumgardner 2005). Thus, not a single atom of ^{14}C formed even 1 million years ago anywhere in or on the earth should conceivably still exist. Therefore, there should be absolutely no measurable ^{14}C able to be detected in fossils claimed to be a million or more years old.

Whitelaw (1970) surveyed all the ^{14}C dates reported in the journal *Radiocarbon* up to 1970 and found that for more than 15,000 samples, all such matter was "datable within 50,000 years as published." These samples included coal, oil, natural gas, and other allegedly very ancient (> one million years old) material. The scientific community never took these anomalies seriously, because these measurements were obtained using the β-decay counting technique, by which it was difficult to distinguish between the decay of ^{14}C atoms and background cosmic rays. Thus, for samples such as these whose location in the geological record mandated they were so old they should be ^{14}C dead, the measurable ^{14}C levels detected were simply attributed to measurement errors that had incorporated the cosmic ray background.

The accelerator mass spectrometer (AMS) method was developed in the early 1980s. It superseded the β-decay counting technique, because it counts ^{14}C atoms directly and so is not compromised by background cosmic rays. Snelling (1997, 1998, 1999, 2000a, b, 2008) had samples of fossilized woods, from Tertiary, Mesozoic and upper Paleozoic strata conventionally dated as 30 to 250 million years old, ^{14}C tested using the AMS method at two laboratories. In all cases ^{14}C levels were obtained that are well above the AMS detection threshold. Values ranged from 7.58±1.11 pMC (percent modern carbon, that is, percent of the modern atmospheric $^{14}C/C$ ratio) for a lower Jurassic sample to 0.38±0.04 pMC for a middle Tertiary sample. This range in the $^{14}C/C$ ratio implies radiocarbon ages of between 20,700±1200 and 44,700±950 years, respectively, assuming the modern atmospheric $^{14}C/C$ ratio existed when these trees were alive. Such ^{14}C contents in these fossilized

woods limit their ages to only thousands of years, contrary to their conventional uniformitarian ages of tens to hundreds of millions of years.

Giem (2001) tabulated about seventy AMS measurements, published between 1984 and 1998 in the standard radiocarbon literature, all of organic materials that yielded significant levels of ^{14}C when according to their conventional uniformitarian ages they should be entirely ^{14}C dead. These organic materials included not only fossilized wood, but natural graphite, coal, natural gas, oil, fossilized shells and bones, and even marble, from every portion of the Phanerozoic (Cambrian to Recent) geologic record. All contained detectable ^{14}C levels well above the AMS threshold, with the $^{14}C/C$ ratios from those measurements considered the most reliable falling in the 0.1-0.5 pMC range. Giem (2001) argued that instrument error could be eliminated as an explanation on experimental grounds. He further showed that contamination of the ^{14}C-bearing fossil material in situ was unlikely, but theoretically possible, and was a testable hypothesis. While contamination during sample preparation was a genuine problem, the conventional literature showed that it could be reduced to low levels by proper laboratory procedures. He concluded, therefore, that the detected ^{14}C in these samples most likely originates from the original organisms themselves.

Baumgardner et al. (2003) and Baumgardner (2005) selected ten coal samples from the U.S. Department of Energy Coal Sample Bank maintained at Pennsylvania State University. These ten samples provided good representation of U.S. coals geographically as well as with respect to depth in the geologic record. Three were Eocene coals, three Cretaceous, and four Pennsylvanian, spanning 40–300 million years on the conventional uniformitarian timescale. The AMS $^{14}C/C$ results ranged from 0.10±0.03 pMC in a Utah Cretaceous coal to 0.46±0.03 pMC in a Kentucky Pennsylvanian coal (with the laboratory's standard background of 0.077±0.005 pMC subtracted). Of added significance were the averages of the results for each geologic time interval—a mean value of 0.26 pMC for the Eocene coals, 0.21 pMC for the Cretaceous coals, and 0.27 pMC for the Pennsylvanian coals. These data were interpreted as implying that all these coal beds are, in reality, the same 48,000–50,000 radiocarbon years age, which is consistent with their deposition in the Flood year of the biblical timescale.

Baumgardner (2005) also had twelve diamonds tested for ^{14}C by the AMS method. Five of these diamonds were from underground mining of volcanic kimberlite pipes at Kimberley (South Africa), and at Orapa and Letlhakane (Botswana), while the sixth diamond was from the Kankan alluvial deposit in Guinea (West Africa), and the other six diamonds were from alluvial deposits in Namibia. In conventional terms, all these diamonds are regarded as hundreds of millions to billions of years old, having been sourced from the earth's mantle. The AMS $^{14}C/C$ results ranged from 0.10±0.03 pMC for the Kimberley diamond to 0.39±0.02 pMC for one of the Namibian alluvial diamonds (with the laboratory's standard background of 0.077±0.005 pMC not subtracted). The average of the values for the five diamonds from kimberlite mines was 0.04 pMC, and for the seven alluvial diamonds 0.12 pMC, after the laboratory's standard background was subtracted. Similar detectable levels of ^{14}C have been confirmed more recently in other diamonds (Taylor and Southon 2007). This may suggest this ^{14}C is intrinsic to the diamonds, which being extremely resistant to contamination almost certainly have not experienced any recent exchange of their carbon atoms with those in the atmosphere.

For more than two decades the conventional radiocarbon specialists have struggled to understand and explain these significant amounts of ^{14}C, intrinsic to all these organic materials and diamonds, that they have measured well above the threshold of their AMS instruments, when these materials should be ^{14}C dead according to their standard uniformitarian geologic timescale. Invariably they have been forced by their paradigm to conclude that this ^{14}C principally represents intrinsic contamination in the samples when they arrived at the laboratories, with the minor possibilities of background ^{14}C added to the samples in the laboratories during processing, and of instrument background due to the detectors and ion beam (Beukens 1990; Bird et al. 1999; Nadeau et al. 2001; Taylor and Southon 2007; Vogel, Nelson, and Southon 1987). However, contamination due to laboratory processing of samples can be effectively ruled out, due to the harsh chemical treatment of samples designed to remove all possible contamination, even that from handling of samples during field collection, storage and dispatch to the laboratory. Furthermore, the ^{14}C levels being measured in these ancient organic materials after sample preparation swamps any ^{14}C attributable to the supposed laboratory processing and/or instrument backgrounds.

On the other hand, if the long-ages uniformitarian timescale is rejected, then these ancient organic materials would not necessarily be ^{14}C dead, particularly if they really were only 6,000 or so years old since the time of Creation. In the biblical timescale the carbon cycle suffered a catastrophic upheaval at the time of the Flood cataclysm about 4,500 years ago, so ^{14}C "ages" of 48,000–50,000 years for coal beds deposited during that event cannot be absolute or real time ages. Ultimately, what is needed is a method of

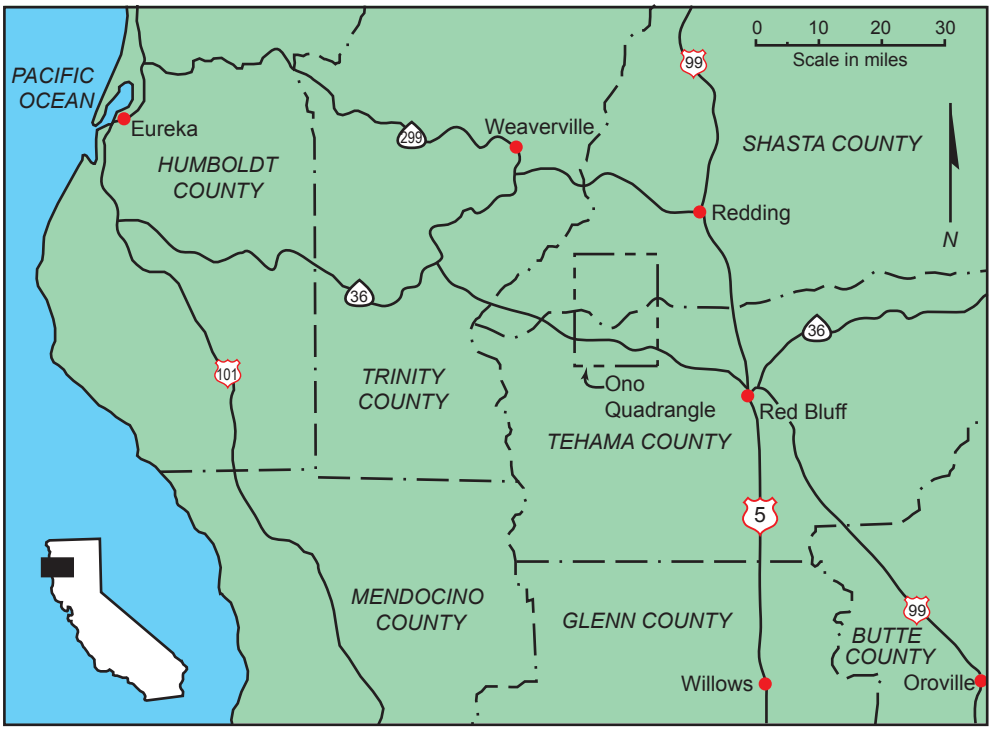

Fig. 1. Map showing the location of the Ono Quadrangle straddling the boundary between Shasta and Tehama Counties near Redding in northern California.

recalibrating these "radiocarbon years" with the real-time, biblical framework of earth history, which takes into account the effects of the Flood, the post-Flood Ice Age, and the decreasing strength of the earth's magnetic field. In the meantime, it is important to continue increasing the database of radiocarbon levels in ancient organic materials from the geologic record.

To-date there appears to be no ^{14}C data for two different types of ancient organic materials fossilized together in the geologic record. It would surely be expected that co-fossilized organic materials should contain similar ^{14}C levels, because the organisms would have originally lived at the same time. However, if in situ contamination is the problem claimed by the conventional uniformitarian view for these elevated ^{14}C levels in ancient organic materials, the different co-fossilized organic materials might be expected to have different ^{14}C levels. This would be due to the different modes of supposed contamination of the different organic materials. A test of just this situation is available in the Cretaceous strata of Ono Quadrangle near Redding in northern California, where wood has been found fossilized with ammonites.

The Cretaceous Strata and Fossils of Ono Quadrangle

The location of the Ono Quadrangle, near Redding in northern California, is shown in Fig. 1. It straddles the boundary between Shasta and Tehama Counties west of Interstate 5 between Red Bluff and Redding. Fig. 2 (after Rodda and Murphy 1987) is a geologic map of the Ono Quadrangle. Of interest are the lower Cretaceous strata of the Budden Canyon Formation.

Previous work

The geology and paleontology of the area, known as the Cottonwood District, have been described in numerous scientific publications spanning more than 140 years, including some of the earliest geological studies in California (Whitney, 1864, 1865). Diller (1889, 1893) and Diller and Stanton (1884) provided more information on the geology of the Cretaceous rocks of the Cottonwood District than any paper for the subsequent 60 years. The latter included a generalized geologic section along the North Fork of Cottonwood Creek with lists of fossils collected at several generalized stratigraphic horizons.

Diller (1894) was the first to describe the late Cenozoic non-marine deposits of the Cottonwood District. Anderson (1902, 1938, 1958) was responsible for describing the Cretaceous fossils from the Pacific coast, mostly Californian ammonites, accompanied by syntheses and generalized discussions of the stratigraphy and historical geology. However, his geologic and locality data were an inadequate basis for subsequent investigations. Instead, Anderson and Russell (1939) remains the basic documentation of the geology and stratigraphy of the late Cenozoic, non-marine deposits of the northern Sacramento valley, including the Tehama and Red Bluff Formations of Shasta County. In the area which this study focuses

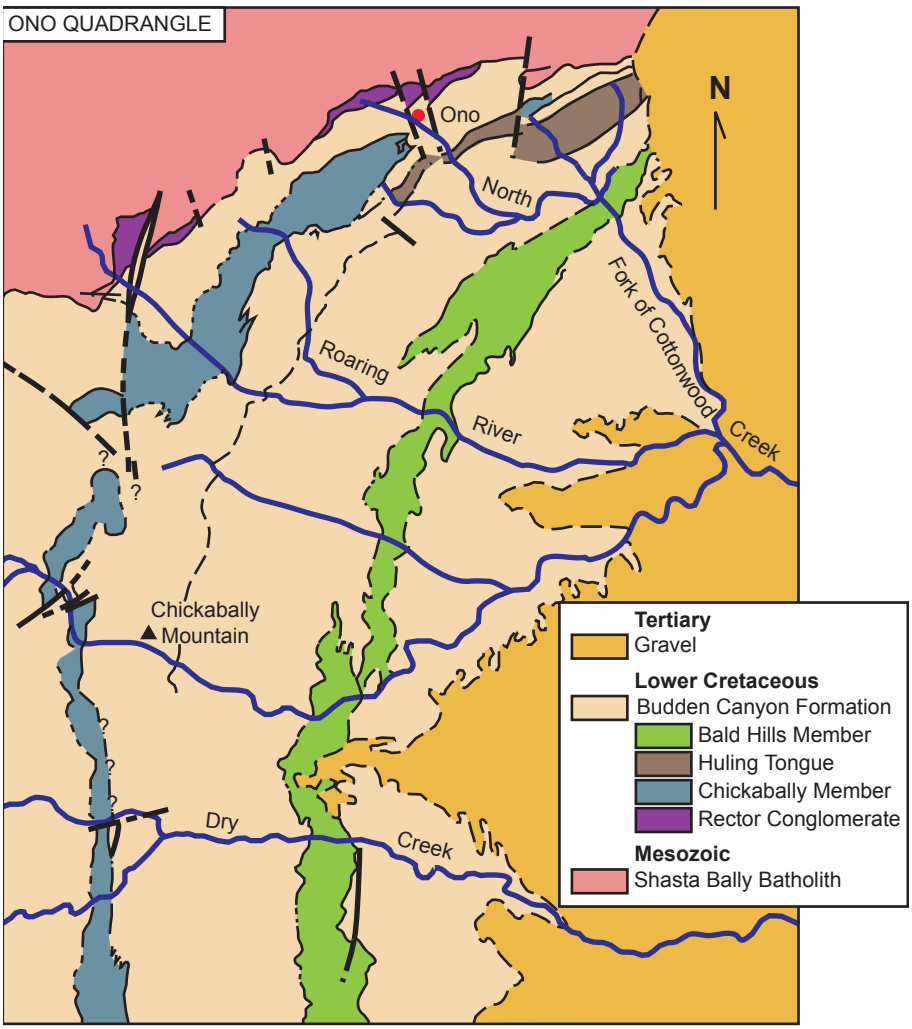

Fig 2. Geologic map of the Ono Quadrangle, showing the exposed area of the lower Cretaceous Budden Canyon Formation (after Rodda and Murphy 1981).

on, it has been supplanted by later more detailed publications.

The principal sources of geologic data for the Cottonwood District of the Ono Quadrangle are detailed geologic maps, detailed stratigraphic sections, and detailed information on the stratigraphic relationships at fossil collecting sites provided by subsequent papers. Murphy, Rodda, and Morton (1969) provides a detailed geologic study of the area. Stratigraphic studies with data on fossil collecting include Murphy (1956), which provides data for lower Cretaceous rocks, and Murphy and Rodda (1959, 1960), which provide data on the area's upper Cretaceous rocks. Jones, Murphy, and Packard (1965), and Hill (1975), provide data for the Huling Creek-North Fork of Cottonwood Creek area.

Many other publications discuss the general distribution and relationships of the geological and fossiliferous units exposed in the Cottonwood District. These include Hacket (1966), Ingersoll (1979), Ingersoll, Rich, and Dickinson (1977), Lachenbruch (1962), Murphy, Peterson, and Rodda (1964), Ojakangas (1968), Olmstead and Davis (1961), Peterson (1966, 1967), Pierce (1983), Popenoe, Imlay, and Murphy (1960), and Repenning (1960).

The shells of Cretaceous marine mollusks, including gastropods (snails), bivalves (clams, oysters, etc.), scaphopods (tusk shells), and cephalopods (ammonites, nautiloids), are by far the most abundant and most extensively described fossils in the Cottonwood District. Of these, the most widely distributed are the ammonites. They are also the most important scientifically, because they serve as the standard index fossils for determining biostratigraphic ages through the Mesozoic (the Triassic, Jurassic and Cretaceous Periods) and for establishing correlations with rock units in distant areas.

For more than 145 years the ammonites and other fossil invertebrates from the Cottonwood District have thus been the subject of numerous papers. Nearly 300 named species of invertebrate fossils have been recognized in the Cretaceous rocks of the area, including 180 species of ammonites, 50 species of gastropods, 50 species of bivalves, 1 species of scaphopod, and 3 species of brachiopods. Of these, 50% were described as new species on the basis of the specimens collected, or probably collected, in the area, mostly from the North Fork of Cottonwood Creek and the Huling Creek drainages.

The majority of the fossil species recorded from the Cottonwood District were described in reconnaissance-level reports, based on highly generalized, commonly inaccurate, locality and stratigraphic data. One of the first fossils described in California was an ammonite from the Cottonwood District, which provided the first recognition of Cretaceous rocks in California (Trask 1855). Gabb (1864, 1869), papers issued by the Second Geological Survey of California (the Whitney Survey), are the first major paleontological reports to describe Californian Cretaceous fossils. Many species were recorded from the Cottonwood District, including some 35 new species based on specimens probably collected along the North Fork of Cottonwood

Creek or along Huling Creek. Stewart (1926, 1930) reviewed and redescribed Gabb's Californian species of fossil gastropods and bivalves, without providing any new geologic data.

Stanton (1893) and Diller and Stanton (1894) provide lists of fossil species (mostly mollusks) collected from generalized stratigraphic horizons along the North Fork of Cottonwood Creek and Huling Creek. Other early paleontological reports that mention the Cottonwood District include White (1885) and Cooper (1888). Anderson (1902, 1931, 1938, 1958) made extensive collections from the Cottonwood District, describing almost 100 new species (mostly ammonites) based on specimens from, or probably from, the drainage areas of the North Fork of Cottonwood Creek and Huling Creek.

Murphy (1956), though he did not extensively describe or discuss the fossils, provided the first detailed geologic map, locality data, and accurate stratigraphic placement of the fossils of the Cottonwood District. That paper, and similar work by Rodda (1959) on the upper Cretaceous rocks, provided the initial stratigraphic and locality data on which several later paleontological studies were partly based. These papers, which include the descriptions of many new species and the redescription of old ones, are Hill (1975), Jones, Murphy, and Packard (1965), Matsumoto (1959a, b, 1960), Murphy (1967a, b, c), Murphy and Rodda (1959, 1960, 1977), Popenoe (1957), and Saul (1973). Matsumoto (1959a, b, 1960) represent a major review of the Californian upper Cretaceous ammonites based principally on a compilation of collections and locality data from many sources.

Other descriptive paleontological papers that include fossils from the Cottonwood District are Saul and Popenoe (1962) and Wiedman (1962). Murphy, Rodda, and Morton (1969) provide additional important geologic and biostratigraphic data for the Ono Quadrangle, while Murphy (1975) is a detailed study of the stratigraphy and paleontology of the lower Cretaceous strata, including those within the Cottonwood District. Since the compilation of Rodda and Murphy (1985) there have been only two further papers that directly concern the invertebrate fossils of the Cottonwood District, namely, Saul (1978) and Popenoe, Saul, and Susuki (1987), both of which describe bivalves and gastropods.

The few, non-molluscan, Cretaceous invertebrates that have been described or recorded from the Cottonwood District include brachiopods and shelled microfossils. Brachiopods are uncommon, and only three species have been recorded (Anderson 1938; Murphy 1956). Rodda and Murphy (1985) reported a diverse assemblage of marine microfossils, including 41 species of foraminifera, 23 species of radiolarian, and 2 unidentified species of ostracods. They also reported three shark teeth and a single fish vertebra from the area. More recently, a further single shark tooth, two fish teeth, one fish scale, and two sections of fish vertebra have been found (Franklin, personal communication). No other vertebrate fossils have been recorded from the area's Cretaceous rocks.

Petrified and carbonized wood are common fossils in many parts of the Cottonwood District. Twigs, leaves and other plant parts have been noted, but there are few published records for the area. Ward (1905) mentions "dicotyledonous leaves" from near the mouth of Huling Creek, but those fossils were never specifically identified or described. Eight species of Cretaceous plants were identified by Fontaine (1905) from specimens collected from a tributary of the North Fork of Cottonwood Creek. Some of those specimens were redescribed by Miller (1975).

Chandler and Axelrod (1961) described one of the earliest fossil angiosperms from a specimen collected by Murphy and Rodda in lower Cretaceous strata along the North Fork of Cottonwood Creek. However, Wolfe, Doyle, and Page (1975) questioned the angiosperm affinities of this specimen, so its significance is equivocal. Nevertheless, Rodda and Murphy (1985) reported undetermined angiosperm seeds, conifer twigs, and seed fern parts from two localities in the same area. More recently, a number of plant seed pods as well as tree cones with seeds have been found in the Cottonwood area (Franklin, personal communication).

The Geology

Two principal geological units are exposed in the Cottonwood District in the northern part of Ono Quadrangle—the Cretaceous (late Flood) marine sedimentary units of the Budden Canyon Formation, and the overlying non-marine, undifferentiated Tehama-Red Bluff Formations of Pliocene and Pleistocene (post-Flood) age (Rodda and Murphy, 1978, 1985, 1987). Even younger are the thin river terrace deposits and modern channel and floodplain deposits along the major streams. The general distribution of these major geological units is indicated in Fig. 2. They are part of the extensive suite of Mesozoic and Cenozoic rocks that crop out on the western side of the Sacramento River valley. Only the Cretaceous rocks and their fossils are of significance to this study.

The Budden Canyon Formation is composed of predominantly gray-colored, marine mudstone, siltstone, sandstone, and conglomerate, and has been subdivided into seven members (fig. 3). In the Cottonwood District the maximum thickness of the Budden Canyon Formation is about 6,700 meters (22,000 feet) along the Dry Creek-Budden Canyon type section. To the north the Formation thins. Based on its fossil content the Formation ranges in geologic

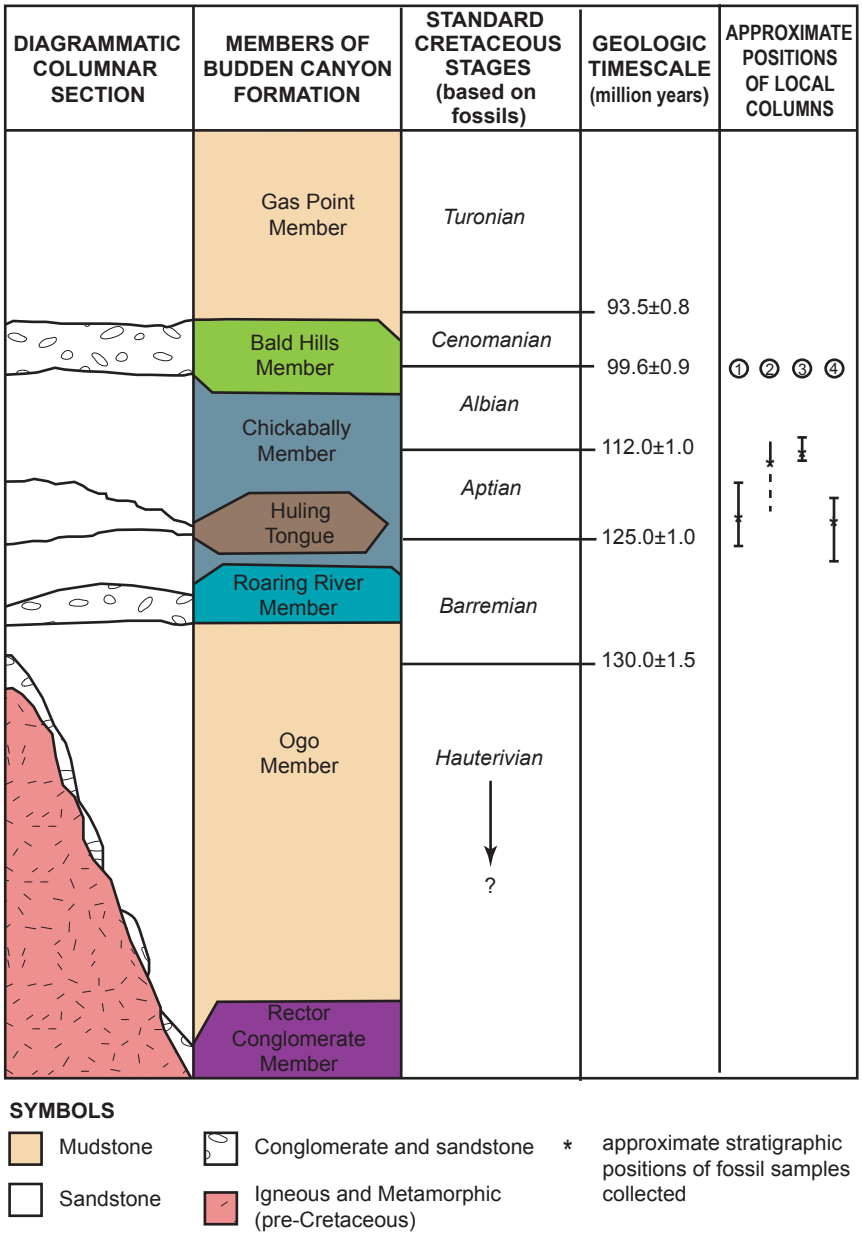

Fig 3. Diagrammatic classification of the members of the Budden Canyon formation plotted against the biostratigraphic stages of the Cretaceous and the geologic timescale as determined by radioisotope dating (after Gradstein et al. 2004 and Rodda and Murphy 1987). The approximate stratigraphic positions of the local strata columns from which each samples was collected is also shown.

age from the early part of the Lower Cretaceous (Hauterivian) at more than 130 million years ago, to the middle part of the Upper Cretaceous (Turonian) at less than 90 million years ago (Gradstein, Ogg, and Smith 2004), a supposed total time span of at least 40 million years (fig. 3).

In the area the strata of the Budden Canyon Formation strike north to northeast and dip to the east and southeast (fig. 2). The oldest (lower) part of the strata sequence is to the west and north where the Formation laps onto the older igneous and metamorphic rocks of the Klamath Mountains. The principal streams flow eastward and southward across the strike of the Formation, and expose the strata in regular sequence from oldest to youngest (fig. 2). The Budden Canyon Formation consists mostly of fine-grained mudstones and siltstones which form rounded hills mantled by deep, mostly grass-covered soil. Outcrops are virtually confined to the bottoms and banks of streams and gullies.

Within the study area (figs. 2 and 4) only the lower half of the Budden Canyon Formation is exposed. This portion is 900–1,200 meters (3,000–4,000 feet) thick along the North Fork of Cottonwood Creek and Huling Creek drainages. Rodda and Murphy (1987) acquired more detailed and comprehensive data on the Cretaceous stratigraphy exposed in these drainages, substantiating the accuracy of earlier mapping, and providing increased documentation of the density and patterns of faulting. They reported that field observations and examination of air photos indicated numerous small faults in zones parallel to and extending away from previously known major faults. Thus this extensive faulting, in these Cretaceous strata where there are few distinctive marker beds, renders most measured stratigraphic sections discontinuous by an unknown, but presumably small, amount. From their field observations, Rodda and Murphy (1987) maintained that the displacements on these small faults are almost all less than the thickness of one ammonite zone. Furthermore, this recognition of the abundance of small faults in some areas (for example, near the confluence of Bee Creek with the North Fork of Cottonwood Creek—fig. 4) had required modification or replacement of some previously measured and described stratigraphic sections.

Another feature Rodda and Murphy (1987) reported as now known to be more extensive than was

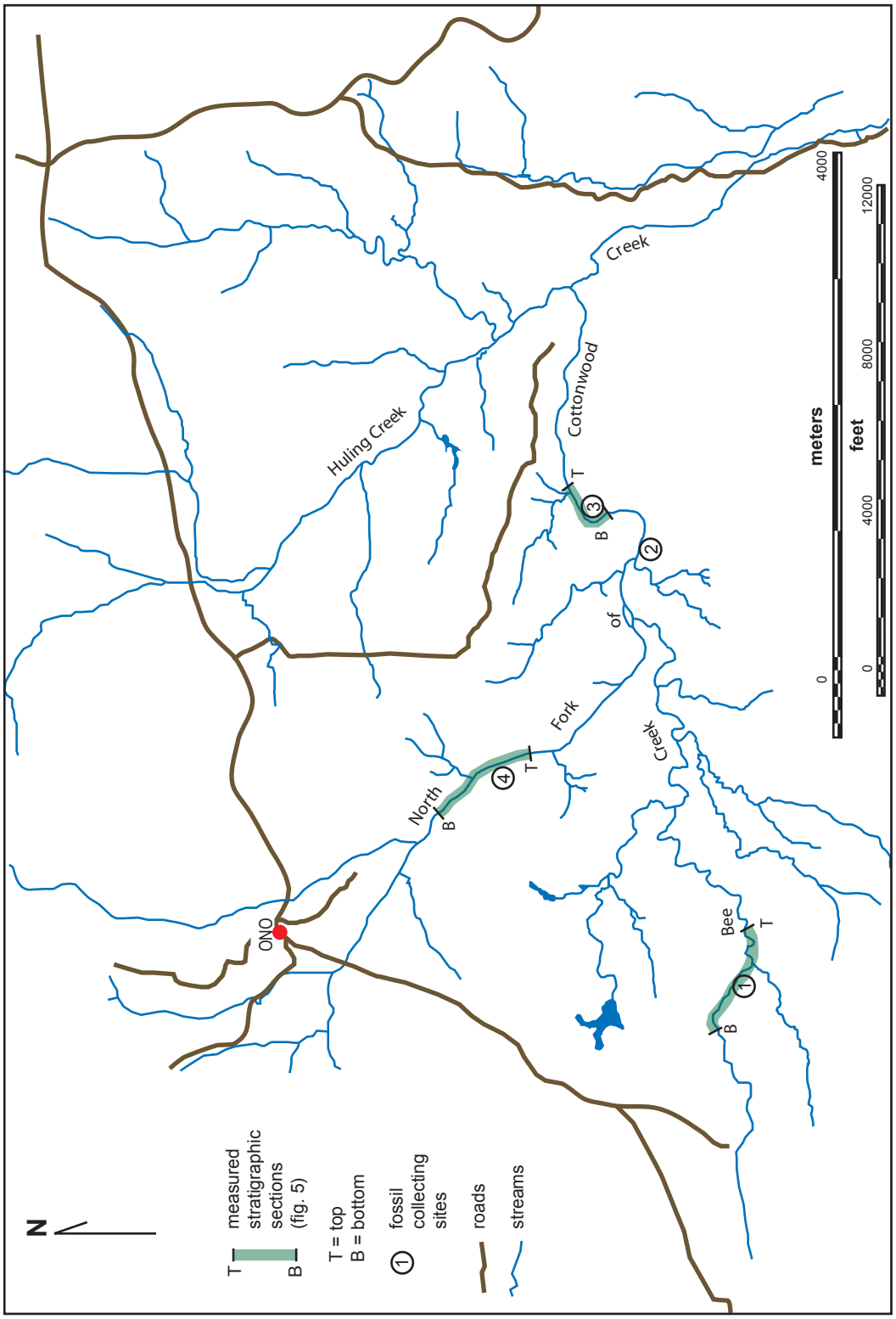

Fig. 4. Map of the North Fork of Cottonwood Creek drainage area near Ono in the northern section of Ono Quadrangle, Shasta County, showing the measured stratigraphic sections from which the fossil samples were collected (after Rodda and Murphy 1987).

previously recognized is the early post-depositional submarine slumping of the Cretaceous strata. This slumping, well exposed in some stream bluffs, has locally folded, contorted, or disrupted the bedding, and is another cause of discontinuous measured stratigraphic sections. They also recognized that the primary sedimentary structures of most of the mudstone and siltstone strata (the most common rock types), and some of the sandstone layers, have been obliterated by the intensive burrowing of the diverse infauna that must have densely populated the seafloor when these Cretaceous sediments were deposited and buried them. These burrowing animals essentially homogenized the fine-grained sediments, except where early-formed calcareous nodules locally stabilized the mud and silt.

Rodda and Murphy (1987) also significantly increased the available data on paleocurrent directions for these Cretaceous strata, supporting previous conclusions of generally southward-flowing bottom-currents being responsible for their deposition. Furthermore, they interpreted the presence of two previously unrecognized depositional environments in the Cretaceous rocks exposed along the North Fork of the Cottonwood Creek. An interval in the upper Albian Stage is marked by greensands and phosphatic sand grains that accumulated in broad shallow channels. Another interval is marked by shallow channels filled with a mixture of shallow-water shells, including many oysters, which contrast with the apparently deep-water aspect of these Cretaceous strata. They claim that the apparent shallow-water interpretation of these deposits is supported by the recognition of shallow-water foraminifera in this interval.

The Fossils

Well preserved fossil invertebrates, mostly ammonites, are found occasionally in most parts of the Budden Canyon Formation, but the outcrops along the North Fork of Cottonwood Creek and its tributaries are especially rich collecting sites. According to Rodda and Murphy (1987) they comprise the finest stratigraphic sequence of Cretaceous fossils in North America, and possibly the world. Some of the richest outcrops include the exposures along the North Fork of Cottonwood Creek and the branches of Huling Creek (fig. 4). Some 300 named species of Cretaceous invertebrates have been described or identified from the numerous fossil localities in this area.

Typically, the fossils, especially the ammonites, occur in limestone nodules scattered in the mudstone and siltstone outcrops. A collecting locality commonly is a single fossiliferous nodule, and when that is collected the locality no longer exists. Later collecting may discover additional fossils in the same outcrop after a few years of additional weathering and erosion, but not necessarily at the same spot. Some fossil localities are in the coarser-grained sandstones and conglomerates, but these mostly contain thicker-shelled non-ammonite mollusks.

Rodda and Murphy (1987) accurately located the fossils they collected from measured stratigraphic sections along Bee Creek, Huling Creek and the North Fork of Cottonwood Creek (fig. 4). They found that most collecting localities from earlier paleontological studies were too generalized or poorly described to be plotted on detailed stratigraphic sections like theirs. However, they endeavored to carefully locate the stratigraphic horizons where many of the fossil species described in early publications had been found, but not previously located on detailed measured sections.

Rodda and Murphy (1987) found that within the Cretaceous rocks of this area (fig. 4), invertebrates, mostly mollusks, are the most abundant and important fossils. Of these, ammonites are the most significant. Other groups they recovered included decapod crustaceans, bivalves, gastropods, scaphopods, barnacles, and foraminifera. A few specimens of fossil vertebrates and plants (other than fossil wood) were recovered also. They thus increased the number of fossil collecting sites in this area by at least 50%. Their study also provided much additional control on stratigraphic-geographic ranges and, by assumption, time relationships of the known fossil species, especially the ammonites. In addition, the number and diversity of fossil species known to occur in this area was increased significantly, providing improved documentation of the supposed paleogeography and evolutionary history. A particular example was their discovery of an ammonite genus, *Pictetia*, not previously recorded from the western hemisphere.

Rodda and Murphy (1987) recovered approximately 1500 fossil specimens from 609 collecting localities. From these collections they recognized some 175 species, including about 70 species of ammonites, 40 species of other invertebrates, and 64 species of microfossils. Of special significance are the ammonites, the extinct group of coiled, shelled cephalopods, that are found around the world wherever Mesozoic rocks are found. They have thus been studied intensively for their presumed theoretical and practical values for well over a century, being the principal fossils for determining the supposed precise geological (biostratigraphic) ages of Mesozoic rocks. The area studied exposes a remarkable sequence of ammonite-bearing strata, which is especially rich and regarded as complete.

Of the 70 species of ammonites that were recognized in their collections, certain groups were especially well represented—the genera *Puzosia*, *Lytoceras*, *Pseudouhligella*, *Acanthoplites*, and heteromorphs (irregularly coiled ammonites) of great variety (Rodda and Murphy 1987). Their collection also contained genera and species not previously recorded in California—*Pictetia* sp., *Lechites* sp., *Stoliczkaia* sp., *Myloceras* sp., *Lyelliceras* sp., and *Zelandites* sp., of supposed late Albian age; *Colombiceras* sp., of supposed Aptian age; and *Crioceratites* sp. of supposed Barremian age.

An important result related to the evolutionary ammonite biostratigraphy was the discovery by Rodda and Murphy (1987) that the entire sequence of ammonite zones below the Huling Tongue Member of the Budden Canyon Formation is of supposed Barremian age (fig. 3). Additionally, underlying older strata of supposed Barremian age (the lower part of the Chickabally Member) along the North Fork of Cottonwood Creek yielded many and varied fossils,

including ammonites, gastropods, bivalves, nautiloids, belemnites, and decapod crustaceans.

Other molluscan fossils, especially bivalves and gastropopds, are locally common, with richer occurrences of these fossils in the coarser grained rocks—sandstone and conglomerate. Some forms discovered by Rodda and Murphy (1987) were new records for the Cretaceous of California, and several new species were recognized as well. Additionally, they confirmed the wealth of shrimp-like decapod crustaceans previously reported in these Cretaceous rocks of the Cottonwood District by Rodda and Murphy (1985). Numerous specimens, mostly isolated claws, representing at least four different species, were collected from limestone nodules in the drainage of the North Fork of Cottonwood Creek.

Trace fossils are abundant and diverse, especially the filled burrows of benthic infaunal invertebrates such as mud-shrimp and various worms. Most of the mudstones and siltstones were thoroughly burrowed and homogenized by the burrowing activities of these invertebrate seafloor animals. Few samples of these could be collected easily by Rodda and Murphy (1987), but they photographically recorded in the field the varied types and densities. Two basic types are permanent dwelling burrows, mostly vertical, and errant feeding burrows.

The presence of diverse, abundant microfossils in the study area (fig. 4) was confirmed by Rodda and Murphy (1987). Of these, only the foraminifera and radiolarian were identifiable. The ostracods and micro-mollusks had not then been studied in lower Cretaceous rocks of California. They did not recover any coccoliths from any of their samples. Micro-mollusks and microscopic parts of other invertebrates are locally abundant.

The only vertebrate fossils recovered from these Cretaceous rocks were mostly fragmentary fish remains (teeth, scales, and bone). The only identifiable specimens were shark teeth, one of the family Lamnidae, and the other from a cow shark, *Notidanodon* sp., a group not previously reported from Cretaceous rocks in California.

Few fossil plant specimens were collected by Rodda and Murphy (1987), other than fossil wood which is abundant in several stratigraphic sections in the study area (fig. 4). A fossil seed, probably from a conifer, was collected from supposed Barremian age mudstone along the upper drainage of the North Fork of Cottonwood Creek. Other plant fossils included twigs, conifer leaves, and a reed fragment.

The Present Study

The purpose of this study was to test the radiocarbon contents of wood and ammonite shells buried and fossilized together in the same sedimentary rock layers. The literature summarized above clearly indicates that fossilized wood is abundant within several stratigraphic sections of the Cretaceous Budden Canyon Formation strata exposed along the North Fork of Cottonwood Creek and its tributaries in the northern part of Ono Quadrangle near Redding, California. Furthermore, the same stratigraphic sections would undoubtedly also contain abundant marine invertebrate fossils, especially ammonites. Therefore, a field search in this area would be highly likely to find marine shells and wood buried and fossilized together. However, ammonite fossils were to be specifically targeted, because of their stated global significance as index fossils for evolutionary biostratigraphic age determinations of these strata as lower Cretaceous.

Field trips into the study area were undertaken in 2006 by, and with, Pastor Al Franklin, of Grace Baptist Church in Redding, because of his knowledge of the area and its fossil localities, and because of the permission he has to enter the private lands of the area, granted him by the landholders. Four suitable ammonite fossils were successfully found that each had fossilized wood very closely associated with it, the ammonite shells and the wood usually being in direct physical contact with one another.

The locations where each of these fossils were found are indicated on Fig. 4. The relevant portions of local stratigraphic sections, as measured by Rodda and Murphy (1987), with the approximate stratigraphic positions of the ammonite and wood fossils indicated on them, are provided in Fig. 5. Where those local stratigraphic sections fit in relation to the stratigraphy of the Budden Canyon Formation is indicated on Fig. 3, along the approximate stratigraphic positions of the collected fossils. Fig. 6 photographically documents the locations from which the four ammonite with wood fossils were collected, while Fig. 7 shows the fossils themselves.

Laboratory Work

The four samples were first photographed (fig. 7) before any work was performed on them. Then, using a scalpel and tweezers, pieces of the ammonite shells and the fossilized wood were separately broken off of each sample. Pieces were broken off until there appeared to be sufficient material for each radiocarbon analysis, and then suitably sealed and stored. The fossil samples were numbered 1–4, so the broken off pieces of ammonite shell were labelled RNCS-1 to RNCS-4 respectively, and the broken off pieces of fossilized wood were similarly labelled RNCW-1 to RNCW-4. Sample 4 contained both petrified and coalified wood, so pieces were broken off separately, and sealed, stored and labelled as RNCW-4A and RNCW-4B respectively. All nine so-labelled sub-

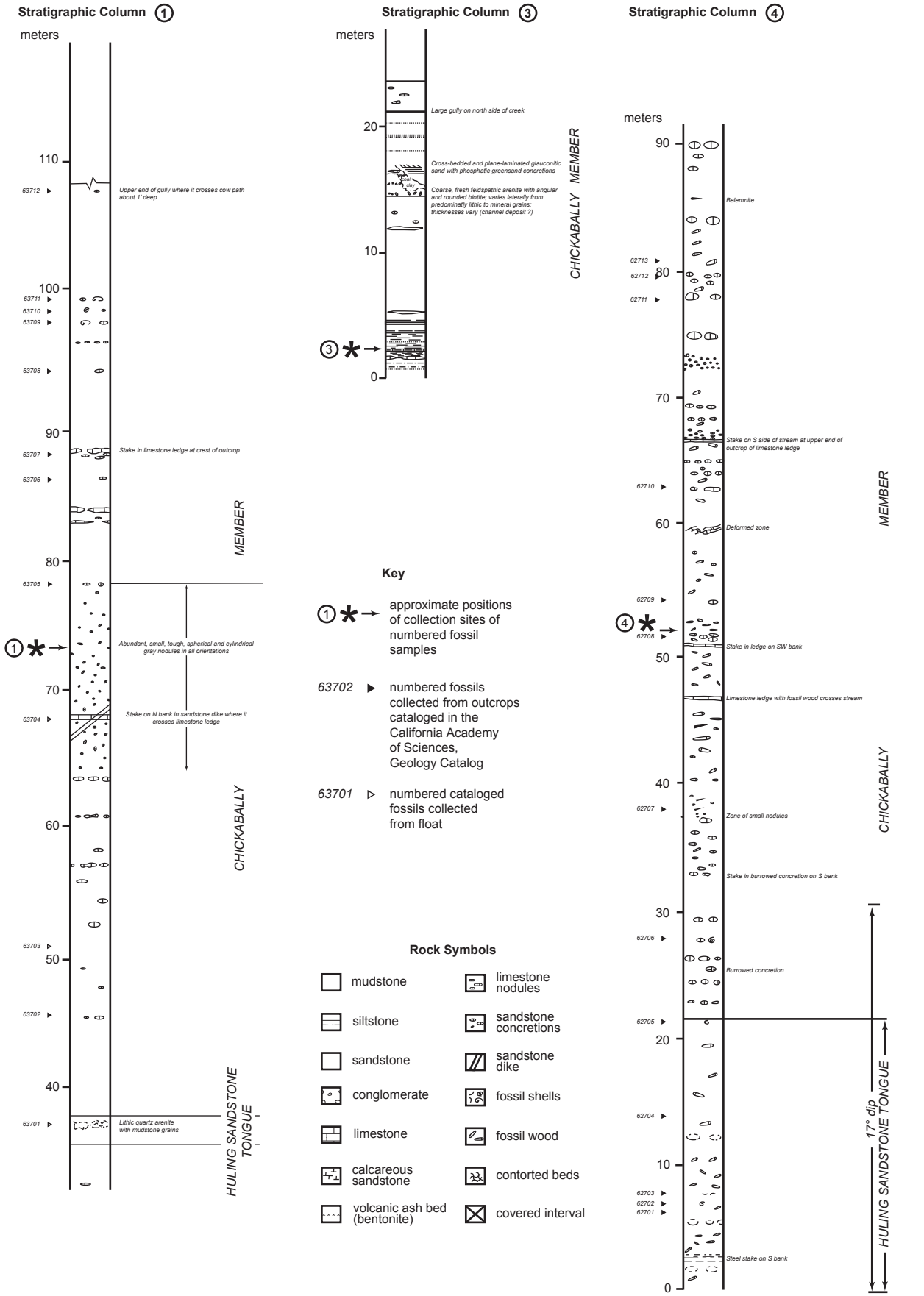

Fig. 5. The local stratigraphic columns from which the fossil samples were collected (after Rodda and Murphy 1987). The location of these measured stratigraphic sections is shown on Fig. 4.

Fig 6. The locations and strata from which the fossilized pieces of wood and ammonites were collected for this study, as shown in Fig. 4. (a) (b) Sample 1; (c) (d) Sample 2; (e) (f) Sampl3 3; and (g) (h) Sample 4.

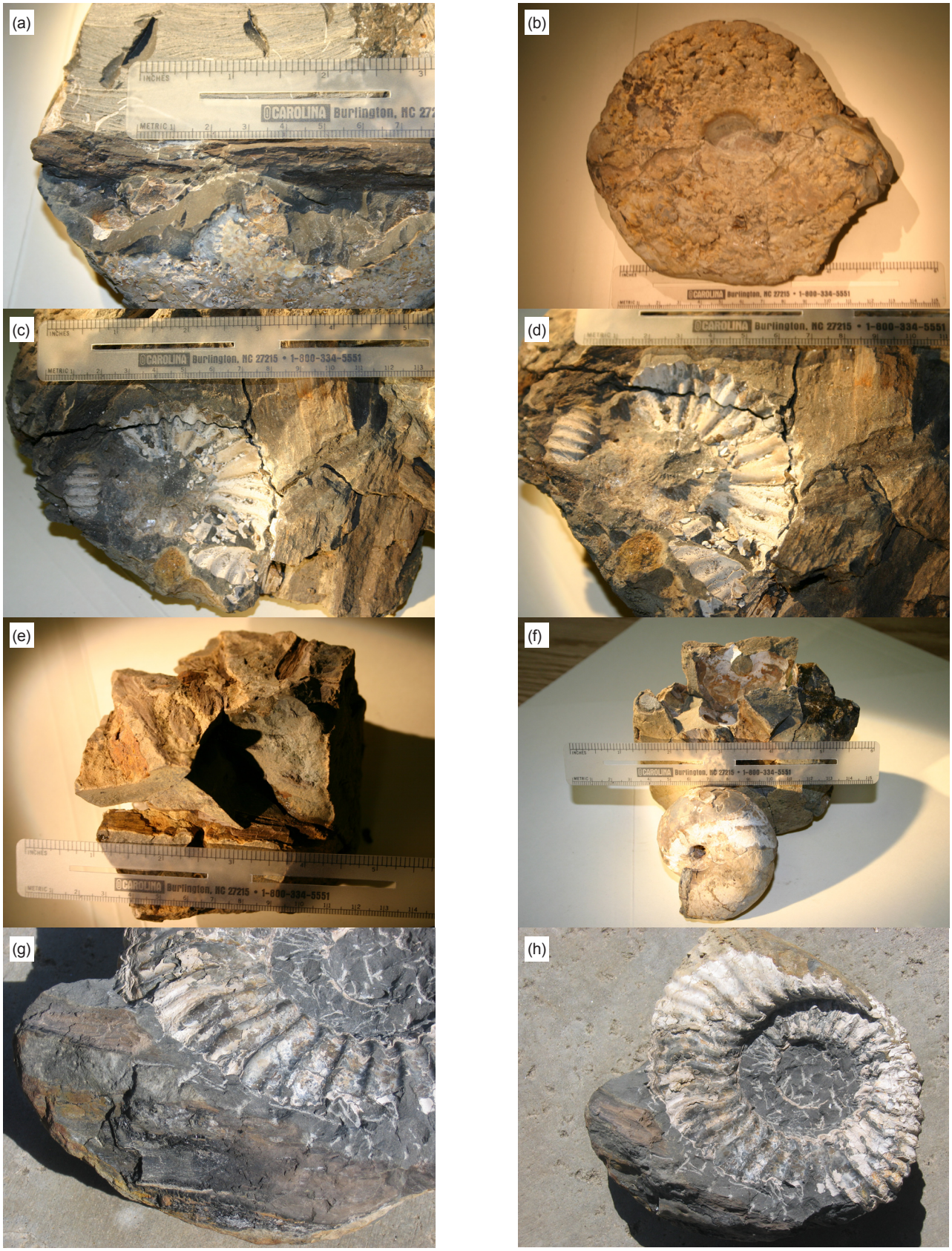

Fig 7. The fossilized pieces of wood and ammonites collected for this study from the localities shown in Fig. 4. (a) (b) Sample 1; (c) (d) Sample 2; (e) (f) Sample 3; and (g) (h) Sample 4.

samples were then submitted to Professor Roelf Beukens at the IsoTrace Radiocarbon Laboratory at the University of Toronto, Ontario, Canada, each sub-sample being accompanied by this laboratory's required "Radiocarbon Sample Submission Form" carefully filled out with location and estimated age details.

At this laboratory, the petrified and coalified wood sub-samples were prepared for radiocarbon analysis with a modified AAAOx pre-treatment (Beukens 2007a, b), the standard procedure developed to guarantee the elimination of any contamination. First, though, the fossilized wood sub-samples were demineralized to remove any contaminant inorganic minerals. This involved drenching the sub-samples in hot and strong hydrochloric acid to dissolve away any calcium, barium, or strontium salts (which is done to avoid producing insoluble fluorides in the next step), and then soaking the sub-samples for at least a week in a hot and strong mixture of hydrochloric and hydrofluoric acids. After this, the acid-soluble humics were removed from what remained of the sub-samples with an extended hot and strong hydrochloric acid treatment. This was followed by an extended cold and fresh alkali extraction.

The laboratory (Beukens 2007 a, b) reported that the dried residues of the petrified wood sub-samples (RNCW-1, 2, 3, 4A) at this point in the procedure did not have any wood structure and resembled detrital material. However, it was concluded that it was possible part of these residues consisted of acid and alkali insoluble humic or tannic compounds, as their carbon contents were low (typically 10%). These residues were then partially oxidized using a chlorite bleach. In the case of the coalified wood sub-sample (RNCW-4B), however, the dried residue consisted of needles with a carbon content normal for organic material. An acid chlorite bleach was also used on this residue to partially oxidize it. These five fossilized wood residues were then all degasified under vacuum before subsequent combustion. Nevertheless, the combustion of petrified wood residue RNCW-4A produced less than 0.1 mg of datable carbon, which was too small for analysis.

The fossilized ammonite shell sub-samples were prepared by the laboratory for analysis via a different process. However, those labeled RNCS-1 and 3 were deemed to contain insufficient shell material to be processed and analyzed. The remaining two shell sub-samples were first washed in cold deionized water. Then the outer surfaces of the shell pieces were removed by leaching with hydrochloric acid, the outer 16% of RNCS-2, and the outer 14% of RNCS-4 (Beukens 2007 a, b). An XRD analysis of the pre-leach residue of RNCS-2 was then undertaken to determine the calcite content of RNCS-2, which was estimated at between 0.5 and 2.0%, the rest of the shell material consisting of aragonite. An estimate of the calcite content of RNCS-4 could not be made as that sub-sample material was considered too small for an XRD analysis.

The remainder of the ammonite shell material in RNCS-2 and 4 was then processed according to the regular treatment for carbonates, namely, hydrolysis of the carbonate to carbon dioxide (CO_2). To achieve this, phosphoric acid in used because it has a low vapor pressure. First though, the phosphoric acid has to be degassed to remove any water or atmospheric CO_2 which might be dissolved in it. The most common method of doing this is via vapor distillation, but at the IsoTrace laboratory this technique is not used. Instead, each sub-sample was mounted in a reactor vessel, containing the phosphoric acid and, in a separate small ampoule, the crushed shell material, connected to a vacuum pump, which pumps the vessel down to below 10^{-4}Tor. By this means the water and most of the CO_2 was first pumped away at around 10^{-3}Tor, the pressure plateauing at that level until all the water was removed. When the pressure dropped from around 10^{-3}Tor to below 10^{-4}Tor any remaining dissolved gases were removed. The reactor vessel was then placed on a shaker to initiate and complete the hydrolysis, without ever exposing the contents to the atmosphere again. The evolved CO_2 was then collected on the same collection system which handled the combustion of the fossilized wood residues. This system is regularly tested by this laboratory with Icelandic spar carbonate and the IAEA (International Atomic Energy Agency) Carrara marble reference material.

The resultant graphite from this treatment and processing of each of the fossilized wood and ammonite shell fragments was then analyzed for radiocarbon (^{14}C) using the IsoTrace laboratory's state-of-the-art AMS (accelerator mass spectrometry) system. Four separate high-precision analyses of each sub-sample were averaged and corrected for natural and sputtering isotope fractionation, using the measured $^{13}C/^{12}C$ ratios. The averaged radiocarbon analysis for each sub-sample reported by the laboratory, after the laboratory's "background correction" of 0.077 percent modern carbon (pMC) was subtracted, was quoted as an apparent uncalibrated radiocarbon age in years before present (BP), using the Libby meanlife of 8,033 years. The quoted errors represent the 68.3% confidence limits.

Results

The results of the radiocarbon analyses are listed in Table 1 (from Beukens 2007 a,b). Note that the laboratory was not able to analyze sub-samples RNCS-1 and 3 (fossilized ammonite shells) and RNCW-4A (petrified wood) due to insufficient

Table 1. Radiocarbon (^{14}C) analytical results (pMC) and calculated apparent ages (year BP) for the fossilized wood and ammonite shells.

Sample	Description	Weight Used (mg)	Percent Modern Carbon (pMC)	Apparent Age (years BP)
RNCW-1	petrified wood	1080	1.896±0.013	33,490±240
RNCS-2	fossilized shell fragment	386	1.224±0.012	36,400±350
RNCW-2	petrified wood	4400	1.118±0.010	37,150±330
RNCW-3	petrified wood	729	1.740±0.012	32,780±230
RNCS-4	fossilized shell fragment	510	0.276±0.005	48,710±930
RNCW-4A	petrified wood	297	—	—
RNCW-4B	coalified wood	382	0.593±0.007	42,390±510

material. However, the six listed radiocarbon analyses would still seem to provide an adequate database for the purpose of this study. Note also that the percent modern carbon (pMC) values listed were reported by the laboratory after subtraction of their "background correction" of 0.077 pMC. Therefore, if this background correction had not been subtracted, the listed apparent radiocarbon ages would only be slightly, to negligibly, younger.

Discussion

Fig. 5 compares the local measured stratigraphic sections for fossil samples 1, 3 and 4 (after Rodda and Murphy 1987) and indicates the approximate stratigraphic locations of the collected fossil samples 1, 3, and 4. Using the position of the Huling Tongue Member (sandstone) as a biostratigraphic marker, the approximate biostratigraphic postions of the stratigraphic sections 1 and 4 have been plotted on Fig 3. (last column). Fossil sample 2 was not collected from a measured stratigraphic section, but from its location marked on Fig. 4 it can be seen that it lies stratigraphically just below fossil sample 3, and stratigraphically well above fossil sample 4. These observations thus enable the biostratigraphic position of measured stratigraphic section 3 relative to measured stratigraphic section 4 (figs. 4 and 5) to be plotted on Fig. 3. Furthermore, the relative biostratigraphic position of stratigraphic section 2, though not measured, can also be plotted on Fig. 3.

The biostratigraphic positions of the stratigraphic sections from which the four fossil samples were collected as plotted on Fig. 3 enable the approximate biostratigraphic positions, and therefore ages, of the four fossil samples to be determined. The four fossilized ammonite and wood samples would all appear to be Aptian in biostratigraphic age (lower Cretaceous), which in terms of the absolute chronology of the geologic timescale equates to approximately 112–120 million years old (Gradstein et al. 2004). However in stark contrast, the fossilized ammonite shells yield radiocarbon ages of only 36,400±350 years and 48,710±930 years, while the fossilized wood found buried with them (literally, as seen in fig. 7) yielded radiocarbon ages of 32,780±230 years to 42,390±510 years (table 1).

The usual response to such a glaring and enigmatic discrepancy in absolute ages is to claim that the ammonite shells and wood have obviously been contaminated with modern carbon, making them date very young when in fact they really are extremely old. After all, as noted earlier, if the entire mass of the earth consisted only of ^{14}C atoms, then because the decay of ^{14}C is so rapid, after only 1 million years not a single atom of ^{14}C should conceivably still exist. Therefore, there should be absolutely no measurable ^{14}C able to be detected in these fossilized ammonite shells and wood if they really are, as claimed to be, 112–120 million years old.

Four sources of potential contamination could be invoked in this instance. First, any contamination in the laboratory can be immediately ruled out, because extreme handling and preparation measures were used in this highly respected academic laboratory, measures that have proved effective in removing any potential contamination. These included extended use of strong acid at elevated temperatures to guarantee removal of any carbonate and other minerals that might have contributed modern radiocarbon to the fossilized wood, and leaching of 14–16% of the outer surfaces of the ammonite shells with hydrochloric acid to remove any modern calcite from the shells that would have substituted for their aragonite and thus contributed modern radiocarbon to them.

However, the only possible contamination that might have been introduced into these fossilized wood and ammonite shells during laboratory processing to prepare them for analysis could have been at the stage where the evolved CO_2 via combustion was then reduced to graphite. It is quite possible that the acetylene used for this reduction could introduce some trace modern radiocarbon contamination, or more correctly, the laboratory background. This, however, would be taken care of by the standard background correction of 0.077 pMC subtracted routinely from the raw analytical results, a procedure that would thus appear to be legitimate. Nevertheless, it can be readily shown that for radiocarbon ages on the order

of 33,000 years or more, the effect of subtracting this standard laboratory background (and therefore the possible contamination due to the acetylene) is small, almost negligible, on the order of only 1%.

That potential trace radiocarbon contamination introduced at the reduction to graphite by acetylene step equates to the "graphitization background" suggested by Taylor and Southon (2007). However, they also suggest four other sources of modern radiocarbon contamination in the laboratory procedures. These, they claim, are due to the acidification and combustion during the sample preparation, the transfer of the graphite to the AMS (accelerator mass spectrometer) sample holder, during any storage, and within the AMS instrument if the detector registers a ^{14}C signal when a ^{14}C-ion is not present in the beam. In order to quantify these potential sources of modern radiocarbon contamination in the laboratory, Taylor and Southon (2007) analysed natural diamonds for ^{14}C by placing them directly within the AMS instrument's sample holder, thus eliminating the acidification, combustion and graphitization steps. Of course, they were assuming the diamonds (being in excess of 100 million years old) contained no radiocarbon, so that any measured by the AMS instrument would be the sum total of their claimed transfer, storage and instrument backgrounds (that is, modern radiocarbon contamination). Nevertheless, the only ^{14}C they measured ranged from 0.005±0.001 to 0.069±0.04 pMC. At such a trivial "background" level, even if such potential laboratory contamination with modern radiocarbon were conceded, it would make no difference whatsoever to the very much higher radiocarbon levels within these ammonite shell and wood fossils listed in Table 1. The 0.077 pMC laboratory background already subtracted by the IsoTrace laboratory would more than adequately cover such contingencies.

The second potential source of any contamination would be any contamination due to handling of the fossil samples—for example, from human hands or plastic storage bags. This can also be definitively ruled out, because any such contamination would only have been on the surfaces of the fossil samples and would have been immediately eliminated by the laboratory's extreme sample preparation techniques, described earlier. Indeed, in the case of the ammonite shells, significant portions of their outer surfaces were deliberately leached by hydrochloric acid to remove any such surface contamination. And the fossilized wood samples were soaked in hot strong acids.

The third potential source of contamination would have been the source area in the ground from where the fossil samples were taken, when they were buried deep below the surface. Here there were definitely two relevant factors. At the time of deposition of the host sediments and burial of the ammonites and wood in them, some of the water which transported the sediments would have been trapped in them. Such connate waters and basinal fluids, especially if the sediments were deposited in a marine environment, could have been quite saline and thus chemically reactive, aided by the raised temperatures due to the depth of burial. Diagenesis of the host sediments occurred around these fossils, primarily resulting in the cementing together of the sediment grains. The internal body cavities of the ammonite shells were infilled with sediments that underwent diagenesis, and the chemical-laden connate waters percolated through the cellular structures of the buried wood to petrify it. In some cases the wood was coalified, indicative of a depth of burial of thousands of meters and elevated temperatures of 100°C or more (Diessel 1992, Stach et al. 1982), though the presence of clay minerals such as montmorillonite can significantly lower the temperatures and the time required for coalification (Hayatsu et al. 1984). The result of these fluids circulating around these ammonite and wood fossils would not have only assisted fossilization, petrification and coalification, but may have also caused secondary calcite replacement of aragonite in the ammonite shells and added contaminant carbonate and silicate minerals, and silica (quartz), to the wood.

However, no carbonate minerals or silica were in any way visibly evident within or clinging to the coalified wood when it was sent to the laboratory, although the petrified wood was obvious impregnated with silica as a result of the petrification process. In any case, such minerals would have been removed from the fossilized wood, even from within it, by the severe demineralizing treatment in the laboratory. For example, the hot and strong hydrofluoric acid would have removed the silica impregnating the wood. This is confirmed by the laboratory's description of the fossilized wood residues (Beukens 2007a, b). Furthermore, the connate waters and basinal fluids buried deeply with these fossils at the time of introducing dissolved minerals, and impregnating the wood with silica while possibly replacing some of the aragonite in the ammonite shells with calcite, supposedly more than 100 million years ago and since, would have only contained old carbon. Thus if such old carbon were added to these fossils, such as in the calcite replacement of some aragonite in the ammonite shells, if anything it would have swamped any radiocarbon in the shells and wood, so that they would have yielded infinite radiocarbon ages, consistent with them being supposedly 112–120 million years old.

This only leaves, finally, the fourth potential source of contamination—namely, the ground and

surface waters that washed over and percolated through these fossils in their host sedimentary rocks right up until the present when sampled. The surface waters particularly would likely contain some dissolved carbonate, and the fluctuating water levels in the streams would have resulted in the alternating wetting and drying of the fossils, the latter depositing whatever salts the water contained. Furthermore, both the surface waters and the fossils when exposed have been in contact with the modern radiocarbon in the atmosphere, making contamination of these fossils with modern radiocarbon seem a likely possibility, which might explain the young apparent radiocarbon ages for these fossils.

However, any soluble inorganic carbonate carbon in the ground and surface waters would not have exchanged with the insoluble organic carbon in the wood, because the two forms of carbon are incompatible. Also, as noted previously, any carbonate mineral deposited within or onto the wood by ground or surface waters would have also been removed by the severe demineralizing treatment with hot and strong acids in the laboratory prior to the radiocarbon analyses. Indeed, the laboratory's reports (Beukens 2007a, b) described the fossilized wood residues as possibly consisting of humic or tannic compounds and needles with a carbon content, all of which were insoluble in the hot strong acids and alkalis used in their demineralizing treatment. As it was only these insoluble organic carbon residues that were subsequently analysed for radiocarbon, there would not have been any contamination of them with modern radiocarbon from either ground or surface waters or even the atmosphere. Such exchanges with the wood could only have occurred when the original trees were alive.

The only question that remains is whether the fossil ammonite shells may have been contaminated with modern radiocarbon in any carbonate dissolved in the ground or surface waters that replaced aragonite in the shells. The laboratory did report (Beukens 2007a) that the pre-leach residue of the fossilized ammonite shell RNCS-2 had an XRD estimated calcite content of between 0.5 and 2.0%. While the laboratory did not say that this 0.5–2.0% calcite content was modern calcite and therefore contamination, it did indicate that a 0.5% contamination of modern calcite would be equivalent to an apparent age of 43,000 years. Clearly, with an estimated 0.5–2.0% calcite content, if this were all modern calcite, then the 36,400±350 years apparent radiocarbon age for the RNCS-2 fossil ammonite shell could all be due presumably to modern calcite contamination. However, Webb et al. (2007) found that if groundwaters have high Mg:Ca ratios, then modern aragonite could be added to fossil bivalve shells, which could also adversely affect radiocarbon dating of such shells. Nevertheless, in respect of this RNCS-2 fossil ammonite shell, the fossilized wood RNCW-2 buried with it (fig. 7c & d), which has been demonstrated already not to have been contaminated with any modern radiocarbon, yielded an almost identical apparent radiocarbon age of 37,150±330 years (table 1). Similarly, the fossilized ammonite shell RNCS-4 yielded an apparent radiocarbon age of 48,710±930 years, and the coalified wood RNCW-4B buried with it (fig. 7g & h) yielded a similar apparent radiocarbon age of 42,390±510 years (table 1). If both these fossilized ammonite shells were contaminated with modern calcite containing modern radiocarbon, then they should both have yielded very young apparent radiocarbon ages, much younger than the apparent radiocarbon ages for the fossilized wood buried with them. Quite clearly, if these fossilized woods are not contaminated with modern radiocarbon, then the similar apparent radiocarbon ages for the fossilized ammonite shells buried with them strongly implies that these fossilized ammonite shells are not contaminated with modern radiocarbon either, even from ground or surface waters.

These second to fourth sources of potential contamination are all outside the radiocarbon laboratories and out of their control, so collectively they have been termed "in situ contamination" (Vogel et al. 1987) or "pseudo ^{14}C-free sample background" (Taylor and Southon 2007). This term has been defined as "^{14}C present in carboniferous material that should not contain ^{14}C because of its geologic age" (Taylor and Southon 2007). That definition unashamedly reveals the bias in assuming such carboniferous material is indeed of geologic age, that is, millions of years old. Moreover, this terminology was introduced by the radiocarbon laboratories over twenty years ago because it was embarrassing that they routinely found radiocarbon levels of 0.25 pMC or more in ancient carboniferous materials (such as coal, calcite, and fossilized wood) that should be truly "^{14}C free" due to their supposed geologic ages (Brown and Southon 1997). To put this into perspective, a measured value of 0.25 pMC is some 450 times higher than the measurement threshold for the AMS instrument. Indeed, all the fossilized wood and ammonite shells analysed in this study yielded pMC levels >0.25 (table 1). Furthermore, as has been forcefully argued already, the severe hot strong acid treatment on the fossilized wood had to have removed any and all potential pre-laboratory "in situ" contamination. Also, the ammonite shells buried and fossilized with them yielded similar measured high radiocarbon levels, suggesting that the radiocarbon measured in both the fossilized wood and ammonite shells was not pre-laboratory "in situ contamination" or "pseudo ^{14}C-free sample background".

It can only be concluded, therefore, that the radiocarbon measured by the laboratory must be real in situ radiocarbon intrinsic to the original wood and ammonite shells, and not contamination of any sort. This does not imply that this radiocarbon is a reliable measure of the true age of the wood and the ammonites. In fact, other fossilized woods analyzed for radiocarbon have yielded various apparent radiocarbon ages from 22,730±170 years (Snelling 2000a) to 44,700±950 years (Snelling 1997, 2000b). However, these measured radiocarbon levels do indicate that the wood and ammonites are young, and not 112–120 million years old. Clearly, the long-age biostratigraphic dating method, using the ammonites and their relative position in the supposed evolutionary history of life on earth calibrated against the "absolute" ages provided by radioisotope dating (Gradstein et al 2004), is totally unreliable. Furthermore, the unproven assumptions on which radioisotope dating is based, and the numerous problems associated with it, are well documented (Snelling 2000c, 2005; Woodmorappe 1999).

It should also be noted that these radiocarbon ages for the fossilized wood and ammonites were calculated on the assumption that these fossilized ammonite shells and pieces of wood had similar radiocarbon contents, when they lived and then were buried together, to the radiocarbon contents of modern marine invertebrate shells and terrestrial trees. However, this assumption can be shown to be false for at least two reasons. First, the Flood removed so much carbon from the biosphere and buried it. There was all the carbon in both marine and land animals, and all the plants, which were destroyed and buried as fossils in Flood-deposited sediments, such as limestones and coal beds. Second, the earth's magnetic field was much stronger in the recent past back to the Flood, and perhaps stronger also back to the Creation Week (Humphreys 1983, 1986, 1990). A stronger magnetic field, relative to the present field, would shield the earth's atmosphere from more cosmic rays, thus resulting in a much lower radiocarbon production rate in the atmosphere through the pre-Flood period when these ammonites and trees lived. These two factors alone thus would have meant that there was much less radiocarbon in ancient organic materials when they were buried during the Flood about only 4,300 years ago. Therefore, if it is wrongly assumed these ammonite shells and pieces of wood contained today's much higher radiocarbon level when they were buried together, then the measured low levels of radiocarbon in them yield apparent ages that are much too old.

What is now required is a recalibration of the apparent radiocarbon ages for these supposedly ancient organic materials that would significantly reduce their true ages to make them compatible with the biblical timescale of earth history. However, so far there doesn't appear to be a discernible systematic pattern of radiocarbon levels (and apparent ages) in the ancient organic materials tested, such as fossilized woods and coal beds, with respect to their relationship to the timing of their burial during or soon after the Flood. For example, the radiocarbon testing of ten U.S. coal beds spanning a significant portion of the fossil-bearing strata record, from the Carboniferous (Pennsylvania), Cretaceous and Eocene, yielded apparent ages of 48,000–50,000 years (Baumgardner 2005; Baumgardner et al 2003). If the Eocene is considered to be very early post-Flood (Austin et al 1994), then why do these Eocene coal beds yield the same apparent radiocarbon ages as the Pennsylvanian (Flood) coal beds? Perhaps the Eocene coal beds also consist of pre-Flood plant debris that "floated" through the Flood and then was buried very soon after. In contrast, the fossilized woods buried as a result of what may be post-Flood (Eocene and Oligocene) volcanic eruptions apparently decimating post-Flood forests around Crinum, Queensland (Snelling 1997, 2000b) and Cripple Creek, Colorado (Snelling 2008) yielded apparent radiocarbon ages of 44,700±950 years and 41,260±540 years respectively. These latter apparent ages might then be consistent with an expected early post-Flood radiocarbon build-up which could have produced younging upwards apparent ages. However, in this study the Cretaceous (late Flood buried) four fossilized woods yielded apparent radiocarbon ages of 32,780±230 years to 42,300±510 years, younger than the Cretaceous coal beds. Similar younger apparent radiocarbon ages of 33,700±400 years, 33,720±430 years, and 22,730±170 years to 28,820±350 years were obtained for Flood-buried Permian (Snelling 1998), Triassic (Snelling 1999), and Jurassic (Snelling 2000a) fossilized woods respectively. Perhaps the low radiocarbon levels in the pre-Flood world were unevenly distributed in the biosphere, according to varying abilities of organisms for radiocarbon uptake or rejection. Continuing investigations are needed.

Nevertheless, Baumgardner (2005) has suggested, based on earlier studies (Brown 1979; Giem 2001; Morton 1984; Scharpenseel and Becker-Heidmann 1992), that the pre-Flood biosphere and atmosphere just prior to the Flood could have had, conservatively, 300–700 times the total carbon relative to our present world's biosphere and atmosphere. Then if we assume the total number of ^{14}C atoms was similar to what exists in today's world, and these were uniformly distributed throughout the pre-Flood biosphere which had 500 times more total carbon than today's biosphere, then the resulting $^{14}C/C$ ratio would be 1/500 of today's level, or about 0.2 pMC, which is equivalent to an apparent radiocarbon age of more than 50,000

years. However, Baumgardner (2005) also took into account the amount of ^{14}C potentially generated in situ from an episode of accelerated nuclear decay during the Flood catastrophe (Vardiman, Snelling, and Chaffin 2005), which could have been comparable to, or even larger than, the amount of ^{14}C that existed in the tissues of pre-Flood organisms. Furthermore, with a stronger magnetic field in the pre-Flood world reducing the ^{14}C production rate in the atmosphere, in the 1,650 or so years between Creation and the Flood it is likely that only a smaller amount of ^{14}C would have been generated compared to today's total amount of ^{14}C atoms. Therefore, the pre-Flood $^{14}C/C$ ratio would have been much lower, and more or less uniform, say 0.05–0.1 pMC, while the in situ component would have been much more variable and dependent on the local U concentrations and amounts of N during the subsequent accelerated nuclear decay episode. This might then account for the wide range of low radiocarbon levels measured in the pieces of pre-Flood wood (referred to above) that were buried and fossilized in sediments during the Flood only about 4,300 years ago while an episode of accelerated nuclear decay was also occurring.

Finally, one further circumstance warrants a comment, namely, the fact that these ammonites and pieces of wood are found buried and fossilized together. The host mudstones have always been designated as having been deposited in a marine environment, in water deep enough for ammonites to have lived, presumably a continental shelf or shallow sea environment. However, woody trees do not live in such environments. And even pieces of wood washed out to sea today float, rather than sinking to be buried on the sea floor with marine invertebrates similar to ammonites. Thus these pieces of terrestrial wood were more likely buried with these marine ammonite shells as a result of sediments (primarily muds) being wash rapidly by ocean waters onto this continental land, consistent with what would be expected to have happened during the Genesis Flood.

Summary and Conclusions

The lower Cretaceous Chickabally Member mudstones of the Budden Canyon Formation have been extensively studied for more than 140 years, and the ammonite fossils in them are significant as index fossils for biostratigraphy. Four samples of ammonites and wood buried and fossilized together in these mudstones were collected in the Cottonwood District near Redding, northern California. Fragments from two of the fossilized ammonite shells and four of the fossilized pieces of wood were analyzed by the IsoTrace Radiocarbon Laboratory at the University of Toronto, Canada. At this laboratory these fragments were prepared for radiocarbon analyses with the standard pre-treatment procedure developed to guarantee the elimination of any contamination. The wood residues were combusted to graphite, while the carbonate shells were hydrolyzed to carbon dioxide and then reduced to graphite. The resultant graphite was then analyzed for radiocarbon using a state-of-the-art accelerator mass spectrometer (AMS) system.

The radiocarbon results ranged from 0.276±0.005 to 1.224±0.012 pMC or apparent ages of 36,400±350 to 48,710±930 years for the fossil ammonite shells, and from 0.593±0.007 to 1.896±0.013 pMC or apparent ages of 32,780±230 to 42,390±510 years for the fossilized wood. Yet the biostratigraphic ages of these fossils, based on the ammonites as index fossils, is Aptian (lower Cretaceous), and the "absolute" geochronologic age 112–120 million years. Therefore, if these fossils were truly that old, then there should have been absolutely no measurable ^{14}C detected in them.

However, the ^{14}C measured in these fossils is well above the detection limit of the AMS instrument. Therefore the usual response to such a glaring and enigmatic discrepancy in absolute ages is to claim that the ammonite shells and wood were contaminated with modern carbon, either in the ground, or during sampling and in the laboratory. Four such sources of potential contamination were examined. In the laboratory the severe pre-treatment of the samples guarantees that any contamination from sampling and handling is totally eliminated. Then even if there were some contamination, as claimed by some, during the combustion and due to instrument background, the estimated ^{14}C level involved would only be in the range 0.005–0.069 pMC. This is a trivial amount of ^{14}C that if conceded would make no difference whatsoever to the very much higher radiocarbon levels measured in these ammonite shells and wood fossils, particularly as the results reported by the IsoTrace Laboratory already have a laboratory background of 0.077 pMC subtracted from them.

Furthermore, potential contamination of the fossils by ground or surface waters while they were still entombed in the mudstones can be ruled out. Any such environmental contamination of the fossil wood would be removed by the severe sample pre-treatment in the laboratory. On the other hand, environmental contamination of the ammonite shells by replacement with modern carbonate ^{14}C can be discounted, because the ammonite shells yielded almost identical ^{14}C levels and apparent ages as the wood buried and fossilized with them.

Therefore, it was concluded that the measured ^{14}C is in situ radiocarbon intrinsic to the ammonites and wood when they were buried and fossilized, so that they are very young, not 112–120 million years old. Furthermore, because the earth's stronger magnetic

field in the recent past reduced the atmospheric ^{14}C production rate, and because the recent Genesis Flood removed so much carbon from the biosphere and buried it, the measured apparent radiocarbon ages are still much higher than the true ages of the fossil ammonites and wood. So their true ages are consistent with their burial during the Genesis Flood only, about 4,300 years ago, when the ocean waters washed sediments and ammonites onto this continental land.

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References

Anderson, C.A., and R.D. Russell. 1939. Tertiary formations of northern Sacramento valley, California. *California Division of Mines, Journal of Mines and Geology* 35:219–253.

Anderson, F.M. 1902. Cretaceous deposits of the Pacific coast. *Proceedings of the California Academy of Sciences, 3rd series, Geology* 2(1):1–55, 12 plates.

Anderson, F.M. 1931. The genus *Fagesia* in the upper Cretaceous of the Pacific coast. *Journal of Paleontology* 5:121–126, plates 15–17.

Anderson, F.M. 1938. *Lower Cretaceous deposits in California and Oregon*. Special Paper 16. Boulder, Colorado: Geological Society of America.

Anderson, F.M. 1958. *Upper Cretaceous of the Pacific coast*. Memoir 71. Boulder, Colorado: Geological Society of America.

Austin, S.A., J.R. Baumgardner, D.R. Humphreys, A.A. Snelling, L. Vardiman, and K.P. Wise. 1994. Catastrophic plate tectonics: A global Flood model of earth history. In *Proceedings of the Third International Conference on Creationism*, ed. R.E. Walsh, pp.609–621. Pittsburgh, Pennsylvania: Creation Science Fellowship.

Baumgardner, J.R. 2005. ^{14}C evidence for a recent global flood and a young earth. In *Radioisotopes and the age of the earth: Results of a young-earth creationist research initiative*, ed. L. Vardiman, A.A. Snelling, and E.F. Chaffin, pp.587–630. Santee, California: Institute for Creation Research; Chino Valley, Arizona: Creation Research Society.

Baumgardner, J.R., A.A. Snelling, D.R. Humphreys, and S.A. Austin. 2003. Measurable ^{14}C in fossilized organic materials: Confirming the young earth Creation-Flood model. In *Proceedings of the Fifth International Conference on Creationism*, ed. R.L. Ivey, Jr., pp.127–142. Pittsburgh, Pennsylvania: Creation Science Fellowship.

Beukens, R.P. 1990. High-precision intercomparison at IsoTrace. *Radiocarbon* 32:335–339.

Beukens, R.P. 2007a. Radiocarbon analysis report. IsoTrace Radiocarbon Laboratory, University of Toronto, Canada, February 9.

Beukens, R.P. 2007b. Radiocarbon analysis report. IsoTrace Radiocarbon Laboratory, University of Toronto, Canada, July 28.

Bird, M.I., L.K. Ayliffe, L.K. Fifield, C.S.M. Tunney, R.G. Cresswell, T.T. Barrows, and B. David. 1999. Radiocarbon dating of "old" charcoal using a wet oxidation, stepped-combustion procedure. *Radiocarbon*, 41(2):127–140.

Brown, R.H. 1979. The interpretation of C-14 dates. *Origins* 6:30–44.

Brown, T.A. and J.R. Southen. 1997. Corrections for contamination background in AMS ^{14}C measurements. *Nuclear Instruments and Methods in Physics Research B* 123:208–213.

Chandler, M.E.J. and D.I. Axelrod. 1961. An early Cretaceous (Hauterivian) angiosperm fruit from California. *American Journal of Science* 259:441–446.

Cooper, J.G. 1888. *Catalogue of California fossils*. Seventh Annual Report State Mineral, pp.223–308. California State Mining Bureau.

Diessel, C.F.K. 1992. *Coal-bearing depositional systems*. Springer-Verlag, Berlin.

Diller, J.S. 1889. Sandstone dikes. *Geological Society of America Bulletin* 1:411–442.

Diller, J.S. 1893. Cretaceous and early Tertiary of northern California and Oregon. *Geological Society of America Bulletin* 4:205–224.

Diller, J.S. 1894. *Tertiary revolution in the topography of the Pacific coast*. U.S. Geological Survey, Annual Report 14, part 2g, pp.397–434, and plates 40–47.

Diller, J.S., and Stanton, T.W. 1894. The Shasta-Chico Series. *Geological Society of America Bulletin* 5:435–464.

Fontaine, W.M. 1905. Notes on some fossil plants from the Shasta Group of California and Oregon. In *Status of the Mesozoic floras of the United States*, ed. L.F. Ward, pp.221–273. Monograph 48, U.S. Geological Survey.

Gabb, W.M. 1864. Description of the Cretaceous fossils. *Geological survey of California, paleontology*, vol.1, section 4, pp.55-236, plates 9–32.

Gabb, W.M. 1869. Cretaceous fossils. *Geological survey of California*, vol.1, section 2, pp.127–254, plates 19–34.

Giem, P. 2001. Carbon-14 content of fossil carbon. *Origins* 51:6–30.

Gradstein, F.M., J.G. Ogg, and A.G. Smith, ed. 2004. *A geologic time scale 2004*. Cambridge, UK: Cambridge University Press.

Hackel, O. 1966. *Summary of the geology of the Great Valley*. Bulletin 190. Sacramento, California: California Division of Mines and Geology.

Hayatsu, R., R.L. McBeth, R.G. Scott, R.E. Botto, and R.E. Winans. 1984. Artificial coalification study: Preparation and characterization of synthetic macerals. *Organic Geochemistry* 6:463–474.

Hill, T.G. 1975. Biostratigraphy of the Upper Chickabally Member of the Budden Canyon Formation (Cretaceous) near Ono, Shasta County, California. M.S. thesis (unpublished), University of California Riverside.

Humphreys, D.R. 1983. The creation of the earth's magnetic field. *Creation Research Society Quarterly* 20(2):89–94.

Humphreys, D.R. 1986. Reversals of the earth's magnetic

field during the Genesis Flood. In *Proceedings of the First International Conference on Creationism*, vol. 2, ed. R.E. Walsh, C.L. Brooks, and R.S. Crowell, pp. 113–126. Pittsburgh, Pennsylvania: Creation Science Fellowship.

Humphreys, D.R. 1990. Physical mechanism for reversals of the earth's magnetic field during the Flood. In *Proceedings of the Second International Conference on Creationism*, vol. 2, ed. R.E. Walsh and C.L. Brooks, pp. 129–142. Pittsburgh, Pennsylvania: Creation Science Fellowship.

Ingersoll, R.V. 1979. Evolution of the late Cretaceous forearc basin, northern and central California. *Geological Society of America Bulletin* 90:813–826.

Ingersoll, R.V., E.I. Rich, and W.R. Dickinson. 1977. *Great Valley sequence.* Field Trip Guide Book. Annual Meeting, Cordilleran Section, Geological Society of America.

Jones, D.L., M.A. Murphy, and E.L. Packard. 1965. *The Lower Cretaceous (Albian) ammonite genera* Leconteites *and* Brewericeras. Professional Paper 503-F. U.S. Geological Survey.

Lachenbruch, M.C. 1962. *Geology of the west side of the Sacramento valley.* Bulletin 181, pp. 53–66. Sacramento, California: California Division of Mines and Geology.

Matsumoto, T. 1959a. Upper Cretaceous ammonites of California, part I. *Kyushu University, Memoirs of the Faculty of Sciences, Series D, Geology* 8:91–172, plates 30–45.

Matsumoto, T. 1959b. Upper Cretaceous ammonites of California, part II. *Kyushu University, Memoirs of the Faculty of Sciences, Series D, Geology*, Special Volume 1: 1–172, plates 1–41.

Matsumoto, T. 1960. Upper Cretaceous ammonites of California, part III. *Kyushu University, Memoirs of the Faculty of Sciences, Series D, Geology*, Special Volume 2: 1–204, plates 1–2.

Miller, C.N. 1975. Petrified cones and needle-bearing twigs of a new taxodiaceous conifer from the early Cretaceous of California. *American Journal of Botany* 62(7):706–713.

Morton, G.R. 1984. The carbon problem. *Creation Research Society Quarterly* 20:212–219.

Murphy, M.A. 1956. Lower Cretaceous stratigraphic units of northern California. *American Association of Petroleum Geologists Bulletin* 40:2098–2119.

Murphy, M.A. 1967a. The Aptian-Cenomanian members of the ammonite genus *Tetragonites. University of California, Publications in the Geological Sciences* 69:1–92, plates 1–7.

Murphy, M.A. 1967b. The ammonoid subfamily Gabbioceratinae Breistroffer. *Journal of Paleontology* 41:595–607, plate 64.

Murphy, M.A. 1967c. Albian and Aptian Tetragonitidae (Ammonoidea) from northern California. *University of California, Publications in the Geological Sciences* 70: 1–42, plates 1–5.

Murphy, M.A. 1975. Paleontology and stratigraphy of the lower Chickabally Mudstone (Barremian-Aptian) in the Ono Quadrangle, northern California. *University of California, Publications in the Geological Sciences* 113:1–52, plates 1–15.

Murphy, M.A., G.L. Peterson, and P.U. Rodda. 1964. Revision of Cretaceous lithostratigraphic nomenclature, northwest Sacramento valley, California. *American Association of Petroleum Geologists Bulletin* 48:496–502.

Murphy, M.A., and P.U. Rodda. 1959. New ammonites from the Albian of northern California. *Journal of Paleontology* 33:103–105, plate 20.

Murphy, M.A., and P.U. Rodda. 1960. Mollusca of the Cretaceous Bald Hills Formation of California. *Journal of Paleontology* 34:835–838, plates 101–107.

Murphy, M.A. and P.U. Rodda. 1977. The type specimens of *Ammonites hoffmanni* Gabb and *Melchiorites indigenes* Anderson (Mollusca: Ammonoidea). *Veliger* 20(2):78–81.

Murphy, M.A., P.U. Rodda, and D.M. Morton. 1969. *Geology of the Ono Quadrangle, Shasta and Tehama Counties.* Bulletin 192. Sacramento, California: California Division of Mines and Geology.

Nadeau, M.-J., P.M. Grootes, A. Voelker, F. Bruhn, A. Duhr, and A. Oriwall. 2001. Carbonate ^{14}C background: Does it have multiple personalities? *Radiocarbon* 43(2A):169–176.

Ojakangas, R.W. 1968. Cretaceous sedimentation, Sacramento valley, California. *Geological Society of America Bulletin* 79:973–1008.

Olmstead, F.H. and G.H. Davis. 1961. Geologic features and ground-water storage capacity of the Sacramento valley, California. Water Supply Paper 1497. U.S. Geological Survey.

Peterson, G.L. 1966. Structural interpretation of sandstone dikes, northwest Sacramento valley, California. *Geological Society of America Bulletin* 77:833–842.

Peterson, G.L. 1967. Lower Cretaceous stratigraphic discontinuity in northern California and Oregon. *American Association of Petroleum Geologists Bulletin* 51:867–872.

Pierce, M.J. 1983. Ground water in the Redding Basin, Shasta and Tehama Counties, California. Water Resources Investigation Report 83-4052. U.S. Geological Survey.

Popenoe, W.P. 1957. The Cretaceous gastropod genus *Biplica. University of California, Publications in the Geological Sciences* 30:425–454, plates 50–51.

Popenoe, W.P., R.W. Inlay, and M.A. Murphy. 1960. Correlation of the Cretaceous formations of the Pacific coast (United States and northwestern Mexico). *Geological Society of America Bulletin* 71:1491–1540.

Popenoe, W.P., L.R. Saul, and T. Susuki. 1987. Gyrodiform gastropods from the Pacific coast Cretaceous and Paleocene. *Journal of Paleontology* 61:70–100.

Repenning, C.A. 1960. *Geologic summary of the Central Valley of California with references to the disposal of liquid radioactive waste.* Trace Elements Investigation Report 769. U.S. Geological Survey.

Rodda, P.U. 1959. Geology and paleontology of a portion of Shasta County, California. Ph.D. thesis (published), University of California Los Angeles.

Rodda, P.U., and M.A. Murphy. 1978. *Paleontological resources reconnaissance: Cottonwood Creek project.* Sacramento, California: U.S. Army Corps of Engineers.

Rodda, P.U., and M.A. Murphy. 1985. *Paleontological survey, Cottonwood Creek project.* Sacramento, California: U.S. Army Corps of Engineers.

Rodda, P.U., and M.A. Murphy. 1987. *Paleontological survey: Hulen Reservoir project.* Prepared for the California Department of Water Resources, Northern district, Red Bluff, California. San Francisco, California: California Academy of Sciences.

Saul, L.R. 1973. Evidence for the origin of the Mactridae (Bivalvia) in the Cretaceous. *University of California, Publications in the Geological Sciences* 97:1–59.

Saul, L.R. 1978. The north Pacific Cretaceous trigoniid genus *Yaadia*. *University of California, Publications in the Geological Sciences* 119:1–65, plates 1–12.

Saul, L.R., and W.P. Popenoe. 1962. *Meekia*, enigmatic Cretaceous pelecypod genus. *University of California, Publications in the Geological Sciences* 40(5):289–344.

Scharpenseel, H.W., and P. Becker-Heidmann. 1992. Twenty-five years of radiocarbon dating soils: Paradigm of erring and learning. *Radiocarbon* 40:85–93.

Snelling, A.A. 1997. Radioactive "dating" in conflict! Fossil wood in ancient lava flow yields radiocarbon. *Creation Ex Nihilo* 20(1):24–27.

Snelling, A.A. 1998. Stumping old-age dogma: Radiocarbon in an "ancient" fossil tree stump casts doubt on traditional rock/fossil dating. *Creation Ex Nihilo* 20(4):48–51.

Snelling, A.A. 1999. Dating dilemma: Fossil wood in ancient sandstone. *Creation Ex Nihilo* 21(3):39–41.

Snelling, A.A. 2000a. Geological conflict: Young radiocarbon date for ancient fossil wood challenges fossil dating. *Creation Ex Nihilo* 22(2):44–47.

Snelling, A.A. 2000b. Conflicting "ages" of Tertiary basalt and contained fossilized word, Crinum, central Queensland, Australia. *Creation Ex Nihilo Technical Journal* 14(2): 99–122.

Snelling, A.A. 2000c. Geochemical processes in the mantle and crust. In *Radioisotopes and the age of the earth: A young-earth creationist research initiative*, ed. L. Vardiman, A.A. Snelling, and E.F. Chaffin, pp.123–304. Santee, California: Institute for Creation Research; St. Joseph, Missouri: Creation Research Society.

Snelling, A.A. 2005. Isochron discordances and the role of inheritance and mixing of radioisotopes in the mantle and crust. In *Radioisotopes and the age of the earth: Results of a young-earth creationist research initiative*, ed. L. Vardiman, A.A. Snelling, and E.F. Chaffin, pp.393–524. Santee, California: Institute for Creation Research; Chino Valley, Arizona: Creation Research Society.

Snelling, A.A. 2008. Radiocarbon in "ancient" fossil wood. *Impact #415*. Dallas, Texas: Institute for Creation Research.

Stach, E., M.-Th. Mackowsky, M. Teichmüller, G.H. Taylor, D. Chandra, and R. Teichmüller. 1982. *Stach's textbook of coal petrology*, third revised and enlarged edition. Gebrüder Borntraeger, Berlin.

Stanton, T.W. 1893. The faunas of the Shasta and Chico Formations. *Geological Society of America Bulletin* 4: 245–256.

Stewart, R.B. 1926. Gabb's California fossil type gastorpods. *Academy of Natural Sciences of Philadephia, Proceedings* 78:287–447, plates 20–32.

Stewart, R.B. 1930. *Gabb's California Cretaceous and Tertiary type lamellibranchs.* Special Publication No.3. Academy of Natural Sciences of Philadelphia.

Taylor, R.E., and J.R. Southon. 2007. Use of natural diamonds to monitor ^{14}C AMS instrument backgrounds. *Nuclear Instruments and Methods in Physics Research B* 259: 282–287.

Trask, J.B. 1855. *Ammonites batesii. California Academy of Sciences, Proceedings* 1:39.

Vardiman, L. A.A. Snelling, and E.F. Chaffin. ed. 2005. *Radioisotopes and the age of the earth: Results of a young-earth creationist research initiative.* Santee, California: Institute for Creation Research; Chino Valley, Arizona: Creation Research Society.

Vogel, J.S., D.E. Nelson, and J.R. Southon. 1987. ^{14}C background levels in an accelerator mass spectrometry system. *Radiocarbon* 29:323–333.

Ward, L.F. 1905. Flora of the Shasta Formation. In *Status of the Mesozoic floras of the United States*, ed. L.F. Ward, pp.211–221. Monograph 48, U.S. Geological Survey.

Webb, G.E., G.J. Price, L.D. Northdurft, L. Deer, and L. Rintoul. 2007. Cryptic meteoric diagenesis in freshwater bivalves: Implications for radiocarbon dating. *Geology* 35(9):803–806.

White, C.A. 1885. *On the Mesozoic and Cenozoic paleontology of California.* Bulletin 15, U.S. Geological Survey.

Whitelaw, R.L. 1970. Time, life, and history in the light of 15,000 radiocarbon dates. *Creation Research Society Quarterly* 7(1):56–71.

Whitney, J.D. 1864. *Preface: Geological survey of California, paleontology*, vol.1, pp.vii–xx.

Whitney, J.D. 1865. *Report of progress and synopsis of the field work: Geological survey of California, Volume 1:Geology.*

Wiedmann, J. 1962. Ammoniten aus der Vascogotischen Kreide (Nordspanien), I. *Phylloceratina, Lytoceratina, Palaeontographica* 118A:120–237, plates 8–14.

Wolfe, J.A., J.A. Doyle, and V.M. Page. 1975. The bases of angiosperm phylogeny: paleobotany. *Missouri Botanic Garden, Annual* 62:801–824.

Woodmorappe, J. 1999. *The mythology of modern dating methods.* El Cajon, California: Institute for Creation Research.