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Paleobotanical Anomalies Bearing on the Age of the Salt Range Formation of Pakistan: A Historical Survey of an Unresolved Scientific Controversy

I presented this paper at the XXIst International Congress of History of Science, which was held in Mexico City, July 8–14, 2001. As a member of the History of Science Society, I applied for and received a travel grant from the National Science Foundation of the United States of America, administered through the History of Science Society, to attend the conference and give this paper. It is probably one of the few times in its history that the NSF gave a grant to an antievolutionist to present an antievolutionary paper at an academic conference.

Introduction

For well over a century the Salt Range Mountains of Pakistan have attracted the special attention of geologists. Starting in the foothills of the Himalayas in northeastern Pakistan, the Salt Range Mountains run about 150 miles in a westerly direction, roughly parallel to the Jhelum River until it joins the Indus. The Salt Range Mountains then extend some distance beyond the Indus. The southern edge of the eastern Salt Range Mountains drops steeply two or three thousand feet to the Jhelum River plain. In this escarpment and other locations, the Salt Range Mountains expose a series of formations ranging from the earliest Cambrian to the most recent geological periods. Such exposures are rarely encountered and are thus of great interest to geologists and other earth scientists. At the bottom of the series, beneath the Cambrian Purple Sandstone, lies the Salt Range Formation, composed of thick layers of reddish, clayey material (the Salt Marl) in which are found layers of rock salt, gypsum, shale, and dolomite. For centuries, the salt has been mined and traded widely in the northern part of the Indian subcontinent. Ever since professional geologists began studying the Salt Range Mountains in the middle part of the nineteenth century, the age of the Salt Range Formation has been a topic of extreme controversy. Some held that it was of early Cambrian antiquity, while others were certain the Salt Range Formation was far more recent. The controversy intensified in the twentieth century when scientists discovered remains of advanced plants in the Salt Range Formation. In this paper, I shall review the history of the controversy, focusing on its paleobotanical aspect, and then

comment on the controversy's importance to historical studies of science and to the study of science and religion.

The History of the Controversy

Scientific investigation of the Salt Range Formation began in the nineteenth century, when Pakistan was part of British India. The Cambrian age of the overlying Purple Sandstone, which contains trilobites, was generally undisputed. But there were various opinions about the age and origin of the Salt Range Formation, usually found beneath the Purple Sandstone. Questions also arose about the relative ages of the Salt Range Formation and the Kohat salt deposits, located to the north of the Salt Range Mountains.

A. B. Wynne (1878, p. 83) surveyed the Salt Range Mountains in 1869–71 and concluded that the Salt Range Formation was a normal sedimentary deposit of Paleozoic age. This view was shared by H. Warth, who had extensive knowledge of the region gathered over twenty years (Wynne 1878, p. 73). Wynne and Warth thought the Kohat salt formations were younger, perhaps Tertiary (Wynne 1875, pp.32–37). These views were shared by W. T. Blanford (Medlicott and Blanford 1879 v. 2, p. 488).

Later, C. S. Middlemiss of the Geological Survey of India (1891, p. 42) proposed that the Salt Marl was not a sedimentary formation. It was instead a secretion from an underlying layer of magma that had intruded beneath the Cambrian Purple Sandstone. R. D. Oldham (1893, p. 112), superintendent of the Geological Survey of India, came to a similar conclusion. This opened up the possiblity that the Salt Range Formation was younger than the overlying Cambrian Purple Sandstone.

The German geologist F. Noetling originally thought the Salt Range Formation was Precambrian (Zuber 1914, p. 334). But in a paper published in 1903 (Koken and Noetling, p. 35), Noetling said the Cambrian Purple Sandstone was the oldest formation in the Salt Range Mountains and assigned the underlying Salt Range Formation a much more recent age, without explicit explanation. Holland (1903, p. 26) reported that Noetling believed that the Cambrian Purple Sandstone and other overlying formations had been pushed over the Salt Range Formation by a massive overthrust. According to this idea, the Salt Range Formation was a normal deposit, the same age as the Eocene salt deposits of the Kohat region, just north of the Salt Range Mountains. This overthrust version was accepted by Zuber (1914).

W. Christie (1914), chemist for the Geological Survey of India, held that the Salt Range Formation was not of igneous origin, as proposed by Middlemiss. He found it to be a normal sedimentary deposit, produced by evaporation of seawater, but he did not say when this occurred.

Murray Stuart (1919) agreed with Christie that the Salt Range Formation was a normal sedimentary deposit. According to Stuart, both the salt deposits in the Salt Range and Kohat regions were both of early Cambrian or Precambrian age. In the Kohat region, the salt lies directly below the "nummulitic" limestones, from the Eocene. Stuart explained this by proposing that an overthrust had removed the Paleozoic and Mesozoic layers, which are found overlying the Salt Range Formation 20 miles away.

In 1920, E. H. Pascoe, in considering all the previous reports, came up with his own conclusion. The Salt Range Formation was a normal sedimentary deposit, of Tertiary (Eocene) age, as was the Kohat salt deposit. Pascoe also believed the Purple Sandstone overlying the Salt Range Formation to be Eocene. The position of the Salt Range Formation and the Purple Sandstone below other formations of Cambrian antiquity was attributed to a massive overthrust.

Robert Van Vleck Anderson (1927) gave the first report of botanical fossil remains from the Salt Range Formation. He noted the presence of "poorly preserved impressions of leaves of a Tertiary or, at earliest, Mesozoic type." The impressions came from shale deposits at Khewra Gorge in the Salt Range. He gave samples to Dr. Ralph W. Chaney of the Carnegie Institution, who said:

"This specimen clearly contains fragments of several specimens of dicotyledonous leaves. This places their age as not older than the Lower Cretaceous when the first dicots appeared. One of the leaves is very probably oak (*Quercus*) and its size and margin strongly suggest the Oligocene species *Quercus clarnensis* from western America. It is of interest to note that I found a closely related species in the Oligocene deposits of Manchuria. Your specimen is almost certainly of Tertiary age" (Anderson 1927, p. 672). From this evidence, Anderson argued for a Tertiary age for the Salt Range Formation as well as the Kohat Salt. The presence of Cambrian layers above the Salt Range Formation was attributed by him to an overthrust.

In 1928, Cyril S. Fox published a study concluding that both the Salt Range and Kohat salt deposits were early Cambrian or Precambrian. He saw no signs of an overthrust. He did not mention Anderson's discoveries.

In his presidential address to the geology section of the Eighteenth Indian Science Congress, G. Cotter (1931, p. 296) disputed Anderson's report of leaf impressions found in the Salt Range Formation. He noted the E. R. Gee had searched the same locality in January 1929 and found no new specimens. Cotter joined Gee for another search in March 1929 and also found no new specimens. Cotter noted that they found "carbonaceous markings, some of which simulated broad leaf impressions." But they were in his opinion "not plant fossils."

Anderson then sent to the Geological Survey of India office his best *Quercus* specimen. Cotter considered it "doubtful." But Pascoe (1930, p. 25) said that the specimen had perhaps been damaged by friction during transit, making it "undeterminable." Pascoe expressed a hope that the specimen had been photographed before it was shipped, but there is no record of such a photograph in Anderson's reports. Some of Anderson's specimens were sent to Professor B. Sahni at Oxford, who, according to Cotter, thought that "the specimens, if they were plants at all, were quite indeterminate."

Cotter (1931, p. 299) also made this interesting observation: "About the year 1924 a large trunk of wood of a modern type and scarcely at all decomposed was found in the salt in the upper tunnel of the Khewra mine. Dr. Dunn, who examined this wood states that the trunk was about 2 ft. in diameter, and that there were several branches associated with it of about 3 to 4 inches in diameter. Prof. Sahni regarded this wood as modern and resembling an *Acacia* now found growing in the Salt Range."

Cotter, after considering all arguments pro and con, said he favored a pre-Cambri-

an age for the Salt Range Formation (1931, p. 300). But before his paper expressing this view went to press, Cotter examined occurences of nummulites, fossil formanifera typical of the Tertiary, discovered by E. R. Gee in the salt marl at Khewra. Cotter, who had originally thought they had been washed into the Salt Range Formation from younger deposits, decided they were native to the Salt Range Formation. In a footnote added to his paper before publication, Cotter (1931, p. 300) reversed the position stated in the paper and declared the Salt Range Formation to be Tertiary. But he regarded it as intrusive, which would explain its position beneath the Cambrian Purple Sandstone. According to Cotter (1933, p. 151), the plastic salt, of Eocene age, was somehow squeezed by geological pressure and other forces into an abnormal positon.

Cotter (1933, p. 150) said that the Khewra nummulites discovered by Gee "occurred in association with plant fragments." He further noted (Cotter 1933, pp. 150–151) that "plant fragments were also found by Mr. Gee in the Salt Marl at the Nila Wahan." Pascoe (1959, p. 569) cites a 1933 report that at Kalra Wahan, a sample of salt marl "yielded not only carbonised stem fragments but also several small leaves of apparently dicotyledenous type." Pascoe (1930, p. 132) also noted that Gee found a small piece of fossil wood in the reddish marls of the Salt Range Formation.

Gee (1934) gave his own opinion about the age of the Salt Range Formation, which he called "the Saline series." He concluded that both it and the Kohat salt deposits were of the same Eocene age. The Kohat salt was in its normal position, but Gee (1934, p. 461) noted that "a very regular thrust of immense dimensions must be postulated in order to explain the present position of the Saline series beneath the early Paleozoics (or pre-Cambrian)." Concerning foraminifera found by him in Salt Range Formation deposits, he admitted that they might be derived from more recent formations (Gee 1934, p. 463; Fermor 1935, p. 64). But Gee (1934, p. 463) noted, "Plant fragments, however, have been found not only in beds of doubtful age but also in beds which are regarded as being definitely *in situ* in the Saline series." He regarded this as evidence the Salt Range Formation was not Cambrian.

Some years later, B. Sahni, then a paleobotanist at the University of Lucknow, reported the existence of numerous plant microfossils in samples taken from the Salt Range Formation at the Khewra and Warcha salt mines. Previously, doubt had been cast on plant fossils from the Salt Range Formation. Critics, said Sahni (1944, p. 462), had pointed out that "in such a highly soluble and plastic substance as the Salt Marl, extraneous material might have penetrated through solution holes or have been enveloped during relatively modern earth movements."

But deep within the mines, Sahni found deposits where such objections could not apply. The salt in these places ran in layers separated by thin layers of saline earth, locally called "kallar." Sahni (1944, p. 462) noted that "the kallar lies closely interlaminated with the salt, in beds which run continuously for long distances and which, although visibly tilted, show no other visible signs of disturbance."

According to Sahni, the salt layers accumulated from evaporation of sea water in coastal lagoons, whereas the kallar represented dust and dirt blown on to the drying salt by the wind. Sahni guessed that the kallar might contain pollen and other plant microfossils. When he examined specimens, he found this to be so (Sahni 1944, p. 462): ".

. . every single piece has yielded microfossils. . . . The great majority are undeterminable as to genus and species, being mainly shreds of angiosperm wood, but there are also gymnosperm tracheids with large round bordered pits, and at least one good, winged, six-legged insect with compound eyes." To Sahni, this meant that the Salt Range Formation must be Eocene rather than Cambrian. Sahni later found plant fragments not only in the kallar, but in associated solid rock layers composed of dolomite and shale.

Around this same time, the Geological Survey of India and an oil company sent a team of geologists to carefully study the Salt Range Formation, and on the basis of their field observations they concluded that it was in normal position below the Cambrian Purple Sandstone and was thus Cambrian in age. This conclusion was announced in a letter to *Nature* (Coates *et al.* 1945). Among the geologists signing the letter was Gee, until recently an advocate of an Eocene age for the Salt Range Formation. The geologists admitted, however, that "our conclusions were arrived at despite certain difficulties, such as the occurrence of minute plant fragments of post-Cambrian age in the dolomites and oil shales, for which we have at present no clear explanation to offer." In other words, it might be possible to explain the presence of plant fragments in the soluble salt layers, but how did they get into solid rock such as dolomite and shale? This line of reasoning is based on the assumption that land plants did not come into being until the Silurian, with advanced plants such as angiosperms not arising until the Cretaceous.

In his presidential address to India's National Academy of Sciences in 1944, Sahni (1945) introduced numerous examples of pollen, wood fragments, and insect parts found in samples of kallar, dolomite, and shale from the Salt Range Formation. In his report, Sahni (1945, p. x) said that "stringent precautions" were taken to prevent contamination of the samples with modern organic remains. He also emphasized that samples were taken from locations where the geological evidence ruled out intrusion from younger strata.

The laboratory techniques employed by Sahni and his assistant, B. S. Trivedi, were rigorous. In a demonstration at a symposium, said Sahni (1945, p. xiv) "a piece of carbonised wood was revealed in a tiny block of dolomite . . . which had been cut and polished on all sides to show it had no pits or cracks visible even with a strong pocket lens. The block was, as usual, passed through a flame and then plunged into a jar of filtered dilute HCl."

In his own address to the National Academy of Sciences, Gee (1945, p. 293) concluded that the Salt Range Formation was a normal sedimentary deposit and in its original position below the Purple Sandstone. This meant it was Cambrian or Precambrian (Gee 1945, p. 305), while Kohat salt was Eocene. This was a change from his earlier opinion that the Salt Range Formation was Eocene (Gee 1934). He saw no compelling evidence for a massive overthrust in the region (Gee 1945, p. 305). Pascoe, formerly a supporter of the idea that the Salt Range Formation was an Eocene deposit covered by an overthrust, placed the Salt Range Formation in the Cambrian section of a new edition of his *Manual of the Geology of India* (Sahni 1947b, p. xxxi).

Gee said that foraminifera of Eocene type found by him in the Salt Range Formation were not *in situ,* as he earlier believed, but were derived from younger forma-

tions. Concerning plant fragments, Gee (1945, p. 296) noted: "Further work on the clay containing plant fragments at Katha led to the discovery of one or two small leaf impressions which were identified by Prof. B. Sahni as belonging to *Acacia,* a genus still existing in the Salt Range area, whilst in the case of the Khewra mine occurrences, the existence of an important thrust-fault nearby, running roughly parallel to the seams of rocksalt, indicated an alternative explanation for the occurrence of these plant fragments." Gee thought they might have been introduced into the salt in relatively recent times.

Concerning the Katha finds, Gee relies on the assumption that *Acacia* is quite recent, and could not possibly have existed in the Cambrian. Concerning the Khewra finds, Gee uses the existence of a fault to explain the presence of advanced plants in a formation he regarded as Cambrian. But he does not explain how close the thrust fault was to the exact places where he recovered plant fragments nor whether the stratification showed any obvious signs of local disturbance. The fact that the salt was still arranged in seams, apparently unbroken, leaves open the possibility that the plant fragments were found *in situ.*

Gee (1945, p. 297) found Anderson's leaf impressions unconvincing, calling them "unidentifiable brownish markings, possibly organic." Gee (1945, p. 299) saw signs of organic deposits in the shales and dolomites of the Salt Range Formation, but characterized them as "too primitive to include resistant skeletons or woody tissues such as might be preserved."

Gee was, however, seriously troubled by the discoveries of Sahni, which were based on careful observation and laboratory work. Apparently, Sahni had demonstrated the existence of advanced plant remains, including woody tissues, not only in the salt and dolomites of the Salt Range Formation but in other kinds of rock as well, such as shale. About the salt and dolomites, Gee proposed that plant fragments could have been introduced into them by "percolating water." But this explanation would not, said Gee (1945, p. 307) apply to the extremely resistant oil shales, in which Sahni had also found microfossils. Gee (1945, p. 306) noted that if Sahni, on the basis of his plant fossils, was correct in assigning an Eocene age to the Salt Range Formation, "then it will be necessary to modify our views regarding the essential characteristics of normal sedimentary and tectonic contacts." According to standard geological reasoning these indicated a Cambian age.

At the Indian National Academy of Sciences annual meeting for 1945, the Salt Range Formation was once more a topic of extended debate. Sahni (1947a, 1947b) gave reports of additional discoveries of angiosperm and gymnosperm microfossils from the salt marl, the oil shales, and dolomites at all levels of the Salt Range Formation. Microfossils of advanced plants were also recovered from core samples from deep borings in the Khewra salt mine. Sahni (1947b, pp. xxxi–xxxvi) gave convincing evidence that the microfossils were not intrusive contaminations. Furthermore, at scientific gatherings in Great Britain, Sahni (1947b, p. xxxix) demonstrated to geologists his laboratory techniques and obtained "fragments of woody tissue" from samples of the Salt Range Formations's dolomites and oil shales.

Sahni (1947a, p. 243) added that "in a fragment of Mr. Anderson's original material

several microfragments of wood have been found." This would tend to support Anderson's identification of leaf imprints in his material from Khewra Gorge. Sahni had accompanied Gee and others to Anderson's site, and had found no similar specimens. Sahni (1947b, p. xx) noted that these circumstances "do not by any means cast a doubt upon the identification of Mr. Anderson's specimen as an oak leaf." Sahni (1947b, p. xx) also noted: "As it turned out, we had been searching at the wrong place." Anderson's oak leaf imprint had come from a spot lower than that searched, and some distance away.

Concerning the advanced nature of the plant and insect microfossils found in the Salt Range Formation, Sahni (1947b, pp. xlv–xlvi) noted: "Quite recently, an alternative explanation has been offered by Mr. Gee. *The suggestion is that the angiosperms, gymnosperms and insects of the Saline Series may represent a highly evolved Cambrian or Precambrian flora and fauna!* In other words, it is suggested that these plants and animals made their appearance in the Salt Range area several hundred million years earlier than they did anywhere else in the world. One would scarcely have believed that such an idea would be seriously put forward by any geologist today."

Gee, by questioning basic evolutionary assumptions about the progression of life forms on earth, introduces another possible solution to the Salt Range Formation controversy. Up to this point, the relatively late appearance of the angiosperms, gymnosperms, and certain insects had been taken for granted. Evidence of their presence in the Salt Range Formation had to be resolved by (1) suggesting they were intrusive into the formation, which was of Cambrian age or (2) suggesting that they were native to the formation proving it was Eocene and invoking a massive overthrust to account for the formation's presence below formations generally accepted as Cambrian. Supporters of the former proposal, including Gee, were troubled, however, by the strength of Sahni's evidence for the *in situ* status of his microfossils. So Gee suggested that perhaps the Salt Range Formation is, after all, Cambrian, as the geological evidence strongly suggested, and the microfossils of angiosperms, gymnosperms,and insects were *in situ.* This could only mean that the angiosperms, gymnosperms, and insects evolved far earlier than allowed by any current evolutionary account. It was a bold proposal, but fell on deaf ears at the time.

Subsequently, evidence for angiosperms and gymnosperms was also found in other beds of Cambrian age overlying the Salt Range Formation. These included microfossils of angiosperms and gymnosperms from the Salt Pseudomorph Beds (Ghosh and Bose, 1947), gymnosperms from the Purple Sandstone (Ghosh, *et al.,* 1948), wood fragments from the Neobolus Shales (Ghosh, *et al.,* 1948), and wood fragments from the Magnesian Sandstone (Ghosh, *et al.,* 1948).

Ghosh and Bose (1950, p. 76) proposed two possible explanations for this evidence of advanced vascular plants in the above-mentioned formations: "1. The geologically known Cambrian beds are of post-Cambrian age. 2. The vascular plants existed in Cambrian or pre-Cambrian times." Ghosh and Bose rejected the first proposal because geologists unanimously agreed that the beds in question were in fact Cambrian. Ghosh and Bose found the second proposal more likely, even though it was "inconsistent with the prevailing concepts of plant phylogeny." They pointed out that there had been discoveries of advanced plant remains in beds of similar age in Sweden (Darrah 1937) and

in the USSR (Sahni 1947b, in note following plates).

Ghosh and Bose (1947) reconfirmed the original discoveries by Sahni and his coworkers of advanced plant remains in the Salt Range Formation itself. They also found fragments of advanced plants from a sample of shale from the Cambrian or pre-Cambrian beds of the Vindhyans of northern India (Ghosh and Bose 1950b) and from a sample of Cambrian rock from Kashmir (Ghosh and Bose 1951). In some cases, Ghosh and Bose (1951b, pp. 130–131; 1952) found fragments of advanced plants (coniferous) in Cambrian rock samples that also contained trilobites. The samples were from the Salt Pseudomorph beds of the Salt Range and the shales of the Rainwar locality in Kashmir.

Other researchers confirmed the work of Ghosh and his associates (Jacob *et al.* 1953), finding evidence for advanced vascular plants, including gymnosperms, in Cambrian rock samples from the Salt Range and other sites in India. Jacob and his coworkers also called attention to similar Cambrian paleobotanical discoveries in Sweden, Estonia, and Russia, as reported by S. N. Naumova, A. V. Kopeliovitch, A. Reissinger, and W. C. Darrah (Jacob *et al.* 1953, p. 35).

German researchers (Schindewolf and Seilacher, 1955) took samples of rock from the Salt Range to Germany, where specialists found no evidence of plant remains. But in his discussion, Schindewolf mentioned that he personally witnessed an Indian scientist obtain plant microfossils from a Cambrian Salt Range rock sample in India. After this, active discussion of the controversy diminished. It is quite possible that this was the result of the partition of India and Pakistan. After partition, members of the Geological Survey of India may not have had such easy access to the Salt Range in the newly independent Islamic state of Pakistan.

In recent years, petroleum geologists have conducted extensive studies of the Salt Range region, with no reference or only slight reference to the debates that took place earlier in the century. Although modern geological reports acknowledge overthrusts in the Salt Range, they unanimously declare the Salt Range Formation to be Eocambrian (Yeats *et al.* 1984, Butler *et al.* 1987, Jauné and Lillie 1988, Baker *et al.* 1988, Pennock *et al.* 1989, McDougall and Khan 1990). One paper (Butler *et al.* 1987, p. 410) mentions discoveries of wood fragments in the salt deep in the mines at Khewra. The authors propose these are intrusive, but neglect to discuss the extensive reporting by Sahni and others ruling out such an explanation for the microfossils discovered in various kinds of rock from the Salt Range Formation.

Discussion

In the early stages of the debates about the nature and age of the Salt Range Formation, fossil evidence did not play a major role. Geological considerations dominated the discussion. With the introduction of paleobotanical evidence by Sahni and others in the 1930s and 1940s, the Salt Range controversy became interesting from a paleontological perspective. Sahni, along with his coworkers and supporters, believed that microfossils of advanced plants and insects, along with a few plant macrofossils (pieces of wood and leaf imprints), indicated an Eocene age for the Salt Range Formation.

They explained the presence of the Salt Range Formation below undisputed Cambrian beds (the Purple Sandstone, the Neobolus beds, the Magnesian Sandstone, and the Salt Pseudomorph Beds) as the result of a massive overthrust.

Advocates of a Cambrian age for the Salt Range Formation challenged Sahni's conclusions on two fronts.

First, they argued that the plant and insect fossils must have been intrusive. But even these opponents acknowledged it would be difficult to explain how such fossils could have intruded into resistant rock such as the oil shales found in the Salt Range Formation. Overall, it seems there is fairly good evidence for the presence of microfossils and even some macrofossils in the Salt Range Formation. Sahni and his coworkers presented good arguments against possible contamination of their rock samples, either *in situ* or in the laboratory.

Second, the advocates of a Cambrian age for the Salt Range Formation argued against Sahni's hypothesis of a massive overthrust, that covered the Eocene Salt Range Formation with Cambrian formations. Opponents disputed the overthrust hypothesis, citing signs of normal contact between the Salt Range Formation and the overlying beds. Modern geological opinion partly favors Sahni. There is evidence of thrust faulting in the Salt Range. But modern geological opinion is also unanimous in assigning the Salt Range Formation to the Eocambrian.

If we stop at this point, the controversy remains unresolved. There still appears to be a conflict between the geological evidence and the paleobotanical evidence. The conflict may, however, be resolved if we adopt the approach taken by Gee, who proposed that an advanced land flora and insect fauna may have existed in the Cambrian or Precambrian. This, of course, challenges accepted views on the evolution of life on earth. But it seems to be the most reasonable way to bring all categories of evidence into harmony.

Support for the existence of advanced vascular plants (including gymnosperms and and angiosperms) in the earliest Paleozoic is supported by (1) reports by Ghosh and his coworkers of microfossils of gymnosperms and angiosperms in the Cambrian beds overlying the Salt Range Formation and in Cambrian beds elsewhere in the Indian subcontinent; (2) contemporary reports from researchers in other parts of the world giving evidence for advanced vascular plants in the Cambrian (see Leclerq 1956 for a review); (3) modern reports placing the existence of the angiosperms as far back as the Triassic (Cornet 1989, 1993). According to standard views angiosperms originated in the Cretaceous. Cornet's work places them in the Triassic, providing a step between the standard view of a Cretaceous origin for the angiosperms and Sahni's evidence showing an angiosperm presence in the Cambrian. According to standard views, the gymnosperms originated in the Devonian, and the first land plants appeared in the mid-Silurian.

Furthermore, a review of scientifically reported evidence related to human origins and antiquity has revealed signs of a human presence on this planet extending back hundreds of millions of years, at least as far back as the Cambrian (Cremo and Thompson, 1993). Appreciation of the existence, extent, and significance of this body of evidence is hampered by uncritical acceptance of current evolutionary conceptions

about the origin and development of life. In their review of Cremo and Thompson's work, in *Social Studies of Science,* J. Wodak and D. Oldroyd (1995, p. 207) said it is important for two reasons. First, it treats many incidents in the history of archeology in much greater depth than previously. And, second, it raises important issues regarding scientific truth claims. Wodak and Oldroyd advised evolutionists to be more cautious in their claims that evolution is an absolute fact. In any case, the book by Cremo and Thompson (*Forbidden Archeology)* did succeed in bringing about serious discussion of the evidential foundations and certainty of truth claims for human evolution. This present paper is an attempt to initiate similar discussion in plant evolution. It would thus appear that historical studies of science may have a role to play in the active work of a scientific discipline.

In my introduction to *Forbidden Archeology,* I acknowledged that the authors were inspired and motivated by their commitment to Vedic and Puranic accounts of the origin and development of life. This attracted the attention of several reviewers (for example, Wodak and Oldroyd 1995, Murray 1995, and Feder 1994). This paper is similarly inspired and motivated. According to Vedic and Puranic accounts, the earth passes through phases of manifestation and devastation known as *kalpas,* or days of Brahma. Each day of Brahma is 4.32 billion years long. During the day, life is manifest on earth. At the end of each day of Brahma, there is a devastation, during which the earth is submerged in cosmic waters. The period of devastation is called a night of Brahma, and is of the same length as a day of Brahma. At the end of the night of Brahma, the earth emerges from the waters of devastation, and life again becomes manifest. Each day of Brahma consists of 14 *manvantara* periods, each composed of 71 *yuga* cycles, each *yuga* cycle lasting 4.32 million years. According to Puranic accounts, we are now in the 28th *yuga* cycle of the 7th *manvatara* period of the current day of Brahma. In other words, we are roughly 2 billion years into the current day of Brahma. Before that, there would be 4.32 billion years of devastation, with the earth submerged in cosmic waters. According to current accounts, the earth formed about 4 billion years ago (within the latter part of the last night of Brahma), and life first appeared about 2 billion years ago (during the first part of the current day of Brahma). This is an interesting temporal parallel between the modern scientific and ancient Puranic cosmologies. But in Puranic accounts, we also find evidence of humans, plants, and animals existing in the first manvantara period of the current day of Brahma. The evidence reported in this paper, in my book *Forbidden Archeology* (Cremo and Thompson, 1993), and in a paper presented at the World Archeological Congress (Cremo 1995) are consistent with the Puranic view.

Conclusion

Paleobotanical and geological evidence from the Salt Range in Pakistan suggests that advanced plants, including gymnosperms and angiosperms, as well as insects, existed in the early Cambrian, consistent with historical accounts in the *Puranas*. When considered in relation to extensive evidence for an anatomically modern human presence extending back to the same period, the evidence from the Salt Range suggests the

need for a complete reevaluation of current ideas about the evolution of life on this planet. One possible outcome of this reevaluation could be the abandonment of the Darwinian evolutionary hypothesis in favor of a model for life's origin and development drawn from the Vedic and Puranic texts.

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