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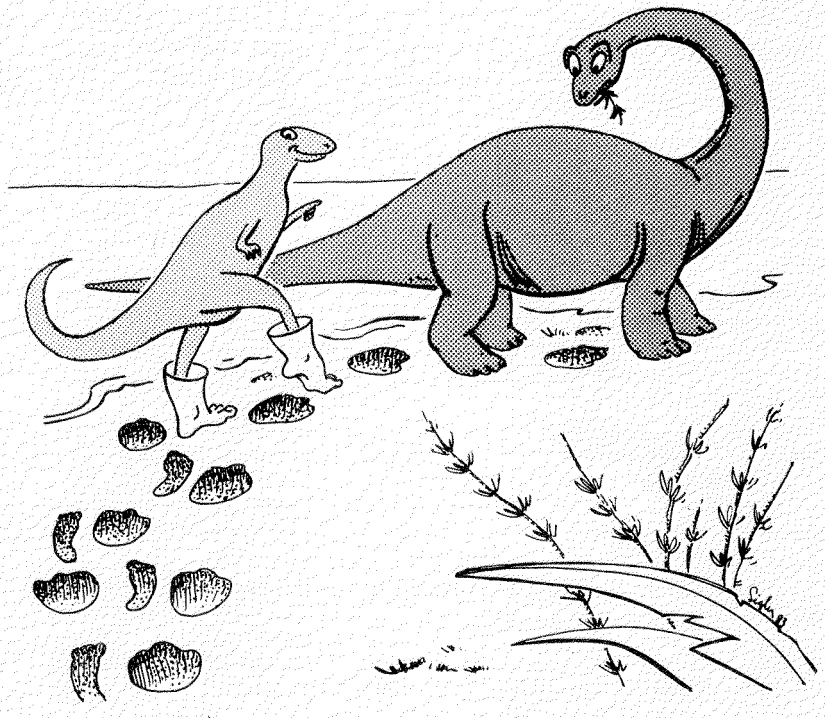

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SPECIAL ISSUE

The Paluxy River Footprint Mystery — Solved

edited by John R. Cole and Laurie R. Godfrey

Did humans and dinosaurs live together in Texas just before Noah's Flood? Creationists say they did, supporting this claim by citing alleged human footprints that have been found side-by-side with those of dinosaurs in the Cretaceous limestone of the Paluxy River near Glen Rose, Texas. But what would a scientific team of noncreationists conclude? *Creation/Evolution* wanted to find out, and so it supported the efforts of Dr. Laurie R. Godfrey to gather together such a team, conduct first-hand investigations, and report the findings. The result is this special issue of *Creation/Evolution* edited by John R. Cole and Laurie R. Godfrey and authored by the following individuals.

JOHN R. COLE earned his Ph.D. in anthropology from Columbia University, specializing in archaeology and cultural anthropology. He is executive director of the Committee for the Scientific Investigation of Claims of the Paranormal and formerly taught at the University of Northern Iowa and the University of Massachusetts at Amherst.

LAURIE R. GODFREY earned her Harvard Ph.D. in anthropology, specializing in paleontology and anatomy. She is associate professor of anthropology at the University of Massachusetts, Amherst, and M. I. Bunting Science Fellow at Radcliffe-Harvard.

RONNIE J. HASTINGS earned his Ph.D. in physics from Texas A & M. He is chair of the Science Department, Waxahachie, Texas High School, and is a member of the Texas Council for Science Education.

STEVEN D. SCHAFERSMAN earned his Ph.D. in geology from Rice University, specializing in invertebrate paleontology. He is president of the Texas Council for Science Education and is a consulting research geologist in Houston.

All have written extensively on various topics of the creation/evolution controversy.

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Editor: Frederick Edwords; **Associate Editor:** Philip Osmon

Introduction

J.R. Cole, L.R. Godfrey, R.J. Hastings, and S.D. Schafersman

When creationist Clifford L. Burdick published in 1950 a short article entitled "When GIANTS Roamed the Earth: Their Fossil Footprints Still Visible!" in the Seventh Day Adventist periodical *Signs of the Times*, he opened a can of worms still not contained. He brought public attention to an issue that had been fairly local up to that time—the claim that human and dinosaur tracks are found together in the same strata and that the human tracks were made by biblical giants.

A. W. McCann (1922), Byron Nelson (1931) and George McCready Price (1935) had previously revived nineteenth century Seventh Day Adventist "Flood Geology," which claimed vaguely that humans and prehistoric animals had lived together before Noah's flood had reshaped the earth about 4800 years ago. However, they lacked the direct evidence that Burdick thought he had found.

Burdick was originally inspired by a 1939 *Natural History* magazine article by Roland T. Bird mentioning the discovery of fake giant human footprints from Glen Rose, Texas—prints that had been carved in the Cretaceous rock. Burdick began his search for these prints in 1945 and managed to locate them in a small museum in Arizona. Refusing to believe that they were carved, he enthusiastically discussed them with his creationist colleagues. In 1961, photographs taken by Burdick of the tracks appeared in *The Genesis Flood* by Whitcomb and Morris. This book, hailed by the creationists themselves as the watershed of the modern "scientific" creation movement, helped spread the Paluxy mantrack claims.

Following the appearance of *The Genesis Flood*, individual creationists and creationist teams began visiting the Glen Rose area looking for new "mantracks" (as they came to be called). Notable among these was Stanley Taylor who, after a 1968 search, returned in 1970 with a full crew and produced the film *Footprints in Stone*. This film gave the mantrack claims an even larger audience and further interest was aroused. As a result, the Institute for Creation Research began their own explorations in 1975—the same year that Erich Von Däniken, author of *Chariots of the Gods?*, sent a cameraman from Europe to film the tracks in order to support his own "ancient astronaut" claims.

The latest in this series of investigators is the Reverend Carl Baugh. He began digging sporadically at the McFall site, upriver from Dinosaur Valley

State Park, in 1982. In a 1983 Bible-Science Association audio tape, Baugh announced his discovery of 44 "human" footprints at the McFall site, some in left-right-left sequences and some stepped on by "*Tyrannosaurus rex*." Most had eroded or dried out, becoming invisible within an hour or so of discovery, thereby making examination by others impossible. (See Table.)

TABLE 1

CARL BAUGH'S "MANPRINTS" AT THE McFALL SITE, 1983

Number of tracks	Average length of tracks	Baugh's comments
28	16"	an individual 8½ feet tall
7	9¾"	called "Beverly" because probably a woman
4	12"	named "Sir George" after former governor of Fiji
5	22"	13' tall, 600 pounds, flat-footed

From such discoveries as these, Baugh concluded that the mantracks were made by people "wading in water, probably searching for clams" between high tides in the "Cambrian" Paluxy area. Then, at high tides, these people returned to temporary safety on the Llano Uplift (Baugh, 1983b), which, incidentally, comprises a distance of about 100 miles each way!

Baugh also carelessly attributed all three-toed (theropod or ornithopod) dinosaur prints in the region to *Tyrannosaurus* and sauropod prints to *Brontosaurus*, indicating perhaps that he was misled by the fiberglass models of *Tyrannosaurus* and *Brontosaurus* on display in Dinosaur Valley State Park. These models were placed there by Arco Oil Company as representatives of two of the suborders of saurischian ("lizard-hipped") dinosaurs which actually made prints in the Paluxy region (Theropoda and Sauropoda, respectively). The models do *not* represent the actual dinosaurs known locally via skeletons or tracks and there is no model of an ornithopod. Glen Rose Cretaceous deposits predate the *Late* Cretaceous appearance of *Tyrannosaurus* by millions of years and postdate the Late *Jurassic* appearance of *Brontosaurus* by a much longer period of time.

Elsewhere (Bartz, 1982b), Baugh spoke glibly of coexisting saber-toothed

tiger tracks at the McFall site, bear tracks at the park, and mammoth tracks and fossils in the general area. He called these "Paluxy Enigmas" that pose problems for scientists who wish to reject the notion that humans and dinosaurs coexisted at the time of Noah's Flood. But, in fact, these statements made his arguments sound even weaker than those of other creationists, since Baugh was describing a Fred Flintstone bestiary of famous fossils that are not associated with the Paluxy River area, were not contemporary with each other, and, more importantly, have not been in any way accurately identified by him. His claims would have at least *sounded* better if his fossil name-dropping had been anything close to accurate. In any case, Baugh declared that his findings made a shambles of the evolutionary sequences built up by supposedly closed-minded scientists who "refuse to look at the evidence" (Baugh, 1983b).

In 1982 and 1983 we accepted the challenge to look at the evidence firsthand. We began as people fully supportive of evolution and we emerged in similar condition. Nonetheless, we sought out as much creationist evidence as we could find, with the intention of rigorously analyzing the data and claims. Others before us had examined some of these claims (Bird, 1939; Neufeld, 1975; Zuidema, 1979 and 1981; Weber, 1981; Godfrey, 1981; Slaughter, in Kirsch, 1982; Langston, 1983), but we wanted to cross-check previous analyses and to draw these and our own on-site research into a report accessible to educators, students, theologians, and others confronted by scientific creationist claims.

We examined as many mantracks as we could, not just those recently publicized by Baugh (1983a, b) and his associates. We measured and photographed alleged mantracks at Dinosaur Valley State Park, a cement-covered "mantrack" in Glen Rose, dinosaur tracks and mantracks at the Thayer Site near New Braunfels, as well as tracks at the McFall site where Baugh has been excavating. We analyzed creationists' published measurements, photographs, and arguments. We sampled a good cross-section of current and past mantrack claims, interviewed local creationists and mantrack skeptics, and consulted with paleontologists familiar with these sites. Two of us, Dr. Hastings and Dr. Schafersman, visited the sites many more times and interviewed creationist excavators, including Baugh.

Later, after we had completed much of our study, creationist Russell Arndt heard a presentation of our findings and said, in effect, "OK, maybe none of the tracks you *saw* were mantracks after all, but they *will* be found there; you haven't seen Dr. Baugh's most recent discoveries, have you?"

This is a common argument. Every pseudoscientific claim we know of falls back on this kind of argument (and the related question, "Were you there when it was discovered?"). Only logic and common sense can answer such objections, because believers can always stay at least one "manstep"

ahead of skeptics. So, rather than attempt the impossible task of replying to *every* mantrack claim, we have tried to discuss the biological/anatomical, geological, cultural, and illogical nature of the claims in general and how they can be evaluated according to the *rules*, instead of particularistic, anecdotal opinions.

Acknowledgements

We wish to thank Lee Mansfield, the Somerville County Museum, and many kind Glen Rose residents. We also thank Dr. Wann Langston, Jr., Dr. Walter Coombs, Dr. Neil Gomberg, Dr. Paul Godfrey, Dr. Eugenie Scott, Dr. Miles Richardson, Dr. Eric Delson, Frederick Edwords, Dan Lorenz, and Dr. Pia Nicolini for their assistance on various aspects of the project.

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Comments and interpretations are the responsibility of the authors and editors, not the organizations or consultants noted above.

Tracking Those Incredible Creationists

R.J. Hastings

As a Texan living close to Glen Rose, I have had the opportunity to observe ongoing creationist fieldwork practically in my own back yard. I have visited the sites of "mantrack" claims in this area more than forty times in a little over two years (with my high school students, with professional colleagues, with my family, and alone). From the time in 1982 when the Reverend Carl Baugh began looking for fresh mantracks on the McFall property using jackhammers, backhoes, and crow bars, I have been able to observe his work in progress, speak with him and his fellow excavators, and interview people visiting the site. I have often been on the scene during excavation, or soon afterwards, to see newly exposed footprints (as were Cole, Godfrey, Schafersman, and others in August 1982 and June 1983, and Schafersman at other times). But, though I have been shown the "best" of the mantracks by Baugh and his colleagues, I have yet to see anything that is convincing.

Often I have raised questions about these mantracks, but answers to my questions have shifted like sand dunes, with separate creationist observers not corroborating each other very well, and even the same informants, including Baugh, changing their responses from month to month. Baugh was initially a gracious host, but as my skepticism became apparent he became less and less willing to share information, and more and more defensive. Nonetheless, his initial hospitality provided me with a good overview of the details of his claims. My observations benefited from access to his opinions and assertions until our relationship gradually cooled.

What follows is a brief combination of ethnography and analysis based upon my acquaintance with Glen Rose creationist excavations from 1982 to the present.

An Investigative Chronology

June 16, 1982. Three students (Burl Barr, Steve Weldon, and Ron Watkins) and I visited the McFall site to observe and videotape Carl Baugh's excavations, as did television crews from Ft. Worth and Dallas who had been invited to witness the discovery of "twenty-four *Tyrannosaurus* prints" and a variable number of "new manprints." We also visited the Park ledge in Dino-

saur Valley State Park to observe and videotape the alleged mantracks there.

At the McFall site, Clifford Wilson, an Australian archaeologist now with the Institute for Creation Research, was on hand to help identify "genuine" human tracks. A group of volunteers there provided the muscle power necessary for the excavation.

During this 1982 excavation, Baugh claimed to have discovered not only Cretaceous human footprints, but also a human handprint with clear thumb impression, a footprint made by a human slipping in the mud, saber-toothed tiger tracks, and unfossilized wood embedded in the same limestone that contained the dinosaur tracks.

Ignoring the priority rules of geological and taxonomic nomenclature, Baugh named the exposed layer of limestone the "Wilsonian Strata" in honor of Clifford Wilson, and he said he named the "man" who left the "mantracks" "*Humanus Bauanthropus*" in honor of a Fijiian hero, Caka(m')bau. A bronze plaque naming *Humanus Bauanthropus* was placed at the site; it also included the date, the sponsors (International Baptist College and Grace Baptist Temple of Duncanville, TX), and a Biblical reference (Job 40:15).

The quality of this excavation was compromised by its single-minded interest in discovering human traces. But, despite the inexperience of the volunteer crew, this crew sometimes took more care to avoid sloppy technique than did Baugh himself. I overheard one volunteer express concern that he may have altered the shape of the track he had been clearing of clay with a hand pick; Baugh replied "If it is a dinosaur print, don't worry about it."

Conclusions hastily drawn and publicly announced were sometimes just as hastily altered. The piece of "wood," for example, later became simply "fibrous material" after it was sectioned. (Actually it was a natural iron oxide deposit.)

After the reporters left, the McFall excavation assumed many of the characteristics of an old-time riverside camp meeting. Mere presence on the site was described as a "blessing." When my students tried to discuss the findings with volunteers, the conversation of the volunteers quickly devolved into a discussion of personal religious beliefs. In this evangelical witnessing we heard far more about the merits of Christian fundamentalism and the evils of disbelief than we did about the human footprints as evidence against evolution. The volunteers were intent upon saving our souls.

The expected television coverage of the day's work turned out to be minimal, but Baugh's sensational discoveries were later featured in the *Bible-Science Newsletter* (Bartz, 1982a,b).

August 19-21, 1982. Laurie Godfrey, John Cole, Steven Schafersman, and I met to study the alleged human footprints at various sites. We visited Dinosaur Valley State Park with Lee Mansfield, paleontology graduate student and

former Park guide. At the McFall site, we observed trackways that had been exposed by Baugh's team only days before and interviewed members of Baugh's team who happened to be at the site and who explained the latest discoveries. We measured and photographed features and videotaped our work.

I could see that the creationists had expanded their efforts at the McFall site since June. But I noticed that some of the shallow dinosaur prints exposed in June were now destroyed, not so much by weathering as by digging and by debris from nearby "human" prints being dumped on them. Features being carefully protected in June were obviously abandoned by August. The creationists' excavations had exposed some genuine dinosaur prints whose quality and paleontological value exceeded most of the accessible dinosaur prints in the state park, yet the creationists clearly were not impressed with them. Only dinosaur prints adjacent to "human" prints were sealed with plastic in an attempt to preserve them from erosion. But, even in these cases, preservation was haphazard and amateurish. Little attention seemed to be paid to the problem of river pollution or obstruction as excavation debris were shoved over the edge of the bank and into the river.

August 23, 1982. I could not be present when Laurie Godfrey, John Cole, and Steven Schafersman visited the Thayer site in Canyon Lake, Texas near New Braunfels. They measured and photographed dinosaur trackways, alleged mantracks, and "wheel tracks."

October 20, 1982. Attorney Fred Weldon and I met Carl Baugh on the McFall site and videotaped his claims concerning a variety of issues. During this taping, Baugh contradicted his own earlier reports of the locations of key discoveries—the "handprint," for example, had moved a half meter or more. When I pointed out this discrepancy, Baugh merely insisted that his latest placement was right. He did not produce horizontal plan maps which would have resolved such questions; I had not observed them being made at the site nor had I seen vertical profiles being drawn.

When confronted with the fact that the marks he called human lacked characteristics of human footprints, Baugh strongly disagreed. *He* could identify toes on particular tracks where we could not; he pointed out pock-marks at the "forward" end of tracks. However, almost identical uneven depressions could typically be seen all around each track and within each, and, in fact, randomly all over the bedrock exposure. When questioned further, he blamed erosion for obliterating the original "perfect" human proportions and features, saying, "You should have been here at the moment of exposure." Anatomical details were said to fade within hours. But when he showed me a photograph of his "best" human footprint, freshly exposed and in pristine

condition, it turned out to be a photograph not of a human footprint but of *Thalassinoides* trace fossils—casts of burrows made by a shrimp-like animal in Cretaceous times. Parallel burrow cast ridges had clearly been mistaken for toes. But, convinced he was right, Baugh cited other mantracks that were "even better," but were "unfortunately" lost to erosion. (Why were there no clear photographs, plan-maps, and videotapes?) I could see that, no matter how easy it was for me to explain the true nature of each successive "best" manprint, tales of "even better" evidence would never cease.

Baugh had a cigar box which he said contained the best evidence yet discovered against the geologic time table—a hammer that had been found by other investigators in 1934 near London, Texas. It was an iron miner's hammer with a wooden handle, and it had been embedded in Ordovician (roughly 500 million year-old) rock. Baugh believes it to be of the same age as the Ordovician beds, thus proving that "Ordovician" is Iron Age, and that Ordovician and post-Ordovician creatures were contemporaries of humans. (Actually the hammer is not Iron Age but nineteenth century; it was clearly a lost or discarded miner's mallet that had fallen into a crack in Ordovician rock and was subsequently sealed in a concretion formed from minerals leaching out of the bedrock. I have repeatedly suggested to Baugh that he radiocarbon date the hammer handle, and he has seemed willing but has not done so.)

October 22, 1982. Steven Schafersman and I just missed meeting Baugh on the site. We met and interviewed creationist Don Garrett and uncovered glaring discrepancies in the claims of major participants in the creationist excavations. For example, Baugh had, on October 20, pointed out some "human" prints that he said were exceedingly clear when first exposed by Don Garrett and himself. But now, Garrett admitted seeing them only weeks after they had been exposed, and could not, therefore, corroborate Baugh's story that they were far "better" when first discovered.

May 7, 1983. Steven Schafersman, Frederick Edwords, other interested parties, and I visited various sites in the Glen Rose area. At the McFall site, we discovered freshly exposed tracks that had probably been worked on only a day or two before. We could see that the creationists had attempted to make casts of some tracks. The features of these tracks (actually distorted three-toed dinosaur footprints) were obscured by the sloppy casting procedures used. River mud was sealed into the bottom of the prints by liquid plastic before the plaster of Paris was poured into the tracks. Trash from this work was left lying about. Edwords extensively photographed this new excavation while I made a videotape record.

Later in the day we learned of Baugh's plans to build a multi-million

dollar creationist museum in the Glen Rose area. The information was on a flyer which said, in part, that the museum displays would include excavated human and dinosaur footprints from the area, a man-made iron hammer which was found in 500 million-year-old rock, a mastodon fossil, a replica of Noah's ark, a flume that would simulate the forces of Noah's Flood, as well as a stone wall "the exact size of Noah's ark." The flyer solicited funds to build the museum, promising a bronze plaque to those who contributed more than $100. Various donor categories were outlined, up to $10,000.

May 8, 1983. Steven Schafersman, Frederick Edwords, other interested parties, and I visited the Thayer site. In addition to the many dinosaur trackways on the property, Helen Thayer pointed out the recent discovery of "dinosaur bones, probably from an *Ankylosaurus*" and examples of "petrified dinosaur hide." But various individuals in our group were able to identify this material as cave deposits and other rocks. Helen Thayer was perturbed at these revelations, but still pointed out two new "probable human footprints," one that she said had recently been confirmed as human by an unnamed foot doctor. (Both were merely erosional features.) We videotaped and photographed these new discoveries as well as earlier discoveries of other "human" footprints and "wheel tracks."

June 3-6, 1983. Laurie Godfrey, John Cole, Steven Schafersman, Pia Nicolini, and I met to begin production on the video documentary, *The Case of the Texas Footprints* (Cole, 1984). This would be based upon the previous year's fieldwork as well as upon new field observations by the same team of scientists, and would replace the amateur video documentary *Footprints in the Mind* (Hastings, 1982) that I had previously prepared.

By this time, the creationists had become aware of growing scientific scrutiny of their work. Analyses of creationist fieldwork claims had reached the public through the writings of Turner (1982), Edwords, Milne and Schafersman, Schafersman, and Stansfield (all 1983), as well as through my 1982 video documentary, and creation-evolution debates held in May 1983 in Dallas, Texas (Schafersman and Edwords vs. Geisler and Anderson) and Oberlin, Ohio (Edwords vs. Gish). This sort of information had caused some local reporters, such as Mary Barrineau of *Westward* magazine, to show more skepticism. Barrineau's article, featuring interviews with Cole, Schafersman, and me, as well as Baugh, would appear on July 24. Baugh was not accustomed to critical reporting, and he became increasingly defensive when I visited him through June.

June 16, 18, 25, 29, and July 1, 1983. I made multiple visits to the McFall site, sometimes accompanied by Steven Schafersman.

On June 18, I met with creationists Gerhard Nickel and John DeVilbiss, advisors to Baugh. Nickel, a high school geology teacher from Newton, Kansas, had cautioned Baugh against declaring featureless and/or eroded depressions human in origin. DeVilbiss, an oil company research geophysicist, was there to do volume measurements of the dinosaur and "human" prints, but he seemed dubious about calling what he observed human. However, both Nickel and De Vilbiss appeared confident that better finds would be made in the future.

On June 25, Schafersman and I interviewed creationist Russell Bixler of WPCB-TV, Channel 40, a Pittsburgh Christian television station. In anticipation of the discovery of notable manprints, he had arrived to aid excavations and to set up television coverage.

Late in June, creationist Clifford Burdick arrived on the scene. Burdick was a human footprint advocate as far back as the 1940s, and a storehouse of recollections concerning "human footprint" sites along the Paluxy. His participation provided a link between contemporary arguments and those of three and four decades ago. On June 29, I met with Baugh and Burdick. On July 1, Schafersman and I met with Bixler, Burdick, and Baugh.

By then, Baugh was openly hostile to us. When Schafersman interviewed him, Baugh only allowed Schafersman to see and photograph his famous hammer in a concretion. He refused to show either of us any manprints, and he refused to show us the moment-of-exposure photographs he said were only a few meters away in his car.

During our meetings, Nickel, Bixler, and Baugh responded to the published criticisms of their mantrack interpretations with unfounded accusations, impugning their critics' motives and abilities. They seemed especially irked by William D. Stansfield's letter to *Scientific American* (1983) that reported conclusions previously published in *Creation/Evolution* (Godfrey, 1981) as well as additional information based on personal communication with Laurie Godfrey. Bixler and Baugh were outraged by Frederick Edwords' column in the March-April 1983 issue of *The Humanist* and both were also angered by my video documentary *Footprints in the Mind*. When pressed, however, it turned out that neither of them had seen *Footprints in the Mind*, but were merely echoing the sentiments of Hilton Hinderleiter of the physics faculty at Pennsylvania State University (cf. Hinderliter, 1984a,b).

The excavation work that involved all these people only uncovered one "human" sliding print, which was no more convincing than previous prints—i.e., devoid of any human anatomical characteristics—and half of an equally unconvincing manprint on a nearby ledge.

December 30, 1983. My son Dan and I attended the Bible-Science Association meeting at Glen Rose which featured Carl Baugh, Clifford Burdick,

Walter Lang, and other leading creationists. I learned that *Footprints in the Mind* had been part of the program, and I was amused at the rumor that the ACLU had financed its production (which was not true). While Baugh supervised more excavation at the McFall site, I was engaged in a lively but frustrating discussion with Walter Lang, Bill Overn, and Ker Thompson, in which they evaded testable issues and questions.

By now it was obvious that the Bible-Science Association and Baugh's project had developed a close relationship. I was shown nothing more than the featureless and poorly cleaned depressions of the type I had seen before, and no new sensational print finds were being claimed. More excitement seemed to be generated by human bones (the "Moab skeleton" from Utah), which Baugh had on display at the meeting hall, but which I was not allowed to inspect closely. It was claimed that the bones were found in Cretaceous deposits. That evening Overn gave a talk on how to disbelieve radioisotope dating, while beside me in the audience Clifford Burdick nodded off to sleep.

January 21, 1984. Gayle Golden (science writer for *The Dallas Morning News*), Steven Schafersman, and I met at Glen Rose for an interview toward her subsequent article on Baugh's work. No more excavation had been done at the McFall site since the winter meeting. Later Golden was able to view videotapes on manprint claims, including *The Case of the Texas Footprints.* Golden reported that Baugh had paid $10,000 for his Moab skeleton and confirmed that Baugh knew at their purchase that the bones had already been dated at 200-300 years.

April 13, 1984. A class of my students and I embarked upon a field trip to Glen Rose to look at the mantrack sites of the area. The McFall site was eroded and most of the depressions were covered with silt and dried mud, but work had started on the Creation Evidences Museum.

May 5-6, 1984. Paleontologist and ichnologist Jim Farlow of Purdue University, Ft. Wayne, Indiana, brought a research team to Texas to gather data on dinosaur trails, including several in the Glen Rose area. Steven Schafersman and I met him in the State Park and traveled with his group to various sites, including the McFall site. Schafersman and I acquainted Farlow with the background of the manprint claims, and Farlow confirmed previous conclusions made by our team concerning mud-distorted or eroded dinosaur prints. Although Baugh was not present, John DeVilbiss was. DeVilbiss now seemed as critical as we were of the alleged manprints so far uncovered, yet he continued, without any evidence, to assume that real manprints were somewhere present.

Farlow showed us evidence that claims about Baugh's Moab skeleton

originated in 1975 when Clifford Burdick believed inaccurate reports on the bones' find by magazine writer F. A. Barnes. No one associated with the find had ever claimed they were part of a Cretaceous layer, as Barnes erroneously reported. Rather, they were *intrusive* into the Cretaceous rock layer.

July 29-August 26, 1984. Over a month's time I made eleven trips to Glen Rose collecting molds from which I made casts of all the footprints comprising the Taylor Trail (of *Footprints in Stone* fame) just downstream, mid-river, from the McFall site. Although some creationists have rejected Baugh's man-print claims, most still cite the Taylor prints as genuinely human, albeit normally inaccessible due to the river's depth. My idea to use an oil-base clay so I could make molds even under water seemed to work and gave me faithful casts. By the end of August severe drought left the Taylor site "high and dry" for the first time in several years. Now the trail was uniquely and directly accessible and I was able to measure and map the whole of it.

During early August, a summer seminar of classes and diggings were conducted by Baugh and Lang at Glen Rose, again under the auspices of the Bible-Science Association. Baugh's Creation Evidences Museum, now open in a small cabin, displayed among other things, Baugh's casts of "footprints" and "handprints" of "*Humanus Bauanthropus*," the hammer-in-stone, the Moab bones, and Burdick's sectioned "mantracks" and "saber-toothed tiger track."

August 3, 1984. Returning to his former congeniality, Baugh invited me to observe present work at the McFall site with his classes and to observe any future work.

August 4, 1984. While student volunteers and I began casting the submerged Taylor prints, we noted that the McFall site had been tidied up but that very little additional excavation work had been done. Two familiar depressions were enclosed in cement and plexiglass plating to combat erosion and humidity, but accumulated moisture inside the enclosure made observation impossible. Baugh had said the previous day that I could break the plating if I wanted, as the preservation was unsuccessful, but someone had already done so. One isolated depression not enclosed was so pitifully cleaned that dried mud was still on its surface and sealed by the liquid used apparently to make a molding. With this mud present, the features of the depression could literally have been sculptured as desired for the mold.

August 11, 1984. After I observed the exhibits at the museum, Baugh arrived to give me directions to his new dinosaur excavation upriver. Parts of a dinosaur skeleton were already encased in a plastic molding and stacked in a corner

of the museum. On site, the dinosaur's pelvic region (about 65 cm in length) was next to be removed. Small blackened fossilized bone fragments were scattered over the site, and only larger pieces were being catalogued and preserved. No treatment of the fossil bones was made before removal. Hydrochloric acid was being brought in to help remove the pelvis from the very hard sandstone layer in which it lay. Baugh had first reported the find as a sauropod, but it was apparently some kind of carnosaur. What Baugh showed me as "claws" from this dinosaur were identified the next day by University of Texas at Austin paleontologist Wann Langston as crocodile teeth. Bones called neck vertebrae by the creationist excavators were identified by Langston as tail vertebrae. When I telephoned Langston on the 13th, he said it was "too late" for professionals to be of any help and that the amateur excavation of the skeleton had already been botched. It was tragic that this unusual and potentially very important find fell into Baugh's hands. It was never clear how he was going to fit this discovery into his creationist scheme, although others at the site made vague comments about Noah's flood washing and crushing the original carcass. Baugh later said he was sending the bones to a lab for carbon-14 dating, confident that they were young enough for that technique (i.e., no more than 50,000 years old). (Sunderland, 1984.)

At the dinosaur site I met Glen Kuban of Cleveland, Ohio. For the last five years, Kuban had been making a careful study of most of the creationists associated with Glen Rose and most of the creationist claims. He also knew quite a bit about the Taylor site, and it soon became apparent to me that Kuban should publish his observations.

September 1, 1984. Steven Schafersman visited the museum and surveyed all the displays. Baugh was very congenial. Meanwhile, I finished preparing and photographing my casts.

September 14-23, 1984. When the Taylor site was "high and dry" Glen Kuban arrived from Ohio to do extensive fieldwork on the whole area. Students Mike White, Marco Bonetti, Alan Daughtry, and Dan Hastings joined me to help Kuban on the weekends. The Taylor trail, the II-D dinosaur trail, the Turnage trail, the Giant Run, and the Ryals trail were eventually cleared and cleaned, thanks to Kuban's efforts. I measured and mapped the II-D trail for comparison with the Taylor trail and with dinosaur trail data provided by James Farlow. Both the Taylor trail and the II-D trail data fitted known dinosaur data nicely. More importantly, clear dinosaur features showed up on the Taylor trail and the Turnage trail as well as on new, undocumented dinosaur trails. These trails were photographed, mapped, and videotaped (Kuban, in preparation).

Kuban tried in vain to have creationists view these newly cleaned and

mapped trails—trails that constitute their most-cited pieces of evidence for human and dinosaur contemporaneity. John Morris said he could not come, and Duane Gish's schedule was said not to allow a visit. However, Baugh was on the scene once and seemed to agree with Kuban's observations. Kyle Davies, from the paleontology department of the University of Texas, on behalf of Wann Langston, made a brief visit to aid interpretation.

September 27, 1984. Al West, a Baugh co-worker for two years, follower of mantrack claims since 1974, and friend of Glen Kuban, went public with his charge that Baugh never had evidence for manprints as claimed. West told reporters (Potter, 1984; UPI, 1984) that he worked with Baugh and his team "under the assumption that we would be looking for scientific evidence and then if we did not find it, we would announce it to the public." But things didn't work out that way. West declared, "I can safely say I have seen no science in their activities. The facts have flat been dismissed." In his view, the evidence went against Baugh's claims, but Baugh didn't report it that way: "In the face of all this evidence, he has continued on telling the public he has man tracks—when they're not." Reporters reminded West of Baugh's claims to have uncovered paths of human prints showing left-right patterns, to which West responded, "I've never seen a path, and I've been right there." He added that Baugh's prints were "totally contrived from his imagination." West had worked directly on excavations and had even made the plaster casts for Baugh of some of the tracks. In this connection, West noted that he had seen some plaster casts which, when they were transformed into fiberglass casts, were made to look more human in the process.

It was West who had sold Baugh and his associates the site for the museum.

For the next few days, local newspapers carried articles in which Baugh tried to blame the sloppiness of excavation techniques on his former colleague, but West countered that he was only following standard and proper procedures.

Conclusion

As a science teacher who has had to cope with the public impact of the creationist manprint claims, I am pleased to have had the opportunity to involve my students and scientific colleagues in evaluating them. In Texas and elsewhere, the supposed mantrack data are a lynchpin in the popular argument against giving thorough coverage to evolution in biology and other science classes. As a result, students often enter and leave high school today with less knowledge of evolution than I obtained as a Texas high school student in the

1960s. *My* students, of course, can visit the Paluxy River to see for themselves how baseless the creationist claims really are, but most students (and parents, teachers, and school board members) in the country cannot easily do so. Therefore, they are left to the mercy of relentless antievolutionary propagandists who offer persuasive "evidence" of a worldwide flood and a young earth.

The most unfortunate aspect of all of this, besides the damaging effects on public education, is the diverting of public attention away from science and towards pseudoscience. Roland T. Bird, who first brought the Glen Rose area to light in the 1930s with his spectacular discoveries of dinosaur trackways, was himself perplexed by the growing interest in mantracks, an interest that threatened to eclipse the important fossils he had put on the map and his efforts to establish Dinosaur Valley State Park. The park was finally opened in 1969, but, just before his death in 1978, he was working to establish a small dinosaur museum at the park entrance. The project failed for lack of the few thousand dollars needed. By contrast, Carl Baugh has achieved his interim goal of a preliminary *creation* museum within a year, purchased ten acres of land for a "permanent" excavation, and now is actively pursuing the rest of the 3.5 million dollars he estimates he needs to complete his museum that is designed to be the size and shape of Noah's ark. Thanks to creationist publicity, the Glen Rose area has become a mecca for fundamentalist pilgrims instead of a source of accurate scientific knowledge about the earth's past. With creationists now conducting expeditions to Mount St. Helens and the Grand Canyon, one can only wonder how many more scientific sites will fall victim to pseudoscientific enthusiasm.

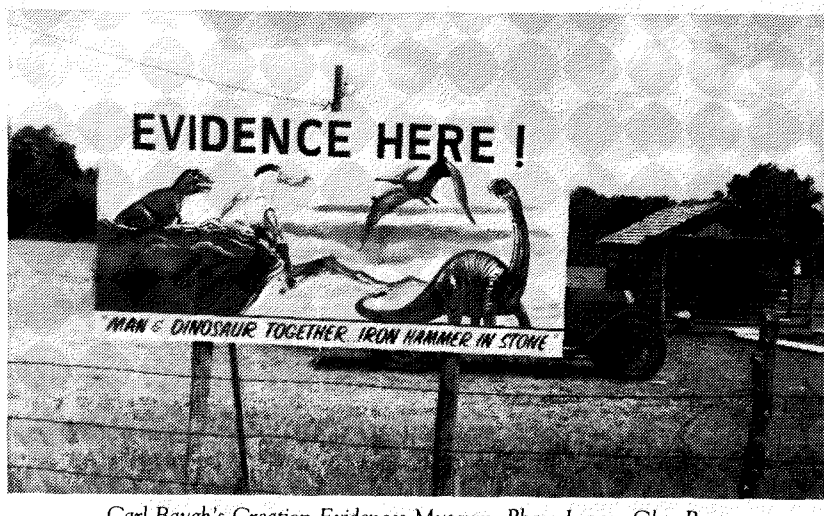

Photo courtesy of Richard L. Tierney

Carl Baugh's Creation Evidences Museum, Phase I, near Glen Rose.

Foot Notes of an Anatomist

L.R. Godfrey

No paleontologist who has studied the flora or fauna of the Comanchean deposits in central Texas has ever reported a human footprint in these rocks. Yet, for decades, the existence of human footprints in these Cretaceous rocks has been touted by creationists as convincing evidence against the geological time scale and evolution. Creationists claim that evolutionists really *know* that there are human footprints there, as do the local folk. At the very least, they say, Roland T. Bird knew; according to the creationists he practically admitted it in the pages of *Natural History* and only later attempted to cover it up (Whitcomb and Morris, 1961; Wilder-Smith, 1968). They agree that some tracks were carved in the 1930s to sell to tourists. But they insist that genuine human footprints also exist there (Bartz, 1982a; Beierle, 1980; Dougherty, 1971, 1982; Fields, 1980; Gish, 1977; Morris, 1976, 1980; Taylor, 1968, 1970a, 1970b, 1971). Most embrace the dogma set forth in 1950 by Clifford L. Burdick in "When GIANTS Roamed the Earth" — that all paleontologists who had visited Glen Rose and surrounding areas for the past half century had been blinded to the truth by their dogmatic belief in evolution! Supposedly, no evolutionists dared admit that the mantracks were real, for mantracks in Cretaceous rock would turn the geological timetable topsy turvy and make a mockery out of evolution. Wilder-Smith (1968:137) put it this way: "It is quite interesting to see what is done in scientific circles with such awkward observations as contemporaneous dinosaur and mantracks. First of all *both kinds of tracks were duly reported*, but it was suggested by Dr. Bird, who first found them, that either the man tracks or the dinosaur tracks must have been falsified, because according to theory, the two could not exist together!" According to Wilder-Smith (1968: 297), "The giant human tracks have perfectly clear toe, heel and arch imprints. . . . pure theoretical prejudice prevented Dr. Bird from recognizing some exceedingly important geological evidence [against evolution]."

How Can We Tell a Human Footprint?

One of those curious twists of fate is that those very mantracks that led Burdick to write "When GIANTS Roamed the Earth" and that led Whitcomb and Morris (1961) and then Wilder-Smith (1968) to ridicule Roland T. Bird are now recognized as fakes by most creationists (e.g., Morris, 1980). Yet photo-

graphs of them still appear in creationist literature. To the human anatomist or physical anthropologist, their fakery is immediately apparent. Most people, however, do not have the knowledge of human anatomy necessary to diagnose the mistakes.

Human footprints differ depending on whether: 1) they are made on hard or soft surfaces; 2) the individual who made them had a normal arch or was flat-footed; and, of course 3) the individual was moving, and at what speed and gait. These conditions might seem to render it difficult to recognize a genuine human footprint, but instead they often facilitate identification, because many features must be right, and conversely many features can be wrong and thus betray spurious human tracks. If, for example, the distance between tracks of a certain length is wrong for a human strider, one can reject a human attribution. What makes track identification difficult is that when tracks are made in soft, wet sediment, mud flowing back into them may obscure anatomical features.

On a nonyielding surface, a human footprint assumes an hourglass shape because the foot bones that articulate with the heel and ankle bones are bound together by strong plantar ligaments to form an arch. One can actually trace an arch in two directions: across the foot and along the long axis of the foot. The arch is high in the middle of the foot, and higher on the inside than on the outside edge. Strong, tight ligaments cause the human foot to behave like a resilient strut; ligaments absorb the compressive stresses that are transmitted to the foot in walking, so the foot muscles have less work to do in resisting these stresses.

This is why, when a person wets the soles of his or her feet and walks across a hard floor, not all of the sole "prints." Just how much *will* contact the floor depends on the arch's strength. (Compare the contact surfaces made by individuals with varying degrees of normal to flat-footedness, Figure 1.) Note that contact is always made by the heel (which strikes the substrate first in normal walking), the outside of the foot, the ball of the foot (the pad under the far or "distal" ends of the bones called "metatarsals"), and the big toe or "hallux." These contact surfaces reflect the normal walking cycle (see Figure 2): "Heel strike" first, followed by "midstance" (when the weight is transferred along the outside to the ball of the foot as the pelvic muscles contract to shift the weight of the body over the supporting leg), and finally "push-off" or "toe-off" (when a person propels himself or herself forward by pushing against the substrate with the big toe). Even on a hard surface, one can see the imprint made by the heel, the outside of the foot, the ball, and the big toe. The little toes typically leave only slight marks on a hard floor, not merely because the pads of the little toes are smaller than the pad of the big toe but because they do not bear the weight of the body during push-off.

Notice also that the lateral toes of the foot possess three small bones

(called phalanges) whereas the hallux or great toe possesses only two, bigger, phalanges. During push-off the little toes curl up (notice how the joints between the three phalanges make this possible) while the big toe flattens. Only the pads of the little toes contact the floor, and the marks they leave are separated from the mark made by the ball of the foot by a narrow space for the upwardly flexed first two phalanges.

If a person walks across a medium such as wet sand, soft enough to yield to pressure but not so wet that the depressions won't hold after his or her feet are withdrawn, the tracks will exhibit another characteristic shape. They will lack an hourglass outline but their depth will vary from great at the heel and ball to shallow in the arch area. The ball will have made a distinct depression deeper on the inside than the outside—a record of the way pressure shifted just prior to push-off. Mud will have oozed into the curl of the little toes, forming a slightly raised line separating the imprints of the pads of the little toes from the ball. In contrast, the depression made by the great toe will show greater continuity with the ball. In short, the rolling stride of humans produces distortions on a yielding surface that show exceedingly well the anatomical features of the human foot and the characteristics of human striding.

The consistency of the supporting surface also affects stride length. A person's stride is impeded on mud because the degree to which foot pressure imparts motion to the body during push-off is proportional to the counter-pressure of the supporting substrate. If the foot slips or sinks in soft mud, more pressure must be applied in order to achieve even slow progress, and the gait becomes relatively inefficient, the stride relatively short.

Anyone can create footprints that do not look terribly human by walking in an awkward manner, e.g., without "pushing-off" with the great toe. This manner of bipedal walking is actually characteristic of some animals such as bears and great apes which occasionally move bipedally (on two legs) but do not have a "rolling" stride. Unlike bears and apes, humans roll their weight from the heel to the big toe, producing an unusually long and efficient stride. If one fails to roll in this manner, stride length will shorten considerably. But we needn't expect that humans walked in such an awkward fashion very often. Even the ancient human footprints preserved in volcanic ash at Laetoli, Tanzania, show heel, arch and ball impressions (Leakey, 1979; Leakey and Hay, 1979; White, 1980), and although the structure of the early australopithecine foot (known from Hadar, Ethiopia as "Lucy") exhibits some clearly *ape-like* as well as modern *human-like* features, it also demonstrates that some human bipedal adaptations had evolved by well over three million years ago (Johanson and Edey, 1981). (See Susman, 1983; Stern and Susman, 1983; Susman and Stern, n.d.; Suwa, n.d.; Latimer, n.d.; Gomberg and Latimer, n.d.; and Gomberg, 1984 for discussions of the complex intermediate morphological adaptations of Lucy's foot and their implications for behavior.)

We will examine relative stride length when we look at alleged series of human footprints in Cretaceous rocks. But first we should dispose of the more obvious mantrack forgeries such as the pair of mantracks that so impressed Clifford Burdick thirty-five years ago (Burdick, 1950; see also Figure 11 in Whitcomb and Morris, 1961; Figure 9 in Wilder-Smith, 1968; and Figure 120 in Wysong, 1976). These were the very mantracks that Bird discovered in an Indian curio shop in Gallup, New Mexico, and that initially led him to the Glen Rose area in 1938 (Bird, 1939; Godfrey, 1981).

Artificially Chiseled Giant Mantracks

Burdick's prized mantracks exhibit a suite of anatomical errors (Figure 3). They are poor representations of the modern human footprint, even poorer representations of what *giant* human footprints might look like, and especially bad representations of what such footprints *made in soft mud* might look like.

First, the toes are too long—far too long—, the big toe far too narrow. The "ball" of the foot is too wide, too far forward, and too deep. It shows no evidence of roll toward the inner edge. The little toes seem to have been carved by someone looking at the *top* rather than the sole of a human foot. They are chiseled on an unnaturally raised plane; they are also artificially fanned. The heel is too narrow, the forefoot too wide, so that while the relative proportion of forefoot width to total length falls marginally within the range of human variation, the relative proportion of heel to forefoot width is far too low. The result is an exaggerated hourglass shape. The artisan was apparently trying to reproduce the imprint a modern human foot (with a normal raised arch) makes on a hard surface. The carver did not succeed at that, and certainly failed to produce a facsimile of a human footprint in soft mud where the hourglass outline disappears, and the arch, however strong, becomes a shallow depression. Furthermore, a giant bipedal animal would be very unlikely to *have* an arch; it would be too heavy.

Now, contrary to creationist claims, there is no fossil evidence of an ancient "race" of giants. Recently Richard Leakey and Alan Walker discovered a "tall" 1.6 million-year-old *Homo erectus*; that individual, nevertheless, falls within the modern size range. The much later Neanderthals were robust, but they were not terribly tall. Modern humans range greatly in size, from the Ituri Pygmies of Zaire to the Nilotic people of Sudan. Abnormal giantism sometimes occurs, often associated with painful swelling as well as shortened lifespan and abnormally *shortened* stride. Nevertheless, an antomist can tell you what the foot of a "normal" giant human might look like, since biomechanical rules of scaling allow us to make predictions even for hypothetical, non-existent, beings. These predictions hold for real footprints made by

the more robust Neanderthals and they allow us to understand the shape of the feet of large mammals that occasionally walk bipedally, such as gorillas or bears. In any case it is abundantly clear that a 12 to 16 foot tall Adam (Dougherty, 1978; Burdick, 1950; Baugh, 1983b) would make a footprint nothing like a scaled-up version of a modern human's.

Let's briefly consider the constraints of size on a bipedal animal's foot anatomy and on its locomotor pattern. There is an upper limit to the size of a striding biped—a limit beyond which the characteristic "roll" from heel-strike to toe-off becomes impossible. This is because the human sort of locomotion depends on the big toe supporting the weight of the body during toe-off. Individuals must be light enough, and the hallux strong enough, so that the big toe will not break from the compressive load and bending stress to which it is subjected in walking. If an exceedingly large human with perfectly "normal" walking gait existed, his or her feet would have had to exhibit a set of allometric structural alterations. Specifically, such a person would have possessed relatively wide feet with weakly developed arches, relatively short little toes and *relatively wide and short great toes.* The latter characteristic is especially important if a rolling stride is to be preserved.

The size limit for a humanlike rolling stride may in fact be exceeded by animals as small as gorillas or bears. Figure 4 compares the outline of a human foot with that of a gorilla. Gorillas weigh approximately twice what humans weigh; male gorillas may exceed 500 pounds. Gorillas normally walk on all fours, but occasionally they move bipedally. When they do, they do not use the big toe for push-off. These so-called non-striding bipeds have relatively shorter cycles than do humans (that is, their step is short relative to hindlimb length or body weight) because they must lift up their feet and place them down flat, *without* rolling off the big toe. The biomechanical properties of a striding foot are fundamentally distinct from those of a non-strider, and these differences are reflected in differences in the morphology of the foot and in the imprint of the foot on both yielding and non-yielding surfaces. A gorilla's foot makes a relatively wide and short impression. The toes curl to the side and make very light imprints. Bear footprints have many similar properties: they are short and wide (with width/length indices in the low 50s rather than the mid-to-high 30s and low 40s characteristic of humans). Because bears do not push-off with their toes, the distances between successive footprints are relatively short.

A humanlike biped capable of making tracks roughly equal in depth to those of a large dinosaur would not be capable of striding in a human fashion; it would weigh too much. The foot would have to be proportionately much wider than the human foot; the imprint would be deepest in back instead of under the ball of the foot, and toe impressions would be relatively light.

The practical jokers who carved the giant mantracks not only did a poor

job of reproducing the shape of a human footprint, but they erred in the wrong direction. They failed miserably to compensate for the grotesquely large size of their subjects. The prints deviate from the modern norm in the wrong direction given *either*: 1) the supposition that they were produced by an animal still capable of modified striding (in a human sense); or 2) the supposition that they were produced by an animal that had exceeded the normal size limits of a humanlike strider, and was using instead a relatively shorter cycle and more flat-footed gait, with greater weight transmission through the posterior part of the foot.

Similar mistakes are exhibited on other chiseled prints, as, for example, another right footprint in Burdick's collection which was figured by Whitcomb and Morris (1961: Figure 10) and used to make the cast which appears in Wilder-Smith (1968: Figure 10). Once again the hallux is far too long given its own width (its width should be increased by about 3/4), and it is about a third too long given the total length of the footprint.

W. Gibbs, the owner of a cement mantrack on the lawn of his Glen Rose sanitarium (Figure 5) says that his mantrack was made by one of the Adams brothers to cover a *genuine* giant mantrack that had been vandalized by some pranksters and thus needed to be repaired. He says that Adams accurately reproduced the true anatomical features of the original mantrack. Morris (1980) also treats this track as genuine. But its great toe is even more grotesquely elongated than that of Burdick's track, both in relation to its own width and in relation to the maximum length of the footprint.

Footprints *in Situ*: The Creationists' Own Published Accounts

Since the late 1960s, creationists have attempted to downplay obviously carved specimens, and to concentrate on exposing "fresh" mantracks, *in situ*. They have published maps and poor photographs of these features (Beierle, 1980; Fields, 1980; Morris, 1980), that should ideally allow one to locate and examine them firsthand. This is often more difficult than it might seem: First because some of them are erosional features which differ little from the surrounding surface—only when they are painted with water can one see their "human" characteristics. Secondly, many of the mantracks reported in the creationist literature have been destroyed by further excavation, direct removal, or erosion. Some are under water most of the time. No casts have been made available to professional human anatomists or ichnologists. However, the creationists' own published field notes, measurements and photographs, however poor, allow us to evaluate their claims.

The creationists' mantrack data are given in Tables 1 and 2. (These measurements were recorded originally in inches or centimeters but are uniformly

Table 1

SOME "MANTRACKWAY" DATA

	TRACK #	WIDTH ACROSS "HEEL" (mm.)	WIDTH ACROSS "TOES" (mm.)		MAXIMUM FOOT LENGTH (mm.)		PACE LENGTH (meters)	
		Fields	Fields	Taylor	Fields	Taylor	Fields	Hastings
TAYLOR TRAIL	H1-7	--	--	--	--	--	1.27	1.28
	H1-6	--	127	--	406.4	--	.51	.73
	H1-5	--	127	--	406.4	--	2.03	1.36
	H1-4	50.8	127	--	381.	--	2.31	.79
	H1-3B	--	--	--	--	--	--	1.09
	H1-3C	--	--	--	--	--	--	.95
	H1-3	--	152.4	--	381.	--	1.32	1.51
	H1-2	--	165.1	--	406.4	--	1.42	1.28
	H1-1	101.6	152.4	--	381	--	1.37	1.35
	H1+1	88.9	139.7	101.6	381.	228.6	1.37	1.49
	H1+2	101.6	165.1	101.6	406.4	348.0	1.24	1.15
	H1+3	101.6	139.7	101.6	457.2	(330.2-406.4)	1.37	1.43
	H1+4	--	139.7	88.9	457.2	(304.8-406.4)	1.12	1.01
	H1+5	76.2	127.	106.6	406.4	304.8	1.24	1.10
	H1+6	101.6	127.	101.6	279.4	228.6	--	--
		Fields / Morris	Fields	Morris	Fields	Morris	Fields	Morris
RYALS TRAIL	Ry-3	90. / 88.9	130.	127.	350.	355.6	--	--
	Ry-2	-- / --	110.	114.3	570.	558.8	1.20	1.19
	Ry-1	-- / --	150.	152.4	400.	406.	1.20	1.19
	Ry+1	-- / --	50.	50.8	400.	406.	1.20	1.45
	Ry+2	-- / 88.9	230.	127.	600.	584.	1.45	1.37
	Ry+3	(removed)					1.00	1.37
	Ry+4	110. / 114.3	120.	127.	750.	737.	1.75	1.04
	Ry+5	80. / 76.2	90.	88.9	460.	457.	1.03	1.32
	Ry+6	70. / 76.2	110.	114.3	600.	610.	1.32	missing

Data from Fields (1980) and Morris (1980)
as well as Hastings (unpublished)

Table 2

INDICES CALCULATED FOR "MANTRACKS" AND GENUINE HUMAN TRACKS

Mantracks with asterisks are outside modern human range; * = too small
** = too big

TRACK		WIDTH/LENGTH INDEX (forefoot x 100/max. length)	HEEL W./TOT. L. INDEX (heel width x 100/max. length)
Homo sapiens (Napier 1973)	Male 1	35.4	27.4
	Male 2	34.8	26.1
	Male 3	41.7	25.8
	Female 1	38.1	24.8
	Female 2	40.9	26.9
	Female 3	37.5	28.1
	Neandertal (cave track)	43.5	30.6
RYALS TRAIL (Morris 1980) p. 219	Ry-3	37.1	25.7
	Ry-2	19.3 *	
	Ry-1	37.5	
	Ry+1	12.5 *	
	Ry+2	38.3	
	Ry+4	16.0 *	14.7 *
	Ry+5	19.6 *	17.4 *
	Ry+6	18.3 *	11.7 *
GIANT RUN TRAIL (Morris 1980) p. 210	H2-1	32.0 *	
	H2-2	52.4 **	
	H2-3	46.8 **	
	H2-4	45.9 **	
	H2-5	35.0	
TURNAGE TRAIL (Morris 1980) p. 214	H3-3	46.3 **	25.9
TAYLOR TRAIL (Morris 1980)	H1-6	31.3 *	
	H1-5	31.3 *	
	H1-4	33.3	
	H1-3	40.0	
	H1-2	40.6	
	H1-1	40.0	
	H1+1	36.7	44.4 **
	H1+2	40.6	33.3 **
	H1+3	30.5 *	30.8-25.0
	H1+4	30.5 *	29.2-21.9 (*)
	H1+5	31.3 *	33.3 **
	H1+6	45.5	44.4 **
PARK LEDGE (measured 1982 LRG)	Park A	36.9	31.1
	Park B	51.9 **	36.6 **
	Park C	50.0 **	
	Park D	39.2	23.1 *
	Park E	33.3	20.5 *
	Morris' average for 14 prints (p. 198)	23.8 *	
McFALL (measured 1982 LRG)	McFall A (Oblong depression near plaque)	21.3 *	
	McFall B (mud-filled dinosaur track)	39.6	18.8 *
	THALASSINOIDES "TRACK"	27.0 *	20.7 *

converted to *millimeters* here for easy comparison. Stride and pace measurements are expressed here in *meters*.) Generally three to five measurements are reported in the creationist literature:

1) *Width across toes* (sometimes "width at center" or just "width"; in the latter case it is unclear where the measurement was taken).

2) *Length*. Presumably maximum length.

3) *Width across heel*. These measurements were inconsistently recorded—most often only by Wilbur Fields.

4) *Pace or stride*. Creationists use the terms "pace" and "stride" interchangeably to mean the distance between one footprint and the next. Thus Wilbur Fields (1980) records "pace" and Morris (1980) records the same measurements as "stride." Morris is technically incorrect. Pace is properly defined as the distance between some fixed anatomical point on one footprint and the same anatomical point on the next footprint (opposite side), whereas *stride* is the distance between that anatomical point and the same feature on the next track made by *the same foot*. Thus stride is roughly (but not exactly) twice the length of a pace in an efficient bipedal animal. Note that pace is measured oblique to stride, and in the case of an inefficient biped whose feet are placed wide apart, pace may be far greater than half the stride. For the sake of accuracy, all of the creationist measurements of distance between two successive tracks are here called *pace*; *stride* is used as defined above.

5) *Depth*. Depth was not consistently recorded. It should be noted that the depth of an impression depends more on the nature of the substrate than on the weight of the animal. Even a very light animal will make deep impressions in mud of almost quicksand consistency. It is thus useful to know depth only if the approximate weight of the animal making the track is known: then the depth can help the footprint specialist decide whether the track was made on a hard intertidal surface, in soft sediment under shallow water, or in deeper water. Similarly, if the track of an animal of unknown weight is preserved adjacent to the track of an animal of known weight, the relative depths can be used to evaluate the weight of the unknown trackmaker. Thus an alleged mantrack inches from a sauropod track of the same depth would be suspect! Also, mud on a lagoonal tidal flat can vary from wet to firm in short distances, so tracks in a single trackway may vary considerably in depth. This phenomenon was clearly recorded in some tridactyl (three-toed) dinosaur tracks preserved at the McFall site near Glen Rose. Trackways contained both very well and very poorly demarcated dinosaur footprints; poor tracks were formed when the dinosaur's foot sank deep into wet mud. Mud then oozed back into the depressions made by the front three toes when the foot was withdrawn, leaving only fanning up front and a distinct, elongated "heel" to the rear. Actually, the "heel" was produced by the dinosaur's hallux, which

points rearward, as it does in modern birds. The resulting elongated depression actually represents only a portion of the dinosaur's foot and can look vaguely humanlike. (Indeed, these marks have been mistaken for mantracks by some creationists, and what is more startling, when these creationists observe good tridactyl dinosaur prints in the same series as their "mantracks," they conclude that the "man" stepped into the dinosaur trackway, or vice versa. It apparently doesn't seem odd to them that their "man" and dinosaur took exactly the same strides and followed exactly the same paths.)

John Morris's (1980) book *Tracking Those Incredible Dinosaurs . . . and the People Who Knew Them* is usually considered the most authoritative creationist source on Texas mantracks. Morris compiled data, many of which had appeared elsewhere (e.g., Fields, 1980), but he remeasured none of the trackways, even though he claims to have "improved" some of Fields's measurements. Thus one finds that *some* measurements from different creationist sources agree remarkably well; they are, in fact, the *same* measurements republished. The differences between them reflect only rounding error that occurs when, for example, Fields's measurements, taken to the nearest centimeter, are expressed to the nearest half-inch by Morris. Striking differences among values for the same features appear when they were measured by *different* creationists at different times. Morris's "improvements" also result in drastic unexplained changes of some measurements.

Of course even when creationists record such measurements as "width at toes" or "width at heel," it is not because they see actual toe or heel imprints. They are simply measuring the wider and (sometimes) narrower ends of elongated depressions which they *take* to be toe or heel marks.

How Can We Tell a Human *Trackway*?

When an animal moves, the impression it makes with its foot depends upon the absolute amount of force transmitted to the substrate and the *way* that force is transmitted to the substrate. This in turn depends upon the weight of the organism, the structure of the foot, and the gait (walking, running, galloping, etc.). The characteristics of a trackway reflect all of these things, as well as the nature of the substrate. In general, the distance between tracks increases with increasing speed, although the relationships change when the animal shifts gait. Because a number of variables are linked (e.g., stepping frequency, speed, pace length, stride length, foot length, stature), one can make fairly good estimates of unknown values for some of these variables when the values for others are known. Thus, for example, a person with a given foot length will have a *comfortable* average pace and stride, a *minimum* pace and stride, and a *maximum* pace and stride. Because humans are highly efficient bipeds,

pace length is always about half the length of a stride, even in slow walking. Minimum and maximum values for pace and stride can be estimated from foot length alone. (See Napier, 1973 and Grieve and Gear, 1966 for discussions of formulae one might use for humans.)

One can use creationist measurements to evaluate the anatomical proportions of alleged mantracks by comparing values obtained for indices of supposed mantracks and actual human footprints. *And* one can use the measurements to evaluate the plausibility of claims that the trackways were produced by striding humans by comparing measured paces with paces projected for humans having mantrack foot lengths. Some human values are given in Table 3, along with formulas for calculating minimum and maximum stride lengths given observed foot lengths. Let us begin with how we might use such data to evaluate one of the "better" supposed human trackways.

The Taylor Trail

Table 1 reproduces the data in Morris (1980: 206) for the so-called Taylor Trail, a trackway excavated by Stanley Taylor's crew and filmed in *Footprints in Stone* (Taylor, 1970a). It is still considered one of the creationists' best trails. This is a genuine trackway made by *some* bipedal animal—but was it human? Taylor measured six tracks in 1970; Wilbur Fields returned to the site in 1977 and produced a second set of measurements on these and several additional tracks in the same series. He retook some of Taylor's measurements (width at "toes" and maximum foot length), and added others that Taylor had not recorded, such as pace length and width across "heel." (Recently a member of our team, Ronnie Hastings, returned to the site when the river was dry and was able to obtain a complete set of measurements for the Taylor trail. Some of these are included in Table 1, along with the available data of both Taylor and Fields. Hastings's measurements will be discussed following an analysis of the creationists' own results.)

It is immediately apparent that there is *no* agreement between the measurements taken by Fields and by Taylor for the same tracks. Morris acknowledges this fact, and then offers an explanation:

> Fields measures the average length at about 16 inches while Taylor found that the best prints, the ones with no evidence of slippage, averaged about 10 inches. Erosion has taken a deadly toll. (Morris, 1980: 207)

This is a rather remarkable explanation, since it seems to offer both erosion and slippage as explanations for the discrepancies between the measurements taken by Taylor and, seven years later, by Fields. Presumably erosion would have taken place between 1970 and 1977; but slippage would have

been present (if at all) in both 1970 and 1977, and no anatomist would include slippage marks in measuring foot length. Given the discrepancies, one must conclude that either Taylor or Fields (or both) didn't know what he was measuring. If we accept Morris's remark about erosion we might be tempted to accept his ten inch (254 millimeter) foot length for the individual who produced this trackway. This is far smaller than even the *smallest* measure recorded by Fields (279.4 mm), and about half Fields's longest measurement (457.2 mm). Fields's average footprint length was 406 mm and his average width at "toes" was 140.8 mm, while Taylor's averages were 314.3 and 99.5 mm. Morris is asking us to believe that erosion lengthened and widened the tracks in seven years by, on the average, more than 50%.

But there are bigger problems. If we decide that the actual length of the trackmaker's foot was Morris's 254 mm (and if we assume that the trackway was produced by a striding human), we obtain estimates of stature of 1.68 meters (5 feet 5 inches), minimum and maximum *stride* of .86 and 1.88 meters, and *maximum pace* of .97 meters. This maximum pace is actually far smaller than the paces recorded by Fields (see Table 1). Fields recorded a series of paces ranging between 1.12 and 1.42 meters and averaging 1.31 meters. These walking paces simply could not have been made by a 5 foot-5 inch (1.68 m) human. They are far too big. They are even too big for a seven-foot tall human. Moreover, Fields recorded some paces of 2.03 and 2.31 meters (but see below). The latter is the maximum pace for a thirteen-foot tall human (assuming we can make such an extrapolation at all with no correction for allometry, which is a mistake)! So, if we accept Fields's pace measurements, we have to throw out all of the measurements taken by Taylor and crew immediately after the trail was first exposed—before, as creationists say, erosion took its toll. Morris's argument that the Taylor Trail was made by a human with 10 inch feet can be refuted by inconsistencies in the creationists' own data set.

There is ample evidence that Taylor didn't know what he was measuring in the first place (how can a single human footprint be 304.8 to 406.4 mm long?). Furthermore, there are internal inconsistencies in the data sets collected by both Taylor and Fields. Fields's lengths vary from 279.4 to 457.2 mm; Taylor's from 228.6 to the vague "330.2 to 406.4 mm." Fields's widths vary from 127 to 165.1 mm; Taylor's from 88.9 to 101.6 mm. If we calculate width/length indices using data collected by *either* investigator, we find marked changes in foot shape along the trail. The discrepancies are even worse when we compare values for indices based on Fields's data with values based on Taylor's data *for some of the same tracks*! For example, track H1+1 has a width/length index of 36.7 (Fields) and 44.4 (Taylor). Worse yet, half of the creationist values for this index fall outside the range of normal human variation (this is especially true of those based on Taylor's data), and more-

over, *they are too low* (Table 2). If *any* of Fields's high footlength measurements are to be believed, we should expect this giant to have had unusually wide feet and thus *higher* than normal values for its width/length indices.

Hastings's detailed map and measurements of the Taylor trail prove beyond any doubt that these tracks could not have been made by a giant human (Figure 6a). They also serve to demonstrate the enormity of measurement and observational errors made by both Taylor and Fields. First of all, despite the poor quality of the tracks in this trail, some of the tracks exhibit faint claw marks and fan out in the front, as is typical of dinosaur footprints. (Hastings informs me that even more distinct claw marks are visible on some of the tracks in the so-called Turnage trail—Morris's "most humanlike" trackway.) Secondly, the Taylor tracks form a pattern that is atypical for humans but not for bipedal dinosaurs: the animal that made them shifted from an irregular somewhat bouncy gait with *uneven* pace and *short* stride to an increasingly regular, faster gait. Track breadth narrowed as the animal assumed a more efficient gait; the feet were placed closer to the central axis of the trail and the stride lengthened. Human tracks tend to be very regularly spaced, and the trails consistently narrow. The pattern and step angles of tracks in the Taylor trail show marked similarities to those known to be made by dinosaurs (compare Figures 6a and 6b).

Finally, it should be noted that Hastings's recorded pace, stride, and foot lengths for the Taylor trail fit known values for dinosaurs and not humans. The shape of the tracks—elongate grooves that are deepest in the centers with some splaying up front—characterizes many poor dinosaur tracks and *not* human tracks. The obvious, most parsimonious, explanation is that this trail was made by a bipedal dinosaur.

Let's Play Hop, Skip and Jump

Footprints in Stone shows creationist Mike Turnage skipping from one mantrack to another in a trail. The point of this frolicking seems to have been to raise the question: If a modern man can skip from one mantrack to the next, wouldn't it have been a snap for the human giants of olden days to have made them? How could a modern human so easily retrace the steps of dinosaurs?

In fact, modern humans *can* hop, skip and jump from one dinosaur track to another in a series. First of all, because they use a rolling stride, humans take relatively long paces for their body size. Secondly, people can s-t-r-e-t-c-h in an awkward manner and almost double their pace for at least one or two steps. Furthermore, while dinosaurs were apparently capable of rapid movement (Halstead, 1982), they often moved slowly (Alexander, 1976; Thulborn, 1982), taking short steps relative to foot length (or, especially, body mass).

PLATES

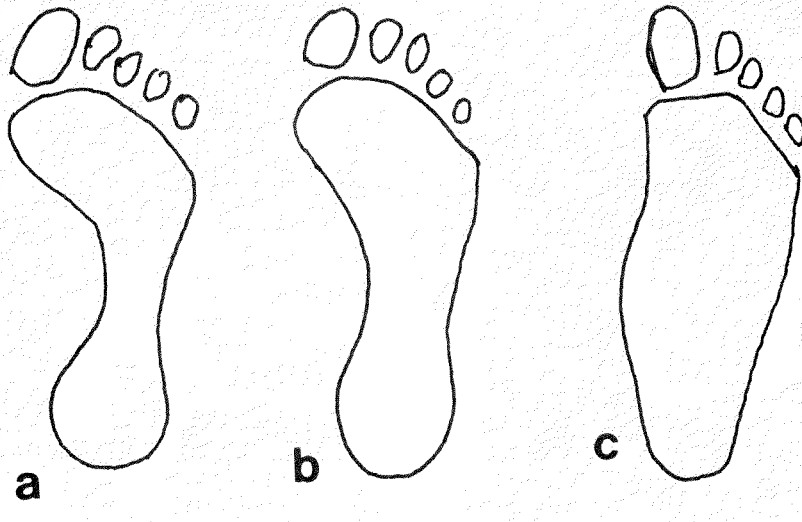

FIGURE 1. Contact areas of human feet on hard surfaces: (*a*) impression made by a normal foot, (*b*) flat-footed imprint, (*c*) imprint made by a severely flat-footed individual. (After Kapandji, 1970, Fig. 80.)

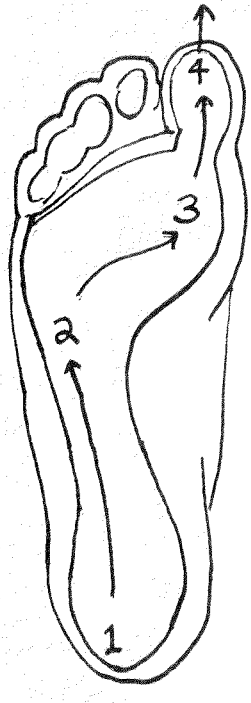

FIGURE 2. Human walking cycle: (1) heel strike, (2) weight is supported at the outer edge of the foot and then forward along solid line as the pelvic muscles contract to shift the weight over the supporting leg while the opposite foot leaves the ground, (3) weight shifts to the ball of the foot as the point of contact moves toward the inner border of the sole, and (4) the big toe supports body weight during push-off. The inner outline shows normal foot contact on hard ground. Depression is deepest at one, three, and four. (After Napier, 1963.)

FIGURE 3. Creationist Clifford L. Burdick with two of his famous carved tracks. The mantrack photographed here appears to be identical to that which Roland T. Bird discovered in 1938 in a Gallup, New Mexico, Indian curio shop. Bird immediately identified the track as a fake.

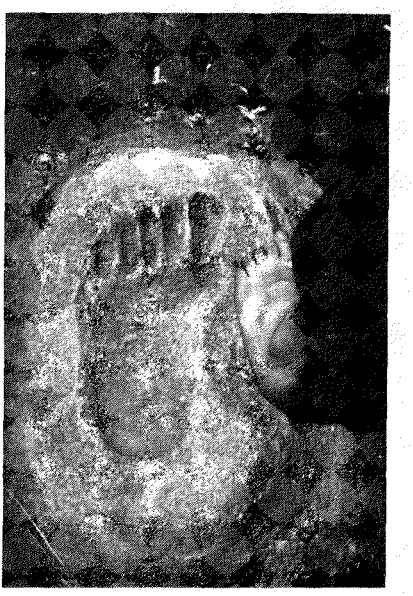

FIGURE 5. Hollow cement cast of an original carved and then "repaired" mantrack. On display in the front yard of Gibbs's Sanitarium in Glen Rose, Texas. (Photo courtesy of F. Edwords.)

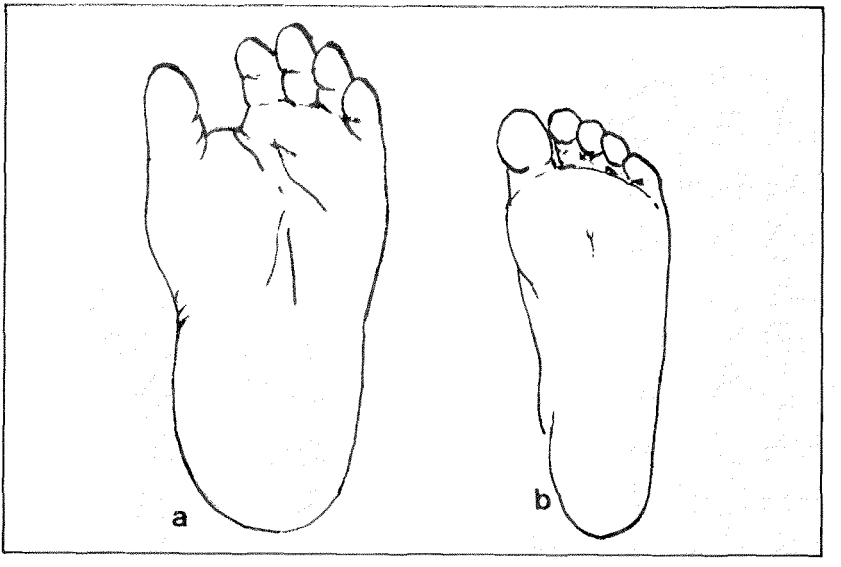

FIGURE 4. The feet of (*a*) a mountain gorilla and (*b*) a human. Note the greater relative width of the gorilla's foot. (After Morton, 1964, p. 41.)

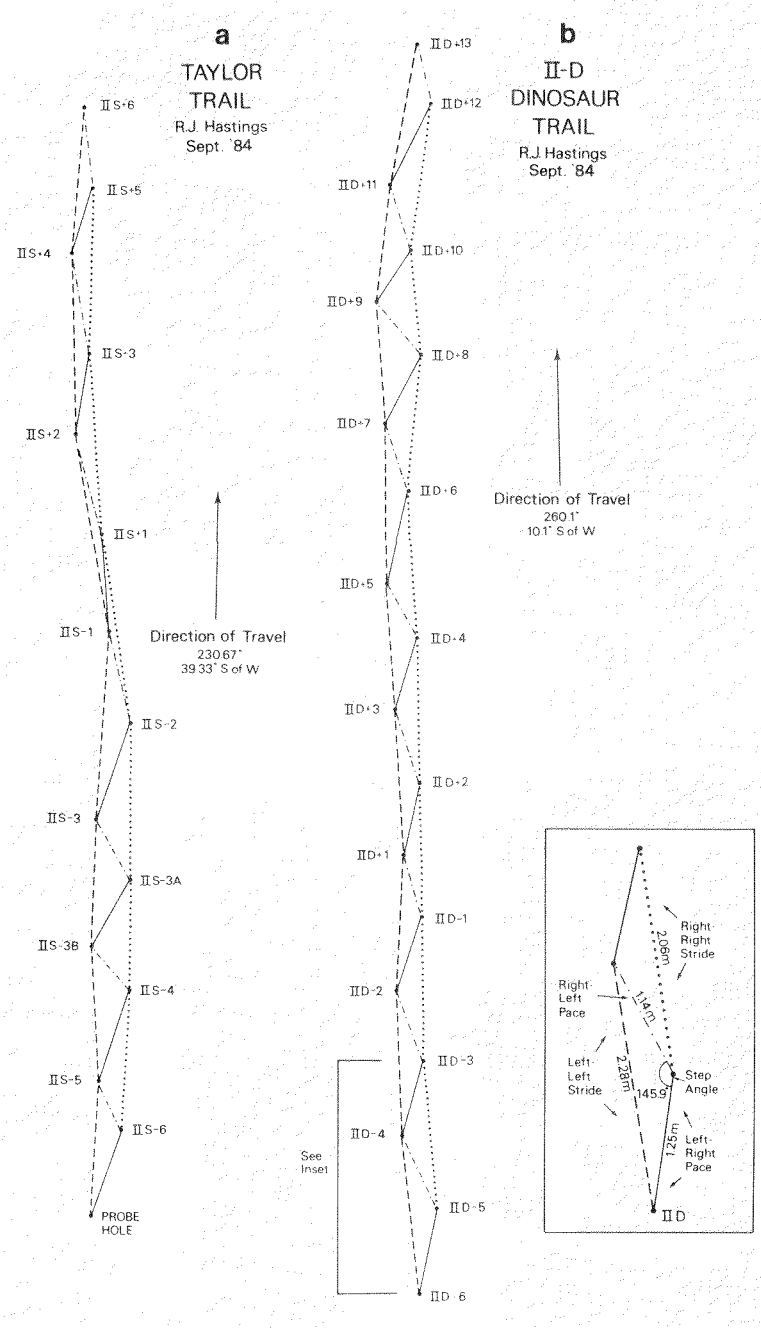

FIGURE 6. Comparison of the Taylor trail and a nearby dinosaur trail. Note the similarities of pattern, step angles, pace, and stride in the two trails. (The numbering system used here is that of Fields, 1980.)

FIGURE 7. Tridactyl dinosaur trail at the Thayer site, Canyon Lake, Texas. (Photo courtesy of F. Edwords.)

FIGURE 10. Laurie Godfrey beside a "mantrackway" on the park ledge, Dinosaur Valley State Park.

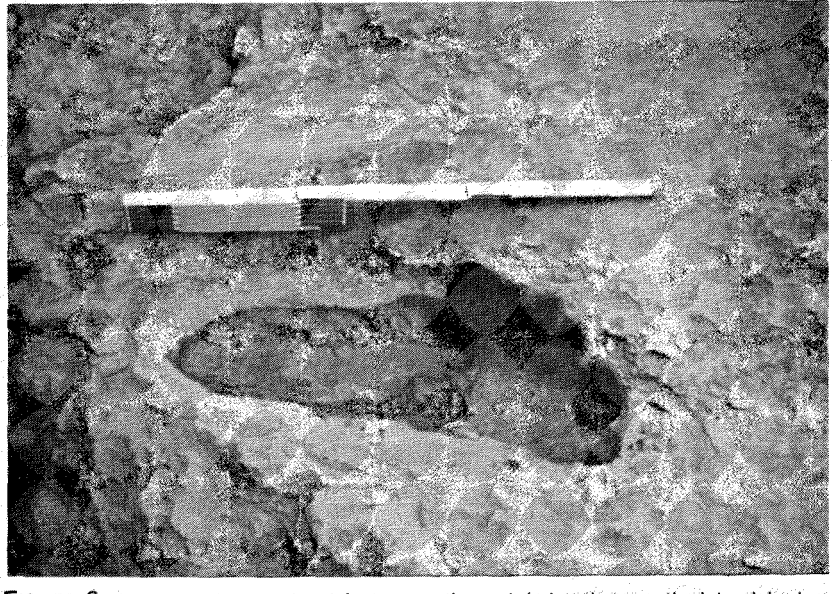

FIGURE 8. An interesting erosional feature on the park ledge that creationists claim is a mantrack.

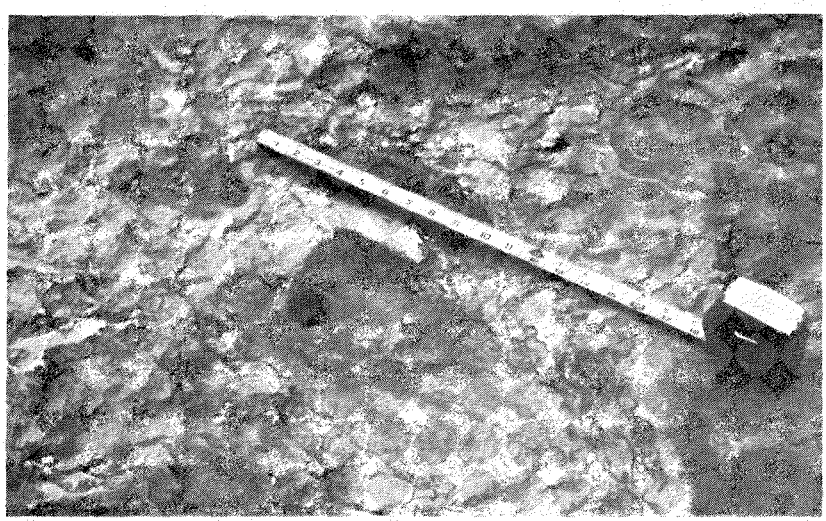

FIGURE 9. Close-up of the "mantrack" closest to Laurie Godfrey in Figure 10. It is an erosional feature, as is the other one.

FIGURE 11. On the left, a clear tridactyl dinosaur track shows the hallux impression to the rear. Baugh identified the same features of the two preceding tracks in this trail as mantracks that had been stepped on by *Tyrannosaurus rex*. He then identified the feature on the right as the third mantrack in this series and erected a *plaque adjacent to these trace fossils*, naming the trackmaker *Humanus Bauanthropus*. The feature on the right is an oblong scooped-out cavity roughly the length of a dinosaur footprint.

FIGURE 12. Mud-infilled tridactyl dinosaur track at the McFall site showing the characteristic fanning at the front and the distorted oblong shape. (Photo courtesy of F. Edwords.)

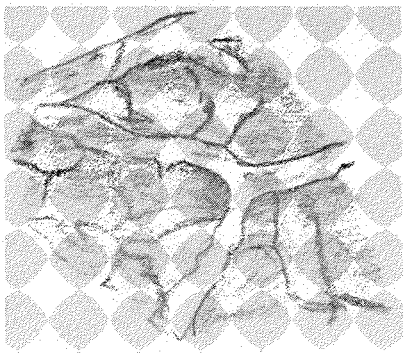

FIGURE 13. Drawing of burrow casts made by *Thalassinoides*. (After Curran and Frey, 1977.)

FIGURE 14. *Thalassinoides* "mantrack" wetted-in by us under the guidance of a Baugh crew member. Parallel *Thalassinoides* burrow casts separate the "toes," but they also zigzag throughout the "sole" of the "foot" and, indeed, the entire limestone ledge. Note the lack of any visible relief and the rectangular shape of this feature.

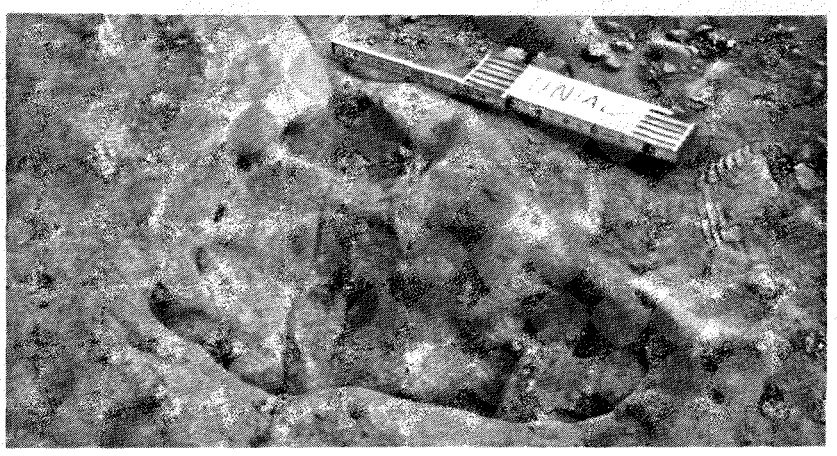

FIGURE 15. Park ledge "bear" track. Note layers of rock undercut by karren solution erosion.

FIGURE 16. Dinosaur footprint at Dinosaur Valley State Park. (Photo courtesy of F. Edwords.)

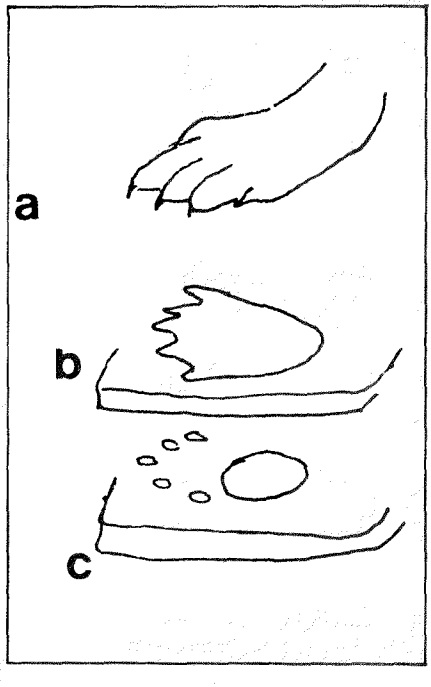

FIGURE 17. Stepping in thin-bedded sediments can result in the formation of *undertracks*. Later, infilling of primary track impressions by more sediment can result in the formation of *overtracks*. (After Heyler and Lessertisseur, 1963.)

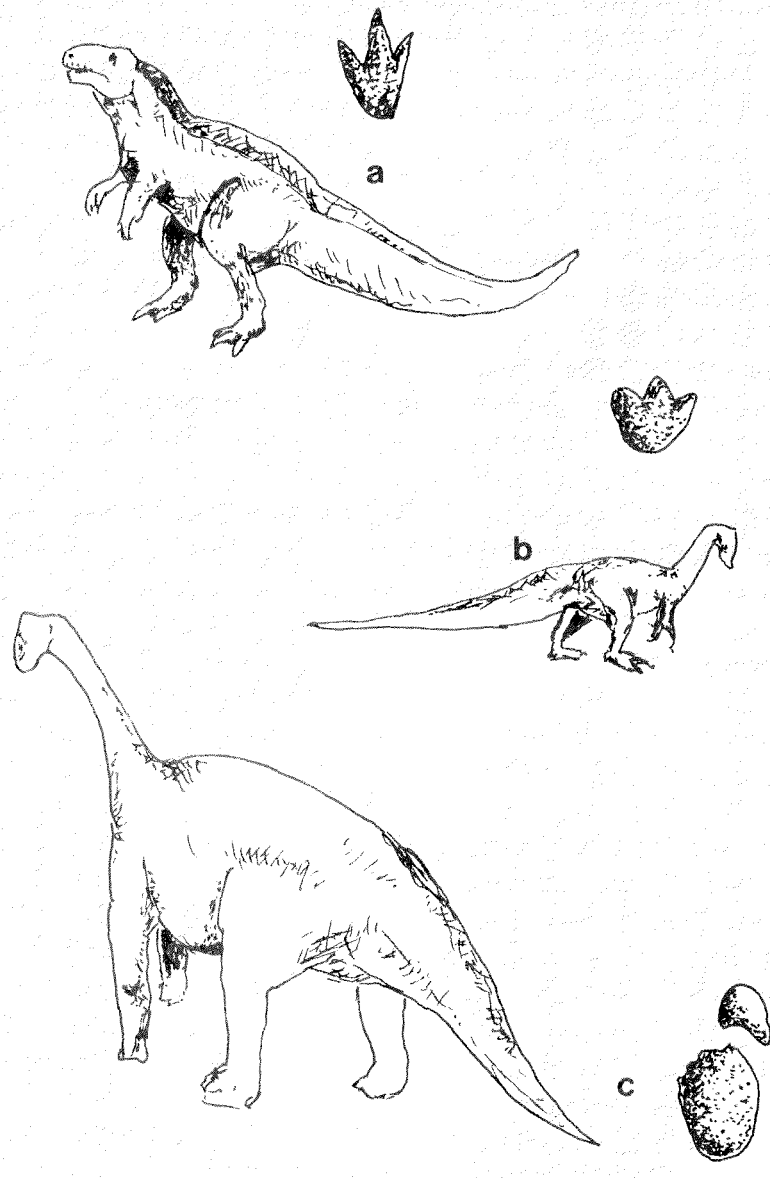

FIGURE 18. Tracks and probable trackmakers: (*a*) carnivorous theropod *Acrocanthosaurus* with *Irenesauripus* track, (*b*) herbivorous *Tenontosaurus* with *Gypsichnites* track, (*c*) herbivorous sauropod *Pleurocoelus* with unnamed hindfoot and forefoot tracks. (After Langston, 1984, p. 43.)

And these Texas dinosaurs were moving on soft mud; humans retracing their steps today are moving on hard limestone. If there *were* humans walking on the mudflats alongside these dinosaurs, they would have taken shorter strides than we can take on the now-hardened rock.

Normally, adult humans walking comfortably take paces of about .6 to .9 meters. Comfortable *strides* will be about twice that. Slowing down or speeding up, the range of possible strides is much greater (see Table 3). A small female may exhibit a normal range (minimum to maximum) in *stride* from about .8 to about 1.8 meters. (Note the possible overlap between *normal pace* and *short stride* lengths.) A tall male may exhibit a normal range in stride length from about 1.0 to 2.25 meters. One exceptionally tall (6 foot 10 inch) male whose pace and stride we measured exhibited a normal, comfortable stride of about 2 meters; his *comfortable* pace length was consistently 1 meter long. Using his foot measurements, his *minimum* stride length can be calculated at a little more than 1 meter, his maximum stride length at about 2.3 meters, and his maximum pace at about 1.2 meters. He was capable of stretching his leg to reach a "super-pace" of 1.7 meters—i.e., 1.7 meters in one stretch-step! If dinosaur tracks in a series are 1.3 meters apart, one can see how people even shorter than this man might easily reach them by stretching. But they could not keep this up in a normal walk. And they would have extra difficulty doing so in mud.

We measured tridactyl dinosaur strides, paces, and foot lengths at the Thayer (New Braunfels) site, and extensive maps of this site plus detailed measurements have been made by paleontologists Wann Langston, Jr., and James Farlow (Figure 7). Foot and stride lengths of other bipedal dinosaurs have been published (see Table 4). New measurements for Texas bipedal dinosaur trackways are currently being compiled by James Farlow.

When the clarity of tracks allows it, precise measurements of pace, stride, lengths, and width can be made. But one must pay careful attention to anatomical landmarks to obtain measurements that can be usefully compared. For example, an ornithopod footprint shows three forwardly facing toes. Different "lengths" can be obtained by measuring along each separate toe. One *Gypsichnites* track, for example, measured 440 mm along the middle toe; 350 and 300 along the lateral toes. Maximum breadth for this particular specimen, across all three toes, was 370 mm. Not surprisingly this large dinosaur had a very high width/length ratio (370/440 or .84). But as is typical of tridactyl dinosaurs, each toe was relatively narrow, and an impression of a single toe gives the dimensions creationists often record as typifying man-tracks. Pace lengths also match typical creationist measurements for man-trackways. For example, this particular ornithopod took 11 steps in 15.81 meters. Pace and stride length changed gradually throughout the sequence, increasing and then decreasing slightly. We measured the following sequence

Table 3

STATURE, PACE, AND STRIDE ESTIMATED FOR HUMANS OF KNOWN FOOT DIMENSIONS

INDIVIDUAL	MAXIMUM FOOT LENGTH mm.	STATURE meters	MAXIMUM PACE meters	MINIMUM STRIDE meters	MAXIMUM STRIDE meters
Male 1	287.0	1.89	1.10	.96	2.27
Male 2	292.1	1.93	1.12	.98	2.32
Male 3	304.8	2.01	1.17	1.03	2.41
Female 1	266.7	1.76	1.02	.90	2.11
Female 2	236.2	1.56	.90	.80	1.87
Female 3	243.8	1.61	.93	.82	1.93
Neandertal	274.3	1.81	1.05	.92	2.17

Foot dimensions of these individuals are taken from Napier (1973)

Formulae based on Napier (1973) and Grieve and Gear (1966):

1) Stature = greatest foot length x 6.6

2) Maximum stride length = stature x 1.2 (or 1.1)

3) Maximum pace length = stature x .58

4) Minimum stride length = stature x .51

(These formulae work reasonably well for humans. They cannot be applied to other animals. Note also that they do not correct for allometry.)

Table 4

FOOT AND STRIDE LENGTHS FOR VARIOUS BIPEDAL DINOSAURS
(based on trackways made by different genera)

DATA BASE	A	B	C	D	E	F	G
MEAN STRIDE LENGTH (meters)	3.0	3.0	2.4	1.3	2.15	2.0	2.25
MEAN HINDFOOT LENGTH (mm.)	530.0	500.0	240.0	270.0	315.0	570.0	520.0

Data from Alexander (1976) and Hastings (unpublished). The data bases represent different studies cited by Alexander.

G = The Taylor Trail (measured by R.J. Hastings)

(strides from tracks 1 to 11, i.e., 1 to 3, 3 to 5, 5 to 7, etc.): 3.11 m, 3.18 m, 3.21 m, 3.17 m, 3.11 m. The longest *paces* were about 1.6 meters. Many trackways at the Thayer site exhibit shorter strides. One dinosaur took 15 steps in 15.1 meters, covering an equal distance in as many steps as is typical of our 6-foot-10-inch human! But then from track 10 to 18 stride length increased *gradually* from 2.04 meters to 2.55 meters as the animal increased its speed. Its longest stride probably exceeds the limit for our tall human subject, but only by a little bit. Overlap in single measurements is obviously not the whole story. The stride lengths of humans and dinosaurs overlap, but the whole gestalt is not the same. The ornithopod that took roughly one-meter-long steps over a short distance had much larger feet than our human does. And it was clearly capable of taking much longer strides. To test human origin claims, the range and combination of foot *plus* stride and pace measurements must be checked.

Bipedal dinosaurs varied tremendously in size; some were quite small. Furthermore, many dinosaurs were "semidigitigrade" or "digitigrade"; not all of their foot contacted the ground even in normal walking. Some species left tracks that were 150 to 200 mm long (shorter than those of modern adult humans) and took 1.5 to 1.8 m walking strides. Some species made tracks over 500 mm long and took normal walking strides of about 3 m. (Running dinosaurs took much longer strides relative to their track lengths.) Walking paces of a meter or more are *rare* for humans and *common* for large bipedal dinosaurs. Human trackways are narrow; bipedal dinosaur trackways are broad or narrow. One can always speculate that "giant" humans took giant paces, but would they have had feet as narrow as individual dinosaur toes or "heels"? Would their feet have been relatively *narrower* than those of modern humans? The laws of scaling seem to indicate that this is impossible.

The Ryals Trail

John Morris (1980: 219) published data collected by Wilbur Fields for the Ryals Trail at the McFall-Taylor site (Table 1). These prints are usually under water but were filmed in *Footprints in Stone*. Morris gives measurements for nine tracks in this series, most taken directly from Fields. Others, which deviate markedly from Fields's primary data, are called "improvements" (e.g., pace length of 1.04 meters instead of 1.75 meters for Ry+4). Minor differences between most of the measures are due to rounding errors. Morris's data are presented in parentheses beside those of Fields.

The Ryals trail is often featured by creationists because it includes a footprint (Ry+2) which is said to show evidence of a human hallux. Although I was unable to examine it firsthand, photographs of it in *Footprints in Stone*

show that it has none of the features of a human great toe impression, and this is, interestingly, confirmed by the creationists' own measurements. The toe imprint is a small hole that is *far* too small (relative to the total length of the impression) to be even vaguely humanlike. To have modern human toe proportions, this "great toe" should be three times its actual size. In fact, it appears to be a claw mark obscured by sediment infilling. As might be anticipated, there are no impressions for lateral toes adjacent to that of the "great toe."

The Ryals trail exhibits all of the classic problems that characterize creationist mantrackways:

1) Measurements such as maximum footlength vary tremendously (in this case, from 350 to 750 mm) indicating at once that the tracks are too poor to exhibit precise anatomical landmarks, or that the creationists had no idea of how to recognize those landmarks, or both. Widths also varied wildly; according to Fields, Ry+2 was almost *five* times the width of Ry+1 (50 versus 230 mm)! The foot seems to have changed shape as well as length, so Fields felt compelled to measure the width of Ry+2 at the center whereas all other widths were measured at the "toes."

2) When measurements are retaken, values reported by different creationists show no agreement (compare the values of 230 and 127 mm. given by Fields and Morris for "width" of Ry+2; compare the pace lengths of 1.75 and 1.04 m given by Fields and Morris for Ry+4; then note that Ry+2 and Ry +4 are, according to Morris, the best of these supposed mantracks).

3) The foot proportions vary as much as individual measurements, so that width/length ratios may double or even triple for tracks in a series (compare 12.5 and 38.3; Table 2)! Moreover, a good many of the values for these indices (in this case nine out of thirteen) fall far outside the range of human variation. This is true of the width/length ratio, the big toe length/total foot length ratio, and the ratio of heel width to total length.

4) Values for indices deviate *in the wrong direction* from allometric expectations for a supposed giant human. Thus the markedly deviant values for the Ryals trail indices shown in Table 2 are all too *low*.

5) Pace lengths match those of dinosaurs and are almost universally outside the range of modern walking humans.

6) The lengths of the features measured match the lengths of known dinosaur footprints.

7) The tracks exhibit none of the tell-tale signs of human footprints—the hallux continuing the ball, the ooze of mud under the toes, the different relative depths of different parts of the imprint.

Dinosaur Valley State Park

Imagine how hard it would be to measure something if nothing was there. Well, all mantracks on the Dinosaur Valley State Park ledge are exactly that—nothing at all. Perhaps I should qualify that statement by saying that they are not *tracks*; they are elongated erosional grooves with nebulous boundaries (see Figure 8). The "*Brontosaurus*" and "bear" tracks (Morris, 1980: 156, 228), are also erosional features. Without the creationists' maps and photos we could never have located them. Actually, none of the park's many dinosaur tracks occur on this particular stratum, but it is a popular mantrack site for visitors unwittingly impressed by erosion.

There is ample evidence that creationists have also had difficulty defining borders and locations of these alleged mantracks. As Milne and Schafersman (1983) point out, one print was illustrated by Morris (1980: 229, top left photo) as a definite left, while both Dougherty (1971 cover photo) and Beierle (1980: 32 and 33) describe it as a definite *right* footprint. Each showed (but in different places) a "big toe" mark. When one looks at these prints without highlighting anything, one sees typical erosional channels and pits. Erosional pits become toes *if* they happen to be roughly the size of a modern human toe (see Figure 9). Erosion creates a very irregular surface on limestone, and river erosion creates elongated grooves roughly parallel to the direction of flow of the river. Some depressions, of course, will be roughly the length of a modern human footprint. These are the features creationists have identified here as mantracks. They occur "in series" only because the direction of river flow was uniform. As might be expected, these mantracks have a host of things wrong with them. The distances between them ("paces"?) are extremely irregular (measuring in one case 2.18 and 1.40 meters for successive "footprints"). The so-called hallux impression, when present, may be wider than it is long (unlike genuine human big toe prints). Whereas the total lengths of some of these features do not exceed those of modern humans, their width/length indices fall in the range of bears rather than humans; compare width/length values for erosional features B and C with actual human values (Table 2). One would *not* expect human footprints of these lengths to be so exceptionally wide. Other, longer, features turn out to be considerably narrower, again contrary to expectations for genuine human footprints (see Figure 10). Unlike the toes of the carved mantracks which are too long, these "toes" (actually erosional pits) tend to be too small and especially too short. None of the features show the tell-tale signs of human footprints. So-called "insteps," "heels," and occasional "toe marks" are formed by karren dissolution, erosional undercutting and the creativity of imagination that allows us to see camels in cloud formations.

The McFall Site

Old Emmett McFall's property is the Reverend Carl Baugh's playground. Baugh (1983b) claims to have found 44 human footprints *in situ* here. While maps and measurements of Baugh's new mantracks have not been published, members of our team were able to visit the site on a number of occasions shortly after fresh mantracks had been exposed. Baugh and members of his crew pointed out track locations to us. A brass plaque commemorating the discovery of *Humanus Bauanthropus* is located near an elongated groove that Baugh took for a giant mantrack.

None of his mantracks are recent erosional features. They all fall into one of three categories, however:

1) *Clear toe impressions of tridactyl dinosaurs.* The limestone beds at the McFall site and other neighboring properties abound with footprints of tridactyl dinosaurs whose tracks have been named *Irenesauripus* and *Gypsichnites* (Langston, 1983). Some "three-toed" dinosaurs actually had four toes. The hallux, situated at the rear of the foot, sometimes dragged in mud, creating a distinct heel impression (Figure 11). The depth or even existence of this rear toe impression depends upon how far the dinosaur's foot sank into the mud. If one is not picky about shape, one can imagine that this heel (or rear toe) mark is an entire human footprint. Needless to say, the "toes" of such footprints are obscure as is, indeed, the entire outline. (But Baugh tries to turn this into an advantage by claiming to have discovered proof that the humans and dinosaurs lived together because of the astounding fact that the humans stepped into the dinosaur tracks or vice versa.) Due to the difficulty of *finding* the front border of these mantracks, lengths of mantracks, three in series, seem to be six inches, ten inches and sixteen inches, for example.

2) *Poor dinosaur tracks.* Other Baugh mantracks are not portions of *clear* dinosaur footprints, rather they are poor dinosaur tracks that have been obscured by partial infilling of mud. They can be found in series with other much clearer dinosaur tracks. Fanning in the front usually shows the axes of three partially-filled toes (Figure 12). One such mantrack at the McFall site measured 480 mm long, 90 mm at the "heel," and 190 mm at the front where the impression fans out and disappears. It should be immediately apparent that these dimensions match those of many creationist mantracks and *fail* to match the expected proportions of human footprints (especially giant human footprints). The "heel" is much too narrow; the length too great. There is no ball impression or any other anatomical feature that characterizes human footprints. The so-called "Giant Run" mantracks (Morris, 1980) are all of this character (Hastings, personal communication).

Some of these depressions are even more obscure. They may be formed when, for example, mudflow completely hides the fanning at the front of a

dinosaur footprint leaving only a slitlike impression, or when the dinosaur makes a scoop mark with a foot or a tail that briefly contacts the surface. The oblong depression located near the *Humanus Bauanthropus* plaque has this character (Figure 11). It scoops up on both sides and is long and narrow. Its length (470 mm) and width (100 mm) match those of nearby clear dinosaur toe prints; these dimensions are certainly wrong for a human footprint, being once again far too long and narrow. The depression is also deepest rather than shallowest in the supposed arch area. The "toes" that some creationists have identified at one end of the impression are actually small and indistinct erosional pits that have none of the characteristics of actual toe marks. One can count five, six, seven—however many one wants. One woman, clearly a believer, told us that the big toe must have been in the middle of the "giant human's" foot because the biggest shallow pit happened to be in the middle.

3) *Thalassinoides.* Perhaps the most remarkable mantracks are those Baugh and his crew created out of invertebrate burrow casts of *Thalassinoides* (Schafersman, 1983). An exposed limestone bed at the McFall site is covered with such burrow casts; they form lattices and ridges that, to the creationists, sometimes separate human toe impressions or saber-toothed cat pads. A member of Baugh's crew showed us the outline of one such mantrack that we were then able to measure (Figures 13 and 14; Table 2). Its "big toe" was 43.6 mm wide and 44.5 mm long—roughly square, in other words—and also far too small for the length of the footprint (450 mm). Its width/length index was too small—outside the range of human variation. None of the salient anatomical features of genuine human footprints was present; in fact, this footprint had no relief at all, except for the burrow cast ridges that covered its entire surface. Genuine trace fossils? Yes! Genuine mantrack? Definitively, no!

Conclusion

Any claim of human and dinosaur contemporaneity based on the alleged discovery of both kinds of footprints in the same rock deposits will be treated seriously by the scientific community only if it is based upon *clear* tracks of both. Excellent dinosaur tracks abound in the Cretaceous rocks of central Texas. In contrast, *all* of the alleged mantracks are miserable. The question addressed in this essay is: how can one recognize a genuine human footprint?

In order to determine that a given depression is a genuine human footprint, we need to understand human footprint anatomy. How do anatomical principles govern variation in foot size and shape? How do the impressions human feet make vary on different surfaces? How is the pace-and-stride pattern humans make constrained by stature and gait? Only after one specifies

the predictions of a hypothesis can one determine whether observations fit them. Thus one tests the hypothesis that a given set of depressions is human by specifying and then looking for tell-tale signs of human anatomy and gait.

When we approached the evidence in this way, we found that the alleged Cretaceous mantracks consistently failed the test of human origin but often passed the test of dinosaur origin. Indeed, some were quite clearly portions of dinosaur footprints. Others—those most responsible for the Paluxy mantrack legend—turned out to be inept carvings. Although these were definitely in the minority, had they never existed it is doubtful that creationists would have focused on the Glen Rose area in the first place.

We not only measured many of the trackways that creationists claimed were human, but we also scrutinized the creationists' published data on mantracks. We consistently found these data to be shoddy and, even when taken at face value, to lead to absurd conclusions about the stride length, foot length, and foot shape of the "humans" that presumably made them. The inescapable conclusion is that there is no footprint evidence in Texas supporting the notion of human and dinosaur contemporaneity.

Mantracks? The Fossils Say *No!*

J.R. Cole, L.R. Godfrey, and
S.D. Schafersman

Paleontological Research in Central Texas

Paleontological research has been conducted in central Texas throughout this century. Dinosaur and other Mesozoic vertebrate bones were reported in the Comanchean Cretaceous rocks near Glen Rose as early as 1887 (Hill 1887; Cope 1894); dinosaur footprints (known to the local Indians as giant turkey tracks) were reported by Shuler in 1917 and 1937. Still, these tracks and fossils were not widely known to the scientific community until Roland T. Bird, a collector from the American Museum of Natural History in New York, rediscovered them while on a fossil hunting expedition in 1938. The story of his Glen Rose adventure was featured in *Natural History* in 1939. Shortly afterward, Bird had huge slabs of track-bearing limestone removed for display at the New York museum and elsewhere, and paleontologists intensified exploration of these and the surrounding Comanchean deposits (Bird, 1939, 1941, 1944, 1953, 1954; Brown, 1941; Albritton, 1942; Langston, 1960, 1974, 1983; Slaughter, 1969; Slaughter and Hoover, 1963; Perkins, 1971). From their research we now know some of the marine and brackish water fishes, frogs, salamanders, crocodiles, lizards, turtles, ichthyosaurs, dinosaurs, pterosaurs (flying reptiles), small primitive mammals, molluscs, echinoderms, ostracods, and arthropods that inhabited what is now Texas 100 million years ago. Even the microfauna is known: a type of miliolid foraminiferan that characterizes nearshore lagoons, forty-nine genera of pollen and spores, and thirteen genera of spiny organic-walled dinoflagellates and acritarchs (the microplankton that cause "red tide") (Langston, 1983). Gentle ripple marks, mats of algae, animal bore-holes and burrows, in addition to the well-preserved dinosaur trackways, attest to the shallowness of the tidal water. During the Lower Cretaceous, from South Florida to Mexico, a great reef-like organic barrier formed between the open sea and a shallow continental shelf. The shelf was covered by many types of carbonate sediments. Nearshore lagoons and tidal flats had lime mud floors that were sometimes covered by very shallow water and sometimes exposed to air. During periods of exposure, countless dinosaurs and other animals crossed and recrossed the mudflats, leaving imprints of their feet in the soft lime mud.

Even though most of these tracks were quickly obliterated by rainstorms or by the next rising tide, conditions on tidal flats are sometimes suitable for the preservation of trackways. The Comanchean deposits of central Texas are

at least as well known for their tracks as for the bony remains of the animals that made them. The rocks containing some of the best dinosaur trackways are composed of alternating layers of terrigenous friable clay marl, soft argillaceous (clayey) limestone, and harder, erosion-resistant limestone. They constitute the 20-foot thick Lower Glen Rose Member of the Glen Rose Formation. This deposit contains most of the alleged mantracks that we examined. Its calcareous or limey layers consist of the remains of countless billions of microscopic skeletal fragments of molluscs, foraminiferans, and algae that lived in the shallow lagoons. Their calcium carbonate skeletons formed the lime mud which later became hardened into limestone. The silty clay-rich layers are composed of lime mud plus a great amount of silt and clay derived from freshwater streams. Periodic, minor floods of these streams washed thin layers of terrigenous silt and clay over the lime mud floors of the lagoons and tidal flats.

In order to be preserved, tracks must be covered by a sediment that contrasts in density and composition with the medium in which they were made. Today we find the best dinosaur tracks near Glen Rose preserved as molds in the hard limestone beds directly underlying beds of much softer terrigenous mudstone or marl. The best of these tracks are simply those that happened to be buried by fine sediments before they could be damaged by other natural processes.

Recent Features in Stone: The Marks of Erosion

We have alluded to the fact that ancient sedimentary rocks contain remnants of actual organisms (fossils) and the traces of their activities (trace fossils). All provide clues to the composition and ecology of life in the past. But exposed surfaces also exhibit features which are recent in origin—erosional structures. Of course those surfaces may have also been modified by erosion *prior* to burial. Such *primary erosion* occurs when the sediments are still fresh and unlithified, whereas modern *secondary erosion* produces pits, channels and potholes on hard rock. One who isn't a specialist might easily confound primary and secondary erosional features, or might confuse *both* with trace fossils. Exposed limestone beds (such as those being cut by the Paluxy River) typically show all of these.

Because of its solubility, limestone is severely affected by leaching or *karren* erosion. Karren erosion occurs on uneven and fissured calcareous beds; it results in the formation of elongated cavities along fractures and depressions which are subjected to increased mineral dissolution by the seepage and pooling of rain water in and around them (Schafersman, 1983; Langston, 1983). It also results in ovoid pitting of exposed surfaces due to the differen-

tial dissolution of the cement that holds clastics (sedimentary fragments) together. These elongated cavities and pits are responsible for some of the oddly shaped "manprints" and "toes" that creationists have described, especially on the Park ledge at Dinosaur Valley State Park (viz., Wilder-Smith's Figures 17 and 18, 1968).

Rapidly moving suspension-laden flood water produces elongated erosional channels or cavities running roughly parallel to the direction of river flow, some of which have been mistaken by creationists for mantracks (Schafersman, 1983; Langston, 1983). Some of these may superficially resemble human footprints, more so because they seem to occur "in series," although they differ in shape and size and are separated by uneven distances. Similarly, "insteps," "toes," and "claw marks" can be produced by *undercutting*—the differential erosion of soft layers below harder, more erosion-resistant beds. In short, river erosion plays havoc with exposed limestone beds, producing intricate surfaces with numerous depressions. Anyone uncritically looking for shapes of any sort can probably find them. Creationists visiting Glen Rose have displayed vivid imaginations; they have made several human trails, a "*Brontosaurus*" track, and a "bear" track out of the erosional features on the Park ledge. The surface exposed there is actually a hard, dense limestone or lime wackestone that contains no tracks of any kind (Schafersman, 1983).

For example, Figure 15 shows the feature that was identified by Stanley Taylor and his crew in *Footprints in Stone* and later by other creationists, including John Morris, as a probable "bear" track. Notice that the so-called claw marks occur in a single soft layer which can be traced along the outline to the left side of the "track" where deep undercutting occurs. Taylor counted five "claw marks"; one can actually count six indentations, but that is irrelevant since none of them is an actual claw mark. These creationists apparently failed to notice that these "claw marks" occur in a single erosion-susceptible bedding plane. They also failed to notice the undercutting that so characterizes erosional features. Actual tracks cannot exhibit such features, since even if a foot sinks down far enough to be partially covered by mud, that mud would slide in or be scooped out by the foot upon removal and would not remain as a rounded overhang. Far from being an enigma that turns the geological time table upside down, this "track" is a simple accident of erosion.

Ancient Features in Stone: Trace Fossils

Not all holes in rocks are due to erosion, of course, and only a stone's throw from the Park ledge are some limestone beds that contain the dinosaur footprints for which the park is famous (see Figure 16). Tracks may be preserved

as molds or casts; with burrows they are called *trace fossils* because they are records or traces of the activities of ancient organisms and not the remains of the organisms themselves. *Ichnologists* specialize in the study of trace fossils, and *ichnology* is now recognized as a subdiscipline of paleontology valuable for the solution of traditional paleontological problems (see Sarjeant, 1975, and other chapters in the same book). Some remarkable trace fossils are known from ancient rocks: trails produced by the pectoral fins and tails of walking fish, locomotor traces of other bottom-dwelling fish, swim marks of dinosaurs barely touching the bottom with their toes (Sarjeant, 1975; Coombs, 1980), and so on. Numerous invertebrate burrow and trail marks have been identified (Frey, 1975; Crimes and Harper, 1975), but many have not received proper study. Some animal or moving object undoubtedly made the marks creationists have called "wheel tracks" at the Thayer site near New Braunfels, for example, but proper identification remains to be made.

Ichnologists study trace fossils in order to gain an understanding of the lifeways and habitats of the organisms that produced them. From the form and depth of a track, an ichnologist can tell whether it was made on a hard surface, in shallow water, or in deep water. A group of footprints in series can reveal even more, because relationships between tracks change when gait and speed shift, so track data can be used to reconstruct the gait and speed at which the animal was moving (Alexander, 1976; Thulborn, 1982).

Of particular interest to us is the fact that it is often possible to identify the trackmaker from anatomical features present on the track. (Some caution must be exercized here since we seldom find skeletons of animals that dropped dead in their tracks!) At the very least, the animal family or order to which the trackmaker belonged can usually be identified. Because extinct genera are usually known from the bony remains of far fewer species than actually existed, it is unwise to attempt fossil track identification at the *species* level. Besides, the feet of species within the same family may be so similar that it becomes nearly impossible to distinguish their tracks even if their foot anatomy is known. Indeed, the footprints made by early members of the hominid *family*, the australopithecines, are strikingly similar to those of modern humans, despite some differences in the bony anatomy of modern human and australopithecine feet.

Because of the taxonomic problems which invariably arise when traditional taxonomic names are used for the identification of trace fossils, ichnologists have opted for a separate system of classification of tracks. This means that a particular dinosaur such as *Acrocanthosaurus* may have made particular tracks that are clearly recognized as compatible with the known foot anatomy of this animal, yet paleontologists will avoid asserting that these were the tracks of *Acrocanthosaurus*. They prefer to give the tracks a new genus name —*Irenesauripus* in this case—and to note the affinity and probable association

of the two. Taxa based on trace fossils are called *ichnotaxa*; a genus name for a track is thus an *ichnogenus*. While this produces a proliferation of names, the incompleteness of the fossil record makes this a sound taxonomic practice.

Trace fossils are considered problematic when the identity of their maker has not been determined. In the case of footprints, this may occur because the foot anatomy of the actual trackmaker is unknown (or the fossil species or genus is itself unknown). Or a track may not be recognized as belonging to a particular animal even when that animal's foot anatomy is known, either because track preservation is poor or because the track was made in an unusual manner.

Track preservation depends upon a whole host of conditions (Sarjeant, 1975; Mossman and Sarjeant, 1983):

1) First, the medium must be able to hold the impression. This means that it must be fine-grained and cohesive—not so coarse that it fails to register details of the undersurface of the foot, not so wet that it is deformed immediately upon withdrawal of the foot, and not so dry that it is easily damaged by wind. If the water table is so high that water fills the bottom of the imprint, some of the details of surface anatomy will be lost. If the medium is too hard or dry when first stepped on, it will not register the entire undersurface of the foot.

2) The medium should be resistant to damage by light rain. Such resistance is enhanced if a track mold made in a moist medium partially dries and hardens before burial.

3) The track must be "cast" before it is damaged or obliterated by wind, water, or trampling. That casting medium must differ in consistency and composition from the molding medium so that it will separate easily after lithification has occurred, and it must itself harden and not erode away.

While it may be rare that these conditions are met for any single trackway, it should be obvious that whenever there is a wash of suspension-laden water from freshwater streams over a limey lagoonal mudflat, the exposed trails will vary in condition from excellent to poor; all of these will be preserved.

The form of a track depends not only on the nature of the substrate in which it was originally impressed and the damage to which it was subjected prior to burial, but the *manner* in which it was originally made. We saw above that a medium may not register the entire undersurface of a foot. It is also true that an animal may not *apply* the entire undersurface of its foot to the ground, and that this depends in part on how it is moving.

For example, Sarjeant (1971) described some elongated tracks produced by bipedal reptiles in some Permian deposits in Texas. The tracks showed the imprints of two digits—a large deeply impressed fourth digit which bore most

of the weight, and a smaller third digit which was only slightly impressed, probably for balance. These tracks were produced by an animal that probably possessed four or five toes all of which might register in *walking*. In other words, this animal became functionally two-toed when moving at high speeds. This is not at all unusual. Many animals are "plantigrade" (walk on the entire undersurface of their feet) when moving slowly and "semidigitigrade" or "digitigrade" (support their weight on their toes alone) when running. In the case of bipedal reptiles, most of the weight is transmitted through the central digit (middle toe), and this is the digit that will be impressed most deeply. It goes without saying that the toe impressions produced in this manner do not resemble the slow walking tracks produced by the same species. It would be easy for someone who is not a specialist to "read" them as mantracks.

So far we have been describing primary tracks, and we have seen that these may not faithfully record all of the details of the surface anatomy of the bottom of the foot. Features called *undertracks* and *overtracks* are also common, and these are even less faithful to dinosaur foot anatomy. They may appear as vague elongated depressions. At the Thayer site near New Braunfels, Texas, overtracks have been mistaken for manprints, and it is highly probable that other "mantrackways" are in reality the undertrackways or overtrackways of bipedal dinosaurs (Milne and Schafersman, 1983; Langston, 1983).

Undertracks were first described by Heyler and Lessertisseur (1963) in thin-bedded European sedimentary rocks. If the layers are sufficiently thin and yielding, the foot of an animal may produce deformation in one or several layers beneath the surface layer. The impressions made in the underlying beds are actually *subtrace* fossils which are usually very different in form from the true footprint mold (Figure 17), losing detail downward through several layers.

Overtracks and undertracks form easily in thin-bedded algae-bearing deposits. Dinosaurs crossing stacks of algal mats common on tidal flats sometimes made impressions in several layers of spongy algae-filled mud. After the tracks were made, they filled again with algae and mud, conforming at first to the shape of the footprint mold. Several additional layers hence, the original shape of the footprint was lost—replaced by a vaguely elongated or oval depression representing the deepest portion of the original track (the middle toe). Today when the bedding planes separate such that the primary mold can be seen, three toes are quite distinct. But when they split apart such that the "undertracks" or "overtracks" are exposed, the anatomical features of the footprint are obscure. Sometimes only one or two tracks in a trackway will retain their overtrack fillings but the outline of the primary impression will be visible around them. This is true at the Thayer site where oval overtracks were taken to be mantracks.

Trace Fossils, Mantracks, and Mantricks

A variety of Cretaceous trace fossils have been mistaken for mantracks. These include invertebrate burrow casts of *Thalassinoides* and at least two ichnogenera of dinosaur footprints: *Gypsichnites* and *Irenesauripus*. There is another unnamed ichnogenus that is common in these deposits—footprints that were probably made by the sauropod *Pleurocoelus*. These, too, may have been mistaken for giant human footprints, but this is uncertain. There are many fewer known tetrapod *ichnotaxa* than there are known taxa based on skeletal remains in the Comanchean Cretaceous deposits of Texas (see Langston, 1974); it is likely that detailed study of the vertebrate footprints will result in the recognition of more ichnotaxa. It is also likely that each ichnogenus listed below represents several species. The tremendous size variation of *Gypsichnites* footprints is improbable for a single species (although ontogenetic variation must be taken into account).

Thalassinoides is the ichnogenus name given to a particular type of crustacean burrow system (Kennedy, 1975; Bromley, 1975; Curran and Frey, 1977). A *Thalassinoides* burrow system is essentially composed of horizontal tunnels and Y-shaped branches and polygons that creationists have mistaken for the pads of "saber-toothed tiger" tracks and for spaces between "toes" of a mantrack (Schafersman, 1983). Similar burrows are known to be made today by thalassinidean shrimp and other organisms that live in shallow muddy estuarine or lagoonal environments (Curran and Frey, 1977). The trace fossil itself is common in shallow-water or supratidal carbonate rocks (Kennedy, 1975); complex burrow systems may form on carbonate substrates when deposition ceases for a while (Bromley, 1975).

The Comanchean dinosaurs belong to two orders: Saurischia (lizard-hipped) and Ornithischia (bird-hipped) dinosaurs. The former includes two suborders of relevance here—Theropoda and Sauropoda; the latter includes the suborder Ornithopoda. These suborders have famous representatives that were *not* in fact present in the Lower Cretaceous. *Tyrannosaurus* was a large Upper Cretaceous carnivorous theropod; the herbivorous *Apatosaurus* (formerly known as *Brontosaurus*) was a Jurassic sauropod. The famous duck-billed, plant-eating *Iguanodon* was an ornithopod that has no known representative in central Texas, but is known from Lower Cretaceous deposits elsewhere and *may* have had a representative, as yet undiscovered, in central Texas at the time (Langston, 1974, 1983).

The animals whose remains have been found in Comanchean deposits were thus relatives of the better known dinosaur genera. They include the carnivorous theropod *Acrocanthosaurus*, the herbivorous ornithopod *Tenontosaurus*, and the sauropod *Pleurocoelus* (mistakenly called *Brontosaurus* in early accounts). See Figure 18.

Acrocanthosaurus was a "three-toed" bipedal dinosaur that actually possessed four toes. The fourth toe, a small clawed hallux, was located somewhat high in the rear of the shank. It probably made the long, slender dinosaur tracks with sharp heel impressions and occasional claw impressions that are common in central Texas (Langston, 1974, 1983). These are given the ichnogenus name *Irenesauripus*. As we have seen, tracks with elongated heel marks fit prominently in the mantrack controversy.

The foot anatomy of another "three-toed" bipedal dinosaur, *Tenontosaurus*, fits *Gypsichnites* better than it fits any other known Comanchean tracks, although known skeletal remains of adult *Tenontosaurus* are too small to have produced the largest of the *Gypsichnites* footprints. *Gypsichnites* tracks range in length from 12 to 24 inches, are broader than those of *Irenesauripus*, and, in contrast to those of *Irenesauripus*, show no hallux impression (Langston, 1983). *Tenontosaurus* is known to have possessed a hallux, but, as Langston suggests, it is possible that the hallux was positioned high enough in the foot to have rarely touched the substrate in normal locomotion. (Think of the dinosaur as walking slightly tip-toe, not always touching the heel to the ground; their feet were very much like those of modern birds.) Langston believes that *Gypsichnites* tracks may represent several species of ornithopod dinosaurs; what is certain is that they were made by bipedal dinosaurs and that overtracks of some of them have been mistaken for mantracks.

Pleurocoelus was most probably responsible for the large quadrupedal sauropod footprints that made Glen Rose famous when Roland T. Bird discovered them in 1938. The local sauropod hindfoot tracks were made by an animal with four forward-facing toes and another, the dew claw, at the rear. Lee Mansfield believes that the roughly elongated shape of the hindfeet plus the distinctive front toe impressions of this animal gave rise to the local giant mantrack legend (Mansfield in Cole, 1984). It is easy to modify a *Pleurocoelus* footprint by adding an extra toe at the front. A chisel and some coffee grinds (to smooth out rough edges) will do it. The new "mantracks" that we have seen are not these, however.

Conclusion

Creationist mantrack claims should be evaluated within the context of what is known about life and environments in central Texas during the Lower Cretaceous Period. For example, the notion that tracks in the Glen Rose area were made by animals and humans fleeing a worldwide cataclysmic flood becomes patently absurd in light of the known (quiet) sedimentary environment responsible for the build-up of the Glen Rose Formation. Furthermore,

when creationists label certain elongate channels or depressions "mantracks," they ignore hypotheses that explain these features far more adequately. Some of the important facts that creationists fail to take properly into account are:

1. Primary erosion can distort dinosaur tracks *prior* to their fossilization, thereby making them less distinct.

2. Secondary erosion of exposed rock surfaces can further obscure genuine tracks that are already fossilized, as well as create elongate channels that may appear to be "in series" (due to uniform river flow). Differential erosion of softer and harder rock layers can form irregularities that may be mistaken for "insteps," "claw marks," or "toe imprints."

3. Erosion by leaching can occur in depressions, fissures or cracks in rocks into which rain water seeps. Such erosion can widen cracks and depressions to form features that may superficially resemble tracks.

4. Under certain conditions, fossilized burrows of small invertebrates may seem to resemble details of the imprint of a human or other footprint.

5. In thin-bedded deposits, animals sometimes leave vague imprints of their feet in the layers of sediment directly underlying the surface into which the original footprints were impressed. In addition, thin layers of sediment washed over the tracks may conform vaguely to the shape of the primary tracks. When hardened, the "undertracks" and "overtracks" formed in this manner will be less distinct than the actual primary footprints, losing detail progressively upward or downward. When these, instead of the primary tracks, are exposed, they can give a false impression of details of the foot anatomy of the trackmaker.

6. The nature of the medium in which an animal leaves its tracks affects the appearance of the tracks. Thus, either on a very muddy or on a very dry medium, details of foot anatomy will be lost and individual toe or "heel" impressions may superficially resemble human footprints.

Anyone making scientific claims must first consider alternative hypotheses and attempt to rule out the less parsimonious of them. Extraordinary, sensational claims require extraordinary proof. In this case, creationists have shown remarkable unwillingness to consider the simplest and, often, seemingly obvious alternative explanations. As we have shown, there are numerous mechanisms by which elongated features are formed in rock. These explanations fit the evidence far better than the notion that giant humans and dinosaurs lived together on the Texas mudflats during the Cretaceous!

If I Had a Hammer

J.R. Cole

Our topic is basically limited to footprint claims, but the subject matter requires glances beyond these limits. Carl Baugh has stepped outside his footprints to claim other anti-evolutionist evidence.

One of his principal pieces of evidence for human contemporaneity with supposedly ancient geological strata is an iron hammer with a wooden handle found near London, Texas by others in the 1930s in an "Ordovician" stone concretion "in the scenario" (but not in the Glen Rose region). "Humanists," Baugh said, claim it is an "18th century miner's hammer." Noting the appearance of the handle, Baugh said a similar-looking piece of wood from Michigan had just been radiocarbon dated 11,500 years old. (He gave no reference and did not blink at the date earlier than his view of creation.) Apparently this was meant to suggest that the hammer was earlier than the *19th* (not 18th) century date other observers have suggested—and to imply that the hammer itself had been subjected to radiocarbon dating, although it had not been (Baugh, 1983b).

The stone concretion is real, and it looks impressive to someone unfamiliar with geological processes. How could a modern artifact be stuck in Ordovician rock? The answer is that the concretion itself is not Ordovician. Minerals in solution can harden around an intrusive object dropped in a crack or simply left on the ground if the source rock (in this case, reportedly Ordovician) is chemically soluble. This is analogous to stalactites incorporating recent objects in their paths as they grow. The rapidity with which concretions and similar types of stone can form is evident in soil caliche development. "Rapid formation of limestone has been shown in coral atolls in the Pacific where World War II artifacts have been found in the matrix" (McKusick and Shinn, 1980).

Lang (1983b:1) writes

> . . . Dr. Baugh had a laboratory in Columbus test the hammer that was found at London, Texas. They used a microprobe to examine the elements in the hammer and the rock in which it was found. As a result of these tests they concluded that the hammer was made by an advanced process of metallurgy which used the equivalent of coke rather than coal to develop the metal. They were convinced the iron formation of the hammer could not have been formed by a meteor. They were also convinced that the rock itself could not have been formed except where there was a great deal of water and a great deal of pressure. They seemed to feel that something equivalent to volcanic pressures was involved here. [Baugh (1983b) said

> the presence of kaolin [clay] is evidence of vulcanism, and vulcanism speeds hardening.]

Except for the odd note about volcanic pressures, a sort of Baugh idea fixee, this confirms what evolutionists have been saying about the 19th century miner's hammer! Why was there no attempt to date the hammer stylistically (it is of recent American historical style) or to subject the metal and/or wood to radiocarbon analysis instead of only doing this to some unrelated stick from Michigan?

Baugh (Baugh, 1983b, Lang, 1983a) further suggested that the hammer might hold the key to the nature of the antediluvian atmosphere which encouraged the growth of giants, because, he said, its chemistry suggested that there was once ten times as much ozone in the atmosphere than there is today. He did not say why this would produce giantism. The claim is absurd. An atmosphere with ten times the current amount of ozone would *not* produce conditions for a Garden of Eden or cause people to grow into giants living hundreds of years; rather, it would be fatal to most trees and cause a massive plague of animal and human cancer and mucous membrane searing.

Baugh (1983b) implied strongly that as a result of his tests of the hammer he was on the track of a wide range of other scientific breakthroughs concerning the early earth's atmosphere and chemical composition—exciting stuff indeed! (Or was he trying to show people a wide range of technical-sounding jargon which could intimidate a layman?) His intermittent Texas research is supposed to be on the track of all sorts of ancient mysteries without half trying—making a joke out of the hard work of doing science.

Besides his other efforts, Baugh has discovered a genuine dinosaur skeleton which he says virtually proves that his mantracks and dinosaurs were contemporary; he identifies it as a sauropod (Bailey, 1984). (According to the paleontologist Dr. Wann Langston, it is a carnivorous three-toed bipedal dinosaur!)

His dinosaur fossil bones are real, however strangely interpreted. On the other hand, his recent claims to have found fossil skulls of a child and a saber-toothed tiger are not simply misinterpreted—they are baseless. Baugh has found odd-shaped limestone chunks or concretions and called them skulls. As Schadewald (1984) notes, they are merely natural silicified limestone nodules with a few needle-like crystaline spurs which have been called teeth. Limestone consolidates and weathers unevenly, yielding odd-shaped lumps such as the "dinosaur bones" in Emmett McFalls's front lawn and at the Thayer site, lumps that are nothing but funny-shaped rocks.

"You just kinda have to use your imagination," said a creationist guide leading people to trackways in 1982 (Turner 1982:149).

It Ain't Necessarily So: Giants and Biblical Literalism

J.R. Cole

In our culture, giants belong to the realm of St. George's dragon and other folklore. Belief in giants as flesh and blood rather than myth can be traced to a prescientific tradition. The Greeks had Prometheus, for example, and Gaea and the Titans; the Scandinavian first being was the giant Ymir whose body parts became the earth when he was slain by Odin and his brothers (a story similar to the Hindus' account of goddess Kali).

Mythic and distant, giants are as easy to comprehend as normal people drawn large. From ancient mythology to *Gulliver's Travels* and *The Attack of the Fifty Foot Woman*, giants are conceived of as outsized but normally-proportioned humans. In reality, however, anatomical size variation follows biological and physical laws of scaling rather than the rules of photographic enlargement. The "attack" of the Fifty Foot Woman should have actually consisted of her collapsing upon her own shattered feet and legs! But, if such creatures are anatomically impossible, they are very much a part of folk beliefs around the world. We can enjoy their feats or comprehend their symbolic lessons or meanings without taking seriously the biological problems of their mere existence because we all know they are really make-believe.

Or, at least *most* of us familiar with the scientific tradition know this. Scientific creationists, however, find ancient, "normally-proportioned" giants acceptable and have even made them a crucial aspect of their case against evolution. As a result, some creationists spend a great deal of time looking for giant tracks in the ground and in the Bible. While most creationists do not claim that all of the supposed human contemporaries of dinosaurs were giants, they do use the huge size of some of their alleged human footprints as proof of the scientific inerrancy of scripture.

Since one can accept the laws of physical scale and still be an antievolutionist, it is curious that scientific creationists build so much of their current argument around the existence of superior human giants. An extremely literal approach to the Bible might well insist that Adam and Eve had to be normal, fully modern humans. In fact, it would seem to require a substantial *evolutionary* change to convert a ten or sixteen foot Adam into a species less than half that tall, as some creationists have claimed (cf., Baugh, 1983b, Burdick, 1950, Dougherty, 1978:51). Burdick (1950:6) unwittingly writes that such

evolution (he calls it degeneration) *has* taken place since the days of Eden when everything was bigger and better than it is today.

> Not only has man decreased in stature from a magnificent specimen ten or twelve feet tall, to an average today of less than six feet, but his average life has shortened from many centuries to little more than half a century. Where do we find any human evolution here?

People convinced that humans and dinosaurs coexisted because the Bible implies they did have already made up their minds, whatever the evidence. There *are* biblical references to "giants," especially in the most popular fundamentalist versions of the Bible, and the first century historian Flavius Josephus (1850) mentions them. We have discussed material evidence elsewhere, but the literary evidence also needs to be examined. What *does* the Bible say?

Beierle (1980:95-98) cites several biblical references to giants: Genesis 6:4 "There were giants in the earth in those days. . . ."; Joshua 18:16 ". . . the valley of the giants on the north . . ." (also, Joshua 15:8); I Samuel 17:4 tells the story of David and Goliath; Deuteronomy 3:11 refers to King Og's bed as nine cubits long (up to 14 feet); Job 40:15 "Behold now behemoth, which I made with thee." Beierle claims that behemoth refers to *Brontosaurus*, and the *Bible-Science Newsletter* (1984b:16) claims the reference is to dinosaurs, at least.

Examined closely, these passages are a bit different from what creationists imply, and there are additional biblical references to giants which can be similarly analyzed. King Og's bed size can probably be ignored (by such standards we could prove that Hugh Hefner is a latter day giant!), but what of other references?

Translations as well as interpretations of meaning differ. In the preface to his history, Flavius Josephus (1850:24) notes that the Pentateuch (the first five books of the Bible) was written enigmatically, allegorically, and philosophically; he saw Genesis as a repository of deeper meanings, not simply an historical primer. Beyond the cloisters of slavish literalism, most biblical scholars today agree.

"Giant" is a common but not universal English rendering of several different Hebrew words, as Unger (1961:402) notes. They include Nephilim, literally "the fallen ones" (Genesis 6:4,5; Numbers 13:33). (The suffix "im" in Hebrew indicates a plural.) Rephaim are "ghosts" as well as the aborigines of Canaan and other areas (Deuteronomy 3:11; Joshua 12:4, 13:12). Anakim, the sons of Anak, are classed with the Rephaim in Numbers (13:33) because of their size. Goliath was a relic of the Anakim (I Samuel 17:4). "Emim" inhabited Moabite land (Genesis 14:5) and were as "tall as the Anakim" (Deuteronomy 2:11). "Zamzumim" were giants in the land of Ammon (Deuteronomy 2:20). These and perhaps other references can be added to Beierle's

catalogue, but even without a closer look it can be seen that the English word "giant" does not seem to be an adequate translation—we at least need "giant type 1, 2, 3, 4," etc.

Each of these references could easily be interpreted metaphorically. For example, David's battle with Goliath represents a weak-looking but valiant early Israel confronting seemingly stronger neighbors and triumphing against the odds. Indeed, a literal Goliath seems less interesting, less evocative of a powerful image and tradition—a diminution of David's symbolic accomplishments. "Jack the giant killer" is a motif common to many mythic histories and folktales, not evidence of one historic event.

The Book of Joshua describes the boundaries of the area inhabited by Judeans. *The Anchor Bible* (Boling and Wright 1982:360) translates Joshua 15:8 as "The boundary went up the Valley of ben Hinnom to the Jebusite ridge (or Jerusalem) from the south. The boundary went up to the top of the mountain opposite Hinnom Valley on the west, at the northern end of Rephaim Valley." Why is this of any interest? Because *The Interpreter's Bible* (Buttrick 1952-1953:628), for example, translates this last clause to read "which is at the end of the Valley of the Giants northward." Joshua 18:16 repeats this description with the same alternative translations. Were Rephaim actually giants? This region is one of the best explored on earth by archaeologists, and no outsized human skeletons have ever been found. There is no more reason to think the natives were gigantic than there is to claim that the San Francisco Giants baseball team consists of gargantuans.

Genesis 6:4 in the Revised Berkeley Version of the Bible (the Gideons International, 1974:4) reads: "There were giants on the earth in those days, and later, too, when the sons of God used to cohabit with the daughters of man, who bore them children, those mighty men of old who made a name." The same passage in *The Anchor Bible* (Speiser, 1964:45-46) reads: "It was then that Nephilim appeared on earth—as well as later—after the divine beings had united with human daughters. Those were the heroes of old, men of renown." Speiser writes that this is a fragment of an older Hittite myth about battling gods who mate with humans. He writes that it may have been included in Genesis, a bit out of context, to suggest the kind of vile conditions the coming flood would be sent to eradicate. Unger (1961:788) gives a similar interpretation:

> The Nephilim are considered by many as giant demigods, the unnatural offspring of the "daughters of men" [mortal women] in cohabitation with the "sons of God" [angels]. This utterly unnatural union, violating God's created order of being, was such a shocking abnormality as to necessitate the world-wide judgement of the Flood.

"Nephilim" also appear in Numbers 13:33 where scouts sent ahead return to report pessimistically that the Israelites should not march into new territory

that Caleb wanted them to conquer. "We saw there the Nephilim, the descendants of Anak, who are the giants. Even to ourselves we looked like grasshoppers, and so we looked to them!" (The Gideons International, 1974). This is obviously the metaphor and exaggeration of people afraid of the prospect of attacking a powerful foe. *The Interpreter's Bible* (pp. 534-535) matter-of-factly discusses the mythic nature of giants and notes that while some spies reported finding giants, others did not—and the Israelites went on to conquer the territory without encountering any. Although Josephus reports differently—that there was a "race of giants" whose bones "are still shown to this very day" (p. 105), he elaborates on the undependability of the spies' reports, saying that they were terrified by the obstacles to capturing the land of Canaan p. 78).

> . . . the rivers were so large and deep that they could not be passed over; and that the hills were so high that they could not travel along for them; that the cities were strong with walls, and their firm fortifications round about them. They told them also, that they found at Hebron the posterity of the giants. . . . [T]hey were affrighted at [the canaanite strengths], and endeavored to affright the multitude also.

Caleb and Joshua had been there, too, and they advised people not to be taken in by frightened lies, and the invasion was carried out successfully. Also, the frightened spies who brought back tales of giants were stricken dead by God for lying (Numbers 14:37-38)!

Job 40:15 is cited on the plaque at the McFall site as an apparent reference to the giant trackmaker dubbed "Humanus Bauanthropus." *The Anchor Bible* passage reads: "Behold now behemoth, which I made as well as you; grass he eats like an ox" (Pope, 1965:321-323). "Behemoth" is usually translated as "hippopotamus" and traced to Egyptian linguistic roots. It is never translated as "giant human" or "*Brontosaurus*" or "dragon," as some creationists claim. The reference to behemoth in Job is simply God's reaffirmation to Job that he created all things.

"Giant" stories in the Bible serve various functions, but giants are never equated with Adam and Eve or other heroes. They are always hated, feared, abnormal, foreign, and perhaps envied, not the scions of a Golden Age. This is particularly obvious in Joshua 13:12 where a remnant of the "giants" are mentioned, "for these did Moses smite, and cast them out" (The Gideons International, King James Version, 1964:226). Monsters and bogeymen beyond the horizon are a nearly universal human myth born of fear or ignorance of the unknown—instruments of social control reinforcing cultural solidarity. The clearest biblical references to giants fit this broad, cross-cultural pattern.

Many historical details in the Bible can be confirmed by archaeology. But if some things can be confirmed, it stands to reason that some things may be

falsified by material evidence. Creationists who accept the challenge to confirm their Bible scientifically would seem to leave open the possibility that the Bible can be proven wrong—something other creationists would call a materialist debasing of faith. That no giant human bones or tracks have ever been found in the Middle East is not proof that they are not there, awaiting discovery, but such a test is not crucial to most believers. Scientific creationists do not accept the possibility of negative evidence, and thus they do not really espouse a "scientific" creationism, because their *a priori* reasoning starts from the premise that the Bible is accurate in every historic and scientific detail, as their organizations' membership oaths make clear.

We have seen that there is no scientific evidence for the existence of pre-flood human giants. But, perhaps more surprisingly, there is no support for pre-flood giants in the Bible, either. The notion that Adam and Eve and most of the people who lived before the Flood grew to great sizes is nowhere stated in the Bible and can in no sense be supported by the few biblical references to various hated and feared "giants." Creationists read the Bible as selectively as they do the geological record and thus fail to see that their preconceived conclusions about scriptural accuracy are poorly served by their work.

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- But Some of Them *Are* Scientists, Aren't They?

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