

Proposal for a Multiyear Study on the Taphonomy of Late Cretaceous  
Vertebrates from the Lance Formation (Upper Cretaceous) on the Hanson  
Ranch, Roxon, Wyoming

Submitted by

Arthur V. Chadwick, Ph.D.  
Professor of Geology and Biology  
Southwestern Adventist University  
Keene, TX 76059

# Proposal to Hanson Research Station

## Summer 2001

### **Abstract:**

This document is a proposal to continue the development of our study on the taphonomy of vertebrate remains in the Lance Formation at the Hanson Ranch. I am proposing to expand the work at our major quarry site on Ridge 4 and to extend the scope of the study with limited exploratory work at other sites in the area. Continued work at the Ridge 4 quarry site will enable us to develop a large enough area for accurate and detailed analysis of the taphonomy in that area. Exploratory work on other ridges (Ridges 1-5) will enable us to determine the taphonomic character and extent of the bed that appears at this time to contain the major vertebrate deposits on the Ranch. The proposal is presented as a four-year project with annual progress reports to be made to the Board.

The main study area is now partially covered by a modular, semi-permanent physical shelter. This shelter and others that may be added will enable work to continue during inclement weather, will provide shade for the work area and security and protection to the site between digging seasons. I am proposing to work with and utilize various groups of students and teachers who may desire to participate in the research, as the Board has suggested. I will seek to coordinate and cooperate with groups of students and staff from a variety of institutions including, but not limited to Southwestern Adventist University. I will continue to offer the classes I have taught in the past. I am and will continue to be in contact with various members of the board who have expressed an interest in bringing groups to the site as plans progress for the 2001 season. A group of teachers at Trinity Christian Academy in Dallas have indicated interest in participating this coming year. These and other plans will be developed consequent to approval of the proposal.

### **Introduction**

The Hanson Research Station in Roxon, Wyoming is dedicated to the scientific development of one of the finest Upper Cretaceous fossil localities in the world, in the context of a Biblical understanding of earth history. This unique blending of a philosophy of great (and mostly unexploited) potential for explaining earth history, with a world-class vertebrate site, makes the Station unique in the world.

There are several approaches that could be taken to developing the potential of the site as an educational resource as well as a paleontological and geological treasure in harmony with the goals of the HRS. Central to the purposes of the Station are the twin goals of educating our youth and the educators of our youth in a scientifically sound, Biblically consistent view of earth history, and of developing the scientific potential of the Station. Therefore I am proposing a research plan that allows the training of college students and teachers in the fundamentals of a Biblically based view of earth history, while developing a site at the station where we can conduct scientific studies. The experiences of the past year have reaffirmed my conviction that this goal is realistic and repeatable.

Previous researchers in the Lance and in other dinosaur bone beds have explained the presence of extraordinary accumulations of dinosaur bones along these lines. "Dinosaurs had favorite crossing points on the Cretaceous river that deposited the Lance sediments. Some of the animals drowned while crossing the river and their remains were trapped in the first bend in the river, where they subsequently were buried in river sediments and preserved." In my opinion, this unchallenged hypothesis, used not only with respect to the Lance, but also for other deposits worldwide, has served to prevent scientists from carefully considering alternative models, including catastrophic ones. We are beginning to unravel the history of these Lance beds, and the history we are seeing thus far appears quite different from this scenario. The vertebrate deposit is in a relatively homogenous mudstone, not river sand. The bones begin to appear within the mudstone consistently about one meter below the contact with overlying sandstone and persist downward over an interval of one meter. At the present level of our knowledge, the bones appear to be graded, with larger bones below smaller ones within the unit. The disposition of the bones in the mudstone suggests strongly that the mud and bones were deposited together as a catastrophic unit. Although we have not yet examined the basal contact of the unit, the upper contact with the sandstone in the area of the quarry appears to be flat lying and conformable. Continued research will address other important concerns about the deposit and the bones contained within it. By the end of this project, we anticipate answers to many questions about the history and deposition of the bones and the mudstone itself.

The research of the past season was extremely rewarding. For the first time we can look at fossil material that is nearly or entirely free from physical or biological weathering in the modern environment. This will enable us to draw conclusions about the preburial condition and history of the bones distinct from any modern influences. Also, we have developed and implemented new technology that allows us to preserve the 3-dimensional relationships of the quarried bones, and we will now be able to relate any future bones recovered to those removed from the site this past season with accuracies measured in millimeters. In addition, the techniques we are presently using to excavate, protect and preserve the bones are far superior to any available as recently as 5 years ago, enabling us to salvage marginal bones and to secure the quality of good bones. As a result, the bones we have recovered this year are in superior condition to any removed from the quarry in previous years. We have also developed techniques and facilities for curating the bones that assure they will be prepared carefully and accurately and preserved for whatever future purposes the HRS may specify. We will be presenting a paper covering the surveying and 3-dimensional modeling techniques we have developed at the site this fall at the Geological Society of America meetings in Reno early in November.

## The Proposal

The Ridge 4 Quarry forms the heart of our current efforts. This site has several years of work committed to it, and during the past season we were able to remove the overburden from the ridge fronting on the old quarry site, to within one meter of the bonebed over an area in excess of 500 square meters, assuring us of a field for continued investigation for years to come. The taphonomic work is just beginning to unfold, with bones being

exposed that have been protected from both biodegradation and weathering by the thick sandstone removed this season and the dense mudstone still overlying the bones. Our research objective will be to excavate a large enough field on the exposed ridgetop to enable quantitative taphonomic conclusions to be reached. The Ark (shelter) now covers a field of about 50 square meters immediately south of the old quarry site on Ridge 4. The shelter was constructed of materials that permit the use of the GPS equipment so that positional data on the bones inside the shelter can still be recorded. Of the area under cover, about one-third has been lowered to the top of the bone bed. The remainder is still at the ground level (i.e. about one meter higher). I am proposing to excavate the remainder of the area underneath the Ark and to continue excavation beyond the limits of the present shelter at least far enough to permit drainage away from the site, during the first season. In subsequent seasons, we will continue to expand the area across the exposed ridge top. If the HRS wishes to increase the area under cover I would adjust my plans to accommodate this. In future seasons, I will continue to work with the developing plans of the HRS regarding their objectives for the site. Within the shelter, we will attempt to preserve and protect select bones in their field positions so that they can be used for educational and display purposes.

I am also proposing to open over the four year period, four small sites for limited data collection on Ridges 1, 2, 3 and 5. These sites would be of limited extent (3-4 meters wide, and 1-2 meters deep) and would be chosen on the basis of ease of access and relationship to present surface and slope, potential for preserving or recovering significant fossil materials and affording the widest possible distribution of data. These additional quarries would permit us to do analyses complementary to those completed this year in the old quarry site and the south quarry. The precise mapping of bones and relationships would be effected using the Javad GPS system and GIS software, as in the main quarry. Using this information we would be able to test, among other things, the lateral extent of the bone bed, the kind and spatial distribution of bones in the bed, the thickness and vertical range of the bones within the unit and the relationship of the bone-containing layer to other stratigraphic markers. These relationships cannot be adequately ascertained from surface examination alone. We would also be able to make reasonable estimates of the number and kinds of animals represented in the deposit. Each site would be completed to a vertical rear wall taken to the base of the bone bed, so that further weathering of remaining materials would be minimized. These quarries would be sequentially opened and worked over the duration of the research proposal, as time and available workers permit.

## Research Procedure

Following procedures implemented this past season, we will train all workers in good field techniques and give supervised experience prior to permitting work in the quarry. Initial introduction to field techniques will be carried out in camp, using materials available there. Students will then work under close supervision until they have had sufficient experience in the field, and until they have a good understanding of when to ask for help. During our field seasons, there will be at least two additional seasoned workers present with extensive experience in the excavation and preservation of fossils.

For the 2001 season these include, Zury Franco who prepared the majority of bones in the HRS collection and is the chief preparator for the Hanson Research Station materials and Dr. Larry Turner, who spent the past two seasons working with me, including last summer as a quarry supervisor. The exact ordering of the work will depend upon what groups are at the site and when they are present. We will follow the procedures outlined below.

We will establish a GPS base station from nearby permanent surveying points. This will serve as a known locality to link the data from year to year. The present high-resolution GPS system has sufficient range to permit the measurement of any locations on the Ranch to sub centimeter accuracy, vertically and horizontally, using this base station and the U.S and Russian GPS satellites. When a bone is encountered, it will be excavated and pedestaled. We will obtain GPS data from the bone and number it. We will next photograph the bone with a numbered identification tag giving the pertinent information about the bone. The excavator will sketch and log the bone. We will then remove it either in a protective plaster jacket or in foil, unless it is to be a display bone in the Ark. Display bones will be repaired and stabilized, then coated with Butvar and left in place. At the end of the season, we will leave partially excavated bones within the Ark that we will coat with Butvar to protect them.

The principal focus of our work over the duration of this proposal will be the Ridge 4 Quarry. Excavation at this site will entail parallel work on the shelter itself. The Ridge 4 quarry shelter is supported at present by 4 eight-foot 8x8-inch treated posts sunk into holes dug through the mudstone. As we excavate the site beneath the shelter, we will have to foot these posts with concrete pads. We will begin work at this site by removal of the meter layer of mudstone overlying the bones within and around the north side of the structure. In parallel with this, we will begin excavating the bone layer itself, beginning again from the exposed north face. We will remove this dirt to the northwest along the tailing surface (from the ridge preparation work) using wheelbarrows. As we remove dirt surrounding the support posts, we will pour concrete footings and secure the posts. We will also need to add four supplementary posts on cement pads at the four corners of the structure as we reach them in the course of excavation.

We will choose four sites on adjacent ridges based upon the following criteria:

1. The site must be relatively accessible. Since supervision and data collection will necessitate frequent visits to the site by the P.I., the site must be located near an existing access or within reasonable hiking distance.
2. The site must be excavatable without removal of substantial overburden. This means it cannot be at the base of a high cliff. This normally will necessitate working through a weathered slope to the bone layer.
3. The site should be one that displays significant fossil material at the outcrop. If there is virtue in preserving materials weathering from outcrop, this virtue should be maximized in the choice of a site.
4. The sites should be broadly distributed so that we can reach conclusions with the broadest possible applicability.

The procedures will be similar to those used in opening the south quarry this past season where we began excavation in order to rescue materials exposed during the site preparation. As we began quarrying, we recognized that the materials were important and valuable and that we would have to continue excavation at that site. We moved two meters up slope and came down from above onto the exposed bones. This left us an area of about 10-12 meters to excavate. While the work there was not finished this season, our intended objective was to complete excavation to a vertical back wall and a flat floor below the bone layer. Once a site is chosen, we will carefully remove biological materials on the surface over the extent of the site. We will then work down from the top into the bone layer, recording each find by the methods elaborated above. After completion of the site, the site floor would be covered with sediment derived from the quarrying to protect it from additional erosion and to minimize impact on the remaining bone layer and on the ecology of the area in each site.

The opening of these exploratory sites is critical to our mission of understanding the origin and history of the bone layer. It would be risky to base general conclusions on a single site or on surface data, no matter how it is developed. Using the GPS technology and careful reconstruction of the taphonomy at these sites, we will be able to draw firm conclusions on the general nature of the deposit that will answer the question regarding whether the deposit represents an accumulation in the bend of a river, or whether this deposit represents a mass catastrophic layer, or something else.

## Site Closure

We will protect the main quarry area inside and around the ark with a layer of straw and a polyfilm tarp at the end of the season. We will construct drainage so that runoff is directed away from the quarry area, and we will shut in the sides of the Ark. We will construct a barbed wire fence around the perimeter to prevent livestock from damaging the building or the site, and to discourage casual visitors. Bones removed from the quarry will be returned to Keene, prepared, and curated into the HRS collection. We will complete the test sites on the other ridges to base level, or failing that, we will cover the sites with tarps and secure them for the season.

Any secondary site that is opened, but not completed by the end of a field season will be covered with a tarp and with sufficient tailings to secure it for the season. Because of the smaller size of these sites, the entire surface can be protected easily. The soil will anchor the tarp, and will protect the tarp itself from weathering.

## Future of the Site

The Ridge 4 site will serve as a test for a variety of concepts, including whether bones can survive exposure to the Wyoming winter. The availability of an excavated display means that the HRS can more easily conduct shorter seminars and orientation workshops for teachers and others. The availability of excavated materials for consideration will enhance the experience of those not involved directly in the excavation process. It will also serve as a demonstration laboratory where the relationship between bones in situ can

be observed and analyzed in a fashion similar to that at the Mammoth site in Hot Springs, South Dakota. In the future, if the Board decides to do so, interpretive display panels could be added.

## Financial Responsibility

All students and staff associated with classes at the Hanson Research Station will be assessed a fee of \$100.00 per season. This money will be paid to the HRS by the person in charge of the group at the time of arrival, or as soon thereafter as feasible. This fee will cover costs of electricity and use of the facility and will contribute to the maintenance of the site.

We will endeavor to leave the facilities in at least the condition in which we found them. Any damage caused by the activities associated with the conducting of this research, or by individuals under my jurisdiction will be my responsibility. An accounting of the disposition of funds associated with the proposed program at the ranch will be submitted to the board at the completion of the summer activities.

## Liability

All individuals involved in the proposed project will sign a statement of personal responsibility supplied by the Hanson Ranch Field Station before the beginning of the project at the Ranch.

## Qualifications of the P.I.

I have been involved in excavation projects at the Station for six consecutive years. During this time I have been responsible for the supervision and preparation of specimens from other sites on the Ranch, as well as supervising and managing groups involved in the work. I have developed techniques for cataloging and displaying the HRS collection on-line. I have developed techniques for accurately recording the size and shape and 3-dimensional position of the bones, and for linking these with photographs of the bones so the quarried bones can be seen in their original positions. This work will be the subject of a presentation at the Geological Society of America meetings this Fall. My formal training in vertebrate paleontology was at University of California under a recognized authority in that field (M.O.Woodburne) and I have been a member of the Society of Vertebrate Paleontologists. I have had considerable experience in fossil excavation in other localities as well, including an on-going research project on fossil cetaceans in Peru that was the subject of a paper given at Geological Society of America last fall and two papers this fall.