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Annual Dues--Members	$6.00
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Single Issues Nos. 30-Present	$2.00

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THE PLASTER JACKET
Florida Paleontological Society, Inc.
Florida State Museum
University of Florida
Gainesville, FL 32611

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Permit No. 94

THE PLASTER JACKET

NUMBER 38 OCTOBER 1981

COLLECTING FOSSIL MAMMALS IN BOLIVIA: THE SOUTHERN CONNECTION

Bruce J. MacFadden
Florida State Museum

A Publication of the
Florida Paleontological Society, Inc.
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Official News

FPS 6th ANNUAL MEETING

The 6th annual meeting of the Florida Paleontological Society, Inc. will be at the University of Florida in Gainesville on October 10th.

Members will assemble at 8:00 a.m. in the Reitz Union auditorium for registration. At 9:00 a.m. scientific papers will begin. Coffee and donuts will be served during midmorning break. At 11:00 a.m. the business meeting will be called to order. Any member wishing to present a paper should contact the secretary by September 1st. The afternoon session will take place at the Florida State Museum and will feature a fossil identification clinic. Members are invited to bring their collections for display and discussion.

THOMAS FARM FIELD CAMP

Members of the FPS, Inc., are invited to plan now for the one-week field camp to be held in June, 1982, at the Thomas Farm Fossil Site. The field camp program was described in *The Plaster Jacket* No. 34. Beginning at the October 10th annual meeting, reservations will be accepted with payment of a fee of $50. By January, any spaces not reserved will be opened to the public. A brochure describing the field camp will be available at the annual meeting.

NEW BOOK ANNOUNCEMENT

Alabama Fossil Vertebrates

An interesting new volume treating all the vertebrate fossil groups from Alabama has just been published at the University of Alabama Press.

Fossil Vertebrates of Alabama (John T. Thurmond and Douglas E. Jones, authors) is the first complete treatment of Alabama's fossil vertebrates and an important contribution to the literature. Alabama is a pivotal state in the geology and paleontology of the Atlantic and Gulf Coastal Plain Province, and many workers consider southwestern Alabama to expose the finest section of Tertiary marine strata in the world. It will be an invaluable reference for workers in vertebrate paleontology and coastal-plain stratigraphy, as well as being very useful to fossil collectors and others interested in prehistory, especially the prehistory of Alabama and the Southeast.

The book also includes a summary of Alabama geology; a section on the general principles of paleoecology; material on techniques of excavation, preservation, and curation of specimens; and over 200 individual drawings permitting identification of many genera and species of fossil vertebrates, especially the sharks and rays. This book treats much less about the mid and late Cenozoic than would a Florida volume, but it provides good coverage of many Paleozoic and Mesozoic vertebrates that are unknown in Florida. It can be purchased at a cost of $23.50 from: The University of Alabama Press, P. O. Box 2877, University, Alabama 35486.

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COLLECTING FOSSIL MAMMALS IN BOLIVIA:

THE SOUTHERN CONNECTION

Bruce J. MacFadden[1]

The fossil mammals of South America have been of great interest to paleontologists since the early 19th century. For example, during the 1830's when Charles Darwin was a young naturalist aboard the *H.M.S. Beagle*, he went ashore in Argentina and collected the remains of bizarre Pleistocene mammals. These specimens were taken back to England where they were studied by

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great anatomists such as Sir Richard Owen. After Darwin's time numerous expeditions have been led to South America, particularly in Argentina, to collect more remains of the unique mammalian fauna from that continent. Research has shown that these bizarre mammals, unknown on any other continent, evolved their different forms as a result of an extended period of geographic isolation during most of the Cenozoic epoch (from about 60 to about 3 million years ago). The foremost mammalian paleontologist of our time, Dr. George Gaylord Simpson, has termed this period of faunal evolution in South America "Splendid Isolation" in a book recently published with the same title (1980, Yale University Press, New Haven).

The next phase of mammalian evolution in South America has occurred during the last 3 million years, the late Pliocene and Pleistocene. During this time, there has been extensive intermingling of mammals between North and South America as a result of the formation of the Panamanian Land Bridge in southern Central America. This dry-land connection, or "land bridge," allowed easy migration for land mammals that had been previously isolated from either North or South America. Paleontologists have termed this event the "Great American Faunal Interchange." Dr. S. David Webb of the Florida State Museum, a leading authority on this interchange, has published numerous papers on this subject.

A little closer to home, the fossil record in Florida provides spectacular evidence for the kinds of mammals that lived in what is now the southeastern United States during the late Cenozoic. In fact, some of the best evidence for the early wave of immigrants from South America are represented by the fossil sloths found in such late Miocene deposits as Mixson's, McGehee, and the Bone Valley region. These occurrences, which range from about 6 to 8 million years old,

significantly pre-date the height of the interchange that has occurred in the last 3 million years. In the numerous Pleistocene localities throughout Florida, the presence of mammals, such as raccoons, gigantic rodents called capybaras, porcupines, armadillos, and gigantic sloths, are abundant evidence of the height of the interchange.

Despite the fact that many collections of Cenozoic South American mammals have been made over the last century from countries such as Argentina, Colombia, and Brazil, little is known from Bolivia. During 1978 and 1981, I was a member of an expedition to Bolivia that was a cooperative venture among the University of Florida, the Los Angeles County Museum of Natural History, and the Servicio Geologico de Bolivia (GEOBOL). Besides myself, the 1978 expedition consisted of Dr. Ronald G. Wolff of the University of Florida, Dr. Kenneth E. Campbell, Jr., of the Los Angenes County Museum of Natural History, Dr. David Frailey, then of the University of Kansas, and Ing. Oscar Siles of GEOBOL. The 1981 group consisted of the author, Wolff, Campbell, Siles, Dr. Carlos Villarroel of GEOBOL, and Dr. Annalisa Berta of the University of Florida.

During these two field seasons, we concentrated our efforts on four localities in Bolivia. These were chosen because collections of fossil mammals had previously been made from these localities, and they span the spectrum of time both before and after the interchange. In order from oldest to youngest, these four sites are (Figure 1) Salla of early Oligocene age, Quebrada Honda of middle Miocene age, Tarija of middle to late Pleistocene age, and Ñuapua of post-Pleistocene age.

Although expeditions to South America are not nearly as exciting as the one depicted in the opening scenes of the Hollywood movie "Raiders of the Lost Ark," they

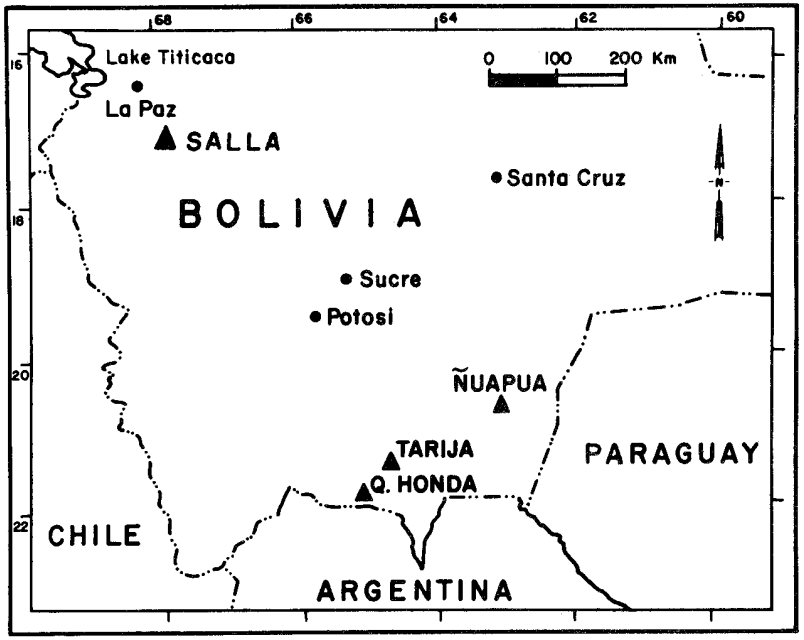

Figure 1. Locations (solid triangles) of the four Cenozoic fossil mammal sites in Bolivia that we collected during the expeditions of 1978 and 1981.

nevertheless do provide an adventurous opportunity to work and tour in an exotic region. Bolivia is a country of contrasts. Culturally, it is a mix of native American Indians and predominantly immigrants of Spanish descent. The population of Bolivia is about 4 1/2 million, which is small in comparison to Argentina and Brazil. Bolivia is a land-locked country. Elevations vary from about 1000 feet in the east to over 20,000 feet along the highest peaks in the Andes. The lowlands of eastern Bolivia consist of humid tropical forests to the north and east and dry scrub land, called "Chaco," to the south. The high country of western Bolivia is dry and consists of two major north-south trending mountain chains of the Andean system, the eastern and western Cordilleras. Between these two Cordilleras, at about 13,000 to 14,000 feet, lies an extensive high flat plain, the altiplano. On the northern altiplano along the Bolivian-Peruvian frontier, lies Lake Titacaca, one of the highest navigable bodies of water in the world. During both the 1978 and 1981 field seasons, we flew into La Paz. The airport of this large city is on the altiplano. The city lies in a basin just below the airport. Considerable adjustment is required to the elevation change in contrast to what we are accustomed to in the United States. But, after a few days, we did not gasp for oxygen as frequently. During the same time, we made contacts with out colleagues at GEOBOL and outfitted our group with supplies. We were then ready to depart for our trip to the localities in the interior.

Ñuapua

Ñuapua had been shown to be a potentially important site for latest Pleistocene, or perhaps post Pleistocene (i.e., within the last 10,000 years), fossil mammals during preliminary work by the French paleontologist, Professor Robert Hoffstetter. In 1978 we spent about one week at this site. We left La Paz by jet to Santa Cruz, where we took an exhausting 8-hour bus trip to Camiri, a small town several hours north of Ñuapua. At Camiri we met our Bolivian contingent from GEOBOL and then were on our way to the site. Ñuapua is located in a sparsely inhabited portion of Bolivian Chaco. This lowland, which is very dry with an abundance of thorny bushes and cacti, extends to the east into Paraguay. From a naturalist's point of view, the Chaco in either country is relatively unexplored, probably as a result of the lack of roads and inaccessibility of the terrain. Accordingly, the present-day mammalian fauna from the Chaco has been very poorly known. Recently Dr. Ralph Wetzel of the

University of Connecticut discovered living populations of the peccary *Catagonus* in the Paraguan Chaco, a genus that previously had only been known from fossil remains and was thought to have been extinct since the end of the Pleistocene.

After arriving in the general region of the Ñuapua site, we set up camp in a local farmer's field. The next day we hiked for about one hour into an area of potentially fossiliferous exposures. We collected a few scraps the first day in the field, but nothing terribly significant. The next day we hit the jackpot. We discovered a series of sediments that represented an ancient small pond (Figure 2). From what is interpreted to be the margin of this paleo-pond, we began to collect hundreds of bones of tiny vertebrates, particularly frogs and rodents. Later the same day an

Figure 2. Vertebrate-bearing sediments at Ñuapua. The human was collected from the sediments in the middle of the photograph.

extraordinary skull and partial skeleton of a human was found weathering out of the sediments. Dr. Wolff spent the next few days doing a careful grid-style excavation of this specimen while the rest of us collected additional fossil vertebrates nearby. Besides the human skeleton and other specimens mentioned above, our week's collecting yielded remains of such mammals as gigantic ground sloths, horses, and llama-like camels. Many of these specimens were from the sediments of the paleo-lake and imply that they lived contemporaneously with the human fossil.

The Ñuapua site has proven to be very interesting. Dr. William Maples, a physical anthropologist at the Florida State Museum, determined that the Ñuapua human was a 50-year old female. Her skull and skeleton exhibited rather pronounced dental caries as well as arthritis, which would not be unexpected for a paleo-Indian of that age. A radiocarbon date on fragments from the skeleton yielded a minimum date of 6600 $\pm$ 370 years before present. Fluorine analysis of human, as well as other mammalian bone fragments associated in the paleo-lake basin, did not discriminate significant differences in uptake of this element. The similarity in fluorine content in these specimens of bone does not refute the notion that the humans and other mammals associated in nearby sediments were contemporaneous. As such, the Ñuapua site represents a very late fauna where human remains are of similar antiquity with a distinct mammalian fauna, of which some of the species, such as the large ground sloths, are not extinct. Figure 3 represents an artist's reconstruction of the paleo-lake vertebrate fauna and environs at Ñuapua during the post-Pleistocene.

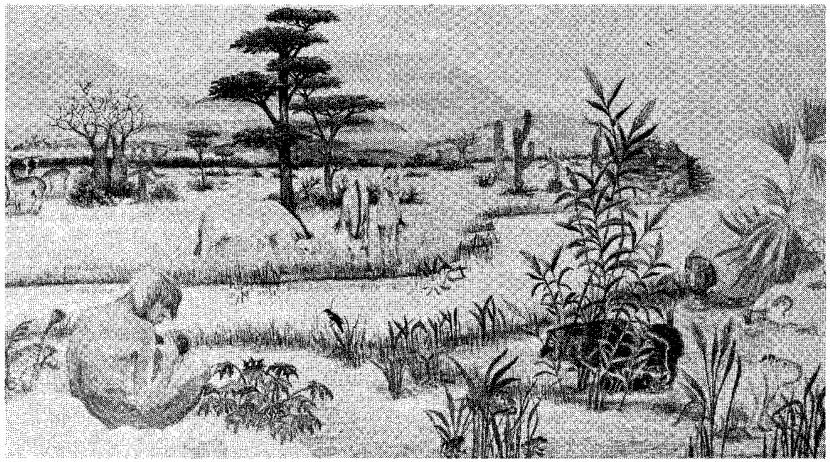

Figure 3. Reconstruction of the vertebrate fauna and environs of the pond margin at the post-Pleistocene Ñuapua site in southern Bolivia. Painting by Chris Williams of the Florida State Museum.

Tarija

The Pleistocene badlands in the basin surrounding the Tarija (Figure 4) have produced a very rich collection of fossil mammals representing the fauna from the height of the Great American Interchange. Although collections from this area had been made by numerous institutions throughout the world, most of these lack meaningful data as to the exact localities of the fossils. Our purpose for returning to this classic area was to collect our fossils with precise locality information along with geological (radiometric and paleomagnetic) data in order to determine the exact ages of these occurrences.

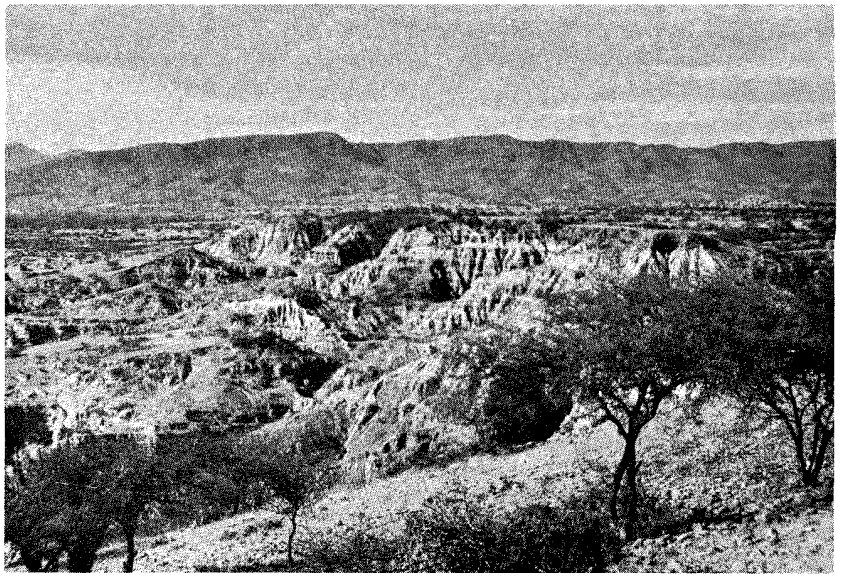

Figure 4. The Tarija basin. Typical badlands exposures that oftentimes yield fossil mammals of Pleistocene age are exposed in the foreground. Along the horizon are foothills of the eastern Cordillera.

From Ñuapua we traveled several hours westward to Tarija, a beautiful city located on the eastern edge of the Andes. Tarija, a city of about 40,000 inhabitants, lies on the banks of the Rio Quadalaquivir at an elevation of about 6,000 feet. Tarija has a decidedly European style to it, probably as a result of the great influx of German and Italian families that immigrated into this region earlier during this century. Some of these Europeans produced grapes and wine along the gentle slopes of the Tarija basin in

the country surrounding the city. Today, the bulk of wine produced in Bolivia comes from this region. Most of this delightful wine is produced for consumption within Bolivia. Unfortunately, it is not exported to the United States. Tarija also serves as a vacation spot for Bolivians from the northern cities. Dave Frailey tells the story that in 1976, when he was riding on a bus bound for Tarija, they crossed a mountain crest and could see the city lying off in the horizon. At that moment some women got up from their seats and shouted "viva Tarija!" During 1978 we spent about six weeks working in this basin. In Tarija we stayed in a comfortable hotel on the plaza in the center of the city (Figure 5). All of the localities that we worked were within a maximum 1/2-hour ride in our jeep and 45-minute walk to the desired exposures. Sometimes on a given day the group

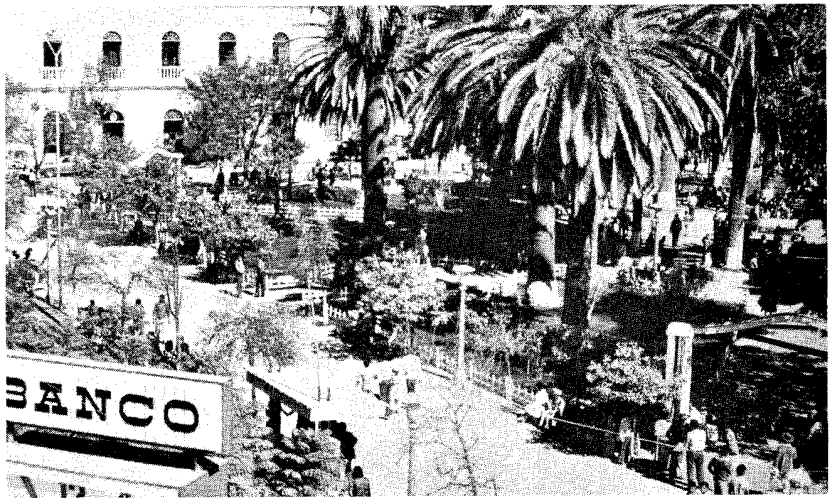

Figure 5. A view of the central plaza in Tarija.

would split up, some taking the jeep and the others hiring a taxi (for the equivalent of several dollars) to drive us as close as possible to the outcrops. A day's work of collecting oftentimes yielded many specimens of rodents, horses, llamas, mastodonts, armadillos, gigantic ground sloths, and occasionally carnivores. One particularly interesting specimen, a lower jaw of a gigantic ground sloth, was collected south of the city by Dr. Frailey (Figure 6). During this work, Oscar and I collected a precise suite of paleomagnetic and ash samples to determine the age of the sediments, and hence the fossils. Since returning to the United States, we have analyzed the paleomagnetic samples and received a radiometric date from our colleagues Noye M. Johnson and Peter Zeitler of Dartmouth College. These data show that the fossiliferous sediments of the Tarija basin span an interval of time from about 1 million to 600,000 years before present.

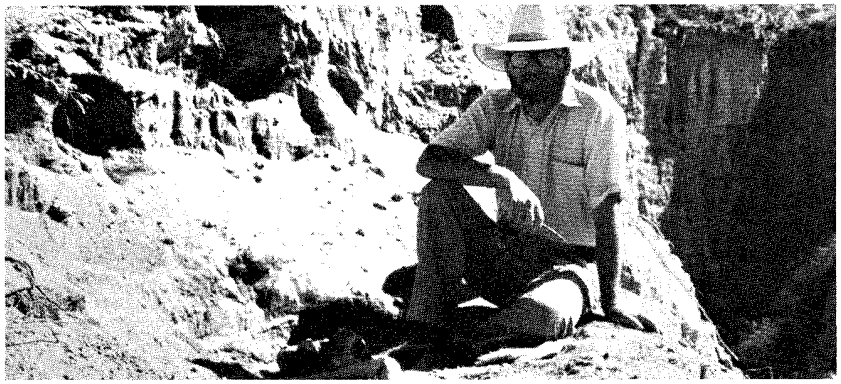

Figure 6. David Frailey collecting the lower jaw and associated skeletal parts of a gigantic ground sloth, Megatherium. Photograph courtesy of Ronald G. Wolff.

This indicates a middle Pleistocene age for the mammalian fauna, or a time during the "heyday" of the Great American Interchange. Future collecting and research on Tarija mammals that is keyed to the paleomagnetic chronology should tell paleontologists information about faunal immigration events in this region.

Quebrada Honda

A small collection from Quebrada Honda, previously made by Hoffstetter and associates, provided tantalizing bait for our intended work. This locality is important because it is richly fossiliferous and represents a middle Miocene age, a time when South America possessed a highly exotic fauna that had evolved in isolation. Quebrada Honda lies just below the altiplano southwest of Tarija at an elevation of about 12,000 feet. From Tarija we traveled by jeep and taxi for about one-half a day into the mountains. When we arrived, we set up camp during the remainder of the first day (Figure 7). Working at high elevations

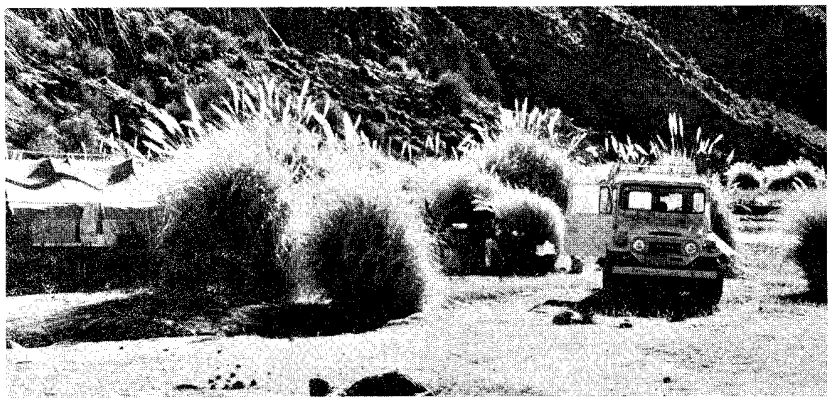

Figure 7. Our camp at Quebrada Honda.

just below the altiplano in remote places such as Quebrada Honda provides a challenging experience. Field work is strenuous and exhausting because of the oftentimes steep climbs to prospect for fossils and collect rock samples in the rarefied atmosphere. As soon as the sun set, temperatures fell dramatically and were below freezing by morning. For breakfast, we had to chip ice to make hot water for coffee. After dark the only place to keep warm was in the sleeping bag. Despite these factors, the paleontological treasures of Quebrada Honda provided appropriate rewards. From these Miocene badlands (Figure 8), and those of nearby Rio Rosario, we collected hundreds of specimens of rodents, edentates, marsupials, and many types of bizarre South American herbivorous mammals. Our week's stay proved to be quite a paleon-

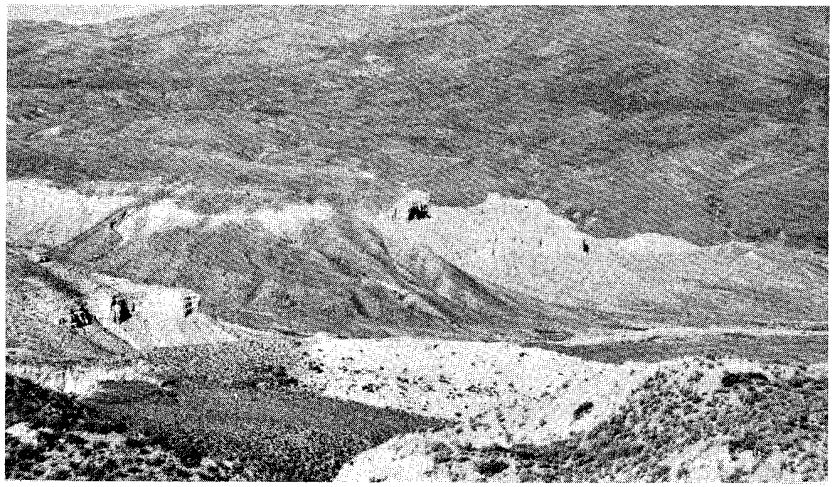

Figure 8. Miocene sediments at Quebrada Honda. The exposures in the middle ground proved to be a rich area for collecting fossil mammals.

tological bonanza. From one area at the base of the Quebrada Honda section, our combined prospecting efforts yielded more than one hundred specimens of jaws and skull fragments of rodents, mostly representing an ancient form closely related to the present day "vizcacha," *Lagostomus*. In addition, we precisely documented the exact fossiliferous zones and collected paleomagnetic and ash samples. Subsequent work on the paleomagnetism conducted at the University of Florida shows that there are numerous reversed and normal zones in the total rock column indicating that these sediments were probably deposited over a period of a few million years.

Salla

During the 1981 field season, much of our efforts were directed towards Salla, a very important early Oligocene site on the altiplano about 50 miles southeast of La Paz. Salla is the earliest fossil site for Cenozoic mammals in Bolivia and is of comparable age to sites in Argentina. The fossil mammals from Salla are known from several scientific publications. The most exciting discovery from this locality is *Branisella*, the earliest-known South American monkey-like primate. In addition, there are numerous species of edentates, endemic herbivorous mammals, and the earliest South American record of rodents. In summary, previous research provided exciting prospects for our intended field work.

During the first few days work at Salla, we stayed in the nearest city with a hotel, Padacamaya, and drove about one hour (each way) to the village of Salla. From the village we then walked for 1 1/2-2 hours into the valley to prospect the fossiliferous exposures. After a few days of general reconnaissance with our colleague from GEOBOL, Dr. Carlos Villarroel, we decided to camp down in the basin near the fossils.

This decision required a certain amount of logistical planning. There are no roads and no water in the Salla basin. So all equipment and drinking water had to be hauled in by burros (Figure 9). We decided to spend a few weeks total working out of two different base camps. Our first camp, the most remote of the two, was a 4-hour hike from the village (Figure 10). Once set up, Ken, Oscar, and I worked this area for about one week. With pleasant weather, and despite a 45-minute walk to an ice-cold stream for a bath once every 3 or 4 days, this was a very pleasant place to do field work. At the end of this work, we were joined by Drs. Wolff and Berta. Although this first area was not very fossiliferous, we completed some important descriptions of the sediments and collections of paleomagnetic samples in the bottom half of the

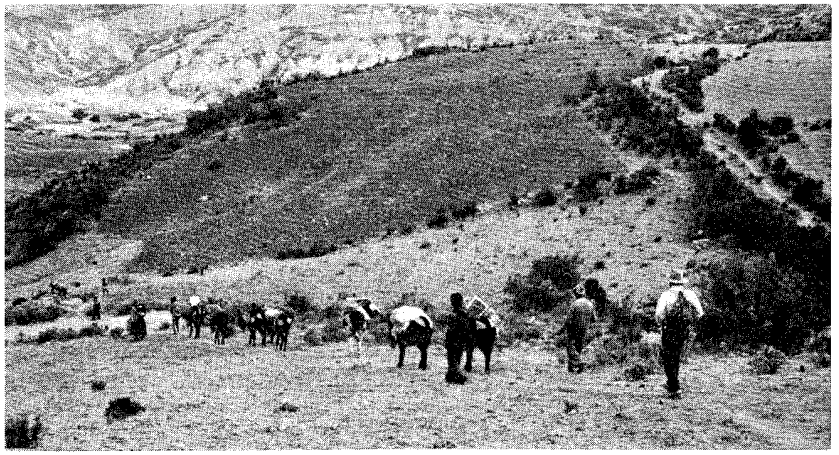

Figure 9. Descending with equipment into the Salla basin. The fossiliferous exposures of early Oligocene age are several miles off in the distance.

Figure 10. Dr. Kenneth Campbell and Felix, our guide and a resident of Salla, unloading equipment at our first base camp.

Oligocene rock column. We then broke camp and spent a day hiking to, and setting up, the second base camp. (Figure 11). At this site there was absolutely no water, and Felix, a resident of Salla and our guide for the region, would use burros to haul in containers of this precious necessity every two days. We were not quite as lucky with the weather as we were at the first base camp. One night it rained and soaked many of our belongings (including sleeping bags and occupants) in one of the tents. Other mornings it was freezing cold, like at Quebrada Honda.

To collect fossils and to integrate specimens with precise chronological and stratigraphic data, every day we would each pick a locality and trace the fossil-

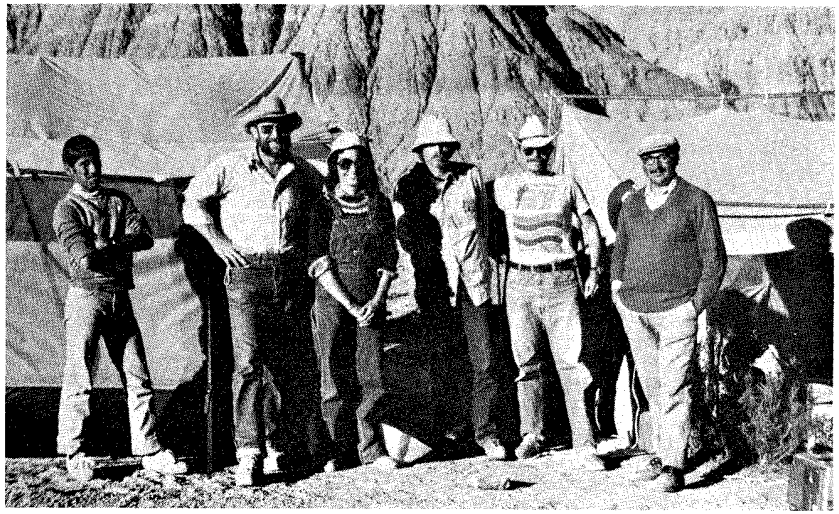

Figure 11. The 1981 field party at the second base camp at Salla. The fossiliferous sediments are in the background. From left to right: Theodoro (GEOBOL field assistant), Ken Campbell, Annalisa Berta, Ron Wolff, the author, and Oscar Siles.

ferous zone. We rapidly determined that most of the specimens around the second base camp were weathering out of a limited interval of some tens of meters in vertical extent. The remaining days were spent concentrating on this productive zone. Drs. Wolff and Berta spent most of their time collecting fossils. Dr. Campbell, Ing. Siles, and I concentrated on describing the rock column and collecting ash and paleomagnetic samples for dating. Salla is probably among the richest sites for fossil vertebrates that I have ever worked. In a good day, one can collect

numerous dozen jaws and skull fragments as well as individual skeletal elements. Our combined efforts of about 2 1/2 weeks at this important locality yielded hundreds, if not a few thousand, identifiable specimens, mostly tiny mammals such as rodents and endemic South American herbivores. These are all integrated into precise locality data so that when the dating analyses are completed, the exact age of the specimens will be available.

Concluding Remarks

The Cenozoic fossil record from South America provides a window on the history of mammals before and during the Great Faunal Interchange. Based on the collections made in 1978 and 1981 by our cooperative expedition, we will obtain a better understanding of this very interesting period in a country that was heretofore inadequately known. The potential for future vertebrate paleontological research in the beautiful and exciting country of Bolivia is unlimited.