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Cover photographs: Petroglyphs in the Piute Historical District. Photographs by Robert E. Reynolds.
A New Paradigm on the Peopling of the New World: Early Fall Thoughts on the Calico Mountains Archaeological Site

Phillip V. Tobias, Director, Palaeo-Anthropology Research Unit, Department of Anatomy and Human Biology, University of the Witwatersrand, Johannesburg, and Visiting Professor, Department of Anthropology, University of Pennsylvania, Philadelphia.

The place of Calico Mountains in the peopling of America is one of the most challenging problems in the archaeology of this continent. It is not a single issue but at least three: the question of the stone tools and the fireplaces at the site; the dating of the site; and the concept of the peopling of this vast offshore island, America.

Congratulations are due to Ruth D. Simpson, her team of enthusiastic workers and the Friends of Calico, on this 30th anniversary of the Calico Early Man Site Project. The roots of this monumental project go back earlier and it was at the beginning of the 1960s that "Dee" Simpson published her first paper on Calico. However, systematic excavations commenced on November 1, 1964 (Simpson, 1979). Anniversaries enable, nay compel, one to look back and retrace the steps by which one has reached the present milestone; they provide an opportunity for a stock-taking; and they are a vantage point from which to look ahead.

Link with Louis Leakey

In the early 1970s L.S.B. Leakey first sparked my interest in the Calico Mountains site. At that time I was heavily involved with my work on the early hominid fossils that Louis and Mary Leakey had recovered from the Olduvai Gorge in northern Tanzania. My association with the Leakeys goes back for close on 40 years; in 1955, as a Nuffield Travelling Fellow at Cambridge University, England, I used to drive up to London about once a week in order to familiarize myself with the wonderful collection of original hominid fossils at the British Museum of Natural History. Among the specimens housed there were several that Leakey had discovered in East Africa in the 1930s. These included the jaw fragment of Kanam and the cranial remains of Kanjera. Both Kanam and Kanjera are situated in the western part of Kenya, on the northern shore of the Gulf of Kavirondo which points eastwards from Lake Victoria. My study of the Kanam jaw was presented at the Pan-African Congress on Prehistory and Paleontology in Kinshasa, Zaire, in August 1959 and my conclusions on the mandibular fragment appear to have pleased Louis and Mary immensely. A few days later, they took me aside and told me that they wished me to undertake the definitive description of the superbly preserved cranium of a very robust australopithecine that Mary had discovered at Olduvai three weeks earlier, which was later to be called Australopithecus boisei (Tobias, 1967).

This started a 20 years' close working partnership between the Leakey family and myself, during which they passed across to me for evaluation and description every hominid specimen that they unearthed. Ultimately this fruitful association culminated in three large volumes that I published on their Olduvai fossils, one on Australopithecus boisei (1967) and two on Homo habilis (1991).

For my own career this was a turning point. I worked in the Department of Anatomy of which Raymond Dart had been the head and so had close personal contact with him and his famed Taung skull. Since undergraduate days I had been bringing back to the Anatomy Department in the Medical School at the University of the Witwatersrand, Johannesburg, fossils I had collected at such famous palaeontological sites as Sterkfontein, Kromdraai, Makapansgat, Bolt's Farm and Gladysvale. Nevertheless, the laboratory study of the fossil remains, it seemed to me, was Dart's preserve on which I did not wish to poach. So it was the Leakeys, and not Dart, who first set my feet on the pathway of serious palaeo-anthropological research.

Those days of the 1960s and 1970s were rich and rewarding ones: Mary Leakey, with abundant financial backing from the National Geographic
Society and other sources, was ensconced at Olduvai and fossils came forth from that treasurehouse of the past with bewildering rapidity. Each time something new and exciting came to light, I would receive in Johannesburg a cable from Louis, saying something like “Come quickly, we’ve got the toolmaker” — and I would drop all of my duties as Head of the Department and fly up to Nairobi.

On one of those visits to Nairobi in the early 1970s, Louis Leakey showed me a handful of broken stones and artefacts from Calico and told me about R.D. Simpson’s early work at the site (Leakey et al., 1970).

**Early Contact with Calico**

When Leakey showed me the tantalizing stone specimens from Calico, I was at once intrigued and impressed by the possibilities. He believed that the first hominids had come across from Siberia to North America as long as 50,000 years before the present, rather than the much more recent dates which most American archaeologists were willing to contemplate. This prospect might have made the peopling of America an even earlier human venture than the peopling of Australia, as it was then conceived. It was, according to Bryan (1979), Louis Leakey’s last great flash of insight. The tools were rather crude, I recall, but that did not worry either Leakey or myself (Leakey, 1979). We were used to the very crude and irregular artefacts that were associated with the earlier phases of stone culture in Africa. Both of us were willing to accept that there was life before the Clovis and Folsom industries! I expressed great interest and Leakey must have passed that on to Simpson in a letter. Sadly he died not long afterwards.

A year or two later, at the 9th International Congress of Anthropological and Ethnological Sciences at Chicago in September 1973, I met Dee Simpson and several of her colleagues and she gave me a private showing of specimens and slides of the site. She acquainted me, in considerable detail, with many aspects of the site and of the archaeological project which was being conducted with the backing of Louis Leakey. This personal contact served only to heighten my interest and I determined to take an early opportunity to visit the site.

Just over a year later in November 1974, while I was a guest of the L.S.B. Leakey Foundation in Pasadena, California, Dee Simpson and Maryella Greene took me to the Calico Mountains site. Shortly before that, she had excavated several supposed fireplaces. These were of great interest, not only for the arrangement of the hearth-stones and the evidence that they had been heated (Berger, 1979), but for a third thing: I noted on that visit that the hearth-stones were pock-marked at intervals. These pock-marks I had often seen on African stone tools of the Middle Stone age and they are interpreted as resulting from fire-damage. They thus provided additional and independent evidence supporting the inference that the circles of stones represented ancient fireplaces (Tobias, 1979).

On a subsequent visit to Los Angeles, Clay Singer showed me some of the wear patterns along the edges of a number of the artefacts. Apart from the evidence of typology and technology, his meticulous study of the signs of trimming and damage along the edges of the artefacts appeared to lend strong support to the interpretation that many of these specimens did, in fact, represent stone implements (Singer, 1979).

Above all, I was struck by the painstaking and punctilious work which Dee Simpson and her team of helpers had carried out in the first dozen years of operations at the site. It was clear that this extraordinarily dedicated, protracted and careful excavation was a model of its kind.

**The Stone Tools**

The examination of the broken and shaped stones from Calico has elicited many severely critical and adverse comments, from those relatively few archaeologists who have taken the trouble to scrutinize the specimens. C.V. Haynes (1973) and H.M. Wormington (1971) have claimed that most of the fractured rocks from Calico are “geofacts,” that is, products of natural fracturing during mud slides. However, as Bryan (1979) has pointed out, this hypothesis “must be subjected to experimental testing before Calico is written off as containing only geofacts” (op cit., p. 75). In their 1984 book on *The Archaeology of California*, Chartkoff and Chartkoff concede that there are some unquestionably human artefacts from the site, but they add, “... almost all of them are surface finds that cannot be accurately dated and that are of styles that could have been employed at any time from the Pleistocene to as recently as the past thousand years.” Hence they are led to summarize on the site as “one of the most controversial, and possibly most ancient, sites in the nation” (op. Cit., p. 385).

In 1979, Bryan opined that “probably the most convincing evidence will come from the detailed wear pattern studies now underway of individual artefacts” (op. cit., p. 75).

Such studies having been made, it was hoped that results which were to be reported at the 1994 anniversary meeting would clarify the matter further.
One remaining thought on the claimed tools is this: In 1979, I pointed out "A mixture of human artifacts with naturally fractured stones is, of course, a well known phenomenon, as anyone who has studied archaeological remains in river gravels can testify. The presence of naturally-produced items does not detract from the artifactual character of a number of the specimens. In other words, the mere presence of a natural source of fracturing in the same area does not of itself disprove the claims made for the more obviously artifactual nature of the specimens, nor even weaken such claims" (op. Cit., p. 97). Of course there are naturally broken items or geofacts among the remains excavated from Calico. There are equally certainly items for which, as Bryan pointed out in 1979, human agency is the most probable cause.

**The Dating and the Concept**

These two aspects are closely interrelated. I believe that a large part of the resistance to the acceptance of the claims for Calico as an ancient site of human habitation, stems from a more general mind-set or paradigm. The prevailing paradigm about the peopling of North America has at least four aspects to it.

First, it has long been held that the earliest arrival of humans in the New World was a relatively recent phenomenon. This *idee fixe* received its most dogmatic formulation at the hands of Ales Hrdlicka, before World War I. In 1907 he was commissioned by the Smithsonian Institution to reassess all claims that had been made for human beings in America deep into the Pleistocene and even in the Pliocene. He had to contend with such claims as those advanced on behalf of the "ape-man" of Nebraska ("Hesperopithecus") and Florentino Ameghino's finds of supposed human cultural remains in the Miocene of Argentina. Hrdlicka had found no good scientific evidence to support these claims of extremely early hominids in the New World. Following Dubois's discoveries of Java man (*Homo erectus*) at Trinil in Java in 1890-1892, Hrdlicka firmly believed in the Asian origins of the hominids. From these roots flowed his extreme opposition to any hypothesis that humans had been in America any earlier than 10 to 20 thousand years ago. He was a man of considerable influence, founder of the American Association of Physical Anthropologists and of the American Journal of Physical Anthropology. His authoritative manner and the *ex cathedra* certitude of his views must have played an overwhelming part in establishing the deep-seated resistance of most American archaeologists to any claims that would have pushed back the dating of the earliest peopling of the New World beyond the limits prescribed by Hrdlicka (c.f. Leakey, 1979).

In 1937, Howard summarized the then divergence of opinion as to when man first arrived in the New World as "between approximately 200 B.C. and 210,000 B.C."! Bryan (1969) made a case for a date of over 35,000 years. Leakey (1979) wanted to set the dating at over 50,000 years B.P. The latest date for the Manix lake deposits is given as 200,000 ± 20,000 years. Much of the opposition to the earlier dates — as Leakey pointed out at the International Conference on the Calico Mountains Excavations — stemmed from a preconceived idea that there could not be stone tools that early in America. One wonders to what extent this mind-set disinclined many archaeologists to examine the proposed artefacts, let alone accept their artifactual nature.

Perhaps the excessively critical attitude towards the very early dating claimed for the Calico stone tools is to be seen as a latter-day vestige of that mind-set to which Hrdlicka's influence had contributed so strongly. To change a paradigm that has been deeply entrenched for at least three-quarters of the 20th century is not easy: many resistances have to be overcome, and the tenets of the old paradigm must be overturned and replaced.

I do not believe that the change of a paradigm occurs in quite the illogical or irrational manner prescribed by Kuhn (1972) in his account of "The Structure of Scientific Revolutions," nor do I subscribe to the cynical view that a new paradigm becomes accepted only once all the upholders of the old one have died off! It is in my experience new evidence, or a new appraisal of old evidence, that says an old set of beliefs and that gains acceptance for a new pattern of thinking.

Perhaps this long-standing mind-set explains why relatively few American archaeologists have been to see the site or have studied the claimed artefacts.

The prevailing paradigm of the peopling of America has long embraced a second aspect, namely that humans spread into America on more than one occasion. When these ideas were becoming entrenched in the pattern of thinking, it was believed that there had been four major glaciations in Europe and North America, separated by interglacials. The major glacials were originally named Gunz, Mindel, Riss and Wurm. Since the end of World War II, it has been realized that this view was greatly oversimplified. The new evidence, furnished by the study of sediments from the deep sea floor, has shown, for instance, that the number of major glaciations was far greater, being
over 8 in the past 730,000 years and 17 in the past 1.7 million years (van Donk, 1976, cited by Klein, 1989).

As is well known, during the glacial periods, enormous quantities of water were locked up on land as ice; the ice sheet was up to three miles in thickness in some places. As a result sea-levels dropped 100 metres or more. The Bering Strait is one of the places where the sea-level is shallow, the depth being only about 60 metres below the present level of the ocean surface. Hence, there must have been many times during the Pleistocene when the land between Siberia and Alaska was exposed as a broad bridge (Beringia). If there were any parts of that bridge which were not glaciated, they would have provided reasonable pathways for the migration of palaeo-Siberian people across the bridge to America.

It is a phenomenon that has occurred wherever islands have been peopled. The peopling of Japan occurred from at least two and possibly three invasions, one down the Sakhalin Island to Hokkaido, a second from the Korean Peninsula across the Korea Strait to Kyushu and Honshu, and possibly, a third from the Kamchatka Peninsula, down the Kuril Islands to Hokkaido. Each route could have been used more than once. Similarly, the peopling of Sumatra and Java occurred on one or more occasions down the Malaysian Peninsula and, when land-bridges permitted, into numbers of islands of the Indonesian archipelago.

The peopling of the American island must have occurred according to the same principles. The main differences from the Japanese case are these: The Japanese islands first had three portals of entry for humanity and secondly were so small that humans, once there, did not have much choice in further travels; they spread either southwards or northwards, depending on the portal of entry. In the case of America, on the other hand, in the era before sea-going craft, there was only a single portal of entry, across the land bridge known as Beringia. Secondly, America was an island of vast dimensions; once humans were there, different migration possibilities were open to them. They could have spread down the Pacific coast of North America or moved into the hinterland, or even returned to Siberia. To move inland, it is postulated, they would have needed an ice-free corridor east of the Rockies, the Sierras and the Cascades (Bryan, 1969; Chartkoff and Chartkoff, 1984).

The door to America, like the doors to Japan and Indonesia, opened and closed on a number of occasions over the 700,000 years since the beginning of the Middle Pleistocene. To take only the last 300,000 years, results based on oxygen-isotope analyses and palaeomagnetic stratigraphy of equatorial Pacific deep-sea cores, show that there were cold stages at the following times:

- Stage 8: 313,000 to 245,000 years B.P.
- Stage 6: 190,000 to 130,000 years B.P.
- Stage 4: 74,000 to 59,000 years B.P.
- Stage 2: 24,000 to 12,000 years B.P.

Earlier terrestrial evidence (Hopkins, 1967) had shown glacial maxima at seven dates within the last 50,000 years, and conversely nine marine transgressions sufficient to submerge the land bridge are testified to by deposits in western Alaska ranging in age from the late Pliocene (about 2 myr) to the Recent.

These various lines of evidence provide the basis for the inference that the Beringian door was open on a number of occasions since the period from 200,000 years ago (the dating of J. Bischoff and R. Schlemon for the Calico fan, according to Dee Simpson, personal communication). During the open door periods, it is assumed that terrestrial forms of animal life spread onto and across the bridge. The question which I should like to raise here is: how many times did humans cross the bridge?

The second postulate of the prevailing paradigm, as set forth by Wormington (1957), is that human cultural traditions, such as the palaeo-eastern (with a greater emphasis on flakes and bifacially flaked implements) could have reached North America at different times and followed different routes southwards. This tenet of the current paradigm is unexceptionable, but I would go further and suggest that the proposed successive peoplings of the New World probably occurred at more than one opening of the Beringial land-connection. In the same way, the fauna seems to have gone eastwards and westwards through Beringia at varying phases of its emergence.

The third tenet of the prevailing paradigm seems to constitute a serious deterrent to the acceptance, or even the contemplation, of the message of the very ancient stone tools of Calico. It has been assumed or implied that, however many times humans spread from Siberia to Alaska, there was continuity from the earliest inhabitation to the later, less controversial signs of human occupation and to the recent native American populations. This is clearly implicit, for example, in the lucid analysis of mid-century thinking on the subject given by Wormington (1957). In other words, implicit in the studies of the peopling of America is the notion that, once the human wave or waves had arrived, they survived. This being the assumption, an obvious corollary is that there should be a sequence of archaeological sites in the American continent.
connecting the earliest trace of humanity to the latest. If Calico were set at 50,000 or even at 200,000 years B.P., there should on this reasoning be anecdata sites filling in the time intervals up to the fairly numerous later-dated sites. There do not appear to be a series of such sites, as far as presently available researches have shown, or else the claims made for deposits with very early dates have been discounted. Therefore, it has been argued, on the assumption that arrival was followed by survival, without such a series of connecting dated sites, the Calico Mountains hypothesis, that humans crossed into America in the Middle Pleistocene, is refuted. This reasoning, it is surmised, underlies the disinclination of many archaeologists to accept the dating or the artefactual character of the broken stones of Calico. The additional assumptions that inhere in this rejection are that there has been an adequate search for early human sites in North and South America and that such sites as are available have been adequately dated. A careful reading of the critical comments made by a number of archaeologists on Bryan’s (1969) article in *Current Archaeology*, reveals signs that these views are reflected in many critics’ comments.

On my analysis, it seems that many of those who reject Calico do it not because a study of the evidence from the site has led them to reject it; rather it is because the implications of the acceptance of the Calico artefacts and dating are at variance with the tenets of the old paradigm. In this sense, Calico would be an example of a premature discovery (Stent, 1972; Tobias, 1994).

As an alternative approach to this problem, I propose that several tenets of the current paradigm are overdue for a change. The two critical tenets of the old paradigm which should be questioned are that humans arrived in the New World only in the late phases of Beringia’s emergence, and that, once humans arrived, they survived, to give rise to those whose remains are found in later, well-attested, American archaeological sites, and ultimately, to the native American populations of recent times. A fourth tenet of the old paradigm — namely the supposed recency of the earliest archaeological remains in the source areas, Siberia — is due also for reconsideration in the light of new evidence from Diríng-Yuríakh in Siberia (see below).

**A Proposed New Paradigm**

The Beringia door, as we have seen, opened and closed on a number of occasions since the emergence of *Homo sapiens* several hundreds of thousands of years ago. Moreover, it has been shown that the climate along the south coast of Beringia would have been surprisingly warm: Chartkoff and Chartkoff (1984) have reminded us that Beringia was more than a narrow neck of land connecting two continents. “It was a subcontinent of its own, up to 1,300 miles wide (2,090 km)” (op. cit., p. 28). It was a broad, low plain. As Hopkins (1979) has indicated, the emergence of Beringia blocked cold Arctic ocean currents from reaching the northern Pacific, and the mild Japan Current, flowing north along the Asian coast, warmed Beringia’s southern shore. “Grasslands and forests developed, and were filled with herds of woolly mammoths, mastodons, horses, bison, and other grazing animals, as well as the beasts that preyed on them, such as Alaskan lions and dire wolves. These animals were able to enter and cross Beringian from either direction. The horse, for example, which evolved in the New World, entered the Old World via the land bridge during the Pleistocene.” (Chartkoff and Chartkoff, 1984, p. 28).

We may expect that the same mild and balmy conditions and the same warm Japan Current would have pervaded with warm Pacific currents the southern and south-eastern coasts of the Chukchi Peninsula of Siberia and the Kamchatka Peninsula on its south-easterly shores, and the inland basin of a much diminished Sea of Okhotsk on its westerly shore. Similar conditions might have obtained on the southern coasts of the Kuril Islands and even of the Aleutians. If there were humans in these areas of North-East Asia at any time in the last part of the Middle Pleistocene and the earlier part of the Late Pleistocene, that is, over the last 200,000 years, there is theoretically no serious climatic reason why they should not have gone across the Beringian land bridge at any of the periods when the door was open. If they were coastal dwellers, beachcombers, strandlopers, it may be surmised that they would have kept to their coastal habitat after reaching America. They might then have occupied the Pacific coast, from the south of Alaska, through the Canadian littoral, as far as California; and the area of their occupation would now be largely submerged off the coast. This narrow, ice-free strip would have been cut off from the hinterland of North America by the glaciated Rockies, Sierras and Cascades. As Leakey pointed out, it is probably not until they reached southern California that they would have encountered an ice-free route into the interior – to Lake Manix and the Calico Mountains.

On my hypothesis, it is proposed that an early crossing of Beringia resulted ultimately in the Calico remains which may, indeed, be as old as 200,000 years B.P., as Bischoff and Schlemon have claimed. It is an important, and I believe, novel feature of my hypothesis that the earliest human
occupants of this continent probably did not survive. Perhaps the Calico occupation lasted for only a few thousands of years and then, for whatever reason, disappeared. On this view, Calico would represent the earliest signs of human habitation in the New World, but those first stone tool-makers and fire-makers do not seem to have contributed to the later populations of America. Their remains are an early testimony to the migratory tendencies of Late Middle Pleistocene humans. Such migratory propensities had already been evidenced in the inferred movements of hominids in the Early Pleistocene, from Africa into south-east Europe and around the Indian Ocean to South-East and East Asia. We need postulate no new sudden development of this pioneering, Viking-like urge to travel, when we consider the crossing of the Beringial land bridge; humans were simply showing, once more, that enterprising and versatile spirit which had been apparent since the emergence of Homo erectus shortly after the beginning of the Pleistocene.

This hypothesis can be tested in a variety of ways. Since the source area for the earliest Americans is accepted as Siberia, what evidence do we have on early human inhabitation of Siberia? It may be mentioned here that a fourth, now outmoded tenet of the prevailing paradigm about the earliest peopling of America was that no very early sites were available in Siberia, most of those known being Neolithic (Wormington, 1957). Without signs of humans in Siberia as early as the Middle Pleistocene, the case for a Middle Pleistocene penetration of humans into and across Beringia would be weakened. Dr. R. Potts of the Smithsonian Institution has kindly drawn my attention to the remarkable discoveries made since 1984 by Y.A. Mochanov and his wife, S. Fedoseeva, at the Diring-Yuriakh sites about 14.5 kilometers up the Lena River from the city of Yakutsk in Siberia. The primitive looking "pebble tools" recovered there have been examined and confirmed as human artefacts by several scholars in the United States of America, including Potts (Bower, 1994; Morell, 1994). Mochanov (1993) has likened the more than 4000 quartzite artefacts he and his wife have recovered to Oldowan industries and he has claimed a date of between 1.8 and 3.2 million years. This date has given pause to most of those who have examined the evidence. Thermoluminescence dating indicates that the tools may be at least 400,000 years old (M. Waters, S. Forman and J. Pierson, cited by Morell, 1994). This dating is approximately the same as that of the older strata of the Zhokoudian cave site, from which Homo erectus pekinensis has been recovered, although the latter cave is 2500 kilometers south of Diring-Yuriakh. Mochanov and Fedoseeva have not found hominid skeletal remains at Diring-Yuriakh. If the thermoluminescence dates are confirmed, it would mean that hominids were able to survive as far north as northern Siberia far earlier than previously believed.

From the point of view of the appraisal of the Calico Mountains material, there are two important implications. First, the fact that humans were present in Siberia in the Middle Pleistocene provides a degree of verification of the hypothesis that some humans spread into America from Siberia before the end of the Middle Pleistocene. Secondly, it should be an objective of high urgency for the claimed artefacts of Calico to be compared with those of Diring-Yuriakh.

Thus, the Calico Mountains hypothesis survives the test of an available source of hominids in Siberia at the apposite time.

A second approach to the testing of the Calico Mountains hypothesis would be to reexamine such early sites in coastal southern California as the Arlington Canyon Site on Santa Rosa Island, the Del Mar, Texas Street, and Buchanan Canyon Sites, and the Sunnyvale, Los Angeles Man, Laguna Woman, and Yuha Desert burials, and to try to obtain new dates for them. Moreover, the search in the hinterland of North America should be intensified, and carefully controlled excavations with the newest dating methods should be carried out on a wide scale. Some or all of these may yield results which would serve to confirm or refute the hypothesis proposed here.

**Conclusion**

Four tenets of the prevailing paradigm about the human peopling of the New World have been defined. An attempt has been made to show that three of these tenets have outlived their usefulness and are no longer tenable. Thus, the prevailing paradigm has tended to inhibit new research and new ideas. A new paradigm has been proposed. The crucial features of this are:

- the earliest peopling of the New World occurred long before the currently accepted dates and, probably, before the end of the Middle Pleistocene;
- the waves of spread of paleo-Siberians into and across Beringia probably occurred at several periods when the Beringian land-connection was open;
- the earliest spread was probably coastal, with a continuation of the way of life which had been pursued by these pioneers previously, on the Asian site of the arbitrary, intercontinental
divide;
- the palaeogeography of glacial and interglacial North America is likely to have militated against the survival of the earliest human occupants and their settlements;
- not all of the earliest occupants of America survived and probably most of the earliest settlements did not persist into the late Pleistocene or the Recent, their remnants being presumably buried beneath the Pacific ocean lapping on the western littoral of North America;
- it is therefore not necessary to postulate that there should be in America an unbroken sequence of archaeological sites and remains dating from the earliest occupation (such as that which may be represented by the Calico Mountains site and remains) to the later well-attested, archaeological sites: the absence of such a series does not, of itself, refute the hypothesis that some of the earliest palaeo-Siberians, such as those identified at Diring-Yuriakh, might have spread into and across Beringia on one of its numerous earlier emergences from the ocean.

On this paradigm, the Calico Mountains site, being inland from the presumably submerged coastal strip of presumptive occupation sites and encampments, may constitute a lucky survival of the most ancient human occupation site in the New World.

Acknowledgments

I am especially grateful to Ruth D. Simpson for her invitation to me to attend the celebratory meeting to mark the 30th anniversary of the Calico Early Man Site project. Unfortunately, I was bidden to another anniversary celebratory symposium in October 1994, namely the 65th anniversary of the Institute of Vertebrate Paleontology and Paleanthropology in Beijing, China. So I was in Asia, hot on the heels of "Peking Man," some of whose probable descendants, a few hundreds of thousands of years later, made the crossing — or, as I think, the crossings — of Beringia to reach the New World. However, my assistant at The University of Pennsylvania, Philadelphia, Julia Lewandowski, a graduate student in anthropology, kindly presented these thoughts on my behalf at the symposium in the San Bernardino County Museum. Dr. Rick Potts of the Smithsonian Institution graciously provided me with information and publications on the Diring-Yuriakh sites in Siberia, and Dr. William Hurley of the University of Toronto kindly provided further information. I am grateful to Julia Lewandowski for typing the original manuscript of my remarks.

References

Berger, R.

Bower, B.

Bryan, A.L.

Chartkoff, J.L. and Chartkoff, K.K.

Haynes, C.V.

Hopkins, D.M. (ed.)

Howard, E.B.

Klein, R.G.

Kuhn, T.S.

Leakey, L.S.B., Simpson, R.D., and Clements, T.

Leakey, L.S.B.

Mochanov, Y.A.

Morell, V.
Simpson, Ruth D.


Singer, C.A.

Stent, G.S.

Tobias, P.V.


Van Donk, J.

Wormington, H.M.

Tale of a Lost Giant

Arda Haenszel, Research Associate, San Bernardino County Museum, 2024 Orange Tree Lane, Redlands, CA 92374

This is the story of a giant anthropomorphic geoglyph that was found in 1952 and not identified, and how it was rediscovered 20 years later.

Ever since 1961, when I learned about the almost accidental discovery and photographing of the Ft. Mojave geoglyphs by a Bureau of Reclamation official in the course of a Colorado River channelization study, I had begged and pleaded with every agency with which I had contact, that had access to aircraft, to be alert for other ground figures along the Colorado. Government agencies particularly in that area, it seemed to me, made frequent flights for other purposes, and could do this without extra expenditure of time or money. The lack of response was frustrating.

Finally in the 1970s the Bureau of Land Management Yuma office was given responsibility for developing the Blythe intaglio groups for more controlled public use. Planner Ken Kuhlman was put in charge, and in the process of formulating the plan, he became fascinated by the unique ground figures, and visited others at sites that were known then, including the Lake Havasu and Ft. Mojave figures.

In 1973 he discovered near Park Moabi a new site on the west bank north of Topock. The San Bernardino County Museum at Redlands was notified, and representatives from there and from the local Needles Chapter were invited to explore and study the site. It was recorded as site SBCM 3015.

I was shown this new addition to the family of Colorado River giants by Maggie McShan of Needles. As in other instances, the site occupied a tongue of the deep-eroded first terrace above the river bottom near Park Moabi. The lone anthropomorphic approximately 60 feet long lay beside an ancient trail that ran down to the river. A few “house rings” were found at the same level across a small draw.

The two-dimensional figure had a relatively small head, a long body, rather long arms, and short, straight legs forming a V, the left one cut off by erosion. The right arm was noticeably disconnected from the shoulder, and curved halfway down the trunk to terminate in a round “hand.”

Mrs. McShan did not reveal the location, but later published a description and sketch of the figure in Footnotes, a little magazine which she edits. But I found that Mr. Kuhlman was probably not the first to discover the figure, and Mrs. McShan was probably not the first to mention it in print. Frank Setzler, in his article in the National Geographic Magazine about the famous Blythe and Ripley groups, had included mention of a new anthropomorphic geoglyph sighted at the last minute near the historic Topock bridge. Intrigued, I asked the Smithsonian for a copy of Setzler’s report on the expedition, seeking more details. But it

Aerial photograph of geoglyph (center, above track running diagonally from left to right). The torso of the figure roughly parallels the track, with legs to right. Photograph by Ken Kuhlman, Yuma area BLM 1974, reproduced courtesy of the Bureau of Land Management.
seems the new discovery was also a mystery to him. All I could find about it was this passage in his published article.

As the amphibian dipped over the Topock bridge, which carries the Santa Fe tracks across the Colorado, I again scanned the ground carefully, for in this area, too, other effigies had been reported. All at once, on a T-shaped mesa farther west, there loomed up the perfect outline of another grotesque figure. Banking sharply to that Dick could bring his camera to bear on the giant, we feasted our eyes upon it.

What a site the big fellow had chosen! From this vantage point he could have watched the first little bands of Spanish explorers, the creaking wagon trains of the pioneers, the coming of the railroad, and finally the flash of the sun on metallic wings.

Like Columbus, Setzler had missed entirely what he was looking for, the Topock Maze, and found something else, hitherto unreported and certainly important. It could not have been the anthropomorph said to have been associated with the maze, for it had been destroyed in 1893. Setzler couldn't understand how he had apparently flown right over the maze and missed it, and still had located a brand new "man" nearby. But I'm convinced that what Setzler saw must have been the figure at SBCM Site 3015.

In 1982, Boma Johnson, archaeologist at the Yuma office of the Bureau of Land Management, included in a paper on Colorado River geoglyphs a sketch of "our man" at SBCM 3015, along with sketches of two other anthropomorphic geoglyphs that had been found in the area of San Bernardino County's Park Moabi. However neither of the latter could have seen the Spanish explorers, the pioneer wagons, the railroad, or airplanes. They both lack heads.

Like some of the other Colorado River geoglyphs, this one has been fenced, and the site now belongs to the Needles Area Museum Association.
Fossil Resources Associated with Federal Lands in California

Gregg Wilkerson, Bureau of Land Management, 3801 Pegasus Drive, Bakersfield CA 93308-6837
Robert E. Reynolds, Earth Sciences Section, San Bernardino County Museum, 2024 Orange Tree Lane, Redlands CA 92374
David Lawler, Far West Geoscience Foundation, 48 Shattuck, Suite 108, Berkeley CA 95630
Benjamin Nafus, California Living Museum, 2404 Kayoming Way, Bakersfield CA 93306

Abstract

Paleontologic localities of significant scientific value occur on public lands in California. Some localities on private land are administered by the Bureau of Land Management (BLM) and the United States Forest Service (USFS) for their mineral resources. There is now an opportunity to protect non-renewable paleontologic resources through establishment of Areas of Critical Environmental Concern or through cooperative agreements with private institutions and other public agencies prior to these resources being lost, vandalized or developed for non-paleontologic purposes. As a positive example, cooperation between governmental agencies and private institutions has resulted in the preservation and appropriate curation of many paleontologic resources from public lands. These localities are important not only because they contain significant paleontologic resources, but because they are field repositories offering insight to past community dynamics and structural activities of the crust, and offer data regarding rates and amounts of fault offset which directly affects the health and safety of California residents. The keys to management of paleontologic resources are (1) inventory, (2) cyclic prospecting for protection, and (3) curation of specimens into retrievable institutional storage to allow research and reporting.

Introduction

Paleontologic localities involving public lands in California are invariably associated with private or military lands. These complications in land ownership provide easy access to some localities which have resulted in their near total destruction. Land ownership and management patterns have lead to the preservation of other localities. Table 1 is a partial summary of some of the more important localities in California. BLM joint venture programs are operating at major paleontologic localities listed below to prospect for paleontologic resource localities, to preserve sites in the field or remove impacted fossils to museums, and to focus collection and preservation efforts where they are needed to preserve fossil resources. Several of these localities have provided time-stratigraphic correlations that have world-wide stratigraphic and paleoecological ramifications. Many provide data on the time of offset, rates of movement, and recurrence intervals of earthquakes and faults.

Management techniques that have proved very effective involve BLM or agency-related mutual assistance agreements with museums and universities. The institutions provide knowledge, expertise, and trained volunteers. Often, arrangements are made for the lead agency to provide supplies and storage containers. The lead agency coordinates access to localities relative to other environmental concerns, including cultural and biological sensitivities.

Museums and universities maintain a database of paleontologic resource localities which is updated as new locations are identified. Research interests of the institutions or management concerns of the agency dictate the priority of overall field work.

Erosion is an ongoing process that exposes fossils on the surface where they are subject to natural forces of destruction as well as casual collection or non-permitted removal. Cyclic prospecting (see Fremd, 1994 and this volume) is an effective management tool for sedimentary formations containing paleontologic resources. Rates of erosion are determined for locality-specific rock types. Localities are revisited when enough sediment has been removed by erosion that exposure of new resources can be expected. Some soft siltstones (e.g., Barstow, Alvord, Avawatz, Cady Mountains, and Red Rock Canyon) weather rapidly and require annual inspection. Other formations of similar age (e.g., Cajon, Crowder) are more resistant to erosion.
and may need prospecting every two to three years. When fossils are collected, they must find their way to an institution with retrievable storage where they are available for study by qualified researchers. Specimens are prepared to a point where they can be identified, and stabilized for conservation. They are then identified and inventoried. Because resources collected from federal lands remain the property of the federal government, the repository institution must maintain detailed records of individual specimens reflecting their status as long-term loans from the land management agency. The management steps are consistent with the Society of Vertebrate Paleontology's (SVP) conformable impact mitigation guidelines (Reynolds, 1995) and with SVP bylaws and ethics (Miller, 1994).

The BLM has a 20 year history of paleontologic resource inventory in the California Desert Conservation Area (CDCA) that includes paleobotanical resources, invertebrate fossil resources, and vertebrate fossil resources (respectively, Axelrod, 1976, Murphy; 1976; Woodburne, 1978).

The National Park Service has a long history of actively managing selected paleontologic resources sites and districts (Wilkerson and others, 1994). Significantly, this management program extends past the collection of fossils and focuses on the active curation, conservation, and descriptive research of the maintained collections from these important sites (Fremd, 1994 and this volume).

The California State Park system administers an excellent example of paleontologic resource management at Anza-Borrego Desert State Park. The park is located on the west side of the Salton Trough and east of the complex San Jacinto fault zone. Here, interfingering marine and terrestrial sediments span a time period between 4 Ma to 300 ka. Resource management extends to invertebrate fossils and fossil plants (Remeika, 1994) as well as fossil vertebrates and their trackways (Remeika and Jefferson, 1994). These fossils have been managed in a framework of biostratigraphy, tephrochronology, and magnetostratigraphy (Lindsay and White, 1993; Reynolds and Remeika, 1993; Remeika and Jefferson, 1993). The park system has developed an integrated system of stratigraphic prospecting, geologic mapping, specimen preparation, public participation, and public interpretation and training in paleontologic resource management.

The specimens, inventory, locality data and associated field notes will reflect the precision within the stratigraphy with which the collection of specimens was made. Because aerial photography and topographic quadrangle maps are readily available, localities can literally be “pinpointed” and precisely documented in the locality database. Some studies go further, documenting specimens and their orientation in the stratigraphy using centimeter grids, allowing detailed study of taphonomy and populations (Bush, this volume; Gonzalez, this volume; Karnes and Reynolds, this volume).

Very little funding is presently available for these cooperative projects. The cooperative efforts of agencies, institutions, and volunteers are particularly notable in the preservation of California’s paleontologic resources.

**Alverson-Coyote Mountain**

The Alverson-Coyote Mountain Area of Critical Environmental Concern (ACEC) was established in 1988 to protect an important, diverse marine fauna with mollusks, fish, sharks, and marine mammals. The Alverson locality has had heavy use due to its location near a dump and gravel quarry. The Coyote Mountain localities are in a mountainous area near a military ordinance range and retain a pristine condition due to limited vehicular access.

**Alvord Mountains**

This important sedimentary and volcanic section spans the Hemingfordian, Barstovian and Early Clarendonian Land Mammal Ages (LMA). Cyclic prospecting the the San Bernardino County Museum (SBCM) and the University of California, Riverside (UCR) has been used to protect and preserve vertebrate fossils exposed by erosion.

**Avawatz Mountains**

This locality contains the best Early Clarendonian LMA terrestrial mammalian assemblage in the Mojave desert. Management techniques include cyclic prospecting to preserve vertebrate remains by SBCM and UCR.

**Badlands-of Bautista, Soboba Hot Springs, and San Timoteo**

Identified as nationally important localities in the 1992 South Coast Draft Resource Management Plan, these localities involve separate facies of the Soboba, Bautista, San Timoteo, and Mt. Eden formations. These localities contain terrestrial vertebrates that help define the rates of movement on the San Andres Fault and San Jacinto Fault that run through nearby major population areas. The Soboba locality contains an important fossilized chaparral and woodland plant community. UCR and SBCM conduct cyclic prospecting in areas of frequent usage to preserve vertebrate fossils.
Table I. Selected paleontologic localities on public lands in California
*Management intensity: R = ongoing research, + = one dig every year, ++ = one dig every two years

<table>
<thead>
<tr>
<th>Locality Name</th>
<th>County</th>
<th>Formations</th>
<th>Age</th>
<th>Land Tenure &amp; Management Intensity*</th>
<th>Important Fossils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alverson (Fossil) Canyon</td>
<td>Riverside</td>
<td>Imperial</td>
<td>U. Miocene</td>
<td>BLM, PRI</td>
<td>Mollusks, other invertebrates, sharks, rays, bony fishes, sea turtle, sea cow, baleen whale</td>
</tr>
<tr>
<td>Alvord Mountains</td>
<td>San Bernardino</td>
<td>&quot;Barstow&quot;</td>
<td>U. Miocene, Hemphillian to Barstovian</td>
<td>BLM, PRI +</td>
<td>Terrestrial mammals</td>
</tr>
<tr>
<td>Avawatz Mountains</td>
<td>San Bernardino</td>
<td>Avawatz/Noble Hill</td>
<td>U. Miocene, Clarendonian</td>
<td>BLM, PRI ++</td>
<td>Terrestrial mammals</td>
</tr>
<tr>
<td>Badlands</td>
<td>Riverside, San Bernardino</td>
<td>San Timoteo &amp; Mt. Eden</td>
<td>Upper Miocene &amp; Pleistocene</td>
<td>BLM, PRI (R) +</td>
<td>Horses, camel, rhinoceros</td>
</tr>
<tr>
<td>Bena Forest</td>
<td>Kern</td>
<td>Chanac</td>
<td>M. Miocene</td>
<td>PRI</td>
<td>Petrified wood</td>
</tr>
<tr>
<td>Cady Mountains</td>
<td>San Bernardino</td>
<td>Hector</td>
<td>U. Oligocene/E. Miocene</td>
<td>BLM, PRI ++</td>
<td>Earliest terrestrial mammals of Mojave Desert</td>
</tr>
<tr>
<td>Calico Mountains</td>
<td>San Bernardino</td>
<td>&quot;Barstow&quot;</td>
<td>M. Miocene</td>
<td>BLM</td>
<td>Insects, spiders, scorpions, lara</td>
</tr>
<tr>
<td>Caliente Mountain</td>
<td>San Luis Obispo</td>
<td>Calliente</td>
<td>Miocone</td>
<td>BLM (R)</td>
<td>Horse (type locality Menychoptes camozensis), camel, rodents</td>
</tr>
<tr>
<td>Cajon Pass</td>
<td>San Bernardino</td>
<td>Crowder, Vaqueros, San Francisco</td>
<td>Miocene, K/T boundary</td>
<td>BLM, USFS, PRI +</td>
<td>Terrestrial mammals, whale, porpoise, sharks</td>
</tr>
<tr>
<td>China Lake</td>
<td>Inyo</td>
<td>White Hills</td>
<td>E.-M. Pleistocene, Ranchololbrean</td>
<td>DOD (Navy)</td>
<td>Ducks, geese, eagles, canids, turkeys, horse, bison</td>
</tr>
<tr>
<td>Comanche Point</td>
<td>Kern</td>
<td>Chanac</td>
<td>M. Miocene</td>
<td>PRI</td>
<td>Elephants, horses, camels</td>
</tr>
<tr>
<td>Coso Mountains</td>
<td>Inyo</td>
<td>Coso</td>
<td>E. Pleistocene, L. Blancan</td>
<td>BLM</td>
<td>Ostracods, fishes, vole, rabbits, camels, peccary, camel, horse, elephant</td>
</tr>
<tr>
<td>Coyote Mountain</td>
<td>Imperial</td>
<td>Imperial</td>
<td>U. Miocene</td>
<td>BLM, PRI</td>
<td>Mollusks, sharks, rays, bony fishes, turtle, sea cow, baleen whale</td>
</tr>
<tr>
<td>Cuyama Phosphate Beds</td>
<td>Santa Barbara</td>
<td>Branch Canyon</td>
<td>L. Miocene</td>
<td>PRI, BLM</td>
<td>Echinoids, mollusks, marine invertebrates, fish</td>
</tr>
<tr>
<td>Democrat Hot Springs</td>
<td>Kern</td>
<td>Kernville Series</td>
<td>Triassic</td>
<td>USFS, PRI</td>
<td>Mollusks, snails</td>
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<tr>
<td>Dutch Flat</td>
<td>Placer</td>
<td>Eocene</td>
<td></td>
<td>BLM, PRI</td>
<td>Petrified wood</td>
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<tr>
<td>Hackberry Mts Wild Horse Mesa</td>
<td>San Bernardino</td>
<td>Early Miocene</td>
<td>NPS, PRI +</td>
<td>Rhinoceros, camels, canids, turkeys, bird tracks, plants</td>
<td></td>
</tr>
<tr>
<td>Goler</td>
<td>Kern</td>
<td>Goler</td>
<td>K/T boundary, Paleocene?</td>
<td>BLM, PRI ++</td>
<td>Terrestrial mammals (oldest in Mojave Desert), turtle, crocodile, multituberculate, condylarthra</td>
</tr>
<tr>
<td>Heald Peak</td>
<td>Kern</td>
<td>Kernville Series</td>
<td>Triassic</td>
<td>USFS, BLM, PRI +</td>
<td>Pelecypods</td>
</tr>
<tr>
<td>Horned Toad Hills</td>
<td>Kern</td>
<td>Horned Toad</td>
<td>U. Miocene, L Pliocene</td>
<td>BLM, PRI</td>
<td>Terrestrial vertebrates</td>
</tr>
<tr>
<td>Kettleman North Dome</td>
<td>Fresno, Kings, Tulare</td>
<td>Pliocene</td>
<td></td>
<td>PRI, BLM +</td>
<td>Oysters, barnacles, other marine invertebrates</td>
</tr>
<tr>
<td>Lindsay</td>
<td>Tulare</td>
<td>Kernville Series</td>
<td>Triassic</td>
<td>PRI, BLM</td>
<td>Microfossils</td>
</tr>
<tr>
<td>Locality Name</td>
<td>County</td>
<td>Formations</td>
<td>Age</td>
<td>Land Use &amp; Management</td>
<td>Important Fossils</td>
</tr>
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<tr>
<td>Lucerne Valley (t)</td>
<td>San Bernardino</td>
<td>Old Woman SS</td>
<td>U &amp; M Pliocene</td>
<td>BLM, PRI</td>
<td>Terrestrial vertebrates</td>
</tr>
<tr>
<td>Manix Lake Bassett Point</td>
<td>San Bernardino</td>
<td>Manix</td>
<td>L. Pleistocene</td>
<td>BLM, PRI ++</td>
<td>Mollusks, horse, crustaceans, fish, turtle, birds, sloth, wolf, bear, sabertooth cat, camels, llama, bison</td>
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<tr>
<td>Marble Mountains</td>
<td>San Bernardino</td>
<td>Latham Shale</td>
<td>E &amp; M Cambrian</td>
<td>BLM, PRI</td>
<td>Trilobites</td>
</tr>
<tr>
<td>McKittrick Brea Pits</td>
<td>Kern</td>
<td>Tar Seep</td>
<td>Pleistocene in Tulare Fm</td>
<td>PRI</td>
<td>Wolf, rat, snake, bird, insects</td>
</tr>
<tr>
<td>Maricopa Brea Pits</td>
<td>Kern</td>
<td>Tar Seep</td>
<td>Pleist. in Monterey Fm</td>
<td>PRI, BLM</td>
<td>Wolf, rat, bird, sabertooth cat, insects</td>
</tr>
<tr>
<td>Mesca Range</td>
<td>San Bernardino</td>
<td>Aztec SS</td>
<td>Jurassic</td>
<td>BLM, PRI +</td>
<td>Dinosaur tracks</td>
</tr>
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<td>Paradise Cove</td>
<td>Kern</td>
<td>Kern</td>
<td>Triassic</td>
<td>BLM, PRI</td>
<td>Fossil leaves in caliche</td>
</tr>
<tr>
<td>Pahrump</td>
<td>San Bernardino</td>
<td>Carrera</td>
<td>Cambrian</td>
<td>BLM, PRI</td>
<td>Trilobites</td>
</tr>
<tr>
<td>Pioneertown</td>
<td>San Bernardino</td>
<td>Pioneertown</td>
<td>U. Miocene</td>
<td>BLM</td>
<td>Terrestrial vertebrates</td>
</tr>
<tr>
<td>Plute Valley Hot Springs</td>
<td>San Bernardino</td>
<td>Plute Valley</td>
<td>Pleistocene</td>
<td>BLM, PRI +</td>
<td>Mammoths, camels, horses. Fossils in fault zones indicate rates of tectonism.</td>
</tr>
<tr>
<td>Punchbowl</td>
<td>Los Angeles</td>
<td>&quot;Punchbowl&quot;</td>
<td>Pliocene: Clarendonian-Hemphillian</td>
<td>County, USFS</td>
<td>Pliohippus, weasel, dog, horses, camel, antelope</td>
</tr>
<tr>
<td>Rainbow Basin</td>
<td>San Bernardino</td>
<td>Barstow</td>
<td>U. Miocene</td>
<td>BLM (R) +</td>
<td>Camels, horses, sabertooth cat, antelope</td>
</tr>
<tr>
<td>Randsburg</td>
<td>Kern</td>
<td>Bedrock Springs</td>
<td>U. Miocene: Hemphillian</td>
<td>BLM, PRI</td>
<td>Mammals, rodents</td>
</tr>
<tr>
<td>Red Rock Canyon</td>
<td>Kern</td>
<td>Ricardo/Dove Spr</td>
<td>Miocene</td>
<td>BLM, CDPR, PRI +</td>
<td>Horse, etc.</td>
</tr>
<tr>
<td>Salt Springs Hill</td>
<td>San Bernardino</td>
<td>Carrera</td>
<td>Cambrian</td>
<td>BLM</td>
<td>Trilobite exoskeletons</td>
</tr>
<tr>
<td>Sand Canyon-Cache Creek</td>
<td>Kern</td>
<td>Bodega, Kinnick</td>
<td>M. &amp; U. Miocene</td>
<td>BLM</td>
<td>Horse, camel, rhinoceros</td>
</tr>
<tr>
<td>San Emigdio Ranch</td>
<td>Kern</td>
<td>Tulare</td>
<td>Pliocene</td>
<td>PRI</td>
<td>Whale, shark, marine invertebrates</td>
</tr>
<tr>
<td>Shark Tooth Hill</td>
<td>Kern</td>
<td>Round Mt. Silt</td>
<td>M. Miocene Barstovian</td>
<td>PRI</td>
<td>Shark, whale, seal, pecans</td>
</tr>
<tr>
<td>Soboba Hot Springs</td>
<td>Riverside</td>
<td>Soboba</td>
<td>L. Miocene-U. Pleist.</td>
<td>BLM, PRI</td>
<td>Woodland chaparral</td>
</tr>
<tr>
<td>Summit Springs</td>
<td>San Bernardino</td>
<td>Latham Shale</td>
<td>Cambrian</td>
<td>BLM, PRI</td>
<td>Trilobites</td>
</tr>
<tr>
<td>Tecopa</td>
<td>San Bernardino</td>
<td>Tecopa</td>
<td>Plio-Pleistocene</td>
<td>BLM, PRI ++</td>
<td>Mammoths, camels, carnivores, horse, small mammals</td>
</tr>
<tr>
<td>Titus Canyon</td>
<td>Inyo</td>
<td>Titus Canyon</td>
<td>E. Oligocene Chadronian</td>
<td>BLM</td>
<td>Rodents, curid, horse, badger, brontothere, rhino, orendor, leptomerycids</td>
</tr>
<tr>
<td>Tunitee Beds</td>
<td>Kern</td>
<td>Okoese</td>
<td>M. Miocene</td>
<td>PRI</td>
<td>Marine invertebrates</td>
</tr>
</tbody>
</table>
Tumey-Panoche Hills  Fresno  Moreno  U. Cretaceous  BLM  Mosasaurs, plesiosaurs
Vaughn Gulch  Inyo  Vaughn Gulch LS  Silurian  BLM  Crinoids, bryozoans, corals
Wheeler Gorge  Ventura  Coldwater Canyon  Jurassic  Eocene  Cretaceous  USDI  Marine invertebrates
Yuha Buttes  Imperial  Imperial  Pleistocene  BLM  Oysters and other invertebrates

Bena Forest

Bena Forest is one of the few known occurrences of petrified wood of Miocene age in the San Joaquin Valley. Negative impacts to the locality are mostly associated with cattle ranching.

Cady Mountains

The Cady Mountains contain the earliest Tertiary terrestrial mammals in the Mojave Desert. They are found in sedimentary basins that resulted from faulting associated with crustal thinning. These fossils are used to date late Oligocene and early Miocene breakup of the Mojave Desert. In recent years, cyclic prospecting by SBCM has resulted in recovery of new taxa (including rhinoceros) from these deposits.

Cajon Pass

Sediments in Cajon Pass are an excellent research and study area, containing Cretaceous elasmosaurs, late Oligocene whales, and land mammals, birds, reptiles, mollusks, and plants from the last 18 million years. Facies of these sediments contain evidence of early movement on the San Andreas Fault. The San Francisquito Formation has the potential to contain the K/T boundary. Formations of different ages have been juxtaposed by movement of the fault. Datable volcanic rocks are absent, but detailed excavation and cyclic prospecting by the SBCM have produced fossils which date the rocks and offsets with great precision.

Calico Mountains

This agate bed preserves exquisite silica casts of insects, larva and spiders. The preservation is so perfect that details of compound eye structure, leg hair follicles, and trachea are seen in SEM micrographs. Much of this locality has been harvested by rockhounds for making belt buckles and other rock jewelry. In 1994 the locality was identified as an Area of Critical Environmental Concern.

Caliente Mountain – Horse Canyon

These localities represent a set of rare vertebrate specimens from the California Coast Ranges. Some of them are within the Caliente Mountain Wilderness Study Area. Others are in the vicinity of Quatal Canyon which has been identified as a special management area for fossils by the U.S. Forest Service. These outcrops are important because they contain numerous paleontologic resource localities that range in age from Hemingfordian, Barstovian, Clarendonian, and Hemphillian LMA. The Caliente Formation lies on the west side of the San Andreas Fault and, when further studied, will relate coastal and marine events to desert localities and structural events. The SBCM and the Natural History Museum of Los Angeles County (LACM) have attempted limited prospecting in this area.

China Lake

Within a military reservation, these deposits have been essentially unstudied for 20 years, and have been disturbed primarily by military activity.

Comanche Point

A unique assemblage of Miocene terrestrial vertebrates is known from this locality a portion of which is within the Tejon oil field. The area was inspected by SBCM in 1990.

Cuyama Phosphate Beds

A rich assemblage of phosphatized invertebrates and fish fossils occur in a unique series of depositional environments which prograde from deep water to shallow water facies. The locality is a wonderful outdoor educational laboratory because students can walk upsection and collect fossils from a sequence of deepening depositional environments.

Democrat Hot Springs – Heald Peak

A roof pendent preserves rare Triassic marine fauna at these localities and is critical in the dating of metamorphic rocks in the Southern Sierra-Nevada.
Dutch Flat
This locality has been vandalized for over 100 years. It contains one of the only remaining petrified forests of lower Eocene age in North America in an unnamed fluvial unit stratigraphically equivalent with the Ione Formation. Informal discussions are underway for BLM to acquire the portions of this locality which are on private land. BLM acquisition would be followed by establishment of an interpretive center at the locality through a Recreation and Public Purpose lease to El Dorado County maintained by a local consortium of non-private foundations.

Goler
The Goler Formation has the oldest mammal fossils known from California. It is located in the southern Basin and Range Province north of the Mojave Desert, and has the potential to yield invaluable data relative to the Garlock Fault which separates the two provinces. Annual visits by USGS, SBCM, UCR, the American Museum of Natural History (New York), the Alf Museum (Claremont) and LACM are exploring these relationships.

Hackberry Mountains and Wild Horse Mesa
Rhinoceros skeletons and flamingo tracks are preserved in early Miocene sediments. These fossils help date the change 18 million years ago from a stable Mojave province to one with active volcanism and extensional faulting. Cyclic prospecting by the SBCM has produced this important collection of vertebrates, footprints, and plants.

Kettleman North Dome
Giant oysters, barnacles and other marine invertebrates occur in great quantity and variety at this locality which lies in the heart of the Kettleman oil field. Some degradation of the paleontologic resource has occurred from oil and gas development.

Latham Shale
The earliest complex life forms in California occur in early and middle Cambrian shale in the Marble Mountains at Cadiz and at Summit Spring in the Providence Mountains. Public collection is allowed using hand tools only. This sedimentary sequence is often studied by geology classes.

Lindsay
Rare microfossils in this ophiolite sequence are important for reconstructing plate tectonic history of central California.

Lucerne Valley
Fossils from this area give important palinspastic information about the date of rise of the central San Bernardino Mountains.

Manix Lake and Basset Point
Containing a wide variety of mammal, fish, and bird fossils, this area includes paleontologic localities in more than 25 square miles. Once filled by 157 square mile Manix Lake, it is now drained by the Mojave River, producing picturesque badlands. A recreational corridor provides access to the fossil localities and has resulted in some degradation from off road vehicles. Much of the resource is contained in the Manix Basin ACEC. The ACEC is monitored by cyclic prospecting with crews from the SBCM and research associates at the Anza Borrego Desert State Park.

McKittrick and Maricopa Brea Pits
Two of four important tar pits in southern California (the others are La Brea and Carpenteria) are either in or adjacent to oil fields. Portions of the tar pits were destroyed in the 1870's-1890's by asphalt mining operations. The McKittrick locality has been almost totally excavated. The Maricopa locality has not been fully studied and several thousand tons of material remain undisturbed. The Caliente Resource Area Draft Resource Management Plan of 1994 identifies these localities as having high paleontological value. Informal discussions for having BLM acquire the locality from Mobile Oil Company, leasing it to Kern County under the Recreation and Public Purpose Act and then having it maintained by the docents from the West Kern Oil Museum, have occurred since 1992.

Mescal Range Dinosaur Track ACEC
The only dinosaurs tracks in California are located in the Mescal Range. Prints of three ichnogenera are preserved in dune sands. Two of the ichnogenera are the same as those in early Jurassic sediments of the Connecticut Valley on the eastern continental margin. The dinosaur tracks are preserved along with those of quadrupeds, insects, and rain drops and ripple marks. Data has been developed by cyclic prospecting and detailed recordation by the SBCM in cooperation with the BLM. Through replication, the prints remain preserved in the ACEC, with copies stored in the museum.
Paradise Cove
A rare assemblage of calichefied leaves has provided important paleoecological information about the evolution of the Sierra Nevada.

Rainbow Basin
The locality is important because it occurs interbedded with a set of thin volcanic layers which have been dated by K/Ar analysis. Paleomagnetic studies have also been conducted for this important sedimentary section. Mammals and index fossils found at this locality have world-wide chronostratigraphic implications. This is the type locality for the Barstovian LMA. Resource management techniques include cyclic prospecting by SBCM and UCR to recover fossils exposed by erosion, and precision excavation has been carried out to provide detailed taphonomic data of faunal assemblages. Trackway replication will preserve data that is subject to erosion. However, Rainbow Basin is a popular recreational destination and resources are subject to damage from off-road vehicle activity and illegal collecting. Recently, camel fossil trackways and fossil horse and camel bones were stolen from this Area of Critical Environmental Concern.

Red Rock Canyon
This locality is partially within a state park. Surrounding BLM lands have extensive vertebrate finds. Some of the most impressive are from Dove Springs, which is also an open area for off road vehicles. This recreational activity continues to degrade the Dove Springs fossil locality. An uninterrupted seven million year sequence of sediments provides important details about the evolution of life in this time period and is the most continuous record for Barstovian-Hemplillian time (excluding the Crowder Formation). In addition, there are important historic and pre-historic localities here. A mono-genus moth of unknown affiliation has been discovered in the past year which apparently lives only in the Dove Springs area. LACM and SBCM conduct cyclic prospecting of the exposures to prevent loss and degradation of fossils. Detailed research has included dating volcanic ashes and paleomagnetic studies.

Sand Canyon
Near new subdivisions and an area of proposed wind farms, these localities, unless protected, will be impacted in a few years by urban expansion. A wide variety of important terrestrial vertebrates are known from the locality.

San Emigdio Ranch
A recent discovery of a whale skull was made at this locality. The find has greatly extended the geographic distribution of whale fossils of Miocene age in the California.

Shark Tooth Hill
Known as the "bone bed", this locality extends throughout a wide area of western Kern County. Near several oil fields, the locality has been vandalized since the 1890's mostly for it's abundant shark teeth many of which are several inches in length. Mostly on private land, the bone bed produces one or two nearly complete skeletons almost every year. Concern for exposure of fossil hunters to "Valley Fever", a sometimes fatal illness, has resulted in tighter control of access to the Shark Tooth Hill. The California Living Museum has a team of volunteer physicians that monitor persons that work in the Round Mountain Formation. Detailed excavations by LACM have produced unique taphonomic data.

Tecopa
Sediments of Lake Tecopa span the Pliocene and Pleistocene Blancan and Irvingtonian LMA. When the lake drained, fractures formed and trapped Rancholabrean age camels and mammoths. Sediments here contain a four million year record of events. Fossils at this popular vacation spot have received impacts from non-permitted collecting. Cyclic prospecting by SBCM has protected many of the exposed resources.

Turritella Beds
Known for its abundant and beautiful invertebrate marine fossils, this locality is exposed for 2 miles along cliffs bordering the Kern River. Restricted access by private land owners has kept the locality from vandalism.

Tumey-Panoche Hills
A critical locality for Mosasaurs this locality has been protected because of restricted access associated with the region's high fire hazard and presence in a Wilderness Study Area. A mosasaur and plesiosaur have recently been discovered and await excavation pending environmental review of the impacts of such an activity on the Wilderness Study Area.

Vaughn Gulch
This locality exhibits a classical sequence of Cambrian to Mississippian units with a wide variety of invertebrate and rare vertebrate fossils.
Wheeler Gorge
This is an important locality for Eocene and Cretaceous flora and fauna in the Transverse Ranges.

Yuha Buttes
Vast oyster beds and other invertebrate fossils form a pavement paleobiologic material which covers several square miles. This interesting geomorphic feature is the result of differential weathering of a death assemblage of fossils which is up to 6 feet thick at the progradational contact of green-tan marine sediments and red silts of the ancestral Colorado River. A BLM-approved motorcycle race course cuts through the locality and some of the fossils are destroyed by this recreational activity.

Conclusions
The rich fossil heritage of public and private lands in California has not been widely appreciated or managed as intensively as have similar localities in other states. Governmental agencies have existing procedures for acquiring and protecting many of these localities through cooperative agreements, Recreation and Public Purpose leases or other land tenure adjustments. Future land use authorizations (e.g. leasing) should contain standard stipulations for the protection of paleontological resources. The Antiquities Act and FLPMA should be amended to extend protection to scientifically important invertebrate and plant fossils. Implementation of this protection should be delegated to local governmental entities through cooperative agreements that would result in regional paleontological management plans. Lists of common fossils could be part of these plans and casual collection of them by amateurs and professionals regulated with relative ease and low cost to the taxpayer. Immediate efforts to preserve these resources should be encouraged through cooperative agreements and partnerships between agencies, institutions, and their volunteers.

References

Murphy, M.A., 1976. California Desert Conservation Area, invertebrate paleontologic resources study. University of California, Riverside, ms on file with BLM.
Cyclic Prospecting to Preserve Vertebrate Paleontological Resources

Ted Fremd, Paleontologist, John Day Fossil Beds National Monument, HCR82, Box 126, Kimberly, OR 97848

Elimination of science is the resource equivalent of book burning
- Bruce Babbitt, Secretary of the U. S. Department of Interior, 1995

Introduction
The conservation of fossils valuable to science is undertaken by stewards of many types of public lands. Among federal land management agencies, the National Park Service (NPS) is unambiguously mandated to provide protection of paleontological resources within congressionally authorized boundaries. NPS Management Policies states that:

Paleontologic resources, including both organic and mineralized remains in body or trace form, will be protected, preserved, and developed for public enjoyment, interpretation, and scientific research in accordance with park management objectives and approved resource management plans.

Management actions will be taken to prevent illegal collecting and may be taken to prevent damage from natural processes such as erosion. Protection may include construction of shelters over specimens for interpretation in situ, stabilization in the field, or collection, preparation, and placement of specimens in museum collections. The localities and geologic settings of specimens will be adequately documented when specimens are collected. (USDI, 1988)

It is plain that merely establishing an area as a park or preserve, without intensive management, cannot insure that fossils will not be lost to the scientific community. On NPS and other federal lands, in many situations collection is the only method to avoid compromising real or potential research data. The fundamental assumptions behind efforts to systematically retrieve important paleontological materials on federal lands are simply that in situ scientifically significant specimens should not be permitted to disintegrate or remain in jeopardy, and that these materials belong in the public trust.

Of course there is tremendous variability in erosional rates, specimen abundances, and corresponding management options for vertebrate-fossiliferous sediments. In many layers of strata, there are few specimens weathering out. In other units, specimens that do become exposed are durable, or the vast majority of remains are simply not scientifically significant. For example, unusual beds containing rich deposits of material such as sharks’ teeth, or containing astonishingly abundant fishes, conodonts, or other taxa exist. Such areas are occasionally invoked by “lands access” groups as a justification for de-regulation; but these exceptions neither support nor refute arguments for frequent vigilance of other types of localities by the scientific community.

In many (particularly Tertiary) depositional basins poorly indurated strata are ideally suited for systematic, repetitive cycles of prospecting and collecting activities, and the timely retrieval of specimens from these outcrops counters losses from erosion or unskilled collection methods. After a brief summary of potential management strategies, this non-technical article will review aspects of a program of “cyclic prospecting,” drawing on broad methodological examples (detailed elsewhere) from the John Day Basin in eastern Oregon.

Paleontological Resource Management Overview

Management alternatives
A variety of actions may be undertaken at fossil localities administered by various government agencies. Administrative options include those listed in NPS-77 (USDI, 1991), a compendium of NPS natural resources management guidelines:
1. No action. Appropriate for sites that have no or low significance.

2. Monitor. Periodic re-examination of a locality to determine if conditions have changed such that different or additional management actions are required. Photographic records should be kept so that changes can be more easily ascertained.

3. Cyclic prospecting. Areas of high erosion which also have high potential for producing significant specimens should be periodically examined for new sites. The periodicity of such cyclic prospecting will depend on the abundance of fossils and the rate of sediment erosion.

4. Stabilization and reburial. Significant specimens which cannot be immediately collected may be stabilized using the appropriate consolidants and reburied. Reburial slows down, but does not stop, the destruction of a fossil by erosion. Thus, this action is to be used only as an interim measure.

5. Shelters. Sites or specimens which are to be exhibited in-situ will usually require protective shelters. Structures range from small plastic domes to large buildings with attendant exhibits and research facilities. However, the use of structures may invite theft or vandalism and present problems of temperature and humidity control and specimen degradation.

6. Excavation. Excavation may be partial (such as the collection of a particular specimen in a fossil reef or the emergency collection of bones in imminent danger of destruction) or complete (an entire skeleton or an entire microvertebrate locality).

7. Closure. Closure may be temporary (such as while an excavation is in progress) or permanent (such as for areas with abundant significant fossil resources which are easily pilfered). Closed areas may be completely withdrawn from public use or restricted to ranger led activities, such as guided hikes.

8. Patrols. Important sites or areas may be in the area of existing patrol routes and should be brought to the attention of patrol rangers. Other areas may require the modification of patrol routes. Patrols may be important in preventing or reducing theft and vandalism.

Clearly, the inherent variability of fossil material and their entombing matrices justifies several of these strategies being invoked concurrently. In many areas combinations of approaches are successfully employed. The Blue Basin area of John Day Fossil Beds, for example, is closed to off-trail traffic without an escort, and specimens are frequently collected during cyclic prospecting episodes.

**Scientific Significance Criteria**

Careful consideration of the above action alternatives is predicated on the determination of scientific significance, which in turn is subject to many variables. A summary (USDI, Chure and Fremd, 1991) was prepared for resource managers in the National Park Service who may be dealing with fossil resources in NPS-77:

There is no single yardstick by which the scientific significance of a fossil can be measured. Some factors will often automatically make a specimen significant. Among these are specimens belonging to poorly known taxa, preservation of soft tissues or delicate structures, specimens showing pathologies or injuries, specimens of unusually large size for their species, specimens showing paleoecological relationships (such as symbiosis, parasitism, commensalism, predation), and association with datable materials (e.g. radiometric, paleomagnetic, or index fossils), to name a few.

However, many other subtle factors may make a specimen scientifically significant. While specimens of poorly known species are always significant, species which are extremely abundant may also be significant because they supply a large sample which can yield data on population structure; individual, ontogenetic, and sexual variation; ontogeny; allometry, etc. Specimens which are broken or incomplete may reveal details of internal anatomy which are not available from more complete specimens. Seemingly mundane specimens may provide important geological and geographical range extensions.

Thus, substantive paleontological knowledge is required in order to properly evaluate the scientific significance of fossils, and input from professionally trained paleontologists is critical for the professional management of fossil resources. The paleontological advisor should be familiar with the particular group of fossils being evaluated. Thus, active and past researchers within the park should be contacted. If no such researchers are available, superin-
tentents should seek assistance from professional societies, such as the Society of Vertebrate Paleontology (for fossil vertebrates), the Paleontological Society (for fossil invertebrates), and the Paleobotanical Section of the American Botanical Society (for fossil plants).

Professional paleontological input should be sought in developing broad groupings of fossil resources with differing significance. These can be prioritized and paleontologists and managers should work together to develop the management actions appropriate for each site.

An evaluation of the significance of a locality, site, or specimen is made as specimens are encountered in the field, and the investigator quickly considers the appropriate action(s) with due consideration of the management goals of the area. In those strata where rates of weathering are determined to be consistent, and not merely episodic, a repetitive system of prospecting may be developed based on observed appearances of new skeletal material over time. Only individuals who are accompanied and/or trained by experienced field specialists familiar with the particular strata should be enlisted in these decision-making efforts.

Vertebrate Fossil Conservation in the John Day Basin

Like many units administered by the National Park Service and other land management agencies, John Day Fossil Beds National Monument (JODA) contains a variety of vertebrate fossil assemblages. Particular strata identified in the John Day Basin for "proactive management" are Oligocene and Miocene strata that entomb Whitneyan and Arikareean paleobiotas, particularly rich in mammalian species. These are thick sequences of bright green zeolitized, tuffaceous silt-, mud-, and claystones that contain more than 120 species of mammals belonging to 30 families (see Table One). The remains are typically very hard, but brittle: once exposed by weathering, freeze-thaw cycles quickly shatter the specimens and destroy them for study. In order to comply with the NPS preservational mandate, a systematic examination of these strata is appropriate on a recurring basis.

Since 1982, the NPS has sponsored the meticulous collection of specimens from exposures within and proximal to the boundaries of the Sheep Rock Unit of John Day Fossil Beds. To date, more than 7,000 specimens have been retrieved by methods described below and elsewhere (Fremd, 1994a-c).

These continuing collecting efforts are important for several reasons:
1. Outstanding individual specimens have been recovered, including new taxa, that would probably have been lost to the public trust.
2. A sample of material has been accumulated that avoids much of the collecting bias that beleaguerers most accumulations retrieved by "specimen" collectors, from both professional and amateur communities. This provides more robust data for statistical analyses of faunal compositions, taphonomy, and paleoecology to name just a few (Fremd, 1988 et seq.).
3. Previous collections accessible for study are plagued by ambiguities in localities and lack stratigraphic precision. This had made "the John Day" particularly vexing for correlation with other important deposits in the world.

In the following sections, some aspects of a cyclic research/management program are reviewed.

Planning

Insuring that the public and the scientific community are well-served requires anticipation of research questions as well as the roles of different allies (see Table Two). Evaluation of the existing literature and manuscripts in preparation, status of reference collections and type specimens, available stratigraphic data, rates of weathering, appraisals of potential associates, and a host of policies and processes must be considered prior to embarking on a formalized schedule of cyclic prospecting. Planners should expect changes in methodology.

<table>
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<th>Table 1</th>
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<td>Mammalian families encountered during cyclic prospecting in certain John Day strata.</td>
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<td>Order Marsupialia</td>
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<td>Order Insectivora</td>
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<td>Order Rodentia</td>
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<td>Order Lagomorpha</td>
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<td>Order Primates</td>
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and assessments of significance within any site. For example, as the process evolves and the numerical size of the collections increases, kinds of specimens that would be retrieved during the early "baseline data" stages of the activity may not be collected in successive years, if scarcity was used as a significance factor.

The JODA project began in 1982 with a contracted effort (Ruben and Wagner, 1984) to ascertain the occurrences of material within selected portions of the national monument. Beneficial as that project was, it became apparent that the NPS needed to be more directly involved in the planning and operational processes, as the accountable agency, to secure the maximum curation and research benefits for the widest public use. A broad, multi-disciplinary coordinated research approach to the complex paleontological features of the basin was adopted and is in progress.

### Stratigraphy and Mapping

Construction of a detailed stratigraphic framework is essential. Measured sections, correlation diagrams, and construction of a composite stratigraphic column, should precede any collecting efforts if possible. In the case of the JODA project, the overwhelming majority of the type specimens and associated collections lack verifiable provenance. Recollection of many sequences with stratigraphic control is helping to constrain temporal ranges of many of the taxa (for examples see Fremd and others, 1994; Fremd and Wang, 1995).

Strata in the project areas were measured using standard techniques (Jacob's staff and clinometer) by monument staff aided by volunteers, contractors, and visiting researchers. Efforts were made to identify and precisely date many of the abundant isochronous tuffs that blanket much of the region. These dated units (Swisher and others,

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**Table 2.** An idealized list of procedures and personnel involved in a federal program of cyclic prospecting and paleontological research.

The columns suggest relative "involvement levels" (L = low, M = medium, and H = high) that might be expected from each group of people and their assets during each part of the research process. For example, one might expect the NPS to be highly involved in curation; a university may be participating in storage; volunteer involvement might be high in field, but less in research due to the level of training required, etc.

Regardless of the relative level of involvement shown for different components, public lands staff should ensure compliance with bureau policies, and must be knowledgeable of research design and significance.

<table>
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<tr>
<th>Procedures</th>
<th>Agency Scientists</th>
<th>Volunteers / Amateurs</th>
<th>Contractors/ Commercial</th>
<th>University / Museums</th>
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<tr>
<td>Planning</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>M</td>
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<tr>
<td>Stratigraphy &amp; Mapping</td>
<td>M</td>
<td>L</td>
<td>M</td>
<td>H</td>
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<tr>
<td>Stereophotos &amp; GIS</td>
<td>M</td>
<td>L</td>
<td>H</td>
<td>M</td>
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<tr>
<td>Cyclic Prospecting</td>
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<td>H</td>
<td>M</td>
<td>L</td>
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<td>Collection</td>
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<td>L</td>
<td>M</td>
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<tr>
<td>Preparation</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>L</td>
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<tr>
<td>Curation &amp; Storage</td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>M</td>
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<tr>
<td>Taxonomy/Related Research</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>H</td>
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<tr>
<td>Publication</td>
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<td>Interpretation</td>
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The precise available on aerial imagery of achieve suitable quality stereo photography of lands collecting aspect the in prep) provide a critical accuracy and "index" for the temporal placement of recovered specimens, an aspect often unavailable on unregulated public lands collecting episodes.

**Stereophotos and GIS**

The methods include use of high-resolution color stereo pairs to delineate specimen occurrences. This quality of photography is rarely available off-the-shelf and must usually be designed and put out for bid specifically for this purpose. At JODA, flight lines and shutter intervals were specified to secure 60% overlap and 30% sidelap (to avoid parallax and achieve suitable stereo imagery). Nine-inch format cameras with a 12" focal length, and flying heights of 1000' above the terrain were selected; thus, a meter on the ground is approximately 1 mm on the photograph. The single most important procedure involves sizing these large scale air photographs for field use such that workers can readily enter the location of specimens quickly, accurately, and verifiably. We have also successfully used remote 35mm stereo cameras mounted on tethered helium-filled blimps.

In the museum, 36" X 36" enlargements of the aerial photography are used to archive specimen locations pinpointed on field sheets of the same scale. From these precise coordinates a simple binary system (using northing and easting coordinates analogous and rectifiable to UTM) is entered into the Automated National Catalog System [ANCS], a dBaseIII+ compiled record system that permits analysis from a variety of database platforms. This permits one to electronically "take the specimen back" to within a meter of where it was exposed. The monument is now developing a GIS system to take advantage of our existing data and evolving technology. A database linked with locality data sheets is kept, augmented by overlays documenting precisely where the prospecting processes were done on a given day.

**Prospecting and Collection**

On non-NPS administered properties, or where land managers may have little enforcement control of the public lands, unauthorized collecting episodes may decimate the exposures and bias attempts to perform taphonomic or faunal analyses (see LaGarry-Guyon, 1994). As a result of a cooperative interagency agreement (Fremd, 1992) between the NPS and the Bureau of Land Management (BLM), resource management and research may proceed unfettered by management boundaries that are often arbitrary from a scientific standpoint. Within the John Day Basin, a variety of staff, including trained volunteers, rangers, visiting museum personnel, and others under the supervision of the John Day Fossil Beds museum/paleontology division prospect the beds within the congressional boundaries in detail under a coordinated schedule. BLM areas can be divided into manageable, "bite-sized" regions that are covered at less frequently scheduled intervals.

In the JODA project, the cyclic timetable has been set for thorough coverage of areas at four year intervals (see Table Three). Photography of all articulated in situ specimens occurs,

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**Table 3. JODA Cyclic Prospecting Schedule.**

Each area to be prospected is listed below with the corresponding prospecting year.

F = Fine Detail; thorough coverage of all attainable exposure. All threatened and significant material recovered and catalogued. Complete overlays and documentation; attempt elimination of collecting bias.

C = Coarse Detail; accessibility, visitor access considered. Some material left in place; rates of weathering study areas; thorough overlay documentation not necessary.

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<td>North Fork</td>
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<td>South Fork</td>
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<tr>
<td>Right-Hand Canyon</td>
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<tr>
<td>Northside Beds</td>
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<td>C</td>
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<td>Slump</td>
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<tr>
<td>Amphitheatre</td>
<td>F</td>
<td>C</td>
<td>F</td>
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<tr>
<td>Blue Creek Beds</td>
<td>C</td>
<td>F</td>
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<tr>
<td>Lone Pine Beds</td>
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<td>South Sheep Rock</td>
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<td>North Sheep Rock</td>
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<td>East Sheep Rock</td>
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<td>West Sheep Rock</td>
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The precise location and physical boundaries of these areas is available on aerial imagery.
which helps document specimen orientations, associated paleosols, and taphonomically important features. Field notes record data in a format that can be keypunched directly into ANCS during cataloging (see Appendix One). Archival polyester processing folders are overlaid onto the aerial photographs depicting where the prospector has been in a given day or set of days; this correlates with the field notes, and helps offset a preference to return to particular “favorite” spots.

It turns out most items observed during cyclic prospecting are left in the field because they are simply not significant (e.g., bone fragments, certain ichnofossils, dental scrap), at least not enough to justify the expense and maintenance for their curation. Occasionally, new material of a previously collected skeleton weathers out. Because of the computerized coordinate system it can be recognized and curated with the original specimen. This allows greater precision in determining taphonomic estimates (such as the Minimum Number of Individuals), as under normal procedures these occurrences would probably be catalogued as separate animals.

It is noteworthy that a variety of volunteers are trained to work with the staff both in the field and in the laboratory. It has been our experience that most “amateur” paleontologists much prefer to ally themselves with scientific endeavors concerning vertebrate fossils, rather than possession-oriented or marketable commodity perspectives.

Curation and Storage

Little purpose would be served by inaugurating a systematic program of cyclic prospecting only to have the resulting collections deteriorate inside; they might as well have stayed in the field. Storage of materials, whether within agency repositories or through cooperative agreements with other museum facilities, should meet the requirements delineated in Special Directive 80-1 (Revised 1990), the NPS Inspection Checklist for Museum Storage and Exhibit Spaces, available from the NPS. This checklist considers spatial and procedural aspects of museum collections storage, the museum environment, security and access concerns, fire protection, housekeeping, and museum collections planning.

The JODA database files resulting from cyclic prospecting are accessed with a variety of Windows®-based software platforms such as IDEALIST, dBASE, and APPROACH. Specimens are catalogued in compliance with the NPS Museum Handbook, which sets high standards for curatorial work throughout the Interior Department and cooperating repositories.

Conclusions

The issue of whether particular specimens should be retrieved or left to ultimately be destroyed is a complex one that requires a solid understanding of the particular strata. Similarly, whether cyclic prospecting may be warranted within a park, monument, or other land management venue varies with the facies, lithology, induration of the sediments, and other factors. For example, within Fossil Basin, Wyoming, a program of canvassing the paludal facies of the Wasatch Formation is very appropriate. In the Green River Formation lacustrine members, however, surface prospecting is aimless and active quarrying is required.

Recently, considerable concern has rightly been expressed regarding the increased dollar value being attached to vertebrate fossils by commercial enterprises. Meanwhile, there is a recognition that specimens are continuously being lost to natural processes. Museums, universities, and other institutions should realize that the cost of sending out a skilled field crew and preparing the material in house is actually a much better curatorial bargain, with far greater research payoffs, than simply purchasing a few display items. Similarly, management agencies entrusted with the stewardship of public lands may find that facilitating the timely retrieval of valuable specimens from the field into dedicated repositories is the best solution to insuring their conservation.

References Cited


Appendix One

Simplified Cyclic Prospecting Recording Procedures

The Project Investigator (PI) is supplied with a standard field note-book and permanent ink pens. Specimens that are observed in the field, or partially collected, or fully collected (whether float or in situ), may be recorded in the book. A field entry should reference, at a minimum, the following information:

- a field number
- taxonomic identity for individuals and lots; general descriptor for composites and locality samples
- nature of material
- whether or not the material was in situ, or float
- name of discoverer and/or collector
- precise photographic coordinates (typical accuracy is +/- 2.0 meters)
- stratum (if in situ), possible range (if float).

This is the minimum amount of information that is required for every collected specimen that is to be accessioned into the museum collection. More documentation accompanies particularly valuable specimens and/or those that require complex excavation, including information such as: preferred orientations, descriptions of the sediment, associations with other material, number of photographs taken, and any completed Taphonomic Field Data Sheets generated.

Field Numbers are arranged by the PI's initials, month, year, and number; thus TF88528 is the 28th number assigned to a specimen, or lot, or composite, in August, 1985 by T. F. A lettered suffix "NC" may follow on the same line, which designates that the material was not collected at the time of the entry, for whatever reason. (Note: if the specimen is later retrieved, a single line is drawn through the "NC" and the collection date written in.).

Taxonomic identity should be established as close to species as possible, but field situations often are not amenable to specific recognition, and material may not be identifiable until prepared. Even complete and well-prepared material may not be identifiable without access to reference material. As far as possible, however, identify the specimen - even if it is only "artiodactyl, unidentified."

Nature of the material should specify the osteological components included (e.g., astragalus, incomplete dentary with p3-m2, etc.). As the data
are logged from the notes into the database, the use of the SVP Bone Morphology Codes is encouraged. The records should also include, in the case of jacketed material, the orientation of bones, proportion of skeleton, etc.

In situ: It is critical for the investigator to judge whether or not material was actually in proper stratigraphic context or arrived there as a result of recent transportation mechanisms (principally water, in this case). "Float" is never pinpointed onto aerial photographs, but the coordinates are still measured and entered into the field notes so that the area can be revisited by future investigators, and so that the general area can be satisfactorily re-examined. All in-situ material is pinpointed when it is collected and/or especially significant. These coordinates are entered into the field notes and catalog records, as well.

Aerial Photographs and lateral images provide a good framework for fixing the position of an object spatially, and can (to some extent) help establish the stratigraphic position. Nevertheless, it is good practice to document the relation of the material to the isochronous tuffs or other markers beds, where identified. Even where superior air photos are available, this provides an independent verification of the "lithostratigraphic assemblage" and helps establish chronological context without reference to the imagery, simply from the catalog records. Mylar overlays provide means to document areas that have been examined until the next cycle.

Detailed paleoecological and taphonomic notes following standard formats are probably not necessary (or appropriate) for this project in many instances. Collectors should err on the side of "over-documentation," however, with particularly noteworthy material. All occurrences in situ should be photographed, with a Brunton compass, scale, and field number in the image.
Identification of Quaternary Geomorphic Surfaces using LANDSAT Thematic Mapper Data, Whipple Mountains, Southeast California

R.C. Anderson and K.K. Beratan, Dept. of Geology and Planetary Science, 321 EH, University of Pittsburgh, Pittsburgh, PA 15260, and R.G. Blom, Jet Propulsion Laboratory, MS 183-501, 4800 Oak Grove Drive, Pasadena, CA 91109

Quaternary geomorphic surfaces developed on alluvial fans in the eastern Mojave Desert of California primarily formed in response to major changes in regional and/or local climate. Mapping and correlation of these surfaces can provide insight into the extent and severity of climatic events. Where age control is available, it may be possible to tie these events to the glacial history of the Sierra Nevadas, and perhaps identify the effect of glaciation on the Mojave Desert. Mapping the Quaternary geomorphic surfaces has proven difficult because distinguishing textural and compositional characteristics of these surfaces are visually subtle and commonly disguised by source rock variation. However, the surfaces are clearly distinguishable on appropriately processed LANDSAT Thematic Mapper (TM) images (Anderson and Beratan, 1993); the processes responsible for progressive landscape modification in this semi-arid region produce a distinctive spectral overprint. Analysis of TM data thus is a promising tool for regional mapping and correlation of Quaternary geomorphic surfaces. In this paper, we present results from TM image analysis of the southern Whipple Mountains, southeastern California. The major topographic elements in this area formed during late Miocene extension (Nielson and Beratan, 1995). Since then, an apron of alluvial fan deposits has accumulated along the flanks of the range, and a series of geomorphic surfaces has developed on this alluvial apron.

A LANDSAT Thematic Mapper (TM) scene (40174-177383; Jan. 5, 1983), with each pixel representing a ~28.5 m area, was processed using the "4-component" technique of Crippen (1989a). This process creates an image consisting of two parts: a chromatic component (red-green-blue) containing spectral information and an achromatic (albedo) component containing topographic information. The chromatic component consists of three band ratios [3/1 (blue), 5/4 (green), and 5/7 (red)], chosen for their lack of redundancy and their sensitivity to lithologic changes (Crippen, 1989b, Crippen and others, 1988). The albedo component is an average of bands 1, 3, and 4.

Eight different Quaternary surfaces were identified on the TM image based on spectral signature and surface texture. These surfaces correspond well with surfaces mapped by Dickey and others (1980). Three different surfaces were examined in detail in the field.

(1) Surfaces that are dark green and smooth on image (Q2b of Dickey and others, 1980) display well-developed rock varnish (~1 mm thick) and desert pavement. Clasts are in clast-to-clast contact with each other, with little fine-grained material seen on the surface. Vegetation is scarce.

(2) Surfaces that are yellow and have a moderately smooth texture on the image (Q4 of Dickey and others, 1980) correspond to the modern drainage network, which generally is incised into older deposits. No rock varnish is present, and no desert pavement formation has occurred. The surface consists of clast-supported cobble-pebble bars separated by sand- and gravel-floored channels. The maximum clast size tends to be smaller than on the other two surfaces.

(3) Surfaces that are beige have a rough texture on the image (Q11 of Dickey and others, 1980) and contain neither rock varnish nor desert pavement.
development. Clast-to-clast contacts are common, but patches of finer-grained material are exposed. Vegetation is scarce. This surface type occurs on slopes connecting surface types 1 and 2.

Comparison between the field data and the image suggest that the primary control on spectral signature (color) is the composition of the source rock; for example, alluvial fans derived from Tertiary volcanic rocks are dark blue to purple on the image, and fans derived from Proterozoic granites and gneisses are green. This dominant spectral signature is modified by the development of rock varnish, with the most strongly varnished surfaces gaining a dark green overprint. The texture is controlled by the degree of desert pavement formation and by erosion. Young surfaces are moderately smooth, with relief developed between bar tops and channels. Following abandonment, the surface becomes progressively smoother as desert pavement develops. Older surfaces lose their pavement surfaces to erosion, and the resulting gullies create a rough surface.

Results from the southern Whipple Mountains are being applied to other areas in the eastern Mojave Desert. The ultimate goal of this research is a regional map of Quaternary geomorphic surfaces.

References cited

Conducting Research in National Parks and Wilderness Areas
Richard L. Anderson, Environmental Specialist, Death Valley National Park, CA/NV, USDI, National Park Service, Death Valley, CA 92328

Death Valley National Park hosts about 60 independent research projects each year. Many researchers do not understand the rules or attitudes of the park. This may lead to park losing beneficial research, the research community losing valuable study sites, or the public losing interesting information. I will review national, regional and local research policies of the National Park Service, restrictions on research methods due to park or designated wilderness status, and the California Desert Protection Act implications on desert research.

Fluvial Deposition at the Asphalt Seeps of Rancho La Brea, California
Jeremy Auldaney, 2885 Calle Sausalito, Riverside, CA 92503

The Rancho La Brea asphalt seeps of downtown Los Angeles, California contain the largest, most diverse assemblage of Pleistocene vertebrate fossils in the world. This is due to the unique method of preservation by asphalt impregnation. Supported by observation, conventional theory claims this deposit is the result of herbivorous mammals getting stuck in pools of asphalt, subsequently attracting carnivores and scavengers to become trapped together in masses.

The sedimentological and paleontological evidence for this theory is weak, and could also also indicate a fluvial deposition like other non-asphalt sites. (1) There is lack of a bias for mostly old (weak) or diseased) among the sabertooth cats (Marcus, 1984, p. 178) and horses (Scott, 1989, p. 79). 2) Fluvial processes at La Brea were the same as other non-asphaltic, but fluvial Rancholabrean Land Mammal Age fossil deposits (Jefferson, 1991, pp. 93-99). 3) There are 2% articulated skeletons as well as associated skeletal parts found in a few clearly fluvial deposits at La Brea, which indicate at least some of the mammals were not trapped (Stock, 1992, p. 14; Woodard, 1973, p. 66). 4) Even though most ichnites (fossil tracks) were destroyed by asphalt movement (1 to 2 meters on the horizontal) and by pit excavations, some ichnites should be preserved around the undisturbed edges of the pits under asphalt flows. At McKittrick, a similar asphalt fossil site in Inyo County which is less disturbed, there should also be ichnites. Yet none are reported at either of these asphalt sites (Schultz, 1938), unlike those at other proven trap sites (Agenbroad, 1984, p. 116). 5) No spiral (torque) green-bone fractures in leg bones are found at La Brea, like those found at other proven trap sites. These fractures would be very common
among animals pulling themselves free of asphalt, which would produce even more fractures than mud, as described by Agenbroad (1984, p. 122).

Literature cited

The Mojave National Preserve: What’s in a Name?
Frank Buono, Assistant Superintendent, Mojave National Preserve, 601 Nevada Highway, Boulder City, NV 89005

When Congress established a unit of the National Park System in the eastern Mojave Desert, they entitled it the "Mojave National Preserve." Immediately questions arose about the title "preserve."

When first proposed the Mojave was to be a national park or a national monument. In the process of compromise that characterizes the path to most units of the National Park System, the title of the park was changed to preserve. In reality, the title itself means very little. It is the law that prescribes the kinds of uses that may be permitted in parks, not the title. Congress often decides to entitle a unit based upon the activities Congress has allowed in that unit. Thus, it isn't the title that prescribes the uses, it is the uses that often prescribe the title.

As a general rule, units of the National Park System do not allow recreational or commercial consumptive uses of park resources. No logging, no disposal of Federally-owned minerals, no grazing, no hunting, no rock-hounding. There are situations where pre-existing property rights may allow otherwise prohibited activities, e.g. mining claims in the Wrangell-St. Elias National park in Alaska. Aside from those situations, Congress may authorize, and has authorized, commercial or recreational consumptive uses in a number of National Park system units.

In the Mojave National Preserve, Congress allowed the continuation of the existing grazing privileges. The principal reason why Congress called the Mojave a "Preserve" was because Congress authorized hunting there. Congress is very careful not to call a unit a "National Park" with a capital "P" if hunting is allowed.

The National Park System contains other national preserves. The first date to 1974: the Big Thicket and Big Cypress of Texas and Florida respectively. Congress titled them "preserves" also but that is where the similarity ends. If we compare the authorized uses in Big Cypress with Mojave they have only two things in common. This illustrates the point that the title does not authorize the uses allowed in the unit, but rather that the authorized uses often prescribe the title.

In reality, Mojave is much closer to Death Valley National Park than to Big Cypress National Preserve both geographically and legally. This presentation discusses why.

Miocene Antilocaprid Horn Core Morphology from Barstow, California
Kally Bush, Earth Sciences Section Intern, San Bernardino County Museum, Redlands, CA 92374

Pronghorns have an 18 million year history in North America, but only one species, Antilocapra americana, exists in North America today. Differences between pronghorns during the late Miocene led to the naming of several species and some confusion in regard to morphologies and systematics. Pronghorn fossils from Barstow were described as early as 1919, but description of the species did not occur until 1937. This study of pronghorn antelope horn cores concerns itself with morphology and measurements of specimens from the Barstow Formation. Comparisons were made to specimens from mid-continent and western states. Questions addressed were: Is the morphology of the horn core proportional to the individual's age? Does the morphology change through the stratigraphy? At what age does the burr occur? Do morphometrics indicate one or more species at Barstow? Which existing species name is applicable? At Barstow preliminary results suggest that the burr is present in most or all ages. In adults,
the burrs may be absent due to damage. The morphology and the size of the horn core is directly proportional to the age of the individual. Because recent antelopes migrate to summer and winter ranges, the frequency of antelope size and morphologies might vary with stratigraphy at Barstow. Two species of *Meryceros* may be present at Barstow: *M. joraki* and *M. crucensis*.

**Nurse Plant Associations of the Joshua Tree, *Yucca brevifolia***

James W. Cornell, Palm Springs Desert Museum, 101 Museum Drive, Palm Springs, CA 92262

The Joshua tree, *Yucca brevifolia*, is the most visually distinctive plant occurring in the Mojave Desert. Its relatively large size and varying appearance have made it the focus of much popular writing and commercial photography. Two national parks and three California state parks have been established, in part, to preserve populations of this yucca. Considering the interest shown by the government as well as the public, it is surprising that there has been little formal research conducted on this species. Almost nothing is known of the factors that affect its distribution and abundance.

One of the densest concentrations of Joshua trees occurs on Cima Dome in the Mojave Desert of San Bernardino County, California. Joshua trees can reach densities exceeding 90 plants per hectare on the dome and the populations today seem healthy, with young trees comprising a large percentage of the population.

On the dome, young Joshua trees under one meter in height are invariably found growing up through perennial shrubs. Less than 1% of young trees occur in the open. So predictable is the association between perennial shrubs and young individuals of *Y. brevifolia* that it is tempting to assume that young trees require the perennial shrubs for survival. It should, of course, be mentioned that over 90% of the perennial shrubs do not have young Joshua trees growing up through their foliage, negating any assertion that the reverse situation is the case — that the shrubs require Joshua trees.

Several perennial species serve as Joshua tree nurse plants on the dome including Mormon tea (*Ephedra nevadensis*), Menodora (*Menodora spinescens*), and Mojave Sage (*Salvia mohavensis*). Some desert plants have been shown to require nurse plants for protection from environmental hazards during their first years of existence. The saguaro cactus, *Carnegiea gigantea*, is probably the best known plant exhibiting this phenomenon (Steenbergh and Lowe, 1969). In the case of the saguaro, nurse plants provide insulation from extremes of temperature and some protection from attacks by herbivores. At this time, it is conjecture as to function of nurse plants for Joshua trees on Cima Dome.

**Acknowledgments**

This research was supported by grants to the Palm Springs Desert Museum from Camilla Chandler Frost, Marjorie S. Merwin and Robert Tracy.

**Literature Cited**


**Structure and Tectonics at the South Edge of an Early Miocene Rift Zone, Central Mojave Desert, California***

B.F. Cox, U.S. Geological Society, MS 875, 345 Middlefield Road, Menlo Park, CA 94025

The southern boundary of the central Mojave extended terrane passes through the Newberry Mountains and Rodman Mountains, about 20-35 km southeast of Barstow, California. A new geologic map of this region shows that the boundary consists of two overlapping sets of east-trending structures that formed under changing tectonic conditions. The dominant structure is a north-dipping major transfer fault that separates a hanging wall of extended lower Miocene (23-19 Ma) continental sediments and volcanic rocks from a footwall of comparatively unextended Mesozoic igneous rocks. This feature corresponds in principle to the Kane Springs fault of previous workers, but its mapped position is significantly revised. The trace of the fault lies north, rather than south, of a large ridge of basement rocks at the southeast end of the Newberry Mountains. West of there, the fault is overlapped by strata deposited near the top of the lower Miocene succession. A linear aeromagnetic anomaly apparently tracks the buried fault about 20 km westward to the Lenwood fault.

New evidence shows that rocks in the hanging wall of the Kane Springs fault were moved eastward and rotated clockwise with respect to footwall rocks. Masses of Miocene avalanche breccia at the southeast end of the Newberry Mountains lie about 6-10 km east of their likely basement source rocks exposed at the west end of...
the Rodman Mountains. A maximum right-lateral displacement of about 20 km on the Kane Springs fault is implied by blocks of leucocratic granite in the northern Newberry Mountains, which may have been offset from similar rocks exposed near Stoddard Valley. Mesozoic dikes intruding granitic rocks in the Newberry Mountains and on neighboring ridges to the west generally trend northeast, whereas similar dikes in nearby ranges south of the Kane Springs fault mainly trend northwest. Combined with other structural and paleomagnetic evidence, the misaligned dikes suggest that hanging-wall rocks were rotated clockwise as much as 90 degrees during rifting. Rotation may have been accomplished by oroclinal bending or by pivoting of fault-bounded blocks. In either case, the rotation may account for the limited lateral displacement of the Kane Springs fault as compared to very large slip on the Waterman Hills detachment fault north of Barstow. The existence of a major transfer fault north of the Newberry Mountains (hypothetical Mojave Valley fault of previous workers) is doubtful. The Waterman Hills detachment fault probably extends southeastward in the subsurface to connect with the Kane Springs fault, thus forming a lower boundary to rifting in the Newberry Mountains and adjacent ranges. However, contrary to a previous interpretation, there apparently are no detachment faults exposed in the Newberry Mountains.

A younger set of right-lateral oblique-slip faults, here termed the Sheep Spring fault system, is superimposed along the trend of the Kane Springs fault, locally intersecting and deforming it in the southeastern Newberry Mountains. Faults of the Sheep Spring system mainly dip southward in opposition to the older north-dipping fault. They bound the south side of the basement ridge at the southeast end of the Newberry Mountains, and they border the north side of a south-facing homocline of steeply dipping lower Miocene strata across the south flank of the range. The fault system and associated homocline apparently developed by oblique-slip transfer faulting during a terminal phase of rifting, when the extended crust of the Newberry Mountains was rebounding relative to unextended areas to the south. The new mapping does not support either of two alternative hypotheses that have ascribed the homocline to reverse-drag folding during extension or to buckling under north-south contraction.

The following page contains information about the Paleontological Excavation Techniques: Robbins Quarry, Barstow Fossil Beds. The paper discusses the excavation process at the Robbins Fossil Quarry near Barstow, with details on the techniques used, the context of the excavation, and the location of the fossils found. The paper is part of the 1996 Desert Research Symposium.
and any other appropriate point. Plaster jackets containing bone concentrations were assigned coordinate pairs at four different points to position the jacket within the grid. After the item was recorded and removed, it was wrapped in fossil-wrapping paper (FWP), taped, and bagged; the specimen field number was written on the bag.

Taphonomic data were obtained during the excavation process and could be developed daily. This allows descriptions of bone concentrations from an individual, spatial distribution, and transportation direction data to be produced. Other pertinent information such as bone breakage (fresh vs. dry bone), bone abrasion, crazing, cracking, gnaw marks and puncture marks can be obtained after specimens are cleaned in the laboratory. Conservation of bones begins in the field with the use of water to break down clays to facilitate removal. Hardeners are used to preserve integrity of bones and fix any fractures that occur during removal. In the laboratory, conservation continues with the cleaning, gluing and final identification of each specimen.

During excavation, the site was maintained by daily cleanup. At the end of the field season, the site was reburied and the area restored to an apparently undisturbed condition. Specimens were returned to the paleontology laboratory at the SBCM for preparation, identification, and curation. The inventory and accession list was finalized, entered into the repository’s records, and submitted with a report to the BLM. Specimens are stored for future research.

Natural History of Three New Intertidal Side Blotch Lizards from the Gulf of California, Mexico
L. Lee Grismer, Department of Biology, La Sierra University, Riverside, CA 92515-8247

Three newly described side blotched lizards, Uta louei, U. tumidarostra, and U. encantadai from the Islas Encantadas Archipelago in the northern Gulf of California share a number of unique adaptations allowing them to exploit an insular, intertidal habitat. The most significant adaptation is a hypertrophied nasal salt gland which acts as an extrarenal organ presumably allowing them to maintain an electrolyte balance. This is especially critical because the majority of their diet consists of the marine isopod Ligia octocentalis whose tissue concentrations of salt may be higher than that of the surrounding sea water. An intertidal life style for these lizards is likely the result of habitat alteration of inland areas by sea birds which use these islands as breeding rookeries. As such, most of the islands are caked in bird guano, altering the soil concentration to such an extent that plants will not grow. With an absence of primary production in inland areas, lizards are restricted to forage for food in the intertidal zone.

The Occurrence of Sauromalus varius on a Satellite Islet of Isla Salsipuedes, Gulf of California, México
Bradford D. Hollingsworth,1 Clark R. Mahrdt,2 L. Lee Grismer3 and Benjamin H. Banta4

A new population of Sauromalus varius is reported from a small satellite islet of Isla Salsipuedes in the Gulf of California, México. Previously, this species was known only from Isla San Esteban. Various reports list the occurrence of S. varius on two additional islands; however, one locality is unconfirmed and probably erroneous, while the second represents a hybrid complex of three different chuckwalla species. Individuals from the new locality are compared morphologically to S. varius from Isla San Esteban and variation in meristic scale counts overlap greatly. The lack of morphological divergence suggests that the Isla Roca Lobos population may have had a recent origin and based on the island’s geographic location it is unlikely the colonization was a natural event. In light of the current endangered status of S. varius, this newly discovered population plays an important role in the conservation and management of the species.

1 Dept. of Natural Sciences, Loma Linda University, Loma Linda, CA 92350
2 Southwest Biological Associates, 9847 Willow Lane, Escondido, CA 92029
3 Dept. of Biology, La Sierra University, Riverside, CA 92515

Differences in Invasion Rates of Yucca Weevils in Two Variants of Yucca whipplei
Travis E. Huxman, California State University San Bernardino, 5500 University Parkway, San Bernardino, CA 92407-2397

Two variants of Yucca whipplei were found to have
significant differences in height, dry weight, volume and surface area of inflorescence. *Yucca whipplei* var. *whipplei* was significantly larger in all characteristics measured compared to *Yucca whipplei* var. *caespitosa*. Differences in the number of yucca weevils, *Scyphophorus yuccae*, which invade, consume, and reproduce in the inflorescence of *Yucca whipplei*, occur between the two populations of variants. Some aspect of these reproductive characteristics may be influencing the number of weevils which invade the plant. The yucca may allocate resources differently in the two variants in order to protect the inflorescence. This may be a behavior difference imposed by different environmental conditions or life history differences which suggest the two varieties are not closely related.

**Late Blancan Acinonyx (Carnivora, Felidae) from the Vallecito Creek Local Fauna of Anza-Borrego Desert State Park, California**

G.T. Jefferson, Anza-Borrego Desert State Park, 200 Palm Canyon Drive, Borrego Springs, CA 92004 and A. Tejada-Flores, George C. Page Museum, 5801 Wilshire Blvd., Los Angeles, CA 90036

Material referable to the genus *Acinonyx*, from the Anza-Borrego Desert State Park, represents the first record of the North American cheetah (Martin and others, 1977; Adams, 1979) in the Pliocene or Pleistocene of California. The specimens, an associated left proximal radius and ulna and isolated podial and metapodial fragments, were recovered from the upper Tapiado and overlying, lower Hueso members of the Palm Spring Formation (Woodard, 1963) in the Vallecito-Fish Creek Basin. This portion of the Palm Spring Formation, which yields the Vallecito Creek Local Fauna (Downs and White, 1968; White and others, 1991) records a transition from paraliminitic to fluvial/flood plain depositional environments (P. Remelka, pers. comm., 1994). Here the strata fall within the lower Matuyama Chron (Opdyke and others, 1977) and are about 2.3-1.9 ma BP, or late Blancan in age (Lindsay and others, 1987; White and others, 1991; Lindsay and White, 1993).

Temporally correlative vertebrate fossil assemblages in the southwestern U.S. include Curtis Ranch, Arizona, and Bautista and Murrieta, California (Lindsay and others, 1987; Repenning, 1987; Reynolds and Reeder, 1991; Reynolds and others, 1991). The age of the material falls within the established range of *A. studeri* (Kurtén and Anderson, 1980). However, the lack of diagnostic cranial or more complete post-cranial specimens precludes a specific assignment.

**Literature cited**


**Geomorphology of the White Fir - Pinyon Woodlands in the Clark, Kingston, New York and Spring-Potosi Mountain Ranges, Eastern Mojave Desert, California and Nevada.**

William V. Jones, 954 South Briargate Lane, Glenwood, CA 91740-4705

Rocky Mountain white fir (*Abies concolor*) [Gord. and...
Glend.) var. concolor) persists as the last component of montane coniferous forest in the eastern Mojave Desert. The relict fir, in association with pinyons (Pinus monophylla Torr.), form an areally restricted woodland community in the Clark, Kingston and New York Mountain ranges in California and Potosi Mountain in Nevada.

White fir's adaptation and survival under adverse desert conditions involves many factors, including climate, physiology, vegetation, soils, geomorphology and reproductive patterns. Complex interactions among these factors or controls sustain white fir populations in this environment. This paper discusses white fir-pinyon woodland geomorphology. Geomorphic controls, such as amphitheaters, high ridges and cliffs, outcrops and talus slopes sustain the white fir-pinyon woodlands of the eastern Mojave Desert.

Previous white fir-pinyon woodland research was floristic in nature, including the mention of a few beneficial climatic and geomorphic factors. Other works discussed both the geology and geomorphology of the white fir-resident ranges. Yet landforms specific to the white fir-pinyon woodland community, including overall interactions and importance, have not been fully described.

Material for this paper was drawn from field notes and other research, conducted as part of the author's M.A. thesis project, on the phytogeography of the lower white fir-pinyon to pinyon-juniper woodland transition in the Clark, Kingston, New York and Spring-Potosi Mountain ranges. The degree was awarded at California State University, Los Angeles, in 1994.

**Marmota flaviventris from Devil Peak Cave, Southern Nevada**

Kyle Karnes and Robert E. Reynolds, *Earth Sciences Section, San Bernardino County Museum, Redlands, CA 92374*

Devil Peak Cave is located at an elevation of 1097 m in the eastern Clark Mountain Range, 6.4 km north of where the California/Nevada state line is intersected by Interstate 15. Preliminarily, this site has produced 21 different taxa. Based on the presence of Nothrotheriops, Camelops, and Marmota, the age appears to be late Rancholabrean. Devil Peak Cave is unique because it has produced a relatively complete skeleton of Nothrotheriops shastense. The cave has yielded an abundance of juvenile and adult, small and large birds, including raptors, as well as egg shell. This site has also produced what may be the first articulated skeleton of *Marmota flaviventris*. This specimen is 73 percent complete.

Near the Nevada border in California, Kokoweef and Antelope Caves, elevation 1768 meters, have produced *Marmota flaviventris*, Ammospermophilus leucurus, and Ochotona princeps. Newberry Cave, in central San Bernardino County, elevation 730 meters, has yielded *Marmota flaviventris*, Ammospermophilus leucurus, and Nothrotheriops shastense. Neither Newberry Cave nor Devil Peak Cave has produced pika.

Marmots are known from the Miocene Clarendonian through the Holocene of North America. They depend upon rainy conditions in rocky, brushy, and arboreous areas where well-drained soil is suitable for burrowing (Kurten and Anderson, 1980). The five modern species are found in all but six of the contiguous states in the U.S.: Arizona, Texas, Oklahoma, Louisiana, Mississippi, and Florida. The Ice Age range occupied much of the west coast and southwestern states. Today, the closest *Marmota flaviventris* lives in the White Mountains northwest of the Clark Mountain Range at an elevation of 3658 m.

**Analysis of a Survey for Desert Tortoise (Gopherus agassizii) on the North Alvord Slope, San Bernardino County, California, Using a Geographic Information System (GIS)**

Jeffery S. Kaufmann, Ph.D., Chambers Group Inc., P.O. Box 67002, Irvine CA 92619-7002, and Irvine Valley College

As part of its effort to gather data on desert tortoise (*Gopherus agassizii*) along its southern border, the National Training Center at Fort Irwin contracted Chambers Group, Inc., to perform a population study of species in a region of approximately 70 square miles. The site, located northeast of Barstow, San Bernardino County, reportedly supports a large desert tortoise population. To complete the 2-year study, Chambers Group, in conjunction with university researchers, developed and implemented a survey protocol that coupled field transect surveys with a Geographic Information System (GIS). The field surveys resulted in spatially arrayed data on desert tortoises, as well as plant dominance, soil types, vegetation communities, and...
physiography. In addition, aerial photographs were analyzed for perennial vegetation and soil disturbance, and satellite imagery was obtained for data on soil chemistry and surface geology. Geostatistical and classification tree analyses were performed on the resultant GIS data-layers to validate the ecological modeling of desert tortoise habitat on the study plot. The results of the study provide a model for future habitat assessments, as well as insight into the management of the large-scale, spatially arrayed data sets. In addition, the importance of geostatistics, remote sensing, and the traditional field survey is discussed.

Late Pleistocene and Holocene Eolian Activity in the Mojave Desert: A Tentative Chronology from Luminescence Dating

Nicholas Lancaster, Desert Research Institute, University and Community College System of Nevada, P.O. Box 60220, Reno, Nevada 89506, Ann Wintle and Michèle Clarke, Institute of Earth Studies, University of Wales, Aberystwyth, U.K., Helen Rendell, Geography Laboratory, University of Sussex, U.K., and Vatché Tchakerian, Department of Geography, Texas A&M University.

Eolian deposits and landforms are widespread in the Mojave Desert, and evidence indicating that eolian activity has been both more extensive and more intense than it is at present occurs throughout the region. The timing of these episodes of enhanced eolian activity is, however, poorly constrained. Thermoluminescence (TL), optically stimulated luminescence (OSL) and infrared stimulated luminescence (IRSL) dating techniques can provide the means to develop a chronology of periods of eolian activity and dune formation by measuring the time since burial of sediments and/or stabilization of areas of dunes.

We report here our initial attempts to develop a luminescence-dated chronology of eolian depositional episodes in the region and discuss its paleoclimatic implications. We identify two major depositional episodes in the past 40 ka: (1) Late Pleistocene (30 - 20ka), and (2) Latest Pleistocene to Early Holocene (15ka - 7ka). Significant periods of Holocene eolian deposition occurred approximately 7 - 5ka, around 4ka, 2.3 - 1.4 ka, and 0.2 ka. Dunes at Kelso were reworked 0.8 - 0.4 ka.

There was a major change in the eolian depositional environment in the Mojave Desert during the early Holocene. Prior to this time sediment supply from fluctuating lakes was apparently sufficient to promote the accumulation of large climbing and falling dunes, even in relatively mesic climates compared to today. After the desiccation of the region in the latest Pleistocene and early Holocene, no further sediment was available from lacustrine sources. Many of the sand ramps ceased to accumulate after around 8 ka. Later Holocene eolian activity was apparently restricted to the major dune fields (e.g. Kelso) and to areas of active sediment supply (the Cronese Basin). Periods of late Holocene dune stabilization occurred in cooler and wetter climates than today. Increased runoff at these times provided sediment for subsequent episodes of dune formation.

Phytoliths of Mojave Desert Soils and Plants

Elizabeth J. Lawlor, Department of Anthropology, University of California, Riverside, CA 92521

Phytoliths (literally "plant-stones") are microscopic silica bodies formed in plants, with characteristic shapes which are largely under genetic control. Since they are inorganic, they tend to be preserved under conditions that destroy seeds and pollen, and thus make a valuable complementary data set for investigating past environments and identifying plants used by prehistoric people (Piperno, 1988; Pearsall, 1989).

I extracted phytoliths from replicates and separate parts of 7 grasses, 6 members of the Agave family, 11 species in 8 dicot families, and 4 gymnosperms. Unfortunately, two key indicators of Mojave Desert vegetation (Larrea tridentata, creosote, and Ambrosia dumosa, white bursage) were found not to produce any distinctive phytoliths. However, two plants did yield phytoliths that are potentially diagnostic below the family level: Oryzopsis hymenoides (ricegrass), with a possibly distinctive short-cell assemblage, and Yucca, with possibly distinctive silicified xylem.

Previous research in other regions indicates other plants that are distinguishable or are likely to be distinguishable in soil samples in the Mojave, including the Poaceae (grass family), Cyperaceae (sedge family), Asteraceae (sunflower family), Boraginaceae (borage family), and Pinaceae (pine family). I found many grass, sunflower-type, and borage-type phytoliths in the more than 50 surface soil samples I examined from the UC Granite Mountains Natural Reserve. I also found a variety of kinds of "jigsaw-puzzle piece" phytoliths in various soil samples. The origin of these is presently unknown, but in other regions they occur in woody

- 35 -
and herbaceous dicots (Bozarth, 1992), and they may prove to be distinctive to the level of genus or species. Further reference work is planned.

Literature cited

**Technological Innovation and Impact: Fulcrum-aided Pressure Flaking**

David E. Lepcog, 8149 Münstead, Hesperia, CA 92345

Replicative studies aid archaeologists in efforts to interpret materials recovered. Often ethnographic analogies and circumstantial evidence are supported by this type of research. This is especially true when dealing with the lithic production technologies of the early fluted point and parallel-flaked point traditions (Crabtree 1966; Flenniken 1978; Callahan 1979).

Investigations of these traditions have been conducted for several reasons. The origins of the fluted point traditions are in North America (Sellards 1952; Wormington 1957; Krieger 1964). The fluted point tradition represents one of the earliest and most widespread bifacially-flaked traditions of this continent. Most archaeologists believe that the parallel-flaked traditions had their origins in the earlier fluted point traditions (Haynes 1954; Agogino 1963; Wormington 1947). Previous methods demonstrated (Crabtree 1966; Flenniken 1978) to reproduce these point styles exhibit unacceptable failure rates, and do not fully explain aspects of flake removal patterns.

My experimentation in the various techniques that may have been used by prehistoric people in producing these enigmatic stone tools has led to the development of an alternate theory. This theory proposes that the appearance of more finely-flaked bifacial point styles in North America near the end of the Pleistocene was due to a technological innovation in flint tool production technology.

This technological innovation can be called fulcrum-aided pressure flaking. This simple improvement in technique involves the application of the principles of leverage when applying pressure flaking techniques. The evidence of this technological improvement is seen through the analyses of the flake removal patterns found on projectile points from the fluted and parallel-flaked traditions.

The implications of this technological development are far reaching. Using this technique, bifacially flaked tools could be made more quickly and with greater assurance of success. Because of these factors, the people who possessed this knowledge would have had great competitive advantage. These groups would have had at their command an abundance of finely-flaked stone tools. This surplus may have sparked experimentation in other technologies such as improvements in projectile point forms, delivery systems and even procurement strategies.

With the success achieved by perfecting this technology, a connection between experimentation and benefit may have been recognized by these early groups. The success of these technologically dependent groups would not have been overlooked by their competitors. Cultural diffusion of this technology may have led to the widespread experimentation in projectile points found in the Archaic.

Literature cited

**Drought Tolerance of Leaves from Plants Exposed to a Global Warming Manipulation in the Rocky Mountains of Colorado**

Michael E. Loik, Department of Biology, California State University, San Bernardino, CA 92407

Drought tolerance was compared for leaves of Artemisia tridentata, Festuca thyurberi and Potentilla gracilis exposed to a global warming manipulation at the Rocky Mountain Biological laboratory, near
Crested Butte, CO. Leaves of the three species were collected from plants growing in situ in heated and control plots, then dried for various periods of time up to 24 h. Tolerance was compared in terms of reduction of relative water content, change in water potential, and changes in chlorophyll a fluorescence quenching kinetics. Relative water content decreased by about 80% for F. thurberi and P. gracilis, but by less than 50% for A. tridentata. Also, plants from heated plots lost water faster than controls for F. thurberi and P. gracilis; for A. tridentata the opposite was true. Water potential for both control and heated-plot leaves decreased below -10 MPa after 24 h drying for F. thurberi and P. gracilis; water potential for A. tridentata decreased little and averaged -2.0 MPa. Quenching of chlorophyll a fluorescence was abolished for F. thurberi and P. gracilis leaves after 8 h drying, and there was little difference between heated and control leaves. Quenching decreased for A. tridentata, but was slower for leaves from heated plots. Leaves from A. tridentata may be better adapted than F. thurberi and P. gracilis to a drier climate in the Rocky Mountains under global warming.

Unique Features of Envenomation by the Mojave Green Rattlesnake (Crotalus scutulatus)
Terry K. Merkin, M.D., M.P.H., Clinical Faculty, UCLA School of Medicine, and Kaiser Permanente Hospital, 9961 Sierra Ave., Fontana, CA 92335

Envenomation by rattlesnakes found in the southern California ecosystems will be compared and contrasted. A slide presentation case report of a snakebite involving the Mojave green rattlesnake will be delivered. Other Crotalidae discussed will include sidewinder (Crotalus cerastes), western diamondback rattlesnake (Crotalus atrox) speckled rattlesnake (Crotalus mitchellii), and the southern Pacific rattlesnake (Crotalus viridis helleri).

Neotectonics of the Ivanpah Valley – Cima – Mid Hills area, Mojave National Preserve, California
David M. Miller and Robert C. Jachens, U.S. Geological Survey, 345 Midfield Road, Menlo Park, CA 94025

Late Cenozoic faults cut rocks and sediment as young as Quaternary in the eastern part of the Mojave National Preserve, including the area of the New York Mountains, Ivanpah Valley, Cima Dome, Kelso Wash, and the Mid Hills. Young structures are defined by the following criteria: 1) mapped faults that cut young materials, 2) sedimentary basins filled with young deposits, including those basins defined by gravity studies, and 3) topographic relief in excess of that expected from the observed rock materials and estimated erosion rates. Structures defined by these criteria, together with neotectonic patterns defined by geomorphic features such as tilted pediments, provide information on the late Cenozoic tectonics of the region.

The largest fault system is the Nipton fault zone, a broad zone of faults and breccia that strikes southwest from near the town of Nipton to Cima, and probably beyond as far as the Kelso Dunes. The fault has about 15 km of sinistral offset, and probably underwent multiple movements during the middle Miocene to Pliocene or early Quaternary. Small sedimentary basins lie close to the fault zone near the town of Nipton. One basin contains breccia sheets interlayers with middle Miocene andesite, suggesting fault activity at the time of eruption. Two of the basins contain unconsolidated gravel with little volcanic material, suggesting that they post-date middle Miocene volcanic eruptions in the area. West of Cima, a fault splay bounds a small basin of unconsolidated gravel. A large gravity low near Ivanpah Lake indicates low-density sedimentary materials 2.5 km thick and two smaller lows near Kelso indicate materials about 1.5 km thick for each. Two of these lows correspond to topographic lows, suggesting recent downwarping. In many places, the east sides of these gravity lows correspond to a steep escarpment that bounds the west side of the New York Mountains, Mid Hills, and Providence Mountains. Even with slow rates of erosion in the desert, this topographic escarpment is unlikely to be more than a few million years old. Although much of the movement on the Nipton fault zone may have been Miocene, these combined features...
suggest that activity has continued along the general trend of the Nipton fault zone into Pliocene or Quaternary time.

The Cedar Canyon fault extends along the north margin of the Mid Hills from Cedar Canyon to the mouth of Caruthers Canyon. The fault cuts units as young as early Quaternary and appears to be a normal fault, with greater than 50 m separation down to the south. Although the fault may have one small sedimentary basin associated with it, it appears to be a relatively small fault within a larger neotectonic block.

Several large upland geomorphic features in the Cima Dome and Mid Hills areas seem to be Miocene or older. Peach Springs Tuff was deposited at about 18.5 Ma on a pediment similar to the present surface on the southeastern side of Cima Dome, suggesting that some of that dome may have formed no later than the early Miocene. A gently sloping pediment extends from the south side of the New York Mountains, through the Mid Hills, and south to I-40. Peach Springs Tuff was deposited on part of the pediment and the 16 Ma Wild Horse Mesa Tuff blanketed much of the surface. The Wild Horse Mesa Tuff thins southward, in the present down-slope direction, suggesting that the middle Miocene surface sloped gently north and was subsequently tilted to the south. Tilting took place before coarse alluvial material was shed southward in Pliocene or early Pleistocene time.

Topographic relief adjacent to the northern Ivanpah Valley, such as the western escarpments of the Lucy Gray Range and McCullough Mountains, is much greater than in the southern Ivanpah Valley and other valleys of the National Preserve. Neotectonic features, such as steep mountain fronts, steep alluvial fans, and asymmetric valleys, coincide with the greater relief of the northern Ivanpah Valley, which indicates that tectonism is more active to the north. The northern area is presently undergoing extension as part of the northern Basin and Range province, while the southern area is part of the relatively stable eastern Mojave tectonic block.

Although the expression of latest Cenozoic tectonic features in the Mojave National Preserve appears to be subdued compared to large normal fault offsets of the northern Basin and Range province and the strike-slip faults of the central Mojave Desert, the area has undergone tectonic activity since Miocene large-scale extension and volcanism of the nearby Colorado River corridor. The late Cenozoic features of this region we suspect collectively resulted in north-south shortening and east-west extension. The tectonic features may result from small adjustments as boundaries with more active adjacent provinces change shape, requiring the eastern Mojave tectonic block to deform. Alternatively, the features may indicate a few large structures of this age that contrast with those in other tectonic provinces not in size but in number.

U. S. Geological Survey Participation in a California Desert Ecosystem Project

Douglas M. Morton, U.S. Geological Survey, Department of Earth Sciences, University of California, Riverside, CA 92521

A workshop was held between the Department of Defense and Department of the Interior to initiate a study of the “California Desert Ecosystem.” The desert area under consideration extends from the northern border of Death Valley south to the U.S.-Mexico border and east to Lake Mead.


A series of meetings will be held to establish priorities for a long-term balanced research program to best understand the “California Desert Ecosystem.” The land managers (DO, BLM, and NPS) agree that the first priority is to complete an inventory of what data/reports currently exist for the California desert area. This annotated spatial-based inventory will be in a searchable electronic form. The second priority is a desert-wide surficial materials map to be closely followed by a vegetation map. The USGS will provide as part of the inventory “base map” data such as DEMs and DLGs, surface water, ground water, geologic, and paleontologic data bases. In addition, the USGS will propose a prototype data management system. Data bases will be updated as required and maintained by the DOI organizations that provided the initial inventory. The data system will probably not be centralized but more likely will be a distributive system utilizing the World Wide Web.
Current Status of SCAMP – the Southern California Areal Mapping Project


SCAMP is a multidisciplinary geological-geophysical cooperative mapping project between the U.S. Geological Survey and the California Division of Mines and Geology. The area currently included in SCAMP is 28 1:100,000-scale quadrangles covering most of southern California. Final SCAMP products for each 1:100,000-scale quadrangle will be a series of digital maps constituting a folio. Maps for each folio will consist of basic geologic, fault-seismicity, isostatic gravity, residual magnetic, physical and chemical properties maps. For populated and critical geologic areas, the geologic mapping is conducted and digitized at 1:24,000; for more remote areas much of the geologic mapping is conducted at 1:62,500 or 1:100,000 and digitized at 1:100,000.

While phasing into digital, maps have been released in conventional analog form. Released open-file maps include geologic compilation for five 1:100,000-scale quadrangles, including El Cajon, Long Beach, San Diego, Santa Ana, and Santa Maria. In addition, geologic mapping has been completed for approximately 50 7.5’ quadrangles. Digitization is complete for the Santa Maria quadrangle and nearing completion for the San Diego and Santa Ana Quadrangles. Digital isostatic gravity and residual magnetic maps have been released for the Victorville, Santa Ana, Palm Springs, Oceanside, and Borrego Valley 1:100,000-scale quadrangles and isostatic gravity maps for the San Diego and El Cajon quadrangles.

In the desert areas, detailed geologic mapping is currently being conducted in the Lancaster, Victorville, Newberry Springs, San Bernardino, Palm Springs, Borrego Valley, Big Bear Lake, Salton Sea, Eagle Mountains, and El Centro 1:100,000-scale quadrangles.

Evidence for Post-Miocene Uplift of the Castle Mountains and Piute Range, Mojave National Preserve, California

Jane E. Nielson, U.S. Geological Survey, 345 Midfield Road, Menlo Park, CA 94025

Locally-erupted volcanic rocks of Miocene age form the skyline and dominate outcrops of the Castle Peaks, Castle Mountains, and Piute Range, in northeastern San Bernardino County and adjacent parts of Nevada. The roughly coeval volcanic sequences are distinctive to each of the ranges: the Castle Peaks sequence comprises piles of coarse volcanic breccia, the Castle Mountains sequence is dominated by light-colored rhyolite flows, tuff, and intrusive domes, and the Piute Range sequence is composed mostly of dark flows and breccia intruded by myriad dikes, sills, and domes. Upper Miocene gravel deposits overlie the Castle Peaks and Castle Mountains sequences on an angular unconformity and interfinger with the uppermost Piute Range volcanic flows, which were erupted 8 to 10 m.y. ago. The preponderant clasts in the gravel unit are rounded cobbles of gneiss and granite, and chert-bearing Paleozoic limestone is common; clasts from the locally-erupted volcanic sequences generally are much less abundant. The Castle Peaks sequence dips gently SE, whereas most dips in the Castle Mountains are moderate (generally 45° or less) to the W and NW. Dips in the eastern Castle Mountains and Piute Range are generally gentle, and may be W or E locally. The volcanic rocks and upper Miocene gravel unit are cut by faults that mostly strike N and NE, rarely NW, and generally dip steeply. Rocks that show the greatest amount of tilting were erupted between 18.5 and about 14 m.y. ago, coincident with at least one event of extreme extension in the nearby Eldorado and Newberry Mountains. However, uplift of the Castle Peaks, Castle Mountains, and Piute Range probably postdated Miocene volcanism and extensional faulting, as indicated by three lines of evidence.

1) Cobble of Paleozoic limestone and Mesozoic granite of the Teutonia batholith are found in exposures of upper Miocene gravel south of the Castle Peaks and in the central Castle Mountains; the closest and most likely sources of the clasts are in the Mescal Range to the northwest and the New York Mountains to the southeast. Transportation of clasts from that area into the Castle Mountains requires a drainage that flowed generally north and
east in late Miocene time. Reorientation of the drainage to the present southeast trend probably was accomplished by post-Miocene faulting and uplift in the area of the Castle Peaks and Castle Mountains.

2) Piute Range flows form a linear buttress on the east side of Lanfair Valley that probably was fault-controlled; in late Tertiary (Pliocene) and early Quaternary time, thick playa deposits accumulated against this buttress. Mixed playa and tufa deposits formed in about the same time frame at another linear buttress of offset pre-Miocene rocks (also down on the west) on the east side of the Piute Range.

3) Two east-trending canyons cut across the Piute Range; these probably represent superimposed late Miocene drainages that became entrenched during uplift and reorientation of the drainage in the late Tertiary, and probably continued into Quaternary time.

The Mojave Rattlesnake in the Eastern Mojave Desert of California

William L. Rader, 808 Fourth Street, #315, Santa Monica, CA 90403-1231

Four species of rattlesnakes inhabit the eastern Mojave Desert: the western diamondback rattlesnake, *Crotalus atrox*; the sidewinder, *Crotalus cerastes*; the speckled rattlesnake, *Crotalus mitchelli*; and the Mojave rattlesnake, *Crotalus scutulatus*. Each of these species can be differentiated by color, pattern, and sculation. While each species has a distinctive set of habitat requirements, they cannot be diagnosed on the basis of environment. The western diamondback rattlesnake, the sidewinder, and the Mojave rattlesnake all frequent a variety of lowland habitats, some of which may be shared. Moreover, elevation cannot be used as a reliable indicator of species. While the speckled rattlesnake is primarily an inhabitant of rocky or mountainous terrain, the Mojave rattlesnake, generally regarded as being a lowland form, has been reported at altitudes of up to 4,950 feet in the Providence Mountains.

The importance of species identification, particularly of the Mojave rattlesnake, is critical. Whereas the western diamondback rattlesnake, the sidewinder, and the speckled rattlesnake all possess venoms that are largely haemotoxic an break down components of the circulatory system, recent research has shown that populations of the Mojave rattlesnake inhabiting Southern California produce a venom that is primarily neurotoxic. This neurotoxin, termed Mojave toxin, which consists of a lethal protein, has been found to be especially virulent and fast-acting. Envenomation in humans may produce less severe immediate local effects at the site of a bite; however, a later, more extreme systemic reaction, notably respiratory distress, may result. Envenomation can further lead to respiratory or cardiac arrest. Therefore, it is important for people who use the eastern Mojave Desert — residents, health-care providers, recreationists, utility workers, government employees — to familiarize themselves with this snake, particularly as distances to adequate medical care in the region may be great. The safest way to interact with a rattlesnake is simply to leave it alone.

Habitat and Terrain Use Analysis of Desert-dwelling Mountain Sheep in the Anza Borrego Desert

Jennifer L. Rechel, Department of Earth Sciences, University of California, Riverside, CA 92507, and California Department of Fish and Game, 1416 Ninth Street, Sacramento, CA 94244

Spatial relationships between habitat and terrain variables were examined for modeling distributions of desert-dwelling mountain sheep (*Ovis canadensis cremnobates*). This sub-population of sheep inhabit the Anza Borrego Desert of eastern San Diego County, in southern California. Their population was estimated at 1,100 in 1979 and has since declined to an estimated 470 animals in 1992. Therefore, public agencies and groups proposed that this population be listed under the Federal Endangered Species Act. Many factors interacted to cause this relatively rapid population decline. They include diseases, high mortality, low recruitment, habitat degradation and loss, and limited access to predator-safe terrain sites.

Mountain sheep radio telemetry data were collected monthly from 1992 to the present and processed in a Geographic Information System (GIS). Habitat and terrain maps were analyzed in the GIS to enable testing of a model that included these environmental components as spatially explicit. I tested the hypotheses that sheep use of vegetation was not significantly different from availability and that sheep were not distributed in proportion to terrain classes. Results show that mountain sheep selected "high desert" vegetation types and avoided "low desert" vegetation types.
Also, they selected steep terrain and avoided flat areas. Additional spatial and multivariate analysis will further improve the predictive value of this model.

The Long Outreach of the Devil Peak Sloth

Robert E. Reynolds, Section of Earth Sciences, San Bernardino County Museum, Redlands, CA 92374

Twenty thousand years ago, a shasta ground sloth (Nothrotheriops shastensis) met its death in a pit cave in the southern Spring Mountains, south of Devil Peak. With this sloth accumulated the remains of artiodactyls, an articulated marmot, an articulated vulture, bird eggs, and thousands of other fossils. First discovered by the Archae Nevada volunteer group in 1990, the fossil remains from Devil Peak Cave prompted volunteer outreach programs that would last for more than five years. The Las Vegas area Bureau of Land Management (BLM) entered into a mutual assistance program with the San Bernardino County Museum (SBCM) to salvage the sloth. Entitled “Partners in the Past,” the program was coordinated through the BLM Area Archaeologist and the Museum Curator. The program involved several phases: (1) field salvage, (2) preparation and identification, (3) replication of sloth remains for exhibit, and (4) research and analysis of additional fossils. Most of the work in this program has been carried out by SBCM Earth Science volunteers.

Detailed excavation at the cave was undertaken after scaffolding was hauled by hand over a mile of terrain. 15,000 pounds of fossiliferous matrix were processed on site through 1/8-, 20-, and 30-mesh screens, and the concentrate was hauled a mile back to the vehicles. At the Museum, the fossiliferous matrix was water washed and manually sorted by volunteers. Other volunteers prepared the sloth and large mammal bones.

Professionals in fossil replication volunteered instruction in the art of mold making. The replication of each bone involved at least 12 steps for a two part glove mold, including hardening and sealing, clay collar manufacture, silicone rubber application, silicone caulk applications, resin support applications, and replication with resin. After anatomy lessons and false starts, the prototype sloth took its outreach posture: erect on hind feet, leaning on a yucca, reaching outward toward the viewer. With the prototype a “go,” the master replica was erected over its steel support.

Meanwhile, research continues on the cave faunas, stored stratigraphically in the Museum collections. Abundant bones from the cave are being used to train volunteers in comparative osteology. A high school intern has completed a paper on an exceptionally complete, articulated marmot from the cave. Volunteers have developed a traveling poster depicting their replication of the sloth. Never did we think that one sloth could teach so much — particularly patience.

GPS, A Structured Data Acquisition Tool for GIS

James J. Rickard, Ph.D., Technical Consultant to Anza-Borrego Desert State Park, 200 Palm Canyon Drive, Borrego Springs, CA 92004

Global Positioning Satellite receivers provide quick and reliable means of acquiring three-dimensional location information in the field. GPS hardware can be used for data acquisition for Geographical Information Systems as well. This paper describes some of the practical operational procedures which are being developed and the software and training required.

The Anza-Borrego Desert State Park is currently gathering natural and cultural resource data to be included into a park general plan. The resource data are being geocoded so that they can be relationally linked to digital base maps. GPS equipment is providing both raw positional calibration and structured point-line-polygon data for coverages in the GIS. The GIS database will allow more rapid, cost-effective mapping and analysis than methods previously used.

The GPS hardware and data reduction programs were purchased from Trimble Navigation. One of the output data formats is for ARC/INFO. Although the interface between the GPS data and the GIS database is functional, it would be optimistic to call it ‘seamless.’ ARC/INFO is a powerful and complex software package which is not simply point-and-click. The Trimble software is also designed for engineers and experienced data manipulators.

The importance of differentially correcting the GPS positional data cannot be over emphasized. Uncorrected positions are often 200 to 300 feet in error due to Selective Availability. This error signal is not random and cannot be reduced by averaging many readings. Differential correction provides a single point resolution of less that 15 feet -- good enough to distinguish which side of a wash you are driving on. This error can be reduced even further, down to a circle of only 2 feet, by averaging 2 minutes of corrected data.

The GIS software programs being used are PC
ARC/INFO 3.4.2 and ARCVIEW 2. The PC version is a very similar subset of the full workstation software. GIS mapping tasks which require a great deal of computer power are being done under contract using workstation ARC/INFO. These include topo contour line, hydrology, geomorphology and vegetation mapping coverages. The rest of the project is being carried out by park staff on desktop PC computers and inexpensive peripherals. The ARC/INFO software allows staff to generate the special purpose (thematic) maps needed for both planning and resource management, e.g., showing camping areas within 500 feet of archaeological sites, or defining significant access corridors used by wildlife.

The park's experience has been that map making is still very much a laborious craft. The design of data dictionaries, database structure, topological queries, and thematic maps require careful attention to data quality and logical preparation. Such a large resource as the Anza-Borrego desert requires a correspondingly large database. Applying the evolving GPS/GIS technologies is challenging. But in the long run it will provide a base for management to make more exact and timely decisions.

GPS Mapping of Desert Roads and Trails
Grace Rickard and L. Louise Jee, Anza-Borrego Desert State Park, 200 Palm Canyon Drive, Borrego Springs, CA 92004

Roads and trails in Anza-Borrego Desert State Park are being newly mapped as part of a resource inventory. The data will be used in various layers of a GIS database for the park's general plan and as a management tool.

There are 600+ miles of dirt and paved roads in the park shown on 35 USGS 7.5-minute topographic maps. During initial study, it was determined that more than a third of the park's roads are either not shown in the correct location, are no longer open to vehicular traffic, or have never been mapped.

Since January, 1994, trained volunteers and staff have been using Global Positioning Satellite (GPS) receivers. The locational data are differentially corrected using satellite signals received simultaneously at a base station located at park headquarters. Two methods are described. 1) For mapping roads from a vehicle, a Trimble Pathfinder Plus is connected directly to a laptop computer loaded with Conterra Touchdown software. This combination allows the laptop screen to display positions in real time and creates line features with annotated points along the route. 2) For mapping trails where all equipment must be carried, a Pathfinder is used alone and records points as you walk. The output is then a series of points which define the trail.

One person received manufacturer training, set up the base station and instructed users. The primary user then wrote manuals for field operation and data reduction which are specific to local needs, software integration and equipment in use.

The use of GPS is becoming more routine as the equipment price falls. Many of the techniques employed on a daily basis will be informative to a variety of uses.

Tips include: Creation of a data dictionary; trip preplanning; personnel, equipment and time requirements; use of a laptop in a vehicle; UTC time; data correction; file management and map plotting.

Caveats include: Inaccuracy of uncorrected data; equipment operation and protection; battery life; lack of satellite reception due to field condition (e.g., narrow canyons) or base station problems; personal safety in desert working conditions; and loss-of-data horror stories.

The Vegetation of Lobo Point and North Wild Horse Mesa, Eastern Mojave Desert, San Bernadino County, California
Thomas A. Schweich, 3008 Fairview Avenue, Alameda, CA 94501

A pinyon-juniper woodland in a small sheltered valley at low elevation in the eastern Mojave Desert, San Bernadino County, California, 3 km northwest of the Hole-in-the-Wall Campground, and nearby pinyon-juniper woodland at the north end of Wild Horse Mesa, are described. The climate of the nearest weather station, Mitchell Caverns, is arid in April through October. The most precipitation falls in August, but the month is still arid. The vegetation of the study area is characterized as a blackbush scrub with pinyons and junipers where microclimate and edaphic conditions permit. Other local studies have shown that vegetation increases in complexity and biomass as elevation increases, and that root interaction is a likely cause of species distribution as species compete for water as a limiting resource. Throughout the Mid Hills, the lowest vegetation
zone is Creosote Bush Scrub. Above that is a Blackbush Scrub, replaced at higher elevations by Sagebrush Scrub, Joshua Tree Woodland, or Pinyon-Juniper Woodland as topography, micro-climate and soil conditions permit.

Fault Activity Assessments, Proposed Eagle Mountain Landfill Site, Eastern Riverside County, California

Roy J. Shlemon, P.O. Box 3066, Newport Beach, CA 92659-0620

The Eagle Mountain Landfill is a proposed 100-yr life, Class III non-hazardous waste facility managed by the Mine Reclamation Corporation. Located about 60 miles east of Palm Springs and 12 miles north of Desert Center, the proposed landfill will occupy a portion of the former 2-mile long and 1,000-ft deep Eagle Mountain Iron Mine operated by Kaiser Steel between 1948 and 1983. Among the myriad of permit requirements are those specifying assessment of activity (time of last displacement) of faults within and near the site. Three major fault systems are identified, all trending to the northwest, and apparently of common tectonic origin. These are informally designated, from west to east, as "Fault A," the "Bald Eagle Canyon fault," and the "East Pit Fault," respectively.

Quaternary sediments immediately overlying the faults were removed during previous mining operations; hence fault activity was indirectly assessed by geomorphic and soil-stratigraphic techniques; namely: 1) interpretation of pre-mining aerial photographs showing former covering fan deposits; 2) relative elevation of fans above modern incised drainage; 3) degree of fan dissection; 4) presence of desert pavement and varnish; and 5) relative soil profile development.

Pre-mining alluvial fans, estimated to be more than about 100,000 yrs old, are unbroken and thus provide a minimum age for the three fault systems. The relative antiquity of these bedrock faults is also particularly well expressed by exposures in the 1,000 ft deep East Pit where the East Pit fault is overlain by about 200 ft of stratigraphically continuous Quaternary debris flows, fan sediments and intercalated buried paleosols. A strongly developed relict and buried paleosol occurs within the upper 12 ft of the East Pit sediments suggesting that these soils, cumulatively, represent about 100,000 yrs of weathering. The underlying section of unbroken debris flows and fan deposits are an estimated 500,000 yrs old. Accordingly, the three Eagle Mountain bedrock faults are "not active" according to present State of California (Water Quality Control Board) criteria. Moreover, the 200 ft thick debris flow and fan deposits in the East Pit of the former Eagle Mountain Mine site probably comprise the most complete exposure of middle and late Quaternary sediments in this part of the Mojave Desert.

Post Landers Seismicity along the Eastern California Shear Zone from Barstow to the Coso Range, Mojave Desert

G.W. Simila, Dept. of Geological Sciences, California State University, Northridge, CA 91330, and G.R. Roquemore, Dept. of Geological Sciences, Irvine Valley College, Irvine, CA 92720

Seismicity along the Eastern California Shear Zone has remained at a high level from Barstow to the Coso Range since the June 28, 1992 Landers earthquake. Focal mechanisms for the larger events are consistent with northwest right-lateral strike slip faulting. Focal mechanisms are less clear near the Garlock fault where an east-west left-lateral solution would also fit the local faulting patterns.

The dominant source regions are in the Barstow area and the Indian Wells Valley/Coso Volcanic Field. Seismicity appears to follow the trace of the Calico-Blackwater faults, the Little Lake fault in Indian Wells Valley and unnamed faults on the east side of Rose Valley adjacent to the Coso Volcanic Field.

We will present the results of our research in the region including numerous focal mechanisms and cross sections that have allowed us to attempt to correlate 1992-1995 seismicity patterns to the regional structure.

GAP Analysis of the Mojave Desert of California

Kathryn A. Thomas and Frank Davis, Biogeography Lab., Dept. of Geography, University of California, Santa Barbara, CA 93106

GAP Analysis of the Mojave Desert is a coarse level conservation assessment of risk to biodiversity. The level of protection afforded to vegetation, as
represented by Holland natural plant communities, and vertebrate species has been evaluated using ARC/INFO GIS.

To develop the GAP Analysis three digital databases were created: 1) A composite coverage of Holland communities in the Mojave Desert; 2) A coverage of predicted distribution of vertebrate species; and 3) A coverage of current land ownership.

Overlay analysis in ARC/INFO of land ownership and vegetation and of vertebrate distribution and land ownership yielded profiles of the administrative status of plant communities and vertebrate species in the Mojave. Levels of management for maintenance of diversity were determined by type of ownership. Plant communities and vertebrate species were classified into three risk classes: critically underrepresented in protected areas, poorly represented, and adequately represented.

Results of the GAP Analysis are presented in GAP Analysis Technical Report: Mojave Ecoregion, available through the National Center for Geographic Information Analysis, UC Santa Barbara, Santa Barbara, CA 93106. The vegetation and vertebrate databases are available by anonymous ftp through the Biogeography Lab, UC Santa Barbara (805 893-7044). GAP Analysis of the Mojave is part of a statewide and nationwide conservation assessment. Information on GAP Analysis for the nine other ecoregions of California can be obtained through the Biogeography Lab.

Petroglyphs in Lanfair Valley

Wilson G. Turner, 10643 Luluene Drive, Whittier, CA 90601

Basalt boulders at Eagle Mountain, a small hill northeast of the site of Lanfair, are covered with petroglyphs. A few of the rock carvings resemble the typical Mojave Desert glyphs, but many are much more similar to glyphs along the Colorado River, and some are reminiscent of work done by the Navajo or patterns found in the Four Corners area. The site also contains unique figures which may represent life forms. The Eagle Mountain site also contains a sequence of “mask” designs, a style found in many places in the Mojave Desert. Such “masks” are found between Lanfair Valley and the turquoise mines in the Halloran Range, near Baker, known to have been mined by Pueblos. The abundance of “masks” at the Eagle Mountain site is notable. Even more “mask” patterned petroglyphs are found at the Telephone Pass site in the Piute Range. The Telephone Pass site and the Eagle Mountain site both lie along the route that would have been followed by prehistoric groups en route to the turquoise mines. But all petroglyphs at a given site were not necessarily created contemporaneously; in some cases, glyphs at prehistoric sites can be identified as having been made by travelers in historic times.

The Mojave Desert Block as a Geologic Analog to the Crust of Europa, a Moon of Jupiter

Randy Tufts, Department of Geoscience, University of Arizona, Tucson, AZ 85721

Images of portions of the Jovian moon Europa reveal what appear to be structures associated with lateral motion of crustal blocks (Schenk and McKinnon, 1989). Wedge-shaped bands may be gaps opened between relatively translating or rotating blocks tens to hundreds of kilometers in size. Such deformation in the “anti-Jove” area of Europa was perhaps created as a result of upwellings in the European mantle. The mantle possibly consists of a liquid water “ocean” that is kilometers deep, overlain by an ice crust only a few kilometers thick (Squyres et al., 1983). A lack of observed deformation within the inferred mobile crustal blocks suggests the existence of a decoupling layer. Such a layer would be consistent with the presence of warm ice or an ocean. The dark material filling the wedge-shaped bands may be fluid mantle material that has upwelled into the crustal opening (see Schenk and McKinnon, 1989).

The geological structure of the Mojave Desert Block may be partly analogous to the anti-Jove region of the European crust. Various models proposed to explain late Cenozoic Mojave Desert geology involve relative motion of small (ca. 50 km) crustal blocks (Carter et al., 1987; Dokka, 1992; Garfunkel, 1974; Richard, 1993). Some of these models predict the development of rhombohedral and triangular basins among the moving blocks. Dokka (1992) infers a relationship between such extensional areas and regions of magmatism in the Mojave. A point of difference among these plus other Mojave Desert models (e.g. Jagiello, 1991; Matti, 1993) regards the existence and timing of tectonic rotation of the Eastern Transverse Ranges. Studies in progress may delineate geomorphic features useful in assessing these Mojave Desert Block models. Insights gained in analyzing Mojave Desert landscapes may be applicable to
interpretation of images of the European surface to be made by the Galileo spacecraft starting in late 1995.

**Literature cited**


**Fire and Succession Along the Semi-arid Margins of the San Bernardino Mountains, California**

Michael J. Wangler, Department of Earth Sciences, University of California, Riverside, CA 92521-0423

Pinyon-juniper woodlands (Pinus monophylla, Juniperus occidentalis, J. californica) of the San Bernardino Mountains were examined for modern and historical fire patterns, post-fire succession, and changes in mature woodlands over a 60 year period. Thirty-eight burns, consisting mostly of high intensity canopy fires, were identified, giving an estimated fire rotation period of 480 years. Burns were primarily colonized by Great Basin sage scrub (Purshia tridentata, Artemisia tridentata, Chrysothamnus nauseosus) at higher elevations (>2000 m), and a mix of California desert chaparral (Ceanothus greggii, Fremontodendron californicum) and Great Basin sage scrub at lower elevations (<2000 m). Conifer species were absent on all burns ≤18 years. Chronosequence sampling shows that shrubs increase in cover and density for ca. 30-50 years, and are joined by P. monophylla recruits ca. 25 years after fire. Mature shrubs, acting as nurse plants, appear to aid in the re-establishment of P. monophylla by providing a favorable microclimate for seedling survival and early growth. After ca. 50 years, increases in P. monophylla densities are phased with a decline in the shrub layer, resulting in the return of open woodlands with sparse shrub understories ca. 90 years after fire. Replication of the 1929-1935 California Vegetation Type Map survey shows a 15% increase in stand densities over a 60 year period indicating only minor changes.
have occurred in this forest type under 20th century fire suppression management.

First Diverse Record of Small Vertebrates from Late Holocene Sediments of Lake Cahuilla, Riverside County, California


As documented by Van De Kamp (1973) and Waters (1983), fresh water lakes have existed intermittently during the Holocene in the fault-bounded Salton Trough of southern California. These lakes were caused by diversions of the Colorado River westwardly into the Salton Trough. Waters provided a stratigraphic and chronologic analyses of the upper 7 meters of lake and fluvial sedimentation, these based on exposures in a 6 km long trench 8 km SW of Indio, California.

Human occupation is well documented for at least the last four lake intervals which date from approximately 1440 ybp (years before present) to approximately 470 ybp. Abundant fresh water mollusks and some vertebrate remains have been recovered. These include a leopard frog, tortoise, white pelican, cormorant, jack rabbit, white footed mouse, horse, and mountain sheep.

Our studies are based on two test trenches, each 4 meters deep, excavated as part of a mitigation program associated with development of a PGA West, Tom Weiskopf signature golf course in La Quinta, California, for KSL Recreation Corporation. The excavation program follows mitigation recommendations advanced by P. Langenwalter (1993) in the original study of the property. The test trenches are 10 km west of the Waters trench. Both trenches yielded a succession of lacustrine sediments interbedded with thinly bedded fluvial sediments. Both lacustrine and fluvial sediments contain abundant mollusks. Diverse small vertebrates including fishes, lizards, snakes, birds, rabbits, and rodents were recovered by screen sieving a total of over 5 tons of sediment from three stratigraphic horizons in one trench. The small vertebrate assemblage contains species that are indicative of both sandy and rocky, brush-covered desert habitat. No species typical of lake shore habitats were recovered. Consequently, the small vertebrates support rapid flooding of the Salton desert basin and insufficient time for migration of lake shore associations before subsequent redescication of the basin. Pollen, diatom, ostracod, foraminifer and mollusk samples are also under study.

Charcoal was recovered from the stratigraphic intervals that yielded the small vertebrates. Radiocarbon age determinations of 1125 ± 80 ybp and 2545 ± 50 ybp for the two uppermost beds sampled indicate that all of our remains are from intervals older than the four lacustrine intervals defined by Waters. The present-day surface at the trench sites is 25 meters below the Lake Cahuilla high-stand, thus the lack of evidence for the four younger lacustrine intervals is an enigma.

Fossil Resources Associated with Federal Lands in California

Gregg Wilkerson, Bureau of Land Management, 3801 Pegasus Drive, Bakersfield CA 93308-6837, Robert E. Reynolds, Section of Earth Sciences, San Bernardino County Museum, Redlands CA 92374, David Lawler, Far West Geoscience Foundation; and Benjamin Nafus, California Living Museum, Bakersfield

Paleontologic localities of significant scientific value occur on public lands in California. Some localities on private land are administered by BLM and the Forest Service for their mineral resources. The opportunity to protect these resources through establishment of Areas of Critical Environmental Concern or through cooperative agreements with private institutions and other pubic agencies is quickly being lost as these localities are vandalized or developed for non-paleontologic purposes. On the other hand, cooperation between government agencies and private institutions has resulted in the preservation and appropriate curation of many paleontologic resources from public lands.

Impact of Wildfire on Saguaro Distribution Patterns

R.C. Wilson, Dept. Of Biology, California State University, 5500 University Parkway, San Bernardino, CA 92407, M.G. Narog, A.L. Koonce and B.M. Corcoran, Pacific Southwest Research Station, USDA Forest Service, 4955 Canyon Crest Drive, Riverside CA 92507

Sonoran desert communities present us with a complex mosaic of species-rich patches of vegetation. Areas once characterized by small
Infrequent fires now support extensive conflagrations across miles of contiguous vegetation composed of flammable exotic grasses and herbs. In these areas, giant saguaro cactus (*Carnegiea gigantea*) populations are becoming severely degraded by fire. These frost intolerant giants have a high post-fire mortality and show no special fire adaptations. Their desert habitats have a long history of human use (which includes about 200 years of grazing impacts). Recently, increased fire ignitions, especially in areas of high public use, are believed to be further impacting vegetation composition and patterns. Temporal and spacial effects of fire on this community have yet to be delineated.

The upland Sonoran Desert communities on the Tonto National Forest, AZ, have had increases in both fire frequency and acreage burned. In May of 1993 an arsonist set numerous fires in the saguaro shrub vegetation type on the Mesa Ranger District, Tonto National Forest. In January of 1994, we began studies that compared burned areas to adjacent areas that had not burned. Patterns of saguaro distribution and their associated vegetation were evaluated in both the burned and unburned areas. Fire girdled saguaros and charred shrub skeletons covered the burned areas. Many woody species were found resprouting from their bases and/or branches. Preliminary results from the burned areas have identified 2 tree species, 6 large shrub species, and 11 smaller shrub species as regenerating from basal or branch sprouting. The average distance of an associated tree or shrub species to severely girdled saguaro individuals was about 1.4 m. About 48% of the saguaros sampled had an identifiable associate tree or shrub within 1 m of its base.

The long term distribution and survival of saguaro populations may be dependent on the restoration and conservation of their associated and potential "nurse plant" species. Further long term studies are necessary if management strategies and techniques for the aggressive restoration of fire degraded areas are to be developed.
San Bernardino County Museum Association  
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Address queries and manuscripts to:
The Editor
San Bernardino County Museum Association
2024 Orange Tree Lane, Redlands CA 92374