SVP
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Guidebook

"Sheep Rock" Original oil painting of Sheep Rock, by Margaret Willis

SVP Field Symposium 2010

John Day Basin Field Conference
John Day Fossil Beds National Monument
(and surrounding basin)
Oregon, USA

June 7 – 11, 2010

Author and Conference Leader
Theodore J. Fremd

Trip Coordinators
Skylar J. Rickabaugh and L. Barry Albright III

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To Fellow Fieldworkers

For your Generosity, Discipline, Patience, Exertion, Mindfulness, and Wisdom

"This Bed's for You."

Guide & Road Log to the 2010 SVP Field Symposium to the John Day Basin

PREFACE TO THE 2010 EDITION

This guide was developed for a three day field symposium sponsored by the Society of Vertebrate Paleontology. **It is intended as an informal, casual guide** for participants, and is largely targeted at the graduate student level but is also easily accessible to the non-specialists. The first SVP field trip guidebook to the John Day Basin was published over 15 years ago, and has been reprinted four times. Although this is a completely new, updated, and considerably expanded revision, some material from the original guide has been incorporated into this one, including the popular "Historical Perspective" sidebars. This guide serves as an "overview" to several of the principal vertebrate fossil localities in the region. Complete coverage of the extensive fossiliferous strata in this basin, with numerous Eocene through Pliocene assemblages spanning forty Ma, deposited in several widely separated basins, is beyond the scope of this short contribution (see the Introduction). This version updates and serves as a replacement for the above noted earlier field guide.

This guide differs from those that typically accompany excursions associated with meetings of professional societies. Although the mileage intervals and commentaries are in the usual format, other aspects may seem unfamiliar. For example, in addition to the references cited, many complete abstracts are furnished for literature pertinent to a particular discussion stop or extended hike, and these are numbered in the body of the text for ready reference.

The layout of this guide is straightforward, and the design should facilitate ease of use during this excursion. Readers will note that specific locality coordinates are not pinpointed on the topographic maps furnished with the road logs. Although it would have been expedient and easier to print these maps, they were omitted for the security of some of the less well-known, sensitive sites. Interested investigators will have an opportunity to consult printouts furnished during the trip of the same maps, with specific pinpointed localities that will be discussed; one may choose to ink them in their copy of the guidebook.

SECTION ONE contains an introduction to the basin and remarks on some of the newer developments in the research concerning the geology, paleontology, and paleoecology of the area. Also in section one is a newly compiled complete (to generic level) faunal list, maps of overall field trip route, an overview of the assemblages, a composite stratigraphic chart, and a very brief history of investigation. Those interested in species-level faunal lists and more detailed stratigraphic sections should know they are available, but overly detailed for this book.

SECTION TWO is the "guts" of the book, comprising the actual Road Log for the trip, and descriptions of the variety of designated stops and hikes. Each designated stop, of which there shall be about ten, includes an overview map and reference to the appropriate assemblage data furnished in Section Three.

SECTION THREE develops composite pictures of the assemblages that can be used to generalize the nature of "baseline" time-averaged faunas sampled at roughly 5 million year intervals. For each general assemblage unit, the reader is provided with:

- a more detailed stratigraphic column that typifies the measured sections where this biota has been sampled,
- a listing of ***some*** of the ***classic*** localities, many of which are impossible to visit on this fieldtrip, with a photograph of a typical outcrop for comparison that should help orient the field observer,
- a newly revised (and necessarily time-averaged) faunal list for each of the major assemblages, representative of many localities containing the assemblage, as well as images of specific specimens from specific localities.
- new reconstructions/illustrations of representative taxa, and portions of each of the eight assemblage-specific murals prepared for the Thomas Condon Paleontology Center (TCPC).

SECTION FOUR consists of the following:

Appendix One provides full text of abstracts cited numerically in the document for ready reference, e.g. (*See Abstract #n*), so that the reader can simply flip to that during the discussion.

Appendix Two is an abbreviated guide to the Thomas Condon Paleontology Center, with descriptions of the concepts incorporated into the design and fabrication of the displays and working areas of this remote Paleontological Field Station.

Appendix Three is a brief glimpse into the many different basins within the region that cannot be visited during this trip. Each of these offers opportunities for new research.

References Cited and Bibliography listings are provided, which include the correct citations for the abstracts in Appendix One. Included are several of the classic, "key" papers concerning the basin and its faunas; while not fully comprehensive, these references should give workers a solid base for work previously undertaken in the basin.

Gaining a clear understanding of the entire John Day basin can be a daunting task, and this guide could easily have been **much** longer. Many topics and materials that might have been included have been left out due to the size constraints of this volume. Nevertheless, I hope the book proves useful to those participants who mark it up during the fieldtrip, and for those who pick it up afterwards. They should consider these road log entries, and descriptions of the strata and biotas, to simply be "a finger pointing at the moon."

Ted Fremd
April, 2010
The University of Oregon

PREFACE TO THE 1997 EDITION (abbreviated)

The road log was assembled with professional vertebrate paleontologists in mind. Thus, the title may suggest a more comprehensive focus than is actually the case. Conspicuous by their absence, for example, are any details concerning the remarkable record of plants, among them some of the most important paleobotanical sites in North America. New monographs on the floras have been published since this field trip was held, and interested readers may consult these. Outstanding invertebrate and trace fossils are also well known from the area, but are barely mentioned in the text. Even amongst vertebrates the coverage is glaringly uneven; indeed, an entire guide could well be written on the fossil fishes alone, for example. The concentration on fossil mammals is largely a reflection of the senior author's own research interests, the historical attention paid to mammals by early collectors, and because of the much more consequential role mammals play in Tertiary biostratigraphy compared to any other taxa.

Interpretations of the geologic relationships of some of the strata also differ amongst workers. Most noteably, our reading of the rocks in the Clarno Unit and the Haystack Valley area differ from those of other colleagues. Work performed since the fieldtrip has confirmed the legitimacy of these different interpretations as falsifiable hypotheses, while not completely invalidating the original perspectives. That this is a complex area capable of supporting a variety of robust explanations should be a source of delight to most earth scientists.

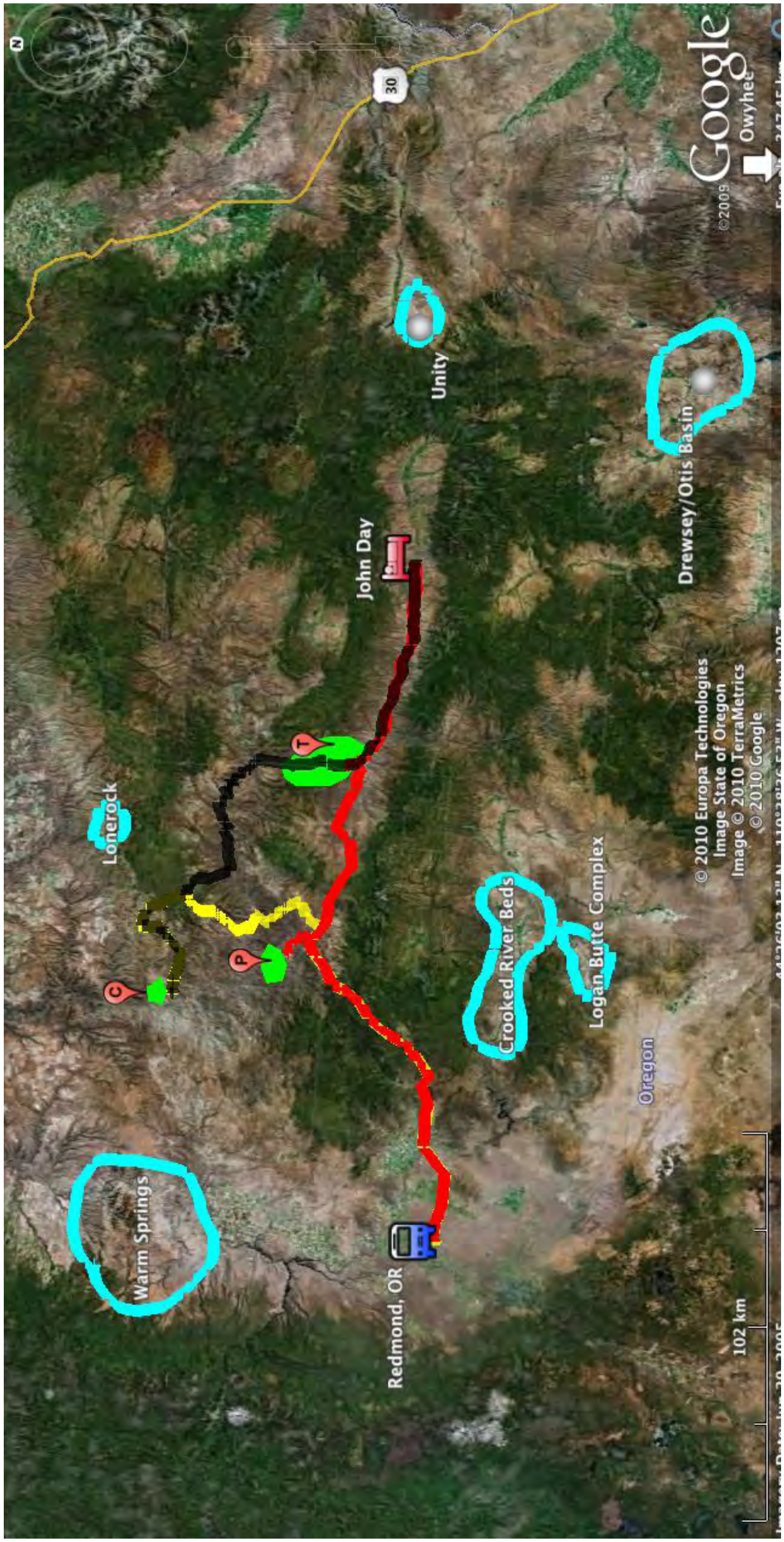
The complexity of the various localities, both in space and time, was largely glossed over owing to the short duration of the field trip. The importance of the basin to paleontological analysis was, if anything, understated in the text. Work accomplished since the 1994 publication has exceeded our expectations in terms of yielding new discoveries; not only of undescribed taxonomic occurrences, but entirely new localities and extraordinarily detailed sections. Some recent developments are the result of work by many individuals, most of them listed in the appendix. The John Day Basin, as a microcosm of global paleontology, illustrates that few research projects can be conducted in isolation any more; specialists from a variety of disciplines enrich the results.

New fossil occurrences and the delineation of stratigraphic relationships in the Rattlesnake, Mascall, John Day, and Clarno Formations, are helping to systhesize both geologic and biologic processes in the early Eocene through late Miocene of the area. Identification of new marker beds, measurements of complete sections, and new collections largely tied to a verifiable framework are clarifying the depositional and structural events in the region. It is doubtful if any existing stratigraphic units will remain intact in years to come. For example, the John Day Formation should be considered as a Group, containing three formations. The Mascall will be redefined based on much more detailed stratigraphic work. The Rattlesnake strata may well be elevated to Group status. The Clarno, long a source of controversy and interdisciplinary "creative tension", needs reappraisal by specialists willing to pool large amounts of disparate data from locally complex sections.

The advent of much higher resolution dating techniques, paleoclimatological inferences permitted by fossil soil analyses, new methodologies of global correlation using paleomagnetic reversal techniques, and precise taxonomic work are yielding exciting new information bases. These in turn permit us to place occurrences of new records of canids, nimravids, insectivores, chalicotheres, tragulids, oreodonts, amphicyonids, and dozens of other families into the global evolutionary pattern.

Discovery of a small basin near Condon, capable of yielding thousands of microvertebrate specimens using screen-wash techniques, is promising to add dozens of new taxa to our faunal lists. Another new locality downstream from Clarno appears to represent the first bona-fide "bone bed" in the green "Turtle Cove" strata. Several lake beds in the Clarno are producing bird tracks, excellent fish fossils, and undescribed leaf associations. The large temporal gap between the Mascall and the Rattlesnake Formations appears to be "filled" by a largely overlooked series of rocks containing gomphotheres and horned rodents . Onward!

Ted Fremd, November 1997
Turtle Cove, Oregon



Geographic orientation and overview of a 3-day field trip route, and unvisited locality regions in "the John Day Country." North is to the left (or up if the figuree is rotated 90 degrees clockwise).

Day One: Red line, Two: Black, Three: yellow (with overlap where route is retraced). Green fill areas visited on this trip: C: Clarno basin, P: Painted Hills area, T: Turtle Cove. Cyan outlines are important basins outside the scope of this excursion but are mentioned in APPENDIX THREE. These include the Warm Springs, Crooked River, Logan Butte, Drewsey/Otis Basin, Owyhee, Unity, and Lonerock sites. Many more localities exist scattered amidst these major areas. ***Modified from Google Earth.***

SECTION ONE: Introduction To John Day Basin Paleontology

The Significance of the John Day Basin

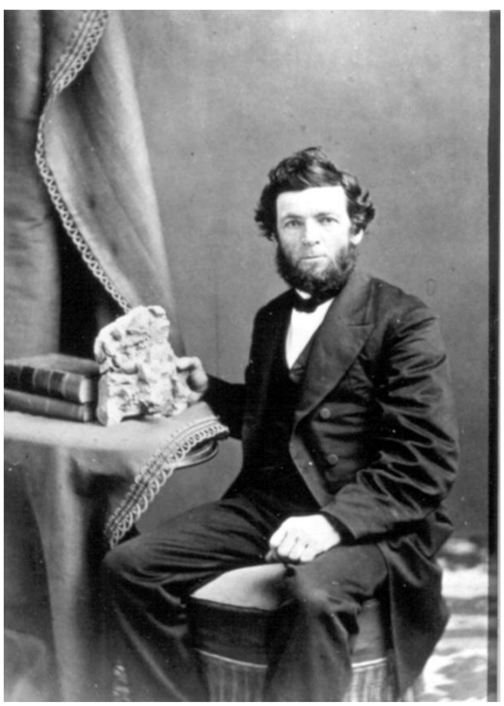
Few places contain as remarkable a record of long-term climatic and biotic change as the John Day Basin of Central Oregon. Even when viewed in isolation, individual fossiliferous strata of the John Day basin deserve their world stature: the Clarno Formation includes significant Pacific Northwest Bridgerian and Duchesnean North American Land Mammal Age (NALMA) assemblages; the John Day Formation has yielded well-preserved material representing over 30 mammalian families and well over 100 species of Whitneyan through early Hemingfordian; the Mascall Formation represents an important early Barstovian (proposed earlier as a "Mascallian") interval; and the Rattlesnake Formation is a recognized principal correlate of the Hemphillian NALMA.

Historical Perspective

- *Ralph Chaney, 1933*

"… no region in the world shows more complete sequences of Tertiary land populations, both plant and animal, than the John Day formations."

The John Day region has a long, colorful, and already well-documented history of investigations, well outside the scope of this guidebook, save for the brief summary below. Readers are encouraged to consult the references in the back of this book, as many of those papers contain comprehensive descriptions of several of the early expeditions.



Thomas Condon, Oregon's Frontier Paleontologist and the first State Geologist. (photo Courtesy the Univ. of Oregon)

The distribution of fossil localities in time and space is impressive. There are over 750 major localities in the basin, only about one hundred of which are visible from the trip route, with less than a dozen that can be field stops in such a short excursion. Some of the important collecting regions, including the Warm Springs, Logan Butte, Lonerock, Unity Basin, and other sites are simply impractical to visit during the trip; a few of these are mentioned in Appendix Three.

The overall significance of the John Day region is due to more than just the presence of large numbers of well-preserved fossils. The largely volcaniclastic sequences in the basin together span over 40 million years, and preserve evidence of profound changes in western North American climate from what was probably the warmest and wettest interval in the Tertiary through the desertification of most regions east of the present day Cascades. Recent work, including single crystal laser fusion (SCLF) Ar^{39}/Ar^{40} dating and isotope analyses, indicates that this record is temporally much more complete and complex than was previously thought.

The last few years have seen the arrival of many interdisciplinary investigators and the enthusiasm is reminiscent of the turn of the century, when the then-dominant John Day Basin paleontologist, J. C. Merriam, assembled botanical, vertebrate, and other paleontological workers of the era into a research group he referred to as "The John Day Associates". These strata show great potential for unravelling some vexing problems in biostratigraphy and paleoclimate records. For example, M. O. Woodburne (pers. comm., 1994) stated "Virtually alone among rock and faunal successions of its age in North America, the John Day Formation is well on its way to becoming the reference standard for documenting land mammal (and plant) evolution from about 40 to 20 m.y. ago. . . . The real and potential significance of the John Day formation to becoming a cornerstone of closely documented mammalian evolution during a critical interval of biotic change in North America (including climatic change, and ecosystem analysis) cannot be overemphasized". One key aspect of the John Day Basin fossil localities is that they are sandwiched between hundreds of meters of additional fossiliferous intervals, abundantly peppered with dateable tuffs.

Historical Perspective

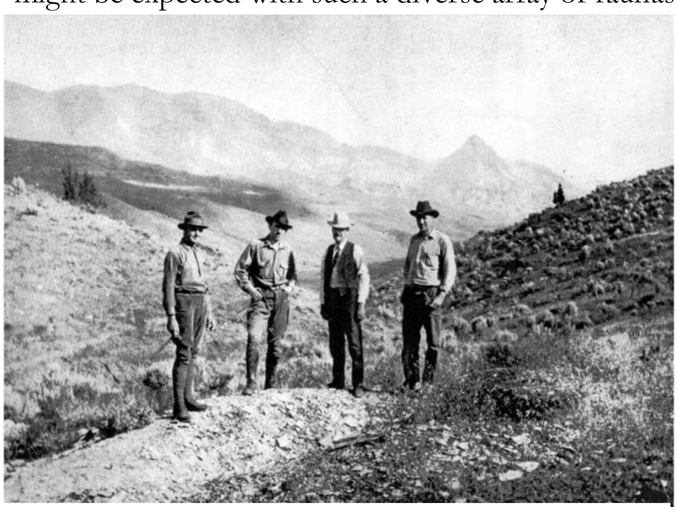
INSTRUCTIONS FROM PROF. MARSH FOR THE 1873 YALE COLLEGE EXPEDITION TO THE JOHN DAY BASIN

- *Charles Schuchert, Professor of Paleontology, Emeritus, Yale University*

We were told to buy a copy of and carefully read a book called The Prairie Traveler'. This gave complete instructions for crossing the plains, telling how to make backfires in case of a prairie fire, how to camp, how to place the wagons as a protection against the Indians, how to make temporary boats for crossing rivers, etc. We were required to carry a Sharp's carbine, 50 caliber, as then used by the Cavalry, a Smith and Wesson's .36 caliber six shooter, and a large hunting knife.

Very Brief History of Investigations

The John Day Basin has a rich and complicated history of fieldwork by a variety of workers, as might be expected with such a diverse array of faunas and floras. Study of fossils from the John Day Basin began roughly 130 years ago and continues today. The work of Thomas Condon, O. C. Marsh, E. D. Cope, J. C. Merriam, Chester Stock, Ralph Chaney, Richard Fisher, Richard Hay, John Rensberger, Arnold Shotwell and many others should definitely be among those consulted for constructing the vital history of ongoing research. The discovery of fossils in the basin was made by soldiers of the U. S. Cavalry during the Civil War. A route was chosen to transport gold from the newly discovered deposits in Canyon City (just south of John Day) to The Dalles on the Columbia River, and the route passed through several of the localities to be visited



The "Cant's Ranch Locality", an enigmatic lacustrine site near Sheep Rock. From L to R: Furlong, Stock, Merriam, and Chaney.

on this trip. The soldiers carried some of these specimens to the Reverend Thomas Condon, a "frontier missionary" in The Dalles, who later became Oregon's first State Geologist. Condon, in turn, sent specimens for identification to Joseph Leidy, O. C. Marsh, E. D. Cope, J. S. Newberry, and many others. These scholars recognized the significance of the specimens, published descriptions of the material, and decided to visit the region.

Much of the paleontological fieldwork completed in the basin since the turn of the century reflects the evolution of the discipline over this time period. In a sense, the developments in the John Day region during the last 130 years reflect a small-scale and temporally compressed version of the larger history of paleontology. A variety of references, outside the scope of this guide, exist to help track these more global changes in the discipline. For example, early work in Northwestern paleontology (ca. 1860's) often consisted primarily of collecting quantities of specimens, preferably large and as complete as possible. Often "professional collectors" were exhorted to accumulate material and they shipped their (largely cranial) finds to the sponsoring eastern institutions. These often were accompanied by labels depressingly vague by today's standards. A great many specimens from the John Day were described as new taxa (see faunal lists) from such material; indeed, most John Day specimens were originally collected early during this descriptive - and sometimes combatively argumentative - phase of paleontologic research, resulting in a plethora of taxonomic synonyms that still plague researchers. "Cope's Bible", of course, is the classic early treatment of the John Day mammals (Cope, 1884).

A variety of field parties visited the John Day Basin before the turn of the century, among them trips sponsored by O. C. Marsh (1873), E. D. Cope (1870s), the Smithsonian (1881), W. B. Scott of Princeton (1889), and J. C. Merriam of the University of California (1899). These resulted in the bulk of the type and figured materials from the John Day Basin. Later, in the 1920s, University of California staff became the major collectors in the area, resulting in the production of important summary papers by Merriam and several others (eg., Merriam and Sinclair, 1907).

Historical Perspective

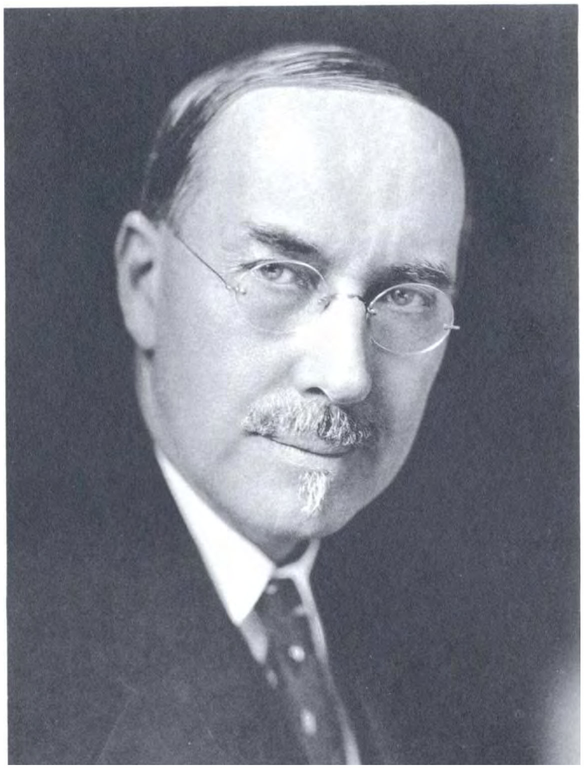
THOMAS CONDON ON BRIDGE CREEK
from a letter to J. S. Newberry, May 31, 1869.

I knew how lively an interest these fossils awakened in my own mind and inferred that if the interest you felt in such things was as much greater as your knowledge of their connection with science was greater than mine, you ought to have them spread before you at once ... I am hungry for a sight of that hill again, when no fear of prowling Indians shall compel me to hold a rifle in one hand and my pick in the other.

Historical Perspective

A DAY IN TURTLE COVE
- Charles Sternberg, 1881

The Beds are hard to explore, as they are almost perpendicular, with here and there a narrow projecting shelf that gives a precarious foothold. Only persons who have had long experience in collecting, and who have enthusiasm enough to risk their lives for science, can hope to meet with success; otherwise they will go away with no specimens, or only fragments some friendly wash has carried to a level place. The beds differ from any that I have ever explored, and a day's climbing among them would convince any but an experienced collector that they were destitute of fossils.... The first year I worked in the beds I got thirteen new species. They will all be described and figured in a work by Professor Cope on the Miocene of Oregon, to be published by the Government.



J. C. Merriam, a principal investigator of the John Day.

During these early investigations, generalized comparisons were made with previously described fossils from regions of what were then considered comparable geologic age (such as the classic badlands sites in South Dakota, Nebraska, and Wyoming). It was only decades later that workers attempted to construct detailed correlations of the strata and biota of beds in the John Day area. Initially puzzling were the differences in the Mascall and Rattlesnake faunas, in part resulting from a mixture of these two very distinct assemblages in early collections. Later workers were more careful to distinguish Rattlesnake Formation float from the 10 million year older Mascall Formation (see, for example, Merriam and others, 1925).

Vertebrate paleontological interest in the Clarno Formation came quite late on the scene with the first publication of a specimen from the "Nut Beds" by Stirton in 1944. Now recognized as one of the few records of terrestrial Eocene mammals in the northwest, significant specimens from this site have been studied (Hanson, 1996) and the work continues. The discovery of the younger "Hancock Mammal Quarry" over 50 years ago has so far resulted in some published descriptions, such as a superb "deltatheridian" skull by Mellett (1969), one of the earliest rhinoceroses (Hanson, 1990, 1996), and new achaenodonts, brontotheres, and amynodonts. Much remains to be done, however (see "recent work", below).

Further developments in the John Day area (and elsewhere) in the 1960s focused on the absolute (radioisotopic) dating of beds. Workers began to look more thoroughly at the rocks and stratigraphic units themselves, refining the column further and subdividing the formations into recognizable members, horizons, and biostratigraphic units. Key to this process in the John Day Formation was the contribution of Fisher and Rensberger (1972), who attempted to define the basic lithostratigraphy and petrofacies of the Turtle Cove area of the eastern facies, and the work of Robinson and others, (1975, 1984) in the western facies.

The actual volcaniclastic deposits within which most of the biotas are found received very little early attention considering their abundance and wide distribution. Not until the early 1960s (e.g., Hay, 1962, et.seq., Fisher, 1960 et.seq.) did attention focus on many of these sediments. Perhaps nowhere more than in the John Day basin is the observation

Historical Perspective

IT'S ABOUT TIME
- field notes of Downs and Green, 1948

The upper and middle further south are supposed to be separated by a rhyolite bed (which Coleman said is continuous with the brown stuff above). This we saw near Humphrey's ranch but didn't get close enough to take a sample because of the mosquitoes. It seems that accurately placed and identified numerous fossils would help straighten out the divisions if any. One of the problems hindering collecting is the cliffs which occur in Upper and Middle John Day. It seems to me that geology (as in Mascall) should be worked out at some time in closer connection than is being done now, and that very accurate location of specimens should be taken for correlation.

of Fisher and Schmincke (1993) true:

> *"Research on volcaniclastic rocks was long neglected, largely because of the 19th century agreement to sub-divide rocks into igneous, sedimentary and metamorphic categories. This placed volcaniclastic materials within a hybrid class by default, and because of the accident of classification, sedimentary rocks composed of volcanic particles were essentially ignored. They were left unstudied for many years by igneous petrologists because they are sediments. Sedimentary petrographers tended to ignore these rocks because they were perceived as belonging to the domain of igneous rocks, a situation that illustrates the profound influence that classification and nomenclature can have upon thought processes and directions of research."*

Another reason the depositional classifications of these strata had been largely ignored, with the notable exception of Hay (1962), is that many units contain only rare sedimentary structures such as cross-beds and channeling; hence their description as "massive tuffs" by many stratigraphers and paleontologists. The sometimes thick "popcorn" weathering surface that covers the badlands of the John Day Basin has also hindered sedimentology and stratigraphic work.

Arnold Shotwell (pipe, no hat) in the field in the early 60s. His work profoundly altered our understanding of Eastern Oregon paleontology and paleoecology.

More Recent Work

Since the classic papers by Merriam and others, work on the deposits within the basin has proceeded intermittently, and no attempt will be made here to summarize these earlier endeavors represented by several hundred published items. Extending earlier work, later investigations tended to focus on taphonomy and paleoecological syntheses of rock units and fossil assemblages, documenting evolutionary change, and biostratigraphy. The following is intended to outline only some of the most recent efforts.

A flurry of new contributions to the John Day literature emerged coincident with a symposium held during the 2001 North American Paleontology Convention, at the University of California, Berkeley, on the 100th year of J. C. Merriam's classic paper, "A Contribution to the Geology of the John Day Basin" (Merriam, 1901). Many of the abstracts resulting from these presentations, or from the more formal full papers that followed, are appended in full in Appendix One, and are numbered by order of appearance in this text (and citations are duplicated in the references cited).

THE CLARNO STRATA

Within the Clarno Formation, dozens of workers from a wide variety of interests have attacked some of the more resolvable problems in the last 20 years, resulting in over 130 papers. A three year project initiated and contracted by the National Park Service (NPS) led to a dramatic increase in the number of known fossil localities, a bracketing of the most significant strata with single crystal laser fusion Ar^{39}/Ar^{40} dating, and a detailed series of measured sections with thousands of thin sections, hand samples, and other data collected for voucher specimens (see Bestland and Retallack, 1994a). These workers report a composite thickness of strata within the Clarno Unit of the National Monument of over 200 meters; elsewhere, it can attain thicknesses an order of magnitude greater.

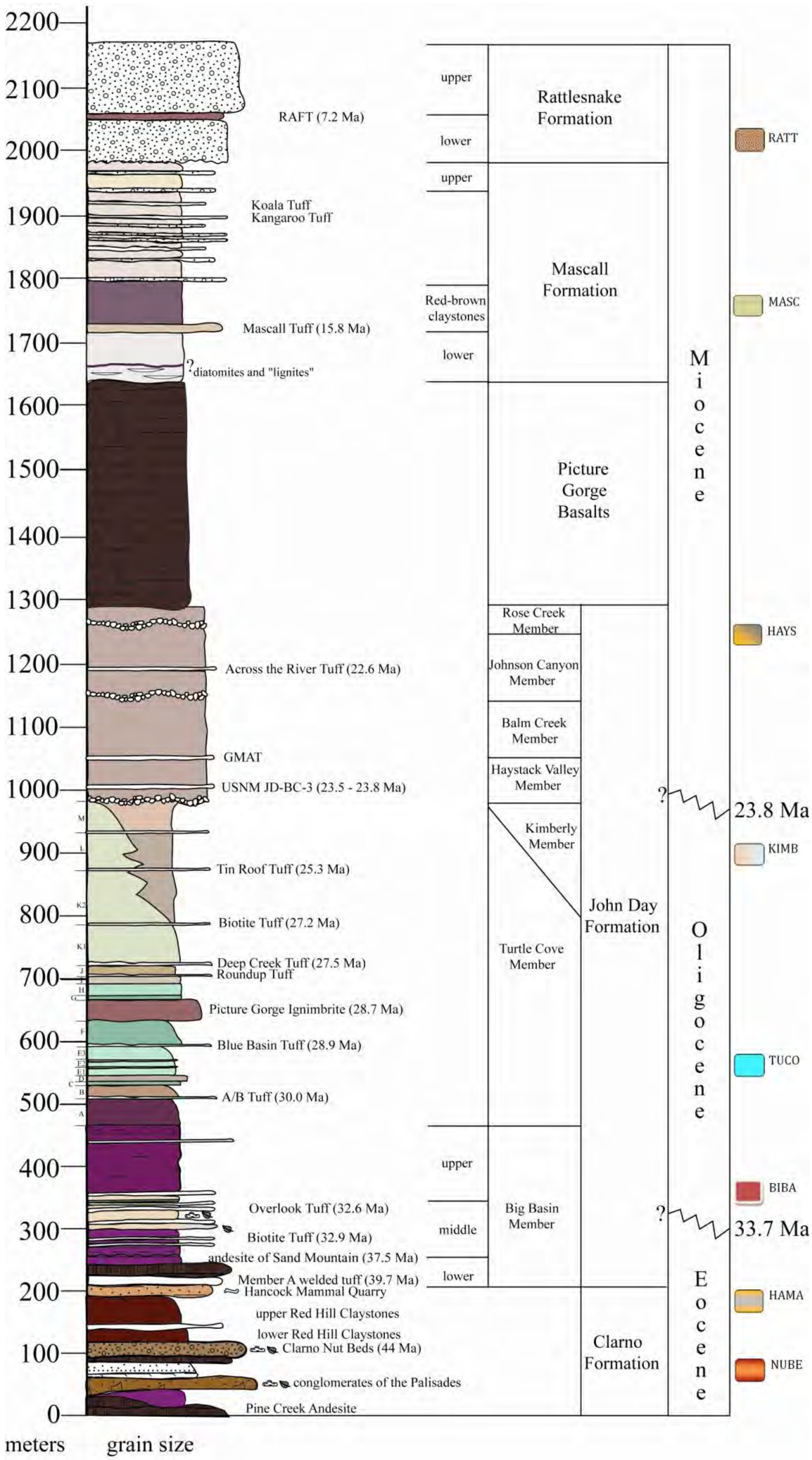
Probably the definitive analysis of the stratigraphy within the Clarno Unit of the NPS is to be found in an paper by a team of Oregon geologists (Bestland and others, 1999). These strata will be viewed on the third day of this trip. We (Bestland and others, 1994, 1999) now recognize 10 distinct stratigraphic subdivisions of the Clarno as it is exposed in the park. These include units such as (see road log)

SILTSTONES OF THE MAMMAL QUARRY
ANDESITE OF HORSE MOUNTAIN
CLAYSTONES OF RED HILL
CONGLOMERATES OF HANCOCK CANYON
MIDDLE CLARNO ANDESITE
CONGLOMERATES OF THE PALISADES
ANDESITE OF PINE CREEK
MAIN SEQUENCE
HANCOCK DACITE DOME
LOWER CLARNO CONGLOMERATES

Although the Clarno Formation deserves careful attention with regard to redesignating it as a Group, with several formations (or alloformations), the lack of lateral continuity of beds over relatively short distances have hampered serious attempts to do this. New analyses, particularly of the biota-entombing paleosols, have been published in an extensive monograph (*See Abstract #1)* that provides a good start. In general, any attempt to gain a comprehensive glimpse of the Clarno strata require examination of rocks far afield from the major vertebrate localities, such as exposures near Horse Heaven, Burnt River, and on the Muddy Ranch to name a few.

Although little new is known concerning the Nut Beds fauna, work on the floras resulted in a superb new monograph on the Clarno Nut Beds (Manchester, 1994). This work represents the first modern taxonomic synthesis of the Clarno flora, and examines tens of thousands of specimens from over 15 widely separated sites. These efforts have resulted in new systematic and evolutionary analyses of a wide variety of taxa, clarified understanding of the prevailing climate during the Middle Eocene in western North America, contributed important biogeographic data (Manchester, 1994), and offer important paleoenvironmental data in direct association with the vertebrate faunas. Other widely scattered Clarno sites have yielded material including ichnofossils, fish, and tetrapod material, usually in lacustrine depositional environments. Other new important analyses of the "Clarno forest" have been described by Wheeler (*See Abstract #2*) and have resulted in an excellent new book (Wheeler and Manchester, 2002) that clarifies that the Clarno is the most specious fossil wood locality on the planet, of any age. Globally, only the floras of the London Clay are comparable.

The vertebrate fossil component of the ~43.8 Ma Clarno Nut Beds (date reviewed in McClaughry et al., 2009) assemblage and the ~40.0 Ma Hancock Mammal Quarry assemblage is localized to small pockets (compared with the distribution of vertebrate faunas in the younger strata to be examined during this field trip), and material is rare. What has been described, however, is intriguing (Hanson, 1973, 1990, 1996); and more material has been collected and is being studied. Newer publications concerning the placement and fauna of the ~ 40 Ma Hancock Mammal Quarry include an overall review of the faunas (*Abstract #3*), a consideration of *Agriochoerus* (*Abstract #4*), a new amynodont (*Abstract #5*), a new brontothere (*Abstract #6)*, and a new achaenodontid (*Abstract #7*).



John Day Basin Master Composite Section

THE JOHN DAY STRATA

A bewilderingly complex series of strata scattered over three major depositional basins, the John Day Formation preserves a unique record of long term change in the biotas in the Pacific Northwest. The eastern facies of the John Day Formation was scrutinized by Fisher and Rensberger (1972), combining diagenetic and faunal analyses. The western facies has been described in Robinson (1975) and Robinson and others (1990), but much work remains. The southern facies, long believed to have a fauna similiar, if not identical to the eastern, has an apparently distinct fauna that suggests a biota adapted to woodlands (*Abstract #8*), as was certainly the case in the early John Day (*Abstract #9*). The first monograph on the "Bridge Creek" floral assemblage in 70 years has been prepared by Meyer and Manchester (1997). Well over 100 floral species are recognized in this study of over 20,000 specimens from many widely separated localities. These strata also contain rare vertebrate materials currently under investigation (see Section Three, BIBA assemblage).

Several projects are underway or have recently been published reinvestigating the classic mammalian assemblages and their biostratigraphic significance, largely reviewed on the second day of this trip. One of these publications combines new paleomagnetic analyses with detailed FAD and LAD data from new collections (*Abstract #10*); attempts to "fit" most historic repository data to stratigraphic horizons seem futile these days, but some specimens with matrix can be retrofit into the column. New material, collected in a verifiable locality framework, augmented by new SCLF dates, may resolve many of the more vexing problems of the evolutionary histories of the faunas. In terms of paleosol-based stratigraphy, recent work by Retallack and others (2000) in the Painted Hills region has revealed a long, enormously complex sequence of units with a composite section well over 400 meters up to the "Picture Gorge Ignimbrite".

New papers treating some aspect of the faunas include mention of a very rare chelonian skull to accompany the abundant shells in "Turtle Cove"(*Abstract #11*), a review of the skull of *Meniscomys* (*Abstract #12*), nimravid biostratigraphy (in prep) (*Abstract #13*), entelodonts (*Abstract #14*), agriochoere "subspecies" or morphotypes (*Abstract #15*), and the first substantive review of peccaries (*Abstract #16*); several other groups are now being studied or much-discussed studies re-invigorated (e.g., Canidae, Wang and Fremd, in prep). At last, an excellent source of screen-washable microvertebrates from the "Kimberly" has been located and a preliminary description and faunal list published (*Abstract #17*).

Detailed redescription of the lithostratigraphy of the problematic "Haystack" strata posed a difficult task, heroically completed by Hunt and Stepleton (*Abstract #18*) and subsequently summarized (*Abstract #19*). After many years of painstaking fieldwork, their efforts clarified what had been an oversimplification of the stratigraphy and resulting faunal distributions. Similar (if less elegant) efforts have lately been undertaken in all of the John Day strata. Meanwhile, several papers examining a variety of paleoecologic parameters of the entire John Day sequence were issued, including Miocene tectonics and global forcing of biodiversity (*Abstract #20*); glacial-interglacial scale paleoclimate change (*Abstract #21*); use of isotopes in ungulate enamel to examine Cascadian uplifts (*Abstract #22*); climatic changes preserved in the Clarendonian strata in the outcrops near Unity Resevoir (*Abstract #23*); and isotopic studies of tectonic effects on ungulate diversity (*Abstract #24*).

A variety of unpublished works exist that were prepared under contract to the National Park Service and/or the Bureau of Land Management concerning the John Day Formation. Two are particularly noteworthy for creating new, informal names for several of the units referred to in this fieldguide.

Contract work for the NPS beginning in 1982 and terminating in 1984 produced a report on bone occurrences by Wagner and Ruben (1984) that included a proposed arbitrary subdivision of the lower strata exposed in Blue Basin into "Units 1-6," (since modified and extended, Fremd, 1988 et. seq.) and introduced the term "Blue Basin Tuff". Work produced by two temporary BLM employees (Hanson and Allen, 1987) led to a small, interesting collection from strata above the Deep Creek Tuff, coined the term "Tin Roof Tuff", and included management recommendations for the bureau. Later refinements extended the biostrat intervals (or "lithosympatric tuffs) from unit A through unit M, including new subdivisions, and named a variety of new tuffs (see Albright and others, 2009, and references cited therein).

THE MASCALL FORMATION

The floras from Mascall strata last received detailed attention in Chaney (1925). The fauna of the Mascall was reviewed most recently by Downs nearly 40 years ago (1956); while the stratigraphy was examined by Kuiper (1988). In 1993, the NPS hired investigators to participate in a more thorough review of the faunas and strata (e.g., Schloeder, 1994 field notes) and measure of the stratigraphic column (Bestland, 1994), which resulted in a complex section 350 m thick, to be seen on Day One of this trip. This is providing much better data within which new collections can be placed with confidence. We anticipate increased attention on aspects of the Mascall in the near future from a variety of disciplines. Moving upsection, interesting reviews by Sheldon of pedogenesis and fossils trapped in intra-basalt flows within the Picture Gorge Basalt subgroup appeared (*Abstract #25*), including reconstruction of the MMCO (*Abstract #26*). Ever since Downs (1960), the Mascall strata (originally considered by Merriam to be a part of the Columbia River Basalt Group) have been variously measured, and little in the way of a cohesive stratigraphic framework was developed. A good start towards this goal, localized in the old "type area" (*Abstract #27*), appeared and represents a new perspective on these strata, as does a new analysis of the paleomagnetic signature of the lower part of the section (*Abstract #28*).

THE RATTLESNAKE FORMATION

Since the classic volume by Merriam, Stock, and Moody (1925), more recent studies on the important Hemphillian strata of the John Day basin are nearly non-existent. An analysis of the strata of the Rattlesnake Formation was most recently published in Enlows (1976); Chaney (1948) reviewed the flora. Martin (in prep.) is completing his effort to elevate the Rattlesnake to a Group, and has made several additions to the fauna. In 1994 the NPS and the BLM began a project redefining the occurrence of fossil vertebrates (Martin, unpub. Reports and in prep). The paleomagnetic data have recently been collected and analyzed (*Abstract #29*). Robinson (1990) reiterated the concept of the "Rattlesnake Ash Flow Tuff", effectively orphaning the paleontologically significant lower and upper fanglomerates that contain the vertebrate assemblages. This should be addressed in the near future, as implied at the NAPC 2001 meetings (*Abstract #30*). These rocks can only be viewed from a distance on the second day of this trip.

In addition to a variety of overall appraisals of the basin (such as alluded to in *Abstract #31*), a large number of managerial, curatorial, and policy perspectives have been published, beyond the scope of this brief review. Two new field guides have been prepared after the publication of the 1994 versions of the SVP field guide and the GSA field trip road log (Bestland and others, 1994). These include a guide to the paleobotany of the John Day Basin, that will be available for consultation during this fieldtrip (*Abstract #32*), and a new consideration of the eruptive sources of the tuffaceous components of the strata (*Abstract #33*) that postulates more precise volcanic sources than were assumed two decades ago (e.g., see below excerpt *).

REGIONAL GEOLOGY: AN EXCERPT FROM BESTLAND, RETALLACK, AND FREMD (1994)

The scenic high desert of north-central Oregon contains colorful volcanic and alluvial rocks of Tertiary age. Due to low rainfall (320 mm annually in Antelope) and temperature extremes (January mean of -1 ^{o}C and August mean of 19 ^{o}C) (Ruffner, 1978) the landscape supports desert scrub of sage and juniper and numerous badlands. In contrast to the present vegetation, fossil plants of Eocene age from the Clarno Formation indicate a climate much wetter, warmer and more equable than at present, more like that of modern lowland Panama or southern China (Manchester, 1981; Manchester & Meyer, in press). The transition from the steamy jungles of the past to the open ranges of today is recorded in a copious fossil record of plants, non-marine snails, freshwater fish, reptiles, and mammals in this region (Merriam and Sinclair, 1907; Merriam and others, 1925; Chaney, 1925; Scott, 1954; Downs, 1956; Cavender, 1968; Wolfe, 1981a and 1981b; Ashwill, 1983; Rensberger, 1983; Manchester and Meyer, 1987; Hanson, 1990).

Profound paleoenvironmental changes are also reflected in thick successions of paleosols ranging in age from middle Eocene to the present (Fisher, 1964; Retallack, 1981, 1991a, 1991b; Pratt, 1988; G.S. Smith, 1988; Bestland and others, 1993). In both the Clarno and John Day formations, packages of paleosols and their corresponding alluvial deposits have been identified and found to span approximately 2-3 million years each (Retallack, 1991a and 1991b; Bestland and others 1993, 1994) . . . Conformable packages of paleosols and alluvial deposits are interpreted as non-marine equivalents of the offlap-onlap relationships of sequence stratigraphy (Haq and others, 1986). The truncation surfaces that separate them are interpreted as stratigraphic sequence boundaries. The change in environmental conditions from one sequence to the next is recorded in the degree of soil development, clay mineralogy, bulk rock chemistry and soil structures of different paleosol types. . . The sequence boundaries, or truncation surfaces, correlate with periods of rapid climate change, whereas the paleosol and alluvial packages were deposited during climatically stable periods.

Regional Geology

Basement rocks in north-central Oregon consist of highly deformed metasediments of Permian age. These rocks are overlain by a thick sequence of Cretaceous marine strata. Both of these units are intruded and overlain by andesitic volcanic and alluvial rocks of the Clarno Formation, which ranges in age from middle Eocene to late Eocene, some 54 to 37 million years old (McKee, 1970; Enlows and Parker, 1972; Rogers and Novitsky-Evan, 1977; Manchester, 1981; Vance, 1988; Walker and Robinson, 1990). The Clarno Formation represents subduction related andesitic volcanism, probably on thin continental crust (Noblett, 1981). The formation is dominated by andesite lava flows and coarse-grained volcaniclastic strata that were deposited in alluvial aprons and braidplains that flanked active volcanoes. The variety of paleosols present in the Clarno Formation can be grouped into the following general types; clayey alluvial paleosols of former floodplains, weakly developed paleosols interbedded with debris flows and andesite lava flows, and residual paleosols with thick saprolite zones between major lithostratigrapic units.

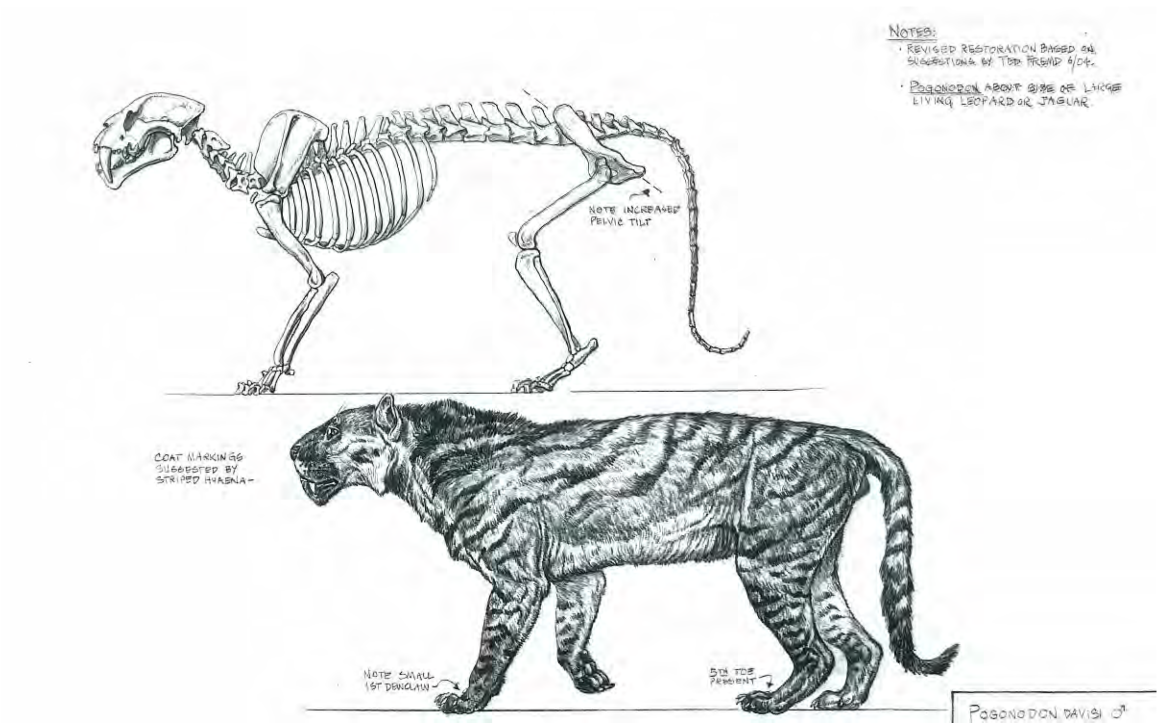
Rhyolitic ash-flow tuffs and dacitic to rhyolitic tuffs are conspicuous in latest Eocene, Oligocene, and early Miocene (39-22 million years) John Day Formation (Peck, 1964; Woodburne and Robinson, 1977; Robinson and others, 1990; Bestland and others, 1993). These primary pyroclastic, alluvial and lacustrine deposits were supplied with volcanic ash from the Western Cascades to the west (Robinson and others, 1984).*

Thus, the Clarno and John Day formations of central Oregon record a late Eocene westward jump of the subduction zone in the Pacific Northwest and a corresponding change from Clarno andesitic volcanism to Cascade volcanism and John Day back-arc basin deposition (Robinson and others, 1984).

The John Day Formation is divided into an eastern and western facies by the Blue Mountains anticline (Robinson and others, 1984). The western facies near Clarno and Madras is informally divided into members A through I based largely on the presence at the base of members of ash-flow tuffs (Peck, 1964; Swanson and Robinson, 1968; Swanson, 1969). The western facies contains coarse-grained volcaniclastic deposits, welded ash-flow tuff sheets, and a variety of lava flow units including trachyandesite flows of member B, rhyolite flows of member C, and alkaline basalts in member F. The eastern facies around the Painted Hills and to the east is divided into four formal members (Fisher and Rensberger, 1972). From bottom to top they are, Big Basin Member (red claystones), Turtle Cove Member (green and buff tuffaceous claystones), Kimberly Member (massive tuff beds) and Haystack Valley Member (tuffaceous conglomerates). The Painted Hills contains the ash-flow tuffs of member A and the "Picture Gorge ignimbrite" (Fisher, 1966) correlated with member H of the western facies. We informally divide the Big Basin Member into a lower, middle and upper member and divide the Turtle Cove Member into a lower and upper member based on the position of "Picture Gorge ignimbrite".

ABOVE: The back side of Sheep Rock. Strata are PGI at lower left corner (and foreground), capped by units G, H, I, and J separated by obvious tuffs, and DCT on upper right.

BELOW: A skeleton of *Pogonodon,* one of tens of new reconstructions of John Day Basin mammals completed under contract and peer review by the renowned paleontological illustrator, Mark Hallett.



John Day Basin Assemblages Made Simple

To help the reader quickly get oriented (in three short days!) to the complexity of the strata and localities that span over 45 million years, the complete composite stratigraphic section is divided into eight "assemblages" that are roughly spaced in five million year intervals. It should be understood that these subdivions are simply convenient fictions in many cases. For example, while the typical Clarno localities conform reasonably well to this sort of oversimplification, one quickly discerns that the "John Day" sequences of Big Basin, Turtle Cove, Kimberly, and Haystack could (and have) each themselves be further subdivided. These subdivisions are noted in Section Three: Assemblages, and should be discussed during the trip. While usually these assemblages are comparable, in some cases a geographically distinct fauna may emerge from strata known to be isochronous. It should be noted that few of the over 700 localities sampled to date have precisely the same faunal list, the reasons for which are themselves intriguing topics for study. These are provided to simply characterize particular aggregations (if not "bins") of taxa found in this variable column, from which individual patterns of distribution and taphonomic features can be further tweazed apart for each discrete locality. For some of these assemblages, there are scores of localities; others (such as the Clarno sites) are represented by only one or two remarkable deposits.

Bio-strat units	Acronym (this guide)	Rounded Ma	Typical chron	Rock-strat units	Type area colors
Rattlesnake ; Hemphillian	**RATT**	8-6	C3BR	Rattlesnake	
Mascall; Barstovian	**MASC**	16-14	C5B?	Mascall	
Haystack; Hemingfordian	**HAYS**	23-18	C6A	Haystack	
Kimberly; m - l Arikareean	**KIMB**	25-24	C7	Kimberly	
Turtle Cove; Whitneyan – Arik.	**TUCO**	30-26	C11	Turtle Cove	
Bridge Creek; Chadronian	**BIBA**	36-31	C15	Big Basin	
Hancock Mam. Q.; Duchesnean	**HAMA**	=40	C18	Upper Clarno	
Nut Beds; Bridgerian	**NUBE**	<45	C20	Middle Clarno	

Simplified index to major stratigraphic assemblages

John Day Basin Vertebrate Fossil Faunal List

Note: NUBE = Clarno Nut Beds, HAMA = Hancock Mammal Quarry, BIBA = Big Basin, TUCO = Turtle Cove, KIMB = Kimberly, HAYS = Haystack Valley, MASC = Mascall, RATT = Rattlesnake. X = Present. Other letters indicate TUCO stratigraphic units (e.g. A-K) or HAYS strata (RC = Rose Creek, JC = Johnson Canyon, HV = Haystack Valley). Updates available – www.nps.gov/joda FAD = First appearance date, LAD = Last appearance date, both are in Ma (millions of years ago). First and last appearance dates represent ages for all North American species, not just those from JODA. Dates compiled from the Evolution of Tertiary Mammals of North America, Volumes 1 and 2 (Janis et al. 1998; 2008) and the Paleobiology Database (http://paleodb.org).

Taxonomic Classification | **Dates** | **Assemblage Units (X = present)**

Class / Order / Family / Genus	FAD*	LAD*	NUBE	HAMA	BIBA	TUCO	KIMB	HAYS	MASC	RATT
Actinopterygii										
Amiiformes										
Amiidae [bowfin]										
Amia			X		X					
Cypriniformes										
Cyprinidae [carp and minnows]										
unidentified cyprinid					X					
Esociformes										
Umbridae [mudminnows]										
Novumbra					X					
Perciformes										
Centrarchidae [sunfish]										
Arcoplites									X	
Siluriformes										
Hypsidoridae [catfish]										
Hypsidoris				X						
"Amphibia"										
Anura										
Ranidae [frogs]										
Rana	23	recent								X
unidentified anuran					X					
Caudata										
Salamandridae [salamanders]							L-M			
Palaeotaricha	30.8	recent			X					

Taxonomic Classification				Dates		Assemblage Units (X = present)							
Class	**Order**	**Family**	**Genus**	**FAD***	**LAD***	**NUBE**	**HAMA**	**BIBA**	**TUCO**	**KIMB**	**HAYS**	**MASC**	**RATT**
"Reptilia"													
	Crocodilia												
		Alligatoridae [alligators]											
			new genus				X						
		Crocodylidae [crocodiles]											
			Pristichampsus	55.4	42	X							
	Chelonia (Testudines)												
		Chelydridae [snapping turtles]											
			unidentified chelydrid			X							
		Emydidae [pond turtles]											
			Clemmys	23.0?	recent							X	X
		Testudinidae [tortoises]											
			Hadrianus	55.4	33.9			X					
			Stylemys						E-F				
	Squamata												
		Boidae [constrictors]											
			Ogmophis	42	11.6				E-F	L-M			
		Rhineuridae [worm lizards]											
			Dyticonastis	30.8	20.6				A-F				
			Rhineura	50.3	13.6				E-F				
Aves													
	Charadriiformes												
		Laridae [gulls]											
			Larus	16?	recent				A-D				
		Scolopacidae [sandpipers]											
			Limicolavis						A-D				
	Falconiformes												
		Cathartidae [New World vultures]											
			unidentified teratorn						A-D				
		Falconidae [falcons]											
			unidentified falconid								X		X
	Galliformes												
		Phasianidae [pheasants]											
			Phasianus		recent				A-D				
			unidentified phasianid						X				
	Pelicaniformes												
		Phalacrocoracidae [cormorants]											
			Phalacrocorax	11.6?	recent				A-D				

Taxonomic Classification (Class / Order / Family / Genus)	Dates		Assemblage Units (X = present)							
	FAD*	LAD*	NUBE	HAMA	BIBA	TUCO	KIMB	HAYS	MASC	RATT
Podicipediformes										
Podicipedidae [grebes]										
Podiceps		recent				A-D				
Mammalia										
Marsupialia										
Herpetotheriidae [opposums]										
Copedelphys	37.2	33.3				X	L-M			
Herpetotherium	55.8	16.3				A-D	L-M			
Peratherium	55.8	38				X				
Xenarthra										
Megalonychidae [sloths]										
Megalonyx	10.3	0.011								X
Pliometanastes?	13.6	4.9								X
Lipotyphla [insectivores]										
Erinaceidae [hedgehogs]										
cf. Amphechinus	23.8	13.6					L-M			
Ocajila	33.9	20.6				K				
Micropternodontidae										
Micropternodus	46.2	20.6				E-F	L-M			
Proscalopidae										
Proscalops	33.9	16.3				K	L-M			
Soricidae [shrews]										
Domnina	46.2	20.6					L-M			
Pseudotrimylus	33.9	13.6				X				
Wilsonosorex	20.6	16.3					L-M			
Talpidae [moles]										
Domninoides	16.3	4.9				K	L-M		X	
Scalopoides	30.8	5.3					L-M			
Creodonta [creodonts]										
Hyaenodontidae										
Hemipsalodon	39.5	35.5		X						
Oxyaenidae										
Patriofelis	50.4	45.9	X							

Taxonomic Classification				Dates		Assemblage Units (X = present)							
Class	**Order**	**Family**	**Genus**	**FAD***	**LAD***	**NUBE**	**HAMA**	**BIBA**	**TUCO**	**KIMB**	**HAYS**	**MASC**	**RATT**
	Carnivora												
		Ailuridae [red pandas]											
			Simocyon	8.1	6								X
		Amphicyonidae [bear-dogs]											
			Amphicyon	18	15						RC	X	
			Daphoenodon	23	17.5					L-M			
			Daphoenus	39.5	27				E-F		RC		
			Mammacyon	27	19.2						X		
			Paradaphoenus	33.4	27				K				
			Pliocyon	16.5	15							X	
			Temnocyon	29.4	18.8				A-D,K		HV		
		Arctoidea [uncertain classification]											
			Nothocyon	29.4?	17.5?				X				
		Canidae [dogs]											
			Archaeocyon	33.3	26.3				X				
			Borophagus	6	1.8								X
			Cormocyon	31.9?	18.8?				E-K				
			Cynarctoides	23	14				A-F		JC		
			Desmocyon	24.8	16.3						JC		
			Enhydrocyon	31.9	18.8				A-D,G-J		X		
			Eucyon	10.3	3.6								X
			Hesperocyon	39.5	27.7				X				
			Leptocyon	27.7	6				E-F				
			Mesocyon	33.4	18.8?				E-K				
			Oregonocyon	30.8?	20.6?				X				
			Osbornodon	33.4	14				E-F				
			Osteoborus	8.8	4.5								X
			Paraenhydrocyon	31.9	18.8				A-F,K				
			Philotrox	29.4	23.0?				X				
			Phlaocyon	23	17.5				A-F				
			Rhizocyon	30.8	20.6				A-J				
			Tephrocyon	16.3	13.6							X	X
			Tomarctus	23	6							X	
			Vulpes	11	recent								X
		Felidae [cats]											
			Machairodus	6	1.8								X
			Nimravides	12.6	4.5							X	X
			Pseudaelurus	17.5	5.2							X	X

Taxonomic Classification				Dates		Assemblage Units (X = present)							
Class	Order	Family	Genus	FAD*	LAD*	NUBE	HAMA	BIBA	TUCO	KIMB	HAYS	MASC	RATT
		Mustelidae [weasels, otters, etc.]											
			Leptarctus	18.8	6?							X	
			Lutravus	7	6								X
			Martes	15.8	recent							X	X
			Mustela	5.2	recent								X
			Oligobunis	23	17.5					L-M			
			Plesictis	27.7	23				E-F				
			Promartes	27.7	17.5						HV		
		Nimravidae [nimravids]											
			Dinaelurus	31.9	27.7				E-F				
			Dinictis	38	29.4				E-F				
			Eusmilus	31.9	23				A-D				
			Hoplophoneus	38	29.4				A-D				
			Nimravus	31.9	23				A-J				
			Pogonodon	33.4	20.6				E-F,K				
			unidentified nimravid				X						
		Phocoidea [stem pinniped]											
			Allocyon	29.5?	28.5?				A-D				
		Procyonidae [raccoons, ringtails]											
			Bassariscus	15.8	recent				K			X	
		Ursidae [bears]											
			Indarctos	8.8	6								X
			Parictis	37.1	29.4				X				
			Plionarctos	7	2.4								X
			Ursavus	29.4	11				X		X	X	
			Ursus?	5.3	recent								X
		Viverravoidea [uncertain classification]											
			Palaeogale	35.5	17.5				K				
	Perissodactyla												
		Amynodontidae											
			Zaisanamynodon	39.5	37.1		X						
		Brontotheriidae											
			Eubrontotherium	37.1	33.4		X						
			Protitanops	41.3	37.1?		X						
			Telmatherium	46.7	45.9	X							
		Chalicotheriidae											
			Moropus	23	8.8?					L-M	JC,RC		
			Tylocephalonyx	18.8	8.8?						X		

Class	Order	Family	Genus	FAD*	LAD*	NUBE	HAMA	BIBA	TUCO	KIMB	HAYS	MASC	RATT
		Equidae [horses]											
			Acritohippus	20.6	13.6						X	X	
			Anchitherium	20.6	11.6					L-M	JC,RC	X	
			Archaeohippus	23	11						JC	X	
			Epihippus	46.7	37.1		X						
			Haplohippus	39.5	37.1		X						
			Hipparion	15.8	6								X
			Hypohippus	18.8	8.8							X	
			Kalobatippus	29.4	20.6					L-M	JC		
			Merychippus	17.5	11						X	X	
			Mesohippus	39.5	23.0?			X	A-D				
			Miohippus	37.1	19.2				A-K	L-M	HV		
			Nannippus	12.5	1.8								X
			Neohipparion	14	2.4								X
			Orohippus	53.5	41.3	X							
			Parahippus	23	11.0?						X	X	X
			Pliohippus	14	5.2								X
		Hyrachodontidae											
			Hyracodon	39.5	29		X						
		Hyrachyidae											
			Hyrachyus	54.2	39.5	X							
		Rhinocerotidae [rhinoceroses]											
			Aphelops	18.8	4.5							X	
			Diceratherium	31.9	14				A-K				
			Floridaceras	18.8	17.5						X		
			Menoceras	23	17.5						JC		
			Subhyracodon	37.1	27.7			X	X				
			Teleoceras	17.5	2.4?							X	X
			Teletaceras	39.5	37.1		X						
		Tapiridae [tapirs]											
			Colodon	45.9	29.4			X					
			Miotapirus	31.9?	17.5				X		JC		
			Nexuotapirus	23	20.4				A-J	L-M	HV		
			Protapirus	41.3	17.5		X						
	Artiodactyla												
		Achaenodontidae											
			Achaenodon	49	41.3		X						
		Agriochoeridae [clawed oreodonts]											
			Agriochoerus	33.9	23				A-F	L-M			
			Diplobunops	46.2	37.2		X						

Taxonomic Classification				Dates		Assemblage Units (X = present)							
Class	Order	Family	Genus	FAD*	LAD*	NUBE	HAMA	BIBA	TUCO	KIMB	HAYS	MASC	RATT
		Anthracotheriidae											
			Elomeryx	33.4	27.7				X				
			Heptacodon	39.5	29.4		X						
		Antilocapridae [pronghorn antelope]											
			Ilingoceras	8.8	4.5								X
			Merycodus	18.8	9.5							X	
			Sphenophalos	9.5	5.2								X
		Camelidae [camels]											
			Aepycamelus	17.5	6								X
			Gentilicamelus	29.4?	19.2?				K	L-M			
			Hemiauchenia	12.5	0.011								X
			Megatylopus	12.5	1.8?								X
			Miolabis	19.2	8.8							X	
			Oxydactylus	23	14.0?						X		
			Paratylopus	34.5	29.4				K		HV, JC,RC	X	
			Pliauchenia	15.8	8.8								X
			Poebrotherium	37.1	27.7					L-M			
			Protolabis	19.2	7						RC	X	
		Entelodontidae [giant "pigs"]											
			Archaeotherium	39.5?	23			X	A-F, K				
			Daeodon	29.4	15.8?					L-M	X		
		Hypertragulidae [mouse-deer]											
			Hypertragulus	39.5	19.2				A-K	L-M			
			Nanotragulus	31.9	18.8				E-J	L-M	X		
		Leptomerycidae [leptomerycids]											
			Leptomeryx	41.3	17.5					L-M			
		Merycoidodontidae [oreodonts]											
			Desmatochoerus	30.8	20.6				G-J				
			Eporeodon	31.9	18.8				A-K	L-M			
			Eucrotaphus	33.4	27.7				A-J				
			Hypsiops	23	17.5				K	L-M	X		
			Merychyus	23	5.2						X		
			Merycochoerus	29.4	17.5				E-K	L-M	X		
			Merycoides	29.4	17.5				K	L-M			
			Mesoreodon	30.8	20.6				A-K				
			Oreodontoides	29.4	18.8				G-K	L-M			
			Paroreodon	19.2	18.8				G-K	L-M	HV,JC		
			Promerycochoerus	30.8	20.6						JC		
			Ticholeptus	18.8	11.0?							X	

Class	Order	Family	Genus	FAD*	LAD*	NUBE	HAMA	BIBA	TUCO	KIMB	HAYS	MASC	RATT
		Moschidae [musk deer]											
			Blastomeryx	19.2	9.5?						X	X	
			Parablastomeryx	20.4	10.3						X	X	
		Oromerycidae											
			unidentified oromerycid?	45.9	33.4	X							
		Palaeomerycidae											
			Barbouromeryx	19.2	15.8						RC		
			Bouromeryx	18.8?	12.5						X	X	
			Dromomeryx	17.5	9.5?							X	
			Rakomeryx	17.5	12.5							X	
		Tayassuidae [peccaries]											
			Cynorca	18.8	15.8						HV	X	
			Hesperhys	19.2	11.0?						BC		
			Mylohyus	8.8	1.8								X
			Perchoerus	33.4	29.4				A-D				
			Platygonus	8.8?	1.8								X
			Thinohyus	33.4	27.7				A-D				
	Rodentia												
		Aplodontidae [mountain beavers]											
			Allomys	32	16				A-D,J,K	L-M	X		
			Alwoodia	30	19.4				G-J	L-M			
			Ansomys	33.7	32				X				
			Campestrallomys	33.9	24.8					L-M			
			Downsimus	33.7	23				X				
			Haplomys	33.7	28				X				
			Liodontia	17.5	5.8				?			X	
			Meniscomys	31.4	23				G-K				
			Niglarodon	31.4?	19.4?				X				
			Oropyctis	32	30				X				
			Parallomys	28	19.4				X				
			Pelycomys	26.3	20.6				X				
			Prosciurus	40.1	30				C-D				
			Rudiomys	28	23				X		X		
			Sewelleladon	28	23				K		HC		
			Tardontia	16	6.7				?			X	

Taxonomic Classification				Dates		Assemblage Units (X = present)							
Class	**Order**	**Family**	**Genus**	**FAD***	**LAD***	**NUBE**	**HAMA**	**BIBA**	**TUCO**	**KIMB**	**HAYS**	**MASC**	**RATT**
		Castoridae [beavers]											
			Agnotocastor	36.6	19.4			?	?				
			Capacikala	31.4?	23				G-K	L-M			
			Castor	7.3	recent								X
			Dipoides	10.5	2.5							X	X
			Hystricops	18.8	7.5						RC		
			Monosaulax	20	9							X	
			Palaeocastor	32	17.5				E-F				
		Cricetidae [New World mice]											
			Eumys	36.9	28				X				
			Leidymys	30	16				K	L-M			
			Microtus (Pleistocene)	2.5	recent								
			Paciculus	30	18				K	L-M			
			Peromyscus	12.1	recent								X
		Dipodidae [jumping mice and jerboas]											
			Plesiosminthus	28	10.1					L-M			
		Eomyidae											
			cf. Apeomys	?	?				X	L-M			
			cf. Arikareeomys	30	23				X	L-M			
			Leptodontomys	28?	5.8				X	L-M			
			Paradjidaumo	46.5	16				K				
			Pseudotheridomys	28	10?				X				
		Eutypomyidae											
			Eutypomys	40.1	23				A-D				
		Florentiamyidae											
			Florentiamys	33.7?	17.5				G-K	L-M			
		Geomyidae [gophers]											
			Entoptychus	30	17.5				K	L-M	HV		
			Gregorymys	30	12.6				X				
			Mojavemys	16	9							X	
			Pleurolicus	30	17.5				G-J				
			Tenudomys	33.7	23						HV		
			Thomomys	12.1?	recent								X
		Heteromyidae [pocket-mice, kangaroo rats]											
			Peridiomys	17.5	12.6							X	
			Prodipodomys	6	1.7							X	X
			Proheteromys	32	12.6					L-M			
			Schizodontomys	30	16					L-M	HV, JC		
		Ischyromyidae											
			Ischyromys	53.4	30				X				

Taxonomic Classification				Dates		Assemblage Units (X = present)							
Class	**Order**	**Family**	**Genus**	**FAD***	**LAD***	**NUBE**	**HAMA**	**BIBA**	**TUCO**	**KIMB**	**HAYS**	**MASC**	**RATT**
		Mylagaulidae [horned "gophers"]											
			Alphagaulus									X	
			Hesperogaulus									X	
			Mesogaulus	29	14.8						X		
			Mylagaulus	18.8?	5							X	X
			Mylagaulodon	28	23						RC, JC		
		Sciuridae [squirrels]											
			Arctomyoides	17.0?	14.8							X	
			Miosciurus	30	28				E-F				
			Petauristodon	19.4?	9					L-M		X	
			Protosciurus	33.7	14.8				F	L-M			
			Protospermophilus	30.8	9				G-K			X	
			Sciurus	12.1	recent								X
			Spermophilus	17	recent								X
	Lagomorpha												
		Ochotonidae [pikas]											
			Desmatolagus	46.2	16.3				K	L-M			
		Leporidae [rabbits]											
			Archaeolagus	26.3	16.3				E-F	L-M	X		
			Hypolagus	20.4	0.3						X	X	X
			Palaeolagus	37.2	20.6				K				
	Chiroptera												
		Vespertilionidae [evening bats]											
			Myotis	30.8	recent								X
		unidentified bat						X					
	Proboscidea												
		Elephantidae [elephants, mammoths]											
			Mammuthus (Pleistocene)	2.4	recent								
		Gomphotheriidae [gomphotheres]											
			Amebelodon	8.8	6								X
			Gomphotherium	15	5.3							X	
			Tetralophodon	11	9.5								X
		Mammutidae [mastodons]											
			Zygolophodon	17.5	11							X	
	Primates												
		Omomyidae											
			Ekgmowechashala	30.8	24.4				G-J				

NOTES

SECTION TWO: Road Logs

The following road logs follow the traditional format with cumulative mileage and waypoints, so that persons wishing to retrace the route can do so. This particular excursion was designed to accommodate a large touring bus, and travels over paved highway for its entirety. Several of the stops, however, included deviations from the main road and traversed over private roads to outcrops that are NOT open to the public. Therefore, this road log comes with a **WARNING**. Several of the stops mentioned in this guidebook included hikes and traverses over private property, with the kind permission of the land owners. Any member of the public is welcome to look at these outcrops from the public byways, of course, but you will be TRESPASSING if you leave the major roads at any of these stops without the landowners permission, preferably written. Also, the Clarno Nut Beds are within the boundaries of land administered by the National Park Service, but the Hancock Field Station (HFS) is a private inholding within the Clarno Unit of the John Day Fossil Beds National Monument and you cannot plan a hike starting at, or crossing, their property. Inquire at the Thomas Condon Paleontology Center at the Sheep Rock Unit of the park, or at the HFS (they are friendly), for potential hiking opportunities and alternate routes; there are many.

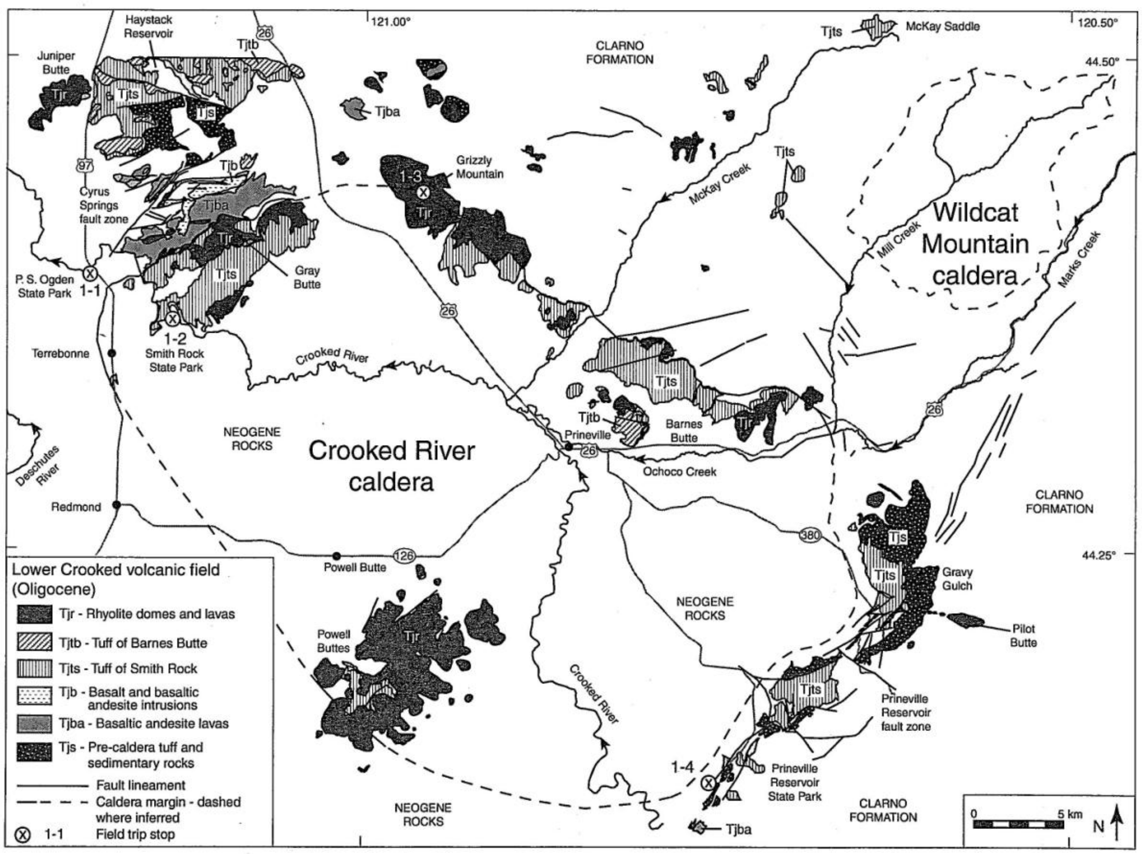
Several of the walks are within John Day Fossil Beds National Monument, and particularly at Painted Hills, Blue Basin, and Foree **you are encouraged to explore the established trails**. Indeed, the interpretive trails in the National Park System units are an excellent way to familiarize yourself with the paleontology of the area. Remember, however, that on ***any*** federal lands, collection of fossil vertebrates – body or trace fossils - without a research permit is ILLEGAL. Furthermore, within the National Park boundaries, collection of ANYTHING – pebbles, flowers, whatever - is a violation of a variety of codes of federal regulations, and you probably will be cited. Simply exercise common sense; it is your responsibility to know whose land you are on.

DAY ONE trip route noted in log. Numbers correspond to road log stops. TCPC: Thomas Condon Paleontology Center.

DAY ONE: REDMOND TO JOHN DAY VIA PAINTED HILLS AND THE THOMAS CONDON PALEONTOLOGY CENTER

Cumulative
Mileage *Description*

(0.0) Begin mileage at the Redmond airport, turn right and proceed North from intersection with parking area.
(0.5) Proceed right on Veteran"s Way.
(0.9) Follow signs to Prineville at the Y intersection
(1.1) Stop sign at 10th St. – proceed straight.
(1.3) Junction with US 126. Proceed East
(6.5) Intersection of Alfalfa Road with Highway 126. To the North is Smith Rock, composed of what was thought to be a welded 16-18 Ma rhyolitic ash flow tuff. The Tuff of Smith Rock consists of an intracaldera facies and is now dated at 29.5 Ma, part of a silicic tuff cone inset into older Eocene rocks. This eruption appears to have formed the Oligocene Crooked River caldera, itself a huge 40 X 30 km depression (McClaughry and others, 2009). Previously unrecognized structures such as this, as well as the recognition of the Wildcat Mountain caldera, and others, has completely changed our understanding of the source magma chambers for much of the Turtle Cove sequence in the John Day, no longer a "Distal Record of Cascade Volcanism" (sensu Robinson et al, 1984).



Inferred locations of the calderas that probably provided much of the tephra of the Turtle Cove strata (McClaughry and others, 2009). Recent discovery of these and other eruptive sources invalidate earlier speculations that most of the ash fall tuffs and ignimbrites had a source in the "ancestral Cascades".

(8.0) Town of Powell Butte
(15.0) Prineville airport.
(16.3) As we begin our descent into Prineville, there is a road cut with cross-bedding and lacustrine shales of the Deschutes Formation, capped by a 4.0 ma basalt.
(16.7) Top of rim looking down into ancient lakebed. As we proceed, pass the Ochoco wayside to the north, perched on a lava flow of the Deschutes Formation. Roadcuts are in paludal and lacustrine units of the Prineville strata.
(17.4) Cross the Crooked River entering Prineville. This river drains some of the classic localities visited by early collectors in what is now recognized as the "Southern Facies" of the John Day Formation. Many of the types and hundreds of other outstanding specimens were collected from exposures along Camp Creek and at Logan Butte up river many miles from here (see TUCO assemblage section and Appendix Three).
(18.0) Jct. Highway 126 and US #26 at the bronze spurs in the intersection. Enter Prineville, one of the early settlements in Eastern Oregon.
(19.6) Intersection of Combs Flat St. Road to south leads to Prineville Resevoir, which has excellent exposures of tuffs and tholeiitic basalt lavas apparently just lateral to the southernmost boundary of the Crooked River caldera (McClaughery and others, 2009).
(20.4) Prineville BLM office to the North. The NPS and BLM have a cooperative agreement for the management of vertebrate fossils in the John Day Basin that permits NPS and affiliated researchers to retrieve significant materials from BLM lands. These are deposited in designated storage in the NPS repository and are available to qualified investigators.
(**21.6**) At 11 o'clock is an unusual welded tuff within the John Day Formation, the 27.5 Ma "Rhyolite of Ochoco Resevoir", overlying "moat-fill" deposits (see McClaughry and others, 2009). We are presently in the so-called "Western Facies" of the John Day; here the fossiliferous claystones that are normally interbedded between the weather resistent welded tuffs are not in evidence as they are elsewhere in the basin.
(24.8) Ochoco Resevoir and Dam
(26.0) Ochoco County Park and campground; a good place to stay right on the water if doing fieldwork nearby.
(27.9) Mill Creek Road. This leads after several miles to "Steins Pillar", a single cooling unit of a welded ash-flow tuff in the John Day Formation (Waters, 1966) that is apparently ca 40 Ma, close in age but slightly older than the Member A tuff which has long defined the base of the John Day Formation (see Retallack and others, 2001). After many years of speculation, it now seems reasonable to hypothesize that the Wildcat Mountain caldera (*sensu* McClaughry and others, 2009) is probably the source of this important, prominent, and very wide spread marker bed.
(29.1) Strata in quarry to the north (left) are resistent Clarno Formation.
(34.0) Ochoco Creek Road.
(35.7) Boundary, Ochoco National Forest. For the next sixteen miles, exposures of Clarno Formation andesites and a melange of other 40-50 Ma volcanics are covered with Ponderosa pine,

Historical Perspective: Dec 1, 1916

- *From The BLUE MOUNTAIN EAGLE, Grant County's newspaper*

"The famous fossil beds of the John Day valley will be an objective point of interest to tourists who are to traverse the state by the route of the (*then not constructed - tf)* John Day Highway. These beds are among the most prolific in rare relics (*sic*) of prehistoric days. They have to the store of scientific research added much of value and of interest. In addition to their value to the scientist they are a marvel to the tourist for their picturesque beauty is worth much. With the opening of travel this way steps should be taken to preserve and conserve these resting places of pre-historic life…. This district should never be turned over to private speculators, but should belong to the people. **It might be well for the government to withhold the lands from entry and establish here a national park**. The land is of little or no value and would do no individual any particular good. As time goes on the value of these beds will be recognized."

Douglas-fir, and western larch. Much of this is interspersed with a confusing mass of lavas, domes, sills, dikes and other earliest John Day rhyolitic deposits.

(38.3) Mill Creek Road; cut is into a Clarno paleosol.

(47.6) Rest Area

(48.2) Road heading north leads to the "Lucky Strike" Thunderegg Mine, which is in the Clarno Formation. Thundereggs are the Oregon State rock.

(49.8) Ochoco Summit- Elevation 4720 feet. Pleasant campground to right; entering the Bridge Creek watershed.

(49.9) Basaltic volcanic conglomerates of the Clarno Formation in the road cut.

(50.9) Bedded tuffs in the roadcuts.

(52.5) The Ochoco Pass fossil locality (Cavender, 1968) is within dark-colored lacustrine shale in the Clarno Formation and intruded by dikes of andesite and veins of calcite. This locality has produced a small, interesting assemblage of fragmentary fish remains. Included in the fauna are catfishes (*Astephus)*, bowfins (*Amia*), mooneyes (*Hiodon*), and suckers (cf. *Amyzon*). These lacustrine strata are overlain by more steeply dipping fluvial beds.

(53.6) At 1 o'clock is Black Butte, elevation 5027 feet, dated at ca 49 Ma; White Butte is actually a massive dacite intrusion (not hornblende andesite, as thought by Wilkinson (1959) dated at ca 42 Ma, to the South at 5627. Both of these Clarno volcanic intrusives emerged through thick sequences of Cretaceous shales and conglomerates that blanketed the region.

Historical Perspective

UCMP EXPEDITION, 1899
June 6, Bridge Creek Beds

After lunch Mr. Hatch and I crossed the creek to the beds further up. Some fine exposures were examined but no trace of remains. The over topping lava contains much tufa which scales off and slides over the sedimentary strata covering it with sharp edged fragments … slipping once I cut the knukles (sic) of my glove to shreds, severely skinning two fingers.

Up and up above the valley, above the fossil beds into the lava terraces among the junipers. Beautiful old trees, rugged and grizzly sentinels around the walls, they keep their everlasting watch over the remains of those animals of another world that have lain buried while generation after generation of these old prophets, each perhaps a thousand years, has sprung up and passed away at the post of their duty. Time is lost and years are but the pulse beat.

(56.1) Grey shales in roadcut. Note extensive faulting and numerous dikes.

(59.5) Branch Creek. At 3 o'clock are excellent Clarno leaf localities (Alex's Canyon and Branch Creek among the most famous) that have yielded abundant flowers and insects. See Day Three for discussion of other Clarno sites.

(60.0) Sargeant Butte at 9 o'clock.

(60.2) West Fork of Branch Creek.

(62.4) Junction with Highway 26 to Painted Hills. We turn off of Highway 26 and proceed North towards the"Painted Hills" area. RESET ODOMETER.

SPUR TURNOUT ON BURNT RANCH ROAD TO THE "BRIDGE CREEK BEDS" AND PAINTED HILLS

This 7.5 mile (15 mile round trip) spur does not effect cumulative mileage on US Highway 26, which will resume count at junction. For those who proceed without turning and visiting Painted Hills, reset odometer here.

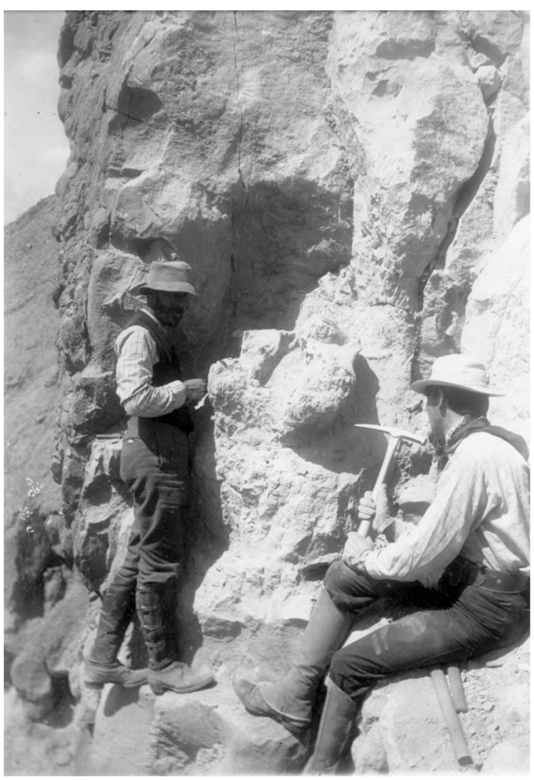
0.0 Pulloff at junction is cut into Clarno andesite.

0.4 Broad white hills to west are Sargent Butte and Sand Mountain, largely made up of finely bedded lacustrine shales of the Bridge Creek lake beds, unconformable overlying (here) Clarno lava flows and the Andesite of Sand Mountain

0.7 Straight ahead are visible important Kimberly member exposures at the foot of Sutton Mountain, one of the locality complexes in this basin. These strata have produced many of the striking, large oreodont skulls in many museum collections such as AMNH, YPM, and UCMP.

1.2 Small informal campground on BLM to west of road. In reddish cutbank on far side of Bridge Creek, a large Pleistocene Columbian mammoth tusk, discovered by a wandering dentist(!), was excavated a few years ago; the specimen is on display in the Prineville BLM District office.

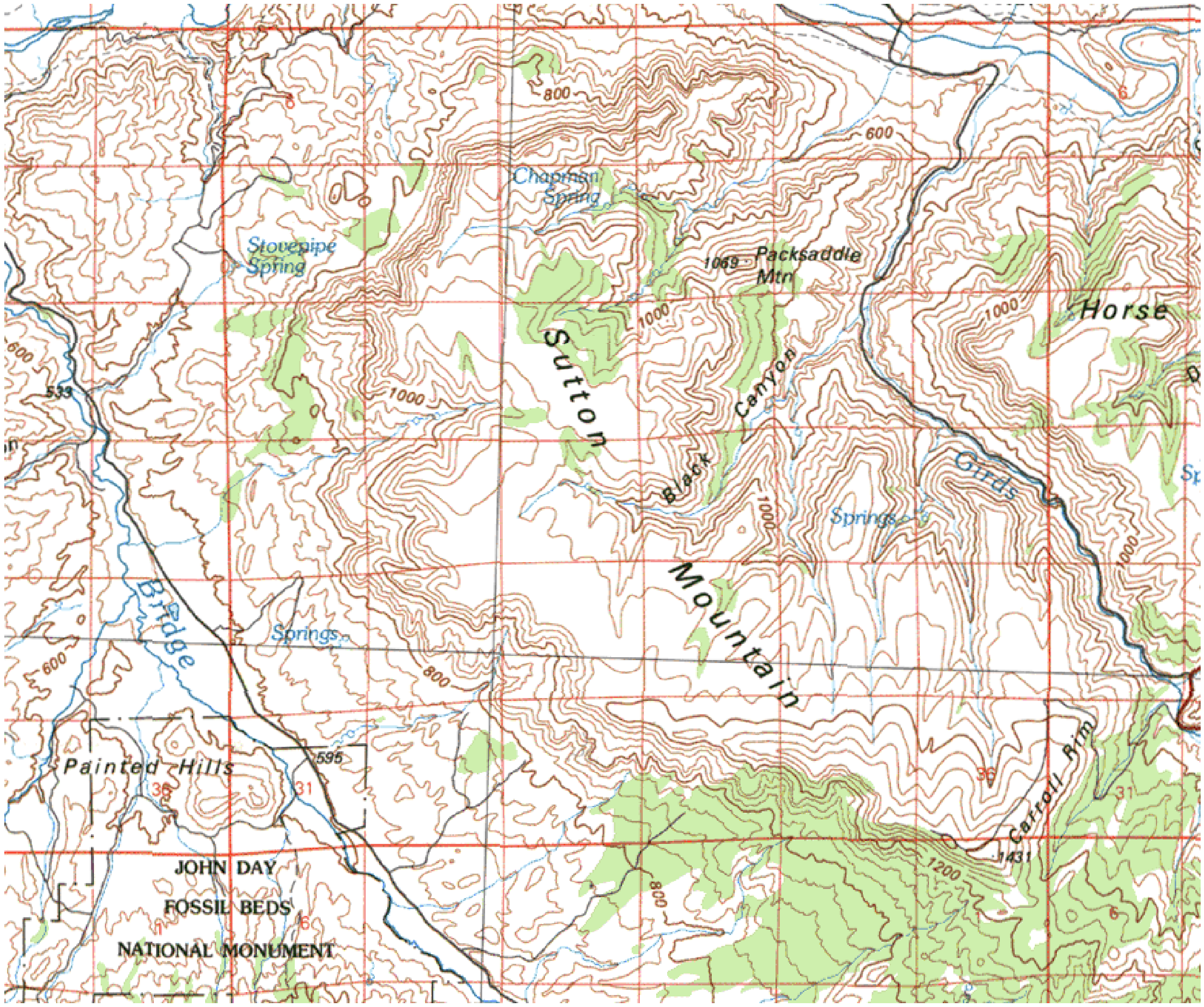
1.5 Meyers Canyon, gouged deeply by a remarkable flood in the 1950s. Upstream up the creek from this point are localities yielding Permian age fusilinids, the oldest fossils in the basin (the oldest Oregon record goes back to the Devonian).
1.7 Rhyolite of Bear Creek, onlapped by Andesite of Sand Mountain in places.
2.6 To the East (right) is little valley leading to stunning exposure in “Ruby Basin”.
2.8 Middle Big Basin member stratified paleosol exposures.
3.0 Rhyolite of Bear Creek. We will see some of the source rocks when we access the Painted Hills Overlook trail.
3.2 Access draw to many localities, such as UCMP localities V6011 (Bridge Creek 3), and V6014, site of one of the earliest chalicotheres discovered (both in N. A. stratigraphy, and historically). The steep basalt cliffs of Sutton Mountain are on top of extensive deposits of much of the stratigraphic column of the John Day Formation. These strata are the source of most of the earliest collections of vertebrate fossils, made in the 1860s. Among the items discovered by the U. S. Cavalry and later brought to Thomas Condon, frontier minister and Oregon's first State Geologist was a specimen of *"Diceratherium hesperius*" (=*annectens)*, YPM10239 from "The Upper John Day, Bridge Creek, Or." This was the very first vertebrate fossil described from the John Day Basin, described and fig'd by Leidy in 1865. Some of the material from Bridge Creek became scattered; a collection of oreodont skulls was made in the winter of 1871 from “near the head of a small stream called Bridge Creek” by Lord Walsingham, an English amateur entomologist. These include the holotypes of *Merycochoerus leidyi* and *M. temporalis* that ended up in the Woodwardian Museum, Cambridge. Many other institutions possess good material from Bridge Creek, particularly complete skulls of the largest oreodonts, but accompanying field data are seldom – if ever – associated.
4.5 Exposures to East, just below the basalt, are important sequences of the “Haystack Valley” strata, more carefully studied in the Turtle Cove region. To West are colorful redbeds of the lower unit of the “Big Basin Member” of the John Day Formation.



J. C. Merriam and Lloye Miller collecting holotype of *Archaeotherium (Elotherium) calkinsi* from Hatch's Gulch locality. Note snake gaiters.

Skull of UCMP 953, the specimen being collected in photo to the left. Collected by University of California Party, 1899, from Loc. 801 upper John Day Beds. UCBG Vol. 4, No. 6, p 132, Pl 15. 1905. "Upper Part of the Promerycochoerus Beds, Bridge Ck. Wheeler Co. Oregon." Some diagnostic postcranial material accompanies the skull.

Photograph from Foss and Fremd, 1998.



Clip from Stevenson Mtn., Oregon, 1:100,000 USGS quad, with JODA locality database markers deleted. The North, West, and South side of Sutton Mountain has 33 major localities, spanning 10 m.y. of faunas.

5.6 Turn left into **Painted Hills Unit of John Day Fossil Beds National Monument** on Bear Creek Road. Gully to the right leads to JDNM-68, UCMP 809 "Hatch"s Gulch", a wonderful thick sequence of "Kimberly" strata and the source of the holotype of *Archaeotherium (Elotherium) calkinsi*. From"Upper Part of the Promerycochoerus Beds, Bridge Ck. Wheeler Co. Oregon. Museum Label reads: Loc. 801 "upper John Day Beds" Coll. UC Party, 1899 UCBG Vol. 4, No. 6, p 132, Pl 15 – 1905.

6.2 Spur road to picnic area

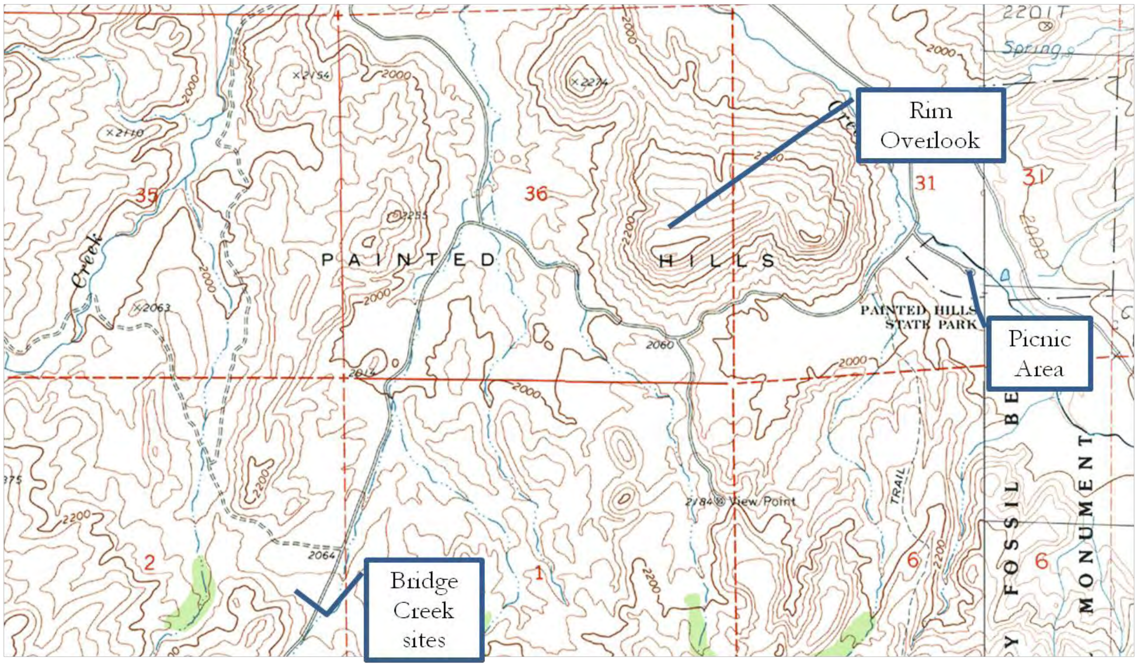
6.4 Turn into the grassy rest area and stop briefly. Note all of the trees and shrubs planted here are genera found in the Bridge Creek flora assemblages. A good view of the Painted Hills rim, capped by the Picture Gorge Ignimbrite, can be seen from this vantage point and has yielded abundant fossils of exactly the same age as Blue Basin. This has been mistakenly named "Carroll Rim" by the NPS; in fact, the "real" Carroll Rim forms the SE buttress of Sutton Mountain, and is in Section 36, not 31, of this township and is 6 miles due east. Best to just refer to this as the Painted Hills Rim until we petition the Board of Geographic Names to rename it "SVP Rim" or …

6.5 Ranger residence.

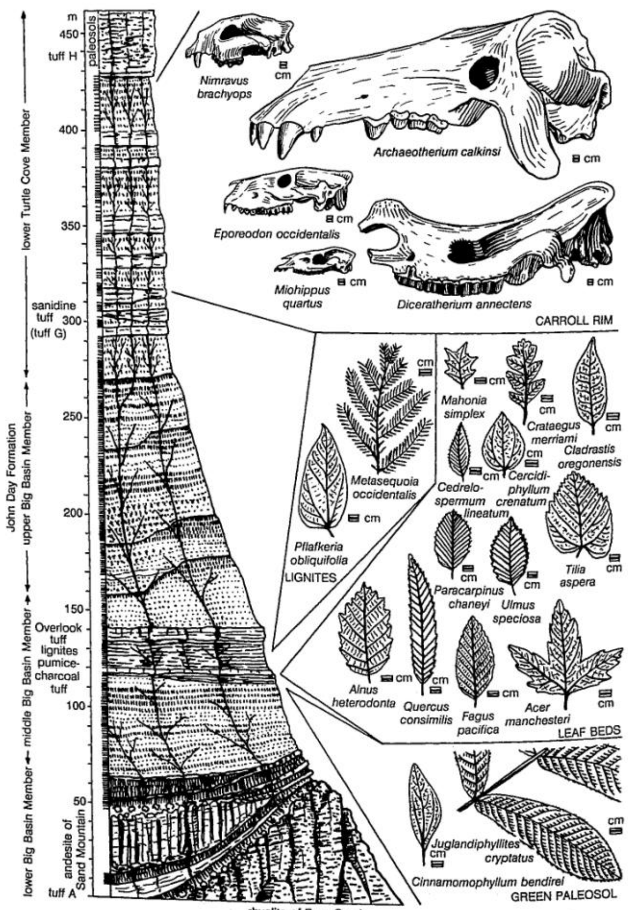
7.5 Painted Hills overlook area. After enjoying the view, proceed to the Painted Hills (Carroll Rim) trail head and commence hike up.

Stop 1-1. Painted Hills Overlook trail

This trail winds up the south flank of a prominent bluff overlooking a variety of outcrops.



ABOVE: Overlook trail and viewpoint. USGS 1:24000 Quad Painted Hills, 1:1 scale.



Stratigraphic cartoon of Painted Hills strata up to "tuff H", the Picture Gorge Ignimbrite (from Retallack and others, 2000).

OPTIONAL EXTENDED LOG:

8.1 Proceed from the parking area trailhead west to road junction past excellent exposures of middle Big Basin member. Many of the dark bands visible along the way are lignite beds that are extensive, containing compressed units of permineralized wood. Other dark spotty units amidst the yellowish layers are nodular, and represent managanese concentrations, possibly from manganese accumulating plants (Retallack and others, 2000). These color bands are paleosols that are actually very well developed after trenching exposes the underlying strata; the mantling of clays that have weathered over the surface to form a regolith obscures much of the underlying complexity. Proceed to the Bridge Creek area, taking the left fork. Right fork leads to "Painted Cove," a small interpretive loop trail into an interesting exposure of lower Big Basin member laterites onlapping a Clarno

rhyolite body (the "Rhylolite of Bear Creek" sensu Retallack and others, 2001).
9.0 "Brown grotto" at 3 o'clock. This is an excellent example of heavily weathered, lateritic paleosols developed along the margins of Clarno lava (rhyolitic) flows, first figured in Hay (1962) and subsequently thoroughly analyzed by Bestland and others (1994). On either side of the road are outstanding exposures of detailed sequences of paleosols interbedded with lacustrine beds, altered air-fall tuffs, lignite deposits, and a host of other volcaniclastics reviewed thoroughly by Bestland and others (1994) and Retallack and others (2001).
9.7 Turn in for bus at kiosk and trail head. Stop for examination of the Bridge Creek flora localities.
Depart from Bridge Creek site. Retrace route to road junction.
30.1 Junction with Highway 26. Proceed east towards the town of Mitchell.
Reset Odometer.

Cumulative Mileage	*Description*

(0.0) Mileage resumes at intersection.
(0.1) Clarno andesite on the left.
(0.4) Gable Creek, type area for the Gable Creek Formation, a 9000 foot-thick sequence of Cretaceous (Albian-Cenomanian?) submarine turbidites (Little, 1987) and fan complex. These strata interfinger with the Hudspeth Formation, marine shales containing abundant ammonites in some localities. Reports of mosasaur, pterosaur, and ichthyosaur scrappy remnants from these strata are not surprising: thorough examination by vertebrate workers is long overdue. Recently a plesiosaur was collected from rocks of this age, about two miles from here and has been tentatively identified as *Polyptychodon*. A cast of this new specimen can be examined at the Oregon Paleo Lands Institute in the town of Fossil, later on this trip; the original is housed at the SDSM&T.
(2.4) Cross Bridge Creek. "Mitchell dike," a volcanic plug to the north, punched through the Cretaceous strata ca 34 Ma, related to Bailey Butte on the right.
(3.3) Entering Mitchell and junction with Service Creek road, where trip loop will emerge in two days.
(6.2) Oregon State University geology field camp to South. According to OSU faculty, this is apparently the longest continuously operating field school in North America. For many years, Ed Taylor of Oregon State University and others have led the Oregon State University geology field schools from this camp. Complex packages of altered sediments and a dearth of specific publications on the Permian exposures make this a very challenging class.
(7.3) For the next several miles are interesting roadcuts into a Clarno volcano and dikes (Keyes Mountain), and its poorly sorted fallout with interbedded xenoliths. Recent highway construction has exposed large, obviously near-vent debris flows, lavas and other volcanic deposits.
(7.5) Paleosol in road cut. Highway engineers reported seeing bone in this material, not verified by the author. Large root casts nearby cast some suspicion on the veracity of these observations, but the possibility of additional Clarno mammal localities is exciting enough to continue periodic checking of such exposures. Andesites and altered volcaniclastics at the beginning of the Keyes Mountain grade. Historical marker discusses H. Wheeler for whom the county was named. Apparently, he was

Historical Perspective

PRINCETON EXPEDITION
July 27, 1889.

It was intensely hot in the beds. A chisel laid in the sun could not be picked up with the bare hand; and, if one left his canteen anywhere but in the shade, he could not swallow the water. The thermometer reached at times a hundred and forty degrees (sic). We met this sort of heat in all our work, after a time growing accustomed to it.

toiling up the old, steep grade carrying U. S. mail along the Dalles to Canyon City road and "was attacked near this spot by indians, mail looted, and coach destroyed, Sept. 7th, 1866." Sit back and safely enjoy more spectacular road cuts up from here to the summit.

(9.8) Keyes Creek Summit (elevation 4389).

(10.0) Large mountain dead ahead is Spanish Peak; from creeks draining this feature were some of the first marine fossils brought to Thomas Condon by cavalry patrolling the Dalles-Canyon City military road.

(13.7) Westernmost exposures of the Rattlesnake Ash Flow Tuff (RAFT) in this region form the resistant ridge caprock. Road cut in RAFT is source of one of many widely scattered samples from which 7.2 Ma date was ascertained by workers at the Berkeley Geochronology Center (Swisher, pers.comm.) facilities.

(18.0) Antone Road to the south. Here the highway veers to follow Mountain Creek. The old route (impassable by bus) along the old Antone road is more geologically interesting, passing exposures of John Day, Clarno, Mascall, and Rattlesnake strata.

(20.3) Columbia River basalts on left; Rattlesnake Ash Flow Tuff on right.

(22.1) Juniper Butte dead ahead, sitting atop green zeolitized tuffaceous paleosols of the Turtle Cove strata of the John Day. Enter a landslide basin; characterized by incompetent slopes and numerous slumps in upper Clarno and the Big Basin member of the John Day Fm. paleosols. To the north, Juniper Butte is the prominent peak capped by multiple layers of Picture Gorge Basalt.

(24.4) View into the John Day Valley. Mountains along south side are the Aldrich mountains; the highest peaks, east of the Aldrich range, visible from here are Canyon Mountain and Strawberry Mountain, the latter 2755 meters (9,038 feet). Much of this terrain was extensively reviewed in a series of papers by Thayer and others (1966). Along this stretch, note resistant monoliths consisting of a Clarno lahar deposit.

(30.2) To the north, up the ravine just west of the Rock Creek bridge, are very good exposures in some of the lowest sections of the Mascall Formation. This is near, but different from, Downs (1956) "McDonald localities" V-4828, UCMP Mascall 17. Well-defined bedding with interbedded tuffs near the base of the Mascall stratigraphic column, and abundant fossil material, make this a site of great potential significance, essentially undiscovered until recently. NPS workers encountered previously undocumented plant and mammal sites in 1993 (e.g., Schloeder, 1994), including portions of a gomphothere, *Merychippus*, and others. *NOTE: most localities outside NPS ownership, such as this one, are either on private or BLM lands. Private landowners often have agreements or scenic easements with the NPS to restrict access and are reasonably hostile to trespassers; all federal lands, of course, require a permit to collect vertebrate fossil materials.*

(31.3) The old McDonald Ranch of Downs (1956), now the "Tri-Creek" ranch. To the south, along Birch Creek, are good exposures of the Mascall including JDNM-70 (=V4827, Mascall 13), the Birch Creek Locality. This site continues to produce interesting material, including a fine skull of *Hesperogaulus gazini* (Hopkins and Calede, in prep), *Arctomyoides, Merychippus*, and others.

(32.4) Optional Stop: JDNM-71 (=V4829), the Rock Creek locality, to the south of the road.. Downs (1956) only cited *Merychippus* from this locality. These exposures have recently produced additional material, including *Cynorca, Dromomeryx,* and *Hypolagus*, and appears suited for prospecting every two years or so. The locality itself is on BLM lands.

(33.1) Optional stop: Roadside Mascall leaf locality. These strata are dirty diatomites representing a shallow

Historical Perspective

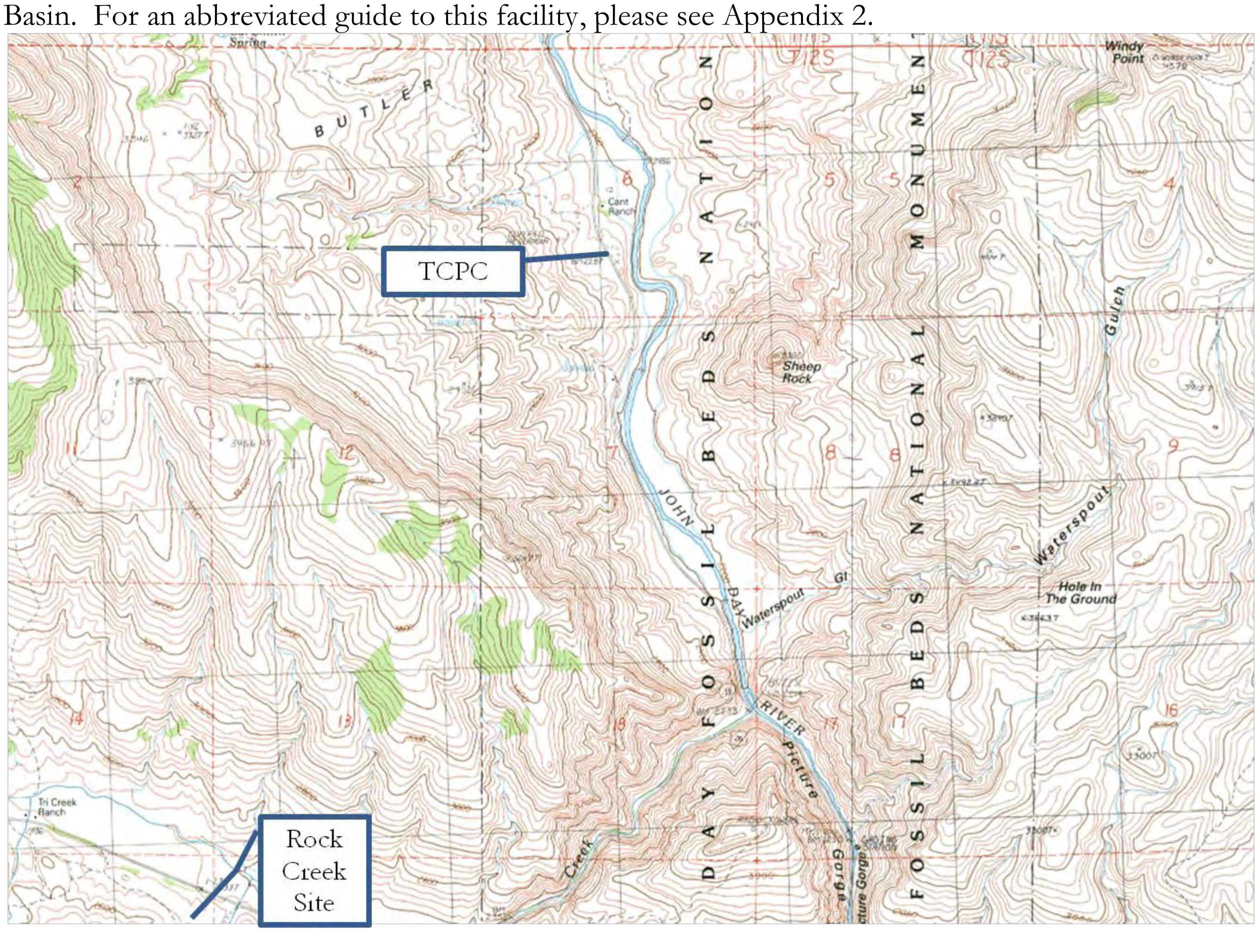
UCMP EXPEDITION
June 19, 1899

The view of the large bed is a most wonderful sight. Cut and furrowed into chasms and pinnacles bare as a tombstone. The first impressions I received was that of Dante's illustrations of the inferno. To heighten the impression some of the strata are of a dull dirty green color most repulsive in tone. What a place for bones of ancient monsters of a long passed age …

lake that existed in the region not long after the last basalts flowed over the area.
(33.4) Enter Rock Creek Canyon and the **Sheep Rock Unit, John Day Fossil Beds National Monument.** Along the way, note the roadcuts into prominent red, baked paleosols in the interbasalt layers.
(34.7) Enter Picture Gorge. Junction of Oregon Highway #19 and U. S Highway 26; proceed north on the former, crossing Rock Creek on the bridge.
(34.9) Inter-basalt flow lacustrine tuffs in the roadcut to the west, below the hexagonal colonnade layer. Sanidine crystals have been collected from the lowest level of this tuff by Swisher and others, and actually provide a robust date for the base of the CRBs in this area.
(35.0) The locality "Entoptychus Snouts" due east, high in section just below the basalts.
(35.3) "Hayes Haven", an important microvertebrate site. From these strata in the small exposures on the east side of the cablecar, NPS staff and volunteers (particularly Rick Hayes) have collected several hundred good specimens, the majority *in situ*. These include many rodents, lagomorphs, tragulids, and canids, as well as a new species of amphicyonid. These strata can be "cut and pasted" to layers in position on the back (northeast) side of Sheep Rock.
(36.5) Sheep Rock overlook to right.

Stop 1-2. The Thomas Condon Paleontology Center

This relatively new field station contains a variety of functional spaces, and was built to facilitate research, curation, and public appreciation of the paleontological resources of the John Day Basin. For an abbreviated guide to this facility, please see Appendix 2.



Locality map of the Thomas Condon Paleontology Center (TCPC), Picture Gorge, and the Rock Creek (Mascall) site. Collage of 1:24000 Quads Picture Gorge East and Picture Gorge West, 1:2 Scale.

Dr. Arnold Shotwell helping load his library into truck for deposit into the NPS TCPC library. No person had a larger impact on preserving the area as a National Monument.

Construction of the TCPC was mandated by Congress with passage of legislation establishing the monument. Beginning with J. C. Merriam, a number of paleontologists urged Congress to establish a national monument incorporating the significant fossil beds. In 1954, J. A. Shotwell of the MNCH at the U of O cooperated with the Oregon State parks to preserve the fossils and develop displays and recreation opportunities and. To his dismay, one of the results was that the State encouraged "pilfering", and he realized that a federal solution was required. Later Shotwell (1967) prepared an influential report on the basin. In it, he wrote "*Nature has provided in the John Day Basin a unique opportunity to see Earth History under the most desirable conditions. The obvious events pointed out by interpretative (sic) aids such as restorations, displays of specimens both in place and otherwise arranged, and instructive signs will open a whole new world to many who never dreamed such things could be seen so clearly*." In 1976, the National Monument was finally created and the TCPC was completed in 2005.

Cumulative Mileage	*Description*

Retrace route back to Highway #26: **re-set odometer to 0 at the junction** and proceed towards John Day.

(0.0) Junction of U. S. Hwy. 26 with Oregon Hwy 19. Proceed south and enter Picture Gorge, the type area for the Picture Gorge Basalts . There are over 60 flows of the Picture Gorge Basalt (PGB), which together cover over 10,000 km^2. Each flow averages over 40 cubic kilometers of material (Tolan and others, 1989). Despite these impressive figures, they amount to less than 2% of the total volume of the Columbia River Basalt (CRB)Group. The PGB has been elevated to Subgroup status by Bailey (1989). Seventeen distinct flows are evident within Picture Gorge, belonging to the Dayville Basalt and Monument Mountain Basalt Formations. These emanated from a system of fissures near the town of Monument, 25 miles NE of the gorge. Merriam originally thought the Mascall was interbedded with the basalts; north of here are lacustrine interbeds between the first and second flow layers.

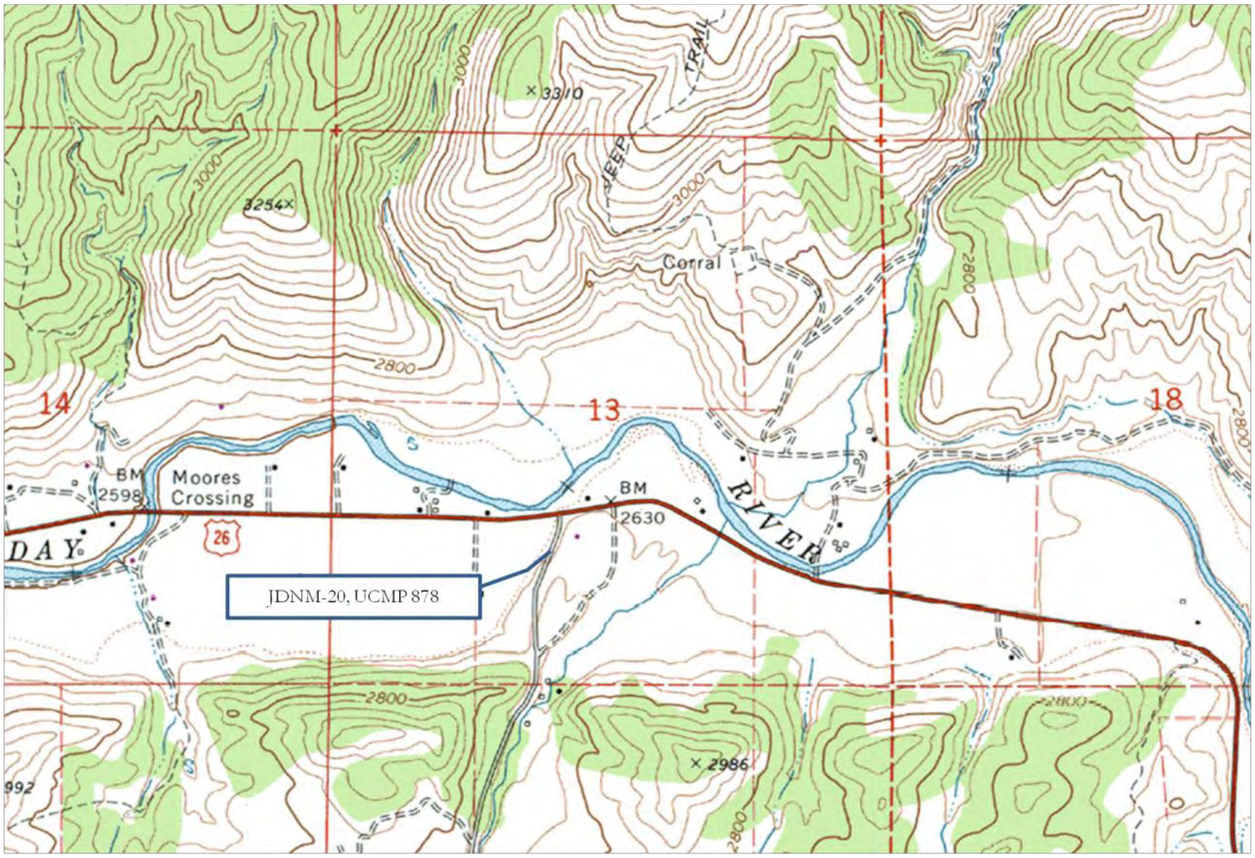
(0.8) At the milepost 125 marker (in fact, throughout the entire gorge) are excellent pictographs, from which Picture Gorge was named. Native Americans - belonging to three major tribal affiliations - frequented this area, fishing for a now-extinct run of salmonids and performing rituals.

(1.5) Emerge from Picture Gorge and enter type areas for both the Mascall and Rattlesnake strata, to be visited the next day.

(1.7) Geologic wayside.
(2.2) Exposures in recent roadcut are in fossiliferous unit of the Mascall.
(2.7) Cottonwood Creek crossing. This creek drainage is the site of some curious Mascall and Rattlesnake specimens (such as YPM40265, what appears to be a gigantic new felid) and a muddled collection history. These "Cottonwood" beds (sensu Cope) were for many years confused with another locality less than 15 miles north of here, the "Fossil Horse Beds on Cottonwood Creek" - which is actually a drainage of the North Fork of the John Day River and is stratigraphically well below the Mascall beds. In fact, the "other" Cottonwood Creek beds are middle John Day and are 29 Ma. The confusion was compounded by a collection of specimens destined for O.C. Marsh having been sent first to the Paris Exposition, around Cape Horn, before ever being curated at the Peabody Museum by Thorpe much later. The Yale Accession Card (No. 1322) reads: "Rec'd from H.G. Grant, San Francisco, Cal. 4 boxes fossils from Oregon (Freight, these fossils were sent to the Paris Exposition 1878. Returned to New York, 1879, April). Shipped to San Francisco same month, and sent to New Haven, Nov. 1879. Leander S. Davis, Col. Fossil Horse Beds on Cottonwood Creek, John Day Valley, Ore". Yet more confusion comes from a tributary of the "other" Cottonwood named Camp Creek that is easily mixed up with the Camp Creek in the southern facies of the John Day near the Maury Mountains, 50 miles to the South. Proceed and cross Battle Creek, flowing through the Cottonwood Ranch.
(5.6) Ferris Creek exposures of the Mascall to the North, the "Old Schneider Ranch" sites of Downs (1956), "Mascall 16" of others. These have yielded good material of *Prodipodomys mascallensis, Dromomeryx borealis*, and much else.
(6.1) Franks Creek Road. This leads ultimately to the Courtrock area and is a route to the classic John Day exposures near Hamilton and Monument through forested uplands.
(6.3) Entering Dayville. Still wild and wooly. "Our Fossils Are Friendly", whatever ***that*** may mean.
Optional Stop: the Dayville Merc to stock up on sundries.
(7.0) Cross South Fork of the John Day River at 2 o'clock. Directly ahead is large slumping exposure of upper and lower fanglomerates of the Rattlesnake, with the Rattlesnake ash-flow tuff in the center.
(7.3) Good Mascall exposures to the north, underneath the "D" below the RAFT, including the "Mackay Ranch localities", V4912, V4913, and others.
(8.6) Geologic wayside on the right.
(10.6) At 3 o'clock is a very thick exposure of Rattlesnake fanglomerates and siltstones. Aldrich Mountain, with fire lookout, is large mountain behind.
(11.2) Picture Gorge Basalts to South exposed in the drainage of Flat Creek are rotated 90 degrees along the trend of the John Day fault. Mascall Formation strata blanketing basalts on the South side of the river canyon.
(13.7) Red weathered interbeds on North side of the road are paleosols that formed between basalt extrusion events.
(16.2) RAFT to north.
(19.8) Optional Stop: Fields Creek Road. Turn right and proceed to small parking area and geologic wayside.

Stop 1-3: The Fields Creek plant/fish locality [gps]

Here is a small "quarryable" exposure of lower Mascall lacustrine beds. These are "dirty" diatomites that include the modern diatom *Melosira italica* , many leaves, large ferruginous specimens of the gastropod *Lymnaea cf. stearnsi*, and not infrequent specimens of a small percid, *Acroplites* (or *Plioplarchus*) *septemspinosus*. There are actually several localities here, on both sides of the river, also collectively known as FIELDS PEAK/JOHN DAY FAULT SITE. Collections made by Condon, Voy, Bendire, Merriam, and Knowlton and Merriam. Belshaw's Ranch site is the white hill about one-half mile northeast of original locality and on north side of military road. Collections made probably by Bendire and by Knowlton and Merriam. Belshaw's Ranch (now owned by the Tirico family), in gulch 1 mile northeast of Belshaw's house and about 2 miles east of original locality. (Fossil Flora of the John Day Basin, Oregon: Frank Hall Knowlton, 1902). These rocks float!

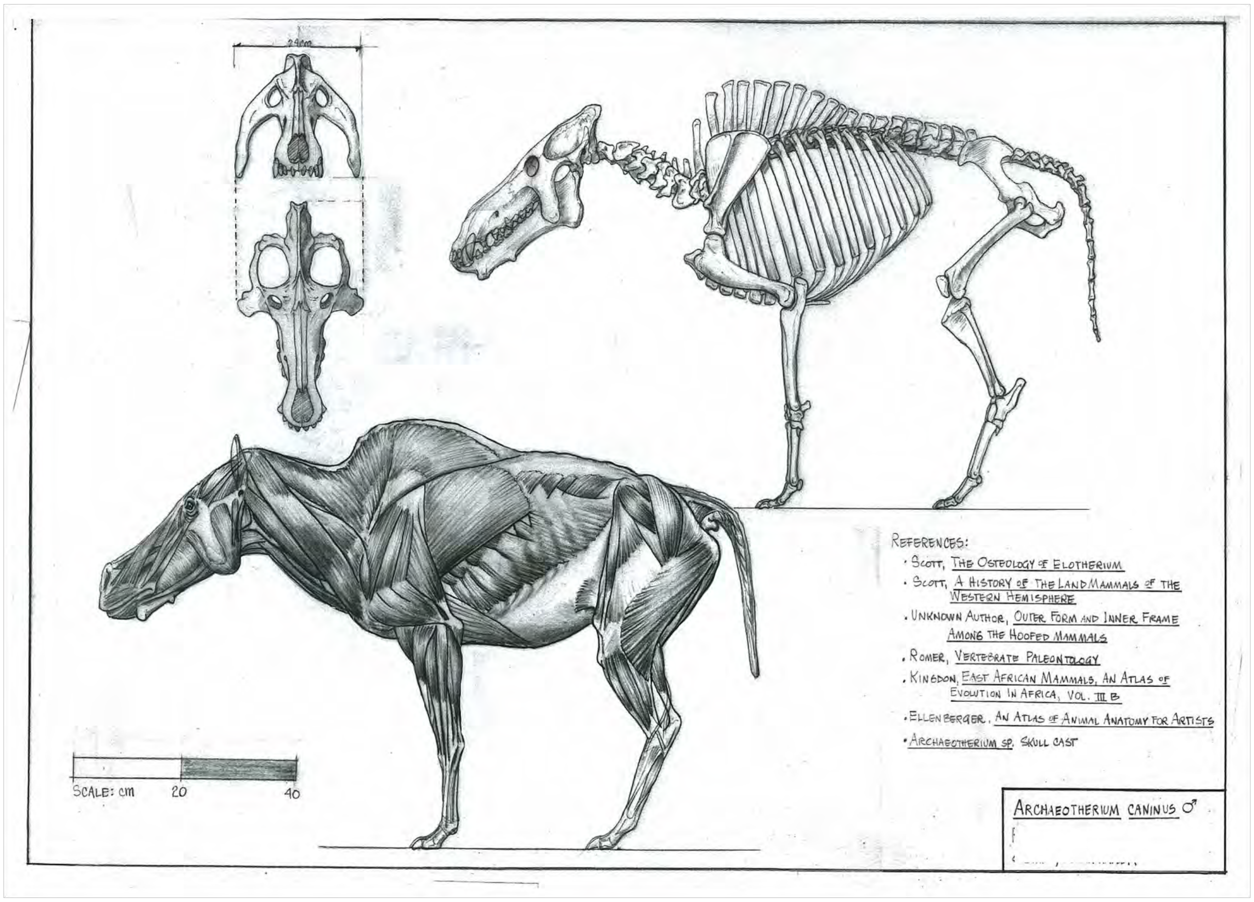


Locality map for stop 1-3. Localities to the north resemble Unity strata as much as Mascall, and need study. Excerpt from USGS 1:24000 Quad Shop Gulch, 1:1.

(20.1) Rejoin Highway 26, turn right (East).
(20.7) There are three classic leaf localities on the north side of the river. Once considered to be the richest paleobotanical locality found in the John Day area, (*Fossil Flora of the John Day Basin, Oregon*: Frank Knowlton, 1902)the Van Horn leaf locality (JDNM-20), is "on the south side of the military road and near bed of stream." These are intriguing strata, that appear to the experienced observer very similar to rocks of the Ironside Formation far to the East in the Unity Basin, but are currently mapped as Mascall.
(21.5) Slope of Fields Peak around corner in road. McClellan Mountain Roadless Area to the south is 20,000 acres of wilderness, very rarely visited by anyone. A primitive old growth forest grows in steep ravines cut into Cretaceous shales and Triassic-Jurassic melange.
(29.9) Entering Mount Vernon.
(31.4) Clyde Holliday State Park (named for a pioneer and early cattle baron). Good exposures of Clarno lahars and interbedded tuffaceous paleosols to the north.
(34.7) Complex packages of ophiolites and serpentine belonging to the Canyon Mountain complex behind exposures of Clarno to the north.
(36.4) Entering the town of John Day.
(37.2) Patterson Bridge road crosses John Day river to North, leads to large federal building shared by NPS, BLM, and USFS and is where to get information, maps, permits, etc.

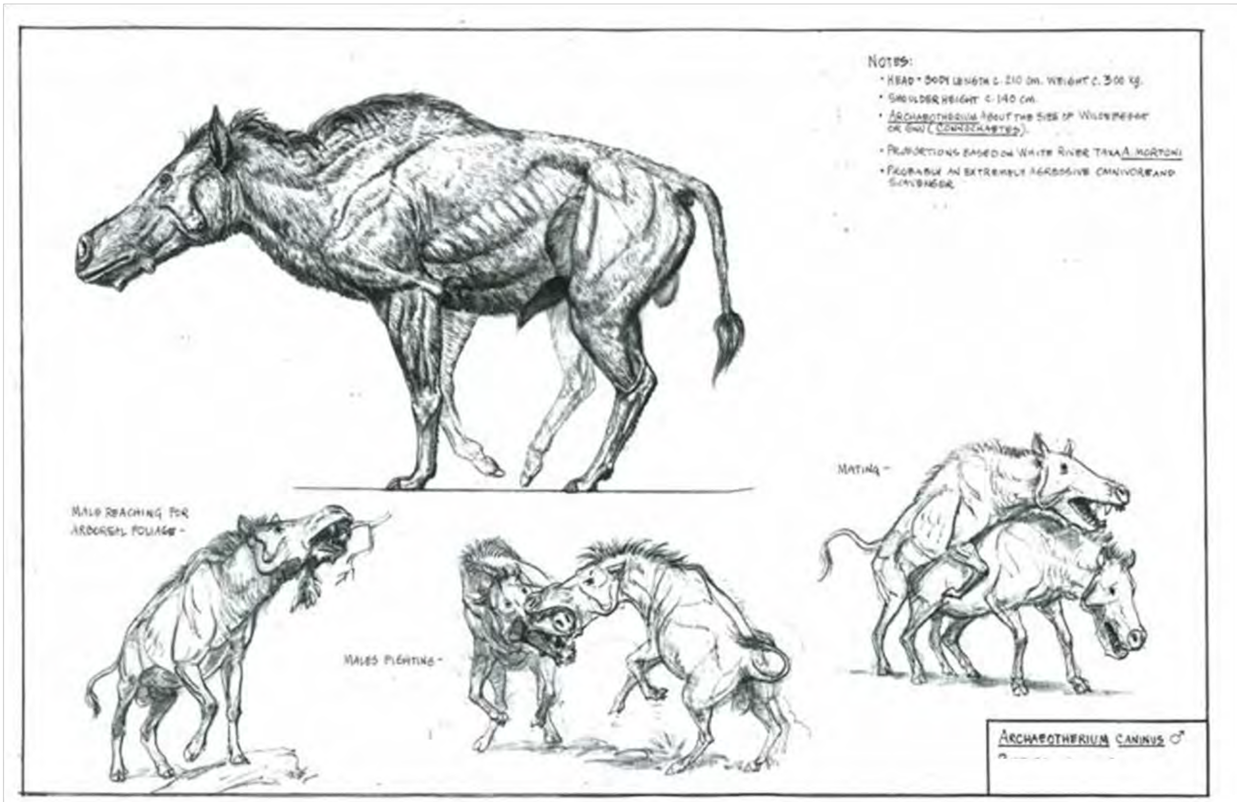
(38.0) Canyon Mountain dead ahead.
(38.3) Best Western motel on corner of Bridge Street, end of day

Evening: John Day; Banquet at the Snaffle Bit.



Mark Hallet's final reconstructions of *Archaeotherium (Choerodon) caninus* Troxell, the common entelodont in the lower portions of the John Day section. Note caption should read John Day, ca. 30-27 Ma, not Rattlesnake. A cast of YPM11665 is currently on a plinth in the patio of the TCPC.

NOTES



NOTES:
• HEAD + BODY LENGTH c. 210 cm. WEIGHT c. 300 kg.
• SHOULDER HEIGHT c. 140 cm.
• ARCHAEOTHERIUM ABOUT THE SIZE OF WILDEBEEST OR GNU (CONNOCHAETES).
• PROPORTIONS BASED ON WHITE RIVER TAXA A. MORTONI
• PROBABLY AN EXTREMELY AGGRESSIVE OMNIVORE AND SCAVENGER
MALE REACHING FOR ARBOREAL FOLIAGE -
MALES FIGHTING -
MATING -
ARCHAEOTHERIUM CANINUS ♂

DAY TWO: JOHN DAY TO CLARNO VIA MASCALL TYPE AREA AND TURTLE COVE

DAY TWO route of road log. Numbered markers correspond to numbered stops in the Road Log text

Cumulative Mileage	*Description*

Bfast @ John Day, Best Western

(0.0) Begin mileage at junction of Highway 26 and Patterson Bridge road, at the Federal Government information sign/large Shell station, across road from Port of Entry.

(0.2) Lumber mill. Hills just to the north, overlooking the town of John Day, are the source of some excellent petrified logs, some of which were retrieved from their locality and hauled to the parking lot of the Thomas Condon Paleontology Center, courtesy of local landowner Rick Page.

Petrified tree locality, source of stumps at TCPC. Town of John Day in right center. Notice stump next to jeep.

(1.1) John Day golf course road to south. To north, note exposures of distinctive green and blue serpentines and ophiolites, part of the Canyon Mountain complex – a Triassic/Jurassic melange.

(3.8) Clarno lahar sequence unconformably atop the Canyon Mountain Tr/J to north of road.
(4.8) The little stone building to the North was built out of Rattlesnake Ash Flow tuff in the 1870s (see historic perspective sidebar).
(4.9) Laycock Creek road heads up hill to left through a thick lacustrine-saturated flow of the RAFT. Gravels further up hill are early Triassic Laycock Creek Graywacke.
(5.5) Clyde Holliday State Park on south. To North, thick sequences of a Clarno lahar unit, here unconformably overlain by units of the Picture Gorge Basalt.
(6.3) Exposure to North is thick unit of the Rattlesnake Ash-Flow Tuff (RAFT), which coverage was originally at least 40,000 km^2.
(7.0) Town of Mount Vernon; junction of U. S. Highway 395. This road leads to the town of Long Creek, to the west of which are many excellent localities of surprisingly brick-red Turtle Cove member John Day strata, not visited during this trip.

Historical Perspective

- *From Oregon Geographic Names*

Mount Vernon
"An early settler owned a prize black stallion named Mt. Vernon. Both the town and the rocky eminence (*a Clarno Fm. Lahar capped by PGB's – TF)* just to the north were named for the horse and the animal was stabled in a small stone building constructed especially for him as protection against Indians and thieves. During the Indian War of 1878 neighbors crowded into the stout little fortress with the horse."

(8.6) Bridge over the John Day river; McClellan Mountain and roadless area to the south, which comprises 20,000 acres of rugged outcrops and wilderness rarely visited. An untouched old-growth forest grows in steep ravines cut into Cretaceous shales and Triassic-Jurassic melange here. We are travelling along the fault-constrained John Day valley.
(12.9) Moon Creek. To the south is the Moon Mountain complex of uplifted marine strata.
(15.2) Steeply dipping Picture Gorge basalts are completely turned on their side compared to those gently dipping to the North as a result of motion along the JD Fault.
(16.0) Belshaw ranch leaf locality; also contains the small percid *Plioplarchus septemspinosus*.
(17.0) Field Peak road (visited previous day, see **Stop 1-3**).
(19.6) Ranch to north atop thick sequences of lacustrine diatomites and paludal paleosols. Recently, a Grant County Deputy Sheriff decided to dig a big underground mine shaft, 6" high and over 40" long, into these deposits – by hand - and he encountered some interesting strata and plant fossils, and brought them in to be identified. When I marvelled at why anyone would want to build such a huge and dangerous tunnel, he told me "I was bored and wanting something to do."
(19.7) Exposure of Mascall Fm. diatomites in roadcut to north.
(20.6) Odd outcrop to N of highway appears to be a Mascall tuff below the RAFT, and peculiar gravels; but it is actually a RAFT facies that resulted from deposition in a paludal environment.
(21.5) Mascall Tuff bed (Down"s Unit 5) in thick exposures to the south.
(22.5) Steeply dipping Picture Gorge Basalts in hills to the left.
(23.0) Road cut into PGB; note well developed paleosols that are fossiliferous, and prominent faults.
(24.7) Rattlesnake Formation gravels form prominent red outcrops to the south.
(26.0) Sturgeon farm to N of road, fed by remarkably high-output, warm spring water percolating through Mascall strata.
(28.3) To north of road are excellent exposures of fossiliferous Mascall and Rattlesnake outcrops, worked by the local Weatherford family, that developed much of the collection of this age and curated by CIT parties (now at LACM). These include localities 3065 and several of the V49… series cited in Downs (1949).
(28.5) HQ of ODF&W "Murderer"s Creek Wildlife Refuge", which contains several localities.
(29.7) Entering Dayville at bridge over the South Fork of the John Day River (which is the route the RAFT ignimbrite event took to deposit the rim rock, 7Ma, from a vent far south in Harney County.

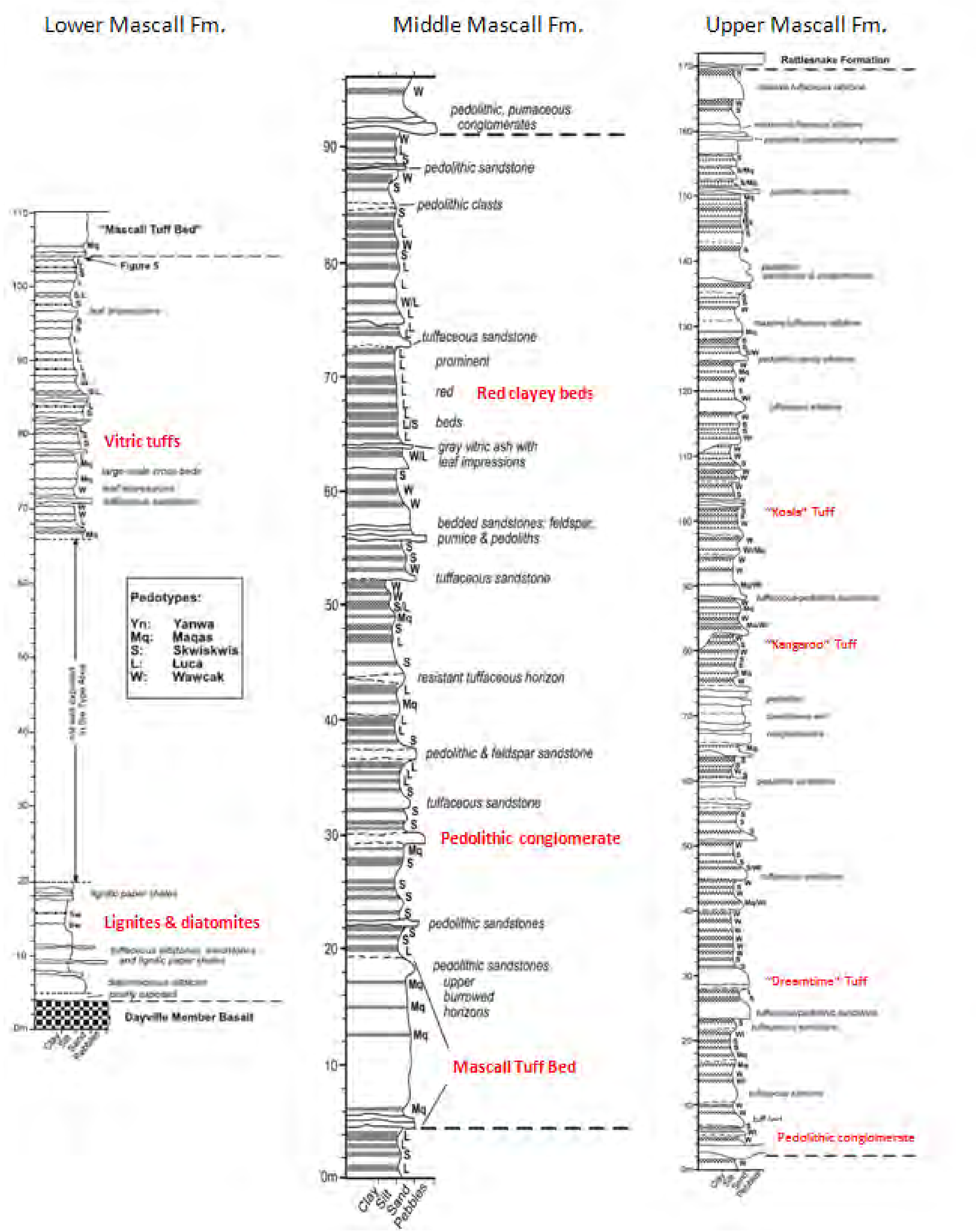
(30.6) Frank"s Creek road to the north; important access to many of the localities from this point to the Gorge on that side of the river.
(31.0) Ferris Creek draw to the North, includes important Mascall sites such as V4830, MASCALL 16, JD-201 and several others. Dromomerycids seem particularly abundant here.
(32.6) Battle Creek.
(34.0) Ahead are paper shales in base of Mascall, directly overlying PGB"s, with abundant leaves and other material – unstudied.
(34.3) Turn off Highway 26 on Grant County #40, the Antone road, to the Mascall Overlook. This road follows the old Dalles-Canyon City military road built during the Civil War. Soldiers patrolling this road were the first to bring some of the remarkable fossils they encountered during their sojourn to the attention of Thomas Condon.
(35.1) Arrive at Mascall Overlook.

Stop 2-1. HIKE: Mascall and Rattlesnake Overlook; walk through Mascall "type areas".

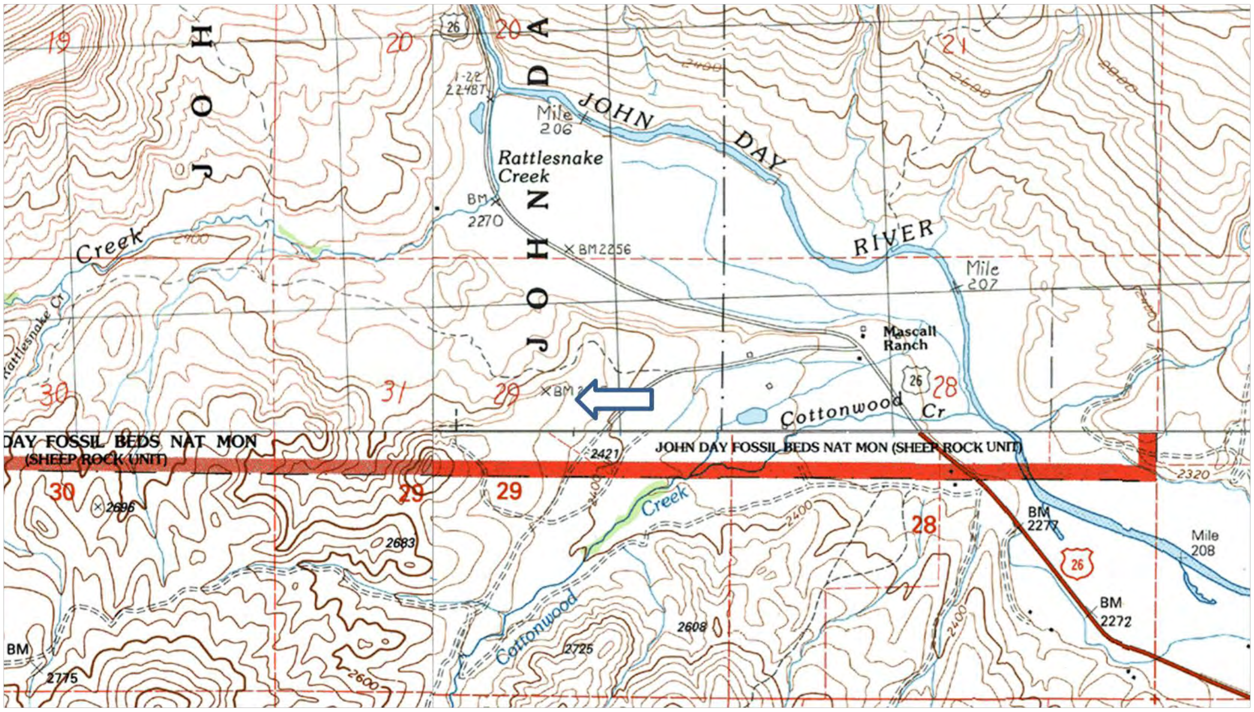
From this vantage point, one can see a "textbook" quality view of the type areas of the Rattlesnake and Mascall Formations. The Mascall is well exposed here, with most of the key units visible. This is the area Merriam had in mind when he wrote: "Along the valley of the East Fork and south of the Blue Mountains, there is found, resting upon the Columbia lava, a series of sediments which have been known in the literature as the Cottonwood beds, the Loup Fork beds, the Ticholeptus beds (in part), and the Amyzon beds. Recently Wortman has placed his palaeontological horizon known as the Protolabis beds in this formation. None of these names appear to be applicable to the formation considered as a stratigraphic unit. . . . It is, therefore, proposed to designate these beds as the Mascall formation. The typical exposure is near the Mascall Ranch, four miles below Dayville." (Merriam, 1901). Included in this view are the "Basin" localities of Downs: V-4823, V-4824, and V-4945. Below and to the north is the classic Highway locality , V-3043. From this site have come several outstanding specimens, including a complete skull of *Merychippus cf. seversus,* JODA1316.

This is still the Mascall Type locality (V3059). Downs (1956) described the area as follows: "3059. . . aerial photo, see 3043; North of Rattlesnake Creek. Bones in prominent, massive white to buff tuff (unit 5 of geologic section)." However, site 3043 on his aerial photo clearly pinpoints the cliff to the east that parallels the road; south of Rattlesnake Creek. From this point, we will walk along part of the measured section up to the "Mascall Overlook", then down the other side to meet the bus.

Since 1901, this general vicinity has also been the type area for the Rattlesnake Formation. Merriam and others (1925) point out that "The area of Rattlesnake exposed in the butte west of Picture Gorge has generally been termed the type section, and although it really represents but a small part of the entire succession within the formation, it was subjected to more careful study than elsewhere, due to the presence of mammalian fossils in the tuff and in the gravel". Later, Enlows (1976) subdivided the Rattlesnake Formation into three members at the type section. Walker (1979) decided to redesignate this area as a "reference locality" for his Rattlesnake Ash Flow Tuff, interbedded "in what had been called the Rattlesnake Formation" (Walker, 1990) - a decision that failed to take into account the thick, vertebrate-bearing beds sandwiching the Ash Flow tuff. A revision of the Rattlesnake strata and delineation of formal members, based on new measured sections should be of benefit (See Prothero and others, 2006; Martin and Fremd, 2001, Martin, in prep).



Composite stratigraphic section of the Mascall Formation in the type area. Some of the distinctive marker horizons, tuffs, and conglomerate layers that serve to subdivide the section are shown in red. Modified from Bestland et al., 2008.



Mascall Overlook (arrow). From this point are visible the "Type Areas" of both the Mascall and Rattlesnake strata. Collage of 1:24000 maps Picture Gorge East, Picture Gorge West, Dayville, and Day Basin Quadrangles at 1:1 scale.

(36.0) Return to junction of Highway 26 and Antone road. The outcrop to the left used to be a fairly steep cliff; in the late 1990s ODOT reduced the height of this, resulting in considerable removal of fossiliferous overburden. Contractor Bill Orr (emeritus professor, U of Oregon) discovered a stunning *Leptarctus oregonensis* partial skull during this process, with well preserved lyrate sagittal crests, now on display at the TCPC.
(36.6) Geological marker; meet bus here if walking through type area. From here, note the terraces cut into the basalts to the north; easily confused as separate basalt flows, these are actually John Day River erosional banks over many, many millenia.
(37.1) Enter Picture Gorge; named for the pictographs, not the scenic beauty. Some of the more remarkable can be viewed by walking past the entrance sign to the river, carefully, then looking downstream onto the outcrop.
(37.5) More pictographs on left at pullout. The whole pictograph story would require a full field trip guidebook.
(38.4) Proceed North on Highway 19.
(40.4) The Thomas Condon Paleontology Center is on the left, Sheep Rock Overlook to the right (East). Note monument to Thomas Condon on bluff overlooking river and Sheep Rock.
(41.0) "Cant's Ranch" leaf locality due west, reported by Chaney and others.
(42.0) "Goose Rock", a highly resistant, well indurated exposure of the Gable Creek Formation. Pollens from this locality suggest an Albian age. Fisk and Aguirre (1987) state "The absence of tricolpate pollen and the presence of distinctive trilete spores suggest a pre-middle Albian and probably Aptian (Early Cretaceous) age for the palynoflora. The overall composition of the palynomorph assemblage is distinct from and older than that of the primarily middle Albian . . . exposed in the Mitchell Inlier to the west, although further study may show that the 'Goose Rock Conglomerate' is equivalent to the „Basal Member" of the Mitchell sequence".
(42.6) Middle Mountain Fault runs perpendicular to the road at this point. The basalt flows to the north of the fault are over 1200 feet lower than those to the south (Fisher, 1964). Several interesting

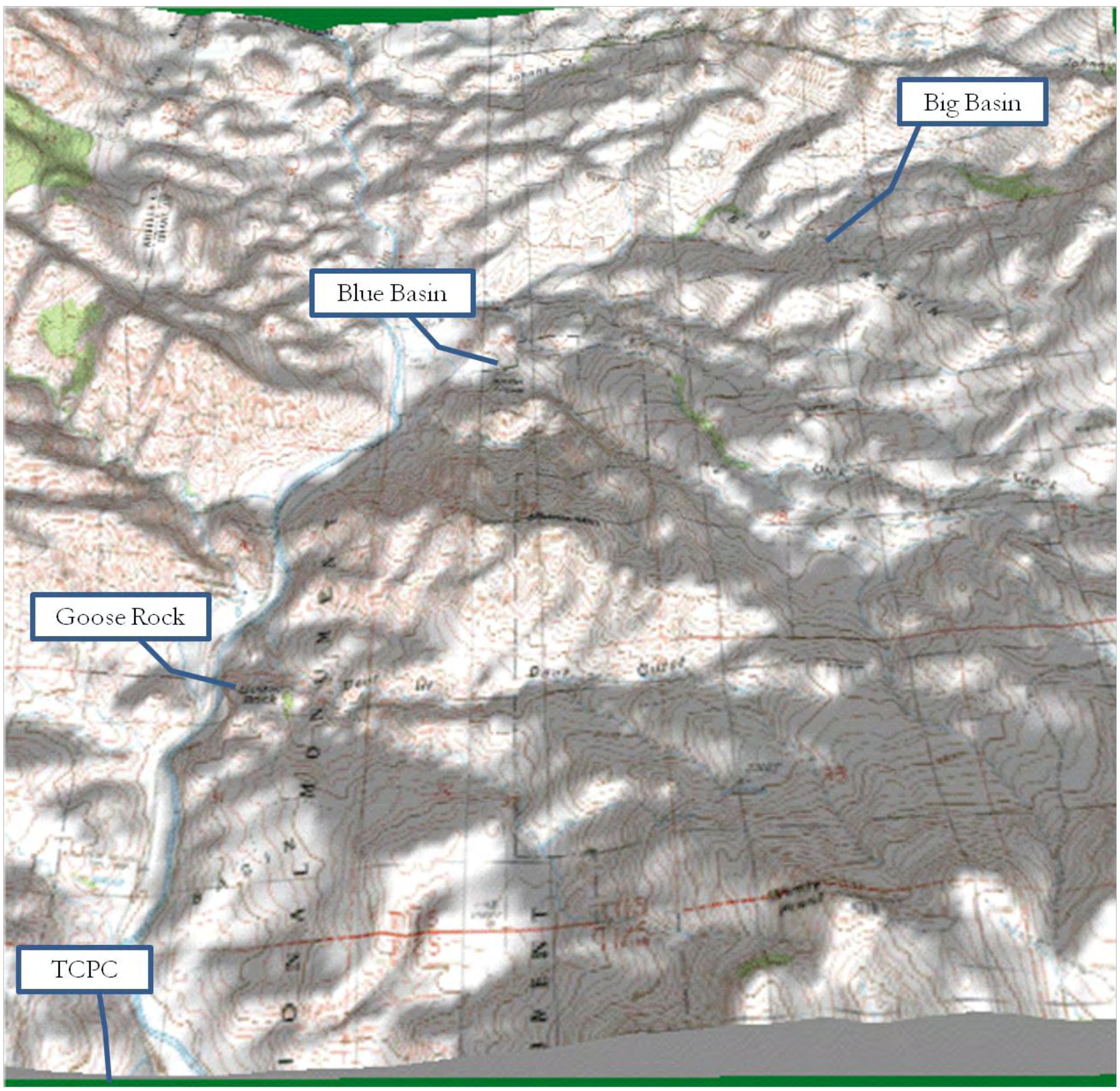
localities of TUCO are exposed along the N side of the fault (out of view from the highway). At this point, we leave Butler Basin, cross the fault, and enter Big Basin.

(43.0) Picture Gorge Ignimbrite cooling units comprise nearly all of the colorful strata to the west.

(43.7) Pull into the Blue Basin trail head and park.

Stop 2-2. HIKE: The Blue Basin locality.

The Blue Basin area is an extensive series of badlands, well worth taking extra time to visit, and contains some of the classic exposures of the TUCO. From these strata have come many thousands of important specimens, and many holotypes as best as can be reconstructed from sometimes woefully vague locality datea. Although this little basin has itself been called Turtle Cove, that name appears to have been originally intended by both Condon and Merriam to refer to the entire basin from Picture Gorge to Kimberly. The "Island in Time" trail leads to the center of the basin.



3-D view of topo of southern end of Turtle Cove, showing location of some features. Stereoview modification of USGS Quadrangles Picture Gorge West and East, 1:24000, 1:2 Scale, 1.5X vertical exaggeration.

The Overlook Trail progresses on the North side of the basin, permitting access to older strata exposed along this side. It is the North side that has exposures of units A, the A/B tuff, and C utilized for the paleomagnetic work illustrated in the figure below.

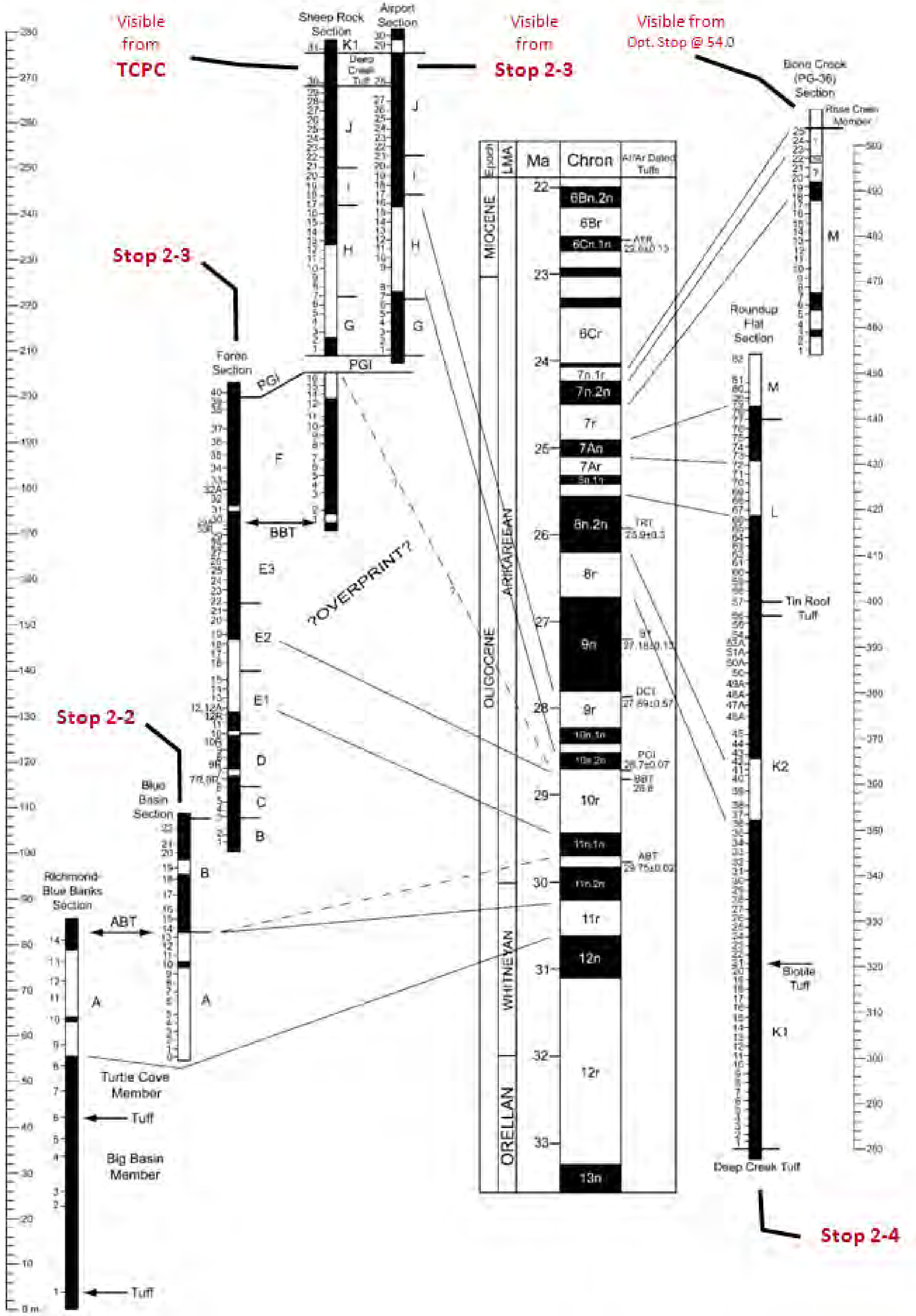
Holotype of *Nimravus brachyops (gomphodus)* AMNH6933, from "John Day River". Genotype Am. Nat. 1880, 844, fig. 7; Bull. Hayd. Sur. Vol. VI, p. 171 (1881) [Included in "Nimravus brachyops" Cope Proc. Phila. Acad. 1879, 170, name only.] 1885, Tert. Vert; 964, pl.lxiia, figs. 1-3, lxiii. Matthew, 1910, Bull. AMNH, xxviii, 311, fig. 11. Toohey, 1959,Bull AMNH, 118, art. 2, 89, 93 (N. brachyops) Eaton, 1961, AM. J. Sci; tables A-B.

(44.3) Optional Stop: Dick Creek road, and views of the type area of the Big Basin Member of the John Day Formation. Road winds up to several excellent localities, including JDNM-54, "Sugarloaf"; V66049, also known locally as "Little Turtle Cove". Also in the Big Basin region is Officer's Cave, allegedly the largest pseudokarst topography cave in North America. "Officer's Cave is the uppermost of four rapidly eroding cave levels constituting a cavern complex about 700 feet long developed chiefly in clay and silt. Its outer room is 35 feet by 43.5 feet by 100 feet and slopes about 45 degrees east into the western end of a narrow linear hill called Officer's Cave Ridge. Dry valleys, blind valleys, hanging valleys, sinkholes, pipes, caves, and natural bridges are abundant. These, together with subterranean drainage, give the area a karstlike development. For such terrains the term 'pseudokarst' is applied" (Parker and others, 1964).
(44.8) To the east are the "Resurrected Oligocene Hills" of Fisher (1964), topographic surfaces preserving 300 feet of relief that was eroded into pre-Tertiary strata. The landscape surfaces that existed in this area just prior to the deposition of the Big Basin member of the John Day are preserved and re-exhumed, due to differential erosion of a hardpan (laterite) formed on the surface of Cretaceous conglomerates. Along this stretch, "Basement complex" is exposed here, consisting largely of metamorphosed Jurassic-Triassic marine melange.
(45.8) Johnny Kirk Spring, a perpetual source of excellent, clean water. A well-known early hermit of the area, "Uncle Johnny" used to bring "bear skulls" (actually oreodonts) to early collectors.
(46.5) Optional Stop & Photo Op: Cathedral Rock.
(46.8) A good example of creative highway planning, cutting off the toeslope on slump surfaces. This stretch is frequently littered with nodules from Unit E of the Turtle Cove Member of the John Day.
(48.0) Excellent sequence showing the Big Basin through Turtle Cove unit biostrat unit A gradual contact.
(48.4) Turn right (east) and follow asphalt surface to the parking lot at Foree. This area contains relatively clean and unfaulted exposure that spans Units B-G, with excellent views of the relationship of the Blue Basin Tuff and the Picture Gorge Ignimbrite on the East side of the river to the Roundup Tuff and Deep Creek Ignimbrite across the valley.

Historical Perspective

UCMP CLIMBERS IN TURTLE COVE
- Lloye Miller, 1899

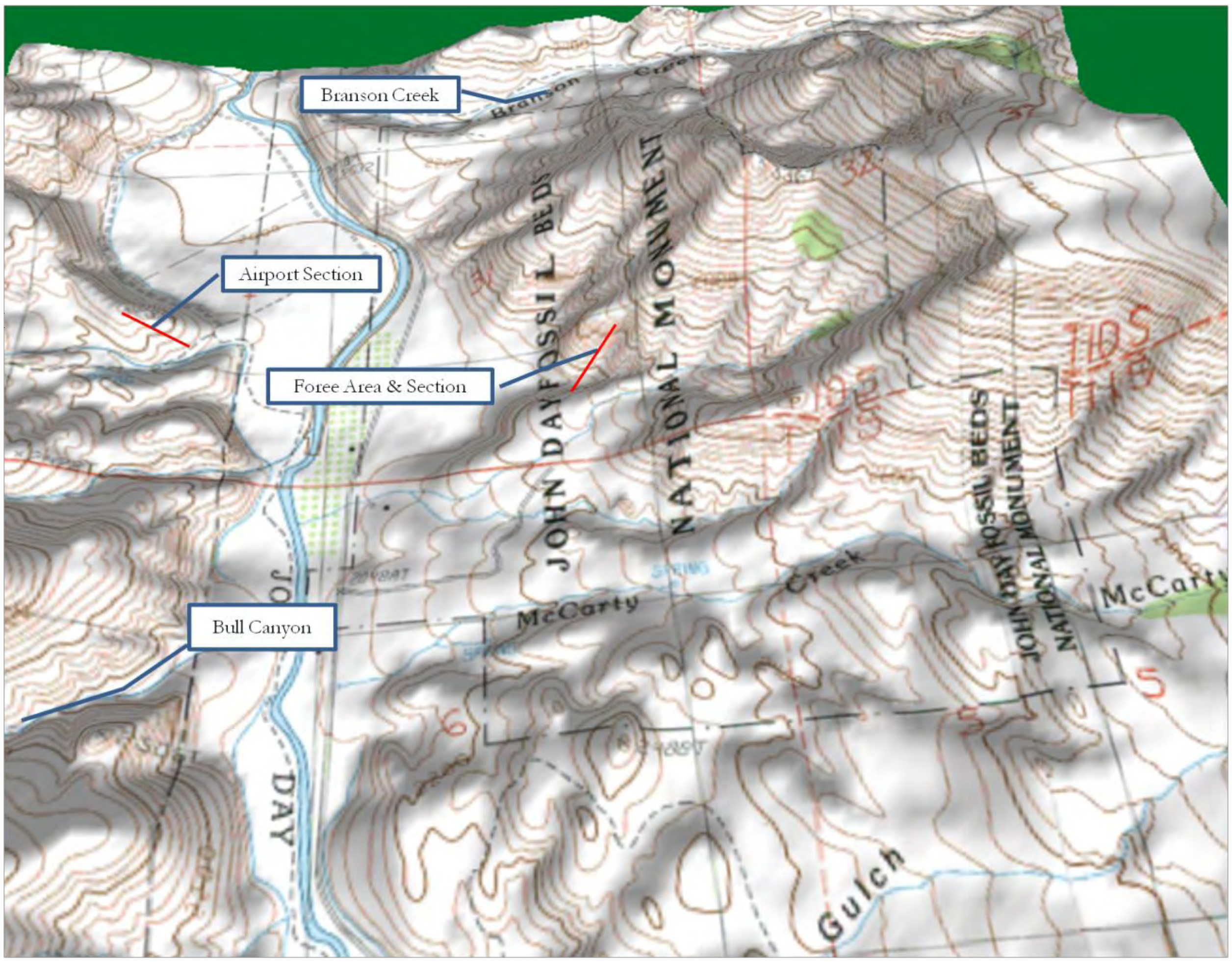
Got stuck near the top of the cliff and came as near Eternity as is altogether wholesome. Almost lost my nerve, had to speak to myself premptorily to keep from breaking down. When I reached a place where I could relax I went all to pieces, falling weak and nauseated as a sick kitten. Hadn't the nerve to climb any more cliffs. Succeeded in finding some good leg bones before evening and became somewhat restored, getting home dead tired shortly before 7:00.



Measured sections and tuffs from Turtle Cove and environs correlated with magnetic polarity timescale. Corresponding stops and vantage points are indicated in Red. Figure modified from Albright et al. (2008).
Key: ABT: A/B tuff; BBT: Blue Basin tuff; PGI: Picture Gorge Ignimbrite; DCT: Deep Creek Tuff; BT: Biotite Tuff; TRT: Tin Roof Tuff; ATR: Across-the-River Tuff.

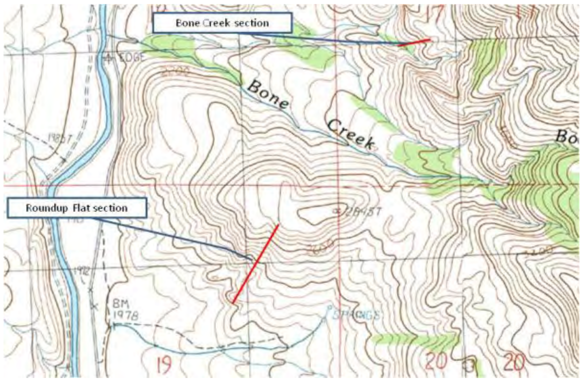
Stop 2-3. Foree Picnic area and badlands

Unlike many of the classic badlands exposures in the North American Tertiary, laterally extensive outcrops within the John Day Formation are not abundant, nor can the same facies be walked out for tens of miles. Specimens are rare. Many hours of prospecting grueling cliffs may yield only a dozen items of interest. Beginning in 1982, field investigators began to retrieve specimens under more systematic conditions than had generally been the case. A system of "cyclic prospecting" begun in 1984 in this and other localities has resulted in the salvaging of thousands of specimens that would have been lost to weathering or inadequate data recording (Fremd, 1995). Two trails offer glimpses of the badlands and overlooks.



Middle Turtle Cove, showing location of the "Foree" section, units B-F, and the "Airport" section, units G-the Deep Creek Tuff. 3-D modification of the Mount Misery 1:24000 Quadrangle, no vertical exaggeration.

(49.5) Return to Highway 19. NPS housing for a law enforcement ranger is to the east.
(49.8) Excellent view east at North Foree beds, one of the cohesive paleomagnetic sections.
(50.5) Road cut in Pleistocene river gravels. Prominent pediment surfaces visible from here. To the west is the "Airport" section on the Longview Ranch one of the best sections to measure the strata between the Picture Gorge Ignimbrite and the Deep Creek Tuff. This locality is where paleomag sampling was done for units G-J.



Location of Roundup Flat and Bone Creek sections. USGS 24000 Mt. Misery Quad., 1:1.

(51.0) Branson Creek. To the east up the two-track are the Branson Creek exposures, JDNM-34, V66115.

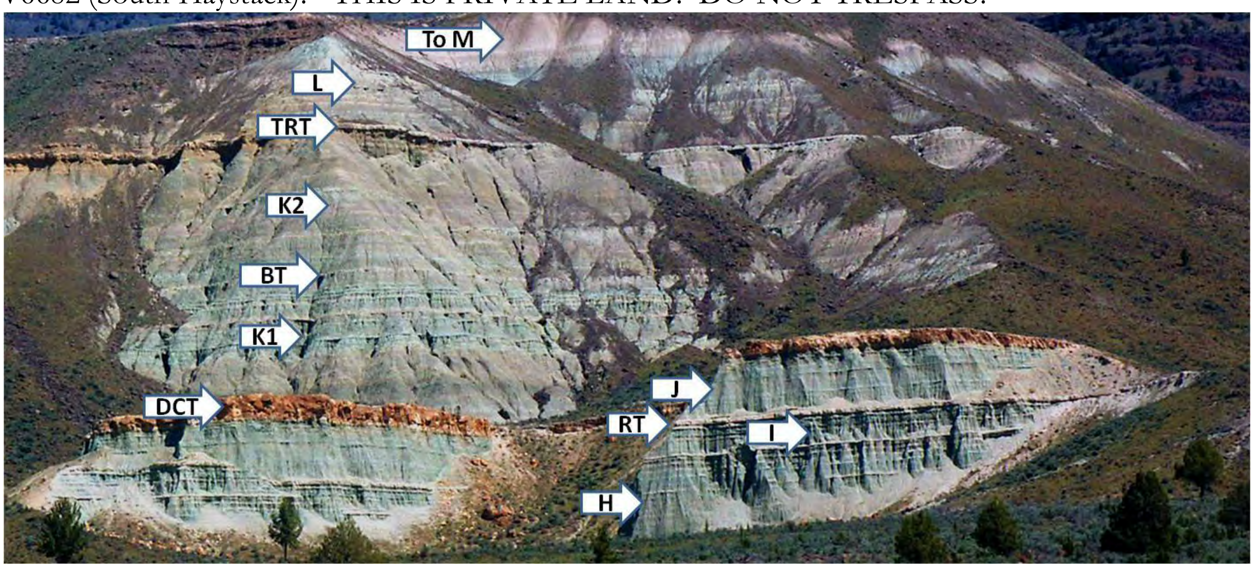
(51.3) Headquarters Longview Ranch to the West. This is the old "Sam Bar" and "W-4" ranch. To the East are good localities of TUCO units B-E, “Leonard” and “Vickie” named after the Breck family, managers of this ranch for many years (note: localities are on BLM).

(51.7) Locality up this drainage some distance produces a disproportionate number of nimravids, thus the name “Nim Ravine” JDNM-169.

(52.6) Gate and road for Roundup Flat.

Stop 2-4. The Roundup Flat Section

From this viewpoint, the units above the Deep Creek Tuff (DCT) can be seen well. The base of this section can easily be confused with the section seen at Foree; but these strata are higher in the column and roughly 1.5 million years younger. Small mammals, often in nodules, are more abundant at this stratigraphic interval than at other times (see faunal list). This is locality JDNM-35 (Roundup Flat); V6682 (South Haystack). THIS IS PRIVATE LAND. DO NOT TRESPASS.



Roundup Flat section, showing tuff-defined lettered subunits (H-M) used for biostratigraphic analysis. RT: Roundup Tuff; DCT: Deep Creek tuff; BT: Biotite Tuff; TRT: Tin Roof Tuff.

(53.6) Crossing Bone Creek culvert,

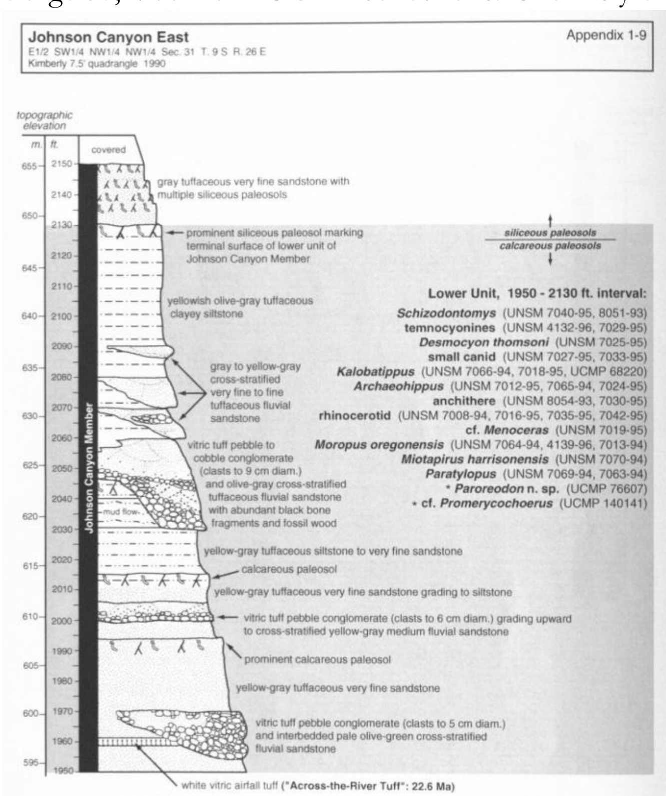
(54.0) OPTIONAL STOP: Fossil (or Bone) Creek locality view.

This is a view of Picture Gorge 36, aka"Drees", aka JDNM-49 Bone Creek, V5954, V76124. This is a very important site, unfortunately too far to walk into on this excursion. It reveals one of the few

UWBM 54870, *Moropus oregonensis* from Bone Creek.

sequences in Turtle Cove from "Unit M" to the gravels marking the base of the Haystack Valley strata, here the youngest layers of the Rose Creek member, where the unconformity between the two is very pronounced. Some interesting mammals have been recovered from here, including one of the few verifiable chalicotheres from the John Day (cf. *Moropus oregonensis*) (Coombs and others, 2001). Also entombed here is a critical segment of J. Rensberger's (1971) entoptychine sequences, a specimen of *Daphaenodon* UCMP76875, paleomerycids, and much other material (See Hunt and Stepleton, 2004). See discussion in the HAYS section of Part Three.

(54.6) To the west can be seen exposures of non-zeolitized John Day material, locality JDNM-46, V6668. This site has produced "*Hesperocyon,*" entoptychines, geomyoids, a camelid, "*Anchitherium,*" *Miohippus,* an entelodont, merycoidodontids, *Nothocyon* sp., a sciurid, lagomorphs, and cricetids. Note erosional contact on top of the Haystack member, complete with basalt-filled paleovalleys.
(55.9) Mouth of Holmes Creek canyon to East. West is JDNM-176, "West of Holmes", also Picture Gorge 37, V66126 in UCMP collections. Site has yielded an interesting faunule, including an LAD for an entelodont upsection .



The Johnson Canyon section from Hunt and Stepleton (2004)

(56.8) OPTIONAL STOP: Across the river is the Black Bone Hill locality, JDNM- 50, V6666, (old UCB #863). Specimens from this site include dentitions of *Paratylopus cameloides* (UCMP1547), *Eporeodon* , canids, *Miohippus* sp., and *Promerycochoerus* material. A tuff (the "Across the River Tuff") from this section appears to be 22.6 Ma (Swisher, 1993, pers. comm.). The prominent Picture Gorge Basalt dike running N-S across river is the Davis Dike, named after the superb early collector, Leander Davis who pretty much saved the Princeton Expedition crew of 1889.
(57.8) Turnoff to Johnson Canyon (NOTE: THIS IS PRIVATE LAND. DO NOT TRESPASS to AVOID SOMETHING VERY UNPLEASANT.)

Stop 2-5. Johnson Canyon

The strata are crossbedded tuffaceous sands at the base of the section, and UCMP, JODA, and Nebraska teams have collected some interesting material definitely referable to Hemingfordian NALMA. This is locality JDNM-144, "Johnson Canyon", aka UCMPD7810, V6431,2. This has yielded an odd *Paroreodon, Paratylopus,* temnocyonines, canids, the mylagaulid *M. angulatus*, a tapir cf. *Miotapirus*, rhinos, equids, tayassuids, moschids, dromomerycids, and other beasts.
(57.9) Cross North Fork of the John Day River; all forks are now united into one river. Orchard to north largest in region.
(58.2) The hamlet of Kimberly. Continue on Highway 19. Time does not permit a trip to the north to numerous localities along the North Fork of the John Day, including historically important sites. These include seven sites along Rudio Creek that have produced several types; several sites at the "Fossil Horse Beds on Cottonwood Creek" have yielded dozens of important specimens including the types of *Micropternodus morgani*, *Proheteromys thorpei*, and many others. Sites near the town of Monument (e.g., Shanks, Fisher, and Stubblefield series) document the fatal error of attempting to use coloration

of matrix in museum collections to identify stratigraphic height of specimens from within the eastern facies, unless one know precisely where the material was retrieved, as can be reconstructed for some of the classic sites. For example, matrix proximal to the 28.7 Ma Picture Gorge Ignimbrite is a deep red near Monument; but a startlingly bright green in Turtle Cove.

(60.0)) Newberry ash on the north side, a recent outpouring of tephra from Newberry Crater, south of Bend, OR.

(61.7) Exposure on right is V70175, Junction 2. This is area where "molds" were taken of outcrop for use in the KIMB display in the TCPC.

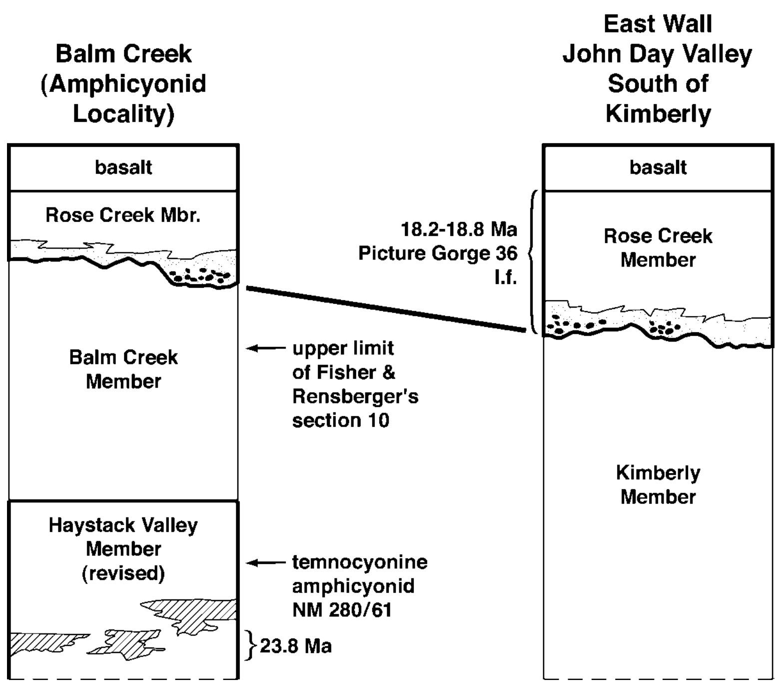
(62.6) Locality to the north is V7170, Junction 3.

(64.3) Shady Grove "Scenic Wayside".

(64.6) Excellent columnar prisms in a basalt flow across the river.

(66.4) Optional Stop: An important cluster of localities to the east. Haystack 8 (V6322) has yielded abundant, apparently well-zoned specimens of rodent taxa (see Rensberger, 1971, 1983). Taxa in UCMP and other collections include ophidians, lacertilians, the amphibaenid *Dyticonastis rensbergeri*, a bird, *Entoptychus wheelerensis*, *Entoptychus minor*, *E. germanorum, E. cavifrons*, a leporid, a proscalopine?, cricetids, castorids, *Allomys*, *Nothocyon*, *Promerycochoerus superbus*, *Phenacocoelus parvus*, and *Meniscomys* sp. Also visible from here is Haystack 6 (Brisbois' Bluff, V6590), a slump of dubious stratigraphic utility with microvertebrate remains.

(66.8) Balm Creek localities to the north (V6698, "Green Band Canyon" of NWMNH). Hunt and Stepleton (2004) have examined these strata in detail, and their work should be consulted including excellent stratigraphic sections that need not be reprinted here. From here, one can see the Haystack Valley member, a grey, massive tuff ("GMAT" of Hunt and Stepleton) that is a useful marker bed, and portions of the Balm Creek and Rose Creek members. Based on faunas of Hemingfordian aspect, stratigraphic thickness, and the likelihood that the unconformity between the "Kimberly" and the Haystack Valley members is of considerable duration, it is likely these strata are at least as young as the fossiliferous components of the upper members of the John Day exposed in the western facies, near Warm Springs.



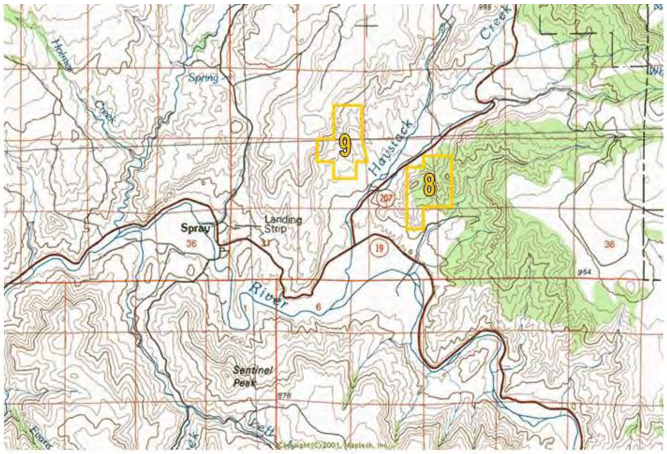
Simplified stratigraphic cartoon (Hunt and Stepleton, 2006)

(67.8) Junction with Oregon Highway 207. "Kahler Basin" is to the north; with numerous localities spanning a wide range of agesare exposed below the basalts. These include JDNM-55, Lawson Ranch; V66102; and numerous localities

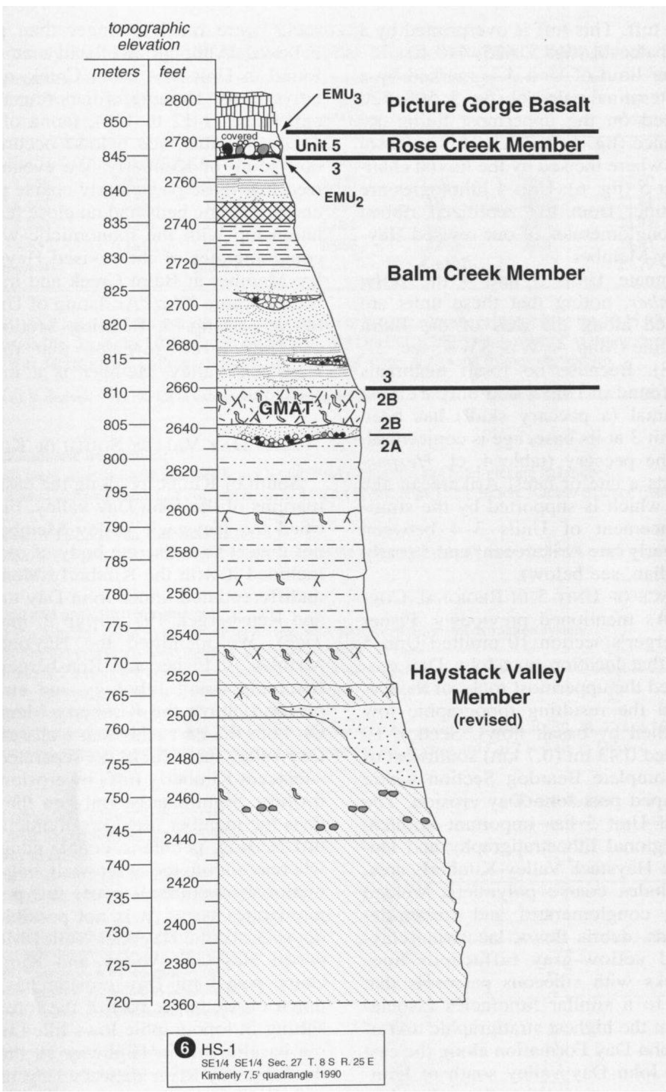
(68.0) Haystack Creek.

Stop 2-6. Crazy Woman Knob & Haystack Valley overview

This exposure is a good place to examine the nature of the contact between members in the upper portion of the John Day, marked at this location by the presence of coarse sands and reworked



Overview of Haystack Valley, with two of the CAMP units (Cooperative Areas for Management of Paleontology). 8: "Balm Creek Beardog", 9: "Haystack Creek Faulted Section".



Stratigraphic section of "the Beardog Section", rocks visible from the road on this trip. From Hunt and Stepleton (2004).

clasts of Picture Gorge Ignimbrite. This perspective back towards the east provides a good discussion stop for reviewing the overall pattern of sediment distribution within the Haystack Valley.

(70.6) Entering the Town of Spray.
(71.3) Infamous Rim Rock Room on the left. Exposures due North are Haystack Member outcrops. While not particularly fossiliferous, this is UCB locality 845 called "Spray"; specimens of *Paroreodon marshi* and *Arhaeotherium (Elotherium) calkinsi* are recorded from this site.
(72.7) Kahler Creek. 3 miles upstream is locality Kahler Basin 2, UCB 859.
(81.3) Muleshoe campground, good staging area for fieldwork except when river is up, when it may be occupied by raft people. For the paleontologist, a float trip from this point to the Clarno bridge provides an excellent opportunity to see exposures of the John Day and Clarno Formations in some spectacular settings, along a wild and scenic river, including some very thick Clarno lahars.
(83.3) Junction with OR 207. Here we lose the John Day River, and will not pick it up again until we reach the bridge at Clarno, many river miles from here.
(83.5) Town of Service Creek.
(91.5) Julia Henderson Pioneer Park; a pleasant picnic site. Best spring water for miles.
(92.3) Shelton Wayside County (was State) Park; camp amidst old-growth Ponderosa pines.
(92.5) Rancheria Rock, a Clarno andesite plug, at 11:00.
(92.8) Road to Twickenham, Rowe Creek, and Painted Hills.
(93.5) Butte Ck. Pass, elevation a low 3788. Roadcut is into Clarno andesites and the Rancheria volcanic sequence.
(96.2) Bear Hollow Campground. Yet another good place to set up camp for field season. There is good water in the camp, provided by spigots: but do NOT drink from the prominent spring as you enter the

camp!
(99.3) Road to right leads to the abandoned logging town of Kinzua. The golf course, three miles up the road, is still in excellent condition and probably one of the most remote in the Northwest…
(100.9) Clarno andesites.
(102.5) Entering Fossil.
(102.8) Turn left at State Hightway 218 (to Clarno, Antelope, and Shaniko).
(108.3) Summit of pass. To the west one can see the modern Cascades on the distant skyline, and imagine the "ancestral" Oligocene Cascades (on a clear day without typical seasonal forest fires).
(111.6) Pine Creek Lane, an alternate route back to Fossil via Eocene volcanics.
(112.6) Pine Creek Ranch information kiosk. This very large property is quasi-public and can be accessed with permission, and contains a large swath of largely unprospected Clarno strata.
(114.1) Canyon narrows as lahar outcrops become more resistant locally.
(115.2) Slow down, and look to the north. This the "Dumbbell Section" measured by Bestland (not in honor of anyone in particular but owing to its shape on the aerial imagery). It contains about 100 meters of andesites, capped by spectacular hoodoos that span over 100 meters of boulder lahars, claystones, and units correlative to the "Hancock Canyon lahar" and the Nut Beds sequence. This in turn is capped by the resistant "Andesite of Horse Mountain" (Bestland and Retallack, 1994a).
(116.3) There are several different lahar outcrops here.
(117.7) Cove Creek. Up this road are many classic collection sites, including Cove Creek, Pentecost Ranch (JDNM-75), and UCMPPA-2, UF246, UOCM 2762, Chaney's sites UCMP125, 127; USNM6880 – all sadly outside the scope of this field excursion.
(118.9) Enter the Clarno Unit, John Day Fossil Beds National Monument; picnic area and interpretive trails accessible from parking lot. To the North, location of two globally important fossil localities: The Clarno Nut Beds and the Hancock Mammal Quarry.
(119.2) Turnout provides access to NPS "Trail of the Fossils." The path winds through interesting leaf-bearing fine-grained lahar facies, up to massive tree trunks preserved as log jams *in situ*. These are the lahars of the Lower Conglomerates of the Clarno Formation at the palisades (see Retallack and others, 2001), proceeding West, they thin out when onlapping an irregular surface of the Andesite of Pine Creek (see Bestland and others, 1999).
(119.9) Turn right and drive through NPS lands into the Hancock Field Station. This is a 10-acre inholding (within the National Monument boundaries) is managed by the Oregon Museum of Science and Industry. Stop at the Hancock Field Station, which is private property within the NPS boundaries. From the undeveloped parking area East of the gate are a variety of trails open to the public, including hikes into Hancock Canyon and the Hancock Tree, the Nut Beds, the (mothballed) Hancock Mammal Quarry, and many other sites.

Eve: Clarno: Hancock Field Station dinner

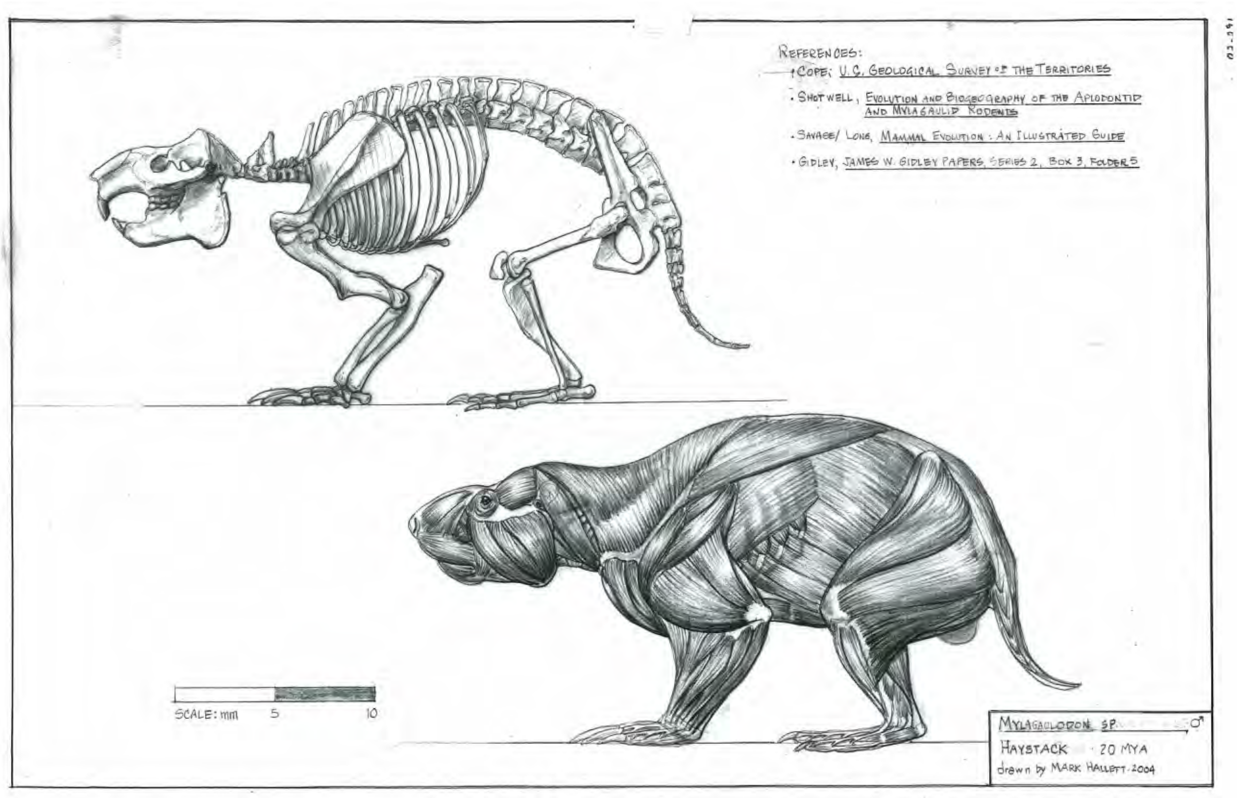
Historical Perspective

ON THE COLLECTION OF AMNH 6938, holotype of *Pogonodon platycopis – from the Museum label*

Professor Cope thus describes the discovery of this unique specimen: In passing the bluffs on one occasion, a member of the party saw on the summit of a pinnacle of the crag what appeared to be a skull. The large shining objects supposed to be teeth attracted his attention, and he resolved to obtain the specimen. He, however, was unable to climb the cliff, and returning to camp narrated the circumstances. The other men of the party successively attempted to reach the object but were compelled to descend without it, and in one case, at least, the return was made at considerable peril. A later attempt, made by Leander S. Davis, of the party, an experienced collector, was more successful. By cutting notches with a pick, in the face of the rock, he scaled the pinnacle and brought down the skull, but at considerable risk to life and limb.

Illustration of AMNH 6938, *Pogonodon platycopis*, "The John Day Tiger", figured in Cope (1884), from Blue Basin. A skull such as this is a rare find in any of the John Day strata; one can prospect for years and not retrieve anything like this.

BELOW: A mylagaulid from the Haystack strata, comparable to *Mylagaulodon* sp. Art by Mark Hallett.

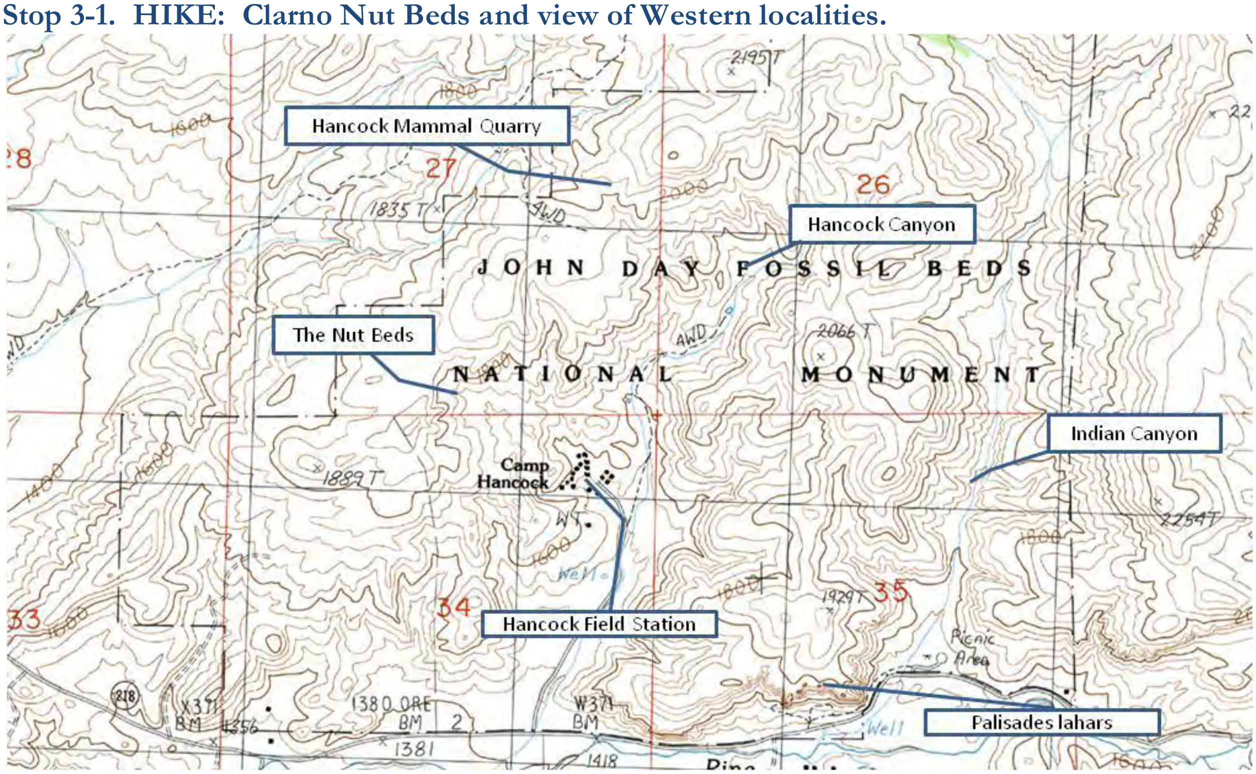


DAY THREE: HANCOCK FIELD STATION, CLARNO NUT BEDS, AND RETURN TO REDMOND VIA FOSSIL AND TWICKENHAM

DAY THREE route of road log. Numbered markers correspond to numbered stops in the Road Log text.

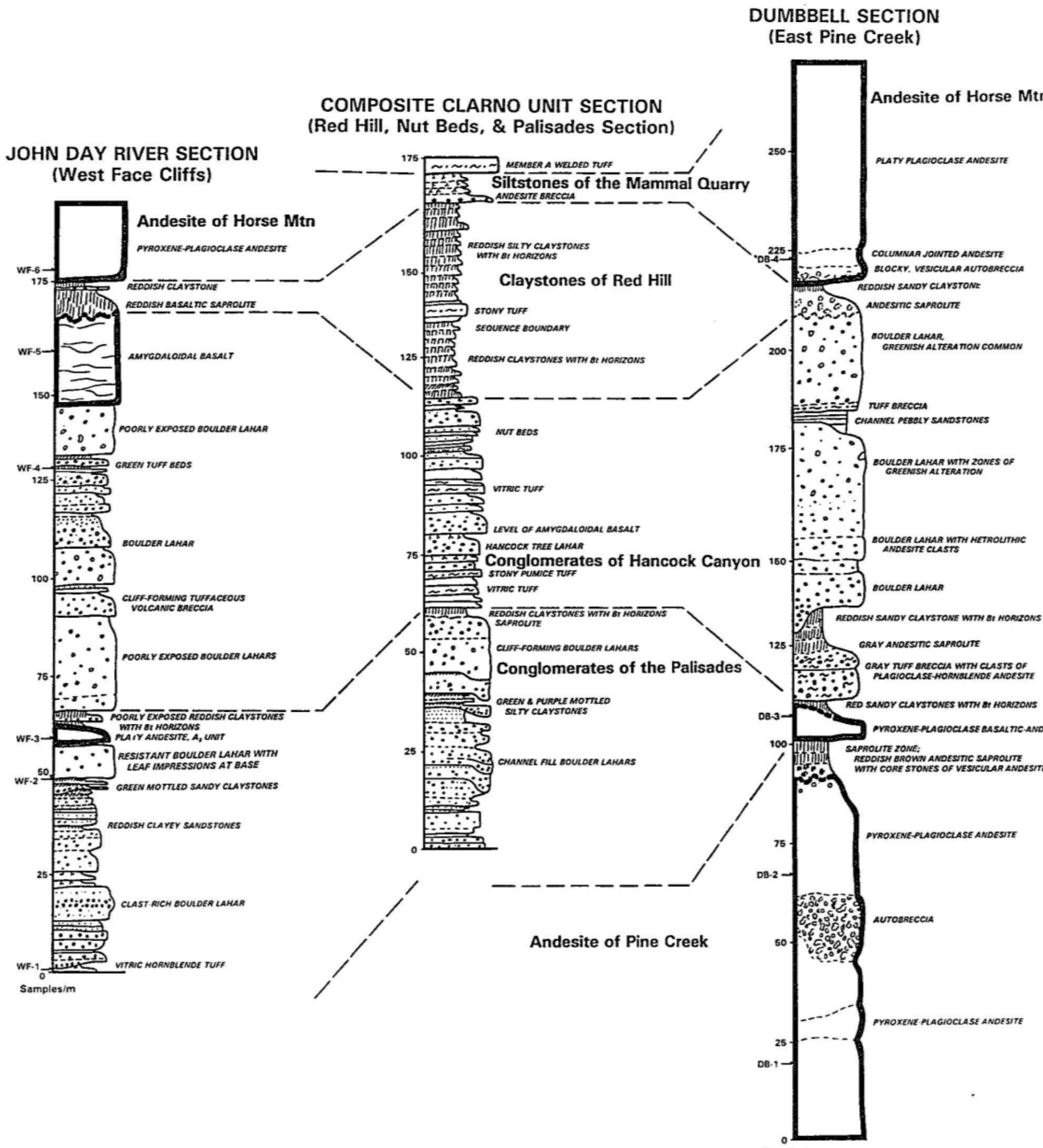
Depart from Hancock"s "Berry Hall" and hike around the hill to approach the Clarno Nut Beds from the south.

Stop 3-1. HIKE: Clarno Nut Beds and view of Western localities.



Overview of southern portion of the Clarno Unit, JDFBNM. Clarno 1:24000 Quadrangle, 1:1 scale.

There are classic paleontological strolls in the area; we will only hike to the Nut Beds. Starting at the Oregon Museum of Science and Industry's *Hancock Field Station*, we will see excellent examples of variability in volcaniclastic depositional environments. Strata range from lahars and debris flows, through lacustrine beds, fine-grained claystones, and paleosols, to intrusives and basalt flows. We will briefly explore a synthesis of three different groups that have worked extensively in the Clarno Unit of the park since the mid-1980"s: NPS contractors and staff, the University of Oregon Field Camp, and Portland State University"s Geologic Field Methods school (See Bestland and others, 1999). For discussion of the NUBE assemblage at the Nut Beds, please consult Part Three.



Generalized strat column at Clarno. West Face cliffs section, Composite of Red Hill, Nut Beds, and Palisades sections, and the Dumbbell section (Bestland and others, 1994)

Reset road log and odometer

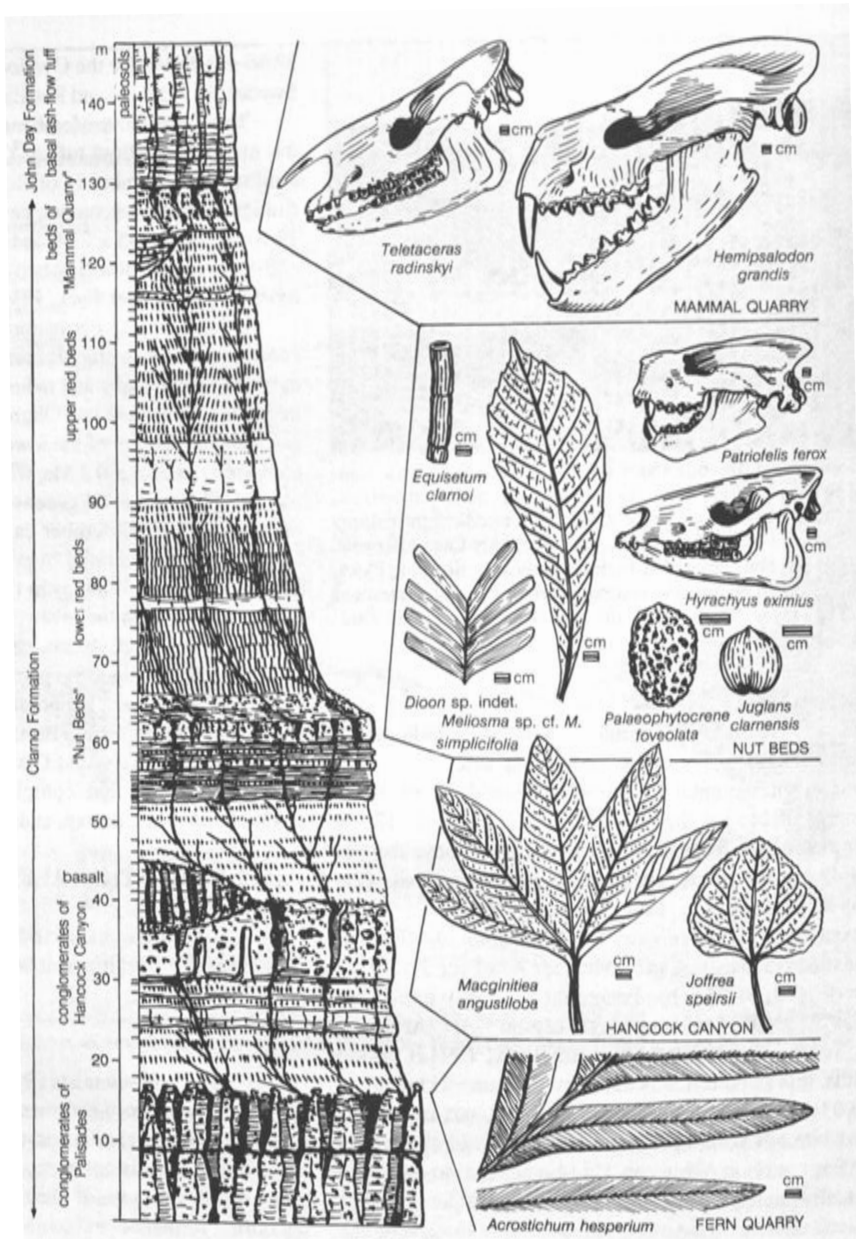
(0.0) Begin mileage at intersection of Highway 19 and NPS-Hancock Field Station road. Proceed East (towards Fossil).

(0.7) Wayside for Palisades trail. Note large fossil trees near top of face; these lahars are older, and about 50 meters below the stratigraphic level of the 44 Ma Nut Beds, and sit directly atop the Pine Creek Andesite (48.4 Ma). Vertebrates would be most welcome from this interval; likely exposures south of the Muddy Ranch may yet yield new sites.

(1.0) Clarno Unit picnic area. Retrace road back to Fossil noting same features from a different perspective.

(17.1) Arrive back in the town of Fossil, junction of 218 and Highway 19.

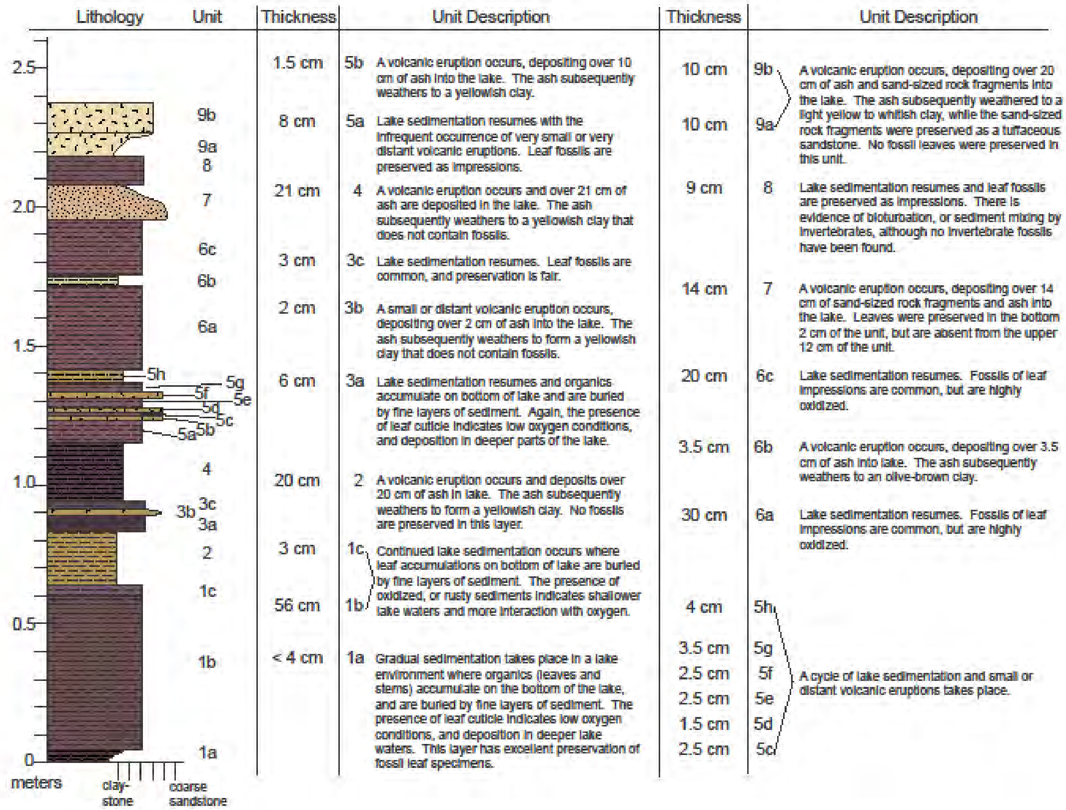
(17.3) OPTIONAL STOP: Pull into High School parking lot and walk to the lacustrine strata forming the hillside north of the football field.



Stratigraphic cartoon of the Clarno stratigraphic column exposed in a thick composite section (from Retallack and others, 2001).

NOTE: This is NOT public land; you are required to check in and register with the site managers to collect at this locality. The regulations have changed over the years, so it"s a good idea to stop in and introduce yourself and possibly pay a fee to collect material from this site.

Stop 3-2. The Fossil High School lacustrine deposits of the Big Basin/Bridge Creek Flora. These beds have long been a source of well-preserved fossil leaves, and are correlative with the lake beds in the Painted Hills Unit of the NPS. In addition to the world-famous leaves, there are many vertebrates including a species of bat (Brown, 1959), two species of salamandrid (*Paleotaricha lindoei* and a new more robust species), varied fishes, and several frogs … all largely unstudied.



Regan Dunn's (2007, unpublished NPS report) stratigraphic assessment of the Wheeler High School locality.

Departing from parking area at High School, proceed down the hill and stop at the Oregon Paleo Lands Institute, on 333 West 4th Street, proximal to the classic Wheeler County Courthouse. Examine the interesting "Mitchell Plesiosaur" recently collected by Jim Martin of SDSM&T on display.

Return to Junction and RESET ODOMETER.

(0.0) Junction of 4th Street and Highway 19.
(2.4) Clarno andesite in roadcut.
(3.5) Kinzua road.
(6.6) Bear Hollow County Park.
(10.0) Rowe Creek Road. Turn right and proceed south towards the hamlet of Twickenham. Road passes a variety of cuts through a series of Clarno volcanics and andesites associated with the Rancheria complex.
(10.7) Rancheria Peak dead ahead, with radio towers on the summit. For the next several miles, proceed through a variety of volcanic apron strata with occasional outliers of hoodoos made up of lahars, volcanic breccia, and other strata of little vertebrate paleontological interest.
(16.8) Red beds are from upper Clarno strata; probably lateral equivalents to the sequence observed at Red Hill but unstudied.
(17.0) Remarkable field vehicle.

(18.0) Large massif to left is Kentucky Ridge, capped by 4018" Kentucky Butte. This feature sits unconformably above Clarno volcanics here; as one proceeds further south, a "clastic wedge" of John Day volcaniclastics thickens and provides new exposures.
(18.7) Rowe Creek Resevoir.
(19.1) To the far left (east) directly under the Columbia River Basalts is uppermost John Day, where it has not been pinched out, presumably by uplift of the Richmond anticline. Brief reconnaissance suggests this is a portion of ?Johnson Canyon member overlain by the Rose Creek member of the Haystack Valley sequence (typified elsewhere by Hunt and Stepleton, 2004). More work should be done prospecting these strata in dozens of these outlying areas.
(20.2) Colorful exposures of the Big Basin member red beds, and first exposure of indisputable Turtle Cove beds to the east.
(20.5) The "Rockin A Ranch", previously known as the Diamond C Ranch, aka UCMP Bridge Creek 7, aka V6016 "Rowe Creek", aka Hay 2, etc. These localities are important in that they represent some of the early collecting sites referred to at and before the turn of the century as "Sutton Ranch", including historic institution collections. Some of these legacy specimens may be shoehorned into at least a rough stratigraphic context, where portions of the distinctive matrix is intact. The material can then be broadly, but not precisely, referenced to the marker beds.
(21.1) Road to west leads to "the Wagner" : a large wilderness area extending to the wild and scenic stretches of the John Day River. If this territory has been well-explored by paleontologists, they haven"t published any of it.
(21.6) The large cuesta to the left is capped by the Picture Gorge Ignimbrite (Peck"s John Day "H"), making a useful benchmark or datum for detailed stratigraphic work up and down the exposures in the area.
(25.0) Bridge over the John Day River. Another useful place to put in boats and prospect downstream.
(25.1) Proceed to the RIGHT at South Twickenham road sign. Travel west on the "Twickenham-Bridge Creek Cutoff Road", which ultimately could take you back to the Painted Hills, or off to the Burnt Ranch localities and many, many other interesting sites in the John Day and Clarno.
(27.4) Good view of the excellent Bridge Creek flora and fish locality north across the river, known as "Twickenham" MSA/F39. Ralph Chaney and other paleobotanists collected many fine specimens here, and it is a much thicker lacustrine sequence than any other Bridge Creek localities, and should be studied in more detail.
(28.0) End of pavement.

Early (Chaney and Crew) and Later (NPS Crew) paleontologists at the Twickenham lacustrine deposits.

Stop 3-3. Twickenham vicinity locality overview, and the JDNM-173 "Collins Ranch" site.


Type specimen of ***Thinohyus decedens*****, UCMP 1989, from flank of Kentucky Ridge near the hamlet of Twickenham.**

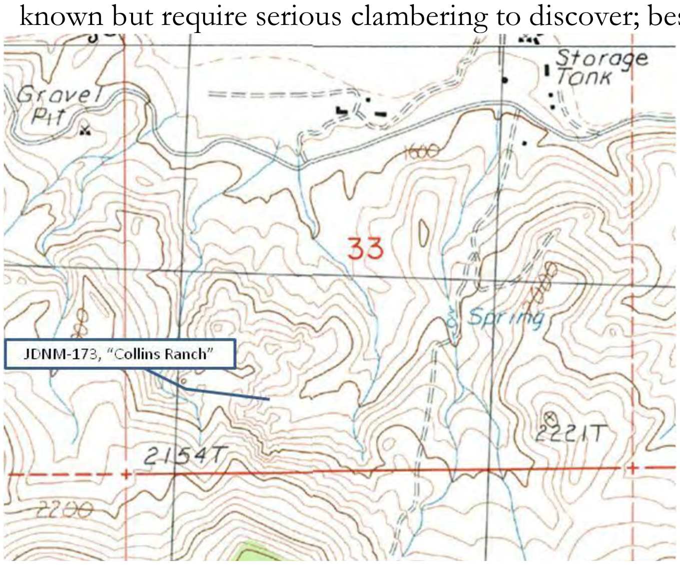
Across the river to the North can be seen much of the entire section, from lower Big Basin John Day to the West side of the Twickenham locality, to the Haystack gravels at the base of the basalts near the top of Kentucky Butte. Localities on the far right are old UCMP localities 892 and 893, "McAllister"s Ranch", that yielded several taxa including the holotype of *Thinohyus* "*Chaenohyus*" *decedens*, UCMP 1989.

To the south is the beginning of Sutton Mountain, a very large feature with dozens of important localities scattered along its flank. Immediately in front can be seen blond, tuffaceous, but not particularly zeolitized strata that are the lateral equivalent of material examined in Blue Basin. THIS IS PRIVATE LAND – DO NOT TRESPASS! This locality, long known as The Collins Ranch site, has yielded an interesting fauna comprised largely of peccaries, a small oreodont, *Miohippus*, a small dicerathere, tantalizing fragments of *Pogonodon*, and a host of other taxa; notably missing (compared to Blue Basin, Logan Butte, and other comparable strata) is the preponderance of tragulids.

After discussion, turn around and drive back to the junction of the Twickenham-Bridge Creek Cutoff and proceed right (south) on Gird"s Creek road. RESET ODOMETER

(0.0) Junction of roads.

(1.9) Beginning of remarkable canyon into basalts of Service Creek, with distinctive hackly textures. In places interbasalt paleosols offer opportunities to study palynomorphs during this interesting climatic interval (Sheldon, 2006). Large pieces of petrified wood and leaves are also known but require serious clambering to discover; best sites are along Butte Creek, west of Fossil.



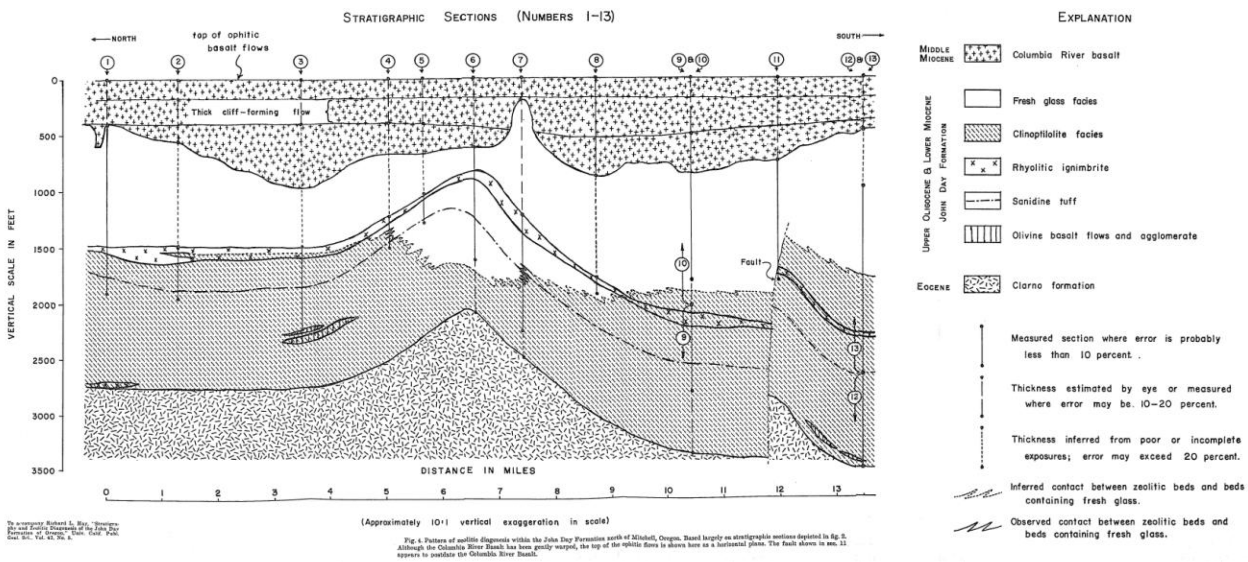
Collins Ranch locality. PRIVATE LAND! USGS map 1:24000 Sutton Mt. Scale 1:1

(3.8) Canyon in basalts. To the west, one can proceed up Black Canyon and come up onto the other side of Sutton Mountain and observe the Painted Hills basin, etc. To the East is Horse Mountain, 2,000" above the road.

(7.3) Junction with Highway. To the left are exposures of the "Blue Banks", with excellent outcrops of the Big Basin to Turtle Cove transition, as well as good exposures of units A – F up to the PGI, all tilted on their side as a result of motion on the Richmond Fault (not visited on this trip). Proceed RIGHT on OR 207 towards Mitchell.

(8.4) On the left of road are not Clarno lahars, but the Gable Creek (Cretaceous) Conglomerate of the "Mitchell Group" (consult excellent road log by Fisk, 1987).

Goose Rock itself is only 20 miles from here, due East.
(10.8) Summit of Pass on north flank of Richmond uplift.
(13.5) On the left is Meyer"s Canyon; a rugged 3-mile hike ends at the Bridge Creek road in just over 3 miles, through some Permian strata. For the engineering geologist, at the base of this canyon are stretches that have been used as examples of what happens when decades of overgrazing was followed by a waterspout-caused flood on soft sediments in the early 1950"s..
(14.8) Mitchell Rock dead ahead.
(16.1) On East of road is cut into Cretaceous Hudspeth Formation shales, with ammonites.
(17.0) Junction with Highway 26. Turn West and retrace route to Redmond.



Hays' stratigraphic collage based on a fence diagram of a dozen observed sections. Note the "fresh glass" facies (synonomized later with the Kimberly Member) crossed temporal boundaries by as much as 2 Ma in the middle sections. Stratigraphic section #3 (third from the left) is the Collins Ranch locality of Stop 3-3. From Hay (1963).

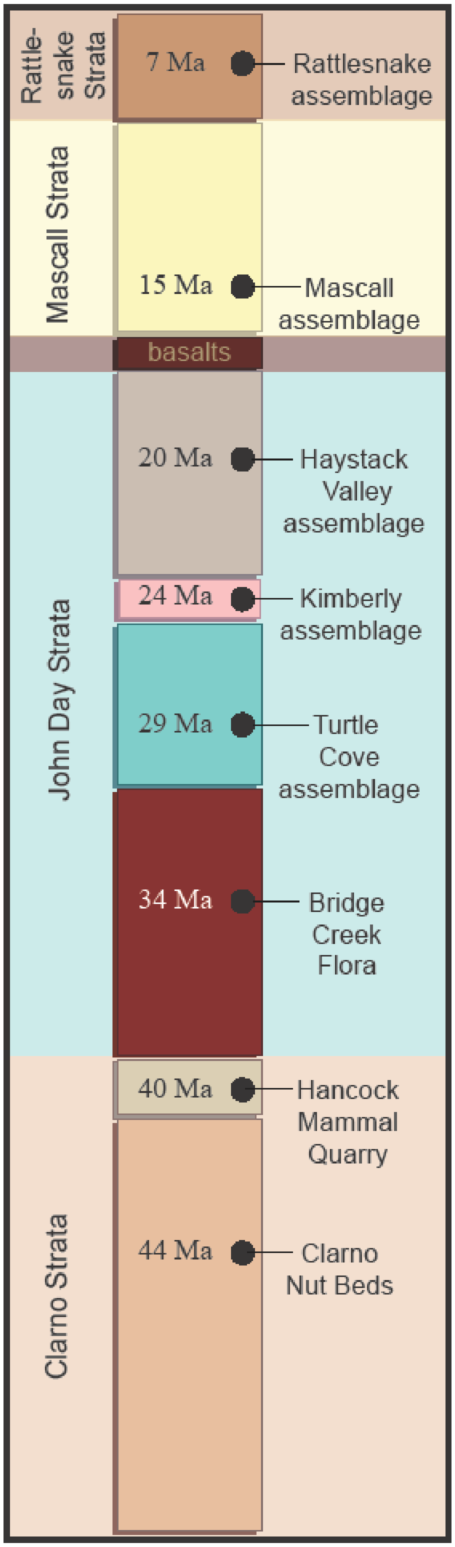
NOTES

NOTES

SECTION THREE: Simple Description Of Assemblages And Faunal Lists

Throughout this guide, abbreviations for eight of the generalized, major assemblages and simplified faunal associations have been provided.

These are, again, as follows:



late Miocene
RATT: distinctive faunas separated from the Mascall by an unconformity to the north, relatively complete sequence to the south and east. A principal correllate of the Hemphillian NALMA.

middle Miocene
MASC: Easily characterized assemblages containing a variety of First Appearance Data (FAD)s typical of the earliest Barstovian.

early Miocene
HAYS: Two diachronous faunas, commonly latest Arikareean (―Haystack‖) unconfomably overlain by strata with rare early Hemingfordian (―Rose Creek‖) taxa.

late Oligocene
KIMB: A continuation of the TUCO sequence, containing distinctive taxa and lineages. Late Arikareean.

early-late Oligocene
TUCO: The ―Classic John Day‖ lies within the Turtle Cove sequence, with many temporal and lateral variabilities. Late Whitneyan through mid Arikareean.

late Eocene-early Oligocene
BIBA: vertebrates (mostly fish and amphibians) found in and/or promixal to lacustrine Bridge Creek shales, C.f. Chadronian

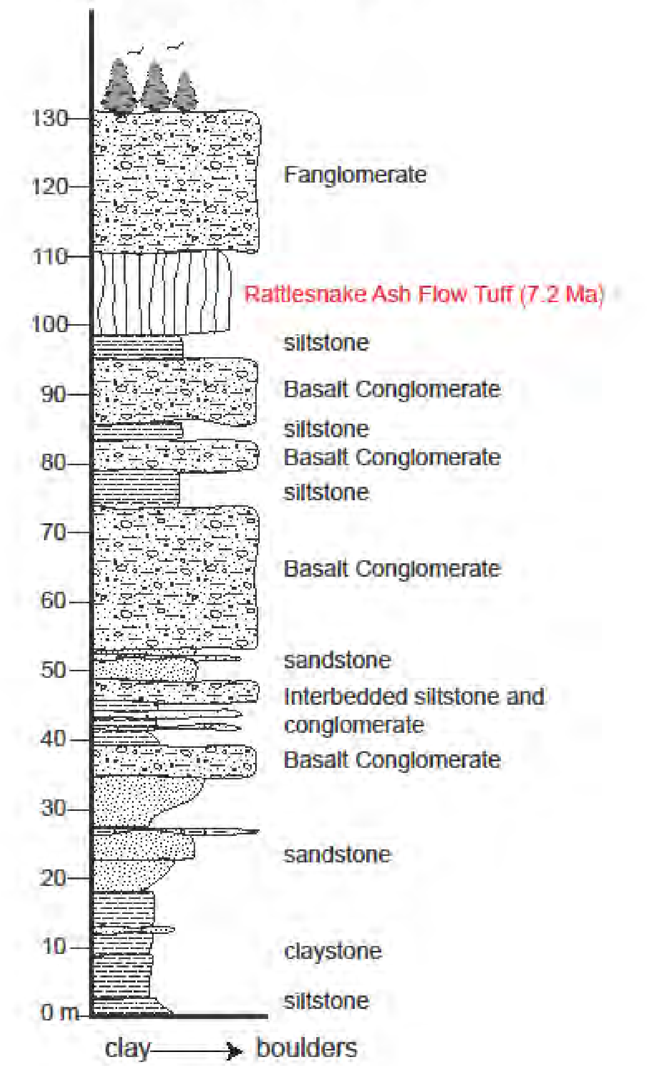
middle Eocene
HAMA: Hancock Mammal Quarry, an exceptional and unduplicated assemblage in the Basin (although see text). Duchesnean.

middle Eocene
NUBE: strata correlative with faunas preserved in the Clarno Nut Beds and its lateral equivalents. Considered a Bridgerian, but distinctive, NALMA local fauna at the principal sites within the NPS Clarno Unit.

RATT: Rattlesnake Assemblage

Major Localities

There are many localities containing Rattlesnake correlative materials scattered over a wide part of Eastern Oregon, but by far the best known and studied are those located proximal to the Type Area, visited on this trip. In historic collections, there are over 30 localities for which coordinates can be ascertained; these include ―Rattlesnake Creek‖ (CIT 13,14, and 15; CIT 183). UCMP localities include ―Upper Birch Creek‖ (UCMP 887, V3506, V7595, V3711, V6521), ―Mitchell Road‖ (V4825), JCM (817), Rattlesnake (3050, 3046, 3057, 3068, 3069) and many others. Many other repositories have small collections, or fine specimens with little data (such as AMNH, YPM, LACM, the NMNH, and so forth). New and better documented collections are curated primarily at the South Dakota School of Mines and Technology (SDSM&T), and at John Day Fossil Beds National Monument.



Generalized RATT stratigraphic section (redrawn from material presented in Martin and Fremd, 2001)

Notes

The majority of the fossiliferous Rattlesnake material is found in pre-RAFT sediments, generally considered to represent a sequence of paleosols, interbedded fanglomerates, and paludal depositional environments. Bone is relatively sparse, and ranges from very well-preserved and relatively complete skulls to microvertebrate dental scatter. A productive unit at about the 75m level has yielded many of the specimens in the JODA collections. Localities south of the prominent cliffs, largely on the flats, are easily prospected and can be correlated with the ―type‖ section with a distinctive tuff bed. Probably the most knowledgeable concerning these strata is James Martin, of the SDSM&T.

John Day Basin – Rattlesnake (RATT) Faunal List

Taxonomic Classification

Class Order Family Genus

- –Amphibia‖
  - Anura
    - Ranidae [frogs]
      - *Rana*
- –Reptilia‖
  - Chelonia (Testudines)
    - Emydidae [pond turtles]
      - *Clemmys*
- Aves
  - Falconiformes
    - Falconidae [falcons]
      - unidentified falconid
- Mammalia
  - Xenarthra
    - Megalonychidae [sloths]
      - *Megalonyx*
      - *Pliometanastes?*
  - Carnivora
    - Ailuridae [red pandas]
      - *Simocyon*
    - Canidae [dogs]
      - *Borophagus*
      - *Eucyon*
      - *Osteoborus*
      - *Tephrocyon*
      - *Tomarctus*
      - *Vulpes*
    - Felidae [cats]
      - *Machairodus*
      - *Nimravides*
      - *Pseudaelurus*
    - Mustelidae [weasels, otters, etc.]
      - *Lutravus*
      - *Martes*
      - *Mustela*
    - Ursidae [bears]
      - *Indarctos*
      - *Plionarctos*
      - *Ursus?*
  - Perissodactyla
    - Equidae [horses]
      - *Hipparion*
      - *Nannippus*
      - *Neohipparion*
      - *Parahippus*
      - *Pliohippus*
    - Rhinocerotidae [rhinoceroses]
      - *Teleoceras*

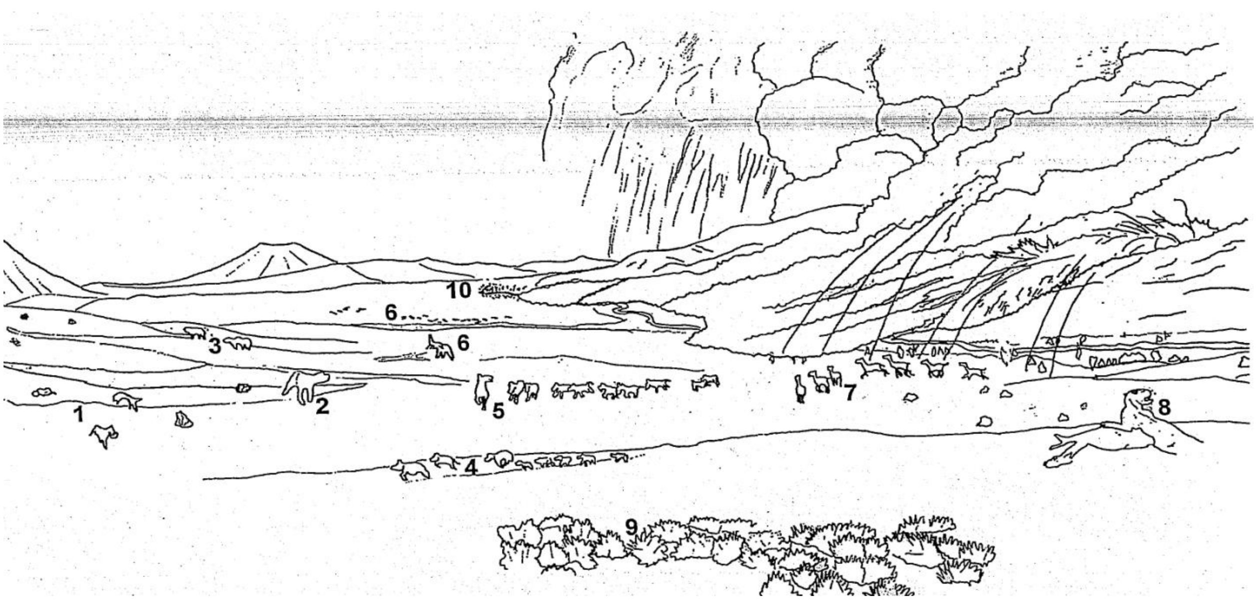
John Day Basin – Rattlesnake (RATT) Faunal List

Taxonomic Classification

Class Order Family Genus

  - Artiodactyla
      - *Ilingoceras*
      - *Sphenophalos*
    - Camelidae [camels]
      - *Aepycamelus*
      - *Hemiauchenia*
      - *Megatylopus*
      - *Pliauchenia*
    - Tayassuidae [peccaries]
      - *Mylohyus*
      - *Platygonus*
  - Rodentia
    - Castoridae [beavers]
      - *Castor*
      - *Dipoides*
    - Cricetidae [New World mice]
      - *Peromyscus*
    - Geomyidae [gophers]
      - *Thomomys*
    - Heteromyidae [pocket-mice]
      - *Prodipodomys*
    - Mylagaulidae [horned –gophers‖]
      - *Mylagaulus*
    - Sciuridae [squirrels]
      - *Sciurus*
      - *Spermophilus*
  - Lagomorpha
    - Leporidae [rabbits]
      - *Hypolagus*
  - Chiroptera
    - Vespertilionidae [evening bats]
      - *Myotis*
  - Proboscidea
    - Gomphotheriidae [gomphotheres]
      - *Amebelodon*
      - *Tetralophodon*

Rattlesnake mural by Roger Witter. View is looking East from what is now the type area of the Rattlesnake strata. Large cone in distance is reconstruction of the Strawberry Volcano, which was a large stratovolcano now greatly reduced and the center of the Strawberry Mountain wilderness. Scene depicts the RAFT event barreling down the South Fork of the John Day canyon from the eruptive center in Harney Basin.



Key to the biota in the Rattlesnake mural. Key to images: 1: *Tomarctos*; 2: *Indarctos*; 3: *Teleoceras*; 4: *Mylohyus*; 5: *Pliohippus*; 6: *Tetralophodon*; 7: *Hemiauchenia*; 8: *Machairodus*; 9: bunch grasses; 10: mixed forest, *Populus, Alnus, Salix, etc.*

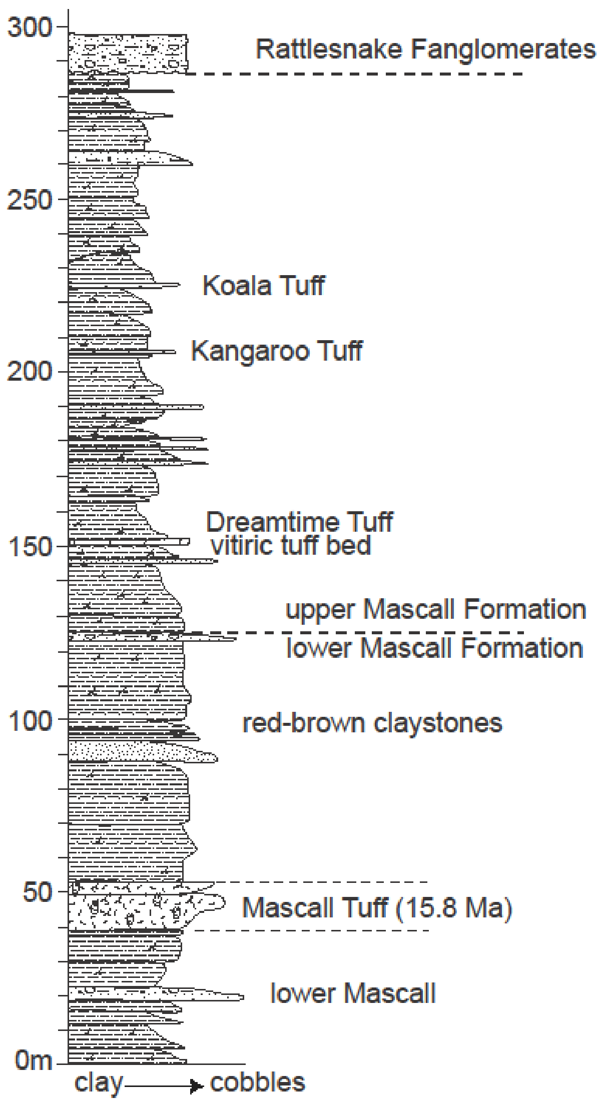
Typical prospecting exposure in the Rattlesnake "Type Area", near locality V6521 confusingly named "Clarno's Ranch". Prominent rimrock is the Rattlesnake Ash Flow Tuff (RAFT), and is a useful marker bed throughout much of the basin.

ABOVE: Mark Hallett's sketch of a *Hemiauchenia* herd fleeing from *Machairodus*-class predator for the mural.

MASC: Mascall Assemblages

Major Localities

The exposures of the ―Mascall‖, in terms of comparable assemblages, are very widespread across Oregon. They include units in the lower Crooked River far south of the type area, within rocks designated as the Simtustus Formation, and also include several problematic outcrops well to the Southeast near Sucker Creek. Downs (1956) figured most of these; some are newly discovered. In historic collections there are over 50 well-documented sites, including ―Van Horn's Ranch‖, CIT 44 ―Sucker Creek‖, the V49—series of Mascall localities cited in Downs (1956) including ―Crooked River‖ sites, ―Grindstone Creek‖, ―Rock Creek‖, UCB localities in or near the type area such as ―Cottonwood Creek‖, ―Confusion‖ (aptly named!), ―Birch Creek‖ (V4827), excellent sites at Ferris Creek, and many lacustrine localities in the lower Mascall diatomites such as ―Field's Creek.‖



Generalized Mascall section as reflected in the type area. Redrawn from data in Bestland and others (2008).

Notes

The Mascall is situated to be thoroughly restudied by vertebrate paleontologists, with publication of a new stratigraphic section (Bestland et al, 2008) and a better understanding of the diversity of localities. The majority of vertebrate material derives from pedoliths proximal to the ―Mascall Tuff‖ bed. Sediments vary from shallow lacustrine micrites, shales, and diatomites to very mature paleosols and tuffaceous overbank deposits. Of the three major stratigraphic subdivisions (see page 2:19 in Road Log), the lower produces the majority of leaves and diatomite units. These become increasingly thick to the East. The middle has yielded most of the characteristic Barstovian mammals, but the upper contains only sparse diagnostic fossils, at least in the ―type area‖. Further south (for example, along the Crooked River), what may be comparable strata have produced a small but intriguing fauna.

John Day Basin – Mascall (MASC) Faunal List

Taxonomic Classification

Class Order Family Genus

- Actinopterygii
  - Perciformes
    - Centrarchidae
      - *"Plioplarchus"*
      - *Arcoplites*
- ―Reptilia‖
  - Chelonia (Testudines)
    - Emydidae [pond turtles]
      - *Clemmys*
- Mammalia
  - Lipotyphla [insectivores]
    - Talpidae [moles]
      - *Domninoides*
      - *Scalopoides*
  - Carnivora
    - Amphicyonidae [bear-dogs]
      - *Amphicyon*
      - *Pliocyon*
    - Canidae [dogs]
      - *Tephrocyon*
      - *Tomarctus*
    - Felidae [cats]
      - *Nimravides*
      - *Pseudaelurus*
    - Mustelidae [weasels, otters, etc.]
      - *Leptarctus*
      - *Martes*
    - Procyonidae [raccoons and ringtails]
      - *Bassariscus*
    - Ursidae [bears]
      - *Ursavus*
  - Perissodactyla
    - Equidae [horses]
      - *Acritohippus*
      - *Anchitherium*
      - *Archaeohippus*
      - *Hypohippus*
      - *Merychippus*
      - *Parahippus*
    - Rhinocerotidae [rhinoceroses]
      - *Aphelops*
      - *Teleoceras*
  - Artiodactyla
    - Antilocapridae [pronghorn antelope]
      - *Merycodus*
    - Camelidae [camels]
      - *Miolabis*
      - *Paratylopus; Protolabis*
    - Merycoidodontidae [oreodonts]
      - *Ticholeptus*

John Day Basin – Mascall (MASC) Faunal List

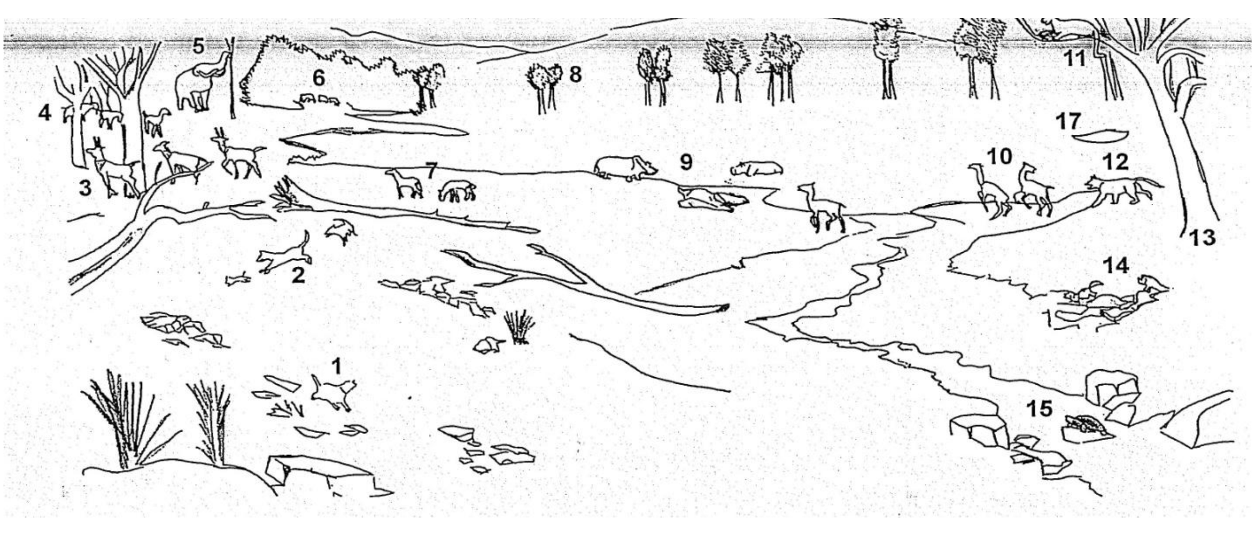
Taxonomic Classification

Class Order Family Genus

    - Moschidae [musk deer]
      - *Blastomeryx*
      - *Parablastomeryx*
    - Palaeomerycidae
      - *Bouromeryx*
      - *Dromomeryx*
      - *Rakomeryx*
    - Tayassuidae [peccaries]
      - *Cynorca*
  - Rodentia
    - Aplodontidae [mountain beavers]
      - *Liodontia*
      - *Tardontia*
    - Castoridae [beavers]
      - *Dipoides*
      - *Monosaulax*
    - Geomyidae [gophers]
      - *Mojavemys*
    - Heteromyidae [pocket-mice]
      - *Peridiomys*
      - *Prodipodomys*
    - Mylagaulidae [horned ―gophers‖]
      - *Alphagaulus*
      - *Hesperogaulus*
      - *Mylagaulus*
    - Sciuridae [squirrels]
      - *Arctomyoides*
      - *Petauristodon*
      - *Protospermophilus*
  - Lagomorpha
    - Leporidae [rabbits]
      - *Hypolagus*
  - Proboscidea
    - Gomphotheriidae [gomphotheres]
      - *Gomphotherium*
    - Mammutidae [mastodons]
      - *Zygolophodon*

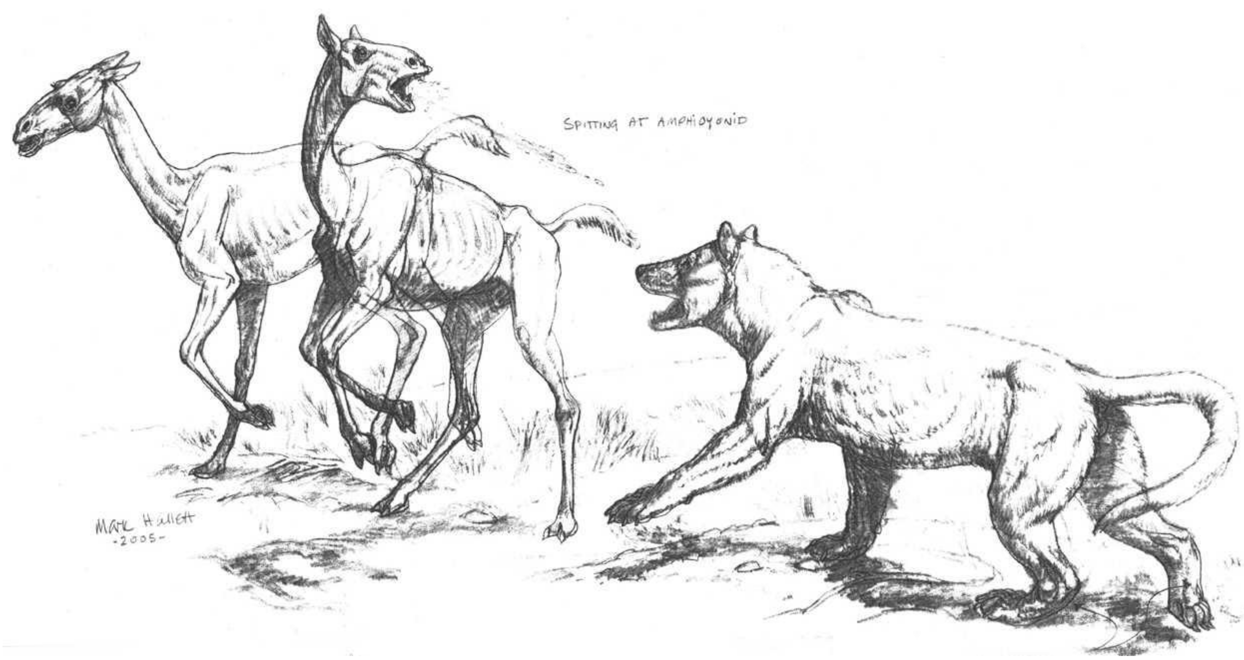
Mascall mural by Roger Witter. The view is towards the North from what is now the Mascall type area. Large "shield" volcano represents the source of the Monument basalt dike swarm, highlands to left are remnants of the Richmond anticline. Note hexagonal surfaces of an exhumed collonade layer of the Picture Gorge Basalt, the primary surface upon which much of the Mascall was deposited either at the terminus of the flood basalt extrusions, or as intra-basalt layers.

Key to the biota in the Mascall mural. Key to images: 1: *Mylagaulus*; 2: *Tephrocyon*; 3: *Dromomeryx*; 4: *Merychippus*; 5: *Gomphotherium*; 6: *Parahippus*; 7: *Archaeohippus*; 8: *Taxodium;* 9: *Aphelops*; 10: *Miolabis*; 11: *Pseudaelurus*; 12: *Amphicyon*; 13: mixed forest: *Celtis, Liquidambar, Quercus, Ulnus, Acer, Fagus, etc.* 14: *Leptarctus*; 15: *Clemmys*; 16: falcon, unidentified; 17: *Dipoides.*



Exposures of the less well-prospected upper section of the Mascall at the type area. The boundary between the upper and middle Mascall strata is the resistant layer at the base of the prominent hill in the foreground.

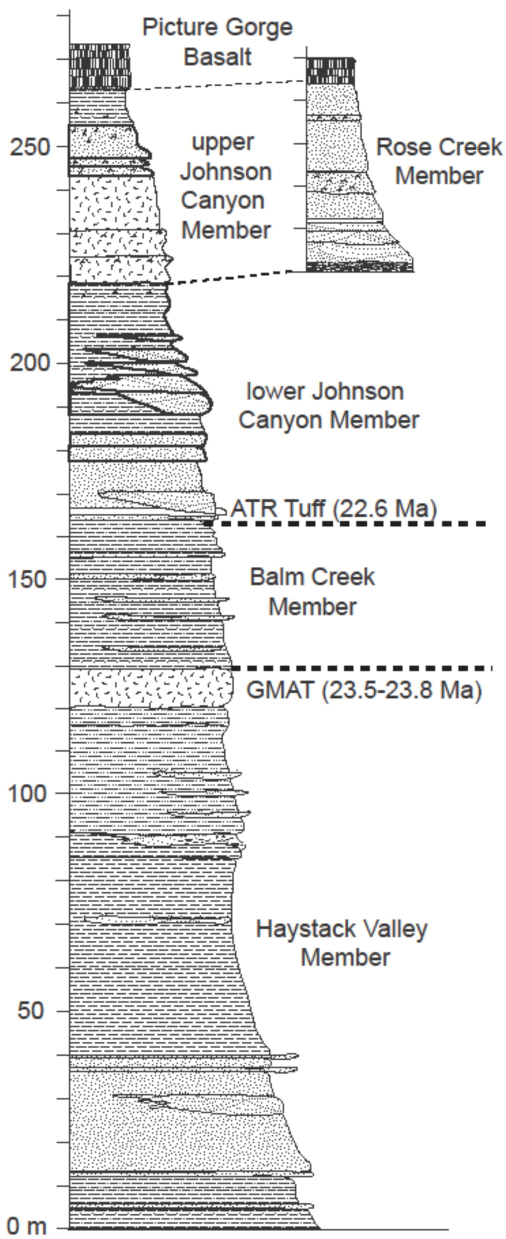
Behavioral sketch for mural, in this case illustrating a camelid spitting at an amphicyonid (probably not a good idea). Over 50 of these kinds of images were drawn up by Mark Hallett to reflect potential behavior to incorporate.



HAYS: Haystack Valley Assemblages

Major Localities

Haystack exposures were long misunderstood, and their complexity ignored, until the many years of work by Hunt and Stepleton (2006, *Abstract #18*). Their analysis requires a careful re-examination of over 80 historic localities in repositories that were thought to be upper Kimberly, or simply listed as ―Upper John Day‖. The key stratigraphic sections for appraising and correlating the units are not necessarily the most fossiliferous. However, several established sites can be confidently assigned to one or more of the four units proposed by Hunt and Stepleton (2004), including v66101 ―Crazy Woman Knob‖, JDNM-186 ―Hopper's Fish Pond‖, several sites on the Warm Springs Reservation including ―Mecca‖, v6322 ―Gray Face Bluff‖ aka Haystack 8, v6590 ―Brisbois Bluff‖, v6306 ―Protapirus‖, JDNM-50 (v6666) ―Black Bone Hill‖, and JDNM-167 ―Big Bend‖. There may be more aliases per locality for Haystack strata than anywhere in the John Day; where possible these recent names have been synonomized in the JODA databases.



Composite section Upper John Day Beds, John Day River valley. Re-drawn from data presented in Hunt and Stepleton (2004).

Notes

Although the Haystack presents a greater variety of depostional environments than most ―John Day‖ strata, typically the Haystack contains more fluvial deposits containing diagnostic bone of any strata in the basin. These lithologies vary from fine sandstones to conglomerates with baseball-sized clasts. At the base of the Rose Creek Member at the Bone Creek site, for example, large jaws have been found undamaged and *in situ* in the basal conglomerate layer. Other sites, such as the pea-gravel beds north of Kimberly, have yielded well-preserved dentitions and avian distal phanges.

***Cf. Merycochoerus* sp. in gravels**

John Day Basin – Haystack (HAYS) Faunal List

Taxonomic Classification

Class Order Family Genus **Rose Creek only**

- Aves
  - Falconiformes
    - Falconidae [falcons]
      - unidentified falconid
- Mammalia
  - Carnivora
    - Amphicyonidae [bear-dogs]
      - *Amphicyon* RC
      - *Daphoenus* RC
      - *Mammacyon*
      - New temnocyonine
    - Canidae [dogs]
      - *Cynarctoides*
      - *Desmocyon*
      - *Enhydrocyon*
    - Mustelidae [weasels, otters, etc.]
      - *Promartes*
    - Ursidae [bears]
      - *Ursavus*
  - Perissodactyla
    - Chalicotheriidae
      - *Moropus*
      - *Tylocephalonyx*
    - Equidae [horses]
      - *Acritohippus*
      - *Anchitherium*
      - *Archaeohippus*
      - *Kalobatippus*
      - *Merychippus*
      - *Miohippus*
      - *Parahippus*
    - Rhinocerotidae [rhinoceroses]
      - *Floridaceras*
      - *Menoceras*
    - Tapiridae [tapirs]
      - *Miotapirus*
      - *Nexuotapirus*
  - Artiodactyla
    - Camelidae [camels]
      - *Oxydactylus*
      - *Paratylopus*
      - *Protolabis* RC
    - Entelodontidae [giant "pigs"]
      - *Daeodon*

John Day Basin – Haystack (HAYS) Faunal List

Taxonomic Classification

Class Order Family Genus **Rose Creek only**

- Hypertragulidae [mouse-deer]
  - *Nanotragulus*
- Merycoidodontidae [oreodonts]
  - *Hypsiops*
  - *Merychyus*
  - *Merycochoerus*
  - *Paroreodon*
  - *Promerycochoerus*
- Moschidae [musk deer]
  - *Blastomeryx*
  - *Parablastomeryx*
- Palaeomerycidae
  - *Barbouromeryx* RC
  - *Bouromeryx*
  - *Dromomeryx*
  - *Rakomeryx*
- Tayassuidae [peccaries]
  - *Cynorca*

- Rodentia
  - Aplodontidae [mountain beavers]
    - *Liodontia*
    - *Sewelleladon*
    - *Tardontia*
  - Castoridae [beavers]
    - *Dipoides*
    - *Monosaulax*
    - *Hystricops* RC
  - Geomyidae [gophers]
    - *Mojavemys*
  - Heteromyidae [pocket-mice]
    - *Peridiomys*
    - *Prodipodomys*
  - Mylagaulidae [horned –gophers‖]
    - *Mesogaulus*
    - *Mylagaulodon* RC
- Lagomorpha
  - Leporidae [rabbits]
    - *Archaeolagus*
    - *Hypolagus*

Haystack Valley mural. Scene is looking North; note deposition of coarse gravels representative of facies in numerous exposures both in the "Haystack Valley", Johnson Canyon, and Rose Creek members. Art: Roger Witter.

Key to Haystack biota. Key to images: 1: *Daphoenus*; 2: *Hypolagus*; 3: *Moropus*; 4: *Daeodon*; 5: *Parahippus*; 6: *Ursavus;* 7: *Miotapirus*; 8: *Gentilicamelus*; 9: *Populus*; 10: *Ginkgo.*

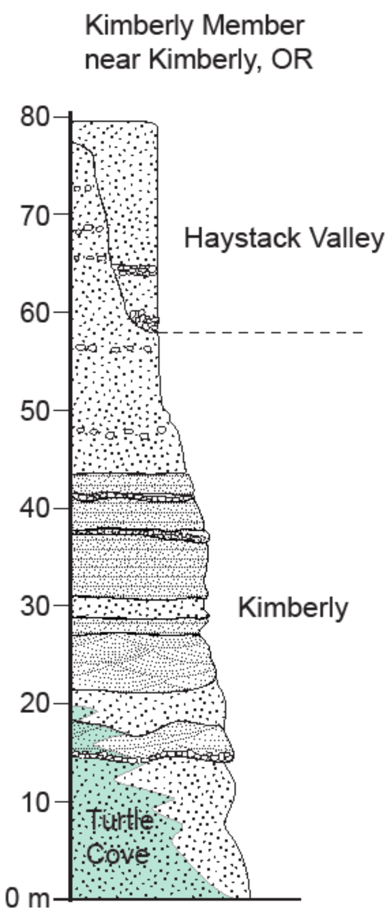
Exposures near base of Johnson Canyon section.

Excellent exposures of the Rose Creek member (RCM) exposed at Bone Creek. Unit sits unconformably atop Unit M of the Turtle Cove/Kimberly section; resistant, ledge forming gravels at the base of RCM contain many specimens, including rare, complete jaws of large mammals.

KIMB: Kimberly Assemblages

Major Localities

One of the larger problems with the characterization of a stratigraphic member based on diagenetic alteration (such as whether any volcanic glass is zeolitized or not) is that it does not serve to refine biostratigraphic distributions. As currently defined, the ―Kimberly‖ facies cross time-stratigraphic units to a large degree; in some cases occurring below the Picture Gorge Ignimbrite. One of the motivations for establishing biostrat units A-M in the ―middle John Day‖ was to alleviate the resulting temporal confusion and instead use isochronous tuffs as boundary units. Workers have not been consistent assigning localities to ―the Kimberly‖; but some classic sites do exist. These include sites up Fossil Creek, V66126 ―Picture Gorge 37‖, v6429 ―Reed's Ranch‖, v6658 ―Stubblefield‖, and sites in ―the Southern Facies‖ such as v6351 ―Shrocks‖, and new localities at the northern fringe of John Day sediments, such as new materials from the upper exposures at Lonerock. Other major areas include outstanding sections on the Warm Springs Reservation, and many of the beds on the west flank of Sutton Mountain.



Generalized Kimberly section as developed from several outcrops in the N end of Turtle Cove, Sutton Mountain, and elsewhere. Lateral variability of thickness of this facies makes a composite stratigraphic column overgeneralized.

Notes

The Kimberly biota definitely requires careful delineation. Most of the exposures seen on this trip are not particularly fossiliferous compared to the underlying strata, but to the north, rich dune-like deposits, have emerged as potentially important vertebrate bearing units. The classic exposures of Kimberly in the basin are at Sutton Mountain, where large nodules not uncommonly contain complete *Merycochoerus superbus* skulls.

John Day Basin – Kimberly (KIMB) Faunal List

Taxonomic Classification

Class Order Family Genus

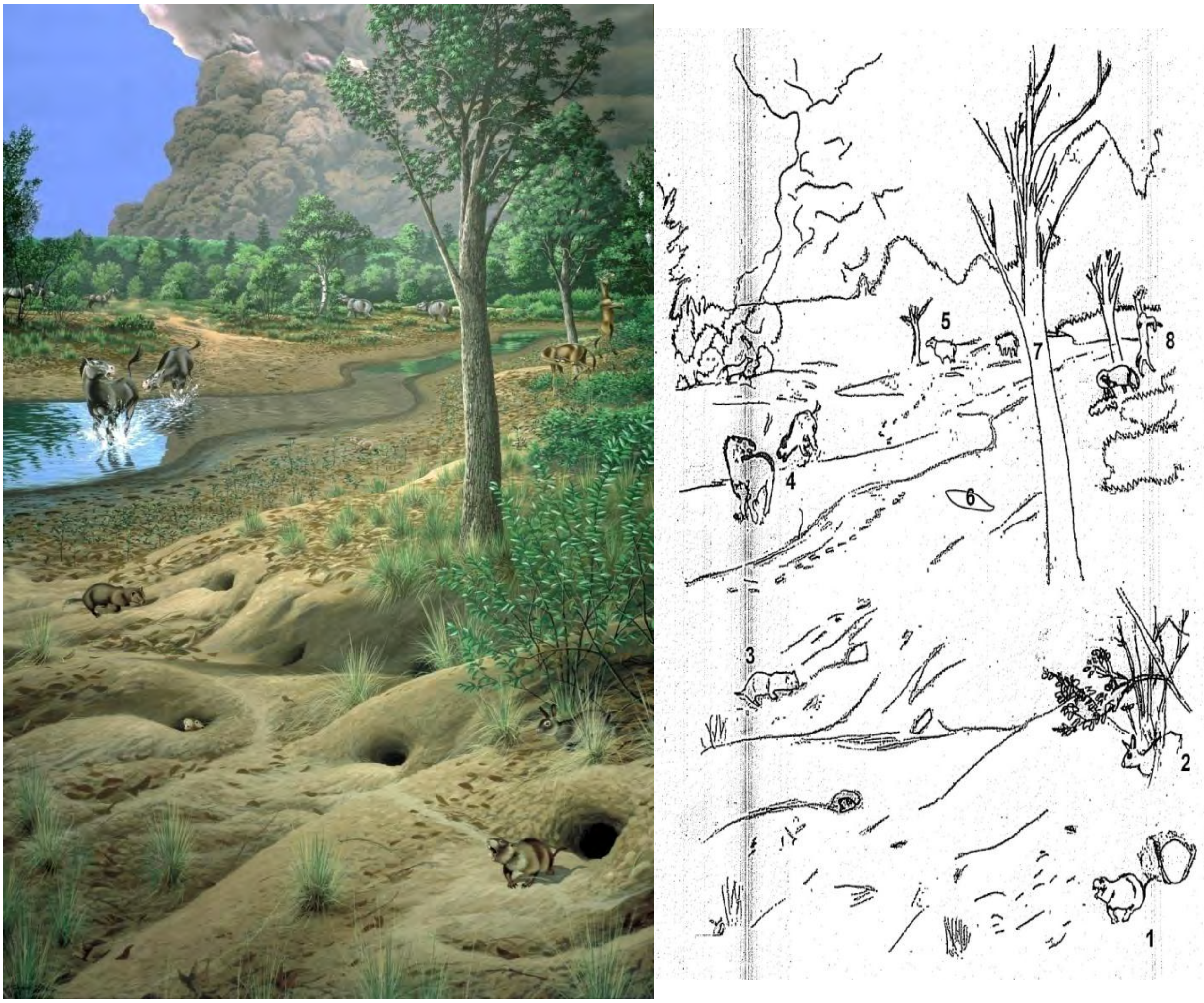
- ―Amphibia‖
  - Caudata
    - Salamandridae [salamanders]
- ―Reptilia‖
  - Squamata
    - Boidae [constrictors]
      - *Ogmophis*
- Mammalia
  - Marsupialia
    - Herpetotheriidae [opposums]
      - *Copedelphys*
      - *Herpetotherium*
  - Lipotyphla [insectivores]
    - Erinaceidae [hedgehogs]
      - *cf. Amphechinus*
    - Micropternodontidae
      - *Micropternodus*
    - Proscalopidae
      - *Proscalops*
    - Soricidae [shrews]
      - *Domnina*
      - *Wilsonosorex*
    - Talpidae [moles]
      - *Domninoides*
      - *Scalopoides*
  - Carnivora
    - Amphicyonidae [bear-dogs]
      - *Daphoenodon*
    - Mustelidae [weasels, otters, etc.]
      - *Oligobunis*
  - Perissodactyla
    - Chalicotheriidae
      - *Moropus*
    - Equidae [horses]
      - *Anchitherium*
      - *Kalobatippus*
      - *Miohippus*
    - Tapiridae [tapirs]
      - *Nexuotapirus*
  - Artiodactyla
    - Agriochoeridae [clawed oreodonts]
      - *Agriochoerus*
    - Camelidae [camels]
      - *Gentilicamelus*
      - *Poebrotherium*

John Day Basin – Kimberly (KIMB) Faunal List

Taxonomic Classification

Class Order Family Genus

    - Entelodontidae [giant "pigs"]
      - *Daeodon*
    - Hypertragulidae [mouse-deer]
      - *Hypertragulus*
      - *Nanotragulus*
    - Leptomerycidae [leptomerycids]
      - *Leptomeryx*
    - Merycoidodontidae [oreodonts]
      - *Eporeodon*
      - *Hypsiops*
      - *Merycochoerus*
      - *Merycoides*
      - *Oreodontoides*
      - *Paroreodon*
  - Rodentia
    - Aplodontidae [mountain beavers]
      - *Allomys*
      - *Alwoodia*
      - *Campestrallomys*
      - *Prosciurus*
    - Castoridae [beavers]
      - *Capacikala*
    - Cricetidae [New World mice]
      - *Leidymys*
      - *Paciculus*
    - Dipodidae [jerboas & etc)]
      - *Plesiosminthus*
    - Eomyidae
      - *cf. Apeomys*
      - *cf. Arikareeomys*
      - *Leptodontomys*
    - Florentiamyidae
      - *Florentiamys*
    - Geomyidae [gophers]
      - *Entoptychus*
    - Heteromyidae [pocket-mice]
      - *Proheteromys*
      - *Schizodontomys*
    - Sciuridae [squirrels]
      - *Petauristodon*
      - *Protosciurus*
  - Lagomorpha
    - Ochotonidae [pikas]
      - *Desmatolagus*
    - Leporidae [rabbits]
      - *Archeolagus*



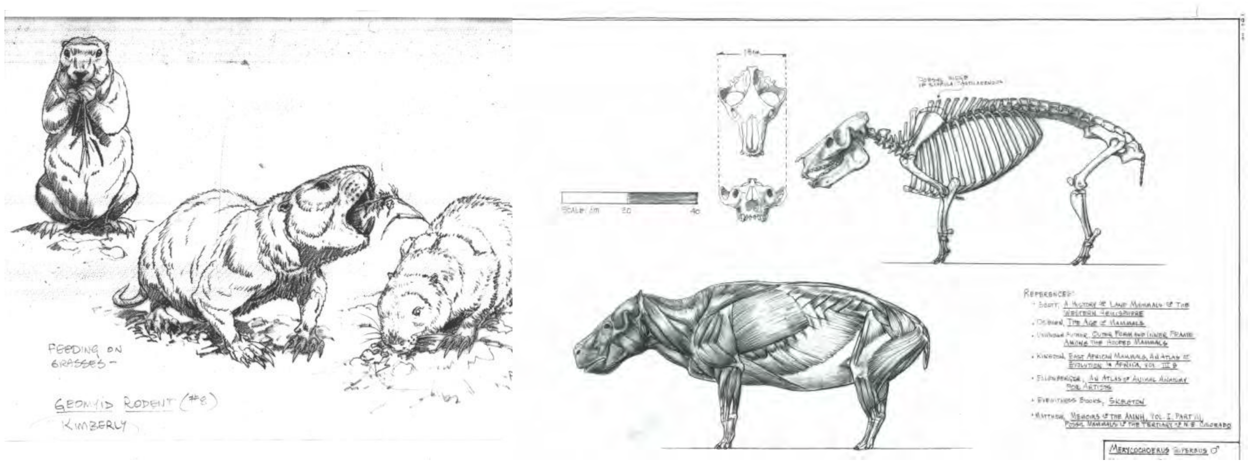
Roger Witter's mural depicting landscape, events, and biota during deposition of the strata corresponding to "the Kimberly" member, really a diagenetic facies. In terms of biostratigraphy, these sediments and species correspond to units K1-M of the master sections.

View is looking West from a locality near the hamlet of Kimberly, OR. A massive eruption suggestive of the depositional history of the paleosols is coming from a caldera not far to the west. Note the paludal environment, the preponderance of burrows, and overall cooling and drying suggested, reflective of the interpretations from the lithostratigraphy and paleosols.

Key to biota: 1: *Entoptychus*; 2: *Archeolagus*; 3: *Leptocyon*; 4: *Kalobattipus*; 5: *Merycochoerus*; 6: *Capacikala*; 7: *Liquidambar*; 8: *Gentilicamelus.*

Exposures of typical Kimberly weathering patterns. This is locality v70175 "Junction 2", 3.1 miles due NE of the hamlet of Kimberly.

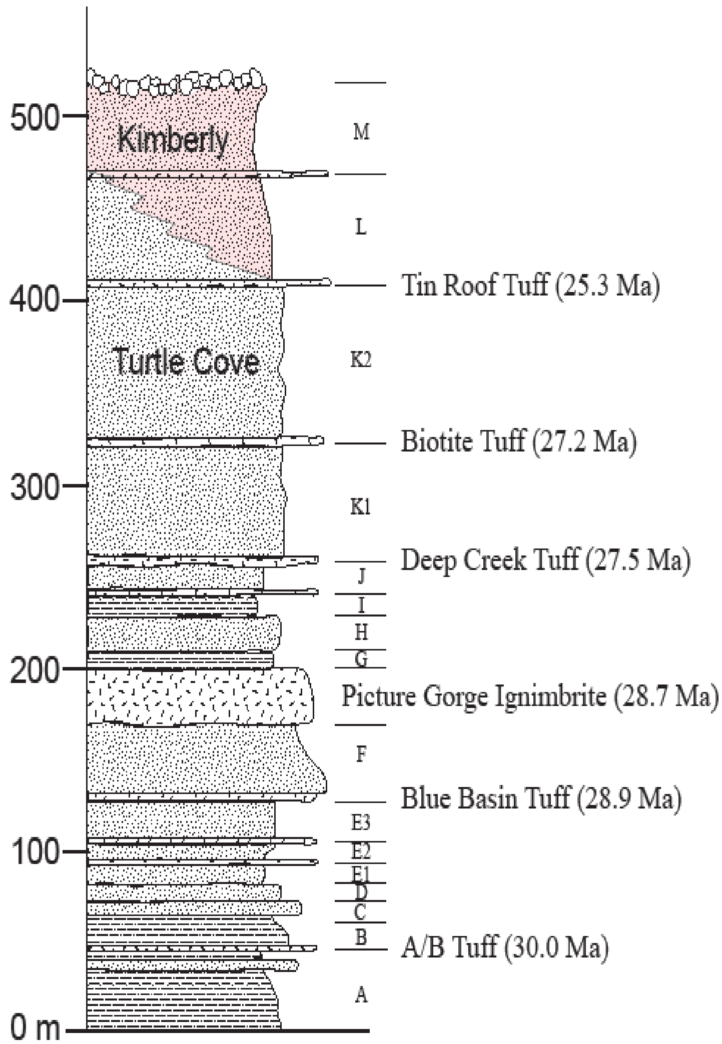
Two of the dozens of behavioral sketches and complete restorations of individual species drawn by Mark Hallett. The scale bar in the center pertains to the large, "*Merycochoerus* – class oreodont" on the right (there are no giant geomyids in the Kimberly).



TUCO: Turtle Cove Assemblages

Major Localities

By far, the majority of localities and materials from the John Day Basin is that from the ―classic‖ Turtle Cove fauna. Many paleontologists learn of the John Day for the first time from the 1000+ page ―Cope's Bible‖ (1884), which contains excellent illustrations of many type specimens. There are literally hundreds of important sites, and this trip will visit a small percentage of them. As mentioned in the discussion of the Kimberly, it is not always possible to distinguish whether a collection was made relative to recently dated tuffs and the biostratigraphic units based on them. The classic localities in the Turtle Cove region (Sheep Rock, Blue Basin, and Foree) are complemented by rich deposits in the Western ―facies‖, such as the Sorefoot Creek beds, and the Southern ―facies‖ as exemplified at Logan Butte. A listing of the other 150 discrete sites would include the red beds of Monument (aka, ―The North Fork‖ of early collectors), the Fossil Horse Beds on Cottonwood Creek, lower Sutton Mountain, Rudio Canyon, lower Roundup Flat, and many others.



Stratigraphic section of Turtle Cove strata, showing location of lettered faunal zones.

Notes

The typical green zeolitized tuffaceous claystones of the Turtle Cove vary widely in texture and color within the ―Eastern facies‖ of these strata, often over less than a kilometer.

John Day Basin – Turtle Cove (TUCO) Faunal List

Taxonomic Classification

Class Order Family Genus

- ―Reptilia‖
  - Chelonia (Testudines)
    - Testudinidae [tortoises]
      - *Stylemys*
  - Squamata
    - Boidae [constrictors]
      - *Ogmophis*
    - Rhineuridae [worm lizards]
      - *Dyticonastis*
      - *Rhineura*
- Aves
  - Charadriiformes
    - Laridae [gulls]
      - *Larus*
    - Scolopacidae [sandpipers]
      - *Limicolavis*
  - Falconiformes
    - Cathartidae [New World vultures]
      - unidentified teratorn
  - Galliformes
    - Phasianidae [pheasants]
      - *Phasianus*
  - Pelicaniformes
    - Phalacrocoracidae [cormorants]
      - *Phalacrocorax*
  - Podicipediformes
    - Podicipedidae [grebes]
      - *Podiceps*
- Mammalia
  - Marsupialia
    - Herpetotheriidae [opposums]
      - *Copedelphys*
      - *Herpetotherium*
      - *Peratherium*
  - Lipotyphla [insectivores]
    - Erinaceidae [hedgehogs]
      - *Ocajila*
    - Micropternodontidae
      - *Micropternodus*
    - Proscalopidae
      - *Proscalops*
    - Soricidae [shrews]
      - *Pseudotrimylus*
    - Talpidae [moles]
      - *Domninoides*
  - Carnivora
    - Amphicyonidae [bear-dogs]
      - *Daphoenus*
      - *Paradaphoenus*
      - *Temnocyon*
    - Hemicyonidae
      - *Nothocyon*

John Day Basin – Turtle Cove (TUCO) Faunal List

Taxonomic Classification

Class Order Family Genus

    - Canidae [dogs]
      - *Archaeocyon*
      - *Cormocyon*
      - *Cynarctoides*
      - *Enhydrocyon*
      - *Hesperocyon*
      - *Leptocyon*
      - *Mesocyon*
      - *Oregonocyon*
      - *Osbornodon*
      - *Paraenhydrocyon*
      - *Philotrox*
      - *Phlaocyon*
      - *Rhizocyon*
    - Mustelidae [weasels, otters, etc.]
      - *Plesictis*
    - Nimravidae [nimravids]
      - *Dinaelurus*
      - *Dinictis*
      - *Eusmilus*
      - *Hoplophoneus*
      - *Nimravus*
      - *Pogonodon*
    - Phocoidea [stem pinniped]
      - *Allocyon*
    - Procyonidae [raccoons and ringtails]
      - *Bassariscus*
    - Ursidae [bears]
      - *Parictis*
      - *Ursavus*
    - Viverravoidea
      - *Palaeogale*
  - Perissodactyla
    - Equidae [horses]
      - *Mesohippus*
      - *Miohippus*
    - Rhinocerotidae [rhinoceroses]
      - *Diceratherium*
      - *Subhyracodon*
    - Tapiridae [tapirs]
      - *Miotapirus*
      - *Nexuotapirus*
  - Artiodactyla
    - Agriochoeridae [clawed oreodonts]
      - *Agriochoerus*
    - Anthracotheriidae
      - *Elomeryx*
    - Camelidae [camels]
      - *Gentilicamelus*
      - *Paratylopus*
    - Entelodontidae [giant "pigs"]
      - *Archaeotherium*

John Day Basin – Turtle Cove (TUCO) Faunal List

Taxonomic Classification

Class Order Family Genus

- Hypertragulidae [mouse-deer]
  - *Hypertragulus*
  - *Nanotragulus*
- Merycoidodontidae [oreodonts]
  - *Desmatochoerus*
  - *Eporeodon*
  - *Eucrotaphus*
  - *Hypsiops*
  - *Merycochoerus*
  - *Merycoides*
  - *Mesoreodon*
  - *Oreodontoides*
  - *Paroreodon*
- Tayassuidae [peccaries]
  - *Perchoerus*
  - *Thinohyus*

Rodentia
- Aplodontidae [mountain beavers]
  - *Allomys*
  - *Alwoodia*
  - *Ansomys*
  - *Downsimus*
  - *Haplomys*
  - *Meniscomys*
  - *Niglarodon*
  - *Oropyctis*
  - *Parallomys*
  - *Pelycomys*
  - *Prosciurus*
  - *Rudiomys*
  - *Sewelleladon*
- Castoridae [beavers]
  - *Agnotocastor*
  - *Capacikala*
  - *Palaeocastor*
- Cricetidae [New World mice]
  - *Eumys*
  - *Leidymys*
  - *Paciculus*
- Eomyidae
  - *cf. Apeomys*
  - *cf. Arikareeomys*
  - *Leptodontomys*
  - *Paradjidaumo*
  - *Pseudotheridomys*
- Eutypomyidae
  - *Eutypomys*
- Florentiamyidae
  - *Florentiamys*

John Day Basin – Turtle Cove (TUCO) Faunal List

Taxonomic Classification

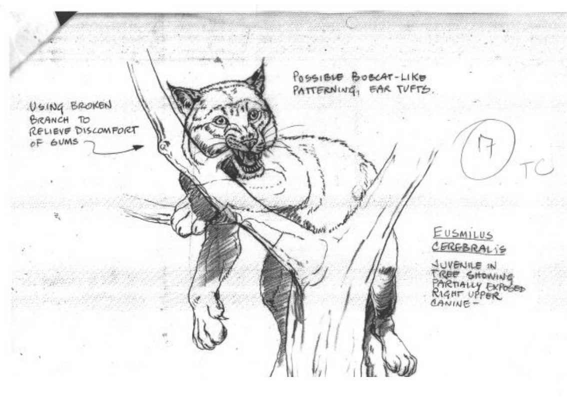
Class Order Family Genus

- Geomyidae [gophers]
  - *Entoptychus*
  - *Gregorymys*
  - *Pleurolicus*
- Ischyromyidae
  - *Ischyromys*
- Sciuridae [squirrels]
  - *Miosciurus*
  - *Protospermophilus*

Lagomorpha
- Ochotonidae [pikas]
  - *Desmatolagus*
- Leporidae [rabbits]
  - *Archeolagus*
  - *Paleolagus*

Primates
- Omomyidae
  - *Ekgmowechashala*

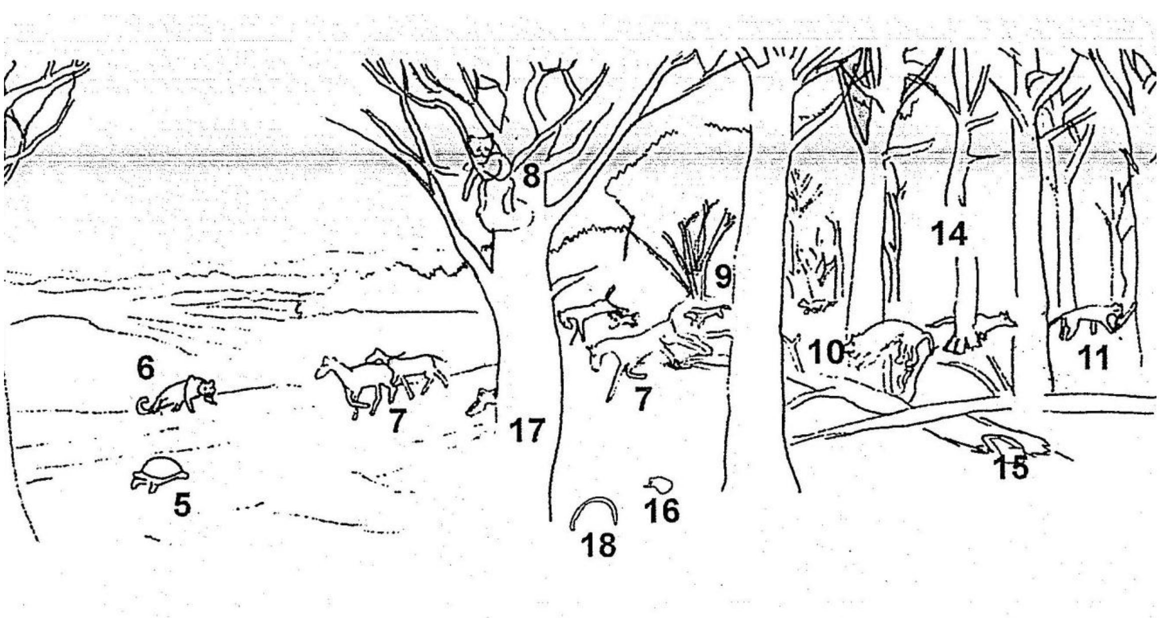
BELOW: *Eusmilus cerebralis,* juvenile with erupting permanent canine, based on specimen JODA 7047 from Logan Butte, OR. Sketch by Mark Hallett.



NOTES

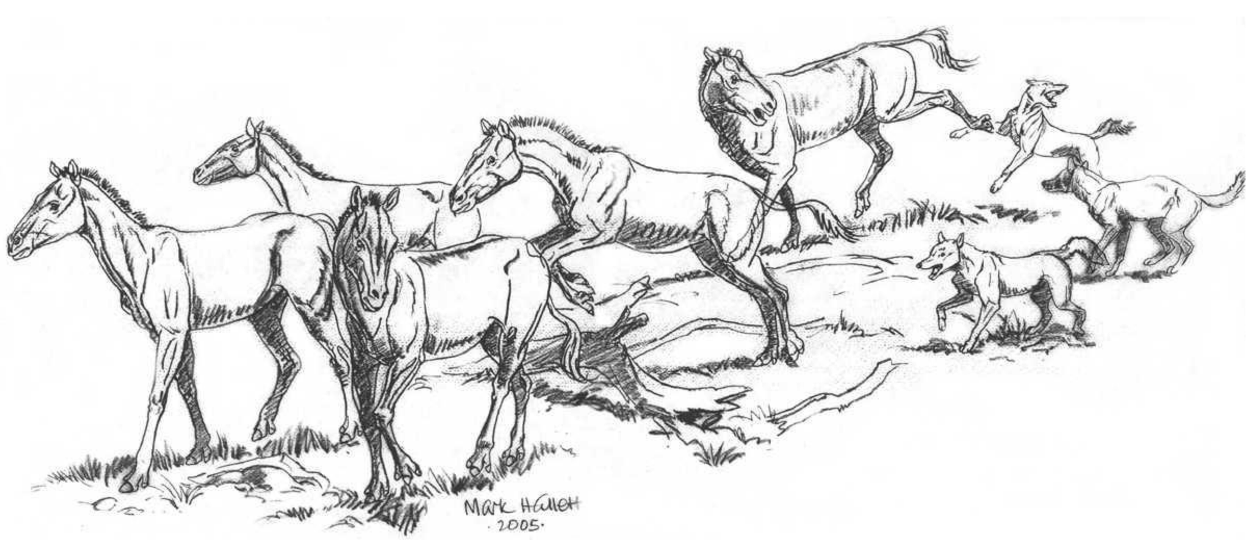
Detail of a mural of the Turtle Cove unit. The entire left side of the mural has been omitted for space. The viewer is looking towards the West from what is now Blue Basin. Mural by Roger Witter and others.

Key to Turtle Cove biotas. Key to images: 1-4: cropped from image. 5: *Stylemys*; 6: *Nimravus*; 7: *Miohippus*; 8: *Eusmilus*; 9: *Mesocyon*; 10: *Agriochoerus*; 11: *Cormocyon*; 14: *Quercus*; 15: *Herpetotherium*; 16: *Micropternodus*; 17: *Celtis*; 18: *Dyticonastis*.



View from Overlook Trail of Blue Basin, one of the classic localities in all of the John Day Fossil Beds. Probably more (non-microvertebrate) specimens have been retrieved from this locality than any of the hundreds of other sites, with the possible exception of Logan Butte. In mid distance are the redbeds of the type area of the Big Basin strata (much better exposed at Painted Hills, and the Picture Gorge Basalts are on the skyline. At the upper left of the photo, the Foree beds are visible as faint light outcrops in the distance.

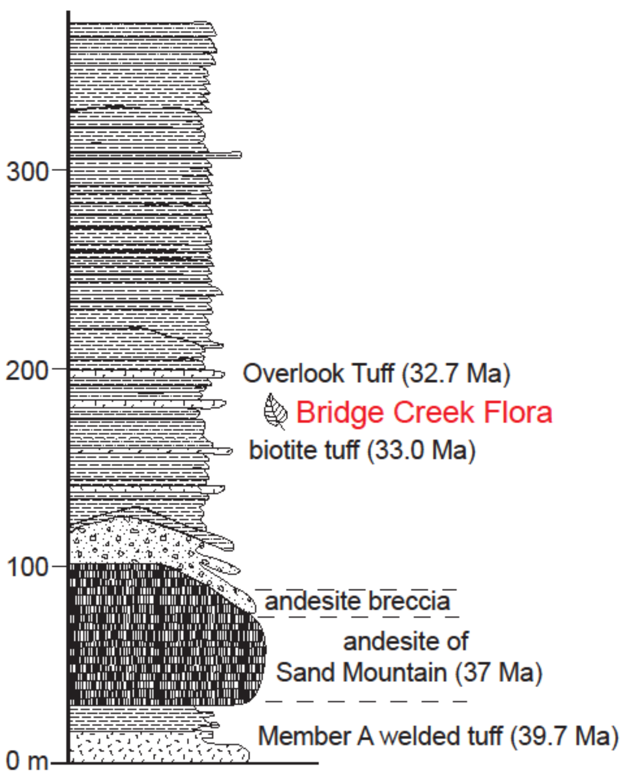
A behavioral sketch for mural of a herd of *Miohippus* being shadowed by borophagine canids. The equid delivering a kick to the canid is suggested by the traumatized skull of JODA 3366 , on display in the TCPC. Mark Hallett illustration.



BIBA: Big Basin Assemblages

Major Localities

The majority, but not all, of vertebrate-entombing strata of the Big Basin are lacustrine, and are typically associated with well-known paleobotanical localities, including some of the globally famous sites. At the upper end of the section, there are several paludal and overbank sites that are ferruginous claystones containing fragments of large mammals, typically entelodonts and rhinocerotids. At the base, potentially lowest John Day strata have yielded several small Chadronian-like taxa, particularly along the exposures of the Crooked River and Lost Creek. The leaf-bearing shales contain a variety of complete vertebrate skeletons, typically fish and amphibians in some localities The vertebrate sites include the type localities of the Bridge Creek flora that Chaney worked extensively (often simply called ―The Leaf Hills‖) within the Painted Hills Unit of JODA; the Wheeler High School exposures in Fossil, OR (source of most of the amphibians); the Knox Ranch sites near Clarno; the Slanted Leaf Hills at the base of Iron Mountain; the Cant's Ranch locality near Sheep Rock (which contains abundant *Novumbra* and pine needles); and the exposures at the bluff near the old townsite of Twickenham. Domestic collections are widely scattered but include major holdings at UCMP, the USGS in Denver, U of Oregon, Portland State U, UWBM, U of Michigan, the Field Museum of Chicago, and U of Florida. Noteworthy material is also in museums in Tokyo, London, Prague, Paris, Budapest, and many other countries (Meyer and Manchester, 1997).



Greatly simplified stratigraphic section of typical exposures of the Big Basin strata, particularly based on localities in the Painted Hills area. Section in Big Basin proper differs, but has yielded few diagnostic vertebrates. A "neotype" area might be relocated when the John Day is redefined as a Group, with the Big Basin consisting of a Formation with three members.

Notes

The lacustrine strata of the Big Basin are widespread across Eastern Oregon. They are a series of time transgressive lenses in the otherwise sparsely fossiliferous red paleosols typified at Painted Hills. The more than 110 species of preserved plants vary widely according to their geographic, ecologic, and temporal parameters. A wide variety of invertebrates including insects, spiders, and other taxa are also associated with the vertebrate remains, offering the possibility of detailed paleoecological analyses in the future.

Taxonomic Classification

Class Order Family Genus

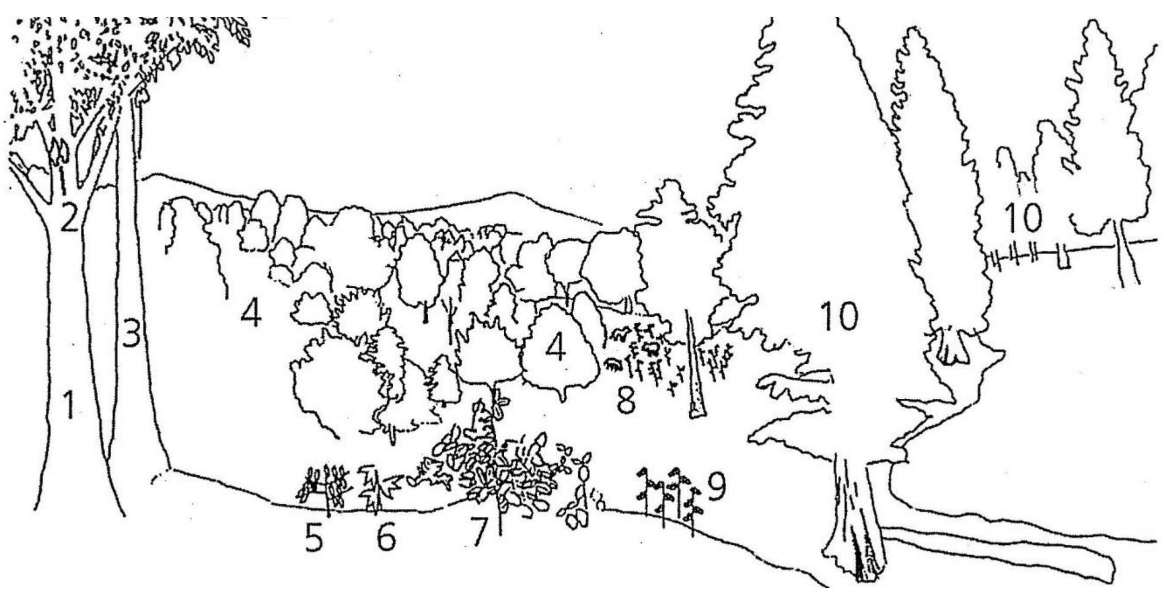
Actinopterygii
- Amiiformes
  - Amiidae [bowfin]
    - *Amia*
- Cypriniformes
  - Cyprinidae [carp and minnows]
    - unidentified cyprinid
- Esociformes
  - Umbridae [mudminnows]
    - *Novumbra*

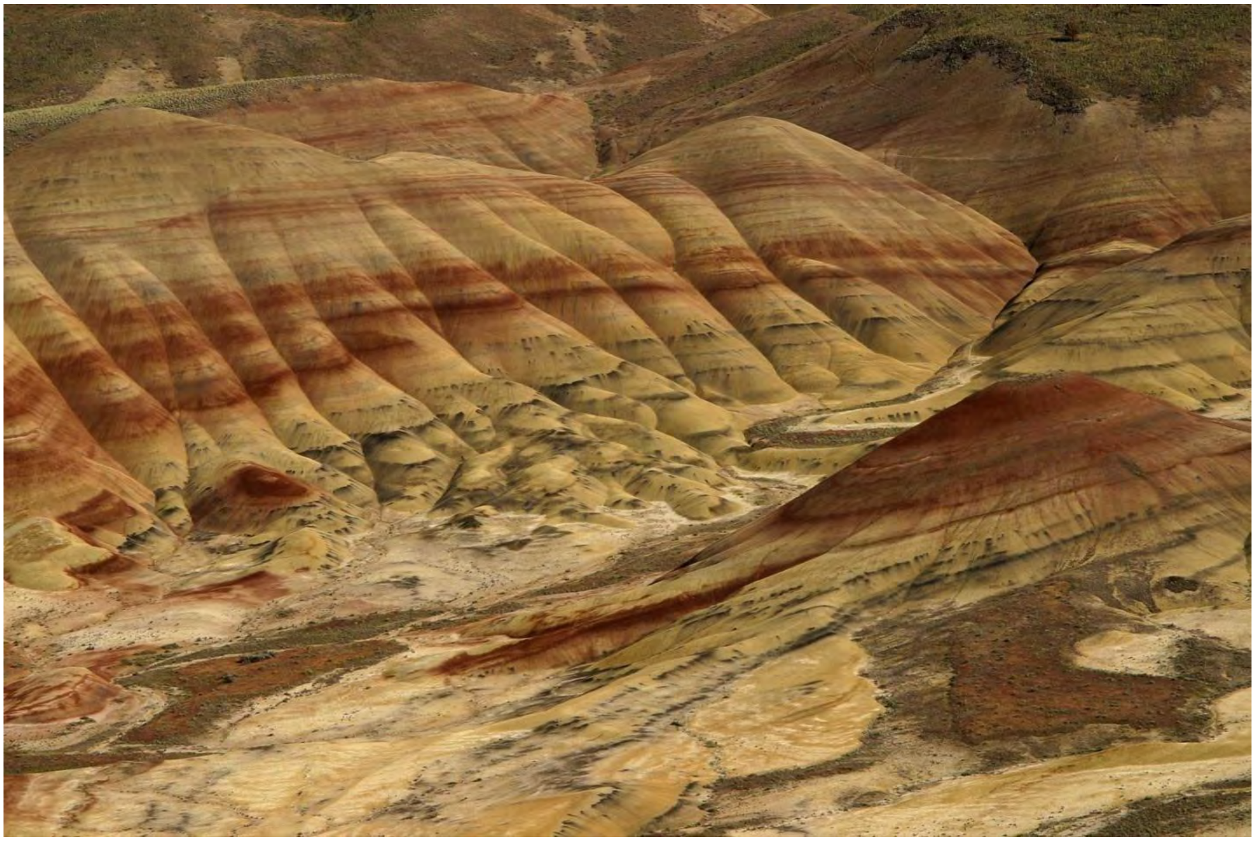
Amphibia
- Anura
  - unidentified anuran
- Caudata
  - Salamandridae [salamanders]
    - *Palaeotaricha*
- Chelonia (Testudines)
  - Testudinidae [tortoises]
    - *Hadrianus*

Mammalia
- Perissodactyla
  - Equidae [horses]
    - *Mesohippus*
  - Rhinocerotidae [rhinoceroses]
    - *Subhyracodon*
  - Tapiridae [tapirs]
    - *Colodon*
- Artiodactyla
  - Entelodontidae [giant "pigs"]
    - *Archaeotherium*
- Chiroptera
  - unidentified bat

A portion of the Bridge Creek mural, representative of the Big Basin assemblages. Here the viewer is facing South from what is today the Painted Hills leaf localities. In the distance, broad volcanic cones are suggestive of the Clarno intrusives. Mural by Larry Felder.

Key to the biota of the Bridge Creek mural; images on the right are missing, including the plethodontid salamander ***Paleotaricha lindoei***. 1: ***Ulmus***; 2: bat, unidentified; 3: ***Juglans***; 4: mixed forest: ***Acer, Ulmus, Juglans, Pinus etc.;*** 5: ***Vitis***; 6: ***Acer***; 7: ***Cercidiphyllum***; 8: ***Mesohippus***; 9: ***Alnus***; 10: ***Metasequoia.***





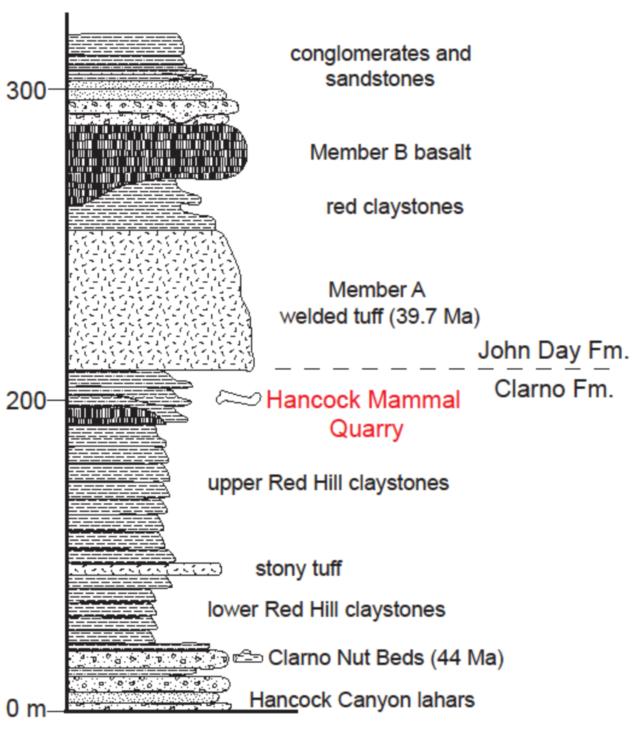
Classic exposures of the Big Basin strata exposed at the Painted Hills. Very little vertebrate fossil material is found in these particular paleosols.

BELOW: more typical well-bedded lacustrine strata of laminated micrites and tuffaceous shales in the Painted Hills region that contain vertebrates including fishes, salamanders, frogs, a bat, and isolated feathers.

HAMA: The Hancock Mammal Assemblage

Major Localities

There is actually only one locality in the upper Clarno Formation that contains material that can be referenced to a NALMA, although a variety of sites far afield have yielded material suggestive of the possibility of more specimens –some day‖. This is JDNM-13, the Hancock Mammal Quarry, aka L775. –This large quarry was excavated primarily between 1955 and 1959 by Hancock, Shotwell and McKenna, and from 1969-1972 by teams from the Oregon Museum of Science and Industry (OMSI). Fossil bones were found within a 1 m thickness of grey to olive siltstones between calcareous conglomerates of the quarry floor and olive siltstones of the weathered and slumped quarry face. Jennifer Pratt reopened the quarry in 1987 and found additional material in place. Further excavation would be worthwhile as the overburden is only about 3-4 meters of soft claystones that are easily removed. This horizon correlates to a stratigraphic level of 122 m in the master section‖ (Bestland and Retallack, 1994). There is an additional quarry to the East of the major excavation that remains relatively undisturbed. The largest collections of material from the Hancock Quarry are the UCMP and the UO, with lesser holdings at JODA and the UWBM. The NPS plans to re-open this quarry to determine the likelihood of additional material, study the paleoenvironment more carefully, and possibly develop an *in situ* display.



Generalized Clarno section as reflected in the vicinity of the Hancock Mammal Quarry. Redrawn from Retallack and others (2001).

Notes

The depositional sequences of the Hancock Mammal Quarry have been recently studied by Pratt (1988), and the strata and fauna reviewed by Hanson (1996). Exposed sections have revealed a variety of depositional environments sandwiching the major mammal-producing horizons. Fragmentary elements from fish and amphibians have been found associated with the leaf-bearing shales and –overburden‖ (mentioned above) that superpose the quarry horizons and a careful study of these overlooked faunas is warranted.

John Day Basin – Hancock Quarry (HAMA) Faunal List

Taxonomic Classification

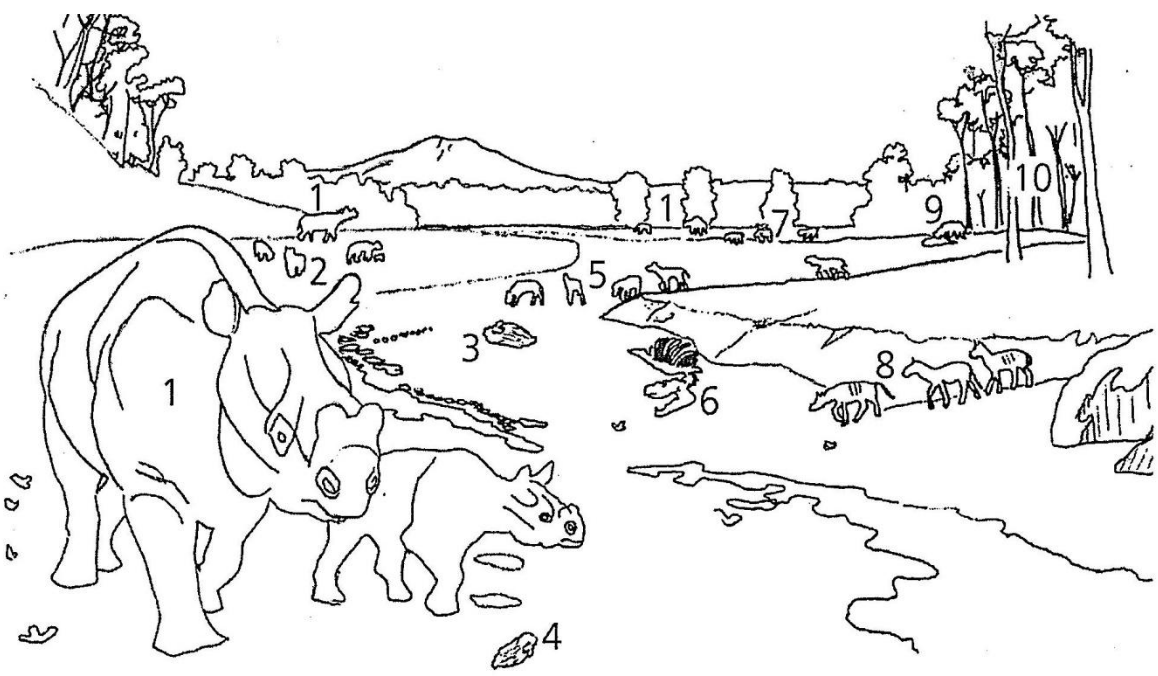
Class Order Family Genus

- Actinopterygii
  - Siluriformes
    - Hypsidoridae [catfish]
      - *Hypsidoris*

- –Reptilia‖
  - Crocodilia
    - Alligatoridae [alligators]
      - new genus

- Mammalia
  - Creodonta [creodonts]
    - Hyaenodontidae
      - *Hemipsalodon*
  - Carnivora
    - Nimravidae [nimravids]
      - unidentified nimravid
  - Perissodactyla
    - Amynodontidae
      - *Zaisanamynodon*
    - Brontotheriidae
      - *Eubrontotherium*
      - *Protitanops*
    - Equidae [horses]
      - *Epihippus*
      - *Haplohippus*
    - Hyrachodontidae
      - *Hyracodon*
    - Rhinocerotidae [rhinoceroses]
      - *Teletaceras*
    - Tapiridae [tapirs]
      - *Protapirus*
  - Artiodactyla
    - Achaenodontidae
      - *Achaenodon*
    - Agriochoeridae [clawed oreodonts]
      - *Diplobunops*
    - Anthracotheriidae
      - *Heptacodon*

Representative depiction of the environment, landscape, biotas, and taphonomic precursors of the Hancock Mammal Quarry (HMQ) and its environs. View is to the south from what is now the HMQ. Dormant volcanic slope in distance depicts one of the many large Clarno epicenters, possibly Rancheria Rock or one of its equivalents in that direction. Note extensive trampling and hoofprints; two of the specimens in the mural represent skulls that show trample marks, and these are on display in the foreground at the TCPC. Mural: Roger Witter. BELOW: Key to images: 1: *Protitanops;* 2: *Protapirus;* 3:*Eubrontotherium clarnoensis* (skull distorted by trampling, UCMP 126100); 4: *Diplobunops* (with hoof-marked skull, UCMP 154593)*;* 5: *Epihippus*; 6: *Zaisanamynodon protheroi* (with trampled carcass); 7: *Teletaceras*; 8: *Haplohippus*; 9: *Hemipsalodon*; 10: vines: Menispermaceae, *Palaeophytocrene, Diploclisia, Juglans, Vitis* and others.

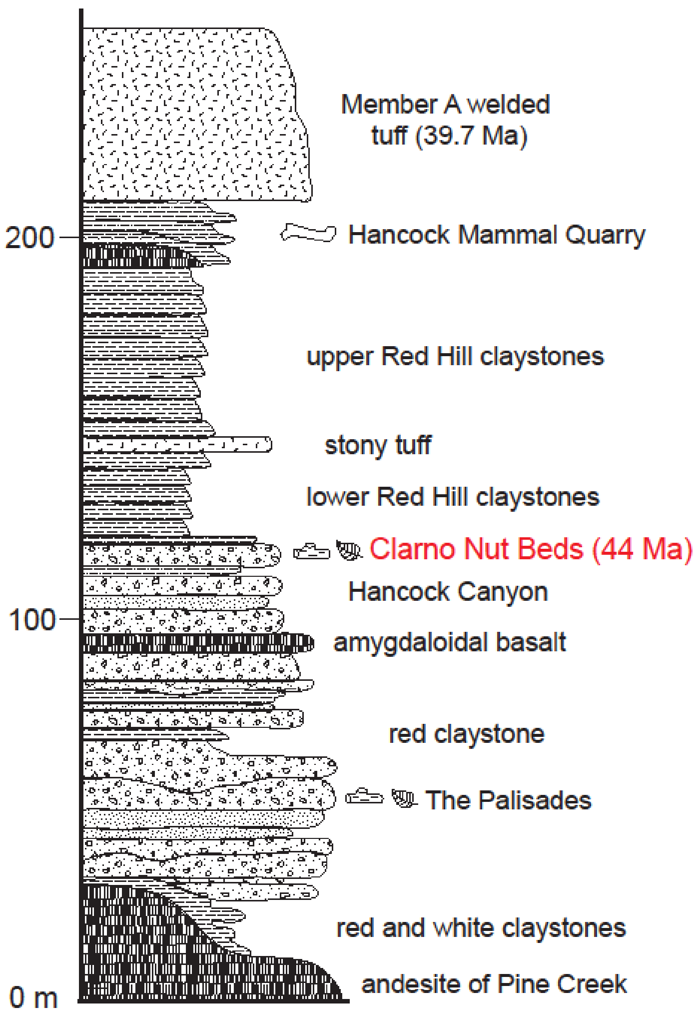


The Hancock Mammal Quarary as it appears today. Note rebar marking grid datum. Below: Lon Hancock (on right) at the quarry, ca early 1950's.

NUBE: The Clarno Nut Beds Assemblage

Major Localities

As is the case with most Clarno localities, the Nut Beds site is unique; there is nothing even vaguely like it anywhere else in the basin that has been described to date. Indeed, the Nut Beds – far more renowned as one of the finest fossil plant localities on the planet, and the most speciose petrified wood site of any age on earth – has an intriguing but rather sparse fauna compared with the other major John Day assemblages. Although comparable depositional environments are not known from Oregon, there are units in the lower Crooked River far south of the type area, that seem to be of the same age but to date have proven to be devoid of vertebrate fossils. The major repositories for specimens from the Nut Beds include the UCMP material, several good fragmentary skull elements housed at the UWBM, and lesser collections at JODA. The likelihood of discovering much more mammalian material is poor, unless major excavations were to be undertaken, as the beds are very well indurated.



Generalized stratigraphic section sandwiching the Clarno Nut Beds in the vicinity.

Notes

The ―Nut Beds‖ strata are about 110 meters upsection from the base of the local Clarno section. The entirety of the Hancock Canyon Unit strata have been generalized as representing a ―debris-flow apron to a braidplain in an area of complex topography, with multiple sources of volcanic sediment‖ (Bestland and others, 1995). The Nut Beds proper can be further subdivided into an upper and lower unit, each with different depositional histories. The lower unit is probably deltaic or floodplain and contains abundant leaves. The upper unit is the vertebrate-bearing massive deposit that may represent a lahar runout, or flood deposits.

John Day Basin – Clarno Nut Beds (NUBE) Faunal List

Taxonomic Classification

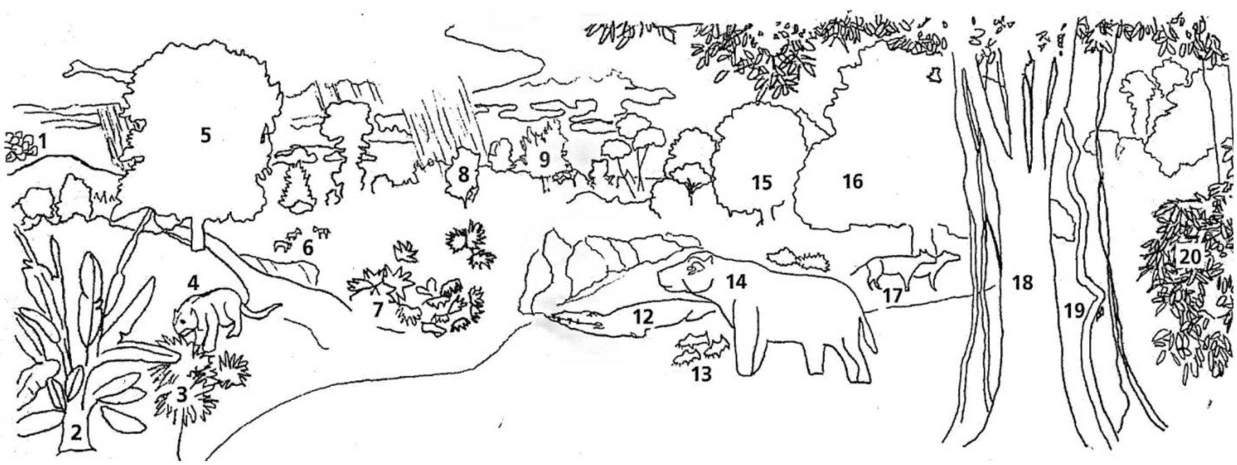
Class Order Family Genus

Actinopterygii
- Amiiformes
  - Amiidae [bowfin]
    - *Amia*

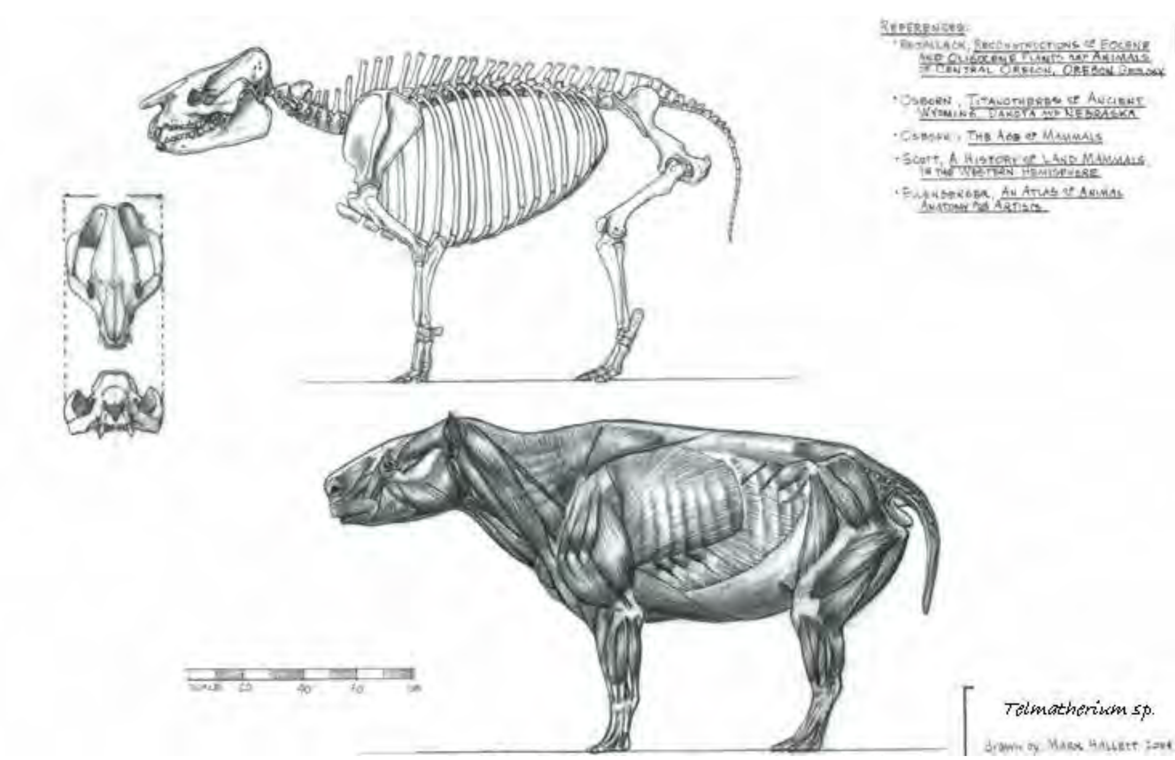
―Reptilia‖
- Crocodilia
  - Crocodylidae [crocodiles]
    - *Pristichampsus*
- Chelonia (Testudines)
  - Chelydridae [snapping turtles]
    - unidentified chelydrid

Mammalia
- Creodonta [creodonts]
  - Oxyaenidae
    - *Patriofelis*
- Perissodactyla
  - Brontotheriidae
    - *Telmatherium*
  - Equidae [horses]
    - *Orohippus*
  - Hyrachyidae
    - *Hyrachyus*

The Clarno Nut Beds as they may have appeared just after the dawn of the deposition of the sequence of John Day deposits. The view is to the NE from what is now the Nut Beds quarry. Note the prominent lahar in the middle left. This mural by Larry Felder has remarkably detailed images of the paratropical forest vegetation, many previously unillustrated. BELOW: Key to images: 1: *Cercidiphyllum*; 2: *Ensete*; 3: *Sabalites*; 4: *Patriofelis*; 5: *Macginicarpa*; 6: *Orohippus*; 7: *Dioon*; 8: *Cornus*; 9: *Juglans*; 10: *Pinus*; 11: *Sabalites*; 12: *Pristichampsus*; 13: cf. *Ictalurus*; 14: *Telmatherium*; 15: *Castanea*; 16: *Magnolia*; 17: *Hyrachyus*; 18: *Laurels*; 19: cicada on vine: *Menisperma; Vitis*; 20: *Meliosma.*



View of the steeply-dipping Nut Beds strata, surmounted by the paleosols of Red Hill. Iron Mountain in the background.
BELOW: A reconstruction of *Telmatherium* sp. from the Nut Beds, a poorly-known taxon, by Mark Hallett.



NOTES

SECTION FOUR: APPENDICES, REFERENCES CITED & BIBLIOGRAPHY

Table of Contents

APPENDIX ONE: COMPLETE ABSTRACTS

Abstract #1

Retallack, G. J., E. A. Bestland, and T. J. Fremd. 2000. **EOCENE AND OLIGOCENE PALEOSOLS OF CENTRAL OREGON**. Geological Society of America Special Paper 344.

Scenic red color-banded claystones of the Clarno and Painted Hills areas of central Oregon are successions of fossil soils that preserve a record of Eocene-Oligocene paleoclimatic change. Conglomerates of the middle Eocene Clarno Formation near Clarno contain largely weakly developed paleosols compatible with an environment of volcanic lahars around a large stratovolcano. Deeply weathered paleosols (Ultisols) around a volcanic dome and overlying these conglomerates indicate a climate that was subtropical (mean annual temperature or MAT 23-25º C) and humid (mean annual precipitation or MAP of 900-2,000 mm). Comparable paleoclimates are indicated by fossil floras from the conglomerates, which show diversity and adaptive features similar to modern vegetation of Volcan San Martin, Mexico.

An erosional disconformity in the Clarno area separated these older beds from less deeply weathered red paleosols (Alfisols) in the middle Eocene upper Clarno Formation. The change in paleosols may represent a decline in both temperature (MAT 19-23º C) and rainfall (MAP 900-1,350 mm), with dry seasons.

Strongly developed lateritic paleosols (Oxisols and Ultisols) in the uppermost Clarno and lowermost John Day Formations in the Painted Hills record return to more humid conditions during the late Eocene. These paleosols are similar to soils of southern Mexico and Central America in climates that are subtropical (MAT 23-25º C) and humid (MAP 900-2,000 mm).

Kaolinitic and iron-rich, red paleosols (Ultisols) of the lower Big Basin Member of the John Day Formation near Clarno and the Painted Hill are erosionally truncated and abruptly overlain by smectitic and tuffaceous paleosols (Inceptisols and Alfisols) of the middle Big Basin Member. This truncation surface can be correlated with the local Eocene-Oligocene boundary. Paleosols of the middle Big Basin Member are most like those of the Central Transmexican Volcanic Belt and indicate an early Oligocene paleoclimate appreciably cooler (MAT 16-18º C) and drier (MAP 600-1,200 mm) than during the late Eocene. Root traces and clay accumulations in the paleosols indicate forest vegetation, also evident from fossil leaves of the lake-margin Bridge Creek flora.

The mid-Oligocene upper Big Basin Member of the John Day Formation includes distinctive brown as well as red paleosols (Alfisols). Its paleosols indicate a paleoclimate drier (MAP 500-700 mm) than before, and more grasses in the forest understory.

Another erosional truncation marks the base of the late Oligocene (early Arikareean), olive-brown lower Turtle Cove Member of the John Day Formation. Calcareous paleosols with near-granular soil structure (Inceptisols and Aridisols) indicate as even drier (MAP 400-600 mm) climate, more open grassy woodland vegetation than previously, and local wooded grassland of seasonally wet bottomlands.

The Clarno-John Day sequence preserves a long-term paleoclimatic record that complements the geological record of global change from deep sea cores and fossil plants. Similarly, it reveals stepwise climatic cooling and drying, with a particularly dramatic climatic deterioration at the Eocene-Oligocene boundary.

Abstract #2

Wheeler, E. A., S. R. Manchester, and M. Wiemann. 2006. **EOCENE WOODS OF CENTRAL OREGON** *PaleoBios* 26(3):1–6.

Eocene terrestrial strata of central Oregon contain abundant and well-preserved fossil woods that are important for understanding past floristic diversity, forest structure, and climate. In addition to the remarkably diverse and well-preserved Middle Eocene wood assemblage of the Clarno Nut Beds in the type area of the Clarno Formation in the John Day basin, there are well-preserved diverse Late Eocene wood assemblages from the vicinity of Post in the Crooked River Basin. The Post assemblages discussed herein share some genera with the Nut Beds fl ora (*Acer, Cercidiphyllum, Quercinium, Ulmus*), but also include some new elements that remain to be described in detail,
including woods referable to the families Anacardiaceae, Fagaceae, Hamamelidaceae, and Juglandaceae. Comparison of the middle Eocene Nut Beds woods to the younger Post woods documents changes in climate, with the Post assemblages indicating increasing seasonality and an increase in deciduousness.

Abstract #3

Hanson, C. B. 1996. **STRATIGRAPHY AND VERTEBRATE FAUNAS OF THE BRIDGERIAN-DUCHESNEAN CLATNO FORMATION, NORTH-CENTRAL OREGON.** *In* Prothero, D. R. and R. J. Emry., eds. The Terrestrial Eocene-Oligocene Transition in North America, pp. 206-236.

Within its type area, the Clarno Formation (Eocene, north-central Oregon) includes Oregon‗s two oldest Tertiary terrestrial mammal localities, numerous fossil plant localities, and many radiometrically dated rock units. Detailed lithostratigraphic mapping has now clarified the complex geologic history and stratigraphic framework which relate these localities and dates to each other and to the geologic record of adjacent areas. Of the five allostratigraphic units recognized within the local Clarno section, the second oldest includes the Nut Beds locality with vertebrates characteristic of the Bridgerian land mammal ―age‖, and the youngest includes the Hancock Quarry locality, the source of a large assemblage of Duchesnean vertebrates. Fossil plants are also preserved in both of these localities and in the middle unit. Those dates which are consistent with the local superpositional sequence also accord with dates on biostratigraphically correlated faunal assemblages elsewhere in North America.

The Nut Beds local fauna, preserved with a lacustrine delta complex, includes species of *Patriofelis, Orohippus, Hyachyus*, and *Telmatherium* which indicate a late Bridgerian North American Land Mammal ―Age‖ (NALMA). This accords with an $^{40}Ar/^{39}Ar$ date of 48.32 Ma, but not with other dates near 44 Ma. A remarkably diverse floral record documents a paratropical to tropical rain forest environment, but, at about 14 million years older than the presently recognized Eocene/Oligocene boundary, it provides little evidence bearing on the rate of climatic cooling near the end of the Eocene.

Hancock Quarry has yielded more than 2000 specimens of large mammals. The fossil-bearing strata lie about 5 to 10 m concordantly below a widespread ignimbrite at the base of member A of the John Day Formation. A recently published $^{40}Ar/^{39}Ar$ date of 39.2 Ma on the ignimbrite is probably more accurate than older K-Ar and fission track dates near 37 Ma. The assemblage represents 14 vertebrate taxa (11 of mammals) consistent with assignment to the Duchesnean NALMA. Two genera (*Epihippus* and *Diplobunops*) are late records of North American lineages. Many of the rest of the mammals appear related to subcoastal Asian taxa (*Procadurcodon* is known only from Hancock Quarry and eastern Asia), and some taxa (*Hemipsalodon*, Nimravidae, *Haplohippus, Protitanops, Teletaceras*, and *Heptacodon*) also appear in Duchesnean or later North American localities. *Protapirus* occurs in Uintan through Whitneyan North American localities and in the late Eocene of Asia and Europe.

Abstract #4

Lander, E. B. and C. B. Hanson. 2006. ***AGRIOCHOERUS MATTHEWI CRASSUS* (ARTIODACTYLA, AGRIOCHOERIDAE) OF THE LATE MIDDLE EOCENE HANCOCK MAMMAL QUARRY LOCAL FAUNA, CLARNO FORMATION, JOHN DAY BASIN, NORTH-CENTRAL OREGON.** PaleoBios 26(3):19–34.

The Hancock Mammal Quarry (HMQ) Local Fauna (LF) is from the uppermost part (Unit E) of the Clarno Formation at the HMQ in the John Day Basin of north-central Oregon. The agriochoerid in the HMQ LF, previously assigned to *Diplobunops* by most workers, now is assigned to the comparatively large agriochoerine *Agriochoerus matthewi crassus*. The latter taxon is based on the record in the Randlett LF from the lower part of the Duchesnean North American Land Mammal Age (NALMA) stratotype in northeastern Utah. The Randlett LF, considered late Uintan in age by most workers, also includes the brontotheriid *Duchesneodus*, presumably the Duchesnean index taxon *D. uintensis*. *Agriochoerus m. crassus* and *D. uintensis* also occur in the early Duchesnean Skyline LF of western Texas, but not in the late Uintan Myton LF from the upper part of the Uintan NALMA stratotype, which underlies the Duchesnean stratotype, nor in any other assemblage of undisputed Uintan age. Moreover, *A. m. crassus* does not occur in any assemblage younger than the Skyline LF or the early Duchesnean NALMA. Based on its P2-M3 length, *A. m. crassus* is approximately 10 to 15% larger than *A. m. matthewi*, which occurs in the Myton LF and in the correlative Lower Badwater LF at localities 5 and 6 in west-central Wyoming. For these reasons, the Randlett LF is removed from the Uintan NALMA and reassigned to the early Duchesnean, where it was placed originally. Correspondingly, the Uintan-Duchesnean NALMA boundary in the Uinta Basin is relocated stratigraphically downward, from a level above the Randlett LF and back to its original position between this local fauna and the underlying Myton LF. The other occurrences of *A. m. crassus* indicate that the HMQ LF also is early Duchesnean, rather than late Uintan, in age.

The earliest interval of comparatively large body size in Agriochoerus is characterized by *A. m. crassus*. Radiometric data from the John Day Basin indicate that the HMQ LF is between 40.0 million and 40.4 million years (Ma) and late middle Eocene in age, and that the Uintan-Duchesnean NALMA boundary is older than 40.0 Ma.

Abstract #5

Lucas, S. G. 2006. **A NEW AMYNODONTID (MAMMALIA, PERISSODACTYLA) FROM THE EOCENE CLARNO FORMATION, OREGON, AND ITS BIOCHRONOLOGICAL SIGNIFICANCE.** PaleoBios 26(2):7–20.

Zaisanamynodon protheroi is a new species of large metamynodontinine amynodontid rhinoceros from the Eocene (late Uintan) Hancock quarry local fauna of the Clarno Formation, Oregon, represented by cranial, dental, and postcranial material. Previously, the Hancock amynodont was referred to *Procadurcodon*, but that genus and its type species are nomina dubia, so specimens from the Hancock quarry, and some of the specimens from Russia previously assigned to *Procadurcodon*, are reassigned to the valid genus *Zaisanamynodon*. *Z. protheroi* is distinguished from *Z. borisovi*, the type and only other species of *Zaisanamynodon*, by the following characteristics: relatively long rostrum, anterior margin of orbit above M2, P2 more complex with anterior and posterior crests connected to metaloph, P2-4 have complete lingual cingula, incisors relatively small (especially I3/i3), lower canine relatively massive and straight, less molariform p3 and no labial groove on lower molars. Asian records of *Zaisanamynodon borisovi* are of Ergilian age, and the record of *Z. protheroi* in the Hancock quarry suggests it is late Uintan in age, which is older than Ergilian and equivalent to part of the Sharamurunian. This suggests that the specimen of *Z. protheroi* from Artyom in eastern Russia is of Sharamurunian age.

Abstract #6

Mihlbachler, M. C. 2007. **EUBRONTOTHERIUM CLARNOENSIS, A NEW GENUS AND SPECIES OF BRONTOTHERE (BRONTOTHERIIDAE, PERISSODACTYLA) FROM THE HANCOCK QUARRY, CLARNO FORMATION, WHEELER COUNTY, OREGON.** PaleoBios 27(1):19–39.

I describe here a new genus and species of brontothere, *Eubrontotherium clarnoensis*, based on two skulls, a mandible, and several other cranial and mandibular fragments recovered from the Hancock Quarry, Clarno Formation, Wheeler County, Oregon. *Eubrontotherium clarnoensis* is a member of a group of relatively advanced Asian and North American middle and late Eocene horned brontotheres, informally referred to as ―eubrontotheres‖, that are characterized by small globular upper incisors. Phylogenetic analysis of the Brontotheriidae produces a clade similar to the original eubrontothere concept. This clade is given formal status as the infratribe Brontotheriita. In addition to Eubrontotherium clarnoensis, Brontotheriita includes the North American species *Notiotitanops mississippiensis*, *Protitanops curryi*, *Duchesneodus uintensis*, *Megacerops coloradensis*, and *Megacerops kuwagatarhinus*. The Asian species *Parabrontops gobiensis* and *Dianotitan lunanensis* also nest within this clade. Based on the possible latest Uintan age of the Hancock Quarry fauna, *Eubrontotherium clarnoensis* is among the earliest known occurrences of Brontotheriita. The phylogeny of the Brontotheriita is incongruous with age assignments based on land mammal ―age‖ biostratigraphy, thus implying one or more middle to late Eocene ghost lineages.

Abstract #7

Lucas, S. G., S. E. Foss, and M. C. Mihlbachler. 2004. ***ACHAENODON* (MAMMALIA, ARTIODACTYLA) FROM THE EOCENE CLARNO FORMATION, OREGON, AND THE AGE OF THE HANCOCK QUARRY LOCAL FAUNA.** *In* Lucas, S. G., Zeigler, K. E. and Kondrashov, P. E., eds. Paleogene Mammals. New Mexico Museum of Natural History and Science Bulletin No. 26, pp. 89-96.

The artiodactyl family Achaenodontidae, represented by the new species *Achaenodon fremdi*, can be added to the fossil mammal assemblage of the Eocene Hancock mammal quarry local fauna of the Clarno Formation in north-central Oregon. Radioisotopic dates from the base of the John Day Formation directly above the Hancock quarry indicate it is older than 39.5-40 Ma. A review of the fossil mammal assemblage from the Hancock quarry indicates it is essentially a mixture of North American endemic taxa (*Protapirus, Epihippus, Diplobunops, Achaenodon*) of Uintan age, and Asian immigrant taxa (*Hemipsalodon, Teletaceras, Heptacodon*) that do not appear elsewhere in North America until the Duchesnean. A late Uintan age for the Hancock quarry local fauna best fits the

radioisotopic and mammalian biochronologic data.

Abstract #8

Hanson, D. A. and T. J. Fremd. 2001. **A JOHN DAY STEPCHILD—THE SOUTHERN BASIN FAUNAL ASSEMBLAGES.** PaleoBios 21(2 (supp.)): 62.

Two major vertebrate fossil assemblages occur in the Camp Creek area (near Logan Butte, Oregon), separated by the "Picture Gorge Ignimbrite" of the John Day Formation. Long characterized as faunally identical to the well-known eastern basin assemblages, recent stratigraphically analyzed collections have revealed a similar, but significantly different fauna. The lower assemblage is characterized by agriochoerids (32% of identified specimens), tragulids (24%), oreodonts (8%), equids (6%), and numerous species of canids (4%) and nimravids (2%). It also produced the only known examples of the marsupial *Herpetotherium merriami*, the ursoid *Parictis primaevus*, the enigmatic *Allocyon loganensis*, and small nimravids. The Turtle Cove fauna, in contrast, consists of 35% tragulids, 25% oreodonts, and 6% rhinocerotids, with agriochoeres representing less than 2% of the faunas. Notable by their absence are the diminutive nimravids and *Allocyon*. The upper assemblage at Camp Creek is characterized by several families of rodents, making up 59% of identified specimens, the exclusive occurrence of the large oreodont *Merycochoerus*, and a near absence of other artiodactyls. The observed disparities between the lower assemblage and the Turtle Cove fauna, previously thought to be temporal, are probably due to local paleoenvironmental factors including proximity to flowing water and elevational effects. Sedimentological evidence supports this conjecture. The southern basin is characterized by numerous channel deposits, almost absent from the eastern basin. These channel deposits range from clayey to sandy lithologies, and are typically incised one to three meters into the underlying sediments. Newly sampled tuffs from the southern basin, correlated with those from Turtle Cove, allow us to confirm that these are, in fact, isochronous assemblages, providing an unusual opportunity to compare temporally equivalent but ecologically different associations.

Abstract #9

Manchester, S. R. and W. C. McIntosh. 2007. **LATE EOCENE SILICIFIED FRUITS AND SEEDS FROM THE JOHN DAY FORMATION NEAR POST, OREGON.** PaleoBios 27(1):7–17.

Silicified fruits and seeds occur in Eocene tuffs in the lower part of the John Day Formation near Post, Oregon. A prominent white tuff immediately overlying the fruit and seed deposit contains sanidine crystals that were used for $_{40}$Ar/$_{39}$Ar radioisotopic dating by the single crystal laser fusion method. The resulting date of 36.21 ± 0.26 Ma (n = 26), provides a good estimate of the actual age of permineralized woods found within the tuff, and a minimum age for the subjacent strata containing fruits, seeds, woods and gastropods. The fruit and seed assemblage includes several genera shared with the middle Eocene Clarno Nut Beds locality (*Diploporus, Sabal, Magnolia, Ampelopsis, Vitis, Alangium, Mastixicarpum, Coryloides, Quercus, Pileospermum, Bursericarpum, Cedrela, Aphananthe, Sabia, Meliosma, Platanus*) indicating their persistence in this region to at least the late Eocene. Additional genera of the Post flora that have not been recorded in the middle Eocene Clarno Nut Beds include *Davidia, Carya*, cf. *Asterocarpinus, Fagus, and Zanthoxylum*. The new radiometric date and new taxonomic identifications improve resolution of the floristic changes that occurred from the middle to late Eocene of this region.

Abstract #10

Albright, L. B. III, M. O., Woodburne, T. J. Fremd, C. C. III Swisher, B. J. MacFadden, and G. R. Scott. 2008. **REVISED CHRONOSTRATIGRAPHY AND BIOSTRATIGRAPHY OF THE JOHN DAY FORMATION (TURTLE COVE AND KIMBERLY MEMBERS), OREGON, WITH IMPLICATIONS FOR UPDATED CALIBRATION OF THE ARIKAREEAN NORTH AMERICAN LAND MAMMAL AGE.** The Journal of Geology, volume 116, p. 211–237.

Although the Arikareean North American land mammal age was first typified in the Great Plains, the succession there contains significant unconformities, a generally poor magnetic record, relatively sparse radioisotopic calibration, and a major faunal hiatus. In the John Day Valley of central Oregon, however, is a thick, remarkably complete sequence of Oligocene through early Miocene strata (the John Day Formation) potentially amenable to addressing these shortcomings and long known to harbor one of the richest records of mid-Tertiary mammals in North America. Since Prothero and Rensberger‘s first magnetostratigraphic study of the John Day Formation in 1985, new advances in geochronology, together with a more comprehensive suite of paleomagnetic sections keyed to new radioisotopic and biostratigraphic data, have greatly enhanced chronostratigraphic precision. In our attempt to refine John Day chronostratigraphy, we sampled nearly 300 sites for magnetostratigraphy over a 500-m-thick interval and used several radioisotopically dated volcanic tuffs for our correlation with the geomagnetic polarity timescale. Many of the rocks analyzed showed unusual magnetic behavior, possibly due to the known zeolitization in this region, thereby precluding an abundance of class 1 polarity determinations. Nevertheless, preliminary results indicate that the Turtle Cove Member stratigraphically upward through the lower Kimberly Member extends from late chron C12n through C7n.1r, or from about 30.6 to 24.1 Ma. Intensive radioisotopic and magnetostratigraphic characterization of these strata provides a framework by which the associated biostratigraphy is assessed for biochronological significance relative to fossiliferous successions of the Great Plains, in turn resulting in reassessment of Arikareean subbiochron (Ar1–Ar4) boundaries. We present a revision of those boundaries that differs from their traditional timing as a hypothesis for testing in other locations.

Abstract #11

Smith, M. E., T. J. Fremd, and R. C Wood. 2001. **DISCOVERY OF A CRANIUM OF STYLEMYS (REPTILIA: CHELONIA) FROM THE TURTLE COVE MEMBER OF THE JOHN DAY FORMATION, CENTRAL OREGON.** PaleoBios 21(2 (supp.)): 117-118.

Although turtle remains are distributed throughout much of the 45 million year sequence represented by the deposits within the John Day Basin, almost all specimens in existing collections are represented only by shell material or limb elements. Particularly vexing is the lack of association of any diagnostic skull material with these typically low-arched carapaces. Previously, *Stylemys* from the John Day Formation has been described based solely on shell morphology due to a lack of cranial elements.

Here, we report the discovery of a nearly complete cranium of a tortoise referable to *Stylemys* (Leidy, 1851) *in situ* with several carapace fragments. This is the first reported occurrence of any chelonian skull material associated with postcranial elements from the John Day Formation. The stratigraphic position can be pinpointed with precision within the K1 unit of the Turtle Cove

Member, approximately 8m above the Deep Creek Tuff recently dated to 27.5 ma. Little has been published on fossil turtles from the Northwest since the work of Hay and Gilmore's work in the early 1900s. The presence of additional material within a definable pedofacies suggests a unique opportunity to provide additional paleoecologic information, as well as population and taphonomic data, about the occurrences of these relatively abundant but rather poorly understood tortoises.

Abstract #12

Hopkins, S. S. B. 2006. **MORPHOLOGY OF THE SKULL IN *MENISCOMYS* FROM THE JOHN DAY FORMATION OF CENTRAL OREGON.** PaleoBios 26(1):1–9.

Aplodontoid rodents are very diverse through the Oligocene and Miocene in North America. They are represented in the fossil record by a number of morphologically distinct lineages, many of which are represented in the John Day Formation of central Oregon. Although the diversity of dental morphologies in this lineage is well understood, skull morphology is well-described for only the mylagaulid and aplodontine lineages of aplodontoids. Less well-preserved skulls have also been described from the basal paraphyletic group of prosciurines and for the allomyines lineage. This
paper describes the morphology of the skull in *Meniscomys*, a taxon that lies at the transition between Paleogene and Neogene groups of aplodontoids. These groups are quite distinct in dental and cranial morphology and inferred ecology. Examination of the skull of *Meniscomys* shows that it retains a number of plesiomorphic characters, but shows some evidence of the shortening, broadening, and flattening that characterizes Neogene aplodontoids.

Abstract #13

Bryant, H. N. and T. J. Fremd. 2001. **THE EVOLUTIONARY HISTORY OF THE NIMRAVIDAE (CARNIVORA) IN THE JOHN DAY BASIN OF OREGON.** PaleoBios 21(2 (supp.)): 35-36.

The Nimravidae is an extinct clade of cat-like carnivorans of late Eocene to late Miocene age. The John Day Basin plays a pivotal role in our understanding of nimravid evolution because the latter stages of the initial North American radiation of this clade are best preserved in its early Arikareean depositional sequence. Six of eleven North American nimravinae species recognized in a recent systematic review are known from the John Day (*Hoplophoneus primaevus, Eusmilus cerebralis, Pogonodon platycopis, Nimravus brachyops, Dinictis cyclops, Dinaelurus crassus*); the latter two species are known only from this area. Although the sources of early collections from the John Day, including the type specimens of five of the above species, are poorly documented, stratigraphically controlled collecting since the mid 1980s, together with the dating of tuffs, has provided a much improved biostratigraphic and temporal framework for interpreting nimravid evolution.

The John Day sequence documents the last five million years of nimravine history (30-25 Mya), and provides an opportunity to follow evolutionary trends and extinction events in this clade within a limited geographic area. Nimravid diversity is high in the earliest portion of the early Arikareean (below the Picture Gorge Ignimbrite; >28.7 Mya); at least the first four species in the above list are present. Later in the early Arikareean, species diversity drops considerably (leaving only the *Pogonodon* lineage, for which there is good stratigraphic control, and possibly *Dinictis cyclops* and *Dinaelurus crassus*). With the improved temporal resolution in the John Day sequence, the involvement of possible causal factors, such as climatic and environmental change and competitive exclusion, in the extinction of the nimravine clade can begin to be assessed. Continued collecting will lead to further refinement in the timing of evolutionary events, and an increasing ability to address these issues in a rigorous fashion.

Abstract #14

Foss, S. E. and T. J. Fremd. 2001. **BIOSTRATIGRAPHY OF THE ENTELODONTIDAE (MAMMALIA: ARTIODACTYLA) FROM THE JOHN DAY BASIN, OREGON.** PaleoBios 21(2 (supp.)): 53.

The temporally continuous units of the John Day Formation form an ideal basis for biostratigraphic investigations. Entelodont fossils have been discovered in all four currently recognized members of the John Day Formation (Big Basin, Turtle Cove, Kimberly, and Haystack Valley). Datable tuffs are present in all four members. The Turtle Cove and Kimberly members are further subdivided into thirteen recognizable subunits (units A-M), each of which contain at least one, but usually numerous, datable primary ash-fall tuff layers.

At least three valid species of entelodonts (*Archaeotherium caninus, A. calkinsi, Daeodon shoshonensis*) have been recovered from the John Day Formation that can be correlated to these subunits, and which, therefore, may be dated with accuracy. Unlike other depositional regions of North America, the temporal record of entelodonts is relatively complete in the John Day. It is possible that there were multiple faunal exchange events between Asia and North America, and that the John Day species represent a continuous record of entelodont habitation in North America from at least the early Oligocene until the earliest Hemingfordian. The biostratigraphic framework established in the John Day allows the direct correlation of entelodont taxa across North America and allows a more complete calibration of entelodont evolution and biogeography world-wide.

Abstract #15

Lander, E. B. and T. J. Fremd. 2001. **LATE WHITNEYAN, ARIKAREEAN, AND EARLIEST HEMINGFORDIAN OREODONTS (MAMMALIA: ARTIODACTYLA: AGRIOCHOERIDAE AND OREODONTIDAE) FROM THE JOHN DAY FORMATION OF CENTRAL OREGON.** PaleoBios 21(2 (supp.)): 82.

Based on the shared occurrences of age-diagnostic agriochoerid and oreodontid species and subspecies, stratigraphically superposed land mammal assemblages in the John Day Formation (JDF) can be correlated with taxonomically similar land mammal assemblages in the upper White River, the Arikaree, and the lower Hemingford Groups (WRG, AG, HG, respectively) in the central Great Plains (CGP). Late Whitneyan assemblages in the lower Turtle Cove Member of the JDF are dominated by *Agriochoerus antiquus guyotianus* and *Eporeodon occidentalis occidentalis,* which also occur in Whitney B/C intervals and/or in the *Leptauchenia* beds of the Brule Formation of the WRG, and by the endemic *Eucrotaphus trigonocephalus*.

Earliest Arikareean assemblages of the JDF are dominated by *E. occidentalis major* and also contain *Oreodontoides oregonensis, A. a. guyotianus*, and *E. trigonocephalus*. With the exception of *E. trigonocephalus*, these taxa also occur in the Brown Siltstone member of the Brule Formation and/or in the Gering and Sharps Formations of the AG. Late early Arikareean assemblages, which occur above the Deep Creek Tuff in the JDF, are dominated by *Merycochoerus superbus* and also contain *E. o. major, O. oregonensis,* and *Merycoides pariogonus*, all of which also occur in the upper Gering and Sharps Formations and in the Monroe Creek Formation of the AG.

Assemblages of presumed early late Arikareean age in the JDF contain *Merycochoerus chelydra chelydra,* which also occurs in the Harrison Formation of the AG. Latest Arikareean assemblages of the JDF are dominated by the endemic *Paroreodon parvus* and contain *Hypsiops breviceps*, which also occurs in the upper Harrison Formation and probably the Upper Harrison Beds of the AG.

Earliest Hemingfordian assemblages in the Haystack Valley Member of the JDF contain *Merycochoerus matthewi, Merychyus elegans arenarum,* and possibly *Merycoides longiceps*, which also occur in the lower Runningwater Formation and the Upper Rosebud Beds of the HG.

Abstract #16

Prothero, D. R. 2009. **THE EARLY EVOLUTION OF THE NORTH AMERICAN PECCARIES (ARTIODACTYLA: TAYASSUIDAE).** *in* Albright, L. B. III, ed. Papers on Geology, Vertebrate Paleontology, and Biostratigraphy in Honor of Michael O. Woodburne. Museum of Northern Arizona Bulletin 65, pp. 509-541.

The understanding of the systematics of the earliest peccaries in North America has long been hampered by poor and relatively scarce material, but new collections help redefine the species and genera, and add greatly to our knowledge of their anatomy and temporal range. The genera *Perchoerus* and *Thinohyus* were confused due to their poor type specimens, but comparison with topotypic specimens of White River Whitneyan *Perchoerus probus* and John Day *Thinohyus lentus* shows that the two genera can easily be distinguished. Even though there are only slight differences in the size and proportions of teeth, the skulls of *Thinohyus* are much more robust, dolichocephalic, with weaker sagittal crests than seen in *Perchoerus*. *Thinohyus* has a large posterior cingulum on M3 with a postero-internal cusp, and diastemata between the canines and first premolars, and sometimes between the first and second premolars. The earliest species of *Perchoerus* is the tiny Chadronian taxon *P. minor*, the smallest peccary yet known, which marks the immigration of peccaries from Asia in the early Chadronian (at least 36 Ma). It is previously known only from a lower jaw, but its skull and upper teeth are described based on new material. Slightly larger is the rare Orellan taxon *P. nanus*, also originally known only from a lower jaw, but here redescribed based on new skull material. Most known *Perchoerus* fossils are of the largest species, the Whitneyan taxon *P. porbus*, although at no time are *Perchoerus* fossils as common as those of most other White River mammals. By the late Whitneyan, the much more robust and dolichocephalic taxon *Thinohyus* appeared in the John Day region of Oregon. Only two valid species are recognized: *T. lentus* (including *T. osmonti*, and possibly *T. pristinus*) and the disjunctly larger and more robust *T. rostratus*. The John Day taxa ―*Chaenohyus decedens," "Thinohyus trichaenus,"* and *"T. subaequans"* are here referred to *Perchoerus probus*.

Abstract #17

Fremd, T. J. and D. P. Whistler. 2009: **PRELIMINARY DESCRIPTION OF A NEW MICROVERTEBRATE ASSEMBLAGE FROM THE ARIKAREEAN (EARLY MIOCENE) JOHN DAY FORMATION, CENTRAL OREGON,** *in* Albright, L. B. III, ed. Papers on Geology, Vertebrate Paleontology, and Biostratigraphy in Honor of Michael O. Woodburne. Museum of Northern Arizona Bulletin 65, pp. 159-170.

Productive wet-screen-sieved microvertebrate sites are notably rare from nearly all of the middle Eocene through late Miocene strata within the John Day Basin. However, recent work from atypical exposures of the late Arikareean ―Kimberly Member‖ of the John Day Formation north of the classic localities has yielded a new assemblage consisting of thousands of specimens. Preliminary analysis suggests that several represented lineages have stronger Asiatic affinities than previously considered. Notable additions to the John Day fauna include a new protosciurine, a new last appearance datum for the didelphid *Copedelphys*, new species of *Proscalops* and *Leptodontomys,* and possibly the first North American record of *Apeomys*. The quarry samples exceed previously described numbers of *Herpetotherium*, *Proscalops* and other erinaceoids, and include new records of *Petauristodon*, *Campestrallomys*, *Plesiosminthus*, *Leptodontomys*, and *Wilsonsorex*. These additions are a result of isochronous depositional variability within the geographic extent of the sequence and a disproportionate number of presumed fossorial inhabitants preserved in a non-zeolitized matrix that permits disaggregation and recovery.

Abstract #18

Hunt, R. M. Jr. and E. Stepleton. 2004. **GEOLOGY AND PALEONTOLOGY OF THE UPPER JOHN DAY BEDS, JOHN DAY RIVER VALLEY, OREGON: LITHOSTRATIGRAPHIC AND BIOCHRONOLOGIC REVISION IN THE HAYSTACK VALLEY AND KIMBERLY AREAS (KIMBERLY AND MT. MISERY QUADRANGLES).** Bulletin of the American Museum of Natural History No. 282, 90 pp.

The John Day Formation of north-central Oregon preserves a succession of speciose, superposed Oligocene through early Miocene mammalian faunas that establish the sequence of mid-Cenozoic mammalian evolution within the Pacific Northwest. Upper John Day rock units initially described by Merriam (1900, 1901) in the Kimberly and Haystack Valley areas were later divided into lower (Kimberly) and upper (Haystack Valley) members by Fisher and Rensberger (1972). We focused our study on the lithostratigraphic succession within the Haystack Valley Member. Rocks previously included in the Haystack Valley Member can be subdivided into four unconformity-bounded, genetic lithostratigraphic units that range in age from ~24 to ~18 Ma, three of the units incorporating age-diagnostic mammalian faunas.

We have identified two principal depositional units within the Haystack Valley Member of Fisher and Rensberger south of Kimberly: (1) Johnson Canyon Member – late or latest Arikareean tuffaceous siltstones and fine sandstones (~?19-22.6 Ma) with fluvial monomictic intraformational pebble gravels, well exposed along the west wall of the John Day Valley; (2) Rose Creek Member – coarse polymictic welded tuff-bearing gravels, debris flows, coarse obsidian-shard tuffs, and fine-grained tuffaceous units, yielding early Hemingfordian mammals (~18.2-18.8 Ma), deposited in angular unconformity on lower units of the John Day Formation along the east wall of the John Day Valley.

At Balm Creek in the type areas of the Haystack Valley Member, the southern limb of the Balm Creek syncline exhibits the most complete local section of the upper John Day rocks, here comprising three members: (1) a revised Haystack Valley Member made up of early late Arikareean ribbed tuffs (~23.5-23.8 Ma) with monomictic welded tuff conglomerate channels, overlain by a gray massive airfall marker tuff (GMAT); (2) Balm Creek Member – tuffaceous late Arikareean siltstones and fine sandstones interbedded with lacustrine tuffs, overlain by stacked fluvial fining-upward sequences and gray airfall tuffs; (3) Rose Creek Member – coarse polymictic welded tuff-bearing gravels, debris flows, lacustrine units, and fine-grained tuffaceous sediments, believed to correlate to the fossiliferous early Hemingfordian unit south of Kimberly.

The complexity of upper John Day rocks (evidenced by marked lithofacies variation within multiple unconformity-bounded subunits, punctuated by numerous paleosols) suggests an early Miocene

depositional regime with more varied local environments and pronounced episodic sedimentation relative to the more uniform Oligocene environments documented by lower John Day strata. Whereas the lower John Day Formation consists of fine-grained volcaniclastic sediments that were deposited in basins with minimal topographic relief, the upper John Day Formation is characterized by a succession of increasingly coarse fluvial channel fills, as well as massive airfall and coarse-shard tuffs, well-developed paleosols, and relict topography. Regional compression appears to have triggered fluvial incision and valley filling from ~24 Ma to at least ~19 Ma. Extension in latest John Day times resulted in the development of half-grabens or grabens both in Haystack Valley and south of Kimberly, ensuring the preservation of upper John Day sediments. Significantly, a final episode of normal faulting appears to have immediately preceded the earliest eruption of Picture Gorge Basalt, as evidenced by flows of the Twickenham Member (PGBS) abutting against vertical fault scarps south of Kimberly. The faunas of the upper John Day units thus play a critical role in dating a complex sequence of tectonic events which preceded the onset of Columbia River Basalt Group flooding in the early Miocene.

Abstract #19
Hunt, R. M. Jr. and E. Stepleton. 2006. **BIOCHRONOLOGIC AND LITHOSTRATIGRAPHIC REAPPRAISAL OF THE UPPER JOHN DAY FORMATION, NORTH-CENTRAL OREGON.** PaleoBios 26(2):21–25.

The circumstances leading to a revised stratigraphy of the upper John Day Formation (latest Oligocene–early Miocene) are described. Fluvial channel deposits, previously believed to indicate synchronous deposition of coarse gravels, and thus employed in regional correlation of upper John Day rocks, were found to contain mammal faunas of disparate ages, to differ signifi cantly in terms of clast composition and clast size, and to be associated with distinctive suites of tuffaceous sediments. A revised Haystack Valley Member is radioisotopically dated at ~23.8 Ma and bears an early late Arikareean fauna. The Rose Creek Member, angularly unconformable above rocks of the Haystack Valley Member and other John Day units, yields an early Hemingfordian assemblage (~18.2 –18.8 Ma) that is the youngest fauna recognized in the eastern facies of the John Day Formation.

Abstract #20
Kohn, M. J. and T. J. Fremd. 2008: **MIOCENE TECTONICS AND CLIMATE FORCING OF BIODIVERSITY, WESTERN UNITED STATES.** Geology, October 2008: v. 36; no. 10; p. 783–786.

Ungulate and carnivore diversity patterns since 30 Ma in different regions of the western United States suggest abrupt increased diversification at 17–17.5 Ma, followed by decreases ca. 11 Ma, and stasis thereafter. Although global climate change presumably affects evolution, we hypothesize that widespread extensional tectonism in the western U.S. also helped drive diversity increases ca. 17.5 Ma through a topographically induced increase in fl oral and habitat diversity. The decreases in diversities ca. 11 Ma, as well as the rapid increase in C4 ecosystems (RICE)worldwide at 7–8 Ma may have responded to climate teleconnections and increased seasonality linked to global cooling and growth of orogenic plateaus, particularly the Tibetan Plateau between 13 and 8 Ma. Thus, biodiversity complexly responds both to climate and to tectonics.

Abstract #21

Retallack, G. J., J. G. Wynn, and T. J. Fremd. 2004. **GLACIAL-INTERGLACIAL–SCALE PALEOCLIMATIC CHANGE WITHOUT LARGE ICE SHEETS IN THE OLIGOCENE OF CENTRAL OREGON.** Geology, v. 32; no. 4; p. 297–300.

Abundant late Oligocene paleosols in eastern Oregon compose a paleoclimatic archive rivaling the resolution of deep-sea cores, recording 105 Milankovitch-scale cycles over the
5.1 m.y. duration of the middle John Day Formation. Paleoclimatic cycles are apparent from the fossil record of snails, mammals, trace fossils, soil structure, depth to calcic horizon of paleosols, and carbon and oxygen isotopic composition of pedogenic carbonate. Interpreted Oligocene alternation between semiarid sagebrush steppe and subhumid wooded grassland has the same amplitude as that inferred during accumulation of the Quaternary Palouse Loess in Washington and Oregon. This similar amplitude is surprising because large ice caps like those of the Quaternary did not extend across North America
or Europe during the Oligocene. Thus ice-albedo amplification of Milankovitch-scale insolation variation cannot explain the similar magnitude of Oligocene paleoclimatic fluctuation.
Weak orbital signals were more likely amplified by greenhouse gases such as CO_2 and CH_4 due to changing carbon budgets in the sea and on land.

Abstract #22

Kohn, M. J., J. L. Miselis, and T. J. Fremd 2002: **OXYGEN ISOTOPE EVIDENCE FOR PROGRESSIVE UPLIFT OF THE CASCADE RANGE, OREGON.** Earth and Planetary Science Letters 204 (2002) 151-165.

Oxygen isotope compositions of fossil equid teeth in the Cascade rainshadow reveal a ~5% decrease in mean N18O since 27 Ma. Isotopic changes are inconsistent with expected effects from global climate change because: (a) the expected isotopic shift to tooth N18O values due to global climate change (~1%) is much smaller than the observed shift, (b) predicted and observed isotopic trends are opposite for Oligocene vs. Miocene samples, and (c) average compositions and ranges in compositions remained unchanged for samples from before and after major global cooling in the mid-Miocene. Accounting for a decrease in relative humidity of at least 15%, we infer a topographically driven secular shift in the N18O value of rainwater of 6-8% since the late Oligocene, which is approximately equivalent to the modern-day difference in N18O values of precipitation and surface waters across the central Cascades. Rise of the central Cascades apparently occurred monotonically over the last 27 Ma, with a hiatus between ~15.4 and 7.2 Ma, possibly related to eruption of the Columbia River Basalts. Progressive volcanic accumulation over tens of millions of years best explains the data, rather than a short-lived uplift event. Paleoseasonality, as inferred from isotope zoning and intertooth variability, decreased dramatically from 7-9% at 15.4 -7 Ma to ~3% at 3 Ma, then increased to 6-8% today. The cause of the decrease in seasonality at 3 Ma may reflect either brief warming during the mid-Pliocene within the context of global tectonic reorganization, or consumption by equids of water from an isotopically buffered Lake Idaho.

Abstract #23

Retallack, G. J. 2004. **LATE MIOCENE CLIMATE AND LIFE ON LAND IN OREGON WITHIN A CONTEXT OF NEOGENE GLOBAL CHANGE.** Palaeogeography, Palaeoclimatology, Palaeoecology 214 (2004) 97– 123.

Clarendonian (12 Ma) fossil soils, plants, molluscs, fish, and mammals of eastern Oregon allow reconstruction of late Miocene paleogeography, paleoclimate, and paleoecology on land between the global thermal maximum of the middle Miocene (16 Ma) and global cooling and drying of the late Miocene (7 Ma). Six different pedotypes of paleosols recognized near Unity and Juntura allow reinterpretation of local mammalian paleoecology. Fossil beavers dominated gleyed Entisols of riparian forest. Abundant camels and common hipparionine horses dominated Alfisols of wooded grassland and grassy woodland. Diatomites overlying mammal-bearing beds have bullhead catfish [*Ictalurus (Ameiurus) vespertinus*], as well as fossil leaves dominated by live oak (*Quercus pollardiana*). Fossil plants and soils of Unity and Juntura are most like those of grassy live oak woodland and savanna on the western slopes of the Sierra Nevada in northern California today. Fossil plants and soils indicate mean annual temperature of 12.9 (7.7–17.7) 8C and mean annual precipitation of 879 (604–1098) mm. Miocene paleoclimatic changes in eastern Oregon show no relationship to changes in oxygen isotopic composition of marine foraminifera, usually taken as an index of global paleoclimatic change. Mismatch between land and sea paleoclimatic records is most likely an artefact of global ice volume perturbation of oxygen isotopic values. Instead, Miocene paleoclimatic change in eastern Oregon parallels changes in carbon isotopic composition of marine foraminifera, presumably through fluctuations in greenhouse gases.

Abstract #24

Kohn, M. J. and T. J. Fremd. 2007. **TECTONIC CONTROLS ON ISOTOPE COMPOSITIONS AND SPECIES DIVERSIFICATION, JOHN DAY BASIN, CENTRAL OREGON.** PaleoBios 27(2):48–61, October 11, 2007.

Oxygen isotope compositions of fossil mammal teeth from basins in interior Oregon, including the John Day basin, were measured to investigate the topographic evolution of the central Cascade Range. Compositions of fossil equid, rhinocerotid, and oreodont teeth within the Cascade Range rain shadow indicate a ~1‰ increase in mean d18O from ~27 Ma to ~7 Ma, followed by a dramatic ~4‰ decrease to the present. The isotope composition of fossil teeth is strongly affected by rainout over the Cascades, so these trends likely indicate nearly constant or slightly decreasing elevations between 27 and 7 Ma, followed by an ~800 m increase in range height to 1600 m in the last 7 Myr. These data are most consistent with replacement of cooler metasomatized asthenosphere by hot, mid-ocean ridge type asthenosphere, including possible erosion of subarc lithospheric mantle or conversion to asthenosphere by heating. Consideration of middle to late Cenozoic climate and tectonic evolution in the western United States suggests that the middle Miocene maximum in ungulate diversity resulted from moderate productivity coupled with tectonically driven topographic variability. Both factors fragment ecosystems, thereby increasing habitat diversity. Subsequent late Neogene reductions in ungulate diversity likely resulted from decreased productivity associated with aridity, and the expansion of grasslands, which decreases habitat diversity by coalescing ecosystems. Regional tectonics, reflected in the height of the Cascade Range and development of extensional structures in central and eastern Oregon, appears a likely driver of faunal evolution.

Abstract #25

Sheldon, N. D. 2003. **PEDOGENESIS AND GEOCHEMICAL ALTERATION OF THE PICTURE GORGE SUBGROUP, COLUMBIA RIVER BASALT, OREGON.** GSA Bulletin, v. 115; no. 11; p. 1377–1387.

Reddened, clay-rich horizons between basalt flows have historically been identified as ‗baked zones" or as zones of lateral groundwater movement. The reddening has been attributed to thermal or chemical alteration of the permeable portion of the basalt flow. Many of these red horizons are instead paleosols that record significant hiatuses in basalt flow emplacement. Paleosols were identified in the field on the basis of features such as horizonation, ped morphology, and root traces. Terrestrial gastropods, fossil plants, and peats also occur locally. Plots of weathering indices, such as base loss, are consistent with a pedogenic origin for these horizons. Ca, Na, Mg, Fe21, and P have been extensively lost from the A and Bt horizons of the paleosols, consistent with modern weathering patterns. K and Rb have been added to the upper portions of the profiles and lost in the lower portions of the profiles relative to the parent material, with Rb added disproportionately.

Historically, this pattern of enrichment has been cited as evidence of K metasomatism. The apparent metasomatism can be explained using a new model in which there was extensive felsic volcanism contemporaneous with pedogenesis, and K and Rb were likely added by windborne ash. The apparent discordance between K and Rb contents of the paleosols can be explained by the presence of land plants because K is an important electrolyte and Rb does not serve any major biological role. This model could account for apparent K metasomatism in other paleosols following the advent of land plants and may be applicable to older paleosols as well.

Abstract #26

Sheldon, N. D. 2006. **USING PALEOSOLS OF THE PICTURE GORGE BASALT TO RECONSTRUCT THE MIDDLE MIOCENE CLIMATIC OPTIMUM.** *PaleoBios* 26(2):27–36.

The Picture Gorge Subgroup of the Columbia River Basalt preserves numerous, minimally altered, interfl ow paleosols that were formed during the middle Miocene climatic optimum. These paleosols are used to reconstruct a high-resolution paleoclimate record. Between 16.0–15.4 Ma ago, mean annual precipitation (MAP) was 500–900 mm/year and mean annual temperature (MAT) was 8–16°C, which is consistent with independent estimates of paleoprecipitation and paleotemperature from fossil plants and paleosols of the contemporaneous Mascall Formation. The record suggests cooling and aridifi cation similar to marine foraminiferal isotopic records. One possible cause for the middle Miocene climatic optimum is transient elevated atmospheric CO2 levels, though some recently compiled marine isotopic records indicate near-modern CO2 levels. This possibility is explored using an equilibrium model to simulate the formation of the dominant Picture Gorge paleosol type. Model results indicate elevated CO2 levels 2–3 times present atmospheric levels were necessary to form the observed mineral assemblage and mass-balance characteristics of the paleosols. This result is consistent with stomatal index studies of gingkos and laurels, which indicate CO2 levels 2–4 times present atmospheric levels.

Abstract #27

Bestland, E. A., M. S. Forbes, E. S. Krull, G. J. Retallack, and T. J. Fremd. 2008. **STRATIGRAPHY, PALEOPEDOLOGY, AND GEOCHEMISTRY OF THE MIDDLE MIOCENE MASCALL FORMATION (TYPE AREA, CENTRAL OREGON, USA).** PaleoBios 28(2):41–61.

The Mascall Formation in its type area has a minimum stratigraphic thickness of 353 m and consists of middle Miocene alluvial floodplain and channel deposits; its overall lithology is dominated by moderately to well-developed Alfisol-, Vertisol-, and Andisol-like paleosols that developed in a humid temperate climate. The formation is divided here into lower, middle and upper members based on conglomeratic and tuffaceous stratigraphic marker beds interpreted as cut-and-fill units that developed during episodes of climatic transition. Its depositional environment was that of a slowly aggrading alluvial floodplain consisting of fine-grained, pyroclastic-derived detritus with small fluvial channels tens of centimeters to a few meters deep. Much of the formation is organized into fining-upward sequences that are 5 to 10 meters thick each with a sandy, tuffaceous, or conglomeratic unit at its base (channel-levee deposits) and overlain by several moderately to well-developed paleosols. Based on time-of-formation estimates of the paleosols, each sequence spans a few tens of thousands of years. The sequences most likely represent climatically forced episodes of rapid floodplain aggradation (channel-levee deposits) followed by slow floodplain aggradation (paleosols). The Mascall Formation strata are geochemically similar to paleosols and volcaniclastic deposits in the Oligocene Big Basin Member of the John Day Formation. The least weathered pyroclastic strata in the formation are rhyodacitic, consisting of about 67 wt % SiO_2, 0.4 wt % TiO_2, and 7 to 8 wt. % combined bases (MgO, K_2O, Na_2O, CaO). Mass balance calculations show the well-developed paleosols have had volume collapse from the primary rhyodacitic parent of about 60%, volume collapse of about 30% when the composition of reworked tuff is used as parent, and less than 10% volume collapse from in situ weathering (calculated from paleosol C horizons as parent).

Abstract #28

Prothero, D. R., E. Draus, and S. E. Foss. 2006. **MAGNETIC STRATIGRAPHY OF THE LOWER PORTION OF THE MIDDLE MIOCENE MASCALL FORMATION, CENTRAL OREGON.** *PaleoBios* 26(1):37–42.

The Mascall Formation in central Oregon consists of about 350 meters of volcaniclastic floodplain siltstones and sandstones exposed in numerous fault blocks in the John Day region of central Oregon. It yields a famous early Barstovian mammalian fauna (part of the Wood Committee‘s 1941 original concept of the Barstovian) that includes at least 33 species of mammals, as well as birds, turtles, fi sh, and freshwater gastropods. The most complete section in the type area was sampled using oriented block sampling. The samples were then subjected to both alternating field demagnetization at 25, 50, and 100 Gauss, followed by thermal demagnetization at 50°C steps from 200 to 630°C. Most samples yielded a stable single component of remanence that passed a reversal test, and was held largely in magnetite with minor goethite overprints. The lower half of the section is of reversed polarity, followed by shorter magnetozones of normal, reversed, and normal polarity to the top of the section. Based on dates of 16.2 ± 1.4 Ma at the base of the section, and 15.77 ± 0.07 Ma in the lower part of the section, we correlate the Mascall Formation with Chron C5Br to Chron C5Bn1n (14.8–16.0 Ma). This correlation is consistent with the early Barstovian age of the fauna, and it matches the pattern seen in other Barstovian magnetostratigraphic sections, such as those at Barstow, California; Virgin Valley and Massacre Lake, Nevada; and Pawnee Creek, Colorado.

Abstract #29

Prothero, D. R., J. M. Hoffman, and S. E. Foss. 2006. **MAGNETIC STRATIGRAPHY OF THE UPPER MIOCENE (HEMPHILLIAN) RATTLESNAKE FORMATION, CENTRAL OREGON.** *PaleoBios* 26(1):31–35.

The Rattlesnake Formation near Picture Gorge in the John Day region of central Oregon consists of about 120 meters of siltstones and conglomerates punctuated by several tuff beds. This formation is well known for its early Hemphillian mammals, and it was originally part of the Wood Committee's (1941) concept of the Hemphillian. Paleomagnetic samples were collected from the type section of the Rattlesnake Formation between Rattlesnake and Cottonwood Creeks 2 kilometers south of Picture Gorge. Samples were demagnetized with both alternating field and thermal demagnetization, and yielded a stable remanence held mainly in magnetite. After cleaning, the normal and reversed directions passed a reversal test, so the remanence is interpreted to be primary. Almost the entire section is reversed in polarity except for the basal 10 meters and a single site near the top of the section. Based on 40Ar/39Ar dates of either 7.2 Ma or 7.05 ± 0.01 Ma on the Rattlesnake Ash Flow Tuff near the top of the section, we correlate the section with magnetic Chrons C3Bn to C3Br2n (6.9–7.3 Ma), or late early Hemphillian in age (Hh2 of Tedford et al. 2004).

Abstract #30

Martin, J. E. and T. J. Fremd. 2001. **REVISION OF THE LITHOSTRATIGRAPHY OF THE HEMPHILLIAN RATTLESNAKE UNITS OF CENTRAL OREGON.** PaleoBios 21(2 (supp.)): 89.

The Hemphillian North American Land Mammal Age (NALMA) was based upon assemblages including that of the Rattlesnake Formation of central Oregon as a principal correlative. Therefore, the faunal content of the Rattlesnake deposits is crucial to the definition of the Hemphillian NALMA. However, recent definitions of the igneous versus sedimentary units of the Rattlesnake succession have brought the lithostratigraphic framework for the faunal constituents into question. The Rattlesnake was described as a formation-rank unit during the first part of the last century. This formation included a basal detrital unit dominated by floodplain sediments, an interbedded ash-flow tuff (RAFT), and an upper detrital unit dominated by basalt conglomerates. More recent workers have elevated the RAFT to formation-rank status with no regard to the sedimentary units above and below. Therefore, we propose that the Rattlesnake Formation be elevated to group status, with all three intervals regarded as formation-rank units. As the group is extended beyond the John Day Basin, additional formations may be added to the group. In the type area of the Rattlesnake Group in the Picture Gorge area of central Oregon, the RAFT has been dated at 7.2 Ma, and the lower formation contains a tourmaline-bearing tuff, bracketing the fossil assemblages. Faunal constituents of the lower formation indicate an early Hemphillian interval; therefore, the radiometric dates aid in determination of absolute ages of the early Hemphillian.

Abstract #31

Fremd, T. J. 2001. **APPRAISING THE SIGNIFICANCE OF COMPLEX ASSEMBLAGES AND DATA DEFRAGMENTATION: AN EXAMPLE FROM THE VOLCANICLASTICS OF EASTERN OREGON.** PaleoBios 21(2 (supp.)): 54-55.

Many stratigraphically complex basins are globally significant in terms of local preservation of long-term processes and events. These are qualitatively characterized by sequences of well-preserved biotas found in association with isochronous index strata that can be correlated with deposits elsewhere. Comparative assessment of the significant features of data-rich basins demonstrates that among such classic Tertiary settings as the Siwaliks and the Bighorn Basin is the lesser-known John Day Basin.

The remarkable temporal continuity of the Tertiary deposits in eastern Oregon was first recognized one hundred years ago by J.C. Merriam of the University of California, Berkeley. However, it was only after Merriam's development of an interdisciplinary group known as, "The John Day Associates," that it was realized that no region in the world shows more complete sequences of Tertiary land populations, both plant and animal, than the John Day Formations. We now realize that these series of strata are exceptional not only in terms of temporal continuity, but in that they also contain multiple, diverse localities formed in laterally variable intrabasin depositional environments, which allows comparison of time-equivalent paleobiomes.

Basins like the John Day are warehouses of stratigraphic information, indispensable for accurate phylogenetic and ecologic studies. Many of the data sets needed for complete analyses and comparative study of such areas are fragmented, however, as a result of non-integration of varied disciplines into a cohesive research framework, unsystematic institutional data storage, and overlooked inter-basin relationships. As a result, there are misconstructions of the quality of the fossil record appearing in overall tabulations, or a failure to recognize correlative units proximal to basin margins. Defragmentation can be achieved for long-term, interdisciplinary analysis of these basins and their margins when paleontological studies, data collection, and storage are performed with the big picture in mind.

Abstract #32

Dillhoff, R. M., T. A. Dillhoff, R. E. Dunn, J. A. Myers, and C. A. E. Stromberg. 2009. **CENOZOIC PALEOBOTANY OF THE JOHN DAY BASIN, CENTRAL OREGON**. *in* O'Connor, J. E., Dorsey, R. J., and Madin, I. P. eds., Volcanoes to Vineyards: Geologic Field Trips through the Dynamic Landscape of the Pacific Northwest: Geological Society of America Field Guide 15, pp. 135-164.

The John Day Basin of central Oregon contains a remarkably detailed and welldated Early Eocene-Late Miocene sedimentary sequence, known for its superb fossils. The field trip examines plant fossil assemblages from throughout the sequence in the context of their geological and taphanomic settings and regional and global significance. The Early to Late Eocene (>54-39.7 Ma) Clarno Formation contains fossil plant and animals that occupied an active volcanic landscape near sea level, interspersed with meandering rivers and lakes. Clarno assemblages, including the ca. 44 Ma Nut Beds flora, record near-tropical ―Boreotropical‖ rainforest, which was replaced during late Clarno time by more open and seasonal subtropical forest. The overlying John Day Formation (39.7-18.2 Ma) was deposited in a backarc landscape of low hills dotted with lakes and showered by ashfalls from the Western Cascades. Fossils and paleosols record the advent of the ―Icehouse‖ Earth during he earliest

Oligocene, with decreasing winter temperature and more seasonal rainfall that supported open deciduous and coniferous forest, much like that of the southern Chinese highlands today. Sixteen and a half million yeas ago the Picture Gorge flood basalt covered the region. Animals and plants fossilized in the overlying (ca. 16 to >12 Ma) Mascall Formation occupied a relatively flat landscape during a warm and moist period known a the Middle Miocene Climatic Optimum. In total this sequence preserves a detailed series of time slices illustrating regional biotic and landscape evolution during the Cenozoic that is highly relevant for deciphering regional and global biotic, climatic, and geological trends.

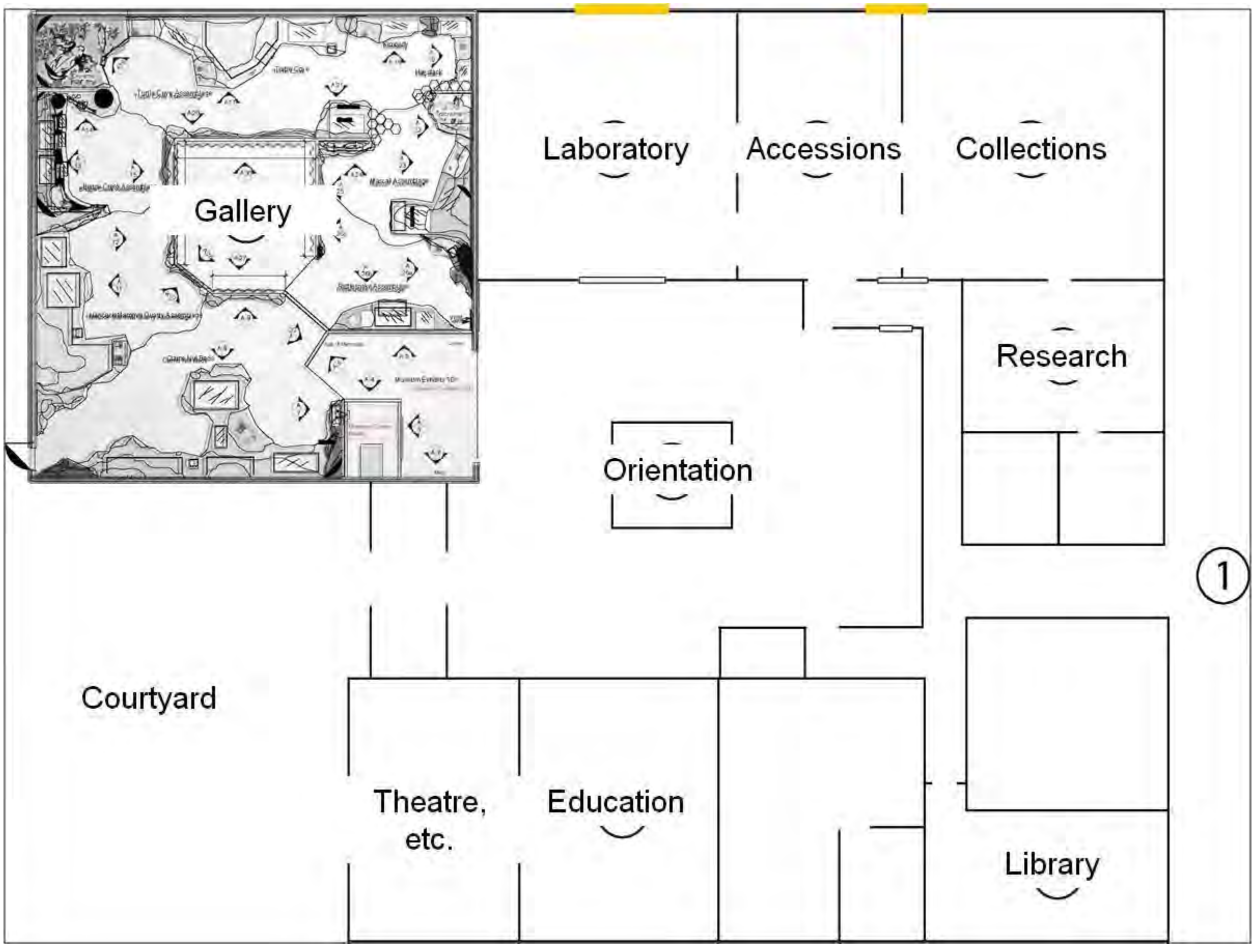
Abstract #33

McClaughry, J. D., M. L. Ferns, M. J. Streck, K. A. Patridge, and C. L. Gordon. 2009. **PALEOGENE CALDERAS OF CENTRAL AND EASTERN OREGON: ERUPTIVE SOURCES OF WIDESPREAD TUFFS IN THE JOHN DAY AND CLARNO FORMATIONS**, *in* O'Connor, J. E., Dorsey, R. J., and Madin, I. P. eds., Volcanoes to Vineyards: Geologic Field Trips through the Dynamic Landscape of the Pacific Northwest: Geological Society of America Field Guide 15, p. 407-434.

The John Day Formation of central and eastern Oregon, contains a widespread assemblage of both ash-flow and airfall tuffs, yet only a few corresponding caldera sources have been identified in the region. Investigators have long speculated on the sources of tuffs in the John Day Formation and have suggested that these pyroclastic rocks were vented from now buried eruptive centers in or marginal to a nascent Cascade Range. Recent detailed geologic mapping in the John Day and Clarno Formations, however, indicated the presence of at least three large-scale rhyolite caldera complexes centered along the northeast-trending axis of the Blue Mountains. This field guide describes a three-day geologic transect, from the scenic high desert of central Oregon eastward across the axis of the Blue Mountains, that will examine the physical volcanology and geologic setting of the 41.50-39.35 Ma Wildcat Mountain caldera exposed along the crest of the Ochoco Mountains, the 29.56 Ma Crooked River caldera at Prineville, and the 29.8 to 28.1 Ma Tower Mountain caldera near Ukiah.

Paleomagnetic sampling of Unit E3 at the Foree Section, ca 1998. Barry Albright drilling as Carl Swisher looks on; data presented in Albright and others (2009). The "Airport Section" is visible in the distance, above the double-layered Picture Gorge Ignimbrite.

APPENDIX TWO: A BRIEF GUIDE TO THE THOMAS CONDON PALEONTOLOGY CENTER.



Introduction

John Day Fossil Beds National Monument is probably the only NPS unit which has enabling legislation that actually mandated the construction - and specific naming - of a facility, the Thomas Condon Paleontology (or Visitor) Center (TCPC). This resulted from negotiations held with the State of Oregon delegation, as all three units of what is now the National Monument – Clarno, Painted Hills, and Sheep Rock – used to be part of the Oregon State Parks system. The land exchange elevated the status (and protection of the resources) of most of the properties from what was the rather unwieldy title of ―Thomas Condon John Day Fossil Beds State Park‖ to a National Monument.

The TCPC officially opened in Summer, 2005, after many years of politicians and concerned citizens attempting to secure funding. Several false starts in the 1980‗s and 1990‗s suggested the structure might never be built, so the embryonic museum collection was moved twice to headquarters facilities in the town of John Day before finally transported into this permanent dedicated storage space. Currently approaching 60,000 catalogued specimens, the anticipated growth of material from ongoing prospecting will be housed in the dedicated museum storage space (COLLECTIONS, above) for many years to come, and is arguably the most important facet of the building.

The objective of the facility is to serve as a center for the conservation and study of the fossils of the John Day basin, and to provide an opportunity for the public to appreciate these resources and the science behind the stories. Thus, the large laboratory, accession storage, and dedicated storage have large windows offering glimpses into the process. The lobby permits orientation and access to flexible exhibits, there is a theatre that often is showing an orientation ―park movie‖, and there are educational spaces. The exhibit gallery provides access to about 500 specimens typical of the surrounding strata. There are also offices for staff and a climate-controlled library currently holding about 15,000 books, rare and historic manuscripts, and reprints relevant to the John Day, including the research libraries of Ted White, Arnold Shotwell, and Dave Whistler.

The following material is an abbreviated version of a guide written for new NPS ―interpreters‖ – those naturalists trained to present this often complex subject matter to the general public. It includes some of the concepts used to make the paleontology of the area accessible and memorable as visitors drive and hike around the area. Explaining the multiplicity of vertebrate, paleobotanical, and other sites in this area is more challenging than at most ―paleontology parks‖ in the NPS and elsewhere, where an Eocene lakebed with fish or a tilted wall of dinosaurs can be more readily grasped by people with varied backgrounds.

Exterior items

As the visitor approaches the building entrance they will have observed the splendid panorama of Sheep Rock, noticed the excellent soft basalt rockwork (Willamette Graystone), and observed several external exhibits on ―the patio‖, including a cast of *Archaeotherium caninus*, YPM 11665 on a plinth. Large blocks of petrified wood retrieved from a locality from just above the city of John Day (see figure on page 2:16) are immersed in the ―landscaping‖.

As the approaching viewer turns to the left, a series of six colorful **icons** adorn the bare soft basalt rock walls. These graphically represent the six major fossil assemblages (the TUCO, KIMB, and HAYS were combined for this purpose) of the John Day Basin that are treated in depth inside the building. Each one consists of casts of original fossils that were set into a clay shape that itself represents the approximate boundaries of the geologic rock units in Oregon that these ―**icon fossils**‖ are found in. Later, the visitor may view the introductory panel in the museum gallery (MG) and will see these same shapes, or outlines, placed on a map of Oregon –making possible the connection between different geologic times and extent of rocks in present-day geographic context. These icons are mounted from oldest to youngest as one walks past them on the way in, and represent the Clarno Nut Beds, Hancock Mammal Quarry, Bridge Creek Flora, John Day beds (further subdivided into three units in the gallery), the Mascall Formation, and the Rattlesnake assemblages. The colors are the hues that are associated with the rock units throughout the presentation. The textures on the ―maps‖ are the actual geologic symbols used on a geologic map or stratigraphic column. The general public, of course, will not usually recognize this but many appreciate it once they discover it or have it pointed out to them. Each of the icon organisms is also featured someplace in each of the murals or in a diorama.

The visitor will encounter these **shapes, colors, and icons** several more times as they explore the building. Examples include the large banners hanging in the lobby; the colors of the floor in the gallery; the time lines on all the interpretive panels and large walls; the **tiles** laid into the interpretive panel for the major murals, and the actual fossils that are highlighted at each of the major display cases. They each serve as ―language-independent symbols‖ with the intent that each of these, by being presented in several different forms and places, will orient the visitor to the fact that this is a place with more than one ―fossil bed.‖ It is also hoped that the visitor will ―connect‖ with the colors and shapes as they tour the park and synchronized signage without the need for what many consider to be technical jargon.

The icons for each ―assemblage: are as follows:

CLARNO NUT BEDS (NUBE): The icon is a large piece of a petrified portion of a lahar ―run out,‖ or mudflow settling area, with dozens of entombed nuts, seeds, pieces of vine, wood, and more fossils. It suggests a conglomeration of fossil plants and different parts that provides a unique appearance and texture characteristic of these deposits.

HANCOCK MAMMAL QUARRY (HAMA): For this icon we chose the skull of the robust carnivorous mammal *Hemipsaladon grandis*, a kind of creodont best known from the HMQ. This skull is displayed in the lobby and also prominently guards the donation box!

BRIDGE CREEK FLORA (BIBA): The icon was chosen just prior to its designation as ―Oregon‘s State Fossil.‖ It is *Metasequoia*, the so-called ―dawn redwood‖ showing foliage, cones, stems, and a piece of petrified wood typical of the strata. Considered a ―living fossil‖, the molds were made from a modern cultivar.

JOHN DAY BEDS (TUCO): Broken down into the three temporal units inside the building, because they span over 20 million years, we chose the ―John Day Tiger‖ *Pogonodon* for this icon. One of three charismatic carnivores chosen for these icons, it is indeed a species uniquely known from the green beds of the John Day. A life-sized reconstruction of this beast is in a diorama in the gallery.

MASCALL FORMATION (MASC): The icon is the skull of *Dromomeryx borealis*, a ―giraffe-deer‖ that is found in abundance in the Mascall and typifies the Barstovian NALMA. Also, there are some hackberry seeds and ―lobey‖ oak shapes molded into place so that the flora is not overlooked.

RATTLESNAKE ASSEMBLAGES (RATT): A peculiar association of teeth, a hint of a skull, and large humerus make this icon something of an enigma; but it is the remains of *Indarctos*, the Asiatic short-faced bear that originally made the Rattlesnake beds famous in the 1920‘s as the first ―proof‖ that mammals emigrated to N. America from Asia.

These icons are specifically placed on the wall *sans* explanatory verbiage: they are simply ―there,‖ the meaning to be discovered. The answers to what these enigmatic figures mean are to be found inside, a formula recommended by our partners and contractors who helped with the design of the presentations; our initial suggestions were considered far too technical for ―most folks.‖

The lobby

As the visitor steps through the door into the lobby, they enter the high-ceilinged area and observe six large banners, which may look vaguely familiar if they puzzled over the icons. This time, though, in addition to the fossil illustrations, they see an outline of a cliff or skyline – which, it turns out, was made from photos of the actual outcrops in the type areas. Also, the ―texturing‖ above and below the icon shape is made from high resolution photographs of the actual sediments that the fossils are found in.

LABORATORY AND STORAGE WALLS

The touch-screen monitor and DVD player, lab camera, and varied computer media feed to the monitor, plasma screen, and other devices associated with the lab. The plasma monitor displays the view through the microscope via a digital camera, or images of field areas, or whatever is desired. Through the window, the observer can see the mechanical preparation stations, fume hood and casting space, and other tools of the trade. Behind the inside door is a specialized room for coarse and microscopic air abrasive devices. To meet NPS museum standards, the general public is not permitted in any of the curatorial spaces.

In the three cases closest to the lab window walls, the description of the laboratory, fieldwork, and collections activities are designed to orient the viewer to the ―work‖ involved in finding, preparing, and storing fossils and are integral to the presentation.

TECHNICAL CASES

The other 6 cases were designed and written by us to be updated or swapped out with another theme in the future. Various topics pertinent to the paleontological disciplines are explored that visitors frequently express interest in. Current topics include biostratigraphy, taphonomy, paleopedology, absolute age dating, interagency resource management, and fossilization. These are written unapologetically for those wanting more ―in-depth‖ information; they were designed for exploration by people after they have gone through the exhibit gallery and perhaps seen the video. People that read them out-of-sequence have expressed surprisingly positive feedback, however.

CONDON

Outside the gallery is a panel describing the importance of Thomas Condon to the history of paleontology and his role in shaping the science of geology in Oregon. A quote concerning evolution is placed in **red** specifically to capsulate Thomas Condon‘s worldview over 100 years ago, and to prepare the viewer for what is to come: evolutionary theory and the evidence. Visitors are interested in knowing that a ―frontier minister‖ found no conflict between evolution and religion.

Museum Gallery entrance foyer

THE MAP

As the visitor enters the gallery, to the immediate left is a large, original 3-D topographic map of the State of Oregon, itself a useful and interesting presentation of the landforms of the state. Overlying this topo are outlines of the distribution of the celebrated rocks of the JD Basin, arranged on plex panels from the oldest and stacked out (toward the viewer) to the most recent. To the left are explanatory panels that point out what these features are. It is important to note that these are rough, cartoon-ish depictions of the overall distribution of sediments – including subcrops (buried exposures) and areas that subsequently weathered away. They are NOT geologic maps of the outcrop, but simplified outlines of the exposures so the public can grasp the extent of the Beds at a glance.

OUTCROPS

The next panel in the sequence consists of 8 photographs of the actual outcrops that best reflect each of the stratigraphic units (the ―John Day‖ element is further subdivided into 3 sub-elements because of the great time extent). These images are where the casts of the outcrop were taken; again, we attempt to clearly orient the viewer to the fact that there are <u>many</u> localities (in fact, over 750) spanning a long time interval.

ORIENTATION TO SIGNIFICANCE OF STRATA DISPLAYS

On the wall to the far right there is a famous quote of Ralph Chaney (one of the world‘s leading paleobotanists of his day) about how ―no region on earth‖ has a better sequence of rocks than the John Day Basin. In fact, we now know that‘s a bit of an overstatement, but it serves to suggest that this has long been known as an important paleontological area.

To the left is a combination of three exhibit elements:

A: High on the wall, a long time ―ruler‖ that divides the last 650 million years of earth history with the placement of the JDB strata magnified (if we were to extend the scale of this to reflect the age of the earth, it would go clear out through the lobby and end on the loading dock). The astute viewer might notice the major assemblages, that color scheme again, and some of the names. They may also notice the call-out of the Cenozoic, and the beginning of the timeline is used repeatedly on all panels. ―Redundancy is a good thing‖ in scientific exhibitry.

B: Beneath the ―time piece‖ is a black-backed vitrine with a variety of (deliberately) unlabeled fossils to simply, artistically, and without imposition of classification or philosophy show the variety and beauty of the fossils found here. There are some mammal skulls and bones, reptiles, a bird, fish, leaves, wood, and even some small snails. The viewer should ―get‖ the fact that a wide variety of different kinds of fossils are to be found here, and it is not just layers of fish or leaves, or dinosaurs, or a horse quarry. This national monument has depth.

C: To the left of the vitrine is a critical panel – it defines the significance of the national monument in simple diction and essentially defines the reason of establishment (although, in truth, half of this was not appreciated when Congress designated the sites) in simple, straightforward English. Many viewers should understand from this what the unlabelled fossils to the right represent.

CATHEDRAL ROCK

Mounted on a magnetically controlled door to the control room (that should not be that noticeable) is a single, simple, but clear photograph of Cathedral Rock and the John Day River (the South and East/Main Fork of it, at least). The caption simply points out how the rocks were named – from the river. It is largely because of the river, and the carving action of it and its tributaries, that these rocks are exposed at all. Without this ―conveyor belt‖ carrying out erosional remnants, most of the layers below the basalts would have been buried and unknown at this time in human history, so we thought it important to include this imagery.

WELCOME…

Finally, just before entering the main room, a simple text welcomes one to the Age of Mammals… clarifying the time frame, absence of dinosaurs, etc. … and a whimsical afterword.

Orientation to Main Gallery displays and concepts

A central philosophy of these exhibits is that they will evolve. When new and more interesting material is collected and prepared, it will replace an existing item. When a hypothesis is overturned, the text will be modified or the mural will be adjusted. The murals are not intended to be static; they should be viewed as a starting point, and they have already undergone one cycle of modification and correction. When new stratigraphic nomenclature is published, the panels will be altered to reflect the new terminology and formation names. If better *Pogonodon, Hypertragulus,* or *Mesogaulus* material is collected that sheds new light on the 3-d morphology of these beasts, they should be redone. When budgetary considerations permit, many of the replica plants should be enhanced, and the eight separate audio tracks could be improved so that they are more localized to the specific display.

The exhibits are laid out in 6 major areas (with one, the Turtle Cove, subdivided into three) for a total of 8 featured ―time slices‖ through the rocks of the Basin, in roughly 5 million year intervals. The space was designed such that the majority of walkers/rollers will proceed to the left (clockwise) at the entry point, largely because the ―Welcome‖ panel is configured to be a sharp left angle. Also, the placement of the large brontothere in the HMQ mural was deliberately positioned to intrigue the viewer into proceeding directly ahead. After this, the walk-through begins by proceeding left, examining the beautiful thin sections of wood, and then walking through each section, ―bouncing‖ off of the geology panels on the opposite wall, then working fully around the outer display areas, and ending at the entrance of the central room (the ―So What?‖ room) A simple brochure, ―Guide to the Exhibits‖, is being produced by staff.

In effect, the arrangement of the TCPC Center in total can be viewed as a reflection of a scientific paper: Introduction and Materials and Methods in the lobby/lab/collections, study specimens and stratigraphy in the gallery, murals forming the hypothesis/Results, and the So What room the Conclusions. It doesn't have to be read ―front to back‖, but it helps.

Throughout the room, the general plan is the same: a large mural that is a **testable hypothesis** of what the area may have looked like, rockwork molded from the actual outcrops preserving the evidence, floor colorings (of durable colorized sonoguard) corresponding to the icon colors, a variety of specimens in cases with museum labels and supplemental larger labels for a few things (erring on showing more specimens and leaving the text to supplemental keys laid out at each case), and on the opposite wall, a panel describing the geology of the area.

Proceeding clockwise, one is moving from the oldest strata to the youngest – from the lowest part of the section up to the highest. This perspective is also reflected in the perspective heights of the murals. Additionally, the Time of Day that each mural is depicting is directly proportional to its position within a 40-million year time span, such that the NUBE is scene at roughly 6:00 AM, and the RATT is painted to depict 6:00 PM, with the intermediate murals in the correct intervals. Also, the orientation of the viewer of the mural is arranged in the same direction as the actual compass bearing and scene a time traveller would have seen at the specific fossil locality; thus, the view from the HAMA is looking south, towards one of the Clarno volcanics such as Rancheria or the Ochocho plugs, and the RATT is facing West towards the then-dormant but still massive 12-10 mya Strawberry Volcano that towered at least 1,000 meters over what is now the Canyon Mountain serpentines and ophiolites of the Tri/Jurassic. Consult Section Three, Assemblages and the key to the murals therein. The general trend of cooling, drying, and increase in seasonality should be apparent.

Murals and Geology Panel walk-through

There are 18,000 pounds of Thoroc on the floor, over the thick reinforced concrete. On top of that are multiple coats of Sonoguard, colored to match the icon colors throughout. Transitions are either abrupt or interfingered depending on the nature of a typical contact in the field. Note the occurrences of embedded leaf impressions, footprints, and other little surprises in ―strata‖ where they are known to exist.

GEOLOGY PANELS

The panels all follow the same pattern: A photograph of a typical outcrop, a composite generalized stratigraphic column with a call-out of a more detailed section, a line connecting the top banner to the placement in the column, some simplified text, and a little ―cartoon‖ of a paleoenvironmental reconstruction based on paleosol analysis and fossils. These were all hand drawn with a rapidograph by our collaborator, Greg Retallack, who very generously donated his time and effort to this effort. Some of these were previously published in our Geol. Soc. of Amer. Special Paper (see Retallack, Bestland, and Fremd, 2000).

LABELS

The L-1 (small) museum labels all follow the same pattern, as follows
Line 1: *Binomial nomenclature*
Line 2: Common name
Line 3: Specimen number
Line 4: Locality, Age

Line 1: the Genus and species (as known) are in *italics*, sometimes with standard zoological shorthands, such as cf. (means ―compare with‖), aff. (means ―is believed to have affinities with‖), sp. (meaning ―species‖), and so forth. If known to family only, that is put there. Rarely, a more general descriptor is used (see below).
Line 2: a common name, usually derived from the etymology of the binomium. We did decide to atttempt a ―common name‖ for many of the organisms, often simply translating the original latin. The public can be vexed that there aren‘t common names for creodonts, or a brontothere, or a hyrachyid ... and simply trying to lump them into a modern analog is misleading.
Line 3: These are the formal, unique acronyms for repositories followed by the specimen number from that collection. JODA is John Day Fossil Beds National Monument collections; UCMP is the Museum of Paleontology, University of California, Berkeley; UWBM is the Burke Museum at the University of Washington, Seattle; AMNH is the American Museum of Natural History, New York City; YPM is the Yale Peabody Museum, and so forth. There are a few items that have numbers like TF7946; that means it‘s a field number and the object hasn‘t been catalogued yet. The first letters are uniquely the collector‘s, then the month, the year, and the numerical sequence. See detailed field note procedures on file with the museum handbooks.
Line 4: First word or phrase is the unique locality name, of which there are over 750. With just over 400 specimens on display in the gallery, one would have to nearly double the size of the exhibit space just to have one specimen from each locality!

Each display region also has a number of larger specimen labels, most of which follow a simple pattern. We took a digital photo of a fossil, and then a digital of that organism‘s reconstruction in the mural. In addition to the technical specimen label being reproduced in the upper right, a few sentences have been added as descriptors that can be improved and produced locally, as needed.

Clarno Nut Beds area

Entering the area, the wet sounds and moisture-laden ambience pervade the scene. Turning to one‘s left, an array of thin sections of Clarno wood (sliced and hand-polished in our lab) is backlit with fiber optics so that great details of the cellular structure are clearly visible. The NUBE has more species of wood (over 76) than any other locality, of any age, in the world; which was not appreciated when first designing the space. As we collect more and better pieces, they will replace what‘s there. The key provides general ID‘s suitable for most of the public; the upper left orange one is a palm, etc.

Rockwork: The large tree in the corner is a cast of the famous ―Hancock Tree,‖ that is located up Hancock Canyon within a lahar within the Clarno Unit of the park. Actual textures were taken from the specimen with pads, and then the final piece was fine-tuned and carved in place from detailed photographs. Elsewhere along this rockwork one will note some details lifted from the outcrops at Hancock Canyon, Face I of the Nutbeds Locality, and the Face III *Equisetum* outcrops. On the opposite wall are textures and sculpted caricatures of the Palisades at Clarno (as is the outline of the banner skyline). These are evocative of a considerably older lahar than that which encapsulates the Nut Beds, but is still a part of the same sequence that contains abundant fossil tree trunks and limbs. This forms the prominent ―icon‖ outcrops one sees from the Clarno picnic area. A distinctive layer on both sides of the walkway that‘s about 4‖ thick, recessed, and lighter color is symbolic of a lacustrine interbed that can be used for correlation in the field; a useful ―prop‖ for a geology-themed talk through the displays. There are many of these ―props‖ placed throughout the displays that can be used in guided tours and talks.

Mural: was painted by Larry Felder, and adjusted at the Contractor‘s facilities (PPI in Portland) to correct anatomical inaccuracies in *Patriofelis, Telmatherium,* and *Pristichampus*. As with all of the murals, the initial sketches of the organisms were prepared by Mark Hallett (see flipbooks for some of them). It is 06:00 AM during the ―wet season‖. The time stratigraphic unit is a composite of the Hancock lahar, *Equisetum* strata, and the Nut Beds depositional events. The perspective is as if one is standing at what is now the Clarno Nut Beds, looking towards the Southeast. A hot spring is evident from the steam rising on the right side, consistent with one model for the diagenetic history of the strata. A not-long-inactive lahar is featured towards the NE, and a hint of a volcanic source of the lahars can be seen in the background.

Specimens: The more important specimens that could be pointed out are the composites filled with vegetative and reproductive plant tissues, the fabulous invertebrates in the small case, the flowers, wood, and of course the primitive and rather ―odd‖ mammals. This is a tiny fraction of the over 300 species of plants and 76 species of woods known from this locality; the vast majority of which have growth habits like vines or lianas. Note the icon palm frond and vines.

Geology photo: The large photograph was taken from Face I of the Clarno Nut Beds, looking towards Face III and V. The prominent stratified redbeds are ―Red Hill‖, a series of 17 well-formed paleosols that are middle-late Eocene. On the right, one sees a glimpse in the upper right of the

John Day A (see below) and a glimpse of the Hancock Mammal Quarry. The small photo is a shot of the classic palisades from the lahar trail, mile 119.2 on Day Two of this trip.

On the opposite wall is a self-explanatory ―How Do We Know‖ panel; note the example is that of a nimravid being reconstructed from bones. This was chosen because soon the viewer will observe the 3-D *Pogonodon* and will hopefully have seen the illustrations and figured out how the scientific community goes about reconstructing a long-extinct beast.

Hancock Mammal Quarry

Sounds are that of wet, slurpy heavy-footed organisms – in fact, they are modern elephants the sound studio taped in South Africa.

Rockwork: The rockwork was modelled after imagery and photographs, as well as from pieces of the material, since the actual quarry has been backfilled. This matrix is close, and also has the advantage of showing the texture of the claystones. The colors are correct. You‗ll note a large ―brontobone‖ on the left side suggestive of actual quarrying; this is the only locality for which actual quarrying of a large death assemblage occurred. The amynodont skull, in jacket, is placed near that as well to suggest jacketing and quarrying without drawing any special attention to it.
On the upper right we added an important rock unit: the shelf at the top of the wall is suggestive of the John Day ―A‖, a welded ash-flow tuff that defines the uppermost Clarno strata from the lowermost Big Basin unit of the ―John Day.‖ Note you can see it from the quarry side (where it is the prominent ridge on the skyline, see the photo on the geology panel) but not from the Painted Hills side of the Bridge Creek (where it isn‗t visible in the field).

Mural: The time-stratigraphic unit is the Hancock Mammal Quarry proper, with some material informed from the Crooked River assemblages. It‗s 07:30 AM in summer, looking south from the Hancock Mammal Quarry towards one of the large currently dormant stratovolcanoes of the Ochocho highlands. Note that several of the skulls in the painting are shown in position just prior to burial, as they may have appeared at the time prior to the deposition of the next fluvial mudfill/clay event. These skulls (especially the crushed *Diplobunops, Zaisanamynodon (=Procadurcodon),* and *Eobrontops*) are on display with larger specimen labels to reinforce this notion, and may pull people into complexity of the scene. The artist, Roger Witter, was encouraged to follow the actual quarry map (see flip books) in laying out the distribution of the bones and carcasses.

Specimens: Visitors note the obvious (―look at all the big things‖) size of some of these perissodactyls, and the diversity of them; the presence of another big reptile; the icon animal *Hemipsaladon* – a bizarre creodont - ; and much more. Most of these are borrowed specimens from the UCMP collections, or UO; our agreement with them is that we will borrow material and make casts, gradually replacing the originals as we go. There are hundreds of more specimens, however, and we will be ferrying new ones up and preparing them in the visible lab area as we progress, returning finished pieces, for a true ―win-win‖ relationship between our institutions.

Geology photo: The large photo is looking East from the rim of the mammal quarry; note the prominent John Day A as the rimrock near the skyline. The inset of Lon Hancock was taken in the early days, ca. late 1950‗s. This will be visible from Stop 3-1 on Day Three of this trip.

Bridge Creek Flora

Rockwork: It should be pretty obvious that this was taken from imagery of the Painted Hills; the ―popcorn texture‖ of the swelled clays was simulated by an ingenious blend of water and air pressure through the cement sprayer (see video). These are something of a caricature in that there isn't any section that looks quite like this up close; instead, we wanted to convey a compressed section such as can be found at Ruby Canyon on the flanks of Sutton Mountain. Interbedded with these, as they are in the field, are the lacustrine shales that contain the majority of the Bridge Creek leaves. These were taken from molds made by our staff at the Allen's Ranch east locality, near the boundaries of the Painted Hills Unit.

Murals: This is the other mural crafted by Larry Felder of New Jersey. It shows a fall scene at 09:00 AM to highlight the fact that *Metasequoia* is deciduous. One is facing towards the south, looking from the Bridge Creek locality across a lake towards the Ochocho highlands of the time. The time-strat unit is taken from the sites at Allen's ranch (type Bridge Creek) and Twickenham localities. See key to mural.

Specimens: The focus of Bridge Creek is rightly on the abundant leaves but vertebrates are known from the sites, as are everything from spiders to caddisflies. The *Metasequoia* icon fossil is featured in one of the cases. Note *Novumbra*, *Palaeotaricha*, and other vertebrates in drawer.

Geology photo: the large photo is of the Painted Hills from Stop 1-1 of this trip. The inset is a closeup of one of the leaf localities at the Allen's Ranch (Leaf Fossil Hills) assemblages, outside the park boundaries, where the cast was made of the lake beds.

To the right, is something of a metaphor: a cast we had produced of a live plant, *Metasequoia* (the Oregon ―State Fossil‖) that Chaney planted, currently growing at the Univ. of Calif. Botanical Gardens. The cast tree is apparently growing out of recent leaf litter (the litter itself was collected from another living direct descendant of the original Chaney tree: the one growing outside of the Department of Geology at the University of Oregon). Next to it is a fossil stump consistent with the genus.

Turtle Cove Assemblage

After the Bridge Creek, the visitor is confronted with a small diorama that makes use of the other side of the *Metasequoia*. The plants were made by Sue Evans-Olson and are entirely based on leaf shapes and venation found in extinct taxa, although only a paleobotanist would probably appreciate this subtlety. The *Pogonodon* and *Hypertragulus* specimens were molded and cast by Norris Peterson in several iterations, each peer-reviewed, and represent the first such attempts to model these taxa anywhere.

Rockwork: The molds for these forms were taken from outcrops up in Blue Basin, from Unit E1 of the Turtle Cove member.

Mural: It's 10:30 AM, in the Spring. Time-strat unit: Unit E prior to deposition of the Picture Gorge Ignimbrite and the Blue Basin Tuff, but shortly after one of the major ash falls blanketed the area... note the ashy hills in the distance. We are looking West across a forested low valley up to Blue Mountain anticline in distance (20 miles or so), with a meandering stream (like the ―black pebble unit‖ in Blue Basin) snaking through the landscape. The scene is primarily a woodland (eastern deciduous forest) with only a hint of grasses growing in the understory, as it would appear that grasses were not yet a significant component of the landscape. The artist, Roger Witter, was tasked to include many subtle elements in this mural: a shadow of a giant teratornid (since we don't have any more than a partial skull and proximal end of a humerus, this is there as a hint), a faintly-seen corpse on the streambank looking somewhat seal-ish (a nod to the presumably phocid relationships of the creature *Allocyon*), canids carting off limbs, horses kicking dogs, the juvenile *Eusmilus* in the tree rubbing its itchy deciduous tooth, and so on.

Specimens: The canid tracks behind the large icon *Pogonodon* skull in the case apex are casts of actual tracks from the A/B tuff up a draw near Sheep Rock, impressed into the Thoroc floor. Other footprints here include the rhinoceros tracks that lead from the rocks to the *Diceratherium* case; although there are some good rhino tracks in the local section, these particular imprints were modeled after ones we photographed at the Ipolytarnoc locality in Northern Hungary of a similar dicerathere. Note the large entelodont skull, the same species as the one mounted on the plinth outside at the entryway.

Geology photo: The large photo is of Blue Basin, taken from the Overlook trail and gives a good overview of the stratigraphy, visible during Stop 2-2 of this trip. The inset is the Foree section, one of the –type sections‖ we established for the –A-M‖ member concept within the Turtle Cove, seen on Stop 2-3.

Kimberly Assemblage

Tragically small space precluded putting many specimens here. The Kimberly unit encompasses the time roughly from the units above the Deep Creek Tuff to the base of the erosional gravels that hallmark the onset of the Haystack Valley and contains a diverse fauna. The assemblage concept is a reasonable simplification, but the stratigraphic terminology should be altered in the future. The exhibits anticipate this, deliberaterly refraining from mention of formal units.

Rockwork: This rockwork was taken from an outstanding exposure of the classic Kimberly non-zeolitized facies, located on BLM property not far from Spray, V70175 –Junction 2‖. See large photo in the geology panel. There is also a hint of the complexity and –intertonguing‖ of these strata with the green Turtle Cove on the vertical wall, which one can see on a much larger scale below the basalts on the face to the North of Sheep Rock.

Murals: It is about noon, in late Spring. The time-strat unit is prior to deposition of one of the major tuff units. 25 million years ago, this ash is –on its way‖ from an enormous caldera to the west. Additional specimen material from Lone Rock and elsewhere, and burrows from Johnson Canyon and environs, supplement the data set culled to produce the image. Painting by Roger Witter.

Specimens: Large oreodonts are typical of certain layers in the K unit of the strata, interspersed with layers containing abundant rabbits and rodents. There is an observable periodicity one can see in the beds (in both coarse and fine scales) that may be correlated with Milankovitch cycles in the Kimberly strata. This interpretation is not without controversy, but the rythmic sedimentary pulses are observable - whatever their origin. –See first, think later, then test. But always see first. Otherwise you will only see what you are expecting. Most scientists forget that‖ - Douglas Adams

Geology photo: Taken at the little hoodoo outcrops that the rockwork was molded from at the Junction 2 locality, 3 miles NW of Kimberly, seen at mile 61.7 on Day Two of this trip. The inset photo is from a locality near Crazy Woman Knob, near the intersection of the Highway 219 with Highway 207, mile 67.8 on Day Two of this trip.

Haystack Valley assemblage

These strata were studied for over a decade by different geologists with different perspectives just prior to our design, and the most thorough treatment of the strata came out as we were writing text and designing stratigraphic sections. Other interpretations are plausible; but it appears these units represent four separate depositional intervals spanning considerably more time than we thought. These strata are another good example of how much more work needs to take place to test a variety of hypotheses. The specific time-strat unit for this assemblage is the deposition of the stratified gravels as seen in localities preceding the age of PG-36, ―Bone Creek‖, with material from the Warm Springs exposures and time-equivalent beds supplementing the picture.

Rockwork: This is based on a typical section of the ―Rose Creek gravels‖ from the upper reaches of the strata. This specific matrix can be found high up the cliff face, just below the basalts, inside the boundaries at Foree. The cobbles we placed at the top of the Kimberly/Haystack divider section are the actual cobbles Hunt and Stepleton used to calculate the intermediate diameter clast counts from the Lone Pine locality, 10 of which are Welded tuffs.

Murals: It is 13:30, early summer, and one is facing towards the north and west. Note the emphasis on the stream, as we see quite a few examples of downcutting and erosion during this time of the record just prior to the onset of the basalts. The beardog looking back at you; the gravid chalicothere to the West, the camels, etc., are all good index fossils for these strata – see key to this Roger Witter mural.

Specimens: Note the ―Boochoerus‖ (the entelodont *Daeodon*) limb, collected many years ago. This is just the upper portion; the complete leg and foot is in collections. This is probably from these strata although the card data is vague, but we have since found dental elements consistent with this species in comparable beds. The *Merycochoerus* jaw was retrieved in the midst of a thick cobble conglomerate. See the specimen key and the assemblage discussion.

Geology photo: The large photograph was taken at the Rose Creek assemblage area; the Haystack units are the ―blond‖ colored gravels on top of the Kimberly visible from mile 54.0 on Day Two of this trip. The inset is an interesting lower unit of what some of us interpret as the Haystack, as exposed up a draw near Johnson Canyon near Kimberly, visible at Stop 2-5.

One walks through a thin passageway that is supposed to represent a walk south through Picture Gorge, essentially travelling upsection. The Picture Gorge Basalt impressions were fashioned after those seen in the colonnade layer to the West of the road just North of the road junction. That‘s a good place, incidentally, to see why originally Merriam included the Mascall Formation in the Columbia Basalt Group; later work reveals that these rocks in the Type Area are really only a peripheral outlier of a much bigger series of three basins running from the Cascades to Idaho.

Mascall assemblage

The time-strat unit for this assemblage is about 30m above the ―Mascall Tuff Unit‖ and its lateral equivalents.

Rockwork: This was lifted from the exposures in the type area, not far from the road at the pulloff south of Picture Gorge. If one looks carefully at parts of this, there are obvious burrow features and other sedimentological components. Where the rock goes up against the Rattlesnake, you‗ll note an exaggerated angular unconformity between the two. This is modelled after an exposure at a locality known as ―Confusion‖, where it actually is that high-angled a fault; in most sections it‗s only about seven degrees.

Mural: It‗s 3:00 PM, during ―the hot season‖. One is looking north; the prominent bulge suggests the feature responsible for the Monument Dike swarm, a very low-angled shield volcanic structure with fins in the distance. The flood basalt bulges are evident and are suggestive of what will later be dikes. Basalt flows are causing the ponding of water, and lakes are forming diatomite (green with algae) in middle distance. A Roger Witter mural.

Specimens: There are some very significant specimens in these cases, including some of the first records of elephantid-like beasts that migrated from Asia. Note the excellent skull of *Tephrocyon*, formerly known as *Tomarctus*. This was collected by Condon himself, and described as a new species, that later appeared in virtually every encyclopedia and textbook as the ancestor of all later dogs. The specimen Condon is holding in the entrance photograph (the one with the red quote) is this specimen before it was prepared in the 1890‗s. Note the icon creature *Dromomeryx* occupying the space front and center in the glass case.

Geology photo: The view should be familiar to many as that visible from the overlook seen at Stop 2-1 on Day Two of this trip; note the variability in paleosols and color patterns. Also note the Rattlesnake Ash-Flow Tuff overlying the strata.

Associated with the Mascall is a panel dealing with climate change. Although the visitor should have surmised that the general pattern is one of cooling, drying, and so forth, there are major fluctuations throughout the Neogene. The John Day Basin preserves these better than most other North American localities. One of these perturbations is the MMCO (Mid-Miocene Climatic Optimum), and the Mascall straddles this interval with a rich record of paleosols. Note the diatomites and other materials useful as proxies for climatic records.

Rattlesnake assemblage

These strata contain the ―principal correlate‖ of the Hemphillian North American Land Mammal Ages, the only unit in the park so designated.

Rockwork: Taken from an exposure near the confluence of Rattlesnake Creek and the John Day. Note typical fanglomerates and streamchannel deposits with interbedded paleosols, and here and there a rhizoconcretion (see lobby cases).

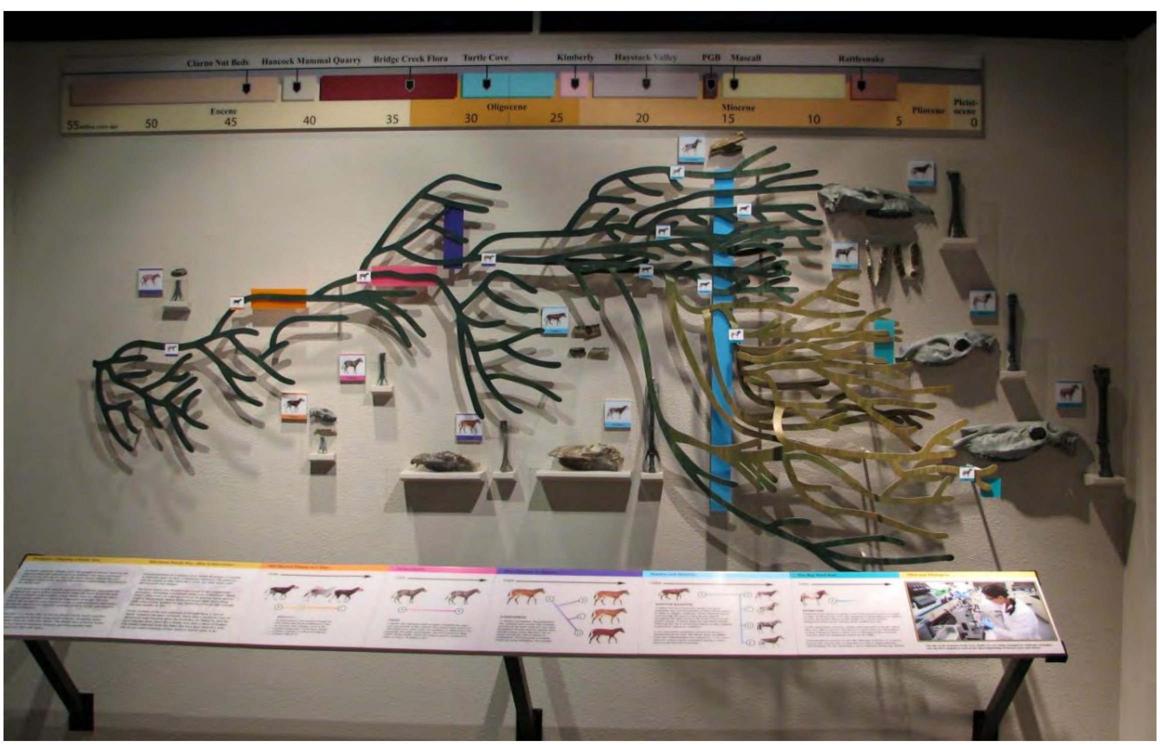
Mural: It‗s 6:00 PM (presumably some of the public may figure out the time proportions of the day vs. the time proportions of the strata), towards the end of August; much more seasonality is evident, much drier, etc. etc. The time-strat of this assemblage is exactly as the first transport phase and cooling unit of the Rattlesnake Ash-Flow Tuff is making its way into the basin from the Harney calderas. Vegetation towards South Fork Canyon is bursting into flames, bombs are flying, and there is smoke in the air. The Strawberry volcanic feature, which is believed to have towered 1,000 meters over its current height, is prominent on the skyline towering over Canyon Mountain and there is snow visible on top of the volcano. The landscape is a flat grassy plain with riparian vegetation along a river corridor indicated by a sinuous line of dense, green, riparian vegetation in the distance to the NE. The ramp of the fault and rimrock of basalt are visible. The scene is of an open woodland to dry shrublands with grasses becoming dominant.

Specimens: The icon *Indarctos* (―India bear‖) occupies a privileged space to itself; it represents one of the earliest documented examples of the migration of species across Beringia. The teeth are virtually identical to those found in a dead ringer of a bear of the same age in India.

Geology photo: A closeup of the Rattlesnake Ash-Flow Tuff atop a paleosol and gravels; the image typifies the strata at the type area for what will be the Rattlesnake Group. This will be visible from Stop 2-1 on Day Two of this trip.

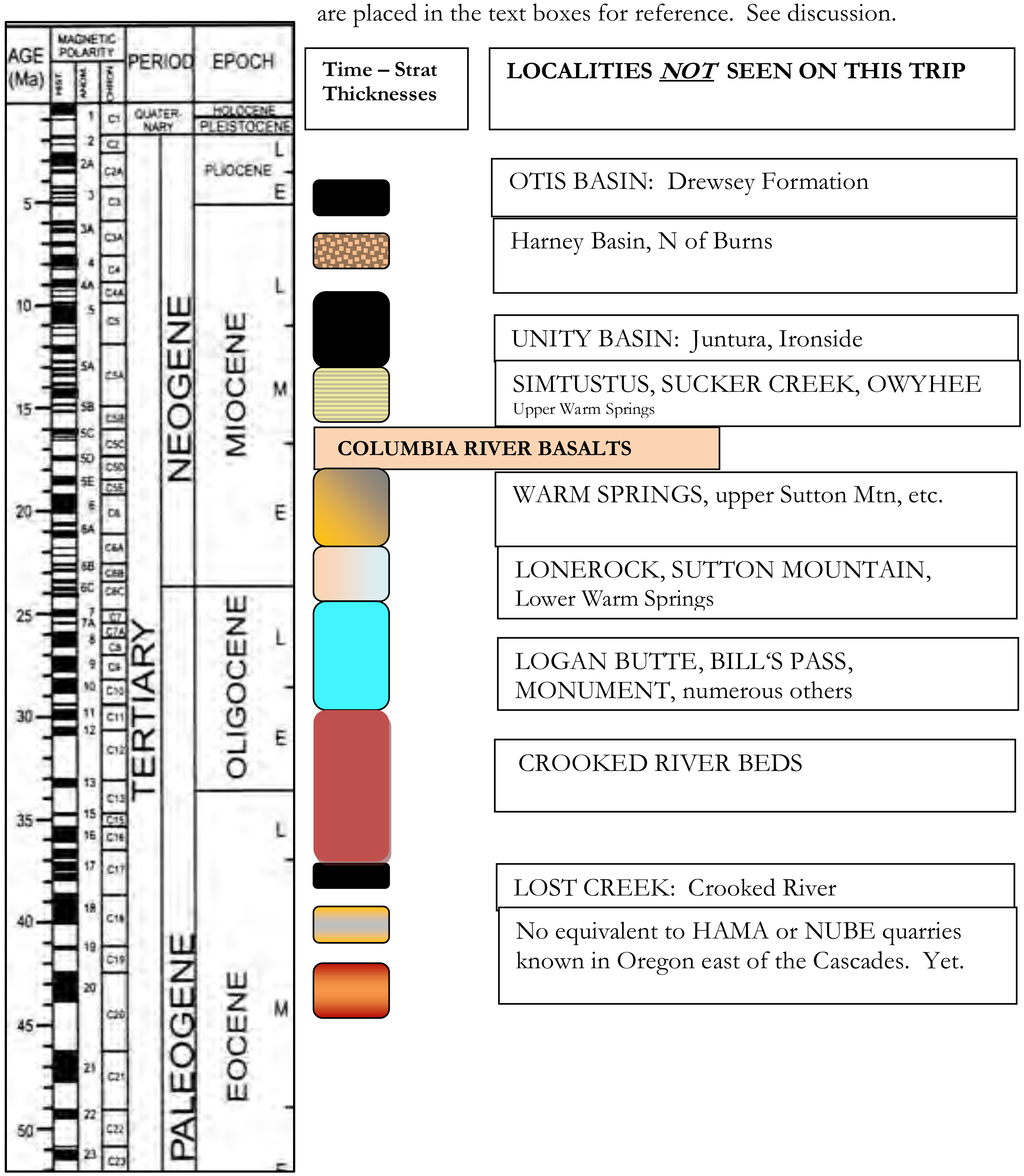
At this point, the visitor enters the ―So What‖ room, which has its own guidebook. One of the featured exhibits concerns equid evolution, consisting of a large, stylized stratocladogram.

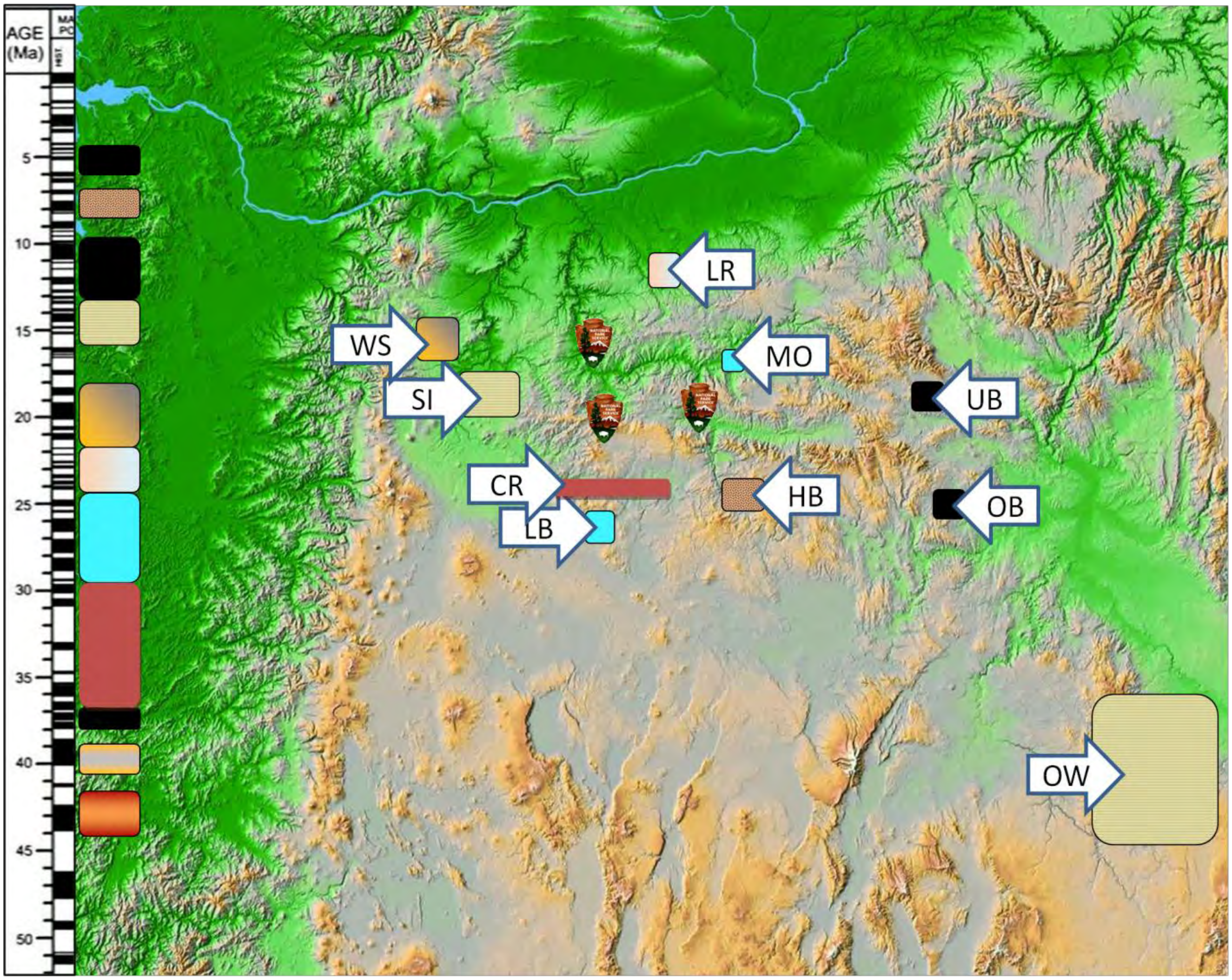
The equid stratocladogram in the "So What" room of the TCPC exhibit gallery. All of the >20 taxa figured in the squares, and the skeletal material, are found in the John Day region.



APPENDIX THREE: OTHER JOHN DAY RELEVANT LOCALITY AREAS IN VICINITY

Within the region, there are dozens of other basins and extensive outcrops that preserve geographic variability within the major assemblages, fill in ―gaps‖ in the stratigraphic and biostratigraphic record, or both. These are cartooned below; sites with no temporal equivalent of rocks viewed on this trip are symbolized with a black bar. Unvisited localities with important correlative assemblages are placed in the text boxes for reference. See discussion.





ABOVE: Spatial orientation of a few of the unvisited exposures on map of Oregon east of the Cascades, color-coded to temporal orientation and correlations with the ―major‖ assemblages.

: symbol represents the three units of John Day Fossil Beds National Monument. To the south is the Painted Hills Unit, east is Sheep Rock Unit (which should be renamed the Turtle Cove Unit), and the furthest north (up) is the Clarno Unit, to be visited on Days 1-3 in that order.

Key to locality groups :

CR: Crooked River. A complex of Clarno and lower and middle John Day sites.
HB: Harney Basin. Exposures of Rattlesnake strata, and sections spanning the 10-8 Ma interval.
LB: Logan Butte. A BLM paleontological area of Critical Environmental Concern (ACEC).
LR: Lonerock. Newly-recognized vertebrate locality in the Kimberly, screenwash site in the JD.
MO: Monument. Many localities in brick-red strata, lateral equivalents to the green Turtle Cove.
OB: Otis Basin. Extends the record up to early Pliocene.
OW: The Owyhee. Enormous area of thick sections spanning 20-10 Ma.
SI: The Simtustus exposures of the Mascall, including sites on Crooked River Nat'l Grassland.
UB: Unity Basin. Very fossiliferous areas east of Unity Resevoir, largely Clarendonian mammals.
WS: Warm Springs. Outstanding sequences within the Confederated Tribes Reservation.

MONUMENT LOCALITIES

Over 50 sites occur east of Turtle Cove surrounding the small town of Monument, OR and Cottonwood Creek. Initially thought to represent Big Basin or even Clarno strata, these brick-red strata are the same age as the sediments in Blue Basin. The Picture Gorge Ignimbrite is the thin resistant unit center right on the far hill (the ―Pflugradville‖ site); higher up the ledge-forming tuff is the Deep Creek tuff.

UNITY BASIN LOCALITIES

This exposure of the ―Windless Canyon‖ outcrop is part of the Ironside Formation, which contains numerous Clarendonian mammals including a complete skull of the proboscidean *Gomphotherium*. There are extensive exposures of these strata all the way south to the Juntura Basin, containing both terrestrial sediments with abundant mammals and diatomites with fish which should be studied (Shotwell, 1968).

LOGAN BUTTE

Extensive badlands containing abundant skeletal material in strata correlative to units A-E (in Turtle Cove) are found south of the Crooked River. A unique fauna includes material not known elsewhere, including the phocid *Allocyon loganensis*, the ―toy sabertooth‖ *Eusmilus cerebralis*, and a fluvial layer with abundant microvertebrates. This is probably the best TUCO site. See Hanson & Fremd (2001) and Dale Hanson‗s thesis.

SIMTUSTUS STRATA

The Simtustus sediments are basically a lateral equivalent of the Mascall Formation, here exposed along a roadcut built for the Lake Simtustus Dam. The strata contain rhinocerotids, *Dromomeryx*, camelids, equids, canids, and other Barstovian vertebrates similar to that found in the type Mascall outcrops.

HARNEY BASIN

Poorly studied, the thick exposures of variable sediments in this region, particularly within the Malheur Wildlife Refuge, contain Clarendonian faunas and appear to bridge the Mascall – Rattlesnake ―gap‖ that exists in the type areas. The Prater Creek (9.8 Ma) and Devine Canyon (8.6 Ma) welded ash-flow tuffs provide good age control.

NORTH OF CLARNO BRIDGE

Several localities are found north of the Clarno Unit, and include very productive horizons such as ―Sorefoot Creek‖ and ―Bill‘s Pass‖ (figured to the left). Near the base of Bill‘s Pass, correlative with Unit B of the Turtle Cove section, is articulated skeletal material of canids, oreodonts, and a peccary in association.

LONEROCK

One of the exposures of the Kimberly strata exposed northeast of Lonerock Creek, these sediments have yielded thousands of small vertebrates thanks to the work of Mr. Dwight Hoy, a volunteer who spent thousands of hours screenwashing. Lower in the section are large mammals including a massive beardog, rhinos, *Merycochoerus*, and equids typical of lower KIMB.

Leptodontomys cf. *douglassi* LM1 or 2

Alwoodia magna rm 1-3

Proscalops sp. A, rm1-3

Plesiosminthus clivosus RM1

Protosciurus rachelae lm1

Leptodontomys n. sp. Lm 1-2

Apeomys or *Arikareeomys* sp. lm1

Desmatolagus sp. lM

Petauristodon sp. RM3

Protosciurus n. sp. lm2

Herpetotherium merriami lM1

Plesiosminthus sp.

LEFT: Examples of microvertebrate material retrieved from the Lonerock locality complex, a northern exposure of the Kimberly assemblage. See Fremd and Whistler (2009) for a brief overview of these new collections. The figures represent more-or-less typical samples and illustrate the quality of preservation from this screenwash locality. The scale bar in all of the photographs is 1.0 millimeter.

From top left, across:

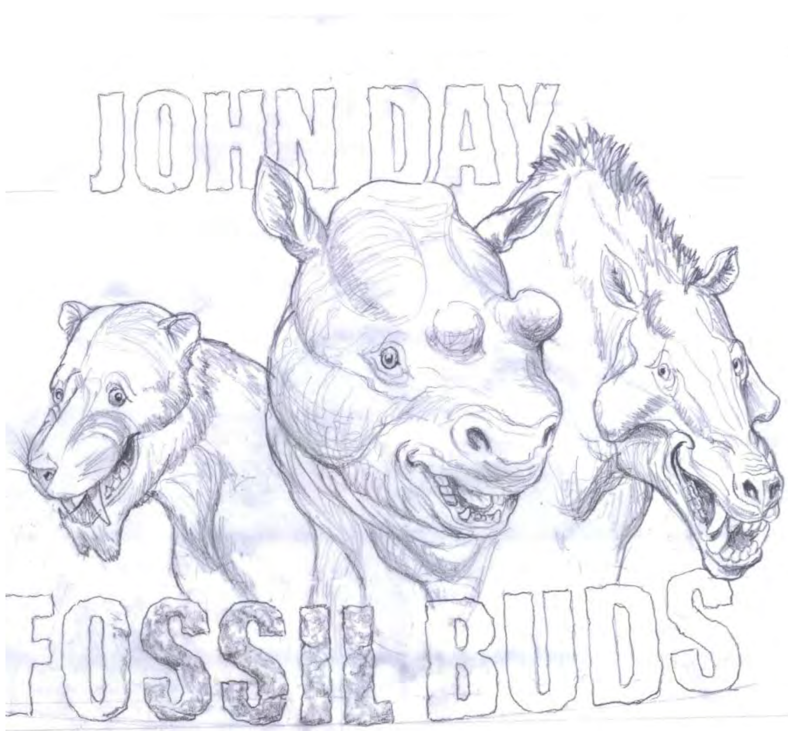
Leptodontomys cf. *douglassi*
Alwoodia magna
Proscalops sp. A
Plesiosminthus clivosus
Protosciurus rachelae
Leptodontomys n. sp.
Apeomys or *Arikareeomys*
Desmatolagus sp.
Petauristodon sp.
Protosciurus n. sp.
Herpetotherium merriami
Plesiosminthus sp.

NOTES

If you have corrections, suggestions, or comments that would improve the next edition of this guidebook, **please** send them to

Tfremd@uoregon.edu

Please include your full contact information.



ABOUT THE ARTISTS:

LARRY FELDER

Internationally respected for his remarkably detailed work with Mesozoic landscapes and dinosaurs, this was Larry‘s first foray into the Paleogene. He painstakingly perfected the floras in two of the featured murals in the Thomas Condon Paleontology Center (TCPC): the Clarno Nut Beds and the Bridge Creek Flora. His collection of works may be viewed at his website- www.larryfelder.com.

MARK HALLETT

One of the most renowned paleontological illustrators alive, Mark‘s collaboration was essential for detailing the osteology and ―fleshing out‖ many of the taxa that had never been attempted by previous artists. He was instrumental in bringing the creatures to life that you see in the murals of the TCPC. His collected works may be viewed at his website- www.hallettpaleoart.com.

DAVE SHIPLEY

Mr. Shipley was the Artistic Coordinator for the development and building of the TCPC. Not only indispensible in the coordination of the design, development, and construction phases of the project, his artwork is displayed in various areas throughout the TCPC; most notably in the Horse Tree exhibit and some necessary refinements in a few of the murals. He disdains websites.

ROGER WITTER

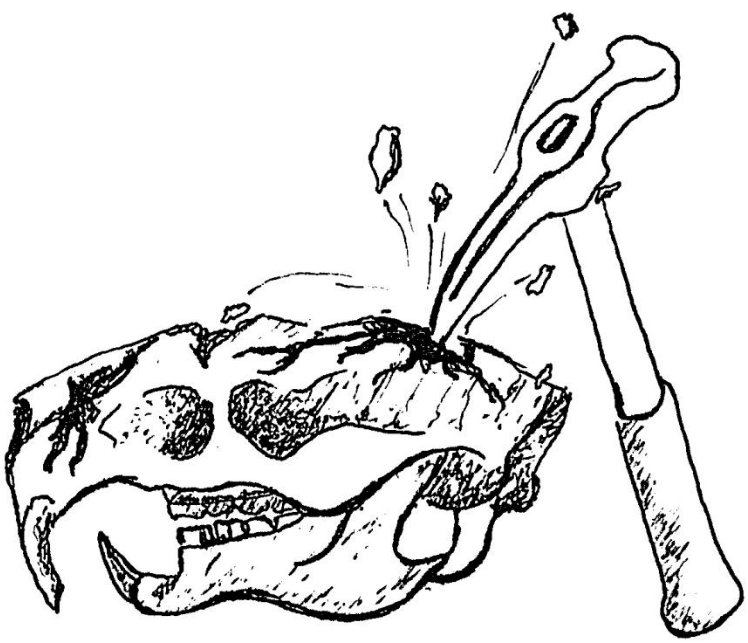
A renowned wildlife artist, most of the TCPC murals are Roger‘s contribution: the Hancock Mammal Quarry, Turtle Cove, Kimberly, Haystack, Mascall, and Rattlesnake. Based on attention to Mark Hallett‘s reconstruction sketches, and many hours of consultation with Fremd and peer reviewers, Roger dedicated his every waking hour for one year producing these murals. His work may be viewed at his website- www.rogerwitterdesign.com

MARGARET WILLIS

The art gracing the covers of this edition is by Margaret ―Maggie‖ Willis, who grew up in John Day, OR. After graduating from Moore College of Art and Design in Philadelphia, she was involved in the first **Artist in the Parks** program in 2004 at the John Day Fossil Beds National Monument, during which these paintings were made. For more about this talented young artist visit her website- http://www.margaretwillis.com.

ACKNOWLEDGEMENTS

First and foremost, Skylar Rickabaugh assisted with assembling the abstracts and references cited, was the Logistics Coordinator for the trip, and was critical to this effort in innumerable ways. Literally hundreds of students, colleagues, curators, NPS employees, volunteers, people from other agencies, many university faculty and staff, and other people have contributed to our knowledge of the John Day. With respect to assembling specific items for this road log, a few were particularly helpful. Regan Dunn formatted and AI‘d many of the graphics, including the stratigraphic charts, and I am grateful for learning I will not have to ever use CorelDraw again. Josh Samuels helped reformat and double check the faunal lists. Scott Foss and Matt Smith were most helpful in several ways and with graphics used in this volume. Barry Albright was the Co-coordinator and reviewed the ms., as did others. Many thanks to Kristen MacKenzie and Helen Strassel for their help during the trip. I am grateful to the owner of the Longview Ranch, Michael Dermody, and the ranch managers Leonard, Vicki, and Bobb Breck; and to Adam Temple, Irene Busmalis, and Alex (a future paleontologist) for their enthusiasm and access to the ―Collins Ranch‖. Many thanks to the Superintendent and Staff of John Day Fossil Beds National Monument for their support – for many years. The SVP staff, especially Kate VanZanten (Administrative Director) and Chris Viglione (Administrator), were invaluable in many ways. They are the best staff SVP has ever had! All the artists, Larry, Roger, Dave, Maggie, and Mark mentioned in the ―About the Artists‖ page helped populate empty pieces of canvas with glimpses of the past. Thanks to VIP Will Landon for taking the remarkable digital images of the murals from his unique camera apparatus. I am grateful to the Guest Scientist Program, co-sponsored by the Geological Society of America and the National Park Service, for support during this project, especially Lisa Norby of the NPS and Anny Jones of GSA. Finally, appreciation to the Department of Geological Sciences, the University of Oregon, for my excellent new office space in the Volcanology building, in which much of this was rewritten.



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"Blue Basin" Original oil painting of Blue Basin, by Margaret Willis