UTAH GEOLOGICAL SURVEY

SURVEY NOTES

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Fossil Discoveries in Grand Staircase-Escalante National Monument

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Design by Vicky Clarke

***Cover:** Utah's earliest documented dinosaur discovery at Flag Point, Vermilion Cliffs, Grand Staircase-Escalante National Monument: the legend of the Thunderbird revealed.*

Photos by John Foster and Alden Hamblin.

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The Director's Perspective

by Richard G. Allis

The article in this issue of Survey Notes promoting the oil and gas prospectivity of Utah raises a timely topic. The current high energy prices will stimulate a growing controversy: the need for continued economic development which does not compromise the unique environmental qualities of the state. During the 1990s Utah's demand for electricity grew at around 4% per year. Surplus capacity in the large coal-fired power plants built during the 1970s and 1980s provided a comfortable cushion for Utah's electricity growth through the 1990s. Today, at the start of winter 2000, electricity supply throughout most of the western U.S. is having difficulty meeting demand, and wholesale prices for natural gas have risen to unprecedented levels ($8–9 per MMBtu on spot markets, over four times the price 12 months ago). Stress on the electricity supply is likely to recur during the summer of 2001 in California, and possibly in other western states, because of delays in the construction of new or expanded power plant capacity.

Utah is rich in fossil fuel resources and should be capable of supporting significant additional electricity generation, whether it be coal- or gas-fired. During the 1990s, Utah's sold production of natural gas tripled, representing a growth rate of over 10% per year. This year, the number of petroleum wells commenced in Utah will be a maximum since the boom exploration years of the early to mid-1980s. Most of these wells are targeting gas, but very few have been genuine wildcats so far. If the high gas prices are sustained, Utah is likely to see many more wildcat wells, and exploration activity approaching the levels seen during the 1980s. New discoveries will be made.

This increased exploration activity and possible proposals for new power plant construction will take place alongside an increasing groundswell of opinion (and regulatory controls) demanding tougher environmental standards. The public and private sectors have grown used to abundant cheap energy in Utah during the 1990s, creating many opportunities now for major consumption savings. However, habits are hard to change rapidly. Technologies for fossil fuel-fired power plants have greatly improved emission quality as well as thermal efficiency since the 1980s. The surface impacts of coal mine operations are now greatly improved with footprints smaller than 25 acres possible, as demonstrated at the new West Ridge mine in east Utah. Improvements in deviated drilling technologies now allow large areas with deep resource potential to be accessed from a single drilling site, also minimizing the impacts in sensitive areas.

Two certainties arising from this situation are that we will see intense public debate concerning allowable sustainable development versus environmental protection, and we will all be paying more for our energy consumption. It is also likely that the 2000s will reverse the trend of the 1990s which was marked by decreasing job opportunities for earth scientists.

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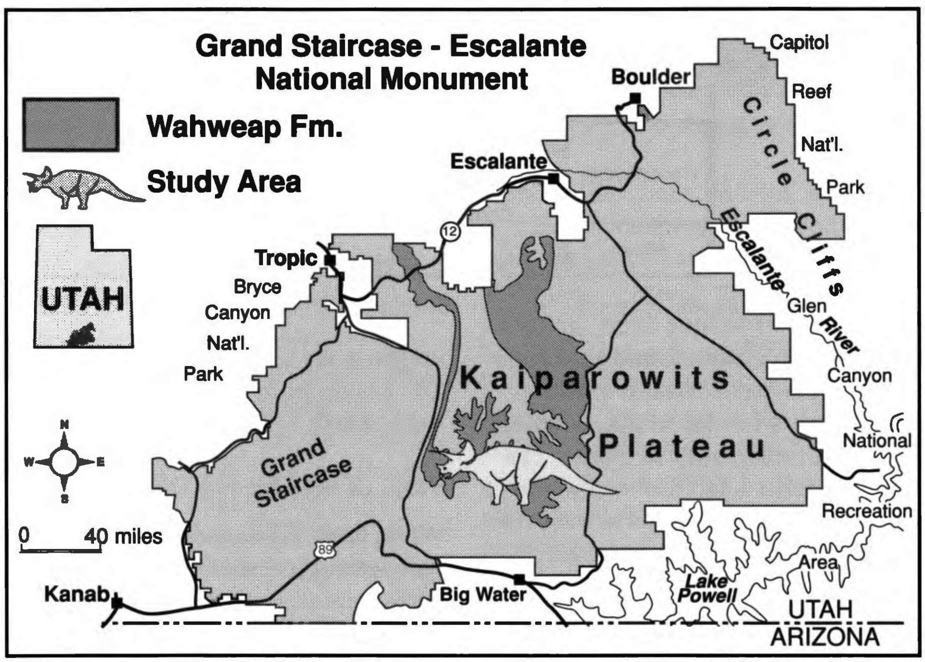
The Quest for New Dinosaurs at Grand Staircase-Escalante National Monument

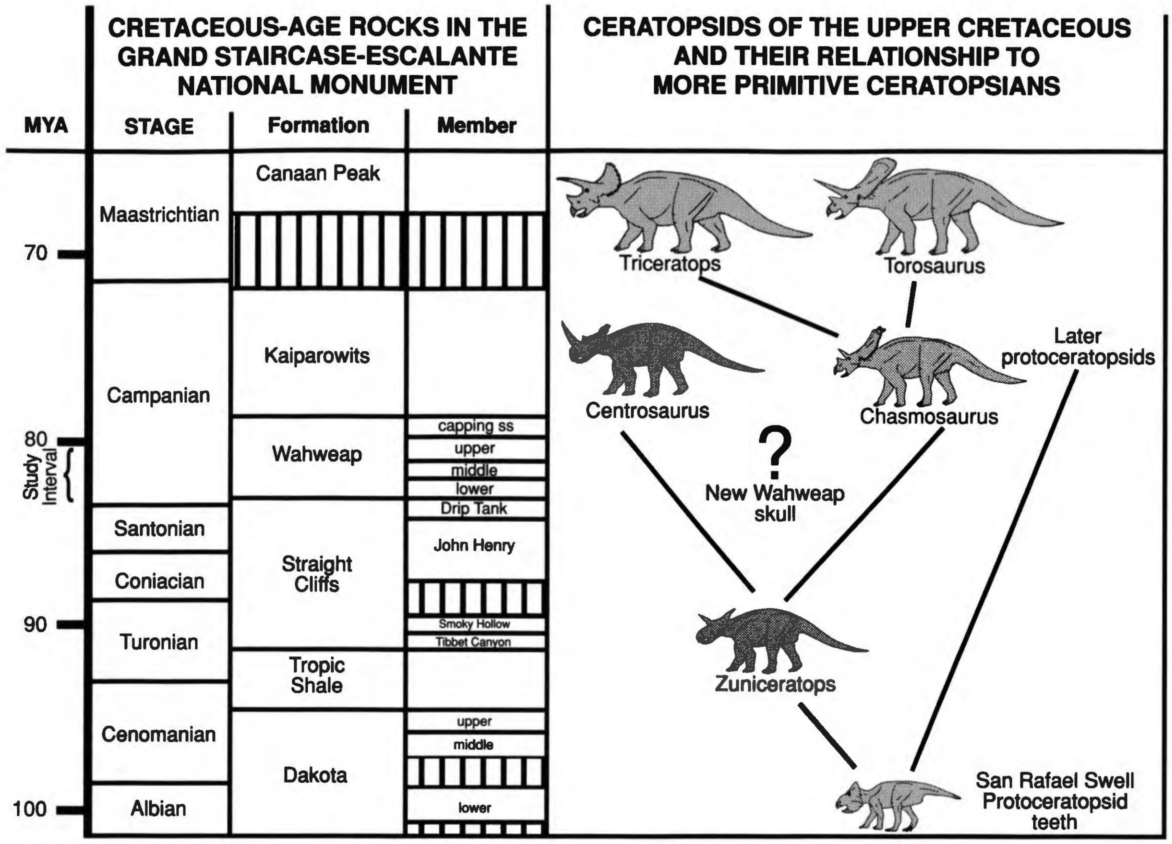
by James I. Kirkland, State Paleontologist

Introduction

During the past 18 years workers from several institutions (University of Colorado, Museum of Northern Arizona, Oklahoma Museum of Natural History, Utah Museum of Natural History, Utah Geological Survey, University of California at Berkeley, and Weber State University) have been conducting paleontological research within the recently designated Grand Staircase-Escalante National Monument (GSENM) in southern Utah. This research has focused on the more than 1¼ vertical miles of sedimentary rocks spanning the last 35 million years of the Cretaceous (the last period of the Mesozoic or "Age of Reptiles") exposed on the Kaiparowits Plateau. Sites have been found in each stage (a subdivision of time in a geological period) representing the Late Cretaceous in this area. This research has generated the most comprehensive and continuous Late Cretaceous fossil record of land animals known in our hemisphere, and possibly the world. In the future, this region will be the global reference for life on land for much of the Cretaceous.



This research has emphasized establishing sites preserving tiny bones and teeth (microvertebrate sites) for the purpose of identifying fossil mammal remains. Sediment containing the bone material is collected from such microvertebrate sites and washed over screens to remove the mud. Coarse material caught on the screens is then sorted under a microscope so the identifiable microscopic bones can be picked out. In this way a broad spectrum of the fish, frogs, salamanders, turtles, crocodilians, and mammals can be recognized. These microvertebrate sites can thus provide scientists with a fairly rapid view of the entire ecology of a locality. For paleontologists interested in fossil mammals, a productive microvertebrate site is considered significant even when it yields only two mammal teeth per ton processed, although most sites studied at GSENM are far more productive than that. Dinosaurs, which represent the top large plant-eaters and meat-eaters in these changing environments, were recognized from the teeth caught in the screens, which can only be identified to the family and in a few cases subfamily level (animals are classified from general to more specific type in the following way using humans as an example; Phylum Chordata, Class Mammalia, Order Primata, Family Homidae, Genus *Homo*, Species *sapiens*). Another point to consider is that a number of dinosaur groups are toothless and thus unrecognizable in microvertebrate sites. Although several thousand dinosaur specimens have been identified throughout the thousands of feet of terrestrial (land-deposited) rocks in GSENM, only two



Relationship of known ceratopsian distribution with strata preserved at GSENM; MYA refers to millions of years ago.

dinosaurs have been found that were complete enough to identify to the genus level. In order to document the diversity of dinosaurs in these rocks at GSENM, the Utah Geological Survey, in cooperation with the University of Utah, has begun a quest for dinosaur skeletons at GSENM that can be specifically identified.

Past and ongoing field research at GSENM suggests that the Upper Cretaceous basal Wahweap Formation has particularly high potential for yielding significant new data regarding the history of life in North America. There is only one named dinosaur from the early Campanian stage (84 to 80 million years ago) of the Late Cretaceous in all of North America. Already, collections of teeth from the basal Wahweap Formation at GSENM show that these rocks in Utah preserve the greatest known diversity of dinosaurs from this age in North America. The exposures of the lower part of the Wahweap Formation paralleling the roads across the southern Kaiparowits Plateau give outstanding access and present an important opportunity to study the land animals and plants from a little-known interval of Earth history.

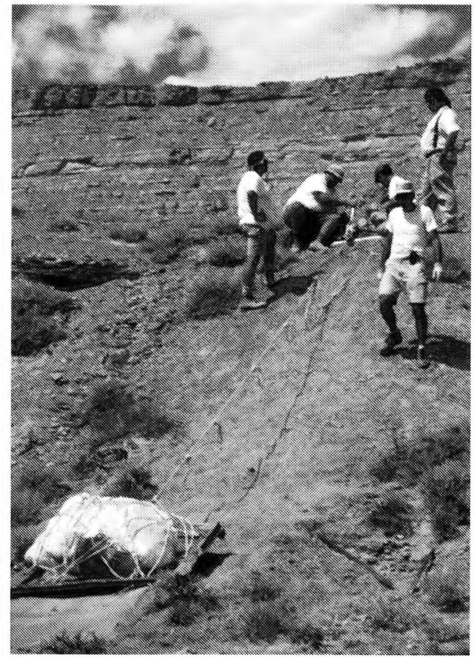
Skull of the Horned Dinosaur

While the UGS was conducting a paleontological survey of GSENM in 1998, a skull of a ceratopsid, or horned dinosaur, was discovered in the basal Wahweap Formation on the south end of the Kaiparowits Plateau. Triceratops is the best known of the ceratopsids, which represent a spectacular family of horned plant-eating dinosaurs that had only been recognized in Late Campanian to Latest Maastrichtian stages (80-65 million years ago) in North America. In addition to their large horns and the frill behind their heads, these dinosaurs are distinguished from their more primitive ancestors in that they have double-rooted teeth. Members of the ancestral and related dinosaur family called protoceratopsids generally lack horns and have single-rooted teeth, but they are grouped with ceratopsids into the ceratopsians based on having a beak and frill behind their head.

The newly discovered skull is the first ceratopsid specimen identified from the Wahweap Formation. Also, it is only the second undescribed ceratopsid species that has ever been found in Utah, following the 1930s description of *Torosaurus utahensis* from the latest Cretaceous North Horn Formation of the Wasatch Plateau, and it is the first new, undescribed genus. Although the skull had been exposed on the surface for several years and had broken into three major sections, it was obvious that it was an important specimen that required salvage. The Wahweap skull certainly represents a new genus as no early Campanian (84-80 million years old) ceratopsid has ever been described.

I had recently identified Utah's oldest known protoceratopsid ceratopsian on the basis of teeth from the upper Cedar Mountain Formation in the San Rafael Swell area of central Utah. Additionally, I co-described the ancestor to the ceratopsids as *Zuniceratops christopheri* from middle Turonian strata (~91 million years old) in west-central New Mexico. This animal has

Dragging large skull block on car roof to access road.



Winching the large skull block upslope.

the distinction being the oldest known ceratopsian with brow horns, but lacks double-rooted teeth. The new Wahweap fossil may provide important insights into the relationships between the ancestral ceratopsians and the better known ceratopsids of the latest Cretaceous.

In August 2000 the UGS, aided by the University of Utah, mounted an expedition to salvage the specimen. First, all the fragments of the skull had to be picked off the surface. Screening the surface guaranteed that no skull fragments were missed. Then the exposed bone surfaces were hardened with glue and encased in a plaster jacket for their safe transportation back to the UGS paleontological preparation lab. The skull sections were encased in a dense sandstone; once plastered, each block weighed hundreds of pounds.

The skull was found about one-third of a mile off an established dirt road and the excavation permit specified that no wheeled vehicle could be used to extract the massive sandstone blocks containing the skull sections. However, dragging the three blocks out to the road was allowable. For this, the roof of an old car was used as a sled. Each block was tied securely to the overturned car roof, which in turn was attached to a long rope for an eight-person team to pull the whole contraption across the landscape to the road. The largest block was pulled up a low slope by means of tow chains and a come-along. Once at the road, a chain hoist was used to lift the blocks into the truck for transport back to Salt Lake City.

In total, the process of collecting the skull took five days. The longest job still lies ahead, as it will take well over a year to remove the hard sandstone from around the bone and stabilize the skull for study. The illustration and description of the skull may take another couple of years, then Utah's newest dinosaur discovery will finally be officially identified and named.

Prospects of the Future

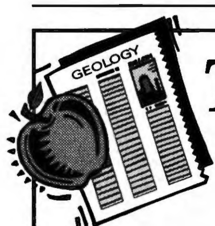
This discovery is just the first of what is expected to be a whole series of discoveries of new dinosaurs from this one thin geological interval as the UGS's research in this area continues over the next several years. Future research on the lower Wahweap Formation will include systematic prospecting for all paleontological resources within 1 to 2 miles of the access roads across the southern Kaiparowits Plateau. All fossil localities will be documented providing detailed information regarding not only the dinosaurs and other vertebrate animals, but also data about the fossil snails, clams, insects, and plants. Significant sites warranting additional research and/or excavation will be identified. A much more complete picture of what southern Utah was like during deposition of the lower Wahweap Formation will be developed from these data. Finally, this information will provide GSENM with data with which to develop specific management tools to ensure the protection and study of these fossil resources for the benefit of all.

Other geological horizons in the Wahweap and other formations in GSENM will certainly yield additional new dinosaurs as research on those geological intervals progresses. Just recently, I had the opportunity to accompany Dr. Scott Sampson and Mike Getty of the University of Utah and Doug Powell and Craig Sorenson of GSENM to examine a site near the top of the Wahweap Formation at the north end of the Kaiparowits Plateau. Here, part of the frill of an adult centrosaurine ceratopsid was found. Centrosaurines are ceratopsids with a short, ornate frill, a large nasal horn, and highly reduced horns above their eyes. This is the first fossil of a centrosaurine ever found in Utah. The future does indeed look bright for new dinosaur discoveries at GSENM.

Lower Campanian (83-79 mya, Aquilan) Dinosaurs in North America

The many indeterminate dinosaurs from the Wahweap Formation of Utah are based on tooth identifications. (Selma Chalk, Alabama (AL); Menefee Fm., New Mexico (NM); basal Two Medicine Fm., Montana (MT); Wahweap Fm., Utah (UT); and Milk River Fm., Alberta (AB); (after Kirkland, in press).

- Theropoda
  - Dromaeosauridae
    - Indet. dromaeosaurine (UT, AB)
    - Indet. velociraptorine (UT)
  - Troodontidae
    - Indet. (UT)
  - Ornithomimidae
    - Indet. (AB)
  - Tyrannosauridae
    - Indet. aublysodontine (UT)
    - Indet. tyrannosaurine (UT, NM, AB)
      - cf. *Albertosaurus* sp. (AL)
- Indeterminate Family
  - cf. *Richardoestesia* sp. (UT)
  - cf. *Paronychodon* sp. (UT, AB)
- Ankylosauria
  - Nodosauridae
    - Indet. (UT, AL, AB)
  - Ankylosauridae?
    - Indet. (UT, NM)
- Ornithopoda
  - Hypsilophodontidae
    - Indet. (UT)
  - Hadrosauridae
    - Hadrosaurinae
      - *Gryposaurus latidens* Horner, 1995 (MT)
      - Indet. (NM, UT, AB)
    - Lambeosaurinae
      - Indet. (UT)
- Pachycephalosauria
  - Indet. (UT)
- Ceratopsia
  - Protoceratopsidae
    - cf. *Montanaceratops* new genus and sp. (MT)
  - Ceratopsidae
    - New genus and species "unprepared" (UT)
    - Indet. (AB)
  - Centrosaurinae
    - Indet. (NM)



Teacher's Corner

NEW! Teaching Packets for your Classroom

The UGS is developing teaching packets that you will be able to check out with a refundable deposit. The first available is the "Earthquake Teaching Packet." Other topics being considered include soils for K-6, guides to rock and minerals, Great Salt Lake, local geology, and volcanoes.

Now available! ***Earthquake Teaching Packet*** contains slides, activities, and more:

- *A Teacher's Handbook on the Earthquake Hazard in Utah*, 1992, created for grades 7-12. In addition to 28 pages of text, the handbook contains diagrams, figures, tables, glossary, 6 activities, and 30 slides with descriptive captions.
- *Earthquake Awareness & Risk Reduction in Utah*, 1991, 24-minute video developed by Utah State University. Explains and illustrates the different ways earthquakes can cause damage, and discusses what can be done to minimize damage.
- *Earthquakes & Utah*, 1997, 8-page brochure answers the questions of where, why, and how often earthquakes occur in Utah; how big they are and how they are measured; and what may happen during an earthquake.
- *The Wasatch Fault*, 1996, 18-page brochure with photos, diagrams, and explanations.
- *Homebuyer's Guide to Earthquake Hazards in Utah*, 1996, 27-page pamphlet describes and illustrates the hazards of ground shaking, liquefaction, fault rupture, slope failure, and flooding.
- *Earthquakes - What You Should Know When Living in Utah*, 22 pages of important information from the Utah Division of Comprehensive Emergency Management.
- *Earthquake Ground Shaking in Utah*, 1994, 4-page pamphlet.
- *Earthquake Hazards & Safety in Utah*, 1990, 4-page pamphlet.

Materials in this packet are appropriate for grades 5-12, with the majority most applicable for grades 7-12.* Call 801-537-3300 to reserve the kit, which must be picked up and returned to our office at 1594 W. North Temple, Salt Lake City. A $25.00 refundable deposit is required.

While you are at our office, you can also pick up several related items (for free!) to use and keep in your classroom (ask Geologic Extension Service staff):

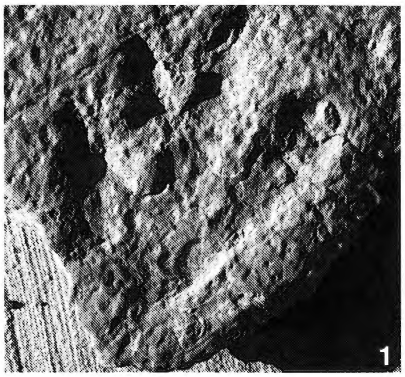
- a colorful poster of a block diagram of the Wasatch fault
- fault block models
- liquefaction-potential maps of Box Elder, Weber, Davis, Salt Lake, and Utah Counties
- fault maps of Box Elder, Weber, Davis, Salt Lake, or Utah Counties

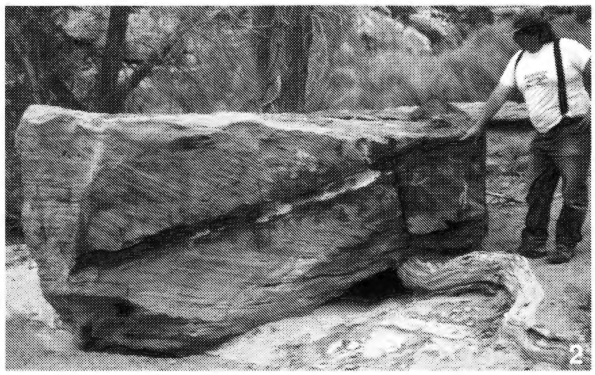
** contact Sandy Eldredge for suggestions for K-6 earthquake-teaching materials.*

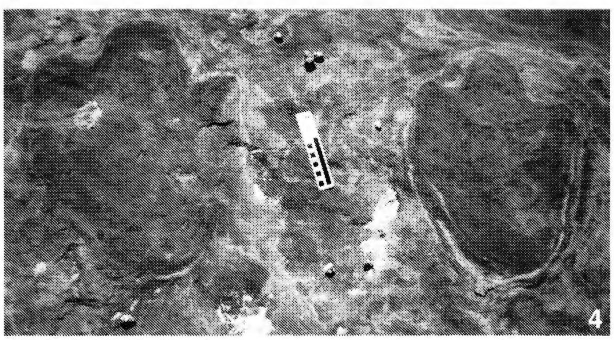
WE WANT YOUR FEEDBACK!

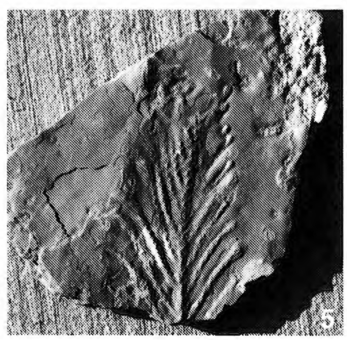
Please contact us with specific requests or ideas for packets that woud be of help to your grade level. Contact Sandy Eldredge at 801-537-3325, 801-537-3400 (fax), nrugs.seldredg@state.ut.us

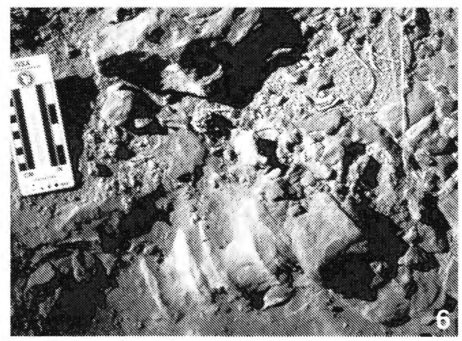
A Pictorial Essay of Fossil Life in the Grand Staircase - Escalante National Monument Unveiled by UGS Staff











1. *Pseudotetrasauropus;* a possible prosauropod dinosaur track from the Late Triassic Chinle Formation.
2. Cast of log in the Late Cretaceous Drip Tank Member of the Straight Cliffs Formation.
3. *Placenticeras;* an ammonite from the Late Cretaceous Tropic Shale.
4. Theropod dinosaur tracks from the top of the Middle Jurassic Entrada Formation.
5. Araucarian conifer branch from the Late Triassic Chinle Formation.
6. A string of tail vertebrae from a hadrosaurid or duck-billed dinosaur in the Late Createaceous Kaiparowits Formation.
7. Theropod dinosaur under-tracks from the top of the Middle Jurassic Entrada Formation.
8. Sauropod dinosaur tracks showing a rare tail drag from the top of the Middle Jurassic Entrada Formation.

Environmental Change and Human Habitation Along the Old River Bed, Tooele County

by David B. Madsen

Introduction

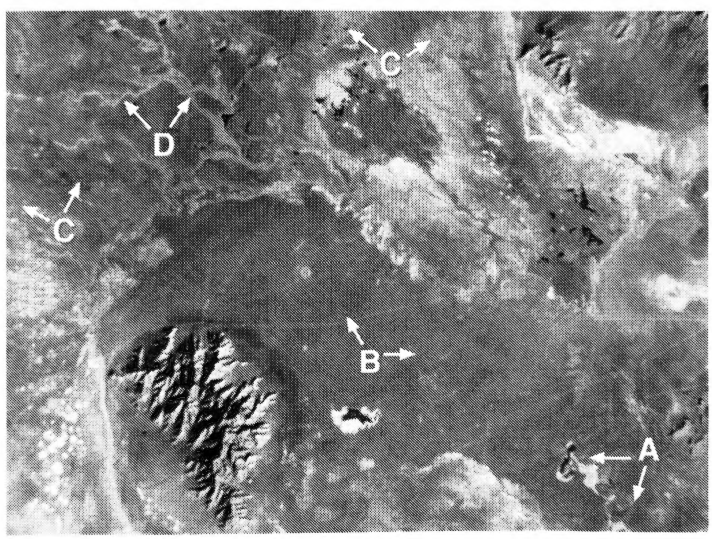
During the regressive phase of the last major highstand of Lake Bonneville, the Old River Bed (ORB) in Utah's western deserts held a river connecting the two major subbasins of the Bonneville basin. Beginning sometime before about 12,000 years ago, the river flowed north, draining the Sevier basin and emptying into Great Salt Lake along its southwestern margin in what is now the Great Salt Lake Desert. Sometime after about 9,000 years ago, water ceased to flow in the ORB and environmental conditions along the channel began to approach those found today. During the approximately 3,000 years of its existence, however, water in the river fed a large marsh/wetland system at the ORB delta and supported a riverine environment along its length. This 3,000-year interval corresponds almost exactly to the earliest "Paleoarchaic" phase of human occupation in the Bonneville basin. Foragers have been drawn to rich marsh/wetland ecosystems throughout the human history of the Great Basin, but archaeological sites of the Paleoarchaic period are particularly associated with Great Basin wetlands.

Because the delta lies entirely within the confines of the U.S. Army's Dugway Proving Ground, as do approximately 20 miles of the lower ORB channel, Dugway Proving Ground and the Utah Geological Survey have entered into a cooperative agreement to investigate human adaptation to environmental change in the ORB delta. Relatively pristine Paleoarchaic sites may exist in the delta area. Most major wetlands in the Great Basin lie at the end of major river systems, such as the Humboldt, Bear, and Carson Rivers, and have been in existence for at least the period of human occupation in the region. As a result of both continuous use of these marshes by foragers and erosional/depositional cycles associated with Holocene climatic changes of the last 10,000 years, intact Paleoarchaic sites are relatively rare. The ORB delta differs in that it was forming for only a limited time during the Paleoarchaic period and, while erosion has taken place since that time, there has been no movement of the marsh ecosystem back-and-forth across the landscape which would result in the disturbance of early sites. Moreover, after about 8,500 years ago, the area became relatively unattractive to hunter-gatherers and the impact that human activities generally have had on early sites in most major wetland systems was probably much more limited.

Our principal research goals in the ongoing project are therefore to: (1) search for, and define the nature of archaeological sites in high-impact areas of the ORB delta, (2) determine the paleoenvironmental parameters, particularly the paleohydrological parameters, that structured the placement of those sites, and (3) identify and map Paleoarchaic sites.

Paleohydrology of the Old River Bed Delta

Primary geomorphic features of the ORB delta consist of the delta itself, mudflats to the north of the delta, and a series of dunes that marks the transition between the two. Two major hydrologic features, which we informally call "gravel channels" and "sand channels," have been identified within this setting. Gravel channels are deposits of coarse sand and gravel that have a curved, slightly mean-



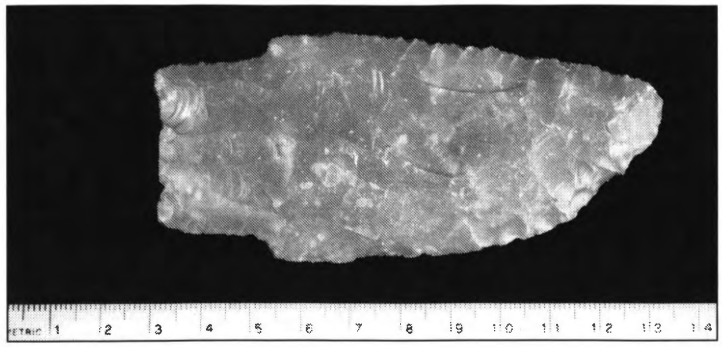
Digitally enhanced satellite image of the Old River Bed delta area in western Utah showing the incised upper channel (A), underflow fan deposits (B), mudflats (C), and the exhumed and topographically inverted gravel channels (D). Granite Peak is the isolated mountain in the lower left. Image courtesy of Jack Oviatt, Kansas State University.

dering, digitate form on the mudflats at the north end of the ORB delta. They are topographically inverted (topographic lows when formed but topographic highs now) and are identified as fluvial in origin by their plan-view form, the composition of the gravel, and their longitudinal profile. Sand channels are not topographically inverted (except where they have been protected by dune formation) and are generally flush with the mudflat surface. They exhibit floodplain morphology, with multiple point-bar sands and meandering patterns. Sand channels are filled with fine to coarse, cross-bedded sand. Abandoned channels and oxbows contain mud, organic debris, and abundant molluscs.

The ORB delta is composed, for the most part, of silts and clays in an underflow fan deposited on the bottom of Lake Bonneville after the lake regressed below the ORB threshold and the ORB river began to dump fine sediment into the lake. As the lake regressed across this underflow fan, the fan prograded to the north, wave action cut a relatively flat surface across its top, and the river channel was incised in the fan at increasingly deeper levels as the lake level dropped. During this initial regressive phase, the water in the river was derived from overflow from the Sevier basin (and, by extension, from the Sevier and Beaver Rivers), and the current in the river was sufficient to support a high sediment load, including coarse sands and gravels in the deeper and swifter current. Sometime just prior to about 10,000 years ago, the Sevier basin stopped overflowing, stream flow in the river was substantially reduced, and as the lake retreated to the north the river ceased to empty into it. By the time the gravel channels had stopped forming, the lake had dropped to an elevation of 4,260 feet. After 10,000 years ago stream flow likely derived from ground-water sources, but this was substantial enough to carry coarse sands in channels 10-15 feet wide and 5-10 feet deep.

Dating of this sequence is currently underway, but the age of the sand channels is relatively well controlled by seven radiocarbon dates directly on materials in the channels and eight others on marsh/wetland deposits associated with the channels. These 15 dates place the formation of the sand channels between about 9,900 and 8,800 years ago. The age of the gravel channels is less clear, but a single limiting date suggests that they began forming after about 12,500 years ago. Additional dates on marsh/wetlands not directly associated with either gravel or sand channels fall between 11,400 and 10,000 years ago. Together with fish remains in the sand channels, these wetlands suggest some water continued to flow in the ORB throughout its entire history.

After about 8,800 years ago, deflation (removal of fine sediment by wind action causing the land surface to be topographically lowered) of the mudflats accelerated. This deflation exhumed the gravel channels and partially exhumed the sand channels. The dunes along the margin between the delta plain and the mudflats likely formed sometime during the early mid-Holocene, and have probably been in place since then. Exposures within the dunes suggest that they have been stabilized a number of times during this period.



This "Cody knife" found along the sand channels of the Old River Bed is characteristic of late Paleoarchaic occupations dating from 9,000 to 10,000 years ago in the eastern Great Basin and northern Great Plains. Image courtesy of Charlotte Beck, Hamilton College.

Archaeology of the Old River Bed Delta

The most complex archaeological sites in the ORB delta are associated with the sand and gravel channels most evident along the eastern and northern margin of the flat delta plain. More precisely, they are associated with the sand channels, since sites on or immediately adjacent to the gravel channels must necessarily be younger than the channels, given the high-energy environment that created them. The gravel channels formed a barrier along which the stream that created the sand channels flowed, and they were apparently used by human foragers as high ground overlooking the sand channels and their associated resources. These sand-channel rivers appear to have meandered extensively through the delta, creating a vast wetland system with relatively few areas suitable for habitation or for activities not directly associated with foraging in the marsh itself. The only dry areas were probably the gravel channels and natural levees formed along the sand-channel margins, and it is these areas where archaeological sites appear to be concentrated.

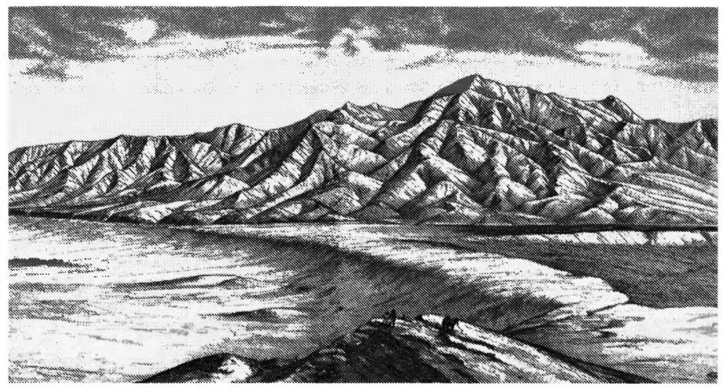
The sites along the sand channels are characterized by the presence of late Paleoarchaic diagnostic artifacts, including numerous Great Basin Stemmed points, that all date between about 11,000 and 7,500 years ago. We have little direct evidence of the foraging activities of the people who occupied these sites, other than that they likely focused on the marsh/wetland resources that dominated the ORB delta landscape at the time. What is most curious about the artifact complex we identified is that it lacks ground stone, suggesting that seed collecting and processing was not part of the subsistence focus. Whether foraging was limited to large and small game animals or included other plant resources such as marsh tubers is presently unknown. It is possible that the fish in the ORB river were also being exploited.

Geoantiquities~Earth History in the Urban Landscape

by Marjorie A. Chan, Geology and Geophysics Dept.
and Donald R. Currey, Geography Dept.,
University of Utah, Salt Lake City

What are geoantiquities?

Geoantiquities are records of Earth history, in which natural landscapes preserve material evidence of geologically recent surface processes and environments. Utah's Lake Bonneville basin contains excellent examples of geoantiquities. The natural records left by 29,000 to 15,000-year-old (24,000-12,700 radiocarbon years) Lake Bonneville are prominent shorelines, deltas, bars, spits, and beaches. These loose, unconsolidated sediments can easily be disturbed and are vulnerable to removal and burial, particularly in areas like the Wasatch Front where growth rates are currently double the national average.



The Stockton Bar, a prominent ridge of beach gravels, as viewed to the east (Oquirrh Mountains in distance) in 1890 (from Gilbert, G. K., 1890, Lake Bonneville: U. S. Geological Survey Monograph 1, 438 p.).

Importance of geoantiquities

Geoantiquities are important for the following reasons:

- Community Aesthetics: Geoantiquities form a picturesque landscape and natural open space (for example, Bonneville Salt Flats, Bonneville Shoreline Trail of the Wasatch Front, Stockton Bar of Tooele County, and glacial valleys and moraines of Little Cottonwood Canyon and Bells Canyon).
- Community Ethics: The community can endow to future generations a window on Earth history, and a landscape preserved to enhance the quality of life.
- Basic Science: Scientists use sediment records to learn what physical, chemical, and biological processes have acted in the geologically recent past. For example, studies on Lake Bonneville geoantiquities tell us about global change, past climatic conditions, and how wind and water influence sediment transport.
- Applied Science: Geoantiquities help us understand geologic processes and allow us to better predict rates of change, and to assess local natural hazards.
- Community and Environmental Education: Geoantiquities provide people of all ages with a natural outdoor laboratory of Earth-surface history (for example, Great Salt Lake, Antelope Island, the Stockton Bar, and shorelines of the Wasatch Front).

Geoantiquities heritage area

The Utah Geoantiquities Heritage Program is an outgrowth of University of Utah research on the interactions of earth science in the urban landscape. Our mission is to inventory regional geoantiquities, identify those that warrant community recognition as geoantiquities heritage areas, and foster community-based geoantiquities heritage planning.

Geoantiquities heritage areas have three essential characteristics: (1) they include intact remnants of distinctive natural landscapes, (2) they contain scientifically important records of geologically recent environmental history, and (3) they are at great risk of damage or loss by consumptive land uses.

The future

The future of geoantiquities lies in the complex and dynamic interactions of Earth science, urban development, informed citizenry, and community vision. We hope that research such as ours will strengthen connections between science and the community and promote informed, wise management of geoantiquities in the urban environment.

For more information see Utah Geoantiquities Heritage Program Web Site: http://www.geog.utah.edu/geoantiquities/index.htm

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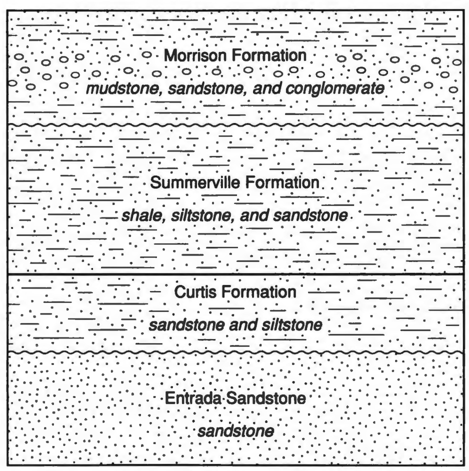
"Glad You Asked"

by Christine Wilkerson

What is a formation?

To classify and map layers of rock, geologists created a basic unit called a formation. A formation is a rock unit that is distinctive enough in appearance that a geologic mapper can tell it apart from the surrounding rock layers. It must also be thick enough and extensive enough to plot on a map.

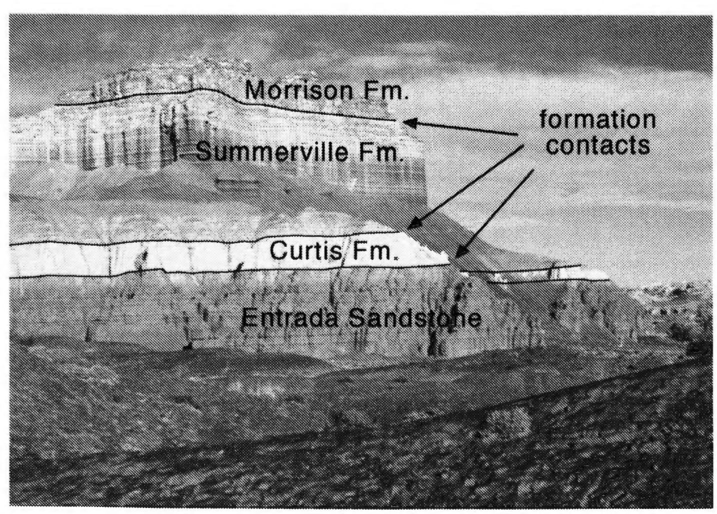
Formations are given names that include the geographic name of a permanent feature near the location where the rocks are well exposed. If the formation consists of a single or dominant rock type, such as shale or sandstone, then the rock type is included in the name. For example, the Entrada Sandstone is a predominately sandstone formation located in southern and east-central Utah. It was named in 1928 after Entrada Point in the northern part of the San Rafael Swell. Formations often contain a variety of related or interlayered rock types, and in these cases the word 'formation' is used instead of a single rock type. For example, the Summerville Formation consists of thin alternating beds of shale, siltstone, and sandstone. This formation was named after Summerville Point, located near the head of Summerville Wash in the northern San Rafael Swell.



Formations are distinctive, mappable rock units that differ from adjacent rocks.

Formations can be lumped together into larger rock units called groups, and divided into smaller units called members. Groups are useful rock units for small-scale mapping and regional studies, and members are useful where it is important to study or keep track of a particular subdivision of a formation. The Entrada Sandstone and Summerville Formation, along with several other formations, are part of the San Rafael Group. In southeastern Utah, the Entrada Sandstone has been divided into three distinct members: the Dewey Bridge Member (bottom), whose lower part is dominated by yellow-gray, flat-bedded sandstone and whose upper part contains mostly red-brown sandstone with "lumpy" bedding; the Slick Rock Member (middle), a red-orange to brown sandstone that is usually striped or banded in color; and the Moab Member (top), a pale-orange to pale-yellow-brown sandstone that weathers to white or light gray.

Before a new formation name will be accepted, a formal definition including a full description of the unit and the location of the type locality must appear in a widely known scientific publication available to geologists. The recommended procedures for classifying and naming rock units are contained in the North American Stratigraphic Code prepared by the North American Commission on Stratigraphic Nomenclature. If you would like to learn more about the Stratigraphic Code, please visit the Commission's web site at www.agiweb.org/nacsn/.



The Entrada Sandstone and overlying formations are exposed at Wild Horse Butte in Goblin Valley State Park, Utah.

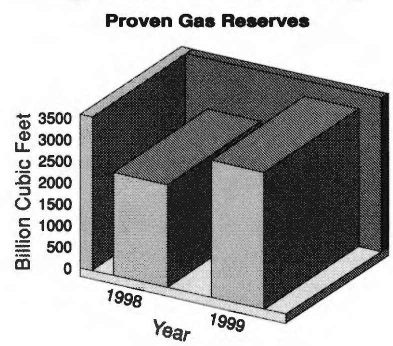
Energy News

Utah is the Place–To Drill for Oil and Gas

by Thomas C. Chidsey, Jr.

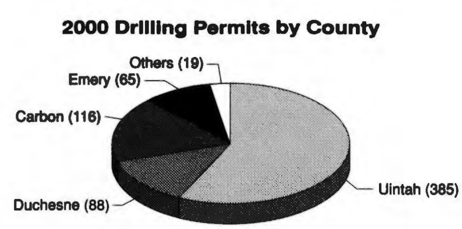
The average American uses 26 barrels of crude oil and 85,000 cubic feet of gas per year (a large tanker truck holds about 285 barrels of oil). Everyone who drives a car knows what gasoline prices at the pump have been doing over the past year, and most recently we have seen the cost of heating our homes skyrocket. There are many factors that have caused the sharp price increases, but the main reason is the difficulty that petroleum producers have in meeting the growing demand for petroleum products. OPEC (Organization of Petroleum Exporting Countries) controls most of the world supply of crude oil and thus the price per barrel. The worldwide supply shortage in turn affects the price of oil produced domestically because the U.S. imports more than half its oil. In Utah, the average wellhead price of crude oil during 2000 was $29 per barrel, more than double what it was two years ago. The wellhead price of Utah natural gas has also risen dramatically from an average of $2 per thousand cubic feet in 1999 to $3.42 per thousand cubic feet in 2000. During December 2000, the average price was $6 with spikes over $12 (based on southwest Wyoming spot gas prices).

Higher petroleum prices affect all of us, but do they also really affect exploration and production drilling domestically, or particularly in Utah? The answer is a resounding yes! Two key, interdependent factors lead to increased petroleum industry drilling efforts: (1) price of oil and gas, and (2) success in discovering commercially productive wells. It does not matter what the price of oil or gas is if companies drill too many dry holes. If that happens, they will leave an area for greener pastures. Fortunately that has not been the case in Utah, which recently had the greatest addition of natural gas reserves in the Rocky

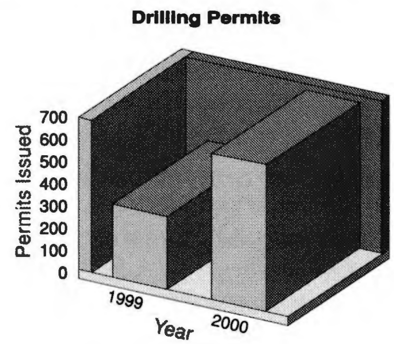


Mountain region, increasing from 2.4 trillion cubic feet (Tcf) in 1998 to 3.2 Tcf in 1999 -- a rise of 35 percent.

These gas-reserve additions were primarily due to successful drilling activities in two areas: the eastern Uinta Basin and the "Ferron Fairway" of east-central Utah. The primary drilling targets in the eastern Uinta



Basin are tight (low permeability - a measure of how well gas or fluids can flow through the pores in rocks) sandstones of the Tertiary Wasatch Formation (62 to 48 million years in age)



and Cretaceous Mesaverde Group (82 to 76 million years in age) deposited by braided, coastal-plain, and alluvial stream channels. The Ferron Fairway produces coalbed methane (gas both generated and produced from coals) from the Cretaceous Ferron Sandstone. Continued interest in these two areas is reflected by the high number of drilling permits issued in 2000, particularly for Carbon, Emery, and Uintah

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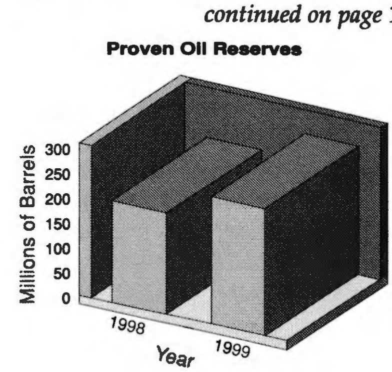


GeoSights

Natural Arches in the Cedar City Area

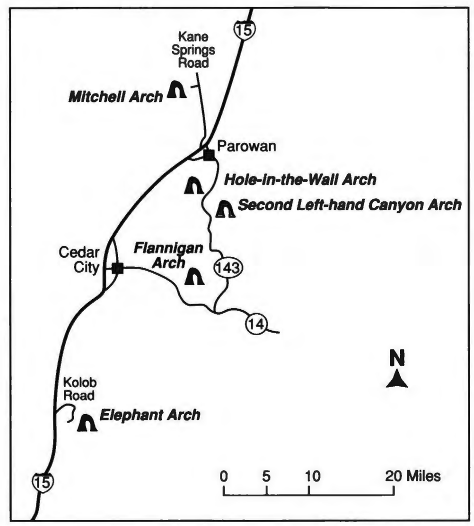
by Steve Heath

Cedar City is near the borders of the Great Basin, the Colorado Plateau, and Utah's largest volcanic complex. Arches, which exist in a variety of geologic formations in this area, exhibit some of the region's geologic diversity. Cedar City generally is not known for hosting arches, yet within a 30-mile radius there are more than a dozen arches. Described here are five of these features.

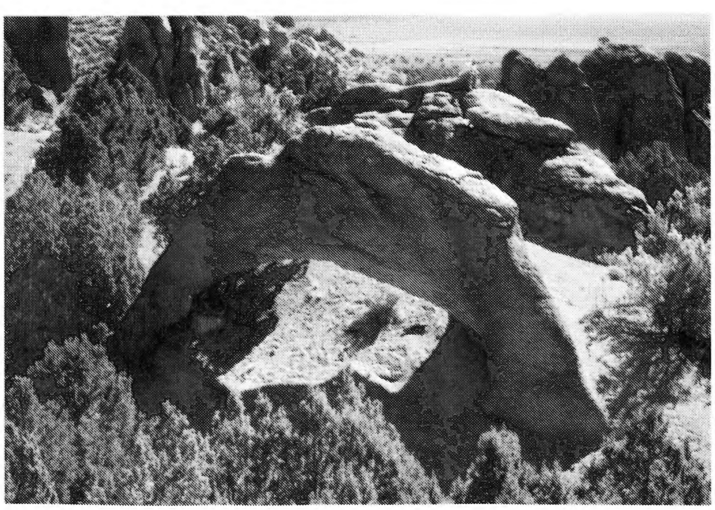
Mitchell Arch is eight miles north of Parowan (northeast of Cedar City), located in section 23, Township 32 South, Range 9 West. The arch is on Bureau of Land Management land and can be reached by a short hike from a jeep road west of the Kane Springs Road. The area contains ash flows from the Tushar Range to the north; Mitchell Arch is in an eroded section of volcanic ash from the Leach Canyon Formation, and spans 32 feet and is 7 feet high in the center of a 60-foot-long rock fin.

Hole in the Wall Arch, locally referred to as **Timpe Arch**, is four miles south of Parowan in section 35, T. 35 S., R. 9 W., on the west side of Parowan Canyon (Route 143) on Dixie National Forest land. The arch can be seen from southern Parowan, and can be reached by driving up a jeep road west of the arch and scrambling up a steep mountain face. Formed in a poorly cemented section of the Grand Castle Formation (an unlikely place to find an arch because of the rock's gravel-like composition), the arch spans about 12 feet and is about $4\frac{1}{2}$ feet high.

Second Left-hand Canyon Arch lies four miles southeast of Hole in the



Wall Arch, in section 19, T. 35 S., R. 8 W. (Dixie National Forest), on the east side of Route 143. One of at least four arches in the upper Claron Formation (pink limestone) along Center Creek, this rectangular arch has a



Mitchell Arch

Hole in the Wall Arch

span of 20 feet and a height of 13 feet, and can be seen from the road traveling down canyon, or reached by an easy hike.

Flannigan Arch is located in Ashdown Gorge east of Cedar City in section 25, T. 36 S., R. 10 W. The tough, wet, 1½ mile hike along Ashdown Creek to the arch begins between mile markers 7 and 8 on Route 14. The arch, which has a span of 120 feet and is 100 feet high, is a very impressive Iron County site and was recommended for National Monument status in 1918. Formed in sandstone of the Iron Springs Formation, the arch is on Dixie National Forest land.

Elephant Arch is south of Cedar City, in the Kolob Canyons section of Zion National Park on the north side of the North Fork of Timber Creek in section 35, T. 38 S., R. 12 W. The arch can be seen from the terminus of the Kolob Road, or reached by hiking the first mile of the Kolob Arch Trail, then heading east towards the cliffs and along the creek until the canyon narrows. From the creek, scramble up the steep north side then east toward the west side of the arch. Located in the base of the Navajo Sandstone and the top of the red Kayenta Formation, the arch spans approximately 40 feet and is about 20 feet high.

Steve Heath has taught mathematics at Southern Utah University for 30 years. He also has a masters degree in the History of Science and has a keen interest in the history of the southern Utah national parks and monuments. Much of his free time is spent hiking and exploring southern Utah. If readers want more information about these arches, contact Mr. Heath at heath@suu.edu

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Counties. The annual number of permits issued to drill wells in Utah increased from 339 in 1999 to 673 in 2000, representing a 99 percent increase.

Utah's 1999 oil-reserve additions were also the greatest in the Rocky Mountain region, increasing from the 1998 level of 210 million barrels to 268 million barrels – a jump of 32 percent. These additions are attributed to recalculation of reserves from existing fields based, in part, on new field models; the successful application of inventive well-completion techniques; and secondary/tertiary enhanced-oil-recovery production (such as flooding oil-bearing rocks with injected water to push more oil to the wells).

As of January 1, 2000, Utah ranked 8th in proven oil reserves and 12th in oil production in the U.S. Utah also ranked 10th in proven natural gas reserves and 12th in gas production. With continued drilling success and the incentive of high prices, Utah is still the place to find oil and gas for the nation's energy needs.

** Data Sources: Energy Information Administration; Utah Division of Oil, Gas and Mining; Dynergy Inc.; Utah Office of Energy and Resource Planning*

Survey News

Congratulations to **Jim Kirkland** for being awarded a limited edition Gold Pin by Vincent Santucci of the NPS. It is awarded to individuals making a significant contribution to the NPS Paleo Program.

Vincent noted that: " The NPS has a good friend in Jim Kirkland. Jim has been intimately involved with paleontological resource inventories in many parks on the Colorado Plateau including: ARCH, CANY, CARE, GLCA, etc. Jim participated in the Arches Scoping Session during 2000 and was directly responsible for a number of new important fossil discoveries in the park. Jim is also a leader in paleo resource protection." A most deserving and prestigious award!

Jo Lynn Campbell, previously working as an Executive Secretary in Parks, is the new UGS Executive Secretary. She will be the secretary for GES, Applied, and Mapping, and will also be responsible for press releases and other UGS/GES media and outreach duties.

Kim Nay has joined the Environmental Sciences Program to augment our GIS capabilities.

Mike Kirshbaum replaces **Scott Gerwe** in the Econ group. He is a recent graduate from the U. of U. and comes to us from a stint with Kennecott.

Tom Dempster, formerly from Billings, Montana, has accepted the position of Warehouse Worker/Geologic Assistant for the ECON section.

Brian Martin is the new "sales guy" for the Bookstore and was recently a driver for Wasatch Transportation, ferrying handicapped kids.

New Publications from UGS

Analysis of septic-tank density for three areas in Cedar Valley, Iron County, Utah - a case study for evaluations of proposed subdivisions in Cedar Valley, by Mike Lowe, Janae Wallace, and Charles E. Bishop, 66 p., Water Resource Bulletin 27, ISBN 1-55791-650-0, 12/2000 .... **$10.95**

Late Quaternary paleoecology in the Bonneville Basin, by David B. Madsen, 190 p., 11/2000, 1-55791 648-9, B-130 .... **$16.95**

Late Mississippian (Arnsbergian Stage E2 Chronozone) ammonoid paleontology and biostratigraphy of the Antler foreland basin, California, Nevada, Utah, by Alan L. Titus, 109 p., 10/2000, 1-55791 649-7, B-131 .... **$11.95**

Geologic map of the Midvale quadrangle, Salt Lake County, Utah by Fitzhugh D. Davis, 11 p., 2 pl., scale 1:24,000, 10/2000, ISBN 1-55791-576-8 M-177... **$8.00**

The geology of Antelope Island, Davis County, Utah, Jon K. King and Grant C. Willis, editors 163 p., 9/00, MP-00-1, 1-55791-647-0 .... **$13.95**

Interim geologic map of The Divide 7.5' quadrangle, Washington County, Utah, by Janice M. Higgins, 71 p., 2 pl., scale 1:24,000, 1/01, OFR-378 .... **$8.30**

Interim geologic map of the Clear Creek Mountain quadrangle, Kane County, Utah, by M.D. Hylland, 12 p., 2 pl., 9/00, OFR-371 .... **$4.50**

Debris-flow hazards, by W.F. Case, 2 p. color flyer, 10/00 PI-70 .... **Free**

Interim geologic map of the Center Creek quadrangle, Wasatch County, Utah, by R.F. Biek, M.D. Hylland, J.E. Welsh, and Mike Lowe, 105 p., 2 pl., 9/00, OFR-370 .... **$12.50**

Interim geologic map of the Manti quadrangle, Sanpete County, Utah, by M.P. Weiss and D.A. Sprinkel, 41 p., 3 pl., 1:24,000, 9/00, OFR-372 .... **$10.50**

Notable Utah rock falls in the 1990s and 1980s, by William F. Case, 11 p., 10/2000, OFR-373 .... **$1.00**

Progress report - Geologic map of the Dutch John quadrangle (east part), Utah, Colorado, Wyoming - year 1 of 3, compiled by Douglas A. Sprinkel, 1 pl., 1:100,000, 11/00, OFR-374 .... **$3.00**

Interim geologic map of the Pintura quadrangle, Washington County, Utah, by Hugh A. Hurlow and Robert F. Biek, 68 p., 2 pl., 1:24,000, 11/00, OFR-375 ..... **$9.40**

Interim geologic map of the Terrace Mountain West quadrangle, Box Elder County, Utah, David M. Miller and Padhrig T. McCarthy, 25 p. 2 pl., 1:24,000, 11/00, OFR-376 .... **$5.00**

Interim geologic map of the Terrace Mountain East quadrangle, Box Elder County, Utah, Padhrig T. McCarthy and David M. Miller, 31 p., 2 pl., 1:24,000, 11/00, OFR-377 .... **$5.50**

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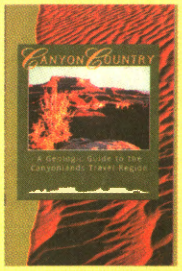
Are you taking a trip to a scenic area in Utah?

Canyon Country: A Geologic Guide to the Canyonlands Travel Region



This user-friendly guide is designed to enhance your travels, and illustrates the geology of the deep, colorful canyons, majestic natural monuments, towering pinnacles, rock arches and bridges, and breathtaking vistas atop mesas. Designated scenic byways are mapped and described in this colorful guide. 25 p. $2.50

Geologic Tours of Northern Utah

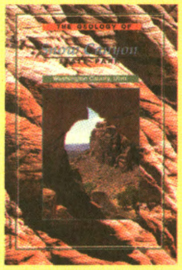
Eight road tours take you through Ogden Canyon, Logan Canyon to Bear Lake, Brigham City, Woodruff, and Idaho (Red Rock Pass), and two hiking tours are illustrated. 98 p. $6.00

Geology and Scenery of the Central Wasatch Range

Color guide through Parleys Canyon, Park City, Guardsman Pass, and Big Cottonwood Canyon. 17 p. $3.00

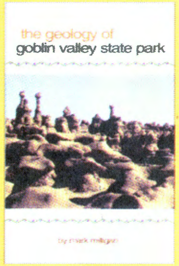
State Parks

The Geology of Snow Canyon State Park

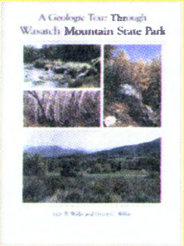


The stark intensity of Snow Canyon State Park's colors, terrain, and vegetation create a surrealistic flair to this striking recreation area. Ancient river systems, desert sands and volcanic eruptions left their mark here and natural forces continue to alter the park's appearance. 16 p. $1.75

The Geology of Goblin Valley State Park



The wonderfully grotesque stone sculptures that are Goblin Valley State Park's main attraction are the consequence of millions of years of geologic history. Diagrams and photos help portray the geology behind these fascinating formations. 21 p. $3.65



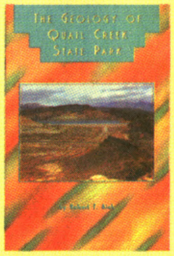
A Geologic Tour Through Wasatch Mountain State Park

Critical geologic terms are defined and maps of four different tours are provided with a list of scenic views through Wasatch Mountain State Park and one of Utah's Olympic venues. 66 p. ... $7.95

Geology & Antelope Island State Park, Utah

Antelope Island contains rocks that date back 3.5 billion years, and they still bear the marks of oceans and continents of other ages. 20 p. $2.50

The Geology of Quail Creek State Park



One of the first things most visitors to Quail Creek State Park notice, apart from the reservoir itself, is the brightly colored, layered rocks of the surrounding cliffs. With detailed photos and insightful descriptions, layers of rock, the park as a whole, and the geological highlights of the region are outlined. 21 p. $3.50

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