Thumbnail Sketch of Kartchner Caverns
and Scientific, Research, and Monitoring Issues

Prepared by Rickard S. Toomey, III and Ginger Nolan May 19, 2005 revision

General Park Info:

Location: 8 miles south of Benson, Cochise County, McGrew Springs 7.5' quad
Area: 714 acres
Facilities: Developed Cave Tours, Discovery Center, 63-Space Campground, Restrooms and Showers, Picnic and Group-use Areas and Ramadas, Hiking Trails
Total cost to develop park, buildings, cave, and infrastructure — $34.6 million
Only 10% of funds from State General Fund, main sources were Parks user fees and Heritage Fund (State Lottery derived).
Vegetation: Desert grasslands, mesquite scrub, and riparian woodlands

General Cave Info:

Entrance elevation: 4665 ft. above msl
Entrances: 1 natural and 3 artificial (1 shaft and 2 tunnels)
Mapped Length: 2.40 miles
Highest Point: 43 feet above natural entrance
Lowest Point: 76 feet below natural entrance
Total vertical extent: 119 feet
Depth below ground surface varies from approximately 10 feet to approximately 260 feet.
Mapped by: Randy Tufts, Gary Tenen, Orion and Jan Knox, and Kartchner Family, supplemented by pre-development mapping by Arizona Conservation Projects, Inc. and development related mapping by Arizona State Parks
In general, the cave is characterized by large rooms. It is largely active with well-developed calcite speleothems. Some areas of the cave flood intermittently.

History:

Main portion of cave discovered in 1974 by Randy Tufts and Gary Tenen
Purchased by state in 1988
Pre-development studies by Arizona Conservation Projects, Inc. — 1989-1991
Shaft Entrance installed May 1994
Portal Tunnel construction begins August 1995
Portal Tunnel breakthrough to cave: Rotunda, October 1996; Throne, December 1996; and Cul De Sac, February/April 1997
Tarantula Tunnel construction begins July 1995
Tarantula Tunnel Breakthrough to cave: October 1996
Rotunda-Throne Room Complex opened for tours — November 1999
Big Room Complex opened for tours — November 2003

Geology and Hydrology:

Kartchner Caverns is developed in the Escabrosa Limestone (Mississippian).
Cave developed in a block of Paleozoic sedimentary rocks (Kartchner Block) between the Whetstone Mountain and San Pedro Valley.

Numerous faults cut block and cave and influence cave development.
Cave developed mainly along single horizontal level at about 4625 ft.
Identified recharge from lateral infiltration of water from Guindani and Saddle Washes and from direct infiltration from area above cave. No surface discharge
General Cave Formation Timeline (modified from Hill, 1999)
~320,000,000 years ago – Deposition of Escabrosa Limestone
~15,000,000 - 5,000,000 year ago – Basin and Range faulting
~500,000 - 200,000 years ago – Dissolution of cave at water-table
~194,000 years ago – Oldest identified speleothem in cave
~120,000 - 70,000 years ago – Major period of speleothem growth
~80,000 years ago – Sloth enters cave and dies
50,000 - 40,000 years ago – Cave Myotis use of Rotunda and Throne Room
~37,000-36,000 years ago – Entrance near Tarantula Room - sediments, bones and snail shells into cave
70,000 - 10,000 years ago – Speleothem growth declines
10,000 years ago - Present – Increasing aridity, continued decreasing speleothem growth.

Cave Mineralogy:

One of the ten most mineralogically interesting caves in the world (Hill and Forti, 1997; Hill, 1999).
Abundant and diverse cave formations (speleothems) of calcite including stalactites, soda straws, stalagmites (including totems and fried eggs), columns, draperies, shields (including parachute, welt, and turnip), flowstone, popcorn, helictites, and boxwork.
First identification of birdsnest quartz, rectorite and nontronite (types of clay) from a cave.
First modern description of nitrocalcite.
Extensive brushite moonmilk formation.
First identification of Turnip shields
21 foot 2 inch long soda straw in Throne Room is one of world's longest soda straws.
Raymond Goldstein (University of Arizona, Department of Physics) leading team to use Kartchner to understand basic dynamics of speleothem growth.

Cave Meteorology:

Cave Air Temperature Pre-development: varied between 65.5°F and 69.9°F; mean for the entire cave ~67.6°F (1989-1991)
Cave Air Temperature Post-development: varies between 70.0°F and 72°F; mean for entire cave near 71°F
Cave temperature higher than mean annual surface temperature of 62.4°F (possibly due to geothermal heating)
Mean relative humidity throughout cave 99.4% (1989-1991), has dropped by about 2% in developed section (1998-2005).
Average evaporation throughout cave 9.4 $mL/m^2/day$ (1989-1991)
Natural cave entrance generally inhales October through May, exhales (weakly) June

through September.
Radon levels average 90 pCi/L and radon daughters average 0.77 WL in main part of cave. Radon varies seasonally (highest in Summer).
CO_2 varies seasonally between about 700 ppm (Winter) and 6100 ppm (Summer).
CO_2 varies spatially with lower values in the Big Room than in the Rotunda and Throne Rooms.
Radon and CO_2 seasonality both probably relate to weak summer airflow.

Rotunda-Throne Complex Facts and Figures:

Rotunda Room dimensions approximately 200 feet long by 120 feet wide
Throne Room dimensions approximately 170 feet long by 145 feet wide
Floor area of rooms approximately 0.5 acres
About 960 feet of tourist trail in cave. Total tour length ~2500 feet walking.
Tours began November 1999.
24 Tours per day with up to 20 people on each tour (480 visitors per day).
Each tour has two guides.
Since opening over 870,000 visitors have toured the Rotunda-Throne area of the cave.
Tour is barrier-free, with paved trails. Grades range to 13%.
Approximately 53 miles of wiring for lights and communication system.
164 lights (mostly 60 watt PIR flood lights on dimmer switches)

Big Room Complex Facts and Figures:

Big Room dimensions approximately 400 feet long by 240 feet wide
Cul De Sac dimension approximately 160 feet long by 85 feet wide
Strawberry Room dimensions approximately 100 feet long by 75 feet wide
Floor area of Big Room complex approximately 1.7 acres
About 1220 feet of tourist trail in cave. Total tour length ~2500 feet walking.
Big Room seasonal tours began November 2003
Tours only between about October 15 and April 15 (due to bat use in summer)
17 Tours per day with up to 15 people on each tour (255 visitors per day).
Each tour has two guides.
Tour is barrier-free, with paved trails. Grades range to 13%.
Approximately 54 miles of wiring for lights and communication system.
348 lights (60 watt PIR flood lights on dimmer switches)

Entrance Tunnels:

Constructed entrance tunnels allow tourists to enter cave without going through the natural opening.
Tunnel from Upper Portal connect to Rotunda, Throne, and Cul De Sac Rooms.
Total length ~920 feet, Average width ~10 feet
Constructed from September 1995-March 1997
Mined using standard hard-rock mining techniques
Blasting in tunnels monitored in cave to prevent damage to cave features
Tarantula Tunnel connects Tarantula Room with Lower Portal.
Total length ~180 feet, Average width ~10 feet

Constructed July 1996 – October 1996
Mainly constructed by trenching, trench fitted with box culvert and reburied.
Tunnel entrances and exits have airlock-like chambers to reduce exchange of cave and surface air.
Tunnels have system to mist visitors with clean water to reduce lint and keep humidity up near conservation chambers.
Tunnel cost between $300 / linear foot (competent rock) and $1300 / linear foot (reinforced areas). Areas just adjacent to the cave cost $3000 / linear foot due to techniques and reinforcing.

Cave Tour Development:

Trails are poured concrete with integrated 18-inch-high lint curbs.
Utilities mainly embedded in trails and curbs. Total conduit used ~13.5 miles.
Trails have sumps to remove dirty wash-down water from cave.
Trails have separate trail and feature lighting to reduce necessary light levels.
Lights are halogen incandescent bulbs (mainly 60 watt with some 100 and 500 watt) that are computer controlled by a Lutron System that allows programming of the duration and intensity of individual lights.
Light levels and duration controlled to reduce impact on cave while maximizing visitor experience.
Lighting developed by Frank Florentine (Smithsonian Air and Space Museum)
Total concrete used ~1460 yards (includes trails, slope stabilization, and shotcrete)
Handrails constructed of 304 Stainless Steel Tubing

Biology:

Myotis velifer maternity colony in Big Room, approximately 1000 adults, in Big Room from about mid-April through end of September.
Oldest recorded Big Room bat usage approximately 400 years ago (based on dating of guano).
38 species of invertebrates have been identified from the cave, including 4 obligate cave dwellers (troglobites), 19 facultative cave dwellers (troglophiles), 1 animal that shelters in the cave but feeds outside (camel cricket) (trogloxene), and 12 animals that occur in the cave only sporadically (accidentals).
The obligate cave dwellers include two species of mite, one terrestrial isopod, and one bristletail.
Up to eight of the cave dwelling invertebrates (including several mites, an isopod, and a bristletail) may be species new to science.
In 2002 a new species of the staphylinid beetle *Stamnoderus* was collected from the constructed entrance tunnels of the cave. This species is awaiting description.
Cave bat (*Myotis velifer*) guano acts as basal food source for a diverse terrestrial cave community.
Cave community dominated by mites, with a variety of other arachnids, springtails, and other insects present.
Mexican long-tongued bat (*Choeronycteris mexicana*) and Townsend's Big-eared bat (*Corynorhinus townsendi*) occur in entrance area.

A variety of bat species use Park's bridge over Guindani Wash for roosting (day and night).

Microbial flora of cave is diverse and varies from developed areas to undeveloped ones.

A diverse fungal flora occurs in the cave and on guano.

Paleontology:

A substantially complete Shasta ground sloth (*Nothrotheriops shastensis*) was recovered from Echo Passage. The bones have been dated to 86,000 ± 5000 years.

Dirt and rubble from an ancient entrance in the Tarantula Room contains animal bone and land snail shells. The entrance was open around 36,000 years ago. Three extinct animals: a horse (*Equus* sp.), a pronghorn (*Stockoceros* sp.), and Conkling's roadrunner (*Geococcyx californianus conklingi*), have been found in the former entrance fill. A variety of animals that are not exinct are also found in the fill; these include frogs, lizards, snakes, birds, and mammals.

Two extinct animals: a javalina (*Platygonus* sp.) and a rabbit (*Aztlanolagus* sp.) were found in an area off the Big Room.

A 100 year old coyote (*Canis latrans*) skeleton was found near the middle of the Big Room.

Bat guano and skeletal material in Rotunda and Throne Rooms dates from ~40,000 to 50,000 years old. The material represents ancient roosts of cave bats (*Myotis velifer*).

Davis (1999) studied pollen and microfossils from speleothems between 194,000 and 76,000 years old. He found modern analogs on Colorado Plateau (about 10°C cooler than modern), but pollen concentrations were too low for strong conclusions.

Bat guano in Big Room extends in age back to at least 400 years ago.

Archaeology:

The cave has no known archaeological significance.

Park has variety of historic and prehistoric archaeological sites.

On-going Monitoring and Impact Management Program:

Since 1991 Arizona State Parks has been monitoring cave microclimate, CO_2, radon, and extensometers for ceiling blocks in some areas. We also monitor several wells (water level and quality) and surface weather.

During construction additional specific monitoring occurred.

We examine lighted areas and foreign materials for algal and fungal growth and treat with a dilute sodium hypochlorite solution as needed. We are examining other treatment options as well. We also modify lights as necessary to reduce growth.

We are currently developing and implementing plans to automate much of the monitoring and increase temporal resolution on the data. We use HOBO dataloggers (Onset Computer Corp.) for long and short term monitoring.

University of Arizona Radiation Control Office oversees our Radon Monitoring program.

Swab samples along Big Room transects for monitoring microbiological impact of tours.

Lint monitoring via dish transects

Working with engineering class at University of Arizona to develop airflow monitoring instrumentation to better understand air balance in cave.

Notable Management Issues

Arizona State Parks is committed to maintaining the cave in as close to a natural state as possible, while providing access for public education

ASP is concerned with the potential for adverse changes to cave microclimate, biota, and beauty

ASP is concerned with land-use issues near the park that could have an adverse impact on the cave or cave resources

Maintenance of a healthy bat population is vital to the cave ecosystem

ASP is developing a long-term cave management plan, as wells as, a long-term research plan and program for the cave

We have developed numerous relationships with agencies and individuals to assist with research and with management issues.

We are developing spatial and non-spatial databases on the park, cave, and region to better understand and manage the cave and other resources in the area.

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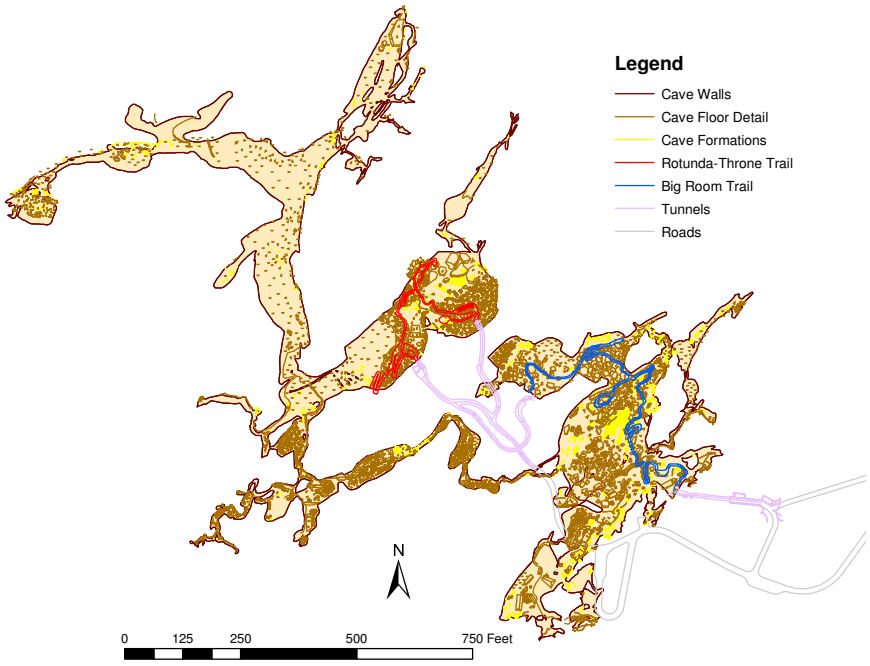
About the Authors

Rickard S. Toomey, III, is the Science and Research Manager for Arizona State Parks. He has held this position since June 2004. Prior to this position he was Cave Resources Manger for Arizona State Parks, a position he held from April 2001. In this position, he oversees cave monitoring and scientific studies at Kartchner Caverns State Park. In addition, he works with other geological, ecological, and GIS issues within State Parks. He has a B.S. in Geological Sciences from Brown University (1985) and a Ph.D. in Geological Sciences from The University of Texas at Austin (1993). His dissertation is entitled *Late Pleistocene and Holocene Faunal and Environmental Changes at Hall's Cave, Kerr County, Texas*. He is on the board of the Cave Research Foundation and was its president since 2004. He has also administered their fellowship and grant program. From 1994 to early 2001 he was at the Illinois State Museum, first as a post-doc, then as a technology and education specialist and finally as an Assistant Curator of Geology. He has worked extensively on cave paleontology, notably on fossil bats. This includes an on-going study of the paleontology of caves at Mammoth Cave National Park. The work at Mammoth Cave has included work on reconstructing cave environments and restoring habitat for endangered bats. He has consulted with various federal, state, and private organizations on cave management issues. Rick worked on the Illinois Department of Natural Resources' Karst Working Group in developing management policies and protection strategies for caves and karst. Rick has been President of the Illinois Speleological Survey.

Ginger Nolan has worked at Kartchner Caverns since 1997. From 1997-1999 she was Cave Environmentalist for the development project. Since 1999 she has been in the Cave Unit. The Cave Unit is in charge of cave maintenance, monitoring, and environmental protection. In 2000 she became head of the Cave Unit. She oversees a staff of six. She also oversees radon monitoring and license compliance.

General Map of Kartchner Caverns



Park Map