



Historical and religious documents describe Ubar — known as Iram in the Koran — as a thriving city that perished in some sort of disaster around A.D. 100. Evidence at the Oman site indicates that much of the settlement fell into a sinkhole created by the collapse of an underground limestone cavern.

If preliminary dates for the site hold up, the discovery provides evidence of urban development in the southern Arabian desert about 1,000 years earlier than scholars previously assumed. However, it remains unclear whether far-flung frankincense trade extended back to 2800 B.C., since scientists place the domestication of camels, relied on by desert traders, at about 1500 B.C.

Excavation at the Oman site will continue until April, when on-site investigators will decide how to proceed with the project, Blom says. — *B. Bower*

### Nuclear waste plans blocked

A federal district judge last week issued a permanent injunction blocking the Department of Energy's (DOE's) plans to begin shipping nuclear waste to an underground storage facility in southeastern New Mexico. Judge John Garrett Penn ruled that DOE must obtain authorization from both Congress and the state of New Mexico before opening the \$1 billion Waste Isolation Pilot Plant (WIPP).

Last October, after years of delays, the department said it would start placing waste in WIPP, but New Mexico won a preliminary injunction preventing the waste shipments (SN: 1/18/92, p.44). In last week's decision, Judge Penn ruled that DOE had not properly assumed control of the WIPP site from the Interior Department. In effect, the decision requires that DOE seek a congressional land transfer. The judge also ruled that DOE must obtain a hazardous waste permit from New Mexico, because the waste contains both hazardous and radioactive materials generated during nuclear bomb production.

Such requirements would significantly delay WIPP's opening. New Mexico will require at least a year, and perhaps two years, to evaluate DOE's permit request, says Kay Roybal, a spokeswoman for New Mexico Attorney General Tom Udall. DOE plans to appeal the federal court's decision. □

## New evidence for black holes in Milky Way

Two teams of astronomers studying different regions of our galaxy have uncovered fresh evidence for the existence of black holes — collapsed stars that possess a gravitational field so strong that not even light can escape their grasp. One research group has found supporting evidence that a massive black hole lurks at the heart of the Milky Way. The other group, studying light emitted by a star orbiting an unseen, compact object some 6,000 light-years from Earth, has deduced that the hidden object is a black hole about the mass of a typical star.

Several researchers call the latter finding one of the most persuasive cases for a black hole in more than 20 years of hunting for these theoretical denizens of the astronomical zoo.

Since black holes by their nature remain hidden from view, astronomers must deduce their presence from their influence on nearby bodies. Consider the curious case of the two stars known as V404 Cygni. In 1989, the Japanese research satellite Ginga found that the stellar duo, consisting of a visible star and an unseen companion, sporadically emitted bursts of X-rays so intense that their luminosity exceeded a million times the total brightness of the sun at all wavelengths.

That observation sparked the interest of Philip A. Charles, based at the Royal Greenwich Observatory in the Canary Islands, Spain. He and his colleagues knew that according to established theory, the X-ray bursts could indicate a black hole: Such radiation is generated when surface material from the visible star succumbs to an unusually strong gravitational tug and falls rapidly onto a disk of matter surrounding its invisible, compact companion.

Last August, after the X-ray and associated optical-light fireworks from V404 Cygni had faded, Charles and his team used the 4.2-meter William Herschel Telescope at La Palma Observatory in the Canary Islands to study the light spectra normally produced by the visible member of the binary system. The motions of its spectral lines indicate that the visible star whips around its unseen companion with a velocity of 420 kilometers per second and has a period of 6.5 days. Such features indicate that the compact object must have a mass at least as large as 6.3 solar masses, bigger than any neutron star allowed by theory. (Neutron stars represent a class of compact stars with gravitational fields weaker than those of black holes.)

Barring speculation that the compact object in V404 Cygni might belong to a hypothetical, exotic group of burned-out stars held intact by the force that binds neutrons and protons together, a massive star must have collapsed to form the

pair's black hole, Charles and his colleagues assert in the Feb. 13 *NATURE*.

Charles calls the findings the most definitive case yet for a black hole, surpassing previous evidence that other X-ray-emitting binary stars in the Milky Way — Cygnus X-1 and A0620-00 — harbor black holes. His team's conservative lower limit for the black hole's mass in V404 Cygni, he says, assumes that the visible star has no mass and that its rotation axis is exactly perpendicular to the line of sight from Earth. Eliminating these extreme assumptions, the unseen object would more likely have a mass eight to 15 times that of the sun, strengthening the black-hole argument, Charles notes.

In contrast, he says, mass calculations for a candidate black hole in Cygnus X-1 are complicated by uncertainties about the mass of its visible member, which could be far lower than assumed.

In a commentary accompanying the *NATURE* article, Joseph F. Dolan of NASA's Goddard Space Flight Center in Greenbelt, Md., says the new work shows that V404 rivals Cygnus X-1 as the most likely black hole candidate so far known.

This summer, Dolan and his colleagues hope to survey several intriguing binary stars, including Cygnus X-1, with the Hubble Space Telescope's high-speed photometer. They plan to look for the swan song of matter as it plunges into a black hole: the emission of a series of light pulses that increases in frequency but grows ever fainter.

On a larger scale, astronomers using the European Southern Observatory's New Technology Telescope in La Serena, Chile, have found a faint infrared emission coming from the very center of our galaxy. Researchers already know the Milky Way's core contains a powerful radio source called Sagittarius A\*, an indicator that our galaxy's center may harbor a black hole 2 million times as massive as the sun. The infrared signal — which eluded detection for years — further supports that notion, says Reinhard Genzel of the Max Planck Institute for Extraterrestrial Physics in Garching, Germany.

Genzel and his colleagues also examined in detail a previously known infrared source about one-tenth of a light-year from the center of the Milky Way. The team found that part of the signal represents a hot bubble of expanding gas, possibly driven by a high-velocity wind from the vicinity of the proposed black hole. Other components of the off-center infrared signal appear to be young, blue stars — making this the first time astronomers have detected such a youthful population near our galaxy's center. Genzel and his colleagues report their findings in the Feb. 6 *NATURE*. — *R. Cowen*