ARCHAEOLOGY

California Social Climbers: Low Water Prompts High Status

NEW ORLEANS—You wouldn't know it from watching Hollywood's glitterati vie for choice tables at posh eateries, but life in Southern California wasn't always so status-conscious. One thousand years ago the original inhabitants, the Chumash, were an egalitarian society of hunter-gatherers living in small villages from Malibu north past Santa Barbara, and on the Channel Islands several miles off the coast. But by the time the Spanish arrived in the 1700s, Chumash society had changed. They had acquired hereditary chiefs, an elite group named "the brotherhood of the tomol" after the intricate planked canoes they made, and ritual and craft specialists. Archaeologists often picture the change from equality to a status-filled society as a slow one, but among the Chumash, at least, there's emerging evidence that social rank was born from a sudden episode of drought—and what one researcher calls "a crucible of violence."

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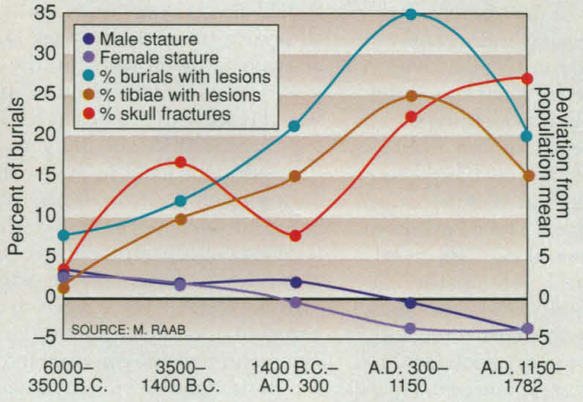
Nasty, brutish, shorter. In a proposed drought (A.D. 1100), violence (*above*) among the Chumash increased; height—affected by diet—decreased.

At last month's meeting of the Society for American Archaeology in New Orleans, researchers linked the first signs of inherited status among the Chumash, such as babies buried with valuable shell beads, to a growing record of climate change and social disruption at just about the same time, from A.D. 1100 to 1300. Data from drowned tree trunks point to a severe water shortage, and other evidence indicates a warming of local ocean currents. At the same time, bodies of the dead indicate the locals were going through a rough stretch: As the water levels dropped, broken skulls, arrow injuries, and signs of disease climbed to unprecedented heights.

Based on evidence from cemeteries, Mark Raab, an archaeologist at California State University, Northridge, argues that bad times drove groups to begin banding together for protection, staking out territory, and forming alliances. This put a premium on skilled politicians and dealmakers, who became the new elite. Not everyone agrees with this interpretation of social change—there's other evidence that canny entrepreneurs with canoes may have gained status by organizing a bead-for-food trade between the islands and the mainland. But scientists are beginning to agree that the overlap between climate and social change is no coincidence. "Archaeologists have tended to think that the emergence of social complexity is a gradual process over thousands of years," says David Hurst Thomas of the American Museum of Natural History in New York. "But this evidence says: No—it could have been more punctuated." And it's spurring researchers to look for concurrent changes in other populations throughout western America.

The evidence for a punctuated climate comes from several sources, including warm-water plankton and shellfish that show up in the normally cold-water Santa Barbara Channel about A.D. 1100 to 1300. Diminished pollen counts in bay sediments also point to less freshwater run-off. But what's got researchers most excited is work on drowned trees in the Sierras by Scott Stine, a paleoclimatologist at California State University, Hayward. At 10 lake and river sites, Stine found old stumps of trees well below the present waterline, indicating that the water level was once much lower than now. In work published in *Nature* in 1994 and since expanded, Stine took radiocarbon dates from the outer growth rings of the stumps, when rising water killed the trees. By counting inward, he could measure the trees' lifetimes and thus the period of low water. He found evidence of two dry times: one from A.D. 800 to 1100 and another from A.D. 1200 to 1350. "Certainly in the Sierras, boy, it was dry. And it seems impossible the coast could have escaped something that hit the Sierras so hard," Stine says.



Chumash graves record signs of such a coastal hit—a period of hardship and scarcity presumably triggered by environmental change. Philip Walker, an anthropologist at the University of California (UC), Santa Barbara, and Patricia Lambert of the University of North Carolina, Chapel Hill, have examined Chumash burials extending over a several-thousand-year span, looking at levels of disease, nutrition, and violent injuries recorded in the bones. "The levels fluctuate, but at that period, personal injuries go way up," says Walker. The percentages of people with bashed-in skulls and arrow points embedded in their bones were very high (see chart). Walker and Lambert also found signs of disease and malnutrition, such as bone lesions produced by infections and defects in growing tooth enamel.

Along with signs of disease and strife, burials of this time began to indicate differences in social status. The main status indicators are shell beads, which were used by the Chumash as money, and soapstone figurines, according to Jeanne Arnold, an archaeologist at UC Los Angeles. Prior to 1000, these were equally distributed among burials and generally found with adults, who presumably acquired them during their lifetimes. But babies buried with beads become more common during the drought period, pointing to inherited rather than acquired wealth. In one cemetery on the mainland, Raab found an infant with 19,000 beads; the average for all burials at the cemetery was about 350. Overall, bead production skyrocketed by at least fivefold, Arnold says.

There are at least two views of how rank grew out of this environmental and social tumult. Raab offers one: "What I see happening is this: The climate begins to skid. As the moisture dries up, people become more territorial." One sign is the cemeteries themselves, he says, in which highly stylized burial positions—unique to a group—may have been used to help stake claims to a particular area. From territoriality grew social complexity. "There's competition for resources, so people organize themselves for defense. Historically, communities that do this become intensely political. They make deals with other villages; they form alliances; they make political marriages. And you get status by making these deals."

Arnold, however, suggests that status was spawned by control of bead production and thus of regional trade. While before A.D.

1000 beads were made throughout southern California, after that time manufacture was concentrated on Santa Cruz and Santa Rosa islands. Arnold thinks this centralization was driven by the owners of the tomols, the expensive 2-ton-capacity canoes that were the islanders' chief link to the mainland. They could trade beads for food, which may have been vital during tough times. "They had the most efficient means of distribution to the mainland, so it made sense for bead producers to funnel their product through the canoe owners. In return, the owners traded with the mainland to bring back food to keep their people well fed."

Both researchers acknowledge that material evidence for these ideas is thinner than they'd like; Raab, for instance, wants to find more signs that mainlanders were losing food sources. And Robert Bettinger of UC Davis says Raab may be overemphasizing the effects of the environment. Bettinger notes that people can adapt to water shortages—as they do in the desert—and long-term social processes could also have produced the status changes Raab has traced. Still, he and others note that the period of climate change, about A.D. 1300, was an unsettled time in a variety of American populations. There's evidence of trade disruption on the central California coast, and the collapse of Pueblo society in the Southwest. "I don't question the overall conclusion. Something did go on here," Bettinger says. The challenge for archaeologists is to figure out exactly what it was.

–Joshua Fischman

PHYSICS

Added Weight for Neutrino Mass Claim

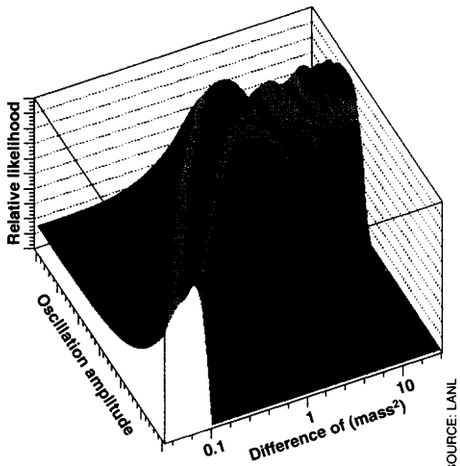
INDIANAPOLIS—Just outside the ballroom where Fred Federspiel described his group's latest results on the mass of the wispy particles called neutrinos, artisans did a brisk business in brightly colored dashikis and kente cloth scarves. The American Physical Society, as it happened, was sharing a conference center with a gospel convention. There wasn't much overlap between the two gatherings—except that Federspiel, a physicist at Los Alamos National Laboratory, had a message for the doubting Thomases in his own field. A large amount of new data from the Liquid Scintillator Neutrino Detector (LSND) experiment, he reported on 2 May, adds up to "very strong evidence for neutrino oscillations"—a tendency to switch identity, which would indicate that neutrinos have mass.

The experiment, located at Los Alamos and involving researchers at 12 different institutions, now has evidence for 22 events in which a neutrino of one "flavor" apparently oscillated, or transmuted, into another flavor. Conventional physics could have produced only four or five events mimicking these oscillations, the group calculated. Described in two papers just submitted to *Physical Review*, the evidence is twice what the LSND group had last fall when it first claimed to have detected neutrino oscillations—a claim that met with some skepticism (*Science*, 22 September 1995, p. 1671). Add to that "a much nicer job" of data analysis, says Frank Sciulli of Columbia University, and "one has to take it seriously. It's an anomaly."

The most tempting interpretation of the anomaly is that neutrinos have mass, for theorists predict that neutrinos can only switch identities if the three known flavors—electron, muon, and tau—have different masses. Although standard particle physics implies that the neutrino is massless, many physicists would be delighted to learn otherwise. Neutrino oscillations could point the way to new physics, and they could explain apparent shortfalls in the number of neutrinos reaching Earth from the sun and from cosmic ray collisions in the atmosphere. And because the universe is swarming with neutrinos, neutrinos with mass could provide some of the invisible dark matter needed to explain how matter coalesced into the large-scale structures seen today.

The LSND group looks for neutrino mass by slamming 800-million-electron-volt protons from an accelerator into a water target. The ensuing reactions send a stream of muon antineutrinos (the antimatter counterparts of neutrinos) into the LSND, a tank filled with 167 metric tons of mineral oil and 1220 light detectors. The muon antineutrinos should almost always pass through the tank without a trace—unless they oscillate into electron antineutrinos along the way. In that case, a fraction of the electron antineutrinos would react with protons in the oil, producing characteristic trails of light.

Aside from doubling the previous data set during 4 months of running time in 1995, the group has become more sophisticated about ferreting out conventional processes that can also produce these light signatures, says D. Hywel White, co-spokesperson for the experiment. On rare occasions, for example, a muon antineutrino can combine with a proton in the tank to produce a neutron and a muon, which in turn can mimic the electron antineutrino signal. But Federspiel developed a method for searching the data leading up to an apparent detection for clues that the event was due to a muon, not a massive neutrino. Because of such improvements, the chance that the new results are a statistical fluke is less than 1 in 10 million, says White: "When the number is that tiny, either there is new physics or we have made a mistake."



SOURCE: LANL

Weight of evidence. LSND's likely range of mass differences between the electron and muon antineutrinos.

Sciulli notes that the positive result persists, although at a much lower confidence level, even when the group discards data from a large part of the tank that a former collaborator had argued is especially vulnerable to spurious events from background radiation and cosmic rays. All in all, says George Fuller of the University of California, San Diego (UCSD), who, like Sciulli, is not a member of the LSND group, "it is very significant that the signal has not gone away with further running. There was some speculation that it would."

The most likely mass the LSND results suggest when combined with limits from other experiments—half an electron volt or a little more—would add about the right amount of heft to the universe for cosmologists' tastes. But it is larger than physicists trying to explain the solar and atmospheric deficits had hoped for. More recent calculations by Fuller and Christian Cardall at UCSD show that the solar and atmospheric mysteries, too, could in principle be explained by LSND's mass range. Still, "the game is not over," says White.

White says the only way to be sure that the particles triggering the LSND are neutrinos that have oscillated and not something entirely different is to redo the experiment with several different detectors or at higher energies, where neutrinos interact with matter more often. A larger number of events would allow the experimenters to look for a predicted sinusoidal variation in oscillation frequency with changes in either neutrino energy or travel distance, says White. The group will soon propose an experiment, to be set up at the Fermi National Accelerator Laboratory's 8-billion-electron-volt booster ring, that could search for this telltale variation, he says. A positive result, everyone agrees, could finally turn neutrino mass into physics gospel.

–James Glanz