taining much older volcanic minerals that eroded from the surrounding terrain. If that were the case, then the Berkeley team may have dated those crystals and the skullcap itself could be younger. Swisher, however, points out that it's unlikely he would have picked out several unusually ancient crystals from both sites. "The fact that both sites gave similar ages supports our view that hominids were in Asia prior to 1.6 million years," he says. Still, he does plan to return to the sites this year to obtain more dates from the layers containing the fossils.

If the dates hold, one scenario to account for them, says Rightmire, is "that people were on the move out of Africa much earlier than we thought." The journey must have begun about 2 million years ago—roughly 600,000 years before the invention of the advanced Acheulean toolkit: handaxes and other bifacial stone tools that were superior to the previous crude choppers and sharp flakes. Louis Leakey, among others, had argued that these more efficient hunting and butchering tools allowed *H. erectus* to extend its range far beyond any earlier human ancestor.

An early departure date, however, makes this claim harder to support. At the same time, it helps to explain something that's long puzzled anthropologists: why the Acheulean toolkit never appears at any Asian *H. erectus* sites, no matter what their age. That's been hard to account for in view of a *H. erectus* that invented the tools in Africa and then pushed on to Asia. Why didn't the tools go along? Swisher points out that if some of the protohumans left the continent before the tools were invented, the absence makes more sense.

If *H. erectus* did make its move without the new toolkit, of course, the species must have had some other advantage over its ancestors that allowed it to travel, perhaps a physical one rather than a technological one. One possibility is that it was built for travel—it was larger than its predecessors and was fully bipedal. Wood suggests that "increased body size allowed them to tolerate water loss," because they had larger bodies that allowed them to store water and food longer. "Maybe they were better able to make it out in the open savanna grasslands. Maybe they were able to leave the shade and water sources for substantial periods of time," he says. Or, suggests University of Michigan paleoanthropologist Milford Wolpoff, there may have been other social and dietary changes that allowed these early colonizers to carry food long distances and move through unfamiliar terrain.

Another possibility is that *H. erectus* did not make a quick exit from Africa after all. Perhaps it was an earlier ancestor, such as *Australopithecus* or *H. habilis*, which moved out of Africa before 2 million years ago—and then gave rise to *H. erectus* in Asia. "These dates could reopen the question of where did *erectus* originate," says paleoanthropologist Christopher Stringer of London's Natural History Museum.

There is, however, one big problem with this idea: "I don't see any fossil evidence for *Australopithecus* or an earlier *Homo* in Asia, like we see in Africa," says Rightmire.

Both these scenarios—a quick departure for *H. erectus*, or an even earlier venture by an ancestor—do leave human origins researchers with a large quandary. There are two different populations of *H. erectus* in two different places almost 2 million years ago. And now, it's anybody's guess which of those two groups gave rise to modern *H. sapiens*—or whether a separate, still-undiscovered species was ancestral to modern humans. Some scientists, such as Liverpool's Wood, question whether the Asians and Africans are even the same species. Almost anything, says Rightmire, is possible.

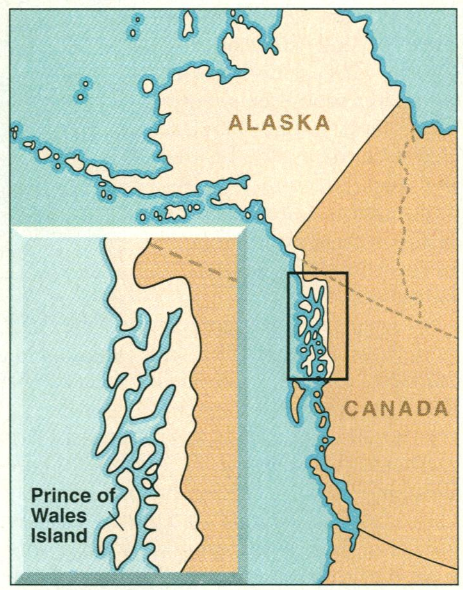
Stumbling on new possibilities, of course, is a regular feature of this field. "Paleoanthropology is always interesting and bound to be surprising," says Rightmire. "Just when everyone is comfortable with something, a new fossil is found or a new date. It certainly keeps us on our toes."

–Ann Gibbons

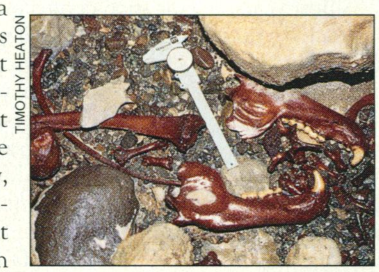
EARLY AMERICANS

A Glimmer of Hope for Coastal Migration

On the map, Prince of Wales Island looks like a stepping stone—one of a chain of islands stretched along the coast of Southeast Alaska. And a stepping stone is just what archeologist James Dixon thinks the island might have been for some of the first Americans, as early as 14,000 years ago. Dixon, curator of archeology at the Denver Museum of Natural History, believes that at least some of the first humans entering North America from Asia didn't follow the inland route most archeologists have advocated. Instead, he and a few other archeologists think they hopped along the coast by boat.



One reason Dixon's view has been in the minority is that existing geological wisdom holds that the Alaskan coast was locked up in ice during the late ice age, when most archeologists believe the first humans entered North America. But Dixon and his like-minded colleagues are now being cheered by recent fossil finds from a cave on Prince of Wales Island, which imply that not all the coast was icebound at that time. That lends plausibility to the coastal migration theory, Dixon says, because it implies that migrants might have found game-rich coastal havens. And there are plenty more caves on the island, offering hope that relics of the first American travelers might be somewhere in the cave system.



Ice-age refuge. Prince of Wales Island and the bear fossils found there *(left)*.

That hope, along with a threat to the caves by logging, is now spurring a major effort to comb them for evidence of human occupation. Caves are always good places to look for artifacts, notes Dixon, because of their alkaline minerals and protection from the elements. "These caves provide a really unique window into the prehistoric past."

The first glimpse through that window came 2 years ago, when an amateur caver stumbled on a fossil deposit in one of the Prince of Wales caves. Paleontologists Timothy Heaton of the University of South Dakota and Frederick Grady of the Smithsonian Institution excavated the deposit and identified the skeletons of four black and grizzly bears, the oldest of which was carbon-dated to 12,300 years ago, as they reported last year in *Current Research in the Pleistocene*. Says Jim Baichtal, a geologist with the U.S. Forest Service on Prince of Wales Island, "If bears were living here, then chances are pretty good that we were not overridden by a blanket of ice as the textbooks have been telling us."

This finding gave coastal migration advocates like Dixon their first evidence of a coastal region that might have been suitable for human occupation at that time, and it revitalized an idea popularized in the 1970s by Knut Fladmark of Simon Fraser University in Vancouver. Fladmark's coastal-migration hypothesis offers an alternative to the traditional route into the Americas: an ice-free corridor geologists think opened up between 12,000 and 15,000 years ago just east of the Canadian Rockies. Fladmark argued instead that at least some of the first Americans came down the coast in boats after crossing the Bering land bridge from Asia. The idea isn't outlandish, says Dennis Stanford, chairman of archeology at the Smithsonian Institution. "We know people were capable of [building] boats at least 40,000 years ago—you had to have a boat to get to Australia—so why couldn't they have used them to come along the coast of Alaska?" And Stanford, who isn't a partisan of the coastal migration idea, says the findings from the caves "sound real exciting."

Still, most archeologists think the odds are against the coastal migration route. Even if there were isolated coastal "refugia," the glaciers jutting out into the ocean elsewhere would have posed formidable barriers, says University of Alaska anthropologist William Workman. The absence of coastal Indian cultures in California before 11,000 years ago also argues against the theory, says Workman. "Why would humans perfect coastal living and then give it up when they hit Washington State—jump ashore and head for the grasslands? I just can't go for that."

But Dixon and Baichtal hope that further exploration of the caves will bolster the theory. They were quick to follow up the initial finding by recruiting amateur cavers to map the cave system and search for artifacts. Baichtal has organized a cadre of marine geologists, botanists, archeologists, and glaciologists to map other coastal refugia on Prince of Wales Island by tracing glacial moraines and changes in sea level. The survey, they hope, will focus the cave exploration by revealing which ice-free areas lay close to the water in the last ice age. Explains Owen Mason, a research associate at the Alaska Quaternary Center at the University of Alaska, who is taking part in the survey, "Studying sea level will tell us where people would have been able to travel."

There's a special urgency to the search, say Baichtal, Dixon, and their colleagues. Carpeting the cave-riddled bedrock on Prince of Wales Island is the Tongass National Forest, scene of Alaska's largest logging operations. Debris from the logging has already clogged some of the caves. And while the logging has recently slowed in sensitive areas, the researchers aren't confident the reprieve will last. Evidence of ice-age mariners that might have escaped the glaciers could still disappear before the chain saw.

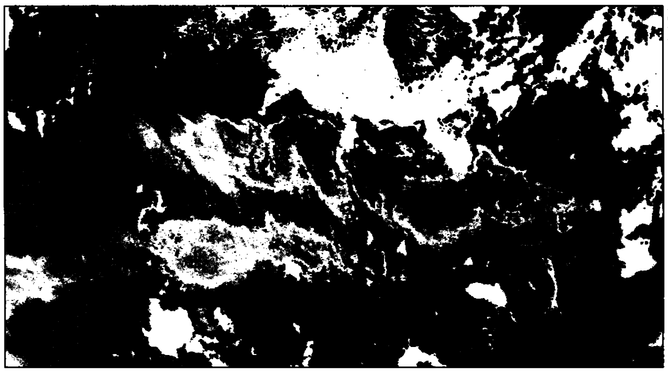
–Lisa Busch

Lisa Busch is a freelance writer in Alaska.

OCEAN CHEMISTRY

Iron Fertilization: A Tonic, but No Cure for the Greenhouse

It's been called the Geritol solution to greenhouse warming: Dose millions of square kilometers of ocean with the tiniest bit of iron, a scarce trace nutrient, and the surface waters would bloom. The burgeoning microscopic plants would absorb carbon dioxide to build their tissues. Then, when they die and sink into the deep sea, they would store away the carbon where it could do no more climatic mischief (*Science*, 27 September 1991, p. 1490). Most oceanographers are deeply troubled by the notion of planetary engineering, but the idea that trace amounts of iron could be vital to the ocean's ecology was so appealing scientifically that they couldn't resist at least a test of it in the real ocean.



NASA

Oceanic oasis. This false-color satellite image shows the fertilizing effect *(red denotes abundant plant life)* of iron from the Galápagos.

The test was carried out last fall in the equatorial Pacific, and "the results were spectacular," says marine biologist Richard Barber of Duke University's Marine Laboratory, chief scientist for the Transient Iron Addition Experiment (IronEx). "Adding iron did in fact stimulate the [phytoplankton]," says chemist Kenneth Johnson of the Moss Landing Marine Laboratory, a colleague of the late John Martin, who first raised the possibility of the Geritol solution several years ago. That's enough to confirm the underlying "iron hypothesis": that the limit on marine life in places like the relatively unproductive northeast Pacific, where essential nutrients such as nitrogen and phosphorus are abundant, is lack of iron.

In spite of the "spectacular" stimulation of plankton growth, the results don't bode well for the possibility of cooling the climate with a dose of iron, as Barber reported last week at the annual meeting of the American Association for the Advancement of Science (AAAS, publisher of *Science*) and the Ocean Sciences Meeting in San Diego. (For additional coverage of the AAAS meeting, see page 1084.) Although many samples remain to be analyzed, it seems that in the ocean, the medicine goes down a little too well. The iron supplement "just didn't stick around very long," says Johnson. Dissolved iron, the kind phytoplankton can use, quickly formed particles that sequestered the iron and eventually sank. The same thing seems to happen to iron from natural sources, say the researchers, which would explain the shortage of iron in the ocean's surface waters in the first place.

Although the researchers expected some iron loss, the experiments that inspired IronEx gave no inkling of its extent. In those experiments, Martin and others took bottled samples of plankton-laden seawater and added iron. In response, the plankton population doubled and doubled again, but those results were suspect because a 1-liter sample bottle is no ocean. For one thing, a liter of seawater may not include some of the larger (millimeter-scale) and therefore rarer animals—such as copepods—that feed on phytoplankton and help keep their numbers down. What's more, bottles have walls, where bacteria can proliferate, perturbing the food web. And nothing can enter or leave the bottle.

To get around these limitations, Martin and, after Martin's death, Johnson and his Moss Landing colleague Kenneth Coale planned IronEx. To stage a realistic test of the iron hypothesis, the researchers decided to enrich iron in a patch of water so large—8 kilometers square—that the enrichment would persist long enough for oceanographers to monitor its effects. Five hundred kilometers south of the Galápagos Islands, where natural iron concentrations are a minuscule 0.03 nanomolar, the researchers dribbled 480 kilograms of iron in the form of iron sulfate solution into the prop wash of a research vessel as it steamed back and forth through the square. The researchers kept track of the patch by measuring levels of the inert and easily measured tracer sulfur hexafluoride, tiny quantities of which were released with the iron solution. As the iron