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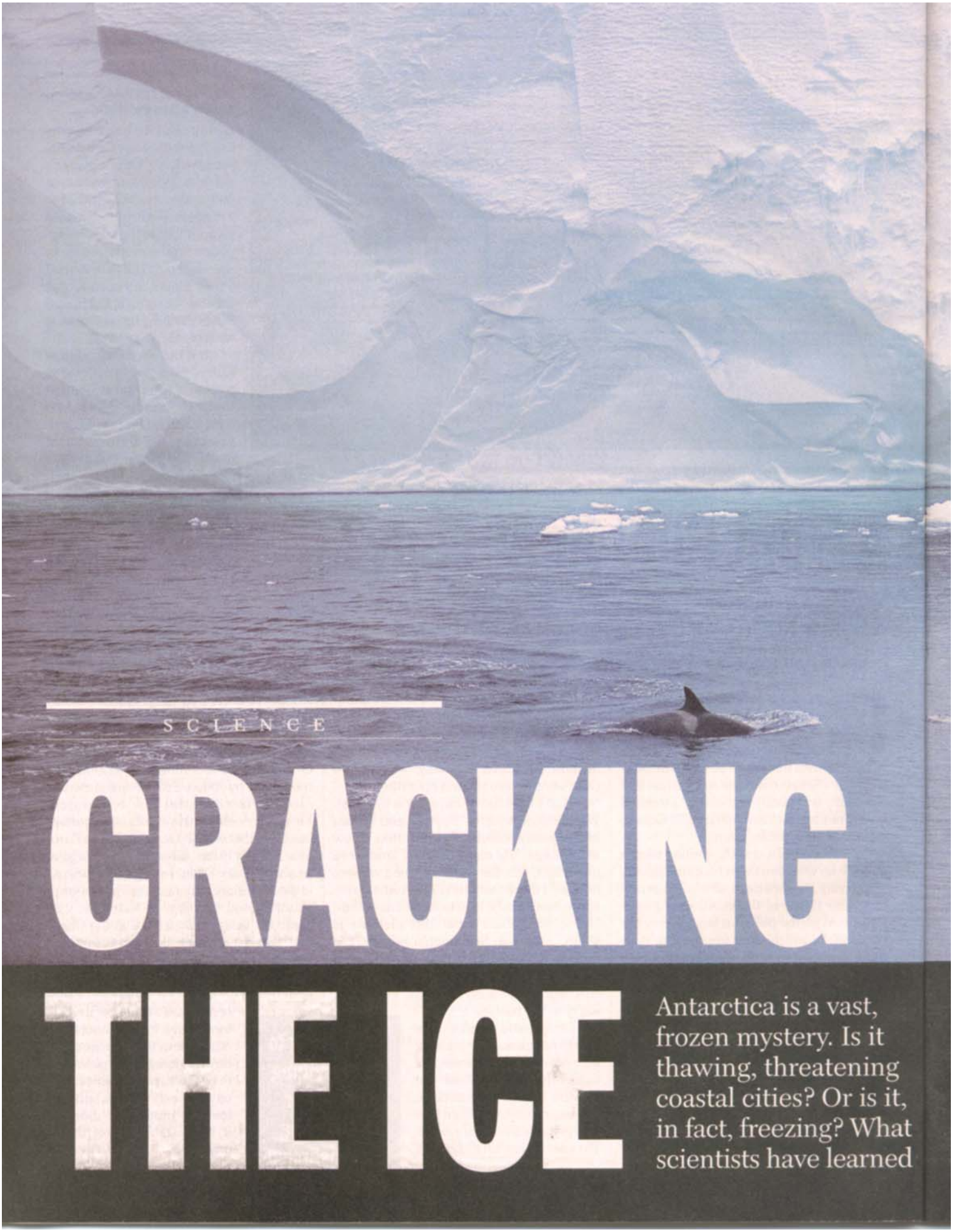
THE STATE OF THE UNION

With the U.S. economy still stalling and the possibility of war against Iraq on everyone's mind, this year's State of the Union address is a critical one for President Bush. Visit Time.com Tuesday evening for TIME White House correspondent John Dickerson's post-speech analysis.

CNN



SCIENCE

CRACKING THE ICE

Antarctica is a vast, frozen mystery. Is it thawing, threatening coastal cities? Or is it, in fact, freezing? What scientists have learned

ICE FRONT

The frigid waters at the edge of McMurdo Sound support a variety of hardy marine animals, including these killer whales and Adélie penguins

PHOTOGRAPH FROM ANTARCTICA BY PAT AND ROSEMARIE KEOUGH—NAHANNI PRODUCTIONS

By J. MADELEINE NASH MCMURDO STATION

THE HELICOPTER HEADS OUT OVER MCMURDO SOUND, crossing a monotonous expanse of sea ice broken only by a smattering of icebergs and occasional clusters of Weddell seals. At last, off to one side, you see it: the Ross Ice Shelf, a mesmerizing expanse of white that stretches to the horizon and beyond. Wreathed in ice fog, the ice shelf takes on the haziness of a mirage. Yet it is all too substantial. Its surface ripples with undulating pressure ridges and solid, wind-hewn waves called sastrugi that move with the ice as it flows inexorably toward the sea.

Like everything else in Antarctica, the Ross Ice Shelf is outsize, a chunk of frozen water bigger than Texas jutting off a continent that is half again as large as the U.S. It is deeply mysterious, for its ice, like the ice that covers the rest of Antarctica, conceals far more than it reveals. Three years ago, the Ross Ice Shelf started calving icebergs so big that they invited comparison with Massachusetts and Connecticut,

FROZEN VALLEY

Lake Hoare, right, is covered by nearly 15 ft. of sediment-darkened ice. It is fed by meltwater that briefly trickles off the Canada glacier, left, in summer

THOMAS NASH FOR TIME

and some of these bergs—including C-19, which broke off the shelf last May—lurk nearby, provoking consternation and wonder.

What does this sudden flood of icebergs mean? Was the ice shelf, as most scientists think, responding to its own internal rhythms of expansion and retreat? Or was it reacting, through some connection in the ocean perhaps, to the general warming that has taken place almost everywhere else?

A quarter-century ago, such questions would not have seemed terribly urgent. But now that the earth is incontrovertibly heating up—2002, climate experts report, edged out 1999 as the second warmest year on record, after 1998—concerns about the overall stability of Antarctica's ice are on the rise. And with good reason. Locked away in that ice, after all, is 75% of the earth's freshwater, enough to raise global sea levels 200 ft. And while no one expects all that ice to melt anytime soon, a significant portion—enough to swamp low-lying coastal zones and menace major cities from Bombay to Boston—conceivably might.

Within the past year, scientists watched in awe as a giant ice shelf disintegrated in the Antarctic Peninsula in just over one month's time, and in a remote region of West Antarctica, satellites have detected an expanse where glaciers are worrisomely speeding up their transport of ice to the sea.

Yet it is hard to gauge what these dramatic developments portend, for despite scientists' best efforts, Antarctica—the highest, dryest, coldest continent on the planet—remains a climatological cipher. For example, while it is clear that the Antarctic Peninsula—a thin sliver of land that juts above the Antarctic Circle—has been rapidly warming, the vast empty spaces of East Antarctica, repository of the greatest ice sheet on earth, appear to be doing the opposite. "Here we have a continent that is so important to our future," says earth scientist Peter Doran of the University of Illinois at Chicago, "and we can't even agree on what's been going on there for the past few decades."

In fact, the most basic questions—Is Antarctica as a whole warming or cooling? Is its ice cover thinning or growing?—cannot yet be answered definitively. For one thing, the continent is too big and measurement points are too few and far between. Also, scientists lack the long-term records needed to put the present in perspective.

This situation is changing, however, as researchers begin systematically to probe Antarctica's ice, rock and sediments for clues. Their work is always arduous, often heroic and sometimes dangerous. This was brought home two weeks ago, when a helicopter shuttling supplies to a scientific field station crashed near McMurdo Sound, injuring two.

TIME visited the region to see the continent close up and assess the state of science there. What we found was a forbidding and extraordinarily complex environment that is just starting to come into focus. Some highlights from our journey:

MARSCAPE: MC MURDO DRY VALLEYS

THAT ANTARCTICA IS SO LITTLE UNDERSTOOD is not surprising, for it is a remote, otherworldly place that in many ways resembles early Mars more than contemporary Earth. And no place is more Martian in character

BIG BERG

After it split off the Ross Ice Shelf in 2000, the giant iceberg B-19 loomed 12 stories above the water and covered an area twice the size of San Francisco

PHOTOGRAPH FROM ANTARCTICA BY PAT AND ROSE MARIE KEOUGH—NAHANNI PRODUCTION

than the McMurdo Dry Valleys, a wedge of rugged, rocky terrain stippled with ice-covered lakes and overhung by glaciers. No diminutive alpine plants cling to the slopes of these valleys. No rodents scurry amid the boulders and scree. No flies or mosquitoes whir through the air; no fish, mollusks or crustaceans dwell in the lakes and streams.

"A valley of the dead," declared explorer Robert Falcon Scott after discovering Taylor Valley in 1903, and at first glance it would seem he was right. Yet there is life in the Dry Valleys, albeit life that is primitive in form and exceedingly cryptic. Minuscule roundworms called nematodes and insects known as springtails constitute what biologists jokingly call the "lions and tigers of the soil." The top of the aquatic food chain is occupied by single-cell protozoa that feed on bacteria.

To describe these organisms as hardy would be an understatement. The Dry Valleys are so cold (the mean annual temperature hovers around −5°F) that glacier-fed streams run no more than six weeks a year, and so arid that what little snow falls turns to vapor almost overnight. Scientists recently reported, however, that sequestered in the 60 ft. of ice that covers one of the largest Dry Valleys lakes, Lake Vida, are dormant but still viable bacteria that have been sealed off from the outside world for some 3,000 years.

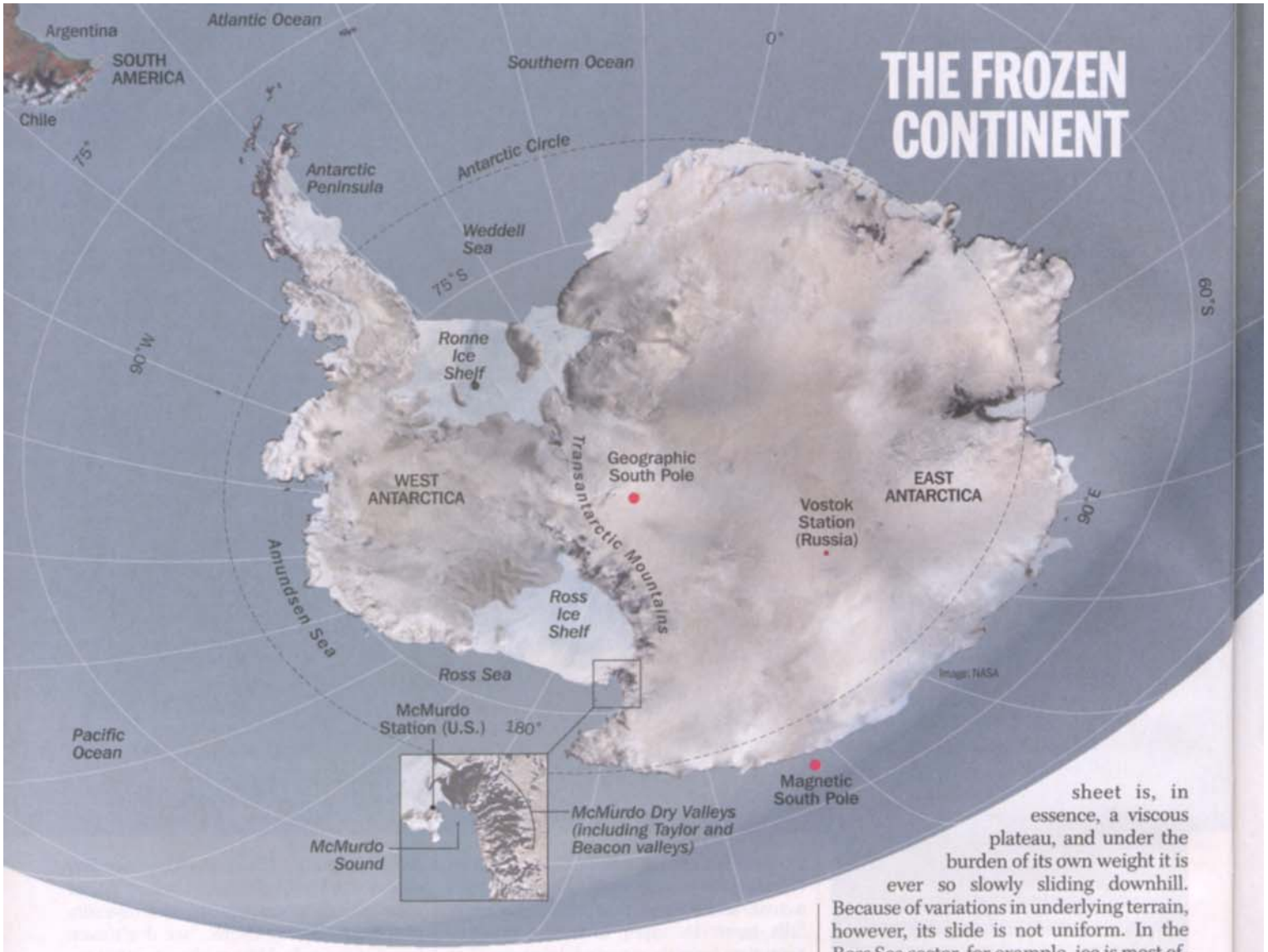
The Dry Valleys are not just a biological laboratory; they are a climate laboratory as well. Between 1986 and 2000, scientists involved in a long-running ecological study documented a succession of cold summers that crimped the short, seasonal ice melt to such an extent that not only did lake levels fall but so did the photosynthetic activity that underpins their biology. Then, last summer, from December 2001 through January 2002, temperatures shot up and lake levels soared. For a brief time, conditions became so balmy that streams of meltwater cascaded off glaciers and ice falls, and the Onyx River flowed with enough vigor to support a series of whitewater rapids.

What does that exceptionally warm summer represent? Was it just a weird anomaly that briefly interrupted longer-term cooling? Or was the cooling trend itself a temporary glitch, as rising lake levels prior to the mid-1980s suggest? "At the moment," concedes Ohio State University geochemist Berry Lyons, "we don't even know if we're looking at changes that are just regional or if they are related to changes on a global scale."

To begin solving this puzzle, scientists working in the Dry Valleys need climate records that extend over a longer period of time, and now it appears they may finally have them. In November, the University of Illinois' Doran and his colleagues retrieved a series of sediment cores from the bottom of three lakes that march up Taylor Valley like Cyclopean footprints: Fryxell, Hoare and Bonney. These cores are layered like the pages of a history book, and the record of geochemical shifts they contain can be used to reconstruct lake levels and stream flow for past centuries. Doran thinks that the record from Lake Fryxell may extend back 15,000 years.

ICEMARE: ROSS ICE SHELF

MCMURDO STATION IS THE SPRAWLING complex of buildings from which the National Science Foundation (NSF) runs the U.S. Antarctic program, and right now



McMurdo has a problem. Those big bergs that are hanging around the neighborhood have pinned up to 40 miles of sea ice next to shore, creating a daunting obstacle course for a nearby colony of Adélie penguins and a serious navigational hazard for people who service the station. The penguins are having trouble getting out to sea to feed—so much trouble that their numbers are in precipitous decline—and the NSF's supply ships are having trouble getting in. Earlier this month the NSF called in a second Coast Guard icebreaker to help clear the ice from McMurdo Sound.

Sooner or later the big bergs will move off and break up. What they will leave behind is a vague sense of menace. For the parent of the big bergs, the Ross Ice Shelf, is a floating extension of the West Antarctic Ice Sheet, which, for the past 10,000 years, has been slowly slipping into the sea. Should that ice sheet start a more rapid slide, it would trigger a lot more havoc than a few hulking icebergs.

Like Julius Caesar's Gaul, the ice that covers Antarctica is divided into three parts. There is the small ice of the Antarctic Peninsula. There is the big ice that covers the solid, continental block of East Antarctica to a depth, in places, of nearly three miles. And there is the middle-size ice of West Antarctica, much of which lies below sea level, so that its outermost fringes come into potentially perilous contact with seawater.

The most obvious danger lies in the melting that would occur if the temperature of Antarctica's salty, frigid waters climbed well above freezing. A greater if less obvious danger is that rising sea levels could undermine the ice sheet, triggering its collapse. Experts are concerned that if the West Antarctic Ice Sheet broke apart in this fashion, global sea levels could rise as much as 16 ft. in just a few decades.

Other factors affect the ice sheet's stability. One of the most important is the balance between the rate at which the ice sheet is growing (because of snowfall) and the rate at which it is shrinking. An ice sheet is, in essence, a viscous plateau, and under the burden of its own weight it is ever so slowly sliding downhill. Because of variations in underlying terrain, however, its slide is not uniform. In the Ross Sea sector, for example, ice is most efficiently conveyed out of the ice sheet's interior by ice streams, which spill onto the Ross Ice Shelf like frozen rivers.

For more than a decade now, scientists have been puzzling over these ice streams, and the consensus they have reached is both reassuring and disturbing. On one hand, they note, the overall rate at which the ice streams are transporting ice—at the relatively brisk clip of hundreds of feet a year—does not seem to have increased in recent decades. On the other hand, the streams have been extremely erratic—accelerating, decelerating, sometimes even stopping. And miles inland, the streams have shown surprising sensitivity to ocean tides, raising the specter that modest rises in sea level could accelerate their flow.

Finally, there is the question of the stability of the Ross Ice Shelf itself. Ice shelves, it turns out, are important to ice sheets for a number of reasons. Among other things, they serve as buffers against currents and wave action and as buttresses that provide structural support. In fact, the absence of ice

shelves may be the reason that glaciers in the remote Amundsen Sea sector of West Antarctica are speeding up their transport of ice to the sea. Earlier this year, in the Antarctic Peninsula, the Larsen B ice shelf showed what can happen when conditions warm. First, rising summer temperatures created meltwater ponds on the surface of the ice shelf, allowing water to pour into cracks. Then pressure exerted by the inflow of water deepened the cracks as relentlessly as a wedge splitting a log. Eventually the ice shelf fell to pieces, like an enormous tree reduced to a jumble of firewood.

FOSSIL AIR: BEACON VALLEY

CARRYING A PICKAX AND SHOVEL, Boston University geologist David Marchant trudges up a snow-dusted side canyon to Beacon Valley. The ground beneath his feet is as intricately patterned as a quilt, and under its rubble-strewn surface lurks a glacier of venerable age. Marchant believes this glacier has been frozen in place for millions of years—and if he's right, the ice in the glacier holds invaluable clues to an earlier epoch of global warming, one that offers a provocative parallel to the warming expected later in this century.

Three million years ago, the mean temperature of the earth was at least several degrees higher than today. Scientists still do not know precisely what caused the warming or how Antarctica responded. One group argues that during this time significant expanses of the White Continent were not merely ice free but covered with low-lying, tundra-type vegetation. But Marchant and his colleagues contend that the vast ice sheet that covers the Antarctic plateau rode out the temperature rise unperturbed.

The mystery that Marchant is grappling with is perhaps the most profound of all. Today Antarctica is synonymous with ice; 98% of its surface is covered by ice. But this was not always the case. Even though the landmass that constitutes Antarctica has occupied a polar position for well over 100 million years, for much of that time it enjoyed a rather pleasant clime. During the Cretaceous Period, for example, areas that today are obscured by ice were covered with forests of conifers and beech, and through them, scientists believe, roamed a variety of animals, including reptiles and dinosaurs.

What changed? The answer, many scientists believe, lies in the breakup of the ancient supercontinent of Gondwanaland, to which Antarctica once belonged. For tens of millions of years, Antarctica was the centerpiece of Gondwanaland, and its winds, like those of then contiguous Australia and South America, were warmed by currents flowing down from the equator. But around 25 million years ago, after the other continents had pulled away, a new current was created—one that circled endlessly round the Southern Ocean, sealing Antarctica off from tropical influence.

That is the bare-bones version of the story. Many scientists think more than that was needed to put Antarctica in its present deep freeze. Among their favorite candidates: a reduction of heat-trapping greenhouse gases, notably carbon dioxide. Supporting this idea are the provocative data scientists pulled from an ice core taken near the Russian station at Vostok. That ice, notes Marchant, contained bubbles of air that spanned the past 420,000 years, and the carbon dioxide in those bubbles tracked the temperature swings that mark the beginning and end of glacial cycles.

Now Marchant has found ice that promises to be more ancient still, as it lies beneath layers of ash that range between 1 million and 8 million years old. Just like the Vostok ice, Marchant's ice contains air bubbles, meaning that it could produce a record of carbon dioxide swings that occurred over this distant and dimly understood interval of time. First, of course, Marchant will have to convince skeptical colleagues that his ice really is that old, that it has not been reworked by geological processes—and this is likely to take some doing. But if that effort proves successful, scientists will have wrested from Antarctica's frozen fortress yet another fiercely guarded secret—in this case, an ancient secret of urgent import to the 21st century. ■

ANCIENT TREASURE

The ice Marchant found, not far from this spot in Beacon Valley, contains air bubbles that may be millions of years old

THOMAS NASH FOR TIME (2)