Married to Antarctica

New theory proposes an ancient wedding between North America and the lonely polar continent

By RICHARD MONASTERSKY

By trade, geologists display a rather cavalier attitude toward the continents. In their minds or on computer screens they frequently rearrange the world, shuffling about Africa and Asia faster than an interior decorator might move sofas.

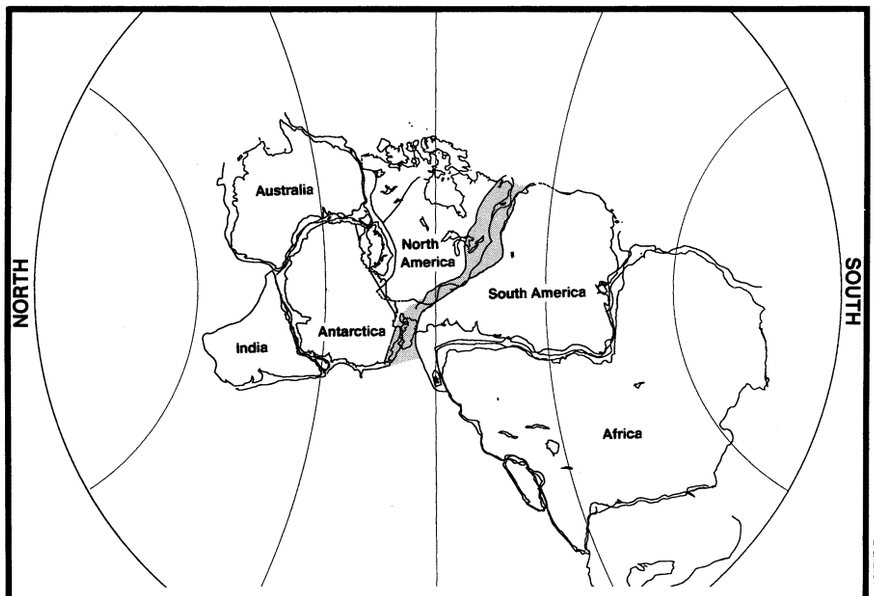
But even those long accustomed to the game of continental twister are doing a double take at a novel theory about Earth's ancient history. Two researchers propose that North America and Antarctica once lay side by side, locked together in a marathon union spanning perhaps more than a billion years.

"I think it's pretty surprising to most people. When I first told it to a colleague of mine, he told me I was out of my mind," says Ian W.D. Dalziel, a geologist at the University of Texas in Austin and one formulator of the new theory. Dalziel and Eldridge M. Moores, from the University of California, Davis, devised independent versions of the hypothesis after Moores visited Antarctica in 1989 on a field trip led by Dalziel.

Plate tectonic experts have long suspected that most of Earth's continents combined to form a giant landmass, existing from about 800 to 600 million years ago, the end of the Precambrian time. The details from that far back remain fuzzy. Yet geologists know that when the unnamed supercontinent splintered apart, some landmass separated from North America's western edge, which at the time ran through the present locations of Montana, Idaho and Nevada. The popular theory among researchers holds that the missing block of continent now forms Siberia.

Moores and Dalziel believe East Antarctica makes a better candidate for North America's long-lost mate, despite the incredible distance now separating the two. They proposed this connection after noticing that certain rocks from the frozen continent bear a close resemblance to those found in parts of the United States.

According to Moores, the Dronning Maud Land section of East Antarctica contains a band of 1.1-billion-year-old metamorphic rocks very similar to the so-called Grenville belt that runs from Texas through the Adirondack Mountains of New York and into Quebec. He suggests that Dronning Maud Land originally sat next to present-day Texas, forming a continuation of the Grenville province into Antarctica.



The world circa 675 million years ago. Map shows one possible arrangement of the continents in a giant landmass that existed between 800 and 600 million years ago. Rocks in East Antarctica resemble those in eastern North America, suggesting that they once formed a single belt (shaded region). Circle shows the present-day position of the South Pole.

If the ancient core of Antarctica was indeed wedded to early North America, the marriage may have lasted for an unusually long time, even by geologic standards. Similar rocks found in Arizona and Antarctica indicate the two continental cores got hitched at least 1.6 billion years ago. Locked together, they wandered the Earth as a unit for hundreds of millions of years and then joined up with other regions to form the late Precambrian supercontinent. North America would have finally divorced from Antarctica about 600 million years ago, when an ocean opened between the two continents.

In Dalziel's view of the ancient world, Antarctica and North America both connected to Australia, which then bordered what is now northwest Canada (see map). After those western connections developed, the eastern side of North America bonded with ancient parts of South America. Dalziel describes North America as a keystone at the center of the late Precambrian supercontinent, which apparently straddled Earth's equator.

Moores and Dalziel are not the first to suggest a connection between the polar continent and North America. More than a decade ago, Canadian geologists proposed a similar idea but never developed the concept, which lay fallow for many years until Moores and Dalziel developed it independently in separate papers, which will appear respectively in the May and June issues of GEOLOGY. The two researchers discussed their work last month at a meeting of the Geologic Society of America in San Francisco.

As news of the Antarctic theory ripples through the geosciences, it is spurring others to take a fresh look at the arrangement of the late Precambrian landmass. "The theory challenges us to ask a whole new set of

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questions. It's extremely testable. That's what's so exciting about it," says Vicki L. Hansen, a geologist with Southern Methodist University in Dallas, who does field work in Antarctica.

Moores agrees the theory raises a host of predictions that geologists can now attempt to verify. If the Grenville belt really does continue into Antarctica, researchers should be able to discern its outline under the ice by collecting gravity and magnetic measurements from an airplane. Similar measurements over North America reveal the Grenville band, even in regions where it hides beneath a cover of younger rocks, Moores says.

On the ground, scientists can carefully compare North American geology with that of Antarctica and Australia. For instance, the theory suggests the northwest Yukon will share similarities in rock type with eastern Australia from the time when the two were possibly connected.

Geologists can also turn to Earth's magnetic field for some help. When certain rocks form, they record an instantaneous imprint of Earth's magnetic field as it exists at that time. The orientation of the field "frozen" in the rock provides a clue to the ancient positions of the continents.

At present, reliable paleomagnetic evidence from the Precambrian period is scant, leaving geologists free to propose almost any conceivable orientation for the continents during that period. But future work in this area should help rein in those ideas and test the validity of the Antarctic-North American hypothesis, Moores says.

Paul F. Hoffman, who reviewed both Moores' and Dalziel's papers for GEOLOGY, has extended their ideas to describe the growth and breakup of the supercontinent. Hoffman, a Precambrian expert with the Canadian Geological Survey in Ottawa, suggests Siberia then lay fastened to North America's northern margin, with parts of Africa clamped to North America's southern side. On the east, he places the ancestral blocks of South America and Scandinavia.

To understand the details of the breakup, as envisioned by Hoffman, picture the supercontinent as three adjacent pieces of pizza leftover in a round pan, with the middle slice representing North America. When the supercontinent splintered, oceans grew first along the eastern and then along the western sides of North America as if someone had cut away the center piece and removed it from the pan.

Hoffman scripts an intriguing scenario for the next act in the continental drama. Geologists know that after the breakup, Australia, Antarctica, India, Africa and South America came back together by about 500 million years ago to form a giant continent called Gondwanaland.

To explain the assembly process, Hoffman proposes that the former neighbors of North America merged through a complicated set of movements resembling the closing of a Japanese fan. In the pizza analogy, the two remaining pieces would rotate away from the gap left by the missing center slice. The left piece would migrate counterclockwise and the right piece would move clockwise, causing the two to meet on the other side of the pan.

Such motion would have turned the continents inside out, so that areas previously on the outer edge of the Precambrian supercontinent would find themselves on the *interior* of Gondwanaland, suggests Hoffman, whose paper is in press at SCIENCE. A few hundred million years later, Gondwanaland would collide with the other continents of the world to form the well-documented supercontinent Pangaea, whose breakup brought about the present lay of the lands.

The importance of these continental connections extends far beyond the bounds of geology, says Andrew H. Knoll, a paleontologist at Harvard University. During the period of the Precambrian supercontinent, Earth experienced some of the strangest events in its history. The chemistry of the oceans went through radical changes never since repeated, and the globe entered several ice ages, one of which is the most extensive known. Animal life suddenly took a giant leap in evolutionary complexity at the end of the Precambrian period. For the first time, the seas were filled with macroscopic multicellular creatures — soft-bodied beings thousands of times larger and more complex than those of previous periods. That biological revolution paved the way for the development of today's multicellular animals.

"There are some times in Earth's history when a lot seems to happen, and there are times when things seem quiet. This is one of the loudest times we have seen," says Knoll.

He and others who study this period believe the continental shufflings may lie at the heart of many of these events. The split-up of the Precambrian supercontinent involved a massive release of heat and gases from Earth's interior — in short, a huge planetary burp. Scientists think that action and the amalgamation of Gondwanaland greatly increased the oxygen content of the atmosphere, allowing the evolutionary development of large animals that could not have formed in the less oxygen-rich environment of previous eras.

"If we really want to understand how the modern world came to be, both biologically and physically, this is the time period we want to learn a lot more about," says Knoll. "Increasingly, I think these tectonic events having to do with the various machinations of a late Precambrian supercontinent may well sit somewhere close to the root of everything that's happening." □

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