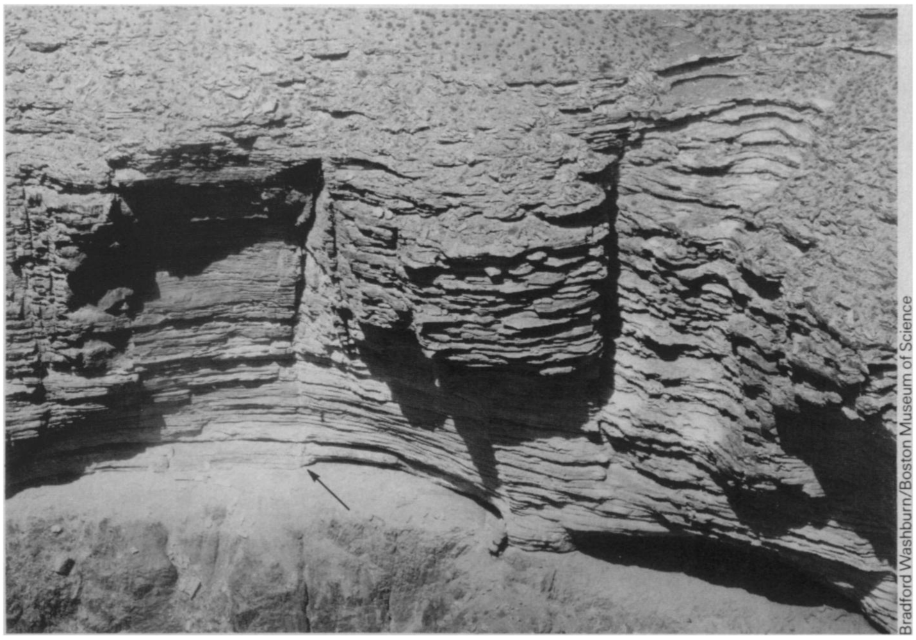
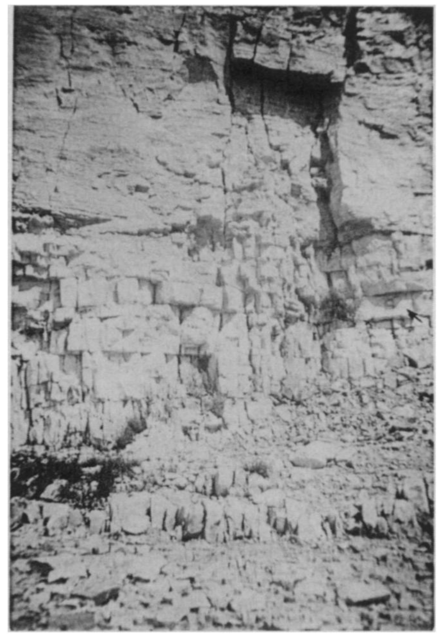
In With the Older



Bradford Washburn/Boston Museum of Science

Scientists were long perturbed by a widespread discontinuity in the layers of sedimentary rock between the Cambrian and Precambrian geological periods. In the Grand Canyon in Arizona, for instance, for millions of years no sediments were deposited so that the rocks just below the Cambrian bear no signs of multicellular animals.



Max and Françoise Debrenne, Musée d'Histoire Naturelle, Paris

These rocks along the Aldan River in Siberia span the boundary with little or no disruption, and clearly log the evolution of shelled animals and their soft-bodied antecedents.

By CHERYL SIMON

Even the most enthusiastic traveler might be daunted by the logistics of visiting the banks of the Aldan and Lena rivers in eastern Siberia. First one flies to Moscow, rides a train thousands of miles to Yakutsk, and then, weather permitting, boards a helicopter or riverboat to seemingly unremarkable spots along the rivers. The visitor may pitch a tent along the river banks, or find lodging in a small village 10 or 20 miles away. But scientists from around the world gladly make the trip — akin to a foray into the Alaskan wilds — just for a first-hand look at what may be the best sequences of rocks spanning the boundary, about 570 million years old, between the Cambrian and Precambrian geological periods.

In the last eight years scientists who study the record of ancient life have visited rock formations in nations including China, the Soviet Union, Great Britain, Canada and Australia. At each site the paleontologists made observations in anticipation of an event to occur this month, the naming of a "golden spike" for the Cambrian-Precambrian boundary. Declaring a brief hiatus from field work and research, the scientists, members of a committee of the International Geological Correlation Project, will meet in Bristol, England. For three days they will present scientific evidence in defense of a particular site. The Siberian rock formations are only two of many sites being considered. Though geological significance is of primary importance, political considerations are far from negligible: it is a point of prestige (as well as convenience) to have a standard boundary between geologic periods set in one's own country. On the fourth day discussion will be suspended as the scientists vote, establishing a reference point for all future studies of the Cambrian-Precambrian boundary.

"I don't think we're going to have an easy time," says Allison Palmer of the Geological Society of America. "We're all going to go away unhappy in varying degrees." The Lena River site is the odds-on favorite, but there is no perfect site, he says, just a series of imperfect ones. The committee's recommendation will be submitted to the International Geological Congress for final approval in 1984.

The rocks are of interest because within the humdrum-looking limestone one of the great events in the history of life is set, literally, in stone. Below the boundary there are almost no skeletal fossils, only traces where soft-bodied, multicellular animals, or metazoans, burrowed or left imprints in sediments as old as 650 million years or older. Then, about 570 million years ago, the marine animals learned to regulate the amount of calcium in their cells. Some scientists think that when there was too much calcium the animals excreted it, relegating it to calcium carbonate or calcium phosphate dumping grounds: shells.

With the appearance of preservable hard parts the Cambrian period and the familiar fossil record began. The development of shells and skeletons allowed rapid advances in biological complexity, which in turn spurred a burst of rapid evolution. Within a few tens of millions of years — moments compared to the 3.4 billion or more years since life first appeared on earth — nearly all major forms of life known today had appeared in the fossil record. This rampant proliferation of life forms is called the "Cambrian explosion."

Since the early days of geology scientists have puzzled over the boundary. Some sequences of rock, such as one in the Grand Canyon in Arizona, show an ab-

After years of study, paleontologists are ready to choose a standard boundary between the Cambrian and Precambrian geological periods. While the decision is a formality, it marks greater understanding of a major evolutionary event: the development of shells.

rupt "discontinuity" or change in the record of life. Sedimentation is not always continual but may stop, for example, as seas advance or recede with the movement of the earth's crustal plates or when erosion removes sediment before new rock layers are deposited. At the Arizona site and others, no sediments were deposited for millions to hundreds of millions of years. Rock layers containing evidence of soft-bodied animals are missing, and it appears that shelly animals evolved with no obvious precursors. This seeming fact worried Darwin, who believed that vindication of his view that evolution proceeded by orderly steps depended on life before the Cambrian.

As it turns out, Darwin's theory of evolution is well supported by less obvious but still conclusive evidence of Precambrian life. The earliest proof is embedded in fossilized remnants of ancient microbial mats. These structures, called stromatolites, today are found worldwide in harsh environments such as extremely salty lagoons or the bottoms of some Antarctic lakes (SN: 4/24/82, p. 284). The oldest stromatolites were built by bacterial communities as soon as 1.5 billion years after the world formed. For 3 billion years bacteria were the earth's dominant life form, reigning until they were pre-empted by the more sophisticated metazoans.

It is only in the last 30 years that scientists have found imprints of soft-bodied Precambrian animals. The trace fossils first were recognized in the Ediacara Hills in southwestern Australia. One of the benefits of the efforts to set a boundary has been the collection of bountiful information about the diversity and extent of Precambrian marine life. Since the early 1960s nearly 20 deposits bearing traces of animals such as shell-less segmented worms, soft corals, and jellyfish have been found.

The view of the boundary has changed. It used to be called "the greatest discontinuity in the history of life," implying that the introduction of hard parts perhaps signaled a major change in earth history, such as a sudden increase in oxygen levels or a change in ocean chemistry. Now, while scientists concur that the early Cambrian was indeed a time of astonishingly rapid evolution, many consider the word "explosion" excessive.

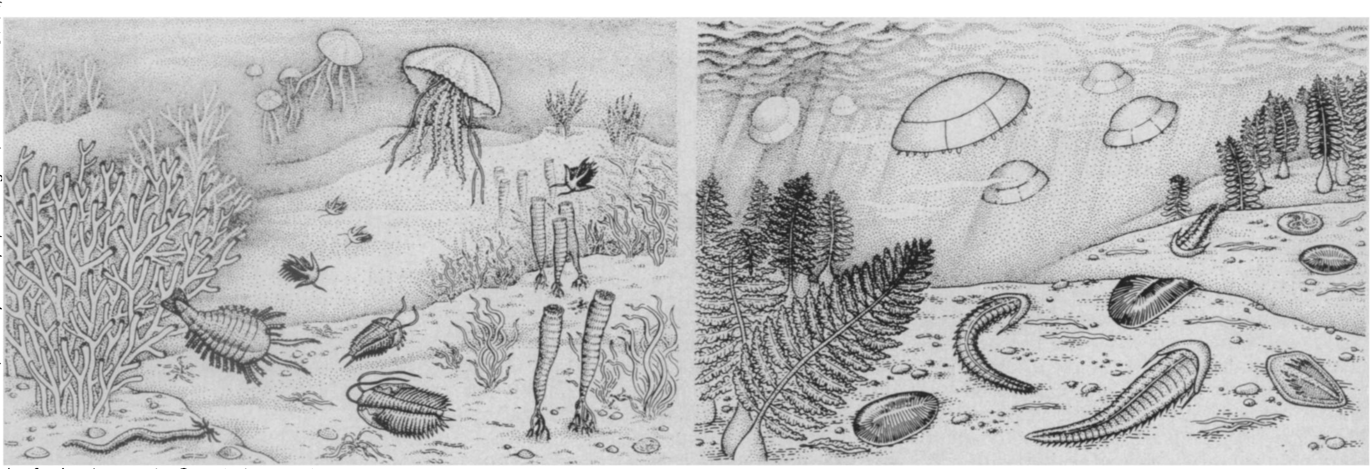
John Sepkoski, a paleontologist at the University of Chicago, contributed to this view in 1979 when he compared rates at which new species developed from the late Precambrian through the early Cambrian to the growth predicted by a simple, widely used model called a sigmoidal curve. The S-shaped curve predicts, for instance, that in a brand new environment (the young earth or a petri dish) populations expand slowly as bacteria or other simple organisms begin to grow. Organisms divide, their offspring divide, and so on, and the population moves toward a period of rapid geometric growth—an explosion. When all niches are filled and all resources allocated, the growth curve levels off. The growth during the late Precambrian through the first 10 million to 20 million years of the Cambrian bears a striking similarity to the model, Sepkoski says. If so, the accelerated pace of development then may reflect the natural course of evolution.

Although scientists often speak about the boundary, its formal designation is important because it will encourage them to use uniform criteria based on the types of fossils and qualities of the rock section chosen when referring to the still fuzzy part of the fossil record. "Before you can discuss what happened at the boundary, you have to agree on where the boundary is," Palmer says.

The committee will set a worldwide *biological* boundary as well as a particular geographical one. Sepkoski likens this effort to "defining the boundary between red and orange." Some animals are clearly Cambrian. Others are clearly Precambrian. It is the transitional animals that fuel debate.

Despite the interest in the boundary itself, the real significance lies in its cause. What led animals to form shells at that moment in history? Are hard parts such as shells and skeletons inevitable products of increasing complexity? Was the appearance of shells really sudden, and how long did it take in geologic time? The years since the Precambrian's end comprise only one-eighth of earth history. As scientists refine details of the Precambrian, they are hopeful that answers will emerge. □

Laszlo Meszoly, in *Early Life* by Lynn Margulis, Science Books Int'l, 1982



Left: In the early Cambrian period, shelled animals inhabited the seas. Right: An artist's version of the marine realm in the late Precambrian, about 700 million years ago. Bodies of shell-less animals are reconstructed from impressions they left in sand and mud.