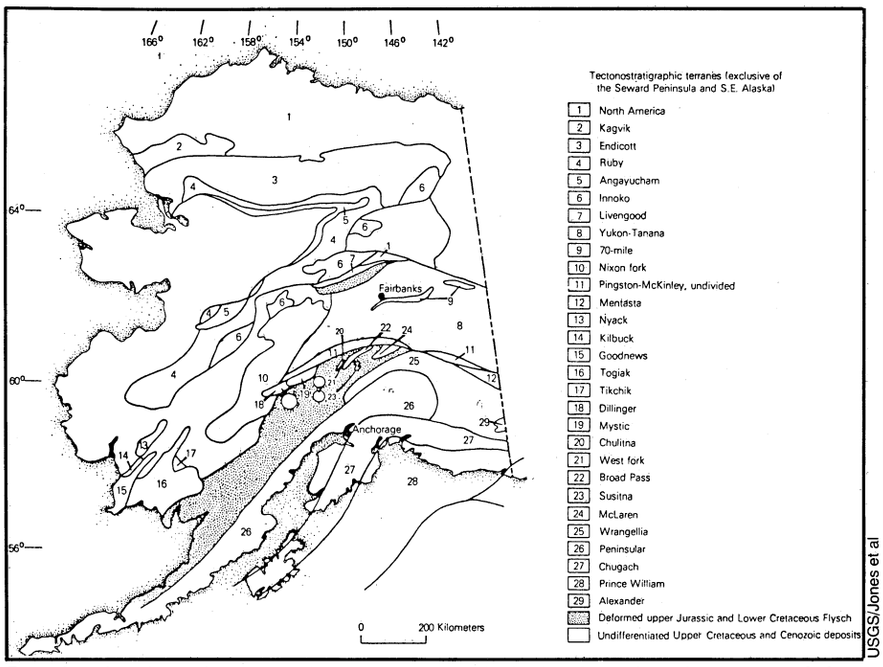
Alaska: The Fragmented Frontier

Geologically, Alaska is a jigsaw puzzle. Only now are the pieces falling in place.

BY SUSAN WEST



Based on fossils, rock types and magnetic data, Alaska has been found to consist of about 50 distinct rock masses. This map shows the 29 major blocks, or terranes, that are believed to constitute the state. Each terrane is outlined and keyed to its name on the right.

The photograph invokes the unconquered Yukon, Klondike Clyde, gold fever. Swaddled in parkas and unrecognizable beneath untamed beards, the prospectors swagger and grin in front of their log cabin. But the picture is Kodachrome, not tintype, and a sign on the cabin belies it all: "Headquarters Alaska Fragment Project." That curious sign, which now hangs with the photograph in the office of Davy L. Jones of the U.S. Geological Survey in Menlo Park, Calif., denotes a remarkable venture: piecing together the state of Alaska.

Alaska, it seems, is not your usual solid chunk of continent. Instead, it appears to consist of as many as 50 separate rock masses, many of which came from some other location. In fact, the only piece of Alaska that may be an original part of the North American continent is a small area near the Canadian border north of the Yukon River, and even that area is suspect. Tectonically, says David B. Stone of the University of Alaska in Fairbanks, the state is "a garbage heap." Stone, Jones and others presented this jigsaw-puzzle picture of Alaska at the recent meeting in San Francisco of the American Geophysical Union.

Alaska is the most dramatic, and at present the most complete, example of a relatively new concept in plate tectonics — that the edges of many continents are made up of blocks of foreign rock that have been slapped against them by plate motions. This concept is called the accretion of tectonostratigraphic terranes, meaning the addition to a continent of rock masses that are structurally and tectonically distinct units.

Geologists are finding this situation to be the rule rather than the exception. Siberia, part of Florida, even part of Nevada now appear to have once been bits of oceanic crust or other continents. Central America may be made of possibly four such foreign blocks, or terranes (SN: 11/17/79, p. 341); California's tortured coast, as well as that of New England, is probably the result of the addition of similar rock masses (SN: 12/27/80, p. 388; 6/9/79, p. 373).

The development of this concept — also called microplate tectonics, although the terranes are not individual plates — is a study in the progressive breakdown of scientific prejudices. For decades, researchers had noted that certain areas contain rock types and fossils that are completely out of place. There was no explanation for how the peculiar rocks got there and they remained an embarrassing skeleton in the geologic closet. Then, with the acceptance of the theory of plate tectonics in the early 1960s, it was possible to understand how, in the jostle of rearranging continents, pieces could be broken off one land mass and reattached to another that was nearby. But when paleomagneticians — geologists who study the ancient magnetic field that is preserved in rocks — found that some rock masses appear to have traveled thousands of kilometers from their origins, other scientists balked. Now, the accumulated weight of paleontological and paleomagnetic data is slowly swinging the pendulum of opinion. Scientists who scoffed at even short-distance journeys by rock masses are proposing an "exploding continent" in the ancient Pacific that scattered its shattered pieces to every side.

In the early 1970s, for example, paleontologists working in Alaska found fossilized remains of extinct single-celled organisms that are foreign to North America but are characteristic of Asia. At the same time, Stone and others uncovered paleomagnetic evidence in southwestern Alaska that indicated that those rocks had formed somewhere farther south. "At that time it wasn't tenable to make the radical suggestion that those rocks had broken off of something in the Pacific so we just had them slide up from the coast near Oregon and Washington," Stone said in an interview. Other researchers from Canada and Washington began to publish similar sorts of results: "Everybody had information like that in their files," says Stone, "but they just held on to it until somebody had the courage to publish."

About 1975, a new technique enabled paleontologists to obtain and date microfossils from a type of rock previously considered unusable. Combined with improved methods in paleomagnetism, the technique allowed researchers to refine their Alaskan data. In 1977, Jones, Norman J. Silberling and John Hillhouse, also of the USGS, published two landmark papers in which they proposed that a long, narrow block, which they called Wrangellia after the Wrangell Mountains, is a distinct alien block that lay within 15° of the equator about 200 million years ago. Given its present position in southern Alaska and British Columbia, of 50° to 60° N, this means that the block may have traveled as much as 9,000 kilometers before running aground on North America.

Since 1977, researchers have continued to identify the fragments that constitute Alaska. The USGS scientists, using both fossils and magnetic data, are preparing a tectonic map to be published this year that will show the extent and structure of all the known terranes. So far, the scientists

have identified 50 major terranes, ranging in size from 1 mile to several hundred miles square, each of which is bounded by major faults that are presumed to be the structures along which the terranes moved. The blocks are geologically quite different, some formed from oceanic crust while others are clearly from the edges of some unknown continent. "You can stand in one spot and see three different terranes within two miles of where you are standing," says Jones. "Continent, ocean deposit, seamounts, all smashed together."

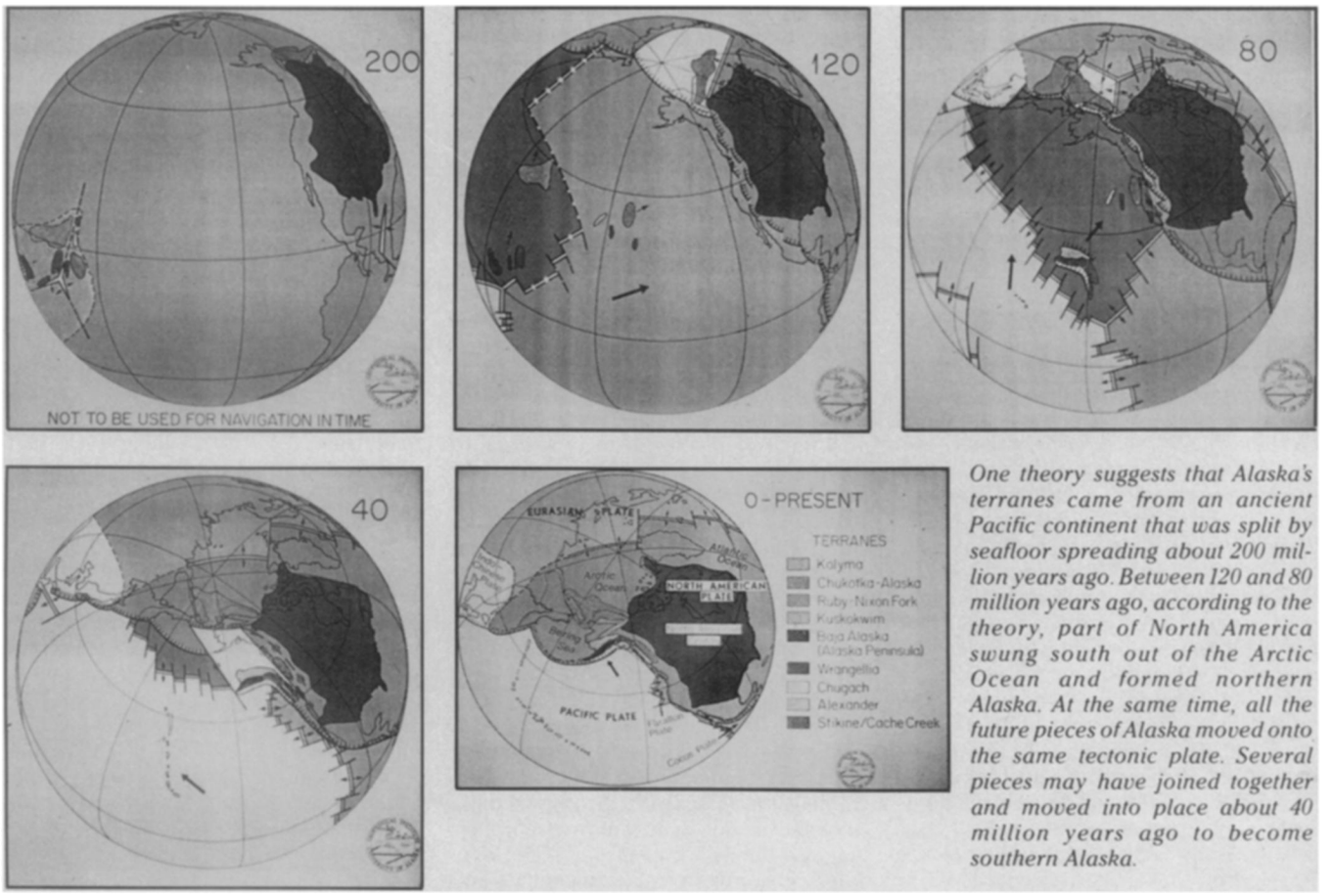
Identification of the terranes is only a preliminary step, cautions Jones, as many questions remain concerning Alaska's fragmented history. The way the terranes have been slapped onto the continent, for example, does not jibe with classic plate tectonic models, he notes. Most geologists believe that continents "grow" as soft sediments are scraped — like butter on the edge of a piece of bread — off the top of a plate as it plunges beneath a continent. In Alaska, however, the blocks have been stacked side by side like plates in a dish drainer instead of scraped and jumbled against the side of North America. The mechanism for this process is not yet apparent, says Jones.

Likewise, little agreement exists as to the timing and amount of movement of the individual terranes. While most agree that the southern Alaska terranes, at least, appear to have formed somewhere to the south, some researchers think that two or more of the pieces welded together before reaching their final destination, while others see those pieces docking, being shoved aside and redocking. For northern Alaska, the data are less clear. Some believe a chunk of North America may have rotated south out of the Arctic Ocean and formed a backstop against which all the other terranes collected, while others suggest that this piece, too, originated in the south.

At the recent AGU meeting, University of Alaska's Stone presented paleomagnetic data for one of the more far-reaching and controversial theories in this debate. About 200 million years ago, he says, a hypothetical continent in the Pacific began to break apart as a spreading center developed beneath it. At the same time, northern Alaska may have broken away from North America and swung south, out of the Arctic Ocean. Stone adds, however, that the presence in that area of major coal deposits as well as dinosaur footprints and remains, is leading him to believe that this piece, too, came from a more tropical region. Between 120 and 80 million years ago, the exploded continent was ferrying away on three plates, when, he suggests, the spreading centers reorganized and all the future pieces of Alaska jumped onto one plate and began to move more northward toward their eventual home. About 80 million years ago, most of southern peninsular Alaska joined together while still far south of its present location, he maintains, and only within the last 40 million years has everything fallen into place. In fact, he says, pieces such as the Aleutians are "still arriving."

It is this last point with which some geologists disagree. Forty million years is a geologically short period in which to move continents or pieces of continents from the equator to high latitudes, they say. While Jones calls Stone's theory "a very nice presentation of ideas," he is not convinced that southern Alaska came together as a piece, nor that the exploding continent could have "jumped" the spreading ridge as Stone suggests. Furthermore, maintain Jones and Silberling, Stone's data were gathered from sedimentary rocks that do not give as clear paleomagnetic data as do other rock types.

Controversial as it may be, Stone's theory is a first attempt to get at the ultimate goal of the "Alaska Fragment Project": rewriting the tectonic history of the Pacific Ocean. The piecemeal origin of Alaska and of other Pacific-bordering continents implies a vastly different picture of the ancient Pacific than previously envisioned. By backtracking — as Stone has attempted to do — researchers hope someday to learn what that picture looks like. Explains Jones: "This changes the whole paleogeographic situation of half the world — the Pacific. Eventually, we will completely reconstruct that half of the world." □



D.B. Stone

One theory suggests that Alaska's terranes came from an ancient Pacific continent that was split by seafloor spreading about 200 million years ago. Between 120 and 80 million years ago, according to the theory, part of North America swung south out of the Arctic Ocean and formed northern Alaska. At the same time, all the future pieces of Alaska moved onto the same tectonic plate. Several pieces may have joined together and moved into place about 40 million years ago to become southern Alaska.