SCIENCE NEWS of the week

Earth's 'Pulses' Tied to Plate Rates

"There are certain times in earth history when all hell breaks loose, and these are separated by more quiescent times," says marine geologist James Kennett. The idea that the planet's geology is punctuated by pulses of mountain building, volcanic eruption and other activity has intrigued scientists for over a century. The suspicion is that some global force periodically invigorates geologic processes. But so far, definitive proof of pulses and their causes has remained out of reach.

A new paper, to be presented in Baltimore next week at the meeting of the American Geophysical Union, takes an important step in this direction by tying together new and old evidence for pulses. Peter Vogt and John Brozena, both marine geophysicists at the Naval Research Laboratory in Washington, D.C., studied the rates at which the six major mid-oceanic ridges churn out new lithosphere (oceanic crust overlying tectonic plates). The researchers found that these spreading rates have fluctuated a number of times over the last 20 million years, causing the tectonic plates to speed up and slow down as they move away from the ridges.

"These fluctuations are shared by all the major plates," says Vogt. "So there is a globally synchronized pattern of acceleration and deceleration." What's more, Vogt has linked this pattern to episodes of increased volcanic activity and other tectonic and even climatic changes.

"This [paper] is fundamental to how the earth works," comments Kennett, of the University of Rhode Island in Kingston, who several years ago presented data supporting pulses of increased volcanism in regions where one plate is being subducted, or pushed down, under another. "Peter asks important questions. We don't have the answers yet ... but in the long term I think he'll be shown to be right."

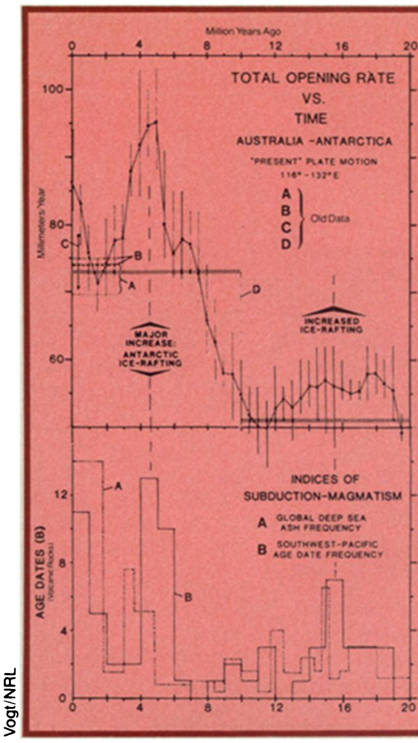
Most geoscientists today assume that the plates move at constant speeds, at least for periods of 10 million years or longer. The new paper shows, however, that plate motion fluctuates much more frequently and that these changes are large enough to be seen in the magnetic record used for dating seafloor rocks. Vogt and Brozena found plate speed fluctuations of up to ± 20 percent of average values. Moreover, the speeds have peaked at two distinct times: 4 million to 5 million years ago; and during the middle Miocene, about 14 to 16 million years ago. Plate speeds have also been increasing over the past 1 million years.

According to Vogt, these peaks are the same periods when the world's major hotspots most actively carried hot rocks from the mantle up to the plates, creating islands like the Hawaiian chain. The periods also correlate with Kennett's data on increased ash and volcanic rocks at subduction zones.

In scanning the literature, Vogt has begun to find other correlations as well. While looking at the results of the Deep Sea Drilling Project's Site 218 in the Bengal Fan off the coast of India, he discovered pulses of coarse turbidites, erosional debris washed to sea from the nearby Himalayas, that coincided with the times of greatest plate speed. This suggests that the Himalayas—which were created in the collision between the Indian and Eurasian plates—have been built up in steps, says Vogt. Faster plate speeds and collision rates result in taller mountains and more erosional debris.

Toward the middle of the Indian plate, scientists have noted large bulges in the ocean floor. The main episode creating these deformations has been dated at about 5 million years ago — again corresponding to a time of faster plate motion.

The researchers also draw a link between spreading rates and climate, although this connection and the possible causal chain is more tenuous. Vogt notes that three of the four major glaciations coincided with times of increased plate speed. The east Antarctic ice sheet, for example, formed during the middle Miocene.



Vogt/NRL

Peaks in the tectonic plates' spreading rates (above) coincide with increased volcanic activity in subduction zones (below) and with glaciation periods, when ice-rafting, or iceberg production, was greatest.

Given that all these different events are intertwined, the question still remains as to what drives them. "I don't think it's a matter of something happening at one part of a plate and ... then all the other plates readjust[ing] in some way," says Vogt. "But what exactly the cause is remains somewhat mysterious."

One possible scenario, he suggests, is that the mantle becomes unstable all at once on a global scale. This leads to more hotspot activity, which could melt rocks beneath the plates, making it easier for them to slide past. Increased production of the mid-oceanic ridges would also act to push plates away from the ridges at faster rates. And faster-moving plates translate into faster subductions, which in turn enhance volcanic activity there. The ash from volcanos might have led to cooling of the climate, but Vogt leans toward another explanation — that taller mountains from faster collisions and elevated land from more productive hotspots would have captured more precipitation, from which ice sheets form. Ice sheets, he points out, have been known to begin at high altitudes.

Kennett, while noting that improved dating techniques are needed before the relationship between pulses can be firmly established, says he thinks the evidence for interconnected pulses of different phenomena is growing. One important implication of the recent paper, both he and Vogt say, is that the magnetic time scale, used by geologists to date rocks, could contain errors that are impossible to remedy because it is based on the assumption that the plates move at constant rates.

Vogt also suggests that the recent findings have a bearing on the current debate over mass extinctions, in which some scientists have proposed that many species periodically perish when comets or asteriods pelt the earth at regular intervals (SN: 4/21/84, p. 250). Until recently, says Vogt, many scientists thought the inner earth capable of producing periodic episodes of activity in its outer shell. "Now, suddenly, those people are being very quiet and we think that any periodicity has to come from outer space," he says.

It's still possible, he suggests, that pulses in seafloor spreading, volcanic activity and other events occur with some periodicity — although not as strictly periodic as the 26- or 30-million-year extinction cycle that's being debated — and that these are related to climate changes and even to mass extinctions. "We shouldn't give up on the earth as being the mother of these phenomena," he says.

—S. Weisburd