SCIENCE NEWS of the week

'Seeing' Continents Drift

Since the theory of plate tectonics was proposed 20 years ago, earth scientists have relied on geologic evidence averaged over millions of years to guess the boundaries and relative motions among the earth's dozen plates — the floating pieces of the planet's outer shell, in which continents and oceanic crust are embedded.

However, remarkable advances in geodetic measurement technology are now enabling scientists to "see" the motions of the earth's plates on a *yearly* basis. In addition to confirming the geologic results concerning the large-scale motion of the plates, these new measurements are being used to home in on the detailed interactions between plates at their boundaries. In particular, scientists attending the recent meeting in San Francisco of the American Geophysical Union (AGU) are using these measurements to identify regions in California, other than the San Andreas fault, where strain may be building up at a worrisome rate.

The two relatively new measurement techniques use space as a reference frame. In Very Long Baseline Interferometry (VLBI), radio signals from distant quasars are monitored at different stations on the earth. The differences in the arrival times for these signals determine the distance between the earth receiving stations. In Satellite Laser Ranging (SLR), these distances are measured by comparing how long it takes for laser light pulses to leave the ground, bounce off a satellite and return to the ground stations.

With VLBI, the more exact of the two techniques, scientists are on their way to being able to measure distances with a precision comparable to measuring the length of 100 football fields to within a human hair. Thomas Herring at the Harvard-Smithsonian Center for Astrophysics in Cambridge, Mass., and his co-workers, working with five years of measurements between sites on the North American and Eurasian plates, think the precision of their distance estimates is approaching several parts in 10^9, based on the repeatability of their data. All in all, the researchers estimate that the two plates are moving apart at 1.9 centimeters per year $\pm$ 0.5 cm/yr. This compares well with the 1.7 cm/yr $\pm$ 0.3 cm/yr geologic value based largely on the spacing between magnetic stripes that were imprinted on the Atlantic seafloor as the basin opened.

VLBI and SLR measurements of the relative motion between the North American and Pacific plates are also consistent with the geologic value of about 5.6 cm/yr $\pm$ 0.3 cm/yr. The Pacific plate is sliding past the North American plate in a northwest direction. The slip between the two plates is responsible for earthquakes along California's San Andreas fault. In fact, the San Andreas is often cited as a classic example of a sliding plate boundary. But 10 years ago, ground-based geodetic measurements began to reveal that the San Andreas was moving at only 3.5 cm/yr. This "San Andreas discrepancy" leaves about 2 cm/yr of deformation to be taken up somewhere else. "We want to know where that deformation is because that is what gives us earthquakes," says Thomas Jordan at MIT.

Jordan and Bernard Minster at Science Horizons, Inc., in Encinitas, Calif., have been instrumental in developing models of plate motion based on geodetic and geologic data. At the AGU meeting, Minster presented the results of recent modeling and data indicating that the deformation across the Basin and Range region to the east of the San Andreas is about 0.7 cm/yr — too small and in the wrong direction to account for the discrepancy. This leaves, presumably to the west of the San Andreas, about 1.5 cm/yr of the deformation — an amount comparable to that at other plate boundaries that produce major earthquakes.

While there were different interpretations of much of the data presented at the meeting, says Jordan, the general picture is very consistent with the existence of a significant strike-slip component to the west of the San Andreas all along the California coastline. Minster and Jordan suspect that much of this missing component is being taken up by the San Gregorio-Hosgri fault system, which has been difficult to study directly because it lies largely offshore.

The VLBI and SLR networks will continue to help test this idea and to evaluate the long-term pattern of stresses in California. The real excitement for Jordan, Minster and others is that these arrays may catch shorter-term changes in stress prior to earthquakes, especially now that NASA's Crustal Dynamics Project plans to make more frequent measurements at fewer stations. "We have a cautious optimism," says Jordan, "that these networks will lead to new insights to the rupture process of really big earthquakes." — *S. Weisburd*

Mixing up a new composite material

A metal's oxide coating is as familiar as rust on an iron surface or the thin aluminum oxide film protecting an aluminum sheet. Now a small company has developed a novel process for mixing a metal with its oxide to create a new class of composite materials. Called lanxides, these materials, unlike other ceramic composites, appear to be tough rather than brittle and relatively inexpensive to produce — qualities that potentially make them useful for armor plating.

The process was discovered and developed by Marc S. Newkirk and his colleagues at the Lanxide Corp. in Newark, Del. The Department of Defense (DOD) provided most of the funding for the research. Details of the project, classified for three years, were released for the first time at a recent Materials Research Society meeting in Boston.

This discovery, says materials scientist Rustum Roy of Pennsylvania State University in University Park, may rank higher than the discovery of the transistor. "It's a major new way to make materials," he says. Roy's laboratory, at the request of DOD, was involved in testing the company's process and studying the material's microscopic structure.

Lanxides are formed in the reaction between a molten metal and oxygen in air or some other vapor-phase oxidant. Normally, such a situation produces an unwelcome scum on the metal's surface. However, by controlling the molten metal's temperature and by adding traces of suitable dopant metals, an inch-thick layer of a metal oxide composite can be grown on the liquid's surface.

In the case of aluminum, the product consists of an interconnected aluminum oxide (alumina) network with metal filling in the gaps. This kind of microstructure is unique, says Roy. What isn't clear is exactly how this structure is physically and chemically created. Somehow metal must soak into the oxide layer while it is being formed.

Under the right conditions, a lanxide composite is considerably stronger than sintered alumina. This makes such a composite potentially useful for armor plating, rocket or jet engines and other applications where a light but tough material is needed.

So far, only the aluminum-alumina composite has been publicly described in detail. However, according to a report in the Dec. 12 NATURE, other lanxide materials have been developed. Newkirk says "hundreds" of inventions arising from the new technology are being patented. The company will release further information at several professional meetings next year and in the JOURNAL OF MATERIALS RESEARCH. — *I. Peterson*