earth sciences

Gathered at the International Symposium on Mechanical Properties and Processes of the Mantle last week in Flagstaff, Ariz.

GEOCHEMISTRY

Water's influence

The content and distribution of water in the mantle appears to be a critical factor in determining mantle properties, reports Dr. P. J. Wyllie of the University of Chicago. This seems to be especially true in the mantle's zone of low seismic velocities and in the zone of high seismic velocities beneath ocean trenches.

Dr. Wyllie studied the effects of water combined with rocks from the mantle to gain information about the possible physical state of the mantle. He found water is stabilized in certain minerals in the upper mantle; at somewhat greater depths it may exist as intergranular fluid.

The most satisfactory explanation for the low-velocity zone, he concludes, involves incipient melting due to traces of water. The amount of magma or molten rock is almost a direct function of water content; it does not vary significantly for wide variations in temperature and depth.

Mantle instability and magma generation, he says, may thus depend upon the regime of water: water rising from the deep mantle for the low-velocity zone, and water carried down from the lithosphere for the zones beneath trenches.

GEOPHYSICS

Compressive tectonics near Gibraltar

A zone of earthquakes between the Azores and Gibraltar helps define the line of interaction between the African and Eurasian surface plates. They indicate compression is taking place near Gibraltar.

A detailed geophysical survey west of Gibraltar, reported by French scientists Xavier LePichon, Jean Bonnin and Guy Pautot of the Oceanic Center of Brittany in Brest, shows that the earthquake activity occurs mostly along a deep trench filled with about six kilometers of highly deformed sediments. To the north the crust has been uplifted more than five kilometers. To the south a broad uplift of the crust is still in progress. Deformation of surface sediments of the trench is still going on but apparently less intensely.

The French team interprets this feature as an incipient trench between two oceanic plates that began to collide at a relatively slow rate of about 1.5 centimeters per year less than 10 million years ago.

TECTONICS

Mantle upwelling

The concepts of sea-floor spreading and plate tectonics are most often applied to oceanic features, but there is good evidence that they can explain the formation of rift valleys on continents as well.

In the southwestern United States, for example, an unsymmetrical upwelling of the mantle is postulated beneath the eastern part of the Basin and Range province and perhaps also the Colorado Plateau. This is probably associated with the extension of the East Pacific Rise beneath the United States.

Results of crustal studies carried out in part by Dr. K. L. Cook of the University of Utah indicate the mantle is relatively close to the surface beneath the Basin and Range province, as shallow as 28 kilometers at Kingman, Ariz. They also indicate an abnormally low density of the upper mantle material.

If the continental crust has overridden the East Pacific Rise more or less continuously, says Dr. Cook, the crust in the Nevada-Utah-Arizona region has apparently failed to remain stationary long enough to be rifted asunder, as has happened in the Gulf of California and the Red Sea.

ROCK MECHANICS

Rock flow at high pressure

In the earth's crust and upper mantle, rock fractures and flows under complex combined stresses. A number of laboratory experiments on rock deformation have been made to study the phenomenon. But most previous experiments with high accuracy have been carried out under a simplified condition of three-dimensional stresses in which forces along two of the three axes are equal, a situation not likely to occur in nature.

Dr. Kiyoo Mogi of the Earthquake Research Institute of the University of Tokyo has developed an apparatus making possible the study of fracture and flow of rocks under triaxial stress in which all three principal stresses are different.

From experiments using the new pressure apparatus, Dr. Mogi concludes that the yielding or fracture of rocks in a region in the upper mantle will occur when the distortional strain energy stored there reaches a critical value that increases with the stress perpendicular to it. He also concludes that the possibility of fracture—the sudden release of energy—in deep regions is higher than was expected from conventional compression experiments.

GEOMORPHOLOGY

Paradox of the ophiolites

A diverse category of rocks collectively termed ophiolites occurs commonly in various stages of fragmentation and deformation in mountain belts, such as the northern Appalachians. They have presented a paradox: They seem to have been formed at high temperatures but placed in their present positions at low temperatures.

Dr. John F. Dewey of Cambridge University proposes a solution. He suggests that the ophiolites represent oceanic crust and mantle produced at oceanic ridges. This would explain their high-temperature origin. As the ocean floor spread, they cooled and were eventually placed near the margins of continents where the plates were descending. He suggests several means by which they could have been squeezed up and thrust onto the continents.