Research Notes

Temperature of a Comet

When the comet Ikeya-Seki passed the earth and whipped around the sun in October 1965, two Caltech scientists had a telescope trained on it from Mount Wilson. Their measurements, the first ever made of a comet's temperature, resulted in some valuable new information. Eric E. Becklin, graduate student in physics, and James A. Westphal, senior research fellow in planetary science, found that variations in the comet's temperature (which was constant from head to tail) were entirely dependent on its distance from the sun, indicating that the comet is essentially a "cold body," generating no heat of its own. They also concluded that this particular comet is composed primarily of metallic material, not ice and dust as has been suggested for comets in general.

This was not Ikeya-Seki's first close pass of the sun, which may account for its unexpected composition. It may be that the lighter-weight elements were "boiled off" in a previous pass. Apparently Ikeya-Seki is part of a larger comet that long ago passed by the sun on the same orbital path and was broken apart; six fragments of that large comet have been observed since 1843, and all have been in the same orbit as Ikeya-Seki. On this latest pass the comet was broken into two pieces and lost about 65 percent of its mass.

Comet Ikeya-Seki, first to have its temperature taken

Blinking Microscope

Borrowing a technique used by astronomers to locate exploding stars, Caltech engineers have developed a microscope that detects small changes in metallic crystals. The unique microscope, which may have wide research applications, can either superimpose one image on top of another or rapidly alternate the images. Normally, similar specimens have been viewed side by side in a split field.

The new microscope was assembled by three materials science engineers—professor David S. Wood, associate professor Thad Vreeland, Jr., and graduate student David P. Pope. They are using it to study the stress-induced movement of dislocation lines in metallic crystals and the ways in which this movement contributes to metal deformation.

Astronomers searching for exploding stars, comets, and asteroids compare pictures of large portions of the sky photographed at different times. By "blinking" two negatives under a low-power viewer (looking at them alternately for a second or less), they can detect small changes in the position or size of objects. Those that have changed position seem to jump back and forth as the images are alternated, and objects that have changed in size seem to pulsate.

The same illusion can now be created when comparing metallic crystals before and after stress is applied. In their work, the engineers compare small x-ray negatives or plastic molds of the crystal surfaces under a magnification of 50 to 500. Disloca-

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tion lines that have moved appear to shift back and forth as the images are alternated.

Gravity Survey

A hidden branch of the San Andreas fault, extending more than 60 miles from the Salton Sea to the Mexican border, has recently been traced by a gravity survey of southern California made by Caltech's Seismological Laboratory. The survey, designed primarily to learn more about the geologic structure of southern California and about variations in the thickness of the area's crust, involved about 30,000 measurements of the force of gravity over the area.

The data were obtained with a gravimeter, a portable device that detects very small differences in the force of gravity. Because denser rocks or minerals produce a greater gravitational pull than lightweight material such as porous sand, a gravimeter moving over an area can delineate structural features many miles beneath the surface.

The survey, which incorporated readings made by scientists at Caltech and elsewhere, showed that one of the southern branches of the San Andreas fault—the Banning-Mission Creek fault—continues southeasterly from the Salton Sea area. Geologists have suspected that the fault did extend in that direction, but were unable to find its trace on the surface. The hidden segment was detected by gravity variations indicative of fault structure.

It was also found that the earth's crust is unexpectedly thin beneath the Imperial Valley—only 13 to 16 miles thick compared to an average over the continent of 20 to 25 miles. The valley, which was once part of the Gulf of California, appears to be a transition zone between the crustal structure that is found under the continent and that which is found under the ocean where the crust is only four to five miles thick.

The survey was coordinated by Shawn Biehler, Caltech research fellow in geophysics, who is now an assistant professor of geophysics at the Massachusetts Institute of Technology.

Structure of Paulingite

In 1963 Sten Samson, Caltech senior research fellow in chemistry, determined the structure of the most complex inorganic molecule ever to have its atomic arrangement figured out—a compound of sodium and cadmium. The job of locating each of the compound's 1,192 atoms took more than a year. Now Dr. Samson and graduate student E. Kent Gordon have used the same technique to determine the structure of Paulingite, the mineral having the largest known basic structural unit of any inorganic material—nearly 3,000 atoms.

Dr. Samson's success in this work is due in large part to his intuitive grasp of the architecture and geometry involved in the groupings of atoms. He

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The oasis of Biskra Palms, north of Indio, results from damming of groundwater along the Banning-Mission Creek fault, a branch of the San Andreas. Caltech geophysicists have now traced the fault to the Mexican border.

uses a two-step technique, first taking an x-ray diffraction photograph of the material to find the size of the basic unit and get a general picture of the symmetry of the atomic arrangement. He then combines the x-ray information with unique "symmetry charts" he has devised, painstakingly working out the exact arrangement of atomic groupings.

The basic unit of Paulingite is a framework of 2,106 silicon, aluminum, and oxygen atoms, with about 800 positively charged metal atoms and water molecules distributed within the framework. The mineral was discoverd several years ago by Barclay Kamb, Caltech professor of geology and geophysics, who named it after his father-in-law, Caltech research associate Linus Pauling, chairman of the division of chemistry and chemical engineering from 1936-58.

The Ice Caps of Mars

The planet Mars is a tantalizing subject for astronomers, close enough for photography of its surface features, but too far away to reveal those features very clearly. As a result, what one man sees, another doubts, and one interpretation is refuted by another. But observers have been fairly well agreed on at least one Martian feature—the ice caps on the poles. Many photographs show them, and spectroscopists have confirmed the presence of water in the ice. Now two Caltech scientists have raised some doubts about *this*; they propose that the ice in the polar caps is actually composed of carbon dioxide (dry ice) rather than water.

Robert Leighton, professor of physics, and Bruce Murray, associate professor of planetary science, have come to this conclusion after completing a study of what the behavior of volatile materials ought to be on Mars. The men think that any water that does exist there, except for a little bit in the ice caps, is probably contained in the form of permafrost under the polar regions and possibly under the temperate regions as well. They also suggest that volatile organic compounds, if they exist on the planet at all, may tend to concentrate in the polar regions.

The Caltech study involved the application of available data to a simple thermal model of Mars. It utilized results of last year's spectacular Mariner IV flight to Mars, primarily the value for atmospheric pressure (about 0.5 percent that of the earth) and the inferred composition of the Martian atmosphere (mostly carbon dioxide).

The scientists first devised a thermal model of the planet's surface. Then, using Caltech's 7094 computer, they evaluated the heat balance for a sample period of several years, computing nightly and annual temperature variations for the surface at various latitudes. With little atmosphere to transport heat energy on Mars and no oceans to equalize temperatures over the planet, it is probable that the surface temperatures there are governed almost entirely by latitude and time of day.

It was found that the minimum nighttime temperature near the equatorial latitudes would remain above 145°K (the freezing point of carbon dioxide on Mars) at all seasons of the year, but would drop considerably below that temperature in winter at subpolar and polar latitudes. Thus, carbon dioxide, the dominant constituent of the atmosphere, would precipitate and accumulate at the higher latitudes during the Martian winter. As for reports of water in the polar caps, there may be a very thin coating on the top which remains as the carbon dioxide underneath evaporates.

Confirmation of these conclusions may come from earth-based observations during the 1967 opposition or from the scheduled 1968 flight of a Mariner spacecraft to Mars, at which time high-resolution measurements of the temperature at the polar caps and on the dark side of Mars are planned.

Pollutant Dispersion in Rivers

Engineers now have a reliable and practical way to predict the dispersion rate of a sudden dose of pollutants in a river as a result of work done by Caltech graduate student Hugo Fischer, now assistant professor of hydraulic engineering at Berkeley. He did the research under the direction of Norman Brooks, professor of civil engineering, in Caltech's Keck Engineering Laboratories.

Dr. Fischer has found a theoretical method for predicting the extent of danger to water supplies from accidental spillage of pollutants. Up to now, such risks were evaluated experimentally by dumping dye into the river and then analyzing how it became diluted as it spread downstream. This method is time-consuming and expensive; it must be done separately for each river, and it is impractical for large rivers. The Fischer method makes use of a mathematical formula that simply requires knowledge of how the depth and currents vary across a section of river—information that is already on file for many rivers.