Ice Ages Attributed to Orbit Changes

New evidence has apparently settled the argument over what causes dramatic changes in global climate and what may happen next. The changes result from subtle, regular variations in the earth's orbit around the sun, and the trend now is toward cooler temperatures, with a new ice age likely within a few thousand years.

In an unusually strong statement of these conclusions, geologist James D. Hays of Columbia University's Lamont-Doherty Geological Observatory this week declared: "We are certain now that changes in the earth's orbital geometry caused the ice ages. The evidence is so strong that other explanations must now be discarded or modified."

Working with Hays were John Imbrie of Brown University and Nicholas J. Shackleton of Cambridge University, England. The research was sponsored by the National Science Foundation as part of an international project called CLIMAP (Climate: Long-range Investigation Mapping and Prediction), currently headed by Hays. Both NSE and Columbia made announcements this week. Detailed results will appear in the Dec. 10 SCIENCE.

In an interview with SCIENCE NEWS, Hays described the three overlapping cycles of variations in earth's orbit that combine to change the climate:

- In a cycle of 23,000 years, the earth advances in its elliptical orbit so that its closest approach to the sun occurs at different times of the year. Now the earth and sun are closest in January; in 10,000 years they will be closest in July. A longer distance between the earth and sun in summer means cooler temperatures, less snow melting and a growth of the polar ice caps. Thus, the present conditions should slowly lead into a new ice age.
- In a cycle of 41,000 years the orbit tilts so that the earth's axis is sometimes more nearly perpendicular to the direction of the sun than at other times. The peak tilting of the axis away from the perpendicular last occurred 9,000 years ago, so the trend is now toward minimum tilt, which also foreshadows a new ice age.

This conclusion can be better understood if one imagines what would happen if the earth's axis of rotation were always exactly perpendicular to the direction of the sun. There would be no seasons and polar ice would never melt, resulting in a permanent ice age. Thus, as the axis moves toward minimum tilt, some 22° away from perpendicular, the poles will grow colder and a new ice age will result.

- In a cycle of 93,000 years the eccentricity of the earth's orbit changes from nearly circular to more noticeably elliptical. This cycle modulates the severity of an ice age caused by the seasonal differences in distance between sun and earth. When the eccentricity is minimal, the effect of the 23,000-year cycle is decreased, for the seasonal differences in distance are slight. The earth's orbit is now midway between the two extremes, progressing slowly toward greater eccentricity.

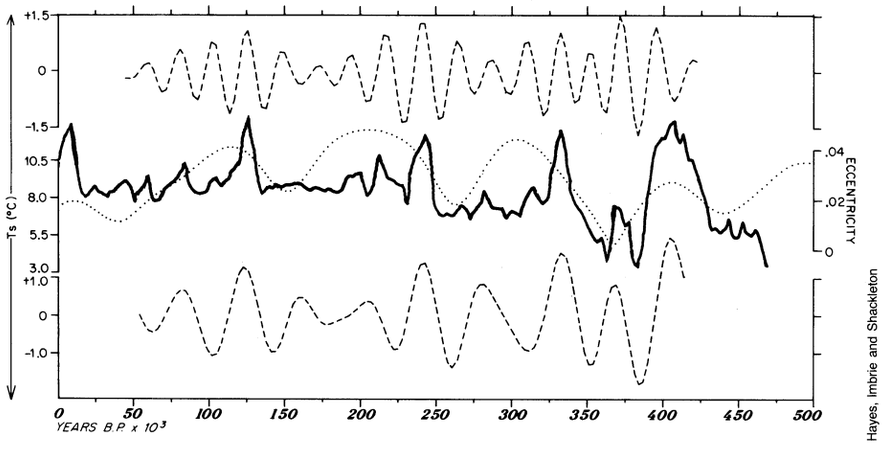
More than a century ago scientists were arguing over whether climate changes might be caused by alteration of incident solar radiation, brought about by variations in the earth's orbit. They recognized that the other planets, particularly Jupiter, would exert enough gravitational pull to cause the variations. In the 1930s, the Serbian geophysicist Milutin Milankovitch carefully worked out the orbital changes that would be involved and postulated a detailed theory of their effects. But an equally detailed chronology of global climatic reversals was needed for comparison. It is the establishment of that detailed chronology that has allowed Hays's group to declare so positively that the Milankovitch theory has been verified.

The team studied two carefully chosen sediment cores taken from a relatively undisturbed portion of the Indian Ocean floor. The location was chosen for its remoteness from any continent, where material washed from the land would have complicated the record. Also, the seafloor at this location is relatively shallow, minimizing transport of material in from other areas. By comparing the strata in the cores to others with known chronology, an unbroken geological record of climate changes over 450,000 years was established—three times longer than previous attempts had been able to accomplish.

By studying the remains of plankta that had lived in the ocean over those years, the team was able to establish a record of water temperatures. The plankton radiolaria is particularly sensitive to temperature changes and observation of the abundance of those preferring warmth or cold led to an estimation of the prevailing water temperature during their lives.

Another set of measurements from the cores helped to establish a record of the amount of water bound in the polar ice caps at a given time. This independent estimation of when ice ages occurred coincides very closely with that inferred from the radiolaria data. As water molecules evaporate from the sea surface, those containing an atom of oxygen-16 isotope will tend to leave the surface faster than the heavier molecules containing oxygen-18. During ice ages, the oxygen-16 molecules are thus more likely to be bound up in the polar caps when they fall back to earth in snow. An enrichment of oxygen-18 molecules in a sediment layer therefore indicates an ice age.

Although a full-blown ice age will take thousands of years to develop, Hays told SCIENCE NEWS that he shares the concern of other climatologists over possible near-term effects of climate changes on agriculture. Even in the early stages of a cooling trend, he says, there could be "a significant impact on the length of growing season, particularly in the northern temperate zones, for example, in the wheat belt of Canada and the Soviet Union." He stressed, however, that the time-scale of the present study is thousands of years, and that one cannot use the data to predict what will happen in the next hundred years or so. □



Variations in eccentricity and climate over the past 500,000 years. Dotted line shows orbital eccentricity. Solid line is newly obtained temperature curve based on radiolaria in two deep-sea cores. Dashed curves show the 23,000-year and 40,000-year components extracted from the overall climatic curve in center.