cluded but now accept as appropriate. Shoemaker finds that if the impacts are assumed to be periodic, the best period is about 32 million years and the last event would have been 2 to 4 million years ago. But at most half of the impacts would be associated with showers, and the significance of any true periodicity seems to be reduced in comparison to that of the list of 11. This "suggests a periodicity," says Shoemaker, "but it also suggests very strongly that there is a background component" of random impacts.

Everyone agrees on one thing—statistical analyses will never decide the question. Muller and his colleagues have just begun a search of the skies for a solar companion, but geochemists have been searching for several years for new layers of iridium-rich sediments that might mark other major impacts besides the one now generally accepted to have occurred 65 million years ago. The search has not been all that productive, so far.

The geological search's single clear achievement has been the confirmation of two impact-related layers only a few tens of thousands of years apart that are about 37 million years old. One layer contains millimeter-size globules of glass called microtektites. These carry no excess iridium, but other evidence indicates that such particles are scattered across the globe by large impacts. The second layer, first noted by Billy Glass of the University of Delaware in 1974, contains tiny, partially crystalline spherules that do contain enough iridium to link them to an impact of an extraterrestrial object, as discovered independently in 1981 by Frank Asaro of the Lawrence Berkeley Laboratory and his colleagues and by R. Ganapathy of the J. T. Baker Chemical Company.

Reports of other microtektite layers 30 to 40 million years old (*7*), some of which may have associated iridium anomalies, are being hotly debated. However, marine paleontologists, including Bruce Corliss of Woods Hole Oceanographic Institution and his colleagues (*8*), agree that even if a comet shower struck then, the major extinctions of that time were not catastrophic, as predicted by the periodic extinction hypothesis, but gradual and apparently linked to progressive climate change. Geochemical searches around the times of other major extinctions besides the one 65 million years ago have thus far failed to produce any clear-cut evidence of large impacts. Reported iridium anomalies have not yet been confirmed by a laboratory having a good track record, have been contradicted by independent analyses, or are associated with fossil bacteria that could have concentrated the iridium from their surroundings.

Frank Kyte of the University of California at Los Angeles has searched a single core of central North Pacific red clay from 1.5 to 4 and 32 to 66 million years ago and found only the iridium layer of 65 million years ago, although much smaller anomalies could have gone undetected. More significantly, Kyte finds no evidence of the surge in iridium deposition expected when a comet shower floods the inner solar system with dust, some of which must settle to the sea floor. So far then, there is little if any undisputed evidence linking periodic impacts and extinctions.—**RICHARD A. KERR**

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Fifteen Years of African Drought

The well-publicized 1972 sub-Saharan drought never went away, but, despite its magnitude and persistence, it is neither a human creation nor unique

When it began, back in the 1960's, the impending drought appeared to be simply a return to more normal weather after the wet decade of the 1950's. From the perspective of 1985, however, the sub-Saharan drought of the past 15 years is seen to have been the worst in 150 years, and the past 2 years were the driest of the century. The exceptional persistence, severity, and broad expanse of the drought suggest that man's role in the disaster has been limited to aggravating human suffering; nature, not man, created the drought. It may be years before this one ends, and it will happen again.

The catastrophe of the sub-Saharan drought began innocently enough toward the end of the 1950's when nearly a decade of unusually wet weather ended and precipitation amounts more typical of the first half of the century returned. But the drop in rainfall did not stop there. A 5-year pulse of dryness peaking in 1972 brought misery and international attention. By 1975, some climatologists thought the drought might be over, but the weather in the sub-Sahara does not always work that way. Once it dries out, it has a tendency to stay dry.

Another, sharper pulse of drought peaked in 1977, equaling the intensity of the 1972 pulse, according to rainfall records for sub-Saharan West Africa compiled by Peter Lamb of the Illinois State Water Survey. In 1979, after once again approaching but failing to reach normal, annual precipitation began falling year

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Drought takes its toll in Africa.

by year, although the looming disaster went largely unnoticed outside Africa. By 1983 the drought was far more intense than in 1972 or 1977. In 1984 it was just as bad, according to reports from 16 of 20 sites, Lamb says.

Longer records compiled by geographer Sharon Nicholson of Florida State University show that at no time in this century has the sub-Sahara received as little rainfall as it has in the last 15 years. Dakar on the west coast of Africa, for example, enjoyed an annual precipitation in the wet 1950's typical of the corn belt of Indiana. In 1983 Dakar received as little rain as the deserts of the American Southwest. And this intense drought extends 6000 kilometers in an unbroken band across the continent, encompassing an area twice that of the continental United States. It even seems to operate in concert with a tendency toward drought, although shorter and less persistent, in Southeast Africa. In light of the continent-wide scale of the drought, Nicholson notes, claims that Africans themselves brought on the drought by stripping away vegetation and altering the reflective properties of the land can have no foundation. The drought is simply too big to be man-made.

The present sub-Saharan drought is also unlikely to be man-made because records of an earlier drought like it have been found. Reliable measurements of precipitation were not made before 1900, but Nicholson has searched noninstrumental records of drought in the 19th century such as diaries, newspapers, official records, and reports of water levels in lakes and rivers. She found that the past century was generally wetter than the present century, but between about 1820 and 1840 the sub-Sahara suffered a drought that was certainly as long as the present one and probably as intense.

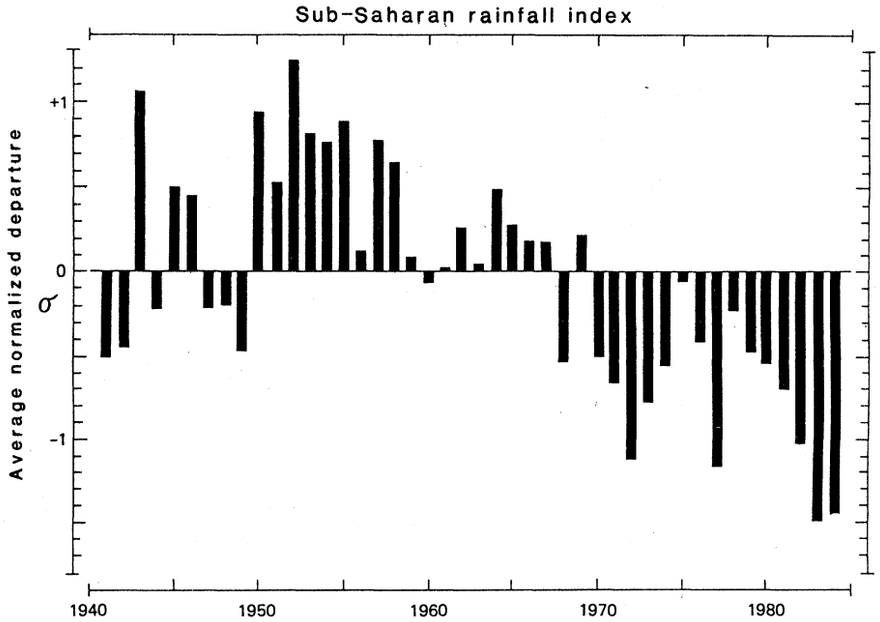
One measure of sub-Saharan drought intensity is the withdrawal of the edge of Lake Chad as more water evaporates from it than drains into it. Nicholson found that Lake Chad was as small during the 1820–1840 drought as it became in 1979. Jean Maley of the University of the Sciences and Techniques of the Languedoc in Montpellier, France, has developed an even longer record of Lake Chad levels from geological studies. This record reveals several earlier severe droughts, the most recent between 1736 and 1758.

Because the sub-Saharan drought seems to be too broad and too common a phenomenon to be caused by man, meteorologists have looked for causes farther afield. In Southeast Africa, where drought tends to be patchier and less persistent, the unusually warm tropical Pacific of an El Niño and its accompanying atmospheric changes seem capable of triggering drought. Eugene Rasmusson of the National Meterological Center in Camp Springs, Maryland, points out that 22 of the most recent 28 El Niños have been associated with below normal rainfall in Southeast Africa. A colder than normal tropical Pacific probably leads to higher than normal rainfall, he says.

El Niño apparently can bring drought to Southeast Africa, as well as Australia and India, but the sub-Sahara marches to the beat of a different drummer. As first suggested by Lamb, the pulses of sub-Saharan drought seem to be associated with the appearance of warmer than normal water in the Atlantic south of 10°N off West Africa. Colder than normal water appears at the same time to the north and across the Atlantic as far as the Caribbean, where it also seems to influence precipitation. This pattern of temperatures appeared in 1972, Lamb notes, as well as in the drought years of 1913 and perhaps 1921, according to recent work by Janice Lough of the University of Arizona. The pattern was there in 1984 and was among the strongest of the century, Rasmusson says.

Encouragingly enough for those interested in forecasting drought, the drought-related sea-surface temperature pattern develops in the months before the crucial summer rainy season of the sub-Sahara. Lamb suspects that changes in ocean currents, induced by changes in atmospheric circulation, redistribute heat in the Atlantic to create the anomalous sea-surface temperature pattern. That process in turn moves the warmest water and the precipitation activity centered over it 300 kilometers to the south, reducing the penetration of moisture-laden winds into West Africa and the sub-Sahara. Although this provides a possible working model for pulses of drought, it does not extend very far along the chain of causation and does not address the question of why sub-Saharan drought can at times, but not always, persist for decades.

The most pressing question is when will the present crisis ease, but meteorologists can only guess. The 1972 pulse intensified for 2 years before it peaked and took 2 years to approach normal again. The current peak of dryness, if it is a peak, was more than 4 years in the making. An equally long return to normal would not surprise anyone. On the optimistic side, if recent history is any guide, this drought could be due to end relatively soon.—**RICHARD A. KERR**



Fair weather and foul

The sub-Saharan drought in a sense began in the 1950's as unusually wet weather turned to normal and then, in the late 1960's, to unusually dry. This graph of an index of annual departures from normal rainfall (1941 to 1974) in sub-Saharan West Africa, prepared by Peter Lamb, shows that long downward trend punctuated by three pulses of intense dryness. The last 2 years—1983 and 1984—are the driest of this century. The 1984 bar includes data from 16 of the usual 20 stations, but data from the four remaining stations are not expected to change its value markedly.

Additional Readings

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