ABRUPT CLIMATE CHANGE AND EXTINCTION EVENTS

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There is a growing body of theoretical and empirical support for the
case of instabilities in the climate system (North, 1984; Broecker et al.,
1985; Berger and Labeyrie, 1987), and indications that abrupt climate
change may in some cases contribute to abrupt extinctions (Crowley and
North, 1988). Theoretical indications of instabilities can be found in a broad
spectrum of climate models - energy balance models, a thermohaline model
of deep-water circulation, atmospheric general circulation models, and
coupled ocean-atmosphere models. Abrupt transitions can be of several
types and affect the environment in different ways. A sudden change in ice
cap size is associated with albedo discontinuities of snow and ice (North,
1984). Incremental changes in precipitation or evaporation could affect
surface salinity (and density) of ocean surface waters, thereby affecting
production rates of deep water. Changes in deep-water circulation could
alter heat transport and affect carbon storage and oxygen levels, both in
depth and in the atmosphere. Abrupt transitions also occur in the
planetary circulation.

There is increasing evidence for abrupt climate change in the geologic
record and involves both interglacial-glacial scale transitions and the longer-
term evolution of climate over the last 100 million years. O-18 records from
the Cenozoic clearly show that the long-term trend is characterized by
numerous abrupt steps where the system appears to be rapidly moving to a
new equilibrium state. The long-term trend probably is due to changes
associated with plate tectonic processes, but the abrupt steps most likely
reflect instabilities in the climate system as the slowly changing boundary
conditions caused the climate to reach some threshold critical point (North
and Crowley, 1985; Crowley and North, 1988).

A more detailed analysis of abrupt steps comes from high-resolution
studies of glacial-interglacial fluctuations in the Pleistocene. Transitions
have occurred in less than 1,000 years. Detailed studies of the Greenland
Dye 3 ice core indicate that at the end of the last glacial maximum the
atmosphere may have shifted states in less than 100 years. Studies of the
last interglacial-glacial transition indicate that the end of the last interglacial
occurred within 1,000-2,000 years. Over a core depth of 3-6 cm, ice volume
increased by 10 X 10^6 km^3. Comparison of the rate of climate change at this
time with the K-T iridium anomaly from Gubbio indicates that both events
occurred over comparable spans of sampling resolution (Crowley, 1988).

Comparison of climate transitions with the extinction record (Crowley
and North, 1988) indicates that many (but by no means all) climate and
biotic transitions coincide - the Late Ordovician, Late Devonian, Early Permian, Eocene-Oligocene, Miocene, and Pliocene. The Cenomanian-Turonian and Toarcian extinction events also coincide with ocean anoxic events that may reflect instabilities in the ocean system. However, at the present time the Cretaceous-Tertiary extinction is not a candidate for an extinction event due to instabilities in the climate system. The K-T is not associated with evidence for either ice cap growth or thermohaline instabilities, nor is the event associated with any significant long-term step in the geologic record. It is quite possible that more detailed comparisons and analysis will indicate some flaws in the climate instability-extinction hypothesis, but at present it appears to be a viable candidate as an alternate mechanism for causing abrupt environmental changes and extinctions.

REFERENCES


