Greenhouse Climate of the Cretaceous and Early Cenozoic

Observations

The Mesozoic Era was warm with no glacial periods.

The Cretaceous Period was especially warm.

- no ice even at the poles for the most part
- tropical vegetation extended to the arctic circle
- forests existed within the arctic and antarctic circles
- reptiles, including dinosaurs lived inside the arctic and antarctic circles

Sea Level

Sea level was high and flooded large continental areas. It was the last major cycle of continental flooding of the Phanerozoic Eon. Cretaceous marine limestones are found well above today's sea level.

The exact sea level is hard to determine but it was probably ~100 - 200 m or so higher than today.

Factors in sea level change:

- changes in seafloor spreading rate (as described in lecture 4 notes)
  slow change: 10s to 100s of millions of years
- continental collisions thicken and shorten the continents so they take up less horizontal space, thereby lowering sea level
  slow change: millions to 10s of millions of years
- glaciation removes water from the oceans
  rapid change: 10s of thousands of years
- thermal expansion/contraction of warming/cooling sea water
  rapid: hundreds to thousands of years

The combination of these effects produced the lowering of sea level since the Cretaceous with slowing seafloor spreading and growth of ice producing most of the sea level change.

Anoxia in the deep sea in the Cretaceous resulted in the preservation of black (organic-bearing) shale on the deep sea floor. Today, the deep sea floor is "ventilated" as a result of the formation of deep ocean currents in the arctic and antarctic.

More rapid seafloor spreading and resulting subduction zone arc volcanism as well as voluminous hotspot volcanism and eruption of flood basalts on land and in the oceans during the Cretaceous would also have outgassed more CO_2.

Climate models require high CO_2 to reproduce the warm climate of the Cretaceous.

Models and observations indicate greater warming at high latitude compared to the already warm tropics.

End of Cretaceous Mass Extinction Event

The dinosaurs and many other animal groups became extinct 65 m.y. ago at the end of the Cretaceous Period.

It is believed that the cause of the extinction was a large meteor, ~10 km across, that slammed into the Earth in the location of the present day north coast of the Yucatan Peninsula, Mexico.

The impact caused a sudden shockwave and thermal impulse that suddenly heated the air which could have quickly killed many organisms and started many forest fires.

Molten rock ejected hundreds to thousands of miles from the impact site started more forest fires.

Immense amounts of ash thrown into the air from the impact and smoke and soot from forest fires darkened the skies for months causing plant growth to greatly decrease and temperatures to decline.

However, once the skies cleared, warm temperatures returned. There was no long-term affect on climate. There is no imprint of climate change preserved in the sedimentary record.

Early Cenozoic warmth

The warmth of the Cretaceous greenhouse climate continued into the Cenozoic.

Fossil evidence of forests at Arctic & Antarctic circles.

Paleocene-Eocene Thermal Maximum (PETM)

a very short (~100,000 yr) warm pulse
at the Paleocene-Eocene boundary, ~55 m.y. ago
evidence from oxygen isotope excursion
sudden change in marine and terrestrial species
also a large shift in carbon isotopes to lighter values indicating sudden release of organic carbon

model: caused, in part, by release of methane clathrate from seafloor
plus some other source of carbon (deep ocean? volcanic metamorphism of marine carbonates?)