Snowball Earth: Episodes when the Earth was Enveloped by Ice

**Major Factor: Continental Configurations**

- **Timing:** 750 to 580 Ma, three separate events
- **Cause:** continents congregated at equator, allowing build-up of ice sheets during cool period.
- **Evidence:** glacial deposits at sea level in equatorial regions, unusual carbonate deposits.
- **Chemical effect:** perturbation of the carbon cycle.
- **Biological effects:** life in refugia; subsequent diversification Cambrian explosion of fauna

Snowball Earth: Gathering of Continents in Equatorial Regions

**Changes in Continental Configurations**

- Animation of temporal variations in positions
**Snowball Earth: A Cyclical Scenario when Earth was Enveloped by Ice**

**Sequence of Events**

- Cooling causes build-up of ice on continents.
- Further cooling as ice reflects solar radiation.
- Volcanic emissions contribute CO\(_2\) which accumulates in atmosphere: few rocks exposed for weathering.
- Eventually CO\(_2\) levels (>300x present levels) produce global warming to ~50°C.
- Catastrophic melting of ice, erosion and carbonate deposition removes CO\(_2\) prompting cooling cycle.
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**Aftermath**
- Sedimentary record of turmoil
- Biological diversification

Causes of Global Extinction

**Extinctions in the Geological Record**
- A persistent natural biological process
- Global climate or environmental change or changes in biogeochemical cycles
  - glaciations, oxicity, $CO_2$ concentrations
- Sea level change
  - transgressions and regressions
- Impact events
- Tectonic connections
  - introduction of predators
- Human intervention

G302 Development of the Global Environment
Cretaceous/Tertiary, K/T Boundary

Nature of Boundary
- Major extinction event (one of the big five)
  - including demise of dinosaurs
- Concept: caused by bolide impact?
  - evidence of impacts through rock record

Evidence for Extra-terrestrial Influence
- Iridium concentrated in meteorites
- Anomalous Ir concentn. in boundary clay
Evidence for Impact
• Sedimentary records
• layers of ejecta
• contain spherules

K/T Boundary

Cratering Effects
• Products
  • shocked quartz, spherules
• Place: Chicxulub (Yucatan)
  • gravity map of subsurface

Chicxulub

shocked quartz

effects and aftermath of cratering
Possible Causes of the ‘Great Dying’

- Reorganization of tectonic plates (Pangaea)
  - competition, predation (terrestrial not marine)
- Changes in atmospheric or ocean chemistry
  - increase in $O_2$
  - oceanic anoxia
    - stagnation
  - $CO_2$ poisoning
- impact
  - site in Australia
    - (200km across; twice Chicxulub)
  - evidence from $^3He$ in fullerenes