Climate Throughout Geologic Time Has Been Controlled Primarily by the Balance Between

Cooling Caused by Major Explosive Eruptions of Evolved Magmas Typical of Island Arcs

and

Warming Caused by Voluminous Effusive Eruptions of Basaltic Magma Typical of Subaerial Ocean Ridges, Island Chains, and Continental Flood Basalts

Peter L. Ward, USGS, retired, Teton Tectonics, Jackson, WY, May 22, 2015
1815: Mt. Tambora, Indonesia
Largest volcanic eruption in recorded history, VEI = 7

A 14,000 foot mountain
160 km$^3$ of ejecta
>71,000 people died

Lowered world temperatures
0.4 to 0.7 °C

1816
Year There Was No Summer
Year Without a Summer
Summer that Never Was
Poverty Year

Krakatau 1883 (6)
Santa Maria 1902 (6?)
Novarupta 1912 (6)
Agung 1963 (5)
El Chichón 1982 (5)
Pinatubo 1991 (6)
Modelled global ocean heat content following the 1883 eruption of Krakatoa with volcanic effect and without

Gleckler et al., 2006

Modelled sea level change following the larger volcanic

Gregory et al., 2006
Last Ice Age Ended During Massive Volcanism in Iceland from 11,750 to 9,375 years BP

Basaltic, effusive volcanism was substantial and nearly continuous in Iceland during the Bolling and Preboreal warmings.

12 of the 13 dated tuyas in Iceland had their final eruptive phase during the Preboreal warming.

A tuya or table mountain formed by eruption of basalt under ice.
The Delicate Balance Between Global Warming and Global Cooling

- **Effusive volcanism**
  - Basaltic
  - Eruption height: generally < 2 km
  - Duration: years to millennia

- **Explosive volcanism**
  - More evolved magmas
  - Eruption height: up to 36 km
  - Duration: hours to days
  - Forms an aerosol in the lower stratosphere

**Eruptions**:
- Krakatoa
- El Chichón
- Agung
- Pinatubo

Duration: 11,750 to 9,375 years to millennia
Large, Explosive Eruptions Form Aerosols in the Stratosphere cooling Earth ~0.5°C for ~3 years

But also deplete ozone leading to mid to late winter warming

Lower tropospheric temperature anomalies from December 1991 to February 1992 after the eruption of Mt. Pinatubo in June 1991

Robock, 2002
Average Annual Ozone Measured at Arosa, Switzerland
Effects of Ozone Depletion and Aerosols

NORMAL CONDITIONS
- UV-C keeps atmosphere warm
- UV-B keeps ozone layer warm
- UV-A & sunlight keep Earth warm

GLOBAL WARMING
- Volcanoes release Chlorine & Bromine
- Depleting ozone cooling ozone layer & warming Earth

GLOBAL COOLING
- Explosive volcanoes also eject Sulfur Dioxide into stratosphere
- Forming aerosols that reflect & disperse sunlight causing net cooling of Earth

GLOBAL WARMING
- CFCs in polar stratospheric clouds (PSCs) release chlorine depleting ozone cooling ozone layer & warming Earth
Global Warming 1970 to 1998

The chart shows the changes in temperature and chlorine levels from 1945 to 2014. The data indicates a steady increase in temperature with a slight decrease in chlorine levels.
Energy of ultraviolet radiation reaching Earth when ozone is depleted is at least 48 times hotter than energy absorbed by greenhouse gases.
Greenhouse Gas Theory is Simply Wrong

1. There is not enough energy absorbed by greenhouse gases

2. The bonds holding greenhouse gases together are clearly observed to absorb radiation, but not to raise temperature

3. The assumption that greenhouse gases slow cooling of Earth ignores the fact that heat is transferred through the troposphere primarily by convection

4. The assumption that greenhouse gases radiate heat back to Earth breaks the Second Law of Thermodynamics

5. You do not stand next to a cold stove to warm up

6. A thermal body cannot warm itself
Wave

Aristotle 340 BC
Descartes 1630
Huygens 1678
Hooke 1680
Fresnel 1814

Particle

Democritus 410 BC
Alhazen 1000
Newton 1670
Planck 1900
Einstein 1905
Electromagnetic Radiation

James Clerk Maxwell published in 1865

A Dynamical Theory of the Electromagnetic Field

But waves and particles are things we can see

We cannot see light

Light is frequency, not waves, particles or wave-particle duality

Just like the frequency of a radio station

Paper on “The Thermodynamics of Climate Change” is available at OzoneDepletionTheory.info
Extrusion of basaltic magma reached a peak 55 to 60 million years ago during the opening of the Greenland-Norwegian Sea. Temperature also reaches a peak.

Storey et al., 2007

Paleocene Eocene Thermal Maximum

Flood basalts lead to:
- Ozone depletion
- Lethally hot climate
- Acidic oceans
- and plant mutations
- Mass extinctions

Massive Expansion of Ice in Antarctica at 34 Ma

Ages of mass extinctions (Ma)

Ages of continental flood basalts (Ma)

Ages of mass extinctions (Ma)

Courtillot and Renne, 2003

7 million km² 91% of the contiguous US in <670,000 years

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Dansgaard-Oeschger Sudden Warmings Caused by Effusive Volcanism Primarily in Iceland?

25 times in the last 120,000 years, local temperatures in Greenland rose 10 to 16°C in less than 40 years, returning to ice-age conditions within a century or more.
In the last 9000 years, volcanism (red) shows a close relationship to temperature (black) and to human history.
Every living thing spends every moment of life adapting to changes in the physical environment and in the social environment.

Climate changes in the physical environment are determined primarily by volcanism, leading to changes in the social environment.
Conclusions

1. Explosive volcanoes form aerosols in the lower stratosphere, reflecting sunlight, cooling Earth

2. Effusive, basaltic volcanoes deplete ozone, warming Earth

3. The balance between cooling and warming is controlled by plate tectonics

4. Sudden changes in volcanism show a close relationship to sudden changes in geologic epochs, ages, and evolution of life on Earth

Volcanoes rule!

OzoneDepletionTheory.info