

How Explosive Volcanic Eruptions Cause Global Cooling While Effusive Basaltic Eruptions Cause Global Warming, **PETER L. WARD** (U.S. Geological Survey retired, P.O. Box 4875, Jackson, WY 83001; peward@wyoming.com).

Climate change, throughout Earth history, has been a delicate balance between explosive volcanic eruptions causing global cooling by forming aerosols in the lower stratosphere that reflect sunlight and effusive basaltic volcanic eruptions causing global warming by depleting the ozone layer. The ozone layer protects life on Earth by absorbing DNA damaging solar ultraviolet-B radiation. When the ozone layer is depleted, more ultraviolet-B reaches Earth, cooling the ozone layer and warming Earth. Five to ten major explosive eruptions per century can increment the world slowly into an ice age. During the last 110,000 years, on the other hand, voluminous extrusion of basalts in Iceland heated the world, within a few years, out of the last ice age twenty-five times, but did not heat the ocean sufficiently so the huge ocean heat content cooled the world back down. Finally 10,000 years ago, 2000 years of volcanism ended ice-age conditions.

Humans also depleted the ozone layer beginning in the 1960s by manufacturing chlorofluorocarbon (CFC) gases. Within a few years, ozone depletion and then average surface temperatures began increasing. In 1985, with discovery of the Antarctic ozone hole, scientists and politicians worked closely together to pass the Montreal Protocol limiting CFC production effective in 1989. By 1993, increases in CFCs stopped. By 1995, increases in ozone depletion stopped. By 1998, increases in air temperature stopped. Temperatures remained constant from 1998 to 2014. Then Bárðarbunga volcano in Iceland, the highest rate of basaltic extrusion since 1783, caused 2015 to be the warmest year on record.