Earth Sciences

Richard Monastersky reports from San Francisco at the joint meeting of the American Geophysical Union and the American Society of Limnology and Oceanography

Volcanoes reign when Iceland thaws

Benjamin Franklin is credited as the first to suggest how volcanoes could cool the Earth's climate, a theory he penned after a severely cold winter in Europe followed the summer eruption of the Icelandic volcano Laki. Ample evidence now supports the idea that eruptions can alter the climate, but what about the reverse process? Can climate shifts affect volcanoes?

Recently, scientists proposed that eruptions on Iceland might be more frequent during warm ages, or interglacials, when Iceland is largely free of ice. Now sediments from the bottom of the Norwegian Sea bolster this theory, report Hans P. Sejrup and colleagues from the University of Bergen in Norway.

Buried within the sediments are four layers of volcanic ash from Icelandic eruptions over the last 300,000 years. According to the researchers, the layers indicate times when intense eruptions wracked the island, spewing out tens to hundreds of times the amount of material emitted during the current era. All of these layers happen to fall within interglacial periods, which punctuate the longer ice ages.

Presumably, the ash layers might not reflect a change in eruptions. It could be that ash appears in the sediments only during interglacials because ice covered the oceans during colder times. Yet evidence from the fossilized bodies of surface plankton discredits this explanation, says Sejrup. The plankton show that during interglacial periods, the sea ice cover in this northern region did not melt during the summer seasons, yet an ash layer still formed in the sediments during that time.

Alternatively, the researchers propose that ice caps help quiet volcanoes by bearing down on Earth's crust, essentially putting a weight on the magma chambers that feed volcanoes. When the ice melts, the pressure on the chambers disappears, allowing the volcanoes to erupt. Some evidence suggests the volcanoes are most active immediately after an ice age.

Active faults buried under Los Angeles

A University of Southern California seismologist has identified two quake-producing faults running directly under sections of metropolitan Los Angeles that could potentially damage the city far more than the San Andreas fault, which lies some 50 kilometers distant. Egill Hauksson mapped the faults through a study of 200 small earthquakes that have shaken the Los Angeles area during the last decade. An analysis of these shocks outlined two broad zones under the city, which he identified as thrust faults hidden in bedrock some 9 to 16 kilometers under the city streets.

On Oct. 1, 1987, a magnitude 5.9 temblor broke one of these buried fractures, the Elysian Park fault, in the city of Whittier, only a few miles east of downtown Los Angeles. The quake alerted Hauksson and his colleagues to the existence of the structure, which they surmised continued under Los Angeles. But it required further study to show that the Elysian Park fault under Los Angeles was active. In the process of tracing this fault, Hauksson discovered the other buried thrust fault.

Because it is unclear how much stress is building along the faults, it is difficult to calculate the earthquake risk from these features, says Haukkson. However, he cautions that even though officials have planned for the possibility of buried faults, building codes may be inadequate to meet the strong shaking these faults could potentially produce within the city.

Sunscreen 4 billion years ago

Scientists have often wondered what kind of molecule shielded the first living cells from a sizzling death due to ultraviolet solar radiation. A group of atmospheric researchers is proposing the newest solution to this problem: sulfur.

In today's world, ozone molecules (O_3) in the stratosphere absorb the dangerous ultraviolet light. This ozone comes from oxygen molecules (O_2) lower in the atmosphere that drift up and are broken down by sunlight. But most scientists believe oxygen did not start accumulating in the atmosphere until relatively recently, about 2.5 billion years ago, when photosynthetic algae arrived on the scene. Since the first living organisms are thought to have developed some 3.5 billion to 4 billion years ago, that leaves about 1 billion years of life without atmospheric ultraviolet protection.

In ozone's absence, ring molecules of sulfur atoms, particularly S_8, might have done the job of absorbing ultraviolet light, theorize James Kasting from Pennsylvania State University in University Park and his colleagues. Sulfur was definitely available, with volcanoes pouring out some 10^{12} tons of it each year. Yet no one knows whether the sulfur disappeared into the oceans or remained in the atmosphere. The sulfur hypothesis requires that Earth's surface temperatures remained above 45°C (113°F), or else the sulfur molecules would condense out of the atmosphere.

While Kasting's group suggests sulfur as a screen, many other scientists believe there was no need for an ultraviolet blocker in the primordial atmosphere, since some primitive life forms seem to be well adapted to high levels of ultraviolet.

Water hyacinths as pollution meters

Measuring the pollution levels of heavy metals in rivers can often be tricky, but hydrologists may have found a potential tool in the form of water hyacinths, report Barbara C. Scudder and Harry V. Leland from the U.S. Geological Survey in Menlo Park, Calif. In a study of a hyacinth species growing in California's San Joaquin River, they found that many elements such as selenium, manganese and chromium concentrate in the root tips. In some cases the levels in the roots reach 2,000 times the concentrations dissolved in the water.

Scudder says these plants, often considered weeds, can stand high levels of toxic metals. She proposes that hyacinths might be particularly useful in detecting substances whose concentrations fall below the limits of traditional methods.

Energetic electrons and the ozone hole

High-energy electrons from the Earth's magnetosphere that dive into the upper atmosphere over Antarctica could be playing some role in creating the ozone hole each spring over that continent, proposes an atmospheric scientist from the University of Houston. William R. Sheldon reports that these electrons may stimulate the growth of cloud particles in the stratosphere. Polar stratospheric clouds, as they are known, are important because scientists think they foster chemical reactions that allow chlorine from chlorofluorocarbons to assume an active form that destroys ozone (SN: 10/15/88, p.249). Without the cloud particles, most chlorine atoms become locked up in inactive compounds.

Electrons enter the story as the first link in a chain of collisions starting high in the atmosphere. When these electrons, traveling near the speed of light in the outer Van Allen belt, rain down into the ionosphere, they hit atoms and produce X-rays. These in turn penetrate the underlying atmospheric layer, the stratosphere, where they ionize atoms. Ionization is known to stimulate droplets to form in supersaturated air.

Scientists have observed that X-rays reach into the Antarctic stratosphere during the summer, says Sheldon, but no one has studied their activity in the polar winter, when temperatures are cold enough for cloud particles to form. Measurements from the Defense Meteorological Satellite Project show far more outer-belt electrons raining down over the Antarctic than the Arctic, which, along with the colder temperatures in the south, could explain why more clouds grow in the Antarctic stratosphere, Sheldon suggests.