Earth Sciences

Stefi Weisburd reports from San Francisco at the meeting of the American Geophysical Union

Making upside-down thunderclouds

Thunderclouds are the keepers of the charge separation between the atmosphere and the earth. Conductive channels made by cosmic rays and radiation in the positively charged atmosphere allow ions to escape towards the earth, which is negatively charged to about half a million coulombs. But the 2,000 thunderstorms that exist at any one time worldwide fight back in two ways. They can unleash negative charges stored in the bellies of clouds to the ground by lightning, or they can coax positive charges up from the earth in a phenomenon called St. Elmo's fire.

Although a number of ideas have been suggested over the last century explaining how the clouds first become electrified, "people have never tried to tinker with thunderstorm electricity on a big scale," says Charles B. Moore at the New Mexico Institute of Mining and Technology in Socorro. Moore and co-workers wanted to see if they could change the polarity of thunderclouds, which are usually charged positively on top and negatively on bottom. So last summer the researchers strung a 2-kilometer-long metal wire across a deep canyon in New Mexico's Magdalena Mountains and applied a −100-kilovolt potential to it so that negative charges were emitted into the air in a current of 300 microamperes.

Out of about 65 clouds that roamed the canyon, the group observed two clear-cut cases of thunderclouds with inverted polarity: negative on top and positive on bottom. These clouds are also thought to have expelled positive charges via lightning.

If these findings are verified next summer, when the researchers plan more experiments with a larger power source, they will show that conditions outside a cloud can affect and even amplify a cloud's electrical state. Moore then wonders if artificially emitted *positive* ions would enhance the cloud polarity that normally exists and thereby locally trigger rainfall sooner. If so — taken with the possible negative charge effects — it raises the unexplored and intriguing question of whether industrial electrostatic precipitators, which routinely spew out plumes of negative charges, or high-voltage direct-current power lines, from which positive charges are emitted, would also affect cloud electricity, he says.

Ocean crust: Magma chamber a must?

Mid-oceanic ridges are the seams of the world. They are boundary lines between the earth's plates, the large chunks of lithosphere in which pieces of seafloor and continents are embedded. They are also the places where the plates are accreted as magma flows up to create new oceanic crust. How this process works, however, is not well understood. Does it require, for example, that a magma chamber be constantly present beneath the ridge? The answer to this kind of question will be important in understanding the dynamic evolution of the plates.

In order to learn more about how oceanic crust is made, John C. Mutter and John B. Diebold, both at Lamont-Doherty Geological Observatory in Palisades, N.Y., and co-workers used seismic reflection profiling (SN: 12/8/84, p. 364) to probe and map with sound waves the internal structure of oceanic crust over 110 million years old in the western North Atlantic. Their seismic lines, which had greater resolution and a longer extent than other data to date, crossed three fracture zones, or transform faults, that run from the American continent through the Mid-Atlantic Ridge and on to Africa and Europe.

The researchers discovered that the structure of the oceanic crust changed gradually and systematically along this line. At the fracture zones themselves, they observed that the crust is thin, less than a third of its normal thickness, and that the seismic maps revealed little internal complexity. Moving away from a fracture zone toward the north or south, however, the crust becomes thicker and a new structure appears in the profile that the researchers have dubbed "horizon R." Mutter notes that crustal material is successively added *beneath* horizon R (which is always horizontal) as the midsection between fracture zones is approached.

Mutter interprets horizon R as the reflection boundary between two types of rocks that form at a magma chamber: gabbros, coarse-grained igneous rocks that crystallize at the upper chamber walls, and cumulates, which settle out in layers at the bottom of the chamber. Between fracture zones, he argues, the presence of horizon R with its underlying layered cumulates implies that when this region was at the ridge, a large and persistent magma chamber once existed to create the thickest oceanic crust. Near fracture zones, the thin crust, lack of cumulates and absence of horizon R indicate little or no magma source, Mutter believes. The magma supply might have become diminished and intermittent, he says, because it was chilled by the crust on the other side of the fracture zone, which researchers have found almost always to be of a different age and hence temperature.

From all of this Mutter concludes: "I think a steady-state [persistent on a geologic time scale] magma chamber is a necessary prerequisite for the sustained accretion of normal oceanic crust."

The waxing and waning of methane

In terms of its potential contribution to the global warming called the greenhouse effect, methane, in company with fluorocarbons and nitrous oxides, is second only to carbon dioxide (CO_2). While there is less methane than CO_2 in the air, scientists believe its growth rate — which previous studies put at about 1.8 percent per year (SN: 12/11/82, p. 375) — exceeds the less than 0.5 percent annual increase of CO_2.

Now Aslam Khalil and Reinhold Rasmussen, atmospheric scientists at the Oregon Graduate Center in Beaverton, have discovered after five years of measurements in Oregon and Tasmania that methane levels fluctuate from year to year, leading them to revise downward their earlier estimates of methane increase. In particular the researchers found a dramatic dip in methane concentrations during the 1982-83 El Niño episode that set global weather and circulation patterns awry.

"El Niño events are very regular phenomena, occurring every two to 10 years," says Khalil. "So in the long run we are quite convinced that methane is not going to increase at the [higher] rate we see between El Niños." The original estimates were higher because they were made before the major El Niño. After incorporating the new data taken during El Niño, the scientists came up with a rate of increase closer to 1 percent per year. This corresponds well with the rate estimated by F. Sherwood Rowland at the University of California at Irvine, who recently found annual methane increases of 1.1 percent after seven years of measurement.

What intrigues the researchers most about the recent finding is that methane levels responded sensitively and rapidly to global atmospheric conditions. The methane drop during El Niño also enables them to study how methane is created, transported and destroyed. Since they do not believe that El Niño greatly altered the production of methane, the researchers are focusing on the possible mechanisms for its removal that might be enhanced by El Niño. One possibility, Khalil suggests, is that El Niño speeds up the flow of air from the northern hemisphere to the tropics, where high levels of hydroxyl ions (OH) are waiting to consume the methane. Or El Niño might act to increase the production of OH.

"In actual fact, the mechanisms for both methane and carbon dioxide, for why they are both low during that period, are still not really known," says Khalil. The researchers plan to compare the behavior of other trace gases during El Niño to that of methane, in hopes of zeroing in on some of the processes involved.