Coal and the Coming (?) Superinterglacial

As the energy-hungry world finds petroleum running out, the nuclear potential frightening, and significant solar conversion still a far-off goal, it has been turning increasingly toward coal as the frontrunner short-term energy hope of the future. No wonder. Coal resources are massive.

Yet some scientists have been peering ahead at a possible dangerous cloud on the horizon of the coal economy. It is not the black cloud of soot associated with coal burning of past times but an invisible and possibly more ominous threat: the inevitable addition to the atmosphere of unprecedented quantities of carbon dioxide from coal combustion.

This week one of the strongest warnings yet on the climate consequences of a coal economy was presented at the spring meeting of the American Geophysical Union in Washington by geochemist Wallace S. Broecker of the Lamont-Doherty Geological Observatory.

The coal economy destines us, he says, to a CO_2-induced "superinterglacial" climate about which we know very little. "Before we take the actions which will lock us into bestowing a millennium of warmer climate on the generations to follow, we had best learn more than we now know about life in this 'superinterglacial' world." Broecker says the problem "could become the single most important environmental issue of the next 30 years."

In addition to developing better computer models to predict how temperature, rainfall and vegetation will be affected, "we must develop contingency plans for the removal of the excess CO_2 from the atmosphere if its effects prove highly objectionable. Indeed," says Broecker, "we must rethink the wisdom of developing technologies for the larger-scale recovery, transport and liquification of coal."

A member of the President's Council of Economic Advisers who has been analyzing the problem, William D. Nordhaus, reinforced Broecker's concern. He said it has severe long-term policy implications.

At the heart of the concern is the well-known warming "greenhouse" effect of CO_2 in the atmosphere and the huge quantities of underground coal being eyed by policymakers trying to find ways to fuel the world's energy needs.

For each ton of fossil fuel burned, roughly three tons of CO_2 is released into the atmosphere. The best evidence shows that to date, combustion of gas, oil and coal has raised the CO_2 content of the atmosphere by 12 percent. Broecker forecasts that to see our way through to what he calls the golden era of solar power a century from now, we will almost certainly have to burn enough of the coal reserves to double the atmosphere's CO_2 content. Best estimates suggest a doubling leads to a 2° to 3°C (5°F) rise in temperature. The warming that brought us from the last period of full glaciation was only about twice that, according to computer analysis of all recent available data. So, points out Broecker: "We are talking about a major climate change. Environmental consequences are likely to be large."

His term "superinterglacial" for these conditions refers to the fact that for the past 10,000 years the earth has been in a relatively warm or interglacial interval between glaciations. "The addition of large quantities of CO_2 will likely push the earth's climate into a realm considerably warmer than that experienced during the last several interglacials. In this sense the post-coal burning era will be 'superinterglacial.' "

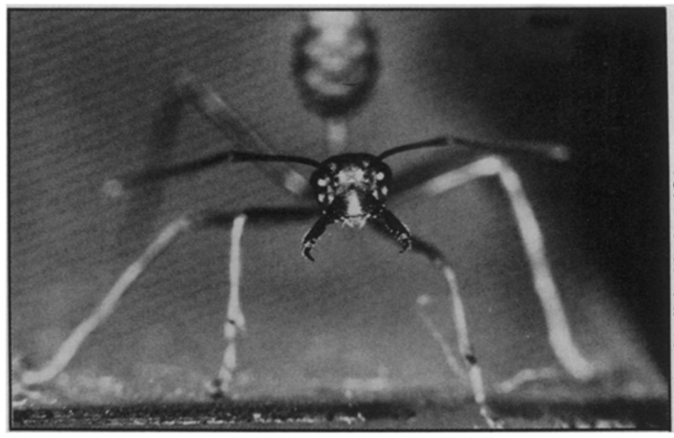
The onset of a coal-burning-caused superinterglacial will not likely be so profound as that which accompanied the change from glacial to interglacial, but it will certainly be more abrupt. "The demise of the conditions responsible for the glacial epoch took at least several hundred, and perhaps as much as several thousand years," Broecker notes. "We will load the majority of our CO_2 into the air in a single century."

Broecker feels the world has, in a sense, been lulled into complacency by the often-noted natural Northern Hemisphere cooling since 1945 that has compensated for the CO_2-induced warming up till now and disguised its effects. But computer simulation based on evidence for cyclical air temperature variations over the last several thousand years that has been found in Greenland ice cores indicates a bottoming-out of the natural cooling, says Broecker. Adding CO_2-induced heating to the simulation, "a dramatic warming is predicted for the latter two decades of this century."

What about the eventual expected end of the interglacial itself? Won't the cooling effect of that counteract the CO_2 warming? Too far off (several thousand years) and too gradual, counters Broecker. "The superinterglacial will have come and largely gone before any significant natural cooling occurs. I see no basis for any argument calling on a natural cooling as a balancing force. . . . The rise toward the superinterglacial will be so rapid that no natural change of comparable magnitude can be foreseen."

What can be done? Soon, Broecker admits, we will be as hooked on coal as we are now on oil. There are no quick answers. But, he says, in policy planning, the climate consequences of the coal economy can no longer be ignored. □

Odor gives home team ants early lead



African weaver ant opens mouth parts and raises abdomen in aggressive stance.

Proceedings of the National Academy of Sciences

In mortal battle, weaver ants defending their own turf triumph in the early skirmishes. This advantage seems to stem not from visual familiarity with an area but rather from its odor. An ant acts confidently and recruits fighters more rapidly when it senses a chemical deposited by fellow nestmates, Bert Hölldobler and Edward O. Wilson report in the May PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES. This territorial pheromone is the latest discovery in the complex communication repertory of the aggressive *Oecophylla longinoda* for exploring, seizing and exploiting new terrain.

Although anecdotal evidence suggests that many kinds of mammals mark their home ranges with scents, only the deposits of house mice and European rabbits clearly alert intruders of the same species. The results of Hölldobler and Wilson are

the first evidence that social insects use pheromones to advertise their territories and deter invasion by members of other colonies.

The colonies of weaver ants, including queens, were collected in Kenya and transported to Harvard University laboratories. There the worker ants wove their characteristic nests of larval silk and leaves on potted grapefruit and fig trees. The ants weave by holding small larvae in their mouthparts and moving them back and forth, like shuttles.

When the researchers extended the area available to a colony, ants deposited large drops of rectal fluids randomly over the new territory. Since other ant species fastidiously discard fecal material in a restricted garbage pile outside the nest, the researchers suspected that weaver ants were posting a specific scent.

To test their suspicion, Hölldobler and Wilson watched ants explore territory marked by members of a different colony. Even if no alien ants have been in the area for the previous 12 hours, the intruding ants display great caution and frequent aggressive posturing, opening their mandibles and lifting their abdomens vertically, as shown in the photograph. The exploring ants also stop often to inspect the marked spots.

The researchers observed fierce territorial battles when they allowed members of two colonies to enter simultaneously an area previously marked by members of one colony. Although in nature battles rage for hours or even days, the researchers interrupted the laboratory match after 30 minutes. At the interruption the investigators determined which side was ahead by the number of ants present from each colony and where the battle lines were drawn.

"That initial outcome is not necessarily the final outcome. We haven't followed these battles all the way through with our colonies because they're too valuable," Wilson says. "The ants look identical. The only way you can identify them is by watching where they're coming and going, the columns streaming back and forth." In all cases the initial victor was the colony that had marked the floor papers with pheromone.

The researchers determined that the territorial pheromone at least partly originates in an ant's rectal sac. They are now beginning an investigation of the chemical nature of the substance. Exactly how ants produce and recognize chemicals unique to members of a colony is one of the most intriguing problems in the study of social insects, Wilson says. He predicts the answer will include genetic factors, as well as differences in diet and even in the materials of the nest.

The question remains whether the territorial pheromone will be found in other insects or whether it is a peculiar adaptation of the exceptionally aggressive weaver ants. □

Possible heavy lepton in Russia

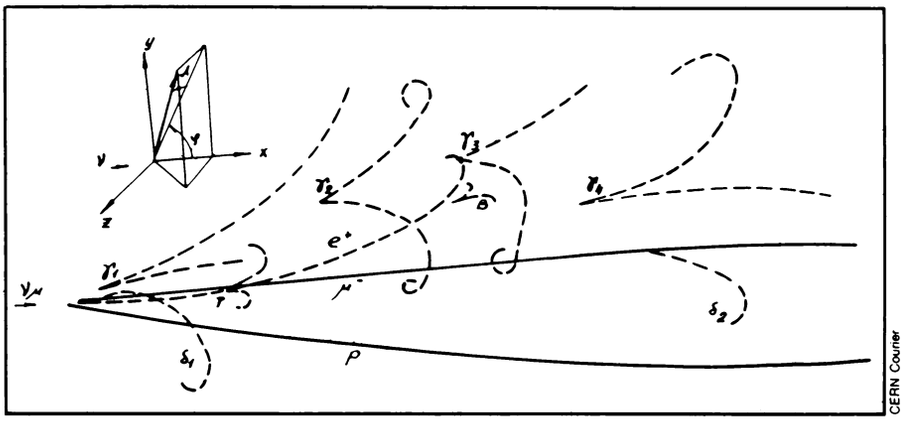


Diagram of Serpukhov event has proton, positron (e^+), and negative muon tracks.

Heavy leptons are among the most sought-after objects in particle physics. The existence of such particles, heavier relatives of the electron and the muon, is postulated by the new unified theories that have particle physicists very excited, and a final proof of the existence of heavy leptons would be a strong point in favor of the theory. Evidence for the apparent existence of heavy leptons has recently come from laboratories in the United States and West Germany (SN: 5/21/77, p. 325; 5/28/77, p. 341). Now there is an apparent heavy-lepton event reported from the other side of the world, Serpukhov in Russia.

Serpukhov is the site of the Institute for High Energy Physics, which has a 70-billion-electron-volt proton synchrotron that was once the most energetic accelerator in the world. One of the experiments now running there uses the proton beam to make a beam of high-energy neutrinos. The neutrinos are fed into a bubble chamber full of a heavy liquid to see if and how they interact with neutrons or protons in the atomic nuclei in the liquid. The first runs of the experiment yielded about 25,000 pictures. Scanning of half of these has produced 500 that show neutrino interactions taking place. One of those 500 can be interpreted as showing the production of a heavy lepton in the neutrino-nucleus collision.

The chief reason for suspecting the formation of a heavy lepton is the appearance of a negatively charged muon and a positron, which theoretically would be the heavy lepton's decay products, among the particles coming out of the interaction. The heavy lepton suspected in this case would be electrically neutral and so would not make a track in the bubble chamber even if it lived long enough to travel a measurable distance.

The favored interpretation of the event is that the neutrino-nucleus collision produces the heavy lepton (designated M^0) and a proton plus two neutral pi mesons. The heavy lepton then decays into a muon, a positron and another neutrino. The mass of the heavy lepton would be something between 1.4 and 2.1 billion electron-volts. Its lifetime would be about 6×10^{-12} seconds.

There is another possible interpretation of the Serpukhov event, which would be equally interesting to particle physicists. That is that the neutral particle produced in the neutrino-nucleus collision is a neutral charmonium meson (called D^0). (There is also American evidence for the D^0.) Any other interpretation of the Serpukhov event is judged to have a very low probability. □

New measurement of muon magnetism

Somewhere in physicsland the value of the intrinsic magnetism of the muon, the muon's magnetic moment, should be etched in stone. The number is, as the May CERN COURIER puts it, "an acid test" of the accuracy of quantum physics calculations, that is, the use of the basic dynamical theory of subatomic physics as a predictor of measurable physical quantities. The long history of experiments to measure this number has also been a strong test of experimenters' ability to devise ever more precise measuring techniques as theorists keep refining their calculations.

Over the years, one series of muon-magnetic-moment experiments has been done at the CERN laboratory in Geneva. The results of the latest one are now in, and they represent an improvement in accuracy by a factor of 38 over previous experiments. This brings the precision to a point where the effects of some very fine-scale and touchy corrections of the total number must be taken into account.

According to the simplest ideas about the electromagnetic behavior of subatomic particles, the muon's magnetic moment, usually designated by the letter g because its other name is gyromagnetic factor,