pleted, but the analysis of the results is still under way.

Meanwhile, Greiner, Gerd Buchwald, Joachim Maruhn, and their co-workers at Frankfurt and Stöcker have explicitly modeled the niobium-niobium system and found the same strong sideward peaks in the distribution of events as the experimentalists saw. At this point, the agreement is mainly qualitative.

Establishment of nuclear compression opens the way to a wide-ranging exploration of the properties of nuclear matter under conditions of varying temperature and density. By using the heaviest possible nuclei and carefully choosing the beam energy, physicists should be able to "adjust" the compression to create the temperature and density of interest. Moreover, during the expansion process, the density will "overshoot" and decrease to less than that of ordinary nuclear matter, so that low densities can be explored as well.

What will physicists find, if they carry out this program? Theorists promise them a rich variety of new states of nuclear matter. One of the most intriguing is the quark-gluon plasma. According to models of the evolution of the universe after the Big Bang, during the first microsecond of existence there were no protons, neutrons, mesons, or other heavy particles. Instead, quarks, which are the entities out of which elementary particles are constructed, and gluons, which cement the quarks together, roamed freely everywhere.

After the first microsecond, the universe had "cooled" enough that the liquid-like quark soup "froze," creating the elementary particles in the process. With a sufficiently powerful accelerator, theorists say, it is possible to reverse this process in nuclear collisions. The nucleons momentarily "melt" and generate a quark-gluon plasma. In effect, scientists would be able to study in the laboratory the kind of matter that only existed just after the Big Bang.

Although it is somewhat conjectural how high a collision energy is necessary, the Nuclear Science Advisory Committee, which counsels the Department of Energy and the National Science Foundation on facilities for nuclear physics, last fall recommended as the highest priority in the field the construction of an accelerator that would allow counter-circulating 30-GeV-per-nucleon beams of heavy nuclei to collide head on. A rough guess on the price was $250 million. The latest results from the GSI-LBL collaboration will not hurt the process of building political support for such a machine.—**Arthur L. Robinson**

An Impact but No Volcano

It had looked as if the arguing would go on for years. Did a huge volcanic eruption or the impact of an asteroid or comet lay down the clay layer associated with the extinction of so many species 65 million years ago? In this issue of *Science* (p. 867), Bruce Bohor and his colleagues at the U.S. Geological Survey (USGS) in Denver present "compelling evidence" that an impact did it. Experts familiar with their discovery believe that, if anything, the USGS researchers are being too modest in their claim. The quartz grains that they found in the clay layer now marking the 65-million-year-old Cretaceous-Tertiary extinctions are engraved by the apparent traces of a highly energetic impact. "It has to be an impact," says Jay Melosh of the University of Arizona. "Nothing else could do that."

For the USGS group, the search for evidence of an impact began with their studies in the Branch of Coal Resources. The mineralogy of the boundary, whether the clay began as volcanic ash or dust from an impact, should be as informative as that of the volcanic ash layers called tonsteins that they had studied in coal beds, they reasoned. Once they found their own exposure of the boundary clay near Brownie Butte in east-central Montana, the USGS workers removed the 99.99 percent of the sample that was clay, leaving mostly quartz grains about 80 micrometers in diameter. Hydrofluoric acid treatment, the last step in the removal of the clay, serendipitously left many of the grains etched by a distinctive pattern of intersecting, parallel grooves precisely oriented with respect to the crystal structure. There was the proof.

The only way known to produce such features in quartz grains is by a high-velocity impact. The shock of the impact—producing in this case pressures of over 150,000 atmospheres—disorganizes the crystalline quartz and produces amorphous glass, but only on planes having particular orientations with respect to the crystal structure. High-velocity shock experiments in the laboratory have produced these planar features and their grooves, as have nuclear explosions. Such features are also found in the debris from known impact craters on Earth, but they have never been found in volcanic ash. As Richard Grieve of Brown University explains, crustal rocks are too weak to contain pressures greater than 1000 atmospheres and, even if trapped gases could generate higher pressure during explosive release, the easily compressed gases cannot transmit that pressure to the relatively incompressible rock. "It just doesn't work," he says.

The USGS group has other evidence. X-ray diffraction analysis of the quartz grains revealed streaking of the normally sharp diffraction spots, which is typical of shocked quartz. It also detected stishovite, a form of quartz formed at pressures above 100,000 atmospheres. "We're sure it's there," says Bohor, but its low abundance has prevented the production of an x-ray diffraction pattern that is strong enough to be reproduced in a journal. They have also seen the planar shock features in quartz from Cretaceous-Tertiary boundary clays at three other sites in east-central Montana and at the now-classic European locales—two sites in Denmark, two in Italy, and one in Spain. Charles Pillmore of the USGS in Denver and his colleagues subsequently discovered similarly shocked quartz at the boundary in the Raton Basin of Colorado and New Mexico.

The unequivocal evidence of highly shocked quartz follows less compelling finds in the boundary clay. These included spherules that presumably condensed from vaporized rock and are too large to have been flung around the globe by a volcano, and osmium isotope compositions that allowed an extraterrestrial or volcanic source but not a continental source (*Science*, 11 November 1983, p. 603). Recently, Jan Smit, Frank Kyte, and John Wasson of the University of California at Los Angeles reported that they have found spheres containing geochemical markers of an extraterrestrial object and magnetite that must have crystallized from a very high-temperature liquid.

Once the shocked quartz grains settle the impact-volcano question, they may be put to further use. Since continents contain abundant quartz and ocean basins very little, these quartz grains may shed light on the question of where the impact occurred.—**Richard A. Kerr**