Ordinary STMs, in contrast, are unable to map sites within such large areas.

This ability to survey the nanoworld should aid efforts to engineer it by planting or dislodging atoms with the tip of an STM or AFM. This interventionist brand of microscopy began in earnest with Eigler and his colleagues at IBM Almaden back in 1990. They made headlines by maneuvering 35 xenon atoms into Big Blue's famous company acronym atop a surface of crystalline nickel. Since then, Eigler and others have built more scientifically interesting structures; these include rings of iron atoms that behave like quantum corrals, constraining electronic motions on surfaces in accordance with the ways of quantum mechanics.

Now, across the hall from M^3 in an acoustically isolated room with a massive metal door, Joseph Stroscio and his colleagues are trying to take the next step in building atom-scale test-beds for quantum mechanics. Their instrument, not yet completed, should be able to modify and scan samples under ultrahigh vacuums, at 2 degrees above absolute zero, and in extreme magnetic fields. Stroscio and his colleagues expect that these experimental conditions will enable them to probe quantum effects to which standard STMs operating under less demanding conditions are blind. "We hope to make [ultrasmall] structures and then ask questions like … what energy does it take to put an electron into the structure," Stroscio says. The answer could feed into the design of prototype data-storage devices that rely on the presence or absence of a single electron.

Costly, specialized devices such as Teague's and Stroscio's, however, are only a small part of what scanning probe microscopy has become since its invention. Thanks to large-scale production at companies including Digital Instruments, Park Scientific, and Topometrix, scanning probe microscopes can cost \$50,000 or even less—complete with a computer package for creating wall-poster images of your favorite sample. Thousands of the instruments are now touring atomic landscapes.

After opening up the nanoworld, scanning probe microscopes have proceeded to democratize it. Without these tools, says Stroscio, "it would be like the Dark Ages."

–Ivan Amato

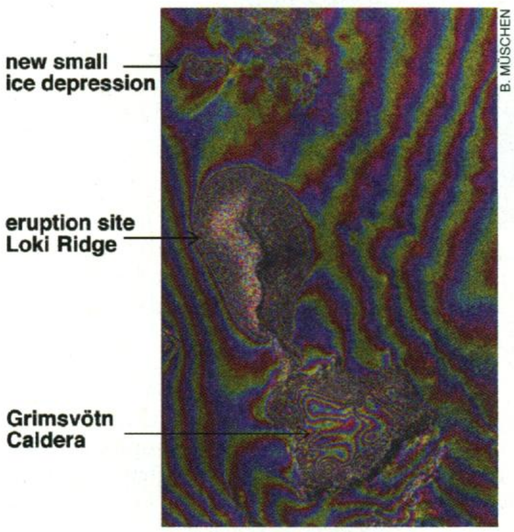
Ivan Amato's book on materials science, Stuff, *was just published by Basic Books.*

RADAR IMAGING

Monitoring a Killer Volcano Through Clouds and Ice

Late in the evening of 30 September last year, seismometers in Iceland detected the beginnings of a volcanic eruption beneath the Vatnajökull Glacier, the largest in Europe. By 2 October, the eruption had forced its way through the 500-meter-thick ice sheet—spewing steam and gas thousands of meters into the air. An estimated 2.3 cubic kilometers of meltwater was trapped beneath the ice and would soon burst out, threatening communities, roads, and communication links in this remote corner of southeast Iceland.

Because of the inaccessibility of the region and the constant cloud cover, which made aerial surveillance difficult, the Icelandic authorities could not tell which way the meltwater would go. They got some timely help, however, from an unlikely source: a cloud-piercing radar satellite and a new image-processing technique that allows researchers to see movements in Earth's surface down to a scale of a few centimeters.



University of Munich geographer Bettina Müschen and several colleagues at the German Aerospace Research Establishment (DLR) in Oberpfaffenhofen were involved in a project sponsored by the European Space Agency (ESA) to study radar images of Iceland from its ERS spacecraft. The team quickly realized that the satellites could help Iceland's disaster management by tracking the meltwater buildup. The synthetic aperture radar on ERS-2 had taken its first images of the Vatnajökull eruption in early October, but the Munich researchers believed that processing radar images of the eruption by a technique called SAR interferometry could generate even more valuable clues for disaster relief.

In this technique, two images are taken from the same vantage point, say, 24 hours apart, and superimposed. The resulting interferogram shows graphically any movement that has occurred in that 24-hour period. ERS mission managers agreed to provide the services of an older spacecraft, ERS-1, then in the process of having its systems checked. On 21, 22, 23, and 24 October, both ERS spacecraft passed over Iceland acquiring images that were then processed into interferograms at DLR. "We detected subsidence of just centimeters per day, which was not visible to the eye. A few days later, [these movements] were confirmed on the ground," says DLR's Achim Roth. "We could see the water going south," says Müschen.

As a result, the Icelandic authorities focused their monitoring and flood defenses to the south of the glacier. On 4 November, meltwater building up in a volcanic crater under the ice lifted the ice sheet and flooded southward. Over the next few days, floodwater and ice blocks of up to 1000 tons took out bridges and power and communication cables en route to the sea, but avoided a nearby village.

Tracking the Vatnajökull eruption was the most dramatic use yet of SAR interferometry, a technique pioneered by researchers at NASA's Jet Propulsion Laboratory in Pasadena, California, in the 1970s that has taken off since the launch of ERS-1 in 1991. "ERS-1 provided the first reliable source of data," says Steve Coulson, who coordinates SAR interferometry research for ESA. Besides making static topographical maps with unprecedented resolution, SAR interferometry is also being used to measure ground movement after earthquakes and volcanoes, the creep of glaciers, landslides, and subsidence caused by coal mining. According to Müschen, German insurance companies are looking into using SAR to assess the risk of natural disasters in different areas. Coulson says the latest application, still at the research stage, is to use interferometry to detect deforestation and different kinds of agricultural land use. SAR interferometry, he says, "seems to be the big thing at the moment."

–Daniel Clery