Thinning down. Ecologists are debating a plan to prevent uncontrollable burns, like this one in Montana, by clearing smaller trees.

cent policies, including suppressing wildfires and logging only mature trees, have allowed western forests to grow unnaturally dense with young trees and made them more vulnerable to fire. Reacting to that criticism, the Administration said last week that it will soon release a plan to dramatically expand an experimental approach to fire prevention that emphasizes aggressive cutting of smaller trees. Although officials of the Interior and Agriculture departments are still working out the plan's details, it is expected to include paying loggers nearly $825 million a year to remove trees too small to be commercially valuable from 16 million hectares of western forests.

The plan draws heavily from insights into fire control on federally managed lands made by ecologist Wallace Covington of the Ecological Restoration Institute at Northern Arizona University in Flagstaff. In one case, for example, the Forest Service paid professional loggers to remove 90% of the trees from a 36-hectare swath of low-altitude ponderosa pine in the Kaibab National Forest near Flagstaff. When a wildfire unexpectedly swept through the area last June, it burned the sparsely populated stand far less severely than the denser surrounding forest.

Pete Fulé, a member of Covington's team, says that drastic thinning of the plot is the reason. With less fuel, the flames could no longer leap from treetop to treetop, he says, and when the fire spread along the ground it ignited only the underbrush. Mechanical cutting is necessary, Fulé says, because thinning forests with controlled burns "has not proven effective, at least in many instances."

But environmentalists say the widespread logging would harm forests, not help them. And some scientists say other combinations of cuts and burns may achieve the same results with less disruption. Covington's approach "doesn't use as wide an array of possible tools as we're using," says Phil Weatherspoon of the Forest Service's Pacific Southwest Research Station in Redding, California. He is involved in an 11-site project that is examining various fire prevention schemes, from mechanical cutting alone to just prescriptive burns. Forest managers, he says, should get data on the potential costs and ecological consequences of various approaches before proceeding.

Heavy thinning also may not address other causes of the recent fires, says Bill Baker, a geographer at the University of Wyoming in Laramie. Before settlers began grazing livestock in western forests, he notes, grasses competed with the young trees that now clog the landscape. "What's missing [from Covington's approach] is an emphasis on restoring grasses," says Baker. "Without it I don't think it's going to work." And Tom Swetnam, an ecologist at the University of Arizona in Tucson, thinks hot, dry weather brought on by La Niña climate patterns may have contributed to the severity of this year's fires—not just the accumulation of combustible young trees. As a result, he says, "there is some danger that [Covington's model] might be overextrapolated in the West."

Covington and his supporters agree that it would be a mistake to treat all forests the same. "We've got a score of forests, all of which burn differently," says Steve Pyne, an environmental historian at the University of Arizona who is involved with Covington's project. But Pyne defends the Arizona site as representative of a common western ecosystem. "I think we understand why [ponderosa pine forests] are burning and what to do about it," says Pyne.

Despite their disagreements, both sides say that federal officials need to do more to prevent future wildfires. "The problem is not that we're doing too much, but that we're not doing enough," says Craig Allen, an ecologist with the U.S. Geological Survey in Los Alamos, New Mexico. The challenge is to come up with a plan flexible enough to fit all the nation's hot spots.

—JOHN S. MACNEIL

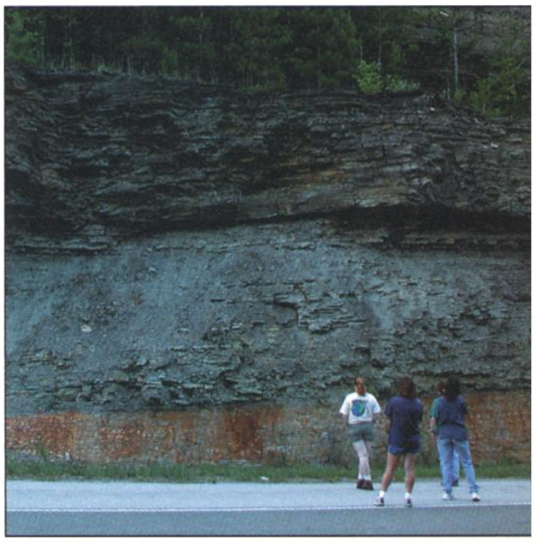
SEDIMENTARY GEOLOGY

Homegrown Quartz Muddies the Water

Next to volcanoes or earthquakes, mudstones are hardly a glamorous subject for geologists. But these widespread strata are an important source of hydrocarbons that migrate into petroleum deposits, and they can reveal much about Earth's history—if they are read correctly. Now a team of geologists has found that a telling feature of many mudstones may have been misinterpreted, throwing into question conclusions about everything from climate to ocean currents.

Mudstone consists mostly of clay, washed from the land to the sea. It also contains fine grains of quartz. The size and distribution of these grains can reveal how far they traveled from shore, the strength of the currents that carried them, or even whether they took an airborne journey from a desert. Such inferences assume that quartz silt, like the clay, came from the continents. However, Jürgen Schieber of the University of Texas, Arlington, and his colleagues show in this week's issue of *Nature* that in some mudstones, most if not all of the quartz silt may have formed in place, probably from the dissolved remains of silica-bearing organisms.

If this kind of homegrown, or authigenic, quartz silt is common, geologists may need to reexamine some of their reconstructions of past environments, including climate. A new "silica sink" could also affect the calculations of how much dissolved silica drifts between mudstone and sandstone. This migration is a prime concern of petroleum geologists, because silica can plug up the pores in rock that might



Look again. New ideas about quartz silt may make geologists rethink their analyses of ancient environments.

CREDITS: (TOP TO BOTTOM) D. KRAUSS/AP; J. SCHIEBER/UNIV. OF TEXAS, ARLINGTON otherwise hold oil. The finding "makes life more complicated," says Kitty Milliken, a geologist at the University of Texas, Austin, who studies mudstones, "but it gives us the tools to be clear and figure it out."

The main evidence for the local origin of quartz silt comes from an analogy with authigenic quartz sand that Schieber observed several years ago. The quartz had precipitated inside sand-sized, hollow algal cysts—tough, protective bodies that algae commonly form when they reproduce. These cysts had been partially compressed by overlying sediment, leaving them with characteristic dents and projections. The same shapes turned up in quartz silt when Schieber and Dave Krinsley of the University of Texas and the University of Oregon examined slices of late Devonian (370-million-year-old) laminated mudstone, called black shales, from the eastern United States. The grains have concentric rings that look as if they were precipitated sequentially. Bordering the quartz grains are amber-colored rims that resemble the walls of algal cysts. Taken together, these characteristics distinguish authigenic from continental quartz, Schieber says.

To double-check the diagnosis of authigenesis, Schieber and Lee Riciputi of Oak Ridge National Laboratory in Oak Ridge, Tennessee, focused an ion microprobe at quartz silt in the shale samples. Quartz silt they had pegged as authigenic from its appearance had oxygen isotope values typical of other kinds of quartz precipitated at low temperatures—and three times higher than that of quartz silt that was not homegrown. They knew that this "imported" quartz had come from metamorphic rocks in distant mountains, because it has a mottled texture typical of metamorphic quartz.

What's most surprising, experts say, is the amount of authigenic quartz in these shales. In some samples, Schieber found that all the silt had grown in place. By volume, the authigenic silt may make up 40% of the shale. The presence of so much homegrown silt may have skewed geological interpretations of mudstone, Schieber says. Mistaking authigenic quartz silt for windborne silt, for example, might lead one to postulate desertlike conditions on land, when in fact the climate may not have been particularly dry. Authigenic quartz could also make it hard to estimate distance from the ancient shore, especially in broad expanses of mudstone that accumulated slowly, such as the late Devonian shales of North America.

How important these findings are depends in part on whether other times and places typically produced shales similarly rich in homegrown quartz. Lee Kump, a geochemist at Pennsylvania State University, University Park, points out that algal cysts tend to be most abundant during particular periods, such as times of stressful environmental conditions, so fewer of these hosts may be deposited in mudstone during happy times. Schieber believes that quartz grains might form in other fossil pores or the spaces between particles. In any case, he's already shown that the truth behind even the most ordinary rocks can be clear as mud.

–ERIK STOKSTAD

MOLECULAR STRUCTURE

Physicists Glimpse How Quasicrystals Boogie

If you have ever tapped a fine wineglass with a fork, you know crystals sing. Now, scientists have proved that quasicrystals, the slightly unpredictable cousins of crystals, can also dance. A new series of rapid-fire photographs has finally captured the expected do-si-do of atoms in the changing latticework of a quasicrystal. Although scientists had observed defects in quasicrystalline structures left behind by the flip-flops, called phasons, this is the first time anyone has spotted a real phason in action.

Unlike humans, molecules shiver less when they get cold. And as the molecules chill out, they are more amenable to bonding with their neighbors. The usual result is a crystal—a periodic pattern of identical clusters of atoms, in which every distance is an exact multiple of the size of the fundamental atomic cluster. It is an elegant picture, and for more than 150 years scientists believed that crystallization was the inevitable result of dropping temperatures.

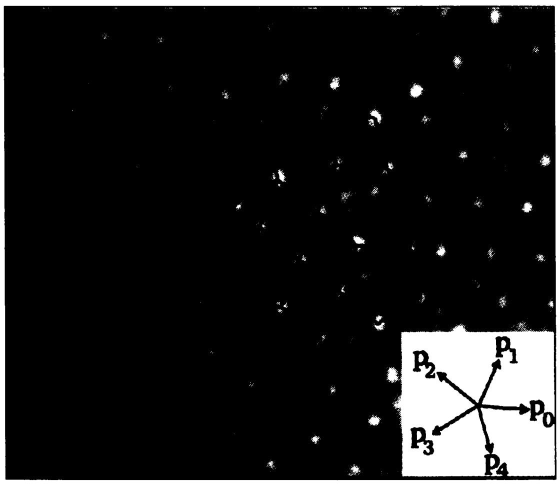
They were wrong. In 1985, Danny Schectman of the Technion–Israel Institute of Technology in Haifa, Israel, discovered an aluminum alloy that cools to form a stable quasi-periodic structure that never exactly repeats. He called the structure a quasicrystal. In contrast to crystals, a quasicrystal has two length scales, says physicist Michael Widom of Carnegie Mellon University in Pittsburgh, Pennsylvania. Some quasicrystals, for example, mix two distinct three-dimensional structures, one hexagonal, the other pentagonal.

Quasicrystals know how to jump and jive. If you pluck one of the wires of a regular crystal, a vibration called a phonon hums through the entire crystal. The single crystalline length scale implies that the phonon is the only possible distortion of the crystal. Extending the connection between length scales and distortions to quasicrystals, theorists predicted that quasicrystals support an extra kind of oscillation called a phason. Phasons rearrange the quasicrystal structures by making individual atoms jump as much as a few angstroms. But no one had ever seen the wiggles caused by a passing phason.

Now, physicist Keiichi Edagawa and his collaborators at the University of Tokyo have for the first time used a high-resolution electron-tunneling microscope to capture the metamorphosis of a quasicrystal on film. They first heated an aluminum-copper-cobalt mixture to 1173 degrees Celsius, then cooled it to room temperature to form a quasicrystal of interlocking hexagonal and pentagonal rhombi. A series of photographs revealed a column of atoms jumping approximately 1 nanometer, the team reports in the 21 August *Physical Review Letters*. The jump changes a hexagonal rhombus to a pentagonal one and makes an adjacent pentagonal rhombus become hexagonal. Within minutes, the column jumps back and flips the rhombi back to the original configuration.

"This is a breakthrough, because we can now see the dynamical effects of phasons," says physicist Paul Steinhardt of Princeton University. But it leaves an important question unanswered: Why do quasicrystals form? Most scientists believe that quasicrystals are the lowest available energy state, so cooling molecules must eventually settle into that state, just as a marble must roll to the bottom of a bowl. Widom, on the other hand, supports the so-called "entropy model" that says quasicrystals continuously flip through a nearly infinite number of equally likely and constantly changing configurations. The new imaging technique may help scientists decide between the two. **–MARK SINCELL**

Mark Sincell is a science writer in Houston.



Rhombus rumpus. Phasons tear through a quasicrystal, shifting the irregular latticework shown in this electron micrograph.

CREDIT: *PHYSICAL REVIEW LETTERS*