would have only a minor impact compared with the more severe depredations of commercial fishers and loggers.

So far, the gamble seems to be paying off. Most caboclos seem pleased by their new status, even though it means that certain forest zones are now off-limits to their use. "We are in a privileged situation," says one village leader. "We are lucky to be able to live here, to stay now that this is a preserve." One reason for their contentment may be that they have been given valuable incentives to compensate them for the restrictions they now face.

Communities have been given aid subsidies, for example, and almost all manual labor used by the project comes from the villages in the preserve. In particular, the project has been careful to select village leaders and sons of leaders as employees. And income-generating experiments, the traditional way sustainable development works, are being tried. These include pilot projects to grow camu-camu and other fruit-bearing trees with commercial potential, and a census of the discus fish is being taken to determine if it can be culled for the aquarium trade.

And Marmontel, who spends much of her time in the preserve and works closely with the caboclos, believes there are signs that the plan to use them as guardians against illegal fishing and logging is working. She has noted marked declines in both activities despite threats and some confrontations from armed gunmen on fishing boats and in logging camps. When the caboclos find an offender, they usually try friendly persuasion, but if the loggers or fishers refuse to leave, the caboclos report them to the project, which in turn calls in a federal ranger.

Whether Project Mamirauá lives up to its early promise and becomes a model for other rain forests remains a long shot against the seemingly inexorable march of rain-forest depletion. But for now it appears to be holding back that march toward this one small but important chunk of the Amazon basin.

–Brian Alexander

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COSMOLOGY

On the Track of Dark Matter in Mica

Researchers have recently been employing some heavy-duty equipment to search for "dark matter"—the mysterious invisible material that some cosmologists believe could account for up to 99.9% of the mass of the universe. With high-speed computers and dedicated telescopes, astronomers are monitoring millions of stars daily, looking for subtle brightness fluctuations caused by interceding clumps of dark matter; others are deploying sensitive detectors underground, patiently waiting to pick up the signal of a rare collision between a single dark matter particle and normal matter. Then there's Daniel Snowden-Ifft. He is looking for dark matter by cracking open old rocks.

Snowden-Ifft, a physicist at the University of California, Berkeley, and his colleagues are taking billion-year-old mica—a mineral composed largely of hydrogen, silicon, oxygen, aluminum, and potassium—and examining it for microscopic trails of destruction. These tracks would be caused by certain theorized dark-matter particles that interact infrequently with ordinary matter. Like photographic film exposed for a billion years, however, ancient mica should have been around long enough to record many encounters if these dark-matter particles exist.

In the end, studying mica may not actually tell us what dark matter is, but it could rule out a number of popular candidates. And this low-cost stategy to narrow the search impresses other seekers of dark matter. "It's a very clever technique. It certainly captures the imagination," says University of Chicago astrophysicist Michael Turner. "I'm impressed by the quality of the work....It's a very elegant method," agrees Bernard Sadoulet, who directs UC's Center for Particle Astrophysics and leads a team working with an underground particle detector made of cooled germanium crystals.

Ancient mica was first enlisted at Berkeley as a particle detector more than a decade ago. Physicist P. Buford Price and his colleagues scanned mica samples gathered from museums with an optical microscope for signs of encounters with proposed particles of magnetism called monopoles. In 1990, Snowden-Ifft, then a graduate student in Price's lab, read about a family of dark-matter candidates called weakly interacting massive particles, or WIMPs. He realized they shared some characteristics with monopoles and proposed searching for them in mica.

DANIEL SNOWDEN-IFFT/UC BERKELEY

Mining mica. Pits like this may unveil dark matter.

Particles such as WIMPs —and monopoles—would normally fly through matter without pause, say theorists. But from time to time, a WIMP should directly collide with an atom's nucleus. If that happened in mica's well-ordered crystal lattice, the recoiling nucleus would knock neighboring atoms out of position, producing a detectable wake of damage. Over its billion-year lifetime, if WIMPS do indeed exist, even a tiny chunk of mica would register many such recoils.

Snowden-Ifft's strategy is to take mica, cleave it, and then etch the new face with hydrofluoric acid for a few hours. The acid eats away faster at sites where mica's lattice has been disrupted by a moving particle, producing microscopic pits. The recoil track from a WIMP collision should produce pits too small for an optical microscope to see, so the team works with an atomic force microscope (AFM), a device that uses a delicate cantilever-borne stylus, like a needle on a record player, to trace the surface of an object with atomic resolution. For a WIMP of a particular mass and size, physicists can calculate the number of tracks they should discover in mica of known age. If they don't see that many tracks, they can rule out the existence of that WIMP and limit cosmologists to thinking about candidate particles that must be smaller or lighter.

The Berkeley group has already carried out a trial dark-matter search on one piece of mica, scanning one thousandth of a square centimeter of the mineral. In that small area, they found no possible WIMP tracks, allowing them to dismiss very large or massive WIMPs. With only this modest initial effort, claims Snowden-Ifft, "we're setting limits comparable to the best detectors to date."

The Berkeley lab is now buying its own AFM and plans to significantly scale up their dark-matter search by looking at more and more mica. "Basically, we're going to scan until we start to see stuff," says Snowden-Ifft. The search should in the end be limited by noise—a background of recoil tracks, indistinguishable from WIMP recoils, produced by cosmic rays or the neutrons of radioactive atoms normally found in and around the mica. Although some researchers feel these background events will prevent the mica effort from progressing much beyond its current limits, Snowden-Ifft believes the technique could eventually set mass and size limits that rule out some popular dark-matter candidates such as WIMPs called neutralinos. The key, he says, is to reduce background noise by finding mica samples less contaminated by cosmic rays and neutrons. If Snowden-Ifft and his colleagues are successful in their paradoxical search to find nothing in mica, "it could cause one to pause and say we should reconsider our [other WIMP] experiments," notes Turner.

–John Travis