gins, suggesting they too flowed slowly.

Stephen Reidel of the Westinghouse Corp. in Richland, Washington, isn't buying Self's geologic arguments by analogy. "I've looked at [the Columbia] flows for 20 years. They're nothing like what we see in Hawaii." He agrees that the older estimates of a few days may be too short to get that much lava out of the ground. "Months seem fine to me," he says, "but a year is probably pushing it." But Donald Swanson of the USGS at the University of Washington, who coauthored the original estimate of days rather than months, isn't ruling out Self's pahoehoe scenario—or any other, for that matter. "I'm [now] at a loss to explain how the flows were emplaced," he confesses.

If Self turns out to be right, flood basalt eruptions would look less promising as a trigger for extinctions, according to climate modeler Starley Thompson of the National Center for Atmospheric Research in Boulder, Colorado. Volcanic debris would be more likely to get washed out by rain before it built up to a high concentration. And without the intense heat of a rapid eruption, says Thompson, sulfuric acid aerosols would be less likely to reach the stratosphere, where they can spread globally and linger for years, blocking sunlight and cooling the climate. Self still sees plenty of destructive potential in these ancient floods, but to know just how devastating they might have been, volcanologists will have to decide how fast is fast.

–Richard A. Kerr

ASTRONOMY

X-rays Make a Smooth Move

The night sky, seemingly serene, is abuzz with signals from our cosmic neighborhood: light, radio waves, and other radiation from stars and gas within our galaxy. This cosmic buzz tends to drown out whispers from the wider universe, but two messages do make it through. One, the cosmic microwave background, is well understood as the afterglow of the Big Bang. The other, a uniform haze of x-rays visible only from space, has been a mystery since its discovery 30 years ago. Pervasive hot gas, supernovae, quasars, and other exotic objects have all been fingered as possible sources, but a new x-ray satellite is now hinting at a more mundane but nonetheless startling candidate: countless galaxies much like our own.

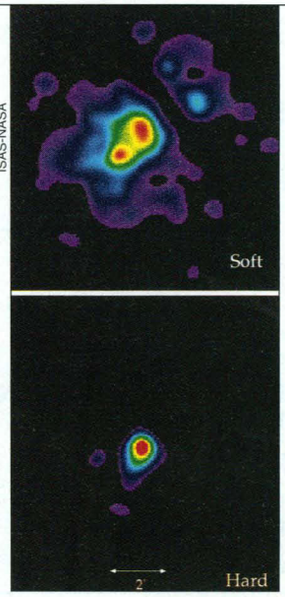
The new candidate made its debut last week in Crystal City, Virginia. There, at the joint meeting of the American Physical Society and the American Association of Physics Teachers, investigators from the joint Japanese-U.S. x-ray satellite ASCA, launched in February of last year, unveiled some early results. ASCA's unprecedented combination of high resolution and sensitivity has enabled researchers to search for graininess in the x-ray background—a hint of the number and brightness of the x-ray sources that compose it. What they've found is an unexpectedly smooth texture. And if ASCA investigator Hajime Inoue of the Institute of Space and Astronautical Science in Japan is correct (not everyone thinks he is), the smoothness implies that the background includes a multitude of weak sources, which might take the form of garden-variety galaxies much like the Milky Way.

The smoothness ASCA has discovered might have come as no surprise a few years ago, when many astronomers thought the x-ray background emanated from a uniform fog of hot gas that was thought to pervade the universe. But that idea was dropped in the early 1990s, when precise measurements of that other universal presence, the cosmic background radiation, showed no signs that the radiation had interacted with any pervasive gas. After the fog vanished, many investigators embraced a new x-ray source: active galaxies and quasars—bright radiation sources that may be powered by massive black holes. To the blurry eyes of most x-ray telescopes, hordes of these sources scattered around the sky would look like a uniform glow.

As x-ray eyes get sharper, however, these point sources should start to pop out; indeed, some already have. ASCA, for example, was able to pick out enough active galaxies to account for about a third of the background. In search of clues to the nature of the remaining sources, Inoue's group compared the brightness of small patches of background. If each patch were made up of a few bright sources just below the detection limit, chance variations in the number of sources per patch should lead to large brightness differences; larger numbers of weaker sources should yield smaller differences.

In fact, the observed differences were minuscule, says Inoue, implying that the x-ray background is composed of swarms of very weak sources—at least 10 of them per square arc minute of sky. Those faint sources aren't likely to be active galaxies, because there simply aren't enough of them in the universe, says ASCA investigator Robert Petre of NASA's Goddard Space Flight Center. "You need far more sources than there are active galaxies. You fall at least an order of magnitude shy," he notes. Inoue and his colleagues think ordinary galaxies in the distant universe—far more common than their powerful active cousins—could do the job.

It will take more than sheer numbers, however, for ordinary galaxies to fit into this picture. To account for the background, they would also need to act as x-ray beacons, like active galaxies in miniature—and ASCA has produced some of the first evidence that they can. Turning its x-ray eyes on a handful of nearby galaxies, the satellite found that their centers glowed brightly, emitting a spectrum of x-rays resembling that of the background.



ISAS-NASA

The normal heart? In the galaxy M106, hard (high-energy) x-rays reveal a central source.

Astronomers can only speculate about what's powering this emission. One possibility, says Inoue, is that many ordinary galaxies have a black-hole engine like those of active galaxies—but it's somehow throttled back. If so, says Peter Serlemitsos of Goddard, who directed the galaxy observations, "the contribution [of these galaxies] to the background can't be insignificant."

But some advocates of active galaxies are standing their ground. Goddard's Elihu Boldt is impressed with the observations of normal galaxies, but he's not convinced that they are a major component of the background. He and his colleagues Takamitsu Miyaji of the University of Maryland, Ofer Lahav of the Institute for Astronomy in Cambridge, England, and Keith Jahoda of Goddard recently analyzed data from an earlier x-ray satellite to tease out a measure of the x-ray emissions from nearby objects. They compared that result with the emissions expected from nearby active galaxies and found a rough match, Boldt says. That implies, he says, that based on the nearby universe, "there's no glaring need for an additional population of sources." But he notes that if the ASCA result on the smoothness of the background does hold up, some other kind of fine-grained sources might be lurking in the far reaches of the universe.

Serlemitsos cautions that the evidence of smoothness "should be considered preliminary" because the ASCA researchers have not ruled out the possibility that it is some kind of artifact. But if the background keeps on looking this smooth, the buzz in the astronomy community may soon be about the extraordinary features of ordinary galaxies.

–Tim Appenzeller