

Bright light source monitors bacterial chromium reduction

Hexavalent chromium, Cr(VI), is a pernicious environmental contaminant. It's widely used as a wood preservative and as a rust inhibitor. It's also highly water soluble, mobile, and toxic.

As it turns out, however, the trivalent form, Cr(III), is relatively insoluble and

al process is by far the most important pathway for Cr (VI) reduction in geological materials. Thanks to the 10-um spatial resolution afforded by the brightness of IR light obtained from the ALS, the group could produce spectromicroscopic "images" whose peaks and valleys show the locations of the action. Fortuitously, a protein in the bacteria, the chromium species, and toluene all have well-characterized IR absorption bands. Most important, the IR light, despite its brightness, doesn't destroy the bacteria, as many other analytical techniques used to study these types of systems do.

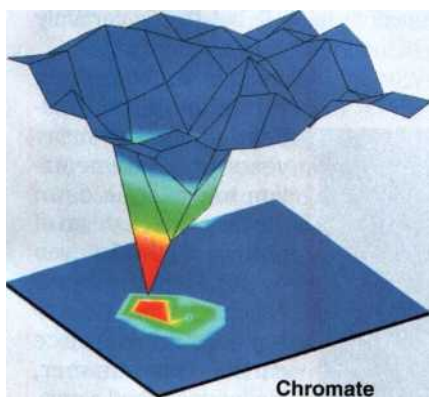
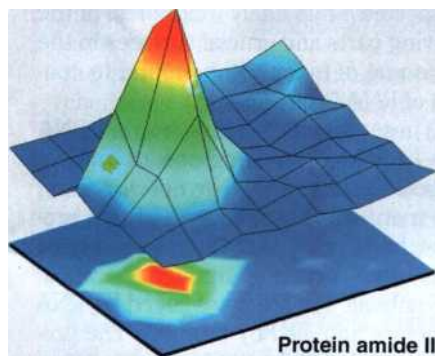
After five days of coexisting with a chromate solution on a smooth piece of magnetite (a mixture of iron oxides), a sample of the bacteria *Arthrobacter oxydans* reduced a good portion of the Cr(VI). By contrast, a control magnetite sample with no bacteria had little effect on the Cr(VI). And a sample of the bacteria to which the group added toluene reduced even greater amounts of Cr(VI). The authors suspect the toluene may provide food for the bacteria. Additionally, the bacteria degrade toluene to produce catechol and other smaller molecules that themselves are reducing agents, Holman says.

Two mysterious new peaks arose in the spectra that the researchers later determined were probably from a Cr(V) compound, an intermediate that had

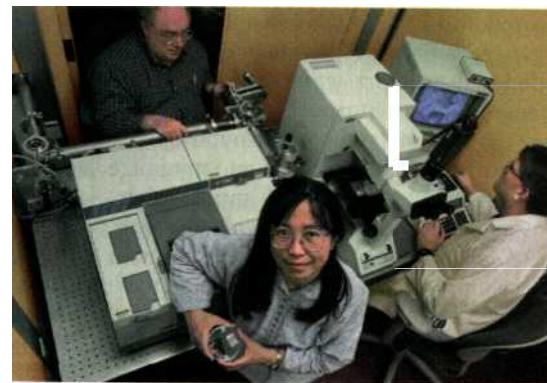
immobile and thus less harmful. So scientists are keenly interested in processes that reduce Cr(VI) species to Cr(III) as potential environmental remediators. It is known that some natural metal oxides and organic molecules can do the job in geological environments. In addition, certain types of bacteria appear to not only thrive in a toxic environment of Cr(VI), but to reduce it to the less mobile and less harmful form as well.

New insight into the Cr(VI)-reducing abilities of these bacteria comes from staff scientist Hoi Ying Holman and colleagues at Lawrence Berkeley National Laboratory in Berkeley, Calif. Using LBNL's bright Advanced Light Source (ALS), they monitored in real time and with unprecedented resolution a bacterial colony and the disappearance of Cr (VI) and corresponding appearance of Cr (III) .

Their study, to appear in the October issue of *Geomicrobiology* (published by Taylor & Francis), shows that the bacteri-



Spectromicroscopy measurements show the spatial distribution of bacteria, indicated by protein amide II (top), and chromate (bottom) on a magnetite sample, after five days. The low chromate levels correspond to the location of the bacteria.



Holman (foreground) with physicists Wayne McKinney (upper left) and Michael Martin (far right), who built the IR beamline apparatus used in the chromium reduction experiments.

previously only been seen in special laboratory microbial systems.

Holman and colleagues also exposed native bacterial colonies to chromate solution on the ragged surfaces of Columbia basalt rock chips taken from the boundary of a contaminated area. They found that after four months, some of the colonies were thriving in Cr(III) compounds, and the Cr(VI) was gone.

Holman's work represents "a good first step" toward applying new surface chemistry analysis techniques to the study of environmental microbial processes, says Derek R. Lovley, head of the microbiology department at the University of Massachusetts, Amherst. "In my opinion, this will be an important emerging area in environmental microbiology over the next several years."

Elizabeth Wilson