Clay minerals are a possible new answer to MRSA and other 'superbug' infections

July 18 2014, by Cheryl Dybas

Are the best medicines hidden in the Earth? French green clays are used for healing Buruli ulcers. Credit: Thierry Brunet de Courssou

Superbugs, they're called: Pathogens, or disease-causing microorganisms, resistant to multiple antibiotics. Such antibiotic resistance is now a major public health concern.

"This serious threat is no longer a prediction for the future," states a 2014 World Health Organization report, "it's happening right now in every region of the world and has the potential to affect anyone, of any age, in any country."

Could the answer to this threat be hidden in clays formed in minerals deep in the Earth?

Biomedicine meets geochemistry

"As antibiotic-resistant bacterial strains emerge and pose increasing health risks," says Lynda Williams, a biogeochemist at Arizona State University (ASU), "new antibacterial agents are urgently needed."

To find answers, Williams and colleague Keith Morrison of ASU set out to identify naturally-occurring antibacterial clays effective at killing antibiotic-resistant bacteria.

The scientists headed to the field—the rock field. In a volcanic deposit near Crater Lake, Oregon, they hit pay dirt.

Back in the lab, the researchers incubated the pathogens Escherichia coli and Staphylococcus epidermidis, which breeds skin infections, with clays from different zones of the Oregon deposit.

They found that the clays' rapid uptake of iron impaired bacterial metabolism. Cells were flooded with excess iron, which overwhelmed iron storage proteins and killed the bacteria.

"The ability of antibacterial clays to buffer pH also appears key to their healing potential and viability as alternatives to conventional antibiotics," state the scientists in a paper recently published in the journal Environmental Geochemistry and Health.

"Minerals have long had a role in non-traditional medicine," says Enriqueta Barrera, a program director in the National Science Foundation's (NSF) Division of Earth Sciences, which funded the research.

"Yet there is often no understanding of the reaction between the minerals and the human body or agents that cause illness. This research explains the mechanism by which clay minerals interfere with the functioning of pathogenic bacteria. The results have the potential to lead to the wide use of clays in the pharmaceutical industry."

Ancient remedies new again

Open pit #10 near Crater Lake, Oregon, showing blue clay sampled by scientist Keith Morrison. Credit: Stan Williams

Clay minerals, says Williams, have been sought for medicinal purposes for millennia.

Studies of French clays—green clays historically used in France in mineral baths—show that the clays have antibacterial properties. French green clays have been used to treat Mycobacterium ulcerans, the pathogen that causes Buruli ulcers.

Common in Africa, Buruli ulcers start as painful skin swellings. Then infection leads to the destruction of skin and large, open ulcers on arms or legs.

Delayed treatment—or treatment that doesn't work—may cause irreversible deformities, restriction of joint movement, widespread skin lesions, and sometimes life-threatening secondary infections.

Treatment with daily applications of green clay poultices healed the infections. "These clays," says Williams, "demonstrated a unique ability to kill bacteria while promoting skin cell growth."

Biogeochemist Keith Morrison sampling an outcrop of blue clay in the Oregon deposit. Credit: Lynda Williams

Unfortunately, the original French green clays were depleted. Later testing of newer samples didn't show the same results.

Research on French green clays, however, spurred testing of other clays with likely antibacterial properties.

"To date," says Williams, "the most effective antibacterial clays are those from the Oregon deposit."

Samples from an area mined by Oregon Mineral Technologies (OMT) proved active against a broad spectrum of bacteria, including methicillin-resistant S. aureus (MRSA) and extended-spectrum beta-lactamaseresistant E. coli (ESBL).

Blue and white clay zones in the Oregon deposit, separated by a vein of rock containing sulfur. Credit: Lynda Williams

What's in those rocks?

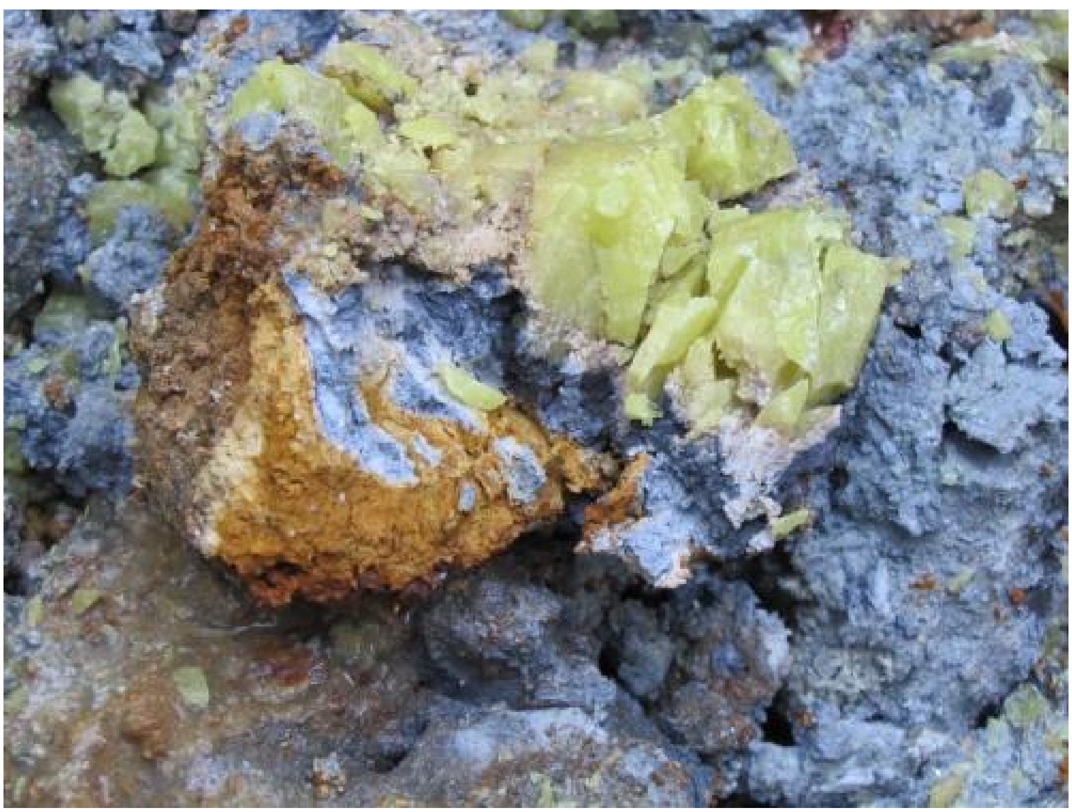
Understanding the geologic environment that produces antibacterial minerals is important for identifying other promising locations, says Williams, "and for evaluating specific deposits with bactericidal activity."

The OMT deposit was formed near volcanoes active over tens to hundreds of thousands of years. The Crater Lake region is blanketed with ash deposits from such volcanoes.

OMT clays may be 20 to 30 million years old. They were "born" eons before deposits from volcanoes such as Mt. Mazama, which erupted 7,700 years ago to form the Crater Lake caldera.

Volcanic eruptions over the past 70,000 or so years produced silica-rich magmas and hydrothermal waters that may have contributed to the Oregon deposit's antibacterial properties.

To find out, Williams and Morrison took samples from the main OMT open pit. Four types of rocks were collected: two blue clays, and one white and one red "alteration zone" rock from the upper part of the deposit.



Nodule of Oregon blue clay, coated with red clay and sulfur crystals encased in white clay. Credit: Lynda Williams

Blue clay to the rescue

The OMT blue samples were strongly bactericidal against E. coli and S. epidermidis. The OMT white sample reduced the population of E. coli and S. epidermidis by 56 percent and 29 percent, respectively, but the red sample didn't show an antibacterial effect.

"We can use this information to propose the medicinal application of certain natural clays, especially in wound healing," says Williams.

Chronic, non-healing wounds, adds Morrison, are usually more alkaline (vs. acidic) than healthy skin. The pH of normal skin is slightly acidic, which keeps numbers of bacteria low.

Scientist Lynda Williams imaging clay interactions with bacteria under a microscope. Credit: Thierry Brunet de Courssou

"Antibacterial clays can buffer wounds to a low [more acidic] pH," says Williams, like other accepted chronic wound treatments, such as acidified nitrate. "The clays may shift the wound environment to a pH range that favors healing, while killing invading bacteria."

The Oregon clays could lead to the discovery of new antibacterial mechanisms, she says, "which would benefit the health care industry and people in developing nations. A low-cost topical antibacterial agent is quickly needed."

Answers to Buruli ulcers, MRSA and other antibiotic-resistant infections may lie not in a high-tech lab, but in ancient rocks forged in a hot zone:

Oregon's once—and perhaps future—volcanoes.

Provided by National Science Foundation