Mineralogists identify a group of minerals that owe their existence to human activity

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Remains of a tin mine in Cornwall, England. Mining for metals has resulted in many minerals that would not have formed otherwise, for example when miners dumped waste materials into the ocean. Credit: Herbythyme, Wikimedia Commons

No other species in Earth's history has left a mark on the planet as

profound and lasting as Homo sapiens. So much so that scientists are increasingly making a case for designating a new geological time period: the Anthropocene. In a paper published this month in the journal American Mineralogist, two UA scientists lend further merit to this idea by identifying for the first time a group of 208 mineral species that originated either principally or exclusively because of human activities.

The team, led by Robert Hazen of the Carnegie Institution for Science, reports that 208 minerals, of the more than 5,200 minerals officially recognized by the International Mineralogical Association, owe their existence to human activities in one form or another.

"In the sediment layers left behind from our age, future mineralogists will find plentiful building materials such as bricks, cinder blocks and cement; metal alloys such as steel, titanium and aluminum; along with many lethal radioactive byproducts of the nuclear age," said Marcus Origlieri, a mineralogist and an associate who works with UA geosciences professor Robert Downs and is one of the paper's co-authors. "They might also marvel at some of the beautiful manufactured gemstones like cubic zirconia, moissanite, synthetic rubies and many others."

Most of the human-mediated, anthropic minerals were created by mining—in ore dumps, through the weathering of slag, formed in tunnel walls, mine water or timbers, or through mine fires. Six were found on the walls of smelters; three formed in a geothermal piping system. One mineral, calclacite, originated in an old museum storage cabinet. Three were discovered in corroded lead artifacts aboard a Tunisian shipwreck, two on bronze artifacts in Egypt and two on tin artifacts in Canada. Four were discovered at prehistoric sacrificial burning sites in the Austrian mountains.

"Given humanity's pervasive influences on the environment, there must

be hundreds of as-yet-unrecognized 'minerals' in old mines, smelters, abandoned buildings and other sites," Downs said. "Meanwhile, new suites of compounds may now be forming in, for example, solid waste dumps where old batteries, electronics, appliances, and other high-tech discards are exposed to weathering and alteration."

How do minerals form and why?

Origlieri: Minerals form because the earth is not just made of dry rock, but of fluids, too. Those things can be transported, moved around and deposited. Think about how sugar dissolves in water: Once you drain out the water, you have sugar crystals. Minerals form in this exact way. For example, when lava rises underneath a continent and cools while still underground, it may form a granite. Or it may come out straight as a gas, like in Yellowstone National Park, where you can see sulfur crystals forming on a rock.

This specimen of fiedlerite, found in Greece, formed after ancient miners dumped mining waste, or slag, into the Mediterranean Sea. Credit: RRUFF Project

Why are there so many different variations of minerals?

Origlieri: It all depends on the environment where the mineral forms. When two deposits form at different depths, at different temperatures, you get different minerals. You can have the same atoms arranged in a different structure and get two different minerals. Calcite and aragonite, for example, are both made by different animal groups that use different biological pathways to make their shells. Ore deposits, like copper, are not the same everywhere in the world. Some places have copper in the

form of metal copper. In others, where there is lack of oxygen, the copper is formed in sulfites. Elsewhere, the copper is oxidized, resulting in copper carbonate. The method of mining changes depending on how the copper occurs in the rock.

In your paper, you make the case for a new geological era based on minerals that owe their existence to man. What is the idea behind that?

Origlieri: Given that humans have had such a big impact on the Earth and the environment, scientists are discussing at what point we should cut off the completely natural and geological era that apparently has ended and start a new era, one recognizing that man has changed the Earth. We argue that one way to indicate this era is the speciation within the mineral kingdom. Other people have talked about nuclear isotopes we have formed; others have talked about layers of plastic that we have created. We cited all of that in our paper. Our list of man-made minerals is just another marker indicating that humans have changed the geological stratigraphy, the sediments that exist. Let's say a future geologist finds those in a sample. These minerals would indicate something that has been perturbed or changed by man. At the time we wrote the paper, we report 208 such minerals. That's 4 percent of all known minerals. Think about that. That's a lot of "Earth made by man."

What's the story behind such man-made minerals?

Origlieri: Part of the definition of a mineral is that it forms without the action of man. That's why plastics aren't minerals. Minerals can form through biological processes. For example, certain minerals are found in dried saguaro cactus, or bat guano, or in the enamel in teeth. The minerals that we talk about in our paper have both completely natural, geological aspects to their formation as well as human aspects. When

you dig a mine, for example, you are exposing minerals that are less stable to oxygen in the air. So you are creating the environment for a chemical reaction, but not deliberately and not in any kind of a controlled manner. In ancient Greece and Rome, for example, people would dump mining waste into the sea, where it would react with the seawater and create new minerals in the process. We call those slag minerals. Those particular minerals wouldn't have formed if man hadn't thrown the stuff into the sea, but since the sea was already there, human activity just changed things by transporting the material. Part of it the process is natural, and part of it isn't.

How are minerals classified and what role does the UA play in that process?

Abhurite recovered by divers from the wreck of the SS Cheerful, a cargo ship

hauling ingots of tin from a smelter when it sank in 1885 off the coast of Cornwall, England. Credit: RRUFF Project

Origlieri: The Commission on New Minerals and Mineral Nomenclature reviews proposals for new minerals made by mineralogists who study minerals. The organization then distributes the information to its voting members. They vote on two criteria: If the mineral seems valid to them, and if they like the name. There are cases in which a proposed name is rejected, for example, because it sounds bad in a foreign language, or maybe they feel it should be named after somebody, or because it sounds too much like an existing or outdated name. The UA hosts the official Mineral List of the International Mineralogical Association. There are 5,231 recognized mineral species at this time. Every year, more than 100 are added to the database. Bob Downs' contribution was that he developed a database from that list that made it accessible to everyone. This resource has links to scientific references, it shows the first time the mineral name was published, what minerals it's related to, and it also includes spectrographic data. It really incorporates a lot of data that is freely available. It really helps scientists who may not have every book ever published, and so with the database they can identify the minerals using this data.

Can you tell us about a mineral that you discovered?

Origlieri: A few years back, a specimen found in a South African manganese mine was brought to a mineral show that looked different than anything I had ever seen. I analyzed it with a technique called Raman spectroscopy, and it didn't quite match anything. Then I did some X-ray diffraction tests, and it didn't match anything. Finally, a chemical analysis showed it was similar to something else, but just a little different. It turned out it was an intermediate between two known

minerals. I characterized it and presented it at the International Mineralogical Association Meeting. It is called Marshallsussmanite.

What are the most likely environments where one would find a new mineral?

Origlieri: Most likely in places where rare elements are concentrated. You'll notice our paper lists a lot of uranium minerals. Uranium reacts with oxygen in the air and whatever else is around. If there are water and carbon around, it forms a carbonate. If there is sulfur around, it forms a sulfate. Anything else in the rock causes another mineral to form. Uranium minerals are very diverse.

Is it conceivable that there are new minerals forming in the depths of some landfill that might be useful for something?

Origlieri: Some may have interesting properties, and may provide ideas for materials scientists to create new compounds. Perhaps there are some naturally forming minerals that haven't been found yet or some made in a laboratory where the arrangement of atoms is a little different that have a desirable property and could serve as a template for a new material. But honestly, a small amount of an exotic mineral won't find too much use. I mean, in general, these kinds of minerals aren't found in large quantities, and most minerals are not exactly pure. For industrial applications, usually you want to control the chemistry of your material.

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