Deadly Minerals: Uranium and Thorium Minerals

by Andrew A. Sicree

Many mineral collectors avoid uranium and thorium minerals because they are radioactive and thus dangerous. But, while radioactives do present a health hazard, they can be collected, displayed, and stored with safety. A little bit of understanding of the nature of their radioactivity goes a long way toward protecting yourself sensibly without becoming paranoid about the dangers of radiation.

A primer on radioactivity

The first fact to be mentioned is that “radiation” is everywhere. For instance, sunlight, infrared light, and ultraviolet light are all forms of electromagnetic radiation, although their energies are low and their abilities to harm us are consequently lessened. Visible light doesn’t do us harm, although it can cause some minerals (such as realgar) to decompose or discolor. Short-wave ultraviolet light (which is higher-energy ultraviolet radiation) can cause tanning, give sunburns, and even eventually contribute to skin cancer, but it is substantially different in impact than the energetic particles or rays that come from the nucleus of certain atoms. Radiation from the nucleus of an atom is called nuclear radiation or radioactivity.

Radioactivity is the release of energetic particles and/or rays during the decay of an unstable nucleus. The nuclei of certain isotopes of all elements are unstable or radioactive. This means that they will, given enough time, decay. They do not decompose completely, but they will breakdown into smaller nuclei and emit some particles and/or rays in the process. For many elements, the unstable isotopes decay so quickly that they do not exist in nature on the Earth. They only exist if they have been made in a nuclear reactor, or the explosion of an atomic bomb. Stars also make them – but that is another story. Collectors are primarily concerned with natural sources of radioactivity.

Natural sources

It is impossible to escape from radioactivity. The radioactive isotope carbon-14 is continuously created in the upper atmosphere and it permeates the air, water, living plants, and our bodies. All uranium is radioactive, and there are traces of uranium in most granites and many other rocks. Some petrified wood and some dinosaur bones are very radioactive because they contain a fair amount of uranium and along with its radioactive decay products. Potassium-40 is another very long-lived radioactive isotope; this means that all potassium is radioactive. (This is another reason that granites are radioactive – they contain potassium feldspars.) So even our bananas are radioactive!

Usually, when people worry about radiation, they are worried about the type of radioactive particles and rays produced by fallout from nuclear bombs and waste from nuclear reactors. This radioactivity has substantially higher energies than ultraviolet radiation. Naturally radioactive minerals release the same types of high-energy radioactive particles and/or rays, but they are always much lower in activity than are bombs and reactors.

Radioactivity in minerals

In the mineralogical world, there are three types of radioactivity that concern us: alpha, beta, and gamma radiation. Alpha (scientists use the symbol α) particles and beta (β) particles are particles. Beta particles are
electrons, and alpha particles are particles that are the same as the nuclei of helium atoms (i.e., they are particles made up of two protons and two neutrons). Gamma (γ) rays are high-energy photons.

Alpha particles are easiest to stop. They’re stopped by five or six inches of air and they won’t pass through your skin. Beta particles are more penetrating. It takes a thin sheet of aluminum or even steel to stop most of them. Gamma-rays are essentially high energy X-rays and they are very penetrating. They will zip right through your body. Unlike ordinary x-rays, a thin lead sheet doesn’t stop gamma-rays. It takes six or more inches of solid lead to stop these little beasties.

Alpha particles may be the easiest to stop, but they can do the most damage if they get inside your body. Because of the penetrating ability of gamma-rays, it really doesn’t matter if a gamma-source is inside or outside your body. The gamma-rays will do the same damage either way. But alpha particles are big particles. They strike with much more impact than a gamma-ray does. If a particle of dust containing an alpha-emitter is sucked into your lungs, the alpha particles do not have to penetrate your skin to get at you. If they are emitted within your lungs they will have a direct impact on lung tissues. They’ll kill cells and damage DNA, possibly leading to lung cancer. This is why it is a good idea to wear a dust mask when trimming radioactive mineral specimens.

Some common radioactive minerals

Commonly collected uranium minerals include carnotite [K₂(UO₂)₂(VO₄)₂·3H₂O], uraninite [UO₂], and autunite [Ca(UO₂)₂(PO₄)₂·10H₂O]. Thorianite [ThO₂] and thorite [ThSiO₄] are among the thorium minerals. “Gummite” is a general term for any of the yellow- and orange-colored secondary uranium oxide minerals (in other words the radioactive yellow stuff that forms when uranium ores weather). Uranium has a rather complicated chemistry so there are a wide variety of uranium minerals. Some of the rarer uranium minerals can be found in pegmatites, concentrated in the center. Uranium minerals also occur in some phosphorus and vanadium deposits because uranium tends to form phosphate or vanadate minerals. Weathering of primary (original) uranium deposits creates a slew of secondary oxidized uranium minerals – many of which are brightly colored yellow or orange.

Dinosaur bones and petrified wood logs will concentrate uranium because the organic matter originally in these fossils created a reduced zone within the fossil. Uranium tends to precipitate in reduced zones so uranium dissolved in groundwater will tend to “drop out” (precipitate) from the water when it encounters buried bones or wood.

Potassium-containing minerals, such as orthoclase (KAlSi₃O₈), are radioactive by virtue of containing potassium-40. But this radioactivity is hard to detect in minerals because the decay products are stable (non-radioactive) so, unlike uranium and thorium, there is no chain of radioactive daughter-products. Also, with a long half-life of 1.3 billion years, the rate of decay is very low.

The uranium-238 decay series

All uranium and thorium minerals are radioactive. This is because of the radioactive isotopes uranium-238, uranium-235, and thorium-232. Each of these isotopes is unstable, but they have very long half-lives so it takes a long time for them to decay away. Uranium-238 has a half-life (the time it takes one-half of the isotope to decay) of 4.5 billion years, uranium-235 has a half-life of 700 million years, and thorium-232 has a half-life of 14 billion years – a pretty long time! Eventually, a stable atom of lead-206 results from the decay of uranium-238. Likewise, stable lead-207 results from uranium-235, and stable lead-208 is the end result of the radioactive decay of thorium-232.
Radon gas

All minerals containing uranium will emit a small amount of radon gas. How is this gas generated? When uranium-238 decays it produces thorium-234, which decays to protactinium-234m then to uranium-234. Uranium-234 decays to thorium-230, which in turn produces radium-226. Up until this point the parent (uranium-238) and its daughters have mostly remained within the uranium-bearing mineral, but when radium-226 decays, it produces an atom of radon-222. Being a noble gas, the radon doesn’t bind to atoms in the mineral and so it will slowly seep out of the mineral along cracks and cleavage planes if it gets the chance.

Once radon gas is in the air, it doesn’t do much damage. You can breathe it into your lungs and it will be exhaled without reacting with your body. Only if the radon happened to decay when it was inside your lungs would it present much of a problem. However, radon-222 will decay to polonium-218, which is also an alpha emitter. When a free-floating atom of radon-222 decays to polonium-218, the resulting polonium-218 atom is ionized (it has a charge). This polonium-218 ion is left floating in the air but, unlike radon, polonium is not a noble gas. It has a strong tendency to react with fine dust particles (or fine smoke particles) in the air. If you breathe one of these polonium-218-laced dust particles into your lungs, you then have an alpha-emitter in direct contact with lung tissues – it isn’t going to kill you immediately, but it isn’t the best recipe for good health.

All uranium minerals continually produce small amount of radon, so they do present a modest health risk.

Ways of limiting your danger

First, collect fewer specimens. Store only those you really need. Second, limit your exposure to the radioactivity. This means to shorten the time you handle them, protect yourself from dust if you are trimming them, use protective shielding when possible (lead sheets, or leaded glass help), and keep the specimens as far away as possible. Even techniques such as placing radioactive specimens in the rear of a display case will decrease exposure. Store your specimens in a well-ventilated area, preferably one that is not in a living space. This prevents them from creating a radon problem in your house. In other words, don’t keep them under the bed, in your basement (radon will migrate) or in a garage attached to your house. Putting them in a locked metal cabinet in a drafty detached garage or a shed is ideal.

You could in theory devise a shielded storage cabinet (with thick lead walls, for instance) that would truncate any alpha, beta, and gamma radiation, but it is very difficult to seal up a specimen so that it does not leak radon gas. Being a noble gas, radon it won’t react with anything in the rock, in the packaging materials, or in your body. Over time it will, however, tend to diffuse out of containers such as zipper-lock plastic bags. A container would have to be completely gas-tight in order prevent long-term leakage.

While it appears that federal regulations do not explicitly prevent collectors from owning or storing radioactive minerals, some state level regulations may come into play. Heightened security conditions may mean that it will become more difficult to transport radioactive specimens. For instance, some friends of mine were stopped at Niagara Falls when they tried to return to the U.S. after a mineral collecting trip in Canada. Apparently, they tripped some type of radiation alarm at the border. They opened the trunk of their car to show the customs officials their rocks and were allowed to pass.
Crystal Matrix Crossword

Radio-Minerals

ACROSS
1 violet uranium oxide mineral
10 low rank soldiers
14 radioactive natural gas
15 Irish king
16 what a cat chases
17 Railroaders of American (ab)
18 yellow uranium vanadate mineral
19 press group (ab)
20 where rivers end
21 selenium
22 mountain state
23 cerium
25 radiation sensitive arsenic mineral
29 has curved beak
31 Samoan garland
33 electron particle radiation
34 what’s up there
35 Great birds
36 motor homes
37 Volunteer State
38 Domestic Mail Manual
39 island in the Aegean Sea
40 Hello
41 Gas Research Inst. (ab)
42 smallest part of element
44 full of animals
45 big, bad, and ugly
47 ___ tide - Christmas
48 Greek B
49 falls powerfully
51 element in Pepto-Bismol
52 Anno Domini
53 magazine for lapidaries
55 residue after oil
56 dinosaur boundary
57 a plagioclase feldspar
62 abominable in the snow
64 plural of datum
65 decay ____
66 opposite of tohate
67 coloring agents
68 thorium oxide mineral

DOWN
1 radioactive bombardment
2 old folks group
3 Navy Disbursing Of. (ab)
4 cheers
5 Head Nurse (ab)
6 national basketball grp.
7 charged particles
8 better than true
9 Europe (ab)
10 friend
11 on the edges
12 feline
13 suite (ab)
18 absence of gas
22 Russian peace
24 bigger than a deer
26 Landing Barge Vehicle(s)
27 where it’s ____
28 what U, Th minerals are
30 box to put things in
32 measure Au concentration
35 friend
36 read only memory
38 on the bottom of coffee
39 corderite
40 slang for radioactive
41 radioactive rock
43 used for washing

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