

<http://www.epa.gov/radiation/tenorm/sources.htm>

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TENORM Sources

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Mining and Resource Extraction

TENORM may be present in mining wastes. These wastes, most significantly from uranium mining, may be generated in large volumes and stored on land near the mine site. The waste rock and soil has little or no practical use. Uranium mine wastes from mines that closed before about 1975 are of particular concern. In many cases, these mines remain unreclaimed today, with the wastes piled near the mine as it was when the mine closed. Below is information about wastes from several resource extraction industries:

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- [Gold and Silver](#)
- [Rare Earths](#)
- [Titanium Ores](#)

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Uranium

The mining of uranium ores by underground, by [in-situ leaching](#), and by surface methods produces large and small amounts of bulk waste material, including excavated top soil, [overburden](#) that contains no ore, weakly uranium-enriched waste rock, and subgrade ores, and evaporation pond sludges and scales. These materials typically contain radionuclides of radium, uranium, and thorium.

Materials	Radiation Level [pCi/g]
	low average high

Uranium Mining Overburden			low
Uranium In-Situ Leachate Evaporation Pond	3	30	low hundreds
Solids	300		3000

Fertilizer Production

The production of phosphates for fertilizer generates wastes in very large volumes that are stored in huge piles called "stacks" that cover hundreds of acres in Florida and other phosphate-processing states. These radioactive materials contain radium and other radionuclides and create large amounts of radon. EPA and state agencies have regulations controlling these wastes. In addition, the state of Florida has created an independent state research agency charged with investigating ways to minimize adverse environmental impacts of the phosphate industry.

Materials	Radiation Level [pCi/g]		
	low	average	high
Phosphate Ore (Florida)	7	17.3-39.5	6.2- 53.5
Phosphogypsum	7.3	11.7-24.5	36.7
Phosphate Fertilizer	0.5	5.7	21

Aluminum

Waste muds created by the extraction of alumina from its ore, bauxite, may contain low levels of radioactivity, usually from uranium, thorium, radium, and their radioactive decay products

Materials	Radiation Level [pCi/g]		
	low	average	high
Ore (Bauxite)	4.4	NA	7.4
Product		0.23	

Production Wastes NA 3.9-5.6 NA

Copper Waste Rock

Mining and extraction of copper by common surface or underground methods can concentrate or expose uranium, thorium, and radium in waste rock. Another extraction method, known as "in-situ" leaching, can transport uranium and thorium into groundwater or surface water at the site. In this method, rather than removing soil and rock to reach the copper deposit, liquids containing chemicals are allowed to seep through copper-bearing rocks and dissolve the copper. It also dissolves radionuclides that may be in the soil and rock. The liquids are captured and the copper is recovered, leaving the radionuclides. Some of the liquids remain and may contaminate water in the area. In-situ leaching may also be used on tailings (waste rock).

Wastes	Radiation Level [pCi/g]		
	low	average	high
Copper Waste Rock	0.7	12	82.6

Gold and Silver

While few studies have been done on these ores, some western mines produced uranium as a secondary product when extracting precious metals. Pitchblende (a naturally occurring material containing low concentrations of uranium) has been found in the same ores as gold and silver. Waste rock from some of these mines may be radioactive.

Rare Earths

Rare earths are a group of elements that have electrical properties that make them useful in electronics and electrical applications. Lanthanides and yttrium are recovered primarily from ores and minerals that naturally contain uranium and thorium. As a result, the waste rock and sludges from the extraction of rare earths also contain these radionuclides.

Materials	Radiation Level [pCi/g]		
	low	average	high
Rare Earths(Monazite, Xenotime, Bastnasite)	5.7		3224

Titanium Ores

Uranium, thorium, and radium commonly occur in titanium ore and monazite occurs in sands from which the titanium is extracted. As a result, the mineral sludges, dusts, and sands from the extraction process may be radioactive.

Materials	Radiation Level [pCi/g]		
	low	average	high
Titanium Ores	8.0		24.5
Rutile	3.9	19.7	NA
Ilmenite	NA	5.7	
Wastes	3.9	12	45

Zircon

Zircon is naturally radioactive, containing small amounts of uranium, thorium and radium in its crystalline structure. It is also mined from deposits containing other radioactive minerals such as monazite.

Materials	Radiation Level [pCi/g]		
	low	average	high
Zircon	68		
Wastes	87		1300

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Energy Production Wastes

- [Coal and Coal Ash](#)
- [Geothermal Energy Waste Scales](#)

- [Petroleum \(oil and gas\)](#)

Coal and Coal Ash

Coal contains trace quantities of the naturally occurring radionuclides of uranium, thorium, and potassium as well as their radioactive decay products. When coal is burned, minerals including most of the radionuclides do not burn and as a result are concentrated in the ash.

Wastes	Radiation Level [pCi/g]		
	low	average	high
Bottom Ash	1.6	3.5-4.6	7.7
Fly Ash	2	5.8	9.7

Geothermal Energy Waste Scales

Using geothermal energy, requires drilling deep holes (boreholes) and inserting pipes for pumping high-temperature fluids from the ground. The rocks that contain the high-temperature fluids may also contain minerals, which tend to form a scale inside the pipes and production equipment. If the rocks also contain radionuclides, such as radium, the mineral scale, production sludges, and waste water will contain TENORM.

Wastes	Radiation Level [pCi/g]		
	low	average	high
Geothermal Energy Waste Scales	10	132	254

Petroleum (Oil and Gas)

The rocks that contain oil and gas deposits often contain water as well. The water will dissolve minerals and radionuclides, such as radium, that are in the rocks. As a result, radium and its radioactive decay products become concentrated in production wastes. Wastes include: pipe scale that tends to form inside oil and gas production pipes and equipment, large volumes of waste water, and sludges that accumulate in tanks or pits.

Wastes	Radiation Level [pCi/g]		
	low	average	high
Produced Water [pCi/l]	0.1	NA	9,000
Pipe/Tank Scale	<0.25	<200	>100,000

Water and Waste Treatment Residues

Water Treatment

Since water comes from streams, lakes, reservoirs and aquifers, it contains varying levels of naturally occurring radioactivity derived from surrounding rocks and sediments. Wastes from municipal water treatment plants receiving this water may concentrate some amounts of this radioactivity, even if the treatment systems were not originally designed to remove it.

Wastes	Radiation Level [pCi/g]		
	low	average	high
Treatment Sludge [pCi/l]	1.3	11	11,686
Treatment Plant Filters		40,000	

Consumer Products Containing TENORM

Some TENORM may be found in certain consumer products. For example, zircon contains minute quantities of uranium and thorium, and is widely used as a glaze for ceramics and metal molds.

The EPA and others working on the problem have identified many sources of TENORM. Identifying sources and determining the potential risks from them remains a major focus of our work.