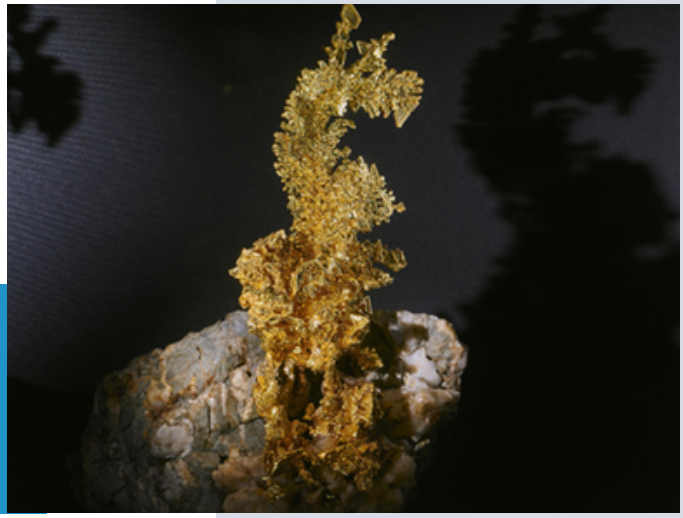
EarthDate

Gold is Abundant



This crystallized gold specimen, nicknamed the "Dragon," shows native gold in its natural form. It formed when hot, mineral-rich fluids moved through cracks in rock and gold slowly crystallized in open spaces, creating delicate wires and branching shapes. The Dragon is currently on display at the Natural History Museum in London on loan from the Houston Museum of Natural Science.

Credit: Courtesy of Houston Museum of Natural Science, Photographer Mike Rathke

Gold is rare. Except in one place on Earth that it's incredibly plentiful. But we'll probably never get to it. Over the course of human civilization, people have searched for gold. Still, we haven't found much – 220,000 tons across all those centuries. By comparison, we've mined seven times as much silver. And 3,000 times more copper.

But we now know there's much, much more gold on Earth.

When the planet formed, more than 4 billion years ago, many metals swirled together in Earth's molten magma, gold among them. Being heavy, it was pulled toward the center, into Earth's core, by the force of gravity. There it bonded with abundant iron. And there it has mostly stayed.

But Earth's interior is not static. The molten magma sometimes upwells toward the surface. Over millions of years these magma currents have carried small amounts of gold and other metals out of the core.

Earthquakes and shifting tectonic plates then brought that magma toward the surface. Some of it precipitated out in veins, which we have mined. And some of that eroded into rivers and streams, and we gathered it there too.
Because it's valued, and doesn't oxidize, most of the gold we've found over the years still exists in pure form and gold-rich alloys, and is still in use – in jewelry, art, electronics, even medicine.

It may be precious, but it's not scarce. It's just that Earth has limited our access.

I'm Scott Tinker.

SWITCH ENERGY ALLIANCE

Background: Gold is Abundant

Synopsis: Gold seems to be everywhere, but most of Earth's gold is locked deep in the core. The gold we mine exists only because rare geological processes concentrate tiny traces near the surface.

Gold Seems Everywhere

- When we think of gold, we picture gold jewelry, gold records, gold teeth, or gold coins. We might also picture the vast gold treasures found in ancient Egyptian tombs, or the gold that adorns royal palaces, crowns, and capitol domes.
- For centuries, gold has been a symbol of wealth, power, and prestige.
- But the amount of gold that Earth has made accessible near the surface is surprisingly small.

Gold shows up in more places than most people realize, from jewelry and coins to electronics, dentistry, space technology, architecture, and even food.

Credit: AI-generated image created with ChatGPT (OpenAI), 2026

How Much Gold Have Humans Used?

- It is estimated that humans have mined about 220,000 metric tons of gold, with nearly two-thirds of that mined since 1950.
- In comparison, about 1,740,000 metric tons of silver and roughly 700 million metric tons of copper have been mined.
- Most gold is used for jewelry or stored as bars with smaller amounts used for electronics and even medicine.
- Because gold is so resistant to corrosion, most of the gold ever mined still exists today, even if its shape and use have changed
- If all the mined gold were melted together, it would form a cube of just 22 meters (72 feet) on each side. That cube would include every bit of gold jewelry, coins, or wiring ever made.
- And it would be valued at today's prices of $4800/oz at about $37 trillion.

Where is Gold on Earth?

- Earth contains far more gold than we have ever mined, but most of it is trapped deep inside the planet.
- In a previous EarthDate, We Are Stardust, we learned how the atoms that formed Earth, including gold, were once part of stars that lived and died.
- Earth's early molten state caused heavy elements like iron, nickel, and gold to gravitate inward as the planet differentiated into layers.
- Because gold bonds strongly with iron, it sank with iron into the core as it formed.
- Earth's crust is only a thin skin, and nearly all the planet's gold lies far below it.
- Earth's gold is not evenly mixed through the planet like chocolate chips in a cookie. It is more like the heavy bits in a trail mix that end up at the bottom of the bag.

Gold on the Move

- Gold may be locked deep in Earth's core and mantle, but small amounts have still managed to reach the surface through geological and hydrothermal processes.
- Earth's interior is not static. It circulates rock through heated convection currents.
  - In some regions, hot mantle material rises in broad upwelling currents and feeds volcanism.
  - These deep-sourced magmas can carry tiny amounts of gold and other precious metals upward over millions of years.

Background: Gold is Abundant

This James Webb Space Telescope image shows the supernova remnant Cassiopeia A, the expanding debris from a massive star that exploded long ago. Explosions like this help create many of the heavy elements found on Earth, including the atoms that later became part of gold.

Credit: By ESA/Webb, CC BY 4.0, https://commons.wikimedia.org/w/index.php?curid=144217206

- But gold does not move easily through solid rock. To travel upward, it must become chemically mobile. Research suggests that sulfur plays a key role in this process.
  - Under extreme temperatures and pressures deep inside Earth, gold can bond with sulfur in ways that allow it to dissolve into molten rock and hot, mineral-rich fluids.
  - This chemistry helps gold hitch a ride upward through the mantle and into the crust instead of remaining locked in place.
- Essentially, heat helps move gold, but chemistry keeps it moving.
- A previous EarthDate episode, Gold from Earthquakes, explored how gold and other metals can be redistributed by seismic activity, offering another window into how precious metals move in Earth's outer layers.

Gold on Earth's Surface

- Even when gold reaches the crust, it is still scattered in tiny amounts.
- Gold only becomes useful to humans when it becomes concentrated. This happens when hot, mineral-rich fluids move through cracks and faults in the crust.
  - As these fluids cool or react with surrounding rocks, gold can drop out of solution and accumulate in veins.
  - Over time, erosion can break down these rocks and release gold into rivers and sediments, creating placer deposits that are even easier to access.
  - The appeal of these accessible deposits drove many gold rushes including those in the Canadian Klondike and California.
- Another magnificent example of this process can be found in the Witwatersrand Basin in South Africa.
  - Through hydrothermal and sedimentary processes, layers of sediment with high gold concentrations accumulated over time and compressed into hard rock formations.
  - The basin stretches for about 300 kilometers (186 miles) and humans have extracted roughly 40,000 tons of gold (nearly 20% of all gold mined to date) from the location.
- Today, gold is often found by interpreting geology, satellite imaging, and geochemistry. Scientists can also combine past and present exploration data using AI to help answer the question of where to dig.

Hidden Gold

- Gold seems common because we see it reused again and again.
- But Earth's accessible gold is rare because the planet locked most of it deep in the core early in its history.
- Gold is not rare because Earth lacks it. Gold is rare because Earth locked most of it away from human access… at least so far.

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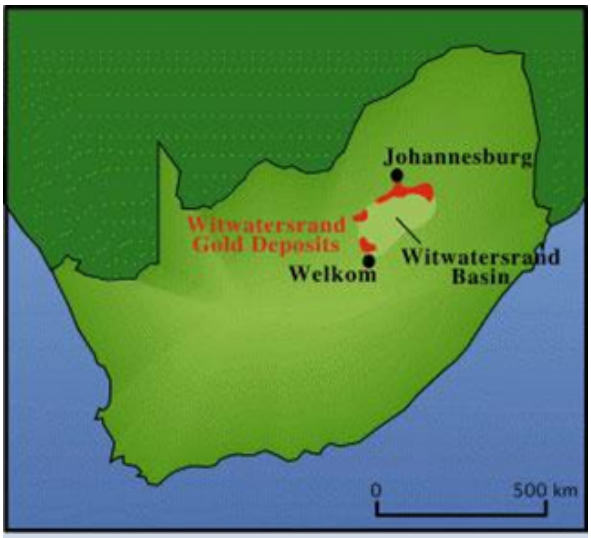
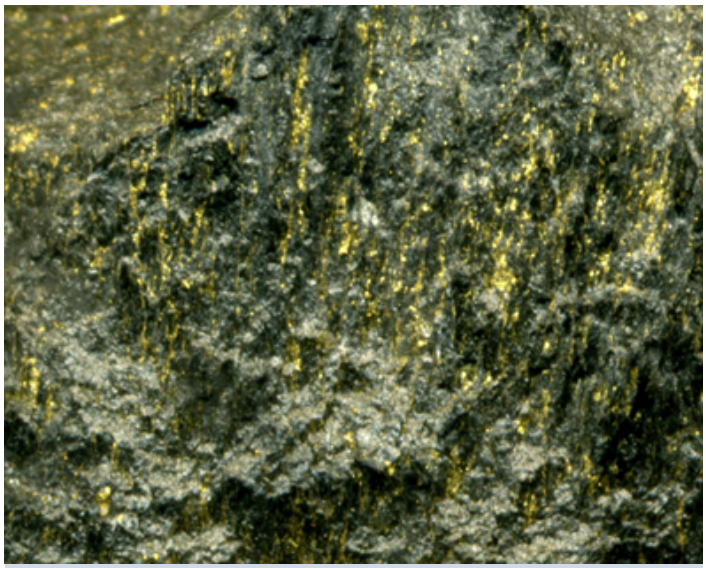


This map shows the location of the Witwatersrand Basin in South Africa, one of the most productive gold regions on Earth.

Credit: By Futura Sciences - http://www.futura-sciences.com/magazines/terre/infos/dossiers/d/geologie-or-magie-alchimistes-686/page/3/, CC0, https://commons.wikimedia.org/w/index.php?curid=33695648



This rock from South Africa's Witwatersrand Basin shows how gold can become concentrated in Earth's crust. Tiny grains of gold are trapped in dark, ancient sediment layers, along with a black mineral, uranite, that is naturally radioactive. Deposits like this are rare, and they help explain why most of the gold humans mine is found in only a few places on Earth.

Credit: By James St. John - Auriferous, uraninitic, hydrocarbon-rich stromatolite rock (Carbon Leader Gold Ore, South Africa) 4, CC BY 2.0, https://commons.wikimedia.org/w/index.php?curid=34347277

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Fact Sheet:
Episode **ED 490**