

Essential Minerals for the Green Revolution – 7 Gold

An essential mineral – or is it?

Ask pupils to suggest as many uses for gold as they can think of.

Then ask them to estimate the percentages of the world's consumption of gold in 2022 in each of the following categories (answers are given in *italics*): Jewellery, (47%); Gold bars, (17%); Central banks and other institutions, (20%); Official coins and medals and imitation coins, (9%); Electrical and electronics, (6%); Other, (1%). {USGS data, Jan 2023}.

Is gold really an essential metal? Ask pupils to discuss. (*Suggestions might include: Most of the world's gold is either worn by those who can afford it, or stowed away in underground vaults, like Fort Knox in the USA. Jewellery is also often kept in vaults for safety. So, a high proportion of the gold which is dug up is extracted from waste rock, often using polluting chemicals, only to be put back underground again. It is "essential" to international finance, but its practical uses, e.g. in electronics are relatively minor and play little part in advancing "green" technology. However, gold is used in mobile phones and pupils might have their own views about how essential such a use is! {but there is abundant gold existing in circulation or as by-products from existing base metal mines to cover this minor proportion of use}*).

What is gold? Gold is a chemical element (Au) with an atomic number of 79 and a very high relative density of about 19. It occurs in veins, known as "lodes" or 'reefs', which may be mined down to great depths.



Fig. 1. The Big Pit' at Kalgoorlie, Australia in 2005 (Brian Voon Yee Yap. This file is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported license)

The world's most productive such mine is the Muruntau Mine in Uzbekistan (2,000,000 ounces per year). Gold-bearing veins may become weathered and eroded, and the gold deposited along with sands in rivers and the sea. Such alluvial gold deposits are known as 'placers' and the gold may be found by panning, which anybody can do with a simple plastic gold-pan.



Fig. 2. Prospecting for gold in a British river (Photo: British Geological Survey P602712)

Gold also occurs along with copper ores such as at the vast Grasberg Copper Mine in Papua, Indonesia.

Gold is recycled wherever possible; e.g. in the USA, about 90 tonnes of scrap gold were recycled in 2022, representing about 36% of the country's reported consumption of gold that year (Source, USGS).

The table shows recycling rates for gold and metals of importance in the world's industries or commerce.

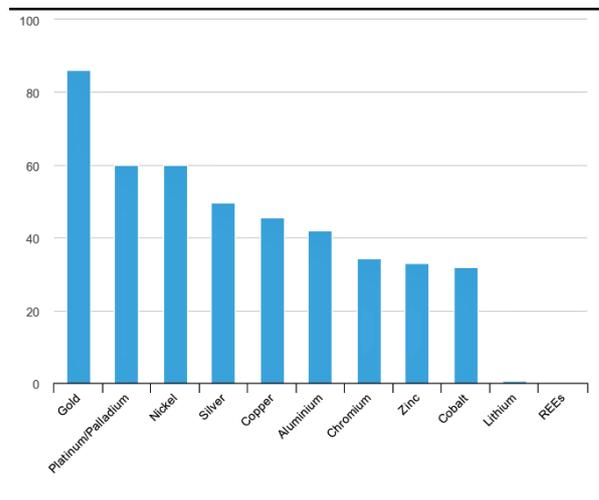


Fig. 3. Recycling rates for 11 named metals and the group of rare earth metals, 2022 (International Energy Agency) IEA 2023; End-of-life recycling rates for selected metals <https://www.iea.org/> License CC BY 4.0

Ask pupils to suggest why there are huge differences in the recycling rates of some of these metals. (*Gold, platinum, palladium, nickel and silver are all of high value and are expensive to produce from the ground, so they are worth the effort of recycling. Copper, aluminium, chromium, zinc and cobalt are major components of electrical equipment and motor vehicles, where scrappage schemes are often well established. Lithium and rare earth metals are of relatively recent introduction into industry, so equipment is not being scrapped yet and there is little to recycle. The technology for recycling of lithium and rare earths is in its infancy. The rare earths are used in small quantities in any one piece of equipment*

and their close relationship in the Periodic Table means that their properties are similar.

The ore from an average gold mine has about 1 gram of gold per tonne of ore. A typical wedding ring weighs about 4 grams. Approximately what weight of waste is left behind to produce enough gold for just one wedding ring? (*About 4 tonnes, but extra waste comes from the barren overburden rock too. For comparison, a builder's "jumbo" bag of sand weighs about 850kg.*)

Waste is one problem, but there are others. To extract the gold from the ore, chemicals such as potassium cyanide and mercury are frequently used. At well-controlled mines, safety measures can be taken, but about 20% of the world's gold is produced by small scale local miners, known as artisanal miners, often working illegally and with few controls.

Look at the pictures of artisanal mining in the Amazon Rain Forest and suggest the problems which it may cause. (See "Context" for suggested answers).



Fig: 4. An aerial view of the results of artisanal mining in the Amazon forests (www.amazonaid.org)



Fig: 5. Artisanal miners at work, separating gold ore from sediments in the Amazon forests (www.amazonaid.org)

Gold is referred to as a 'conflict mineral'. Why is this? In addition to the environmental issues above, the lure of gold attracts criminal elements, who exploit local indigenous populations by pushing them off their land, extorting money from them, or paying them far less than the gold is worth. Some gangs even kill the local people or members of rival gangs. For example, the United Nations estimated that about 66% of the gold mined in Columbia in South America in 2018 was mined illegally. Much of this was linked to drug gangs and guerrilla warfare. Even some large companies sometimes use unethical methods and pollute large areas with little concern for the people who live there.

Ask pupils if they can suggest anything which they, or their families could do, or how they might assist charities which are trying to help. (*Individuals may feel helpless against widespread misuse of people and environments in the production of gold. However, the journalist Simon Reeve, who has uncovered many bad practices across the world in his travels for TV, has set an example by checking that all the gold and gemstones for his wife's engagement ring were obtained through Fairtrade sources, to ensure that they were not contributing to human misery back along the supply train.*)

There are charities which work for improvement, which individuals can support, e.g. in 2018, the World Wide Fund for Nature called on the UK Government to ban the import of gold from Brazil, until it could be proven that it was not sourced from illegal and deforesting gold production. Amazon Aid works to encourage governments, the United Nations, companies, and individuals to work to reduce the negative impacts of destructive gold mining. Some important solutions include "raising awareness through environmental and health monitoring; promoting cleaner mining practices; formalising miners to bring operations under government control; designating protected areas and strengthening indigenous rights; creating alternative or diversified livelihoods; and increasing transparency and traceability in gold supply chains".

The Responsible Mining Foundation states that, "As a sector with large-scale and far-reaching potential, extractive industries can support the achievement of the UN Sustainable Development Goals."

The back up

Title: Essential Minerals for the Green Revolution – 7 Gold

Subtitle: An essential mineral – or is it?

Topic: Raising awareness of the main world uses of gold and the frequent abuses of human rights in some of the main gold producing countries

Age range of pupils: 12 years and above

Time needed to complete activity: 30 minutes, depending on the time spent in further research from on-line sources etc.

Pupil learning outcomes: Pupils can:

- state that, although the main uses of gold are in jewellery and bullion reserves, it is an

important component of some electronic equipment;

- evaluate different possible sources of gold;
- explain why recycling rates for gold are higher than for other metals;
- outline some of the human abuses and environmental degradation involved in gold mining, especially in artisanal mining.

Context: Harm may be caused to the natural and human environment in gold mining activity, both large and small scale, unless rigid safeguards are in place. Mechanised extraction as in Figure 1 creates a large carbon footprint. Damage is especially marked in artisanal mining. Problems suggested by Figures 4 and 5 include: deforestation, with consequently raised rates of erosion; reduction in carbon capture caused by the loss of vegetation; disturbance of the whole ecosystem; overuse of water in separating the gold ore; probable pollution of water by the use of chemicals such as cyanide and mercury to process the ore; appalling working conditions for the workforce; possible removal of indigenous people and destruction of their food sources; possible killing of local people to make way for the mining.

Following up the activity: Pupils could be asked to suggest how their own families could improve on recycling rates for their redundant appliances. Small groups could be asked to follow up some of the information contained in the websites listed below, or those of other charities or government agencies.

Underlying principles:

- Although not a “new mineral” for the Green Revolution, gold is an essential component of

electronic equipment used in communication devices and in the control of renewable energy sources.

- Unless controls are well-enforced, human rights may be abused and pollution of the environment may be caused by emissions or by unsafe disposal of chemicals used in the processes of extracting gold from its ores, collapse of tailings dams etc.
- Conflict frequently arises between mining companies or those in control of artisanal mining and the local population.

Thinking skill development: Establishing the worldwide demand for gold and the apparent need to extend the mining of it involves construction. Metacognition is involved when the plight of local communities involved in artisanal mining is discussed. Applying thinking to new contexts is a bridging skill.

Resource list:

- access to the table and images above

Useful links:

[Gold \(usgs.gov\)](https://www.usgs.gov)

[Gold Mining in the Amazon - Amazon Aid Foundation;](#)

[Responsible Mining Foundation - RMF](#)

Reeve, S. (2021) *Journeys to impossible places*, Hodder, ISBN 9781529364033.

Source: Written by Peter Kennett of the Earthlearningidea team. Thanks to Ben Lepley of SLR Consulting Ltd for advice.

Note: This activity was as accurate as possible in summer 2023

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Essential Minerals for the Green Revolution

Earthlearningidea has compiled a series of activities on the minerals which are essential if modern technology is to be able to reduce the World's carbon footprint. Some are regarded as "critical" minerals and many of them are relatively "new" in terms of needing to be exploited.

This table will be updated as fresh activities are added.

All titles begin with: Essential Minerals for the Green Revolution...

Mineral	Title
Lithium	1 Lithium: an element which is pulling more than its weight in the world
Copper	2 Copper: an element for which the demand is increasing rapidly
Rare Earths	3 Rare Earth Elements: vital components in modern technology
Graphite	4 Graphite: from a pencil to the electric car!
Cobalt	5 Cobalt: mined by children
Tin, Tungsten, Tantalum	6 "The Three Ts": Tin, Tungsten and Tantalum
Gold	7 Gold: an essential mineral - or is it?
Critical minerals	8 Critical Minerals: Essential mineral - critical mineral: what is the difference?