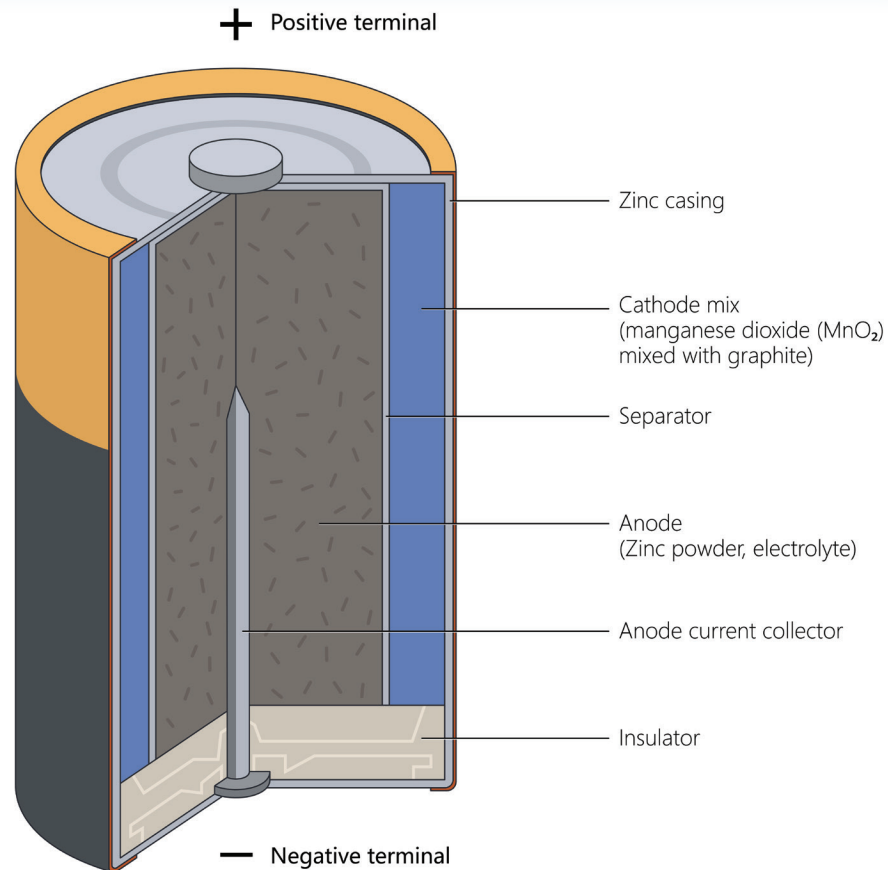


# Alkaline Battery

smoke detectors



remote controls

flashlights

# Lead-Acid Battery

vehicles

backup power  
sources

energy storage

boats

Positive terminal

Negative terminal

Dilute sulfuric acid

Negative electrode plate  
lead hardened with antimony

Positive electrode plate  
lead dioxide

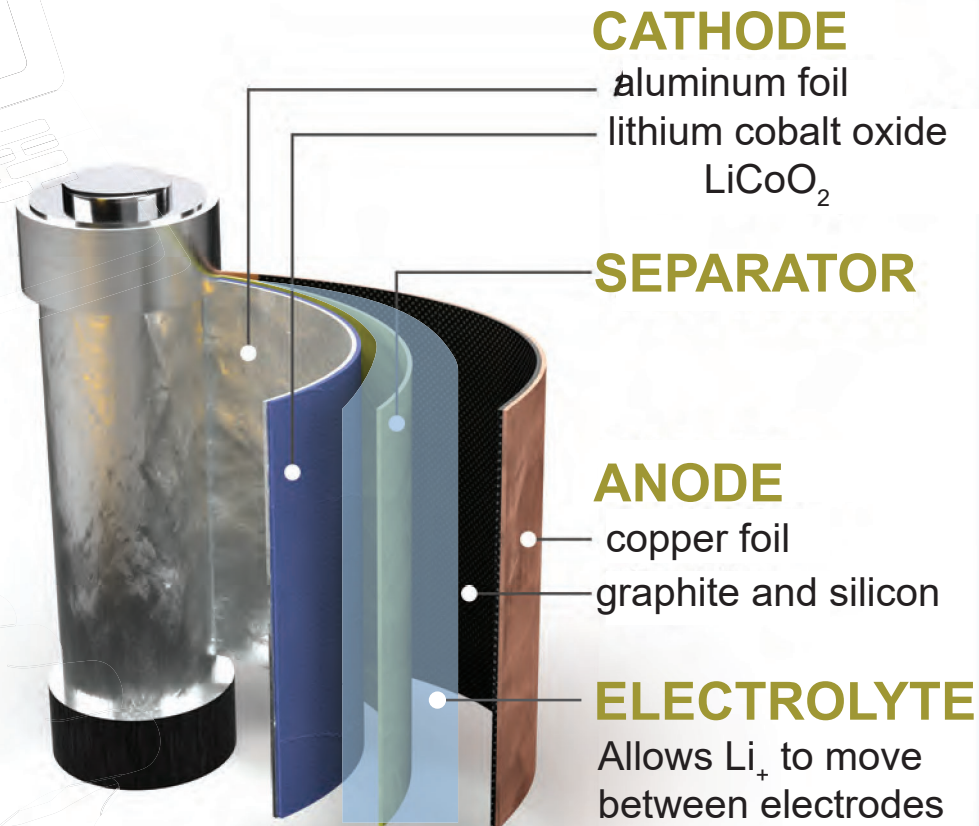
# Lithium-Ion Battery

**laptop computer**

**smartwatch**

**cell phone**

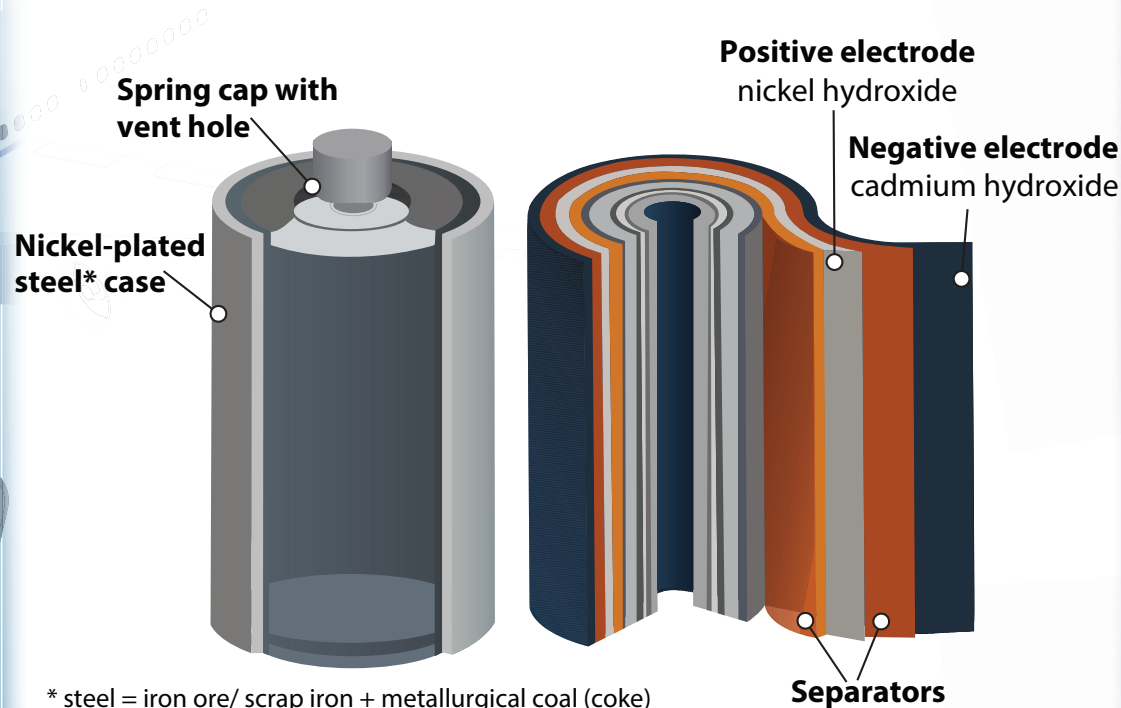
**wind turbines**



# Nickel-Cadmium Battery

**aerospace  
engine start +  
backup power**

**emergency  
lighting**



\* steel = iron ore/ scrap iron + metallurgical coal (coke)  
+ limestone + alloy elements like manganese, chromium,  
nickel, or molybdenum to give the steel certain properties

**remote control  
cars**

**defibrillators**

# Systems-Deposits-Mineral Commodity Table

Table modified from Hofstra and Kreiner (2020) showing mineral commodities associated with types of deposits that can occur in a mineral system. Note that most commodities are associated with more than one system. The description explains the geologic setting that can host different types of mineral deposits formed in the same environments. Ag, silver; Al, aluminum; As, arsenic; Au, gold; B, boron; Ba, barium; Be, beryllium; Bi, bismuth; Br, bromine; Ca, calcium; Cd, cadmium; Co, cobalt; Cs, cesium; Cr, chromium; Cu, copper; F, fluorine; Fe, iron; Ga, gallium; Ge, germanium; Hf, hafnium; Hg, mercury; I, iodine; IOA, iron oxide apatite; IOCG, iron oxide copper gold; In, indium; K, potassium; Li, lithium; Mg, magnesium; Mn, manganese; Mo, molybdenum; Na, sodium; Nb, niobium; Ni, nickel; P, phosphorus; Pb, lead; PGE, platinum group elements; Rb, rubidium; Re, rhenium; REE, rare earth elements; Sb, antimony; Sc, scandium; Se, selenium; Sn, tin; Sr, strontium; Ta, tantalum; Te, tellurium; Th, thorium; Ti, titanium; Tl, thallium; U, uranium; V, vanadium; W, tungsten; Y, yttrium; Zn, zinc; Zr, zirconium. Aluminum (Al) mainly occurs as clay minerals, alunite, or bauxite. Barium (Ba) occurs as the mineral barite. Fluorine (F) occurs as the mineral fluorite (fluorspar). Mineral commodities are grouped by those that are associated in a deposit type so there may be repeat of listed commodities per system.

| Mineral System Name | System Description                                                                                                                                                                                                      | Mineral Commodities                                                                                                                                        |
|---------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Alkalic porphyry    | Beneath oceanic or continental volcanoes, where hot fluids related to magmas rich in sodium or potassium moved upward and outward, split into liquid and vapor, mixed with groundwater, and reacted with existing rock. | Bi, Mo<br>W<br>Ag, Au, Cu, Mo, Pb, Zn<br>Al, potash<br>Ag, Au<br>Clay (kaolin)<br>±As, Bi, Ga, Ge, In, Mn, PGE, Sb, V                                      |
| Arsenide            | In continental rifts, where fluids from metamorphic rocks deep below the ground ascended to shallower levels.                                                                                                           | Ag, As, Bi, Co, Ni, Sb, U                                                                                                                                  |
| Basin brine path    | Where water flowed from shallow ocean basins with high evaporation rates downwards outwards into permeable rock layers.                                                                                                 | Ag, Co, Cu, Pb, Zn±Ga, Ge, In, PGE, Re, U, V<br>Br, Cs, I, Li, potash, Mg, salts, Sr, Rb, Zn<br>Co, Cu, Mo, Re, REE, Sc, Se, U, V<br>Barite<br>Sr minerals |
| Carlin-type         | Where water from precipitation mixes with fluids from deeply buried igneous rocks.                                                                                                                                      | Ag, As, Au, Hg, Sb, Tl                                                                                                                                     |

| Mineral System Name                    | System Description                                                                                                                                                 | Mineral Commodities                                                                                                 |
|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| Chemical Weathering                    | Areas that had enough rainfall to chemically dissolve and concentrate elements.                                                                                    | Al (bauxite)<br>Clay (kaolin)<br>Ni, Co<br>Nb, REE<br>U<br>Mn<br>Ag, Au<br>Cu<br>Fe<br>Ag, Pb, Zn<br>PGE            |
| Climax-type                            | In continental rifts were silica-rich and silica-poor magmas release hot fluids that move upward and outward, mix with groundwater, and react with existing rocks. | Be, fluorspar, Nb, Sc, Ta, Y<br>Mo, Sn, W<br>Ag, Au, Cu, Pb, Zn<br>U<br>Sn<br>Clay (kaolin)<br>Al (alunite, potash) |
| Coeur d'Alene-type                     | In places where uplift of buried sedimentary rocks caused release of hot fluids that chemically altered the rocks they flowed through.                             | Ag, Co, Cu, Ga, Ge, In, Pb, Sb, U, Zn                                                                               |
| Hybrid magmatic REE / basin brine path | Where hot gases from magma, containing carbon dioxide and hydrofluoric acids, cooled down and mixed with deep, salty groundwater that replaces carbonate rocks.    | Be, fluorspar, Nb, REE, Ti                                                                                          |
| IOA-IOCG                               | Where brines and fluids in magmatic provinces react with hot rocks to form iron oxide-rich mineral assemblages.                                                    | U<br>Fe<br>Mn<br>Au, Co, Cu, Se, U<br>Fe, P<br>Ag, Au±As, Bi, Co, Cu, Ga, Ge, In, Mo, Ni, Pb, Re, Sb, Te, Zn        |
| Lacustrine evaporite                   | Drainage basins with no outlet (that don't reach the ocean) that occur in dry or very dry climates, where elements in lake water were concentrated by evaporation. | B, borate, carnallite, Cs, gypsum, Li, magnesite, Mg, Mn, nitrate, potash, Rb, salt, soda ash, W, zeolite           |
| Mafic magmatic                         | Large areas of igneous rocks related to magmas from earth's mantle or from meteorite impacts.                                                                      | Ag, Au, Co, Cr, Fe, Ni, P, PGE, REE, Se, Te, Ti, V                                                                  |

| Mineral System Name | System Description                                                                                                                                                    | Mineral Commodities                                                                                                                                                               |
|---------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Magmatic REE        | In continental rifts or along deep faults where magmas from the mantle released hot fluids to deposit rare earth elements in adjacent rocks.                          | REE, P<br>Ba, Cu, fluorspar, Nb, P, REE, Sr, Ta, Th, U, Y                                                                                                                         |
| Marine chemocline   | In an ocean, where deep salty groundwater flowed into and chemically interacted with oceanwater, leading to an increase in bioproductivity and deposition of metals.  | Au, coal, Mo, Ni, PGE, V<br>phosphate (phosphate rock)<br>Co, Fe, Mn                                                                                                              |
| Marine evaporite    | Shallow oceans in dry or very dry climates, where elements in seawater were concentrated by evaporation.                                                              | Mg<br>Potash<br>Gypsum<br>Salt                                                                                                                                                    |
| Metamorphic         | Rocks containing organic carbon, rare earth element phosphate minerals or uranium minerals that were placed under heat and pressure.                                  | Graphite<br>Mg<br>REE, Th, U, Y                                                                                                                                                   |
| Meteoric convection | Hot water, sulfur-poor systems that form at shallow levels in volcanic arcs.                                                                                          | Ag, Au, Hg, Sb, Te                                                                                                                                                                |
| Meteoric recharge   | Where oxidized water from precipitation displaced older water in underground sandstone aquifers.                                                                      | Co, Mn, PGE, REE, Sc, U, V±Re<br>U<br>Mg                                                                                                                                          |
| Orogenic            | In places where old volcanic and sedimentary rocks were geologically "squeezed", forcing hot fluids to escape that chemically altered the rock they flowed through.   | Ag, Au, Sb, W<br>Hg, Sb<br>Graphite                                                                                                                                               |
| Placer              | Drainage basins and along shorelines, where water once flowed due to gravity, tides or wind-driven wave action.                                                       | Au, barite, Fe, fluorite, gems (includes Ti, REE, Zr, Hf and other minerals that accumulate in modern or ancient beach sands), Hf, Mn, Nb, PGE, REE, Sc, Sn, Ta, Ti, Th, U, W, Zr |
| Porphyry Cu-Mo-Au   | Below oceanic or continental volcanoes where hot fluids move upward and outward, split into liquid and vapor, mix with groundwater, and react with surrounding rocks. | Ag, Au, Cu, Mo, PGE, Re, Sc, Te, U<br>Mo, Sn, W<br>Hg, Sb<br>Clay (kaolin)<br>Mn<br>Mg<br>Al (alunite), potash                                                                    |

| Mineral System Name       | System Description                                                                                                          | Mineral Commodities                                                                                |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| Porphyry Sn               | In back-arc settings where granites formed from melted sedimentary rocks release hot fluids that react with existing rocks. | Cs, Ta<br>Be, Sn, W<br>Ag, Au<br>Ag, Au, Cu, Pb, Zn<br>Clay (kaolin)<br>Al (alunite), potash       |
| Reduced intrusion-related | Continental magmatic arcs where magmas interacted with carbon- and pyrite-rich sedimentary rocks.                           | Ag, Au<br>Ag, Au, Cu, Mo, Pb, W, Zn<br>Sb<br>Graphite                                              |
| Volcanogenic seafloor     | Near submarine volcanoes, where hot volcanic fluids mixed with cool oxygenated seawater.                                    | Ag±Co, Au, Bi, Cu, Ga, Ge, In,<br>Pb, Sb, Sn, Zn<br>Barite<br>Fe<br>Fe, Ge, Mn, Ni±Co, REE, Sc, Te |

#### References Cited

Hofstra, A.H., and Kreiner, D.C., 2020, Systems-Deposits-Commodities-Critical Minerals Table for the Earth Mapping Resources Initiative (ver. 1.1, May 2021): U.S. Geological Survey Open-File Report 2020–1042, 26 p., <https://doi.org/10.3133/ofr20201042>.



