September 8, 2025

News and notes

Canada Geese (*Branta canadensis*) on Crescent Lake, September 3, 2025

This week, before going on to discuss the geology of Rare Earth Minerals, we will first look at some news items I thought were interesting.

Comments

If anyone has comments on any of my postings, please leave a comment on the Linkedin page for the posting or email me at raymondreichelt@gmail.com.

Geopolitics

- Mapping The Passport Power Of Major Nations In 2025.
- India Vows to Keep Buying Russian Crude Oil.
- Russia's Gazprom Signs Deal with China to Build the Power of Siberia 2 Pipeline; geopolitical analysis here.
- Geopolitics and mining: Miners: The US Push-Back.

Research and News

- Intermediate Water Sources and Sediment Provenance in the High-Latitude South Pacific Ocean (Campbell Plateau) During the Paleogene.
- Signals of the paleo-Kuroshio Current: The Pleistocene Chinen Formation, Okinawa Island, south-west Japan.

- Ages of boulder armored benches document varying Fremont River tributary incision rates, Teasdale-Torrey lowlands, Utah, USA.
- Formation of breccia pipes associated with a hydrogen-rich hydrothermal system on the east Caroline plate in the West Pacific; Phys.org summary here.
- Detecting and preserving biosignatures in sulfate minerals prone to instability.
- Determination of Fluorine Concentration in Topaz Using Raman Spectroscopy.
- Constraining Earth's core composition from inner core nucleation; Phys.org summary here.
- Making a reef: Caught in the act: calcareous algae creating undescribed morphologies of mesophotic algal reef.
- British Geological Survey: New seabed sediment maps reveal what lies beneath the waves.
- Geochemistry: $Fe(II)_{aq}$-induced transformation of Fe-rich precipitates from a hydrothermal field.
- Dynamic deep marine oxygenation during the Early and Middle Paleozoic; Phys.org summary here.
- Multi-method geochronology and isotope geochemistry of carbonatites in the Aileron Province, central Australia.
- Planetary geology: Long-term and multi-stage ice accumulation in the martian mid-latitudes during the Amazonian.
- Carbonatite geology: Baddeleyite containing ordered srilankite (ZrTi2O6) from Eppawala, Sri Lanka.
- The Magnetic Fingerprint of Pulsed Granite Magma Emplacement and Alteration: Slaufrudalur Pluton, Iceland.
- Uranium Addition and Loss in Serpentinites: The Potential Role of Iron Oxides.
- Pulsed biogenic methane emissions coupled with episodic warming during the Toarcian Oceanic Anoxic Event; Phys.org summary here.
- Subaerial oxidative uranium mobilization at the culmination of the Great Oxidation Event.
- Alluvial geology: Hothouse Hydrology: Evolving River Dynamics in the Eocene Montllobat and Castissent Formations, Southern Pyrenees.
- Disentangling Partial Melting and Crustal Recycling Signatures in Ocean Island Basalts With Multivariate Statistics.
- Ferrimagnetic Structure of 3C Pyrrhotite (Fe_7S_8) From Neutron Diffraction.
- USGS Unveils New National Geologic Map.

- US. Department of the Interior Releases Draft 2025 List of Critical Minerals.
- Canada Geological Map Compilation.

Plate Tectonics

- True and Apparent Polar Wander From Sluggish to Active Lid Tectonics.
- Resolving Crustal and Subcrustal Dynamic Sources in Continental Arc Magmas: The Cenozoic Andean Arc of Central Chile.
- Thermo-Mechanical Rift Evolution of Large Igneous Province Crust.
- Transfer of Strontium and Carbon From Subducting Sediment Into the Leading Edge of the Mantle Wedge.
- All Aligned on the Western Front of North America? Analyzing the Stress Field in the Northern Cordillera.
- Spatiotemporal evolution of a newly recognized Late Cretaceous fold-and-thrust belt in the western slope of southern Peru: Evidence for selective inversion and hybrid thick- and thin-skinned shortening.
- Crust and uppermost mantle structure beneath the Kinki district, Japan: Relationship to isolated deep low-frequency earthquakes.
- The Transition to Tectonic Control of Magmatism in the East African Rift System—The 20 Ma Samburu Event.
- Deep-Focus Earthquakes Under Northeast China—An Imprint of the Complex Tectonic History of Pacific Plate Subduction.
- The Galápagos Islands: Scientific Insights from the Core-Mantle Boundary to the Atmosphere.

Paleontology

- Geochemistry and paleontology: Lithium isotopes in Palaeozoic stem-tetrapod bioapatite: Preservation, controls, ecology and oceanographic insights.
- New Paleogene records of cartilaginous fishes (Chondrichthyes) from central Chile, including the oldest lamnid diversity from the southeastern Pacific.
- Ancient host-associated microbes obtained from mammoth remains.
- A New Eusauropod Dinosaur from the Lower and Middle Jurassic Wangmen Formation of Ningming County, Guangxi, South China; SciNews summary here.
- A new large hypercarnivorous crocodyliform from the Maastrichtian of Southern Patagonia, Argentina.

Mining and Energy

- Ancient rocks in Australia reveal one of world's most promising new niobium deposits – report.
- Geophysics and petroleum exploration: High Impedance Mudstone Associated With Sand Injection Complexes: Significance for Basin-Scale Fluid Retention and Escape.
- Gold: 'Exciting day' at Goose Lake as Nunavut's fourth mine begins production.
- Saskatchewan's bold move to keep the coal-fired power plants operating past 2030.
- Lithium processing from pegmatite ore: The effect and implication of impurities on the calcination of α spodumene for lithium extraction.
- Infographic: Who controls uranium?
- Alberta Boasts Record-High Oil Production.
- 09/02 Ten counties in the Permian Basin account for 93% of U.S. oil production growth since 2020.
- Mapped: Europe's Crude Oil Imports by Country in 2024.
- Energy firm reveals plans to build 18 next-gen nuclear reactors around globe: 'Delivering energy security'.
- Exploration technique: Soil Geochemistry Toward Lithium Pegmatite Exploration: Building a Machine-Learning Predictive Algorithm via Portable X-Ray Fluorescence.
- Ore deposit geology: Lithium in the Eastern Brazilian Pegmatite Province: A Synthesis Highlighting Spodumene-Rich Deposits.
- Poland to build Europe's first of its kind small-scale nuclear power plant in Włocławek.

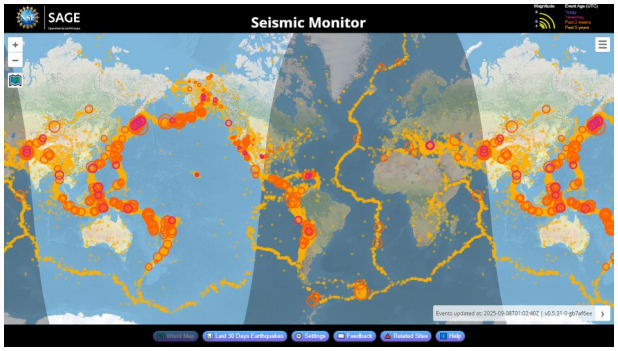
Environmental Geology and Hydrogeology

- Scientists Discover Mysterious Freshwater Reservoir Beneath the Ocean Floor. How Did It Get There?
- Repurposing polyethylene terephthalate plastic waste to capture carbon dioxide; Phys.org summary here.
- A prudent planetary limit for geologic carbon storage.
- Abandoned Queensland coal borehole found to be emitting 10,000 cars' worth of greenhouse gas.
- Improved plastics recycling: Stable single-site organonickel catalyst preferentially hydrogenolyses branched polyolefin C–C bonds; Phys.org summary here.
- A Chinese mining company is accused of covering up the extent of a major toxic spill in Zambia.

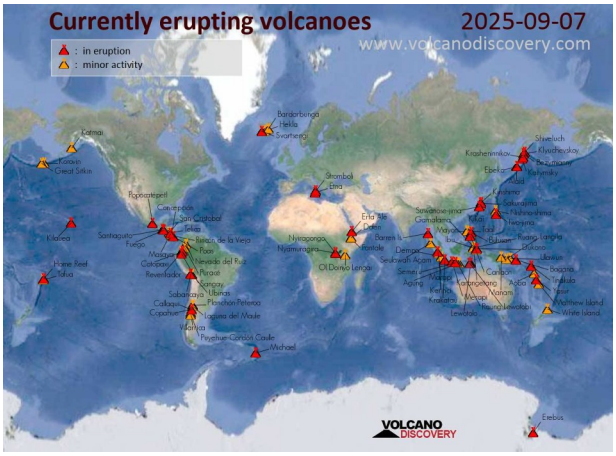
Glaciers and Climate Change

- Alaska DOT drone team livestreamed Juneau's glacial outburst flood to emergency managers.
- Unexpected decline in the ocean carbon sink under record-high sea surface temperatures in 2023; Columbia Climate School summary here.

Volcanoes, Earthquakes and Geohazards



Seismic Monitor



Active Volcano Map

Volcanoes

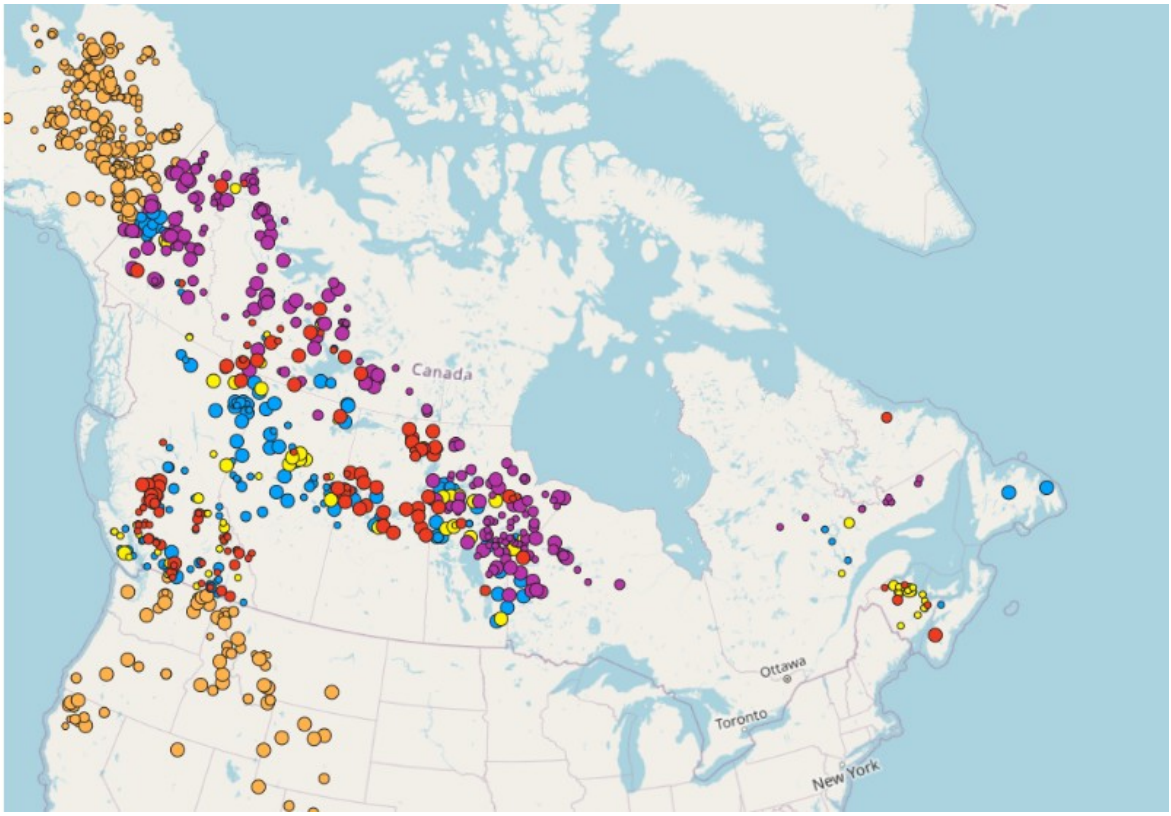
- Smithsonian / USGS Weekly Volcanic Activity Report.
- United States Geological Survey (USGS) Volcano Observatories:
  - Cascades Volcano Observatory Weekly Update.
  - Volcano Watch – Dick Fiske, one of HVO's very best.
  - Yellowstone Caldera Chronicles: Modernizing geologic mapping in Yellowstone: The role of geodatabases in the field.

Earthquakes

- Euro-Mediterranean Seismological Centre (EMSC).
- Earthquakes Monitoring Live Worldwide.
- Seismic swarm rattles northern Nevada; USGS summary for largest earthquake here.
- A clearer view of the current phase of unrest at Campi Flegrei caldera; Phys.org summary here.
- Research: A Scientific Vision and Roadmap for Earthquake Rupture Forecast Developments, A USGS Perspective.

- Deadly M6 earthquake strikes northeastern Afghanistan; EMSC summary here; there are plenty of aftershocks recorded.
- We drilled deep under the sea to learn more about mega-earthquakes and tsunamis.

Wildfires and Other Geohazards



Interactive Wildfire Map September 7, 2025
Credit: ©Canadian Wildland Fire Information System

- California: Razor Fire reported in Siskiyou County on Sep. 7.
- Canada's terrible, no good, very bad wildfire season isn't over yet, as BC ignites.
- Landslide: At least 1,000 dead after landslide in Sudan's Darfur wipes out village.
- Erosion: Mapping urban gullies in the Democratic Republic of the Congo; Phys.org summary here.

Free Geology Books and Other Stuff

Free geology books can be downloaded from these sites:

- OreZone Readers and Experts Telegram Channel; the Ore Zone channel also shows employment opportunities for geologists.

- The Groundwater Project has many groundwater geology books for free download; also they now have a Free Online Learning Module: Pumping Test Analysis; new book Modern Subsurface Contaminant Hydrology.
- Free Groundwater Modeling Course – HydroGeoCenter.
- From Western Australia: Carbonatite, lamprophyre and host rocks in the northern Aileron Province.
- Two volumes of Geology of Indonesia now can be accessed for FREE/GRATIS. The books can be accessed from: vol 1 https://lnkd.in/eH6Gcka4; vol 2 https://lnkd.in/egTYmpjk.
- Brett Davis' book on veins in a deforming rock mass: "The Veining Bible"; also at this site.
- From the Mineralogical Society of America: Handbook of Mineralogy.

Upcoming Events

- The 52nd Congress of the International Association of Hydrogeologists,15-19 September 2025, Melbourne Australia.
- GeoManitoba 2025 78th Annual Canadian Geotechnical Society Conference & 9th Canadian Permafrost Conference, RBC Convention Centre, Winnipeg, Manitoba, September 21 – 24, 2025.
- 29 September – 1 October 2025, Stuttgart, Germany, Nature Conference on Advancing Perovskite-Based Photovoltaics.
- Thursday 2nd October 2025, Early Career Hydrogeology Conference 2025, Leeds U.K.
- Australia: 12–18 October 2025, Earth Science Week.
- November 3 – 4, 2025 Central Canada Mineral Exploration Convention 2025 Victoria Inn Hotel & Convention Centre, 1808 Wellington Avenue, Winnipeg, Manitoba R3H 0G3, Canada, Early Bird pricing is in effect until midnight October 1.
- 5th International Professional Geology Conference (IPGC), November 5 to 7, 2025, Zaragoza, Spain.
- Saskatchewan Geological Open House, December 1 to 3, 2025, Delta Bessborough Hotel, Saskatoon; Registration for the 2025 Conference now open.
- Groundwater Week 2025, December 9-11, 2025 in New Orleans.
- 2025 Society of Petroleum Engineers Distinguished Lecturer Schedule.
- List of geoscience events in 2025 from the International Union of Geological Sciences.
- American Geophysical Union List of Upcoming Meetings.
- The Geological Society: Events & Courses.
- "Geology Hour" Online, evenings on the 3rd Monday of the Month from the Geological Society of the Oregon Country.

September 8, 2025

Rare Earth Elements – Part 2

Introduction

Figure 1 – Mountain Pass Rare Earth Mine & Processing Facility, California
Credit: Tmy350, Creative Commons Attribution-Share Alike 4.0 International license

In last week's posting, we looked at the 15 elements in the Lanthanide Series plus Scandium and Yttrium that are commonly called the Rare Earth Elements (REE). This week we'll look at the geology of the minerals and rocks that contain REE.

Minerals that Contain REE

The main economic sources of REE are the minerals bastnaesite, monazite, and loparite and the lateritic ion-adsorption clays. However, around 160 minerals contain REE, some sources say as much as 250, this site claims to be a definitive list. Here are a few of the more common minerals containing REE, arranged by mineral type:

Carbonate Minerals

- Bastnaesite – (Ce/Nd/Y/REE)(CO_3)F, most commonly found in metamorphic rocks and pegmatites.

- Parisite-(Ce) $CaCe_2(CO_3)_3F_2$ and Parisite-(La) $CaLa_2(CO_3)_3F_2$ – originally associated with emerald in a bituminous limestone.

- Synchysite – $Ca(Ce/Nd/Y/REE)(CO_3)_2F$, is found in REE bearing pegmatites and as a hydrothermal mineral in granite, alkali syenite and carbonatite.

Halite and Fluoride Minerals

- Fluocerite – $(La,Ce)F_3$, first described in 1845 from hydrothermal veins in granite in Sweden, also found in pegmatites.
- Fluorite – CaF_2, found hydrothermal veins, in some greisens, granites, pegmatites and high-temperature veins, and as a component of some marbles and other metamorphic rocks.

Oxide Minerals

- Aeschynite-(Ce) $Ce(TiNb)O_6$, and Aeschynite-(Y) $Y(TiNb)O_6$ – found in nepheline syenite rocks
- Euxenite – $(Y,Ca,Ce,U,Th)(Nb,Ta,Ti)_2O_6$, found in granite pegmatites and detrital black sands.
- Fergusonite – $REENbO_4$, found in magnesian skarn around carbonatite derived dolomitic marble.
- Loparite-(Ce) – $(Na,REE)_2Ti_2O_6$ in nepheline syenite, in pegmatites, and in carbonatites where it replaces perovskite.
- Samarskite – $YFe_3+Nb_2O_8$, occurs in REE bearing granite pegmatites.

Phosphate Minerals

- Apatite – $Ca_5(PO4)_3(Cl/F/OH)$, frequently found within hydrothermal crystals in pegmatites and also as nodular concretions in clays and shales.
- Brockite - $(Ca,Th,Ce)PO_4 \cdot H_2O$, occurs in granite and granite pegmatite.
- Monazite – $REE(PO_4)$, found in pegmatites and especially in in alluvial sands originating in the weathering of pegmatites.
- Wakefieldite – found in pegmatites
- Xenotime – YPO_4, found in pegmatites, as well as in gneisses rich in mica and quartz.

Silicate Minerals

- Allanite – $(Ce,Ca,Y,La)_2(Al,Fe^{+3})_3(SiO_4)_3(OH)$, found in granite pegmatites, granite, granodiorite, carbonatites, alkaline rocks, and alkaline pegmatites.
- Britholite – $(REE,Ca)_5[(Si,P)O_4]_3X$ where $X = F^-$, $(OH)^-$, Cl^-, first found in in a nepheline syenite pegmatite, also found in syenite gneiss complexes.
- Cerite – $(Ce,La,Ca)_9(Mg,Fe^{3+})(SiO_4)_6(SiO_3OH)(OH)_3$, found in carbonatites and in other deposits associated with REE.
- Dollaseite-(Ce) – $(CaCe)(MgAlMg)F[Si2O_7][SiO_4](OH)$, can generally be found as dark brown crystals in mineralized dolomite-tremolite rocks as well as in rocks containing fluorite and phlogopite.
- Gadolinite – $(Ce,La,Nd,Y)_2FeBe_2Si_2O_{10}$, found in syenite pegmatite veins.

- Stillwellite – $(Ce,La,Ca)BSiO_5$, can be found as a replacement mineral of metamorphosed calcium-rich sediments and in alkalic pegmatites in syenite.
- Thortveitite – Sc_2Si_2O7, found in in granitic pegmatites.
- Titanite – $CaTi(SiO_4)O$, also called sphene, occurs as an accessory mineral in igneous rocks; in schists, gneisses and other metamorphic rocks, and is also found as a detrital mineral in some sedimentary deposits.
- Zircon – $Zr(SiO_4)$, occurs widely in igneous metamorphic rocks as well as in sediments derived from those rocks.

Geological Environments for REE

As you can see from even this short list of REE minerals, these minerals occur in many geological environments. However, we can group these environments into three main categories: magmatic rare earth deposits, metamorphic rare earth deposits, and sedimentary rare earth deposits. Let's take a closer at these categories.

Figure 2 – Pegmatitic Peralkaline Nepheline Syenite, Khibina Massif, Kola Peninsula, Russia
Credit: James St. John, Creative Commons Attribution 2.0 Generic license

Magmatic rare earth deposits can be found in a variety of igneous rocks. General categories of magmatic rare earth deposits include: peralkaline igneous rocks, carbonatites, and pegmatites. They can also be found associated with iron oxide copper-gold deposits and porphyry molybdenum deposits.

Figure 3 – Former Mary Kathleen Mine, Queensland, Australia, a Skarn Deposit
Credit: Geomartin, Creative Commons Attribution 3.0 Unported license.

Metamorphic rare earth deposits mainly consist of two kinds of occurrences: in migmatized gneiss and in uranium-rare earth elements skarn.

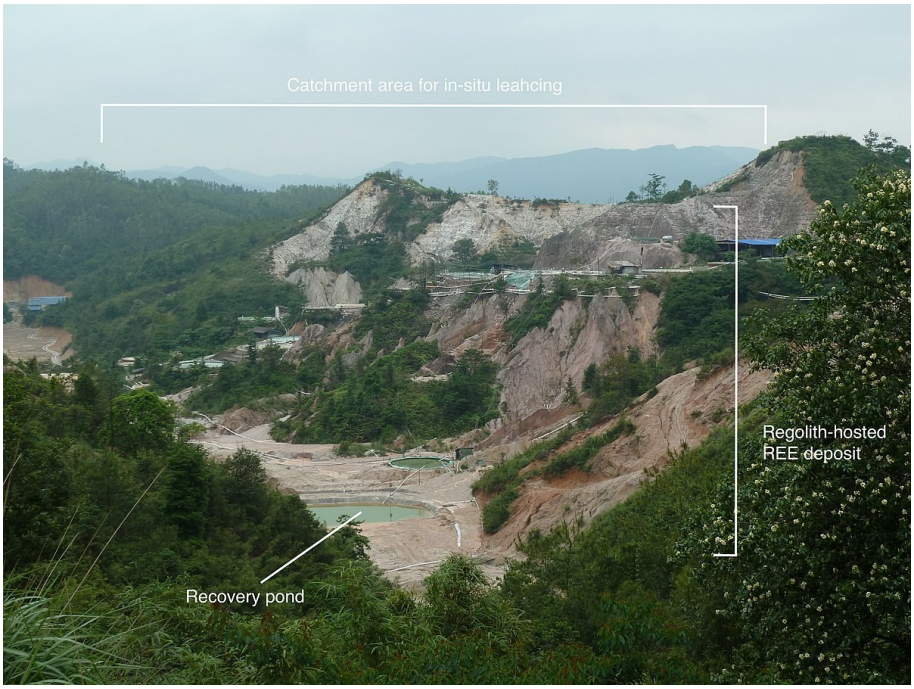


Figure 4 – Regolith Hosted REE Deposit, China
Credit: Kevnmh, Creative Commons Attribution-Share Alike 4.0 International license

Sedimentary rare earth deposits are associated with erosion from magmatic rare earth deposits, metamorphic rare earth deposits and the accumulation of REE in sediments sourced from a wide range of

localities. Many of these are regolith hosted deposits. These deposits include: stratiform phosphate deposits, carbonatite-associated sediments, granite-associated laterites, and bauxite. REE can also be found in placer deposits made up of material eroded off of bedrock, these include both current placer deposits and ancient paleoplacer deposits. Another important type of sedimentary deposit containing REE are ion absorbing clays found in China and Madagascar. There have also been investigations into obtaining REE from coal deposits and fly ash, as well as from from mine tailings.

World-wide Occurrence of REE

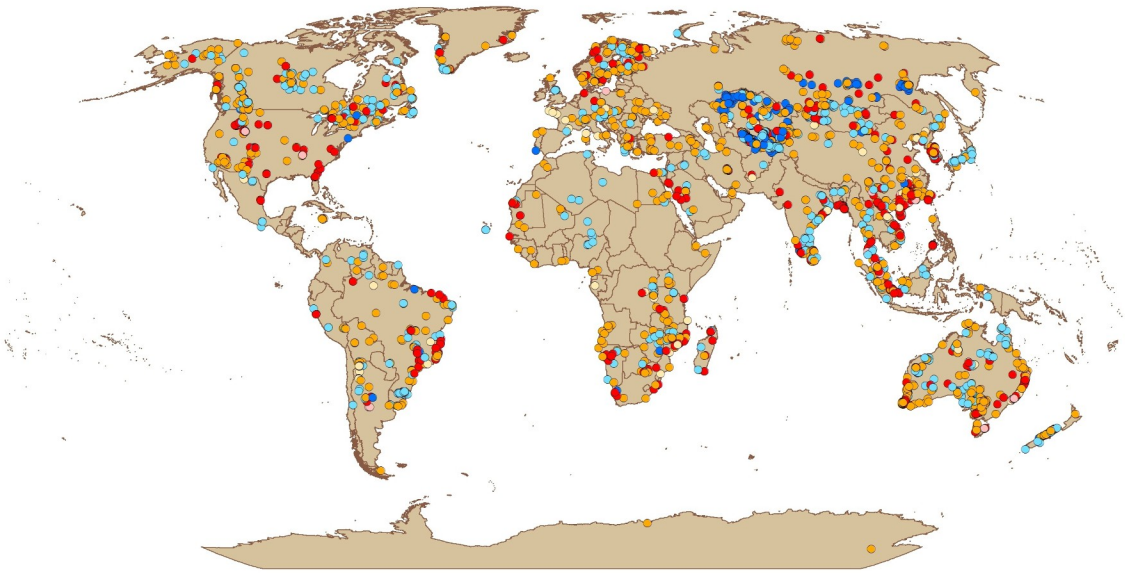


Figure 5 – Global Occurrence of REE
Credit: USGS Global Rare Earth Element Occurrence Database, public domain

Figure 5, shows the world-wide occurrence of REE and if you want to dig into the associated data points on the map, check out the accompanying spreadsheets and text in the USGS Global Rare Earth Element Occurrence Database. For those with less patience, here a brief summary of where REE are found in the world:

China is the largest REE producer with commercial deposits at the Bayan Obo Mining District in Inner Mongolia. Other REE deposits are located in Jiangxi, Guangdong, and Sichuan provinces.

The United States is seeking to further develop REE deposits at Mountain Pass, California, which was once the world's leading producer, and other potential REE deposits in Alaska, Wyoming, and Missouri.

Australia is a significant producer of REE from Mount Weld in Western Australia.

Brazil has known REE carbonatite deposits at Araxá and Catalão.

India has monazite sands along the coast that contain REEs.

Vietnam, the Dong Pao mine, located in the northern region, is known for its REE deposits.

Russia has known REE deposits in the Kola Peninsula and other regions.

Canada, exploration and development projects for REE are underway in several provinces, including Quebec and Saskatchewan.

In **Africa**, several countries are exploring and developing REE projects, including: Madagascar, Malawi (Songwe Hill and Kangankunde), and Tanzania.

Summary

REE turned out to be a very big field to look at. For more information, check out the links in the text above. While not as all-consuming as search for gold (talk to the gold bugs), REE promises to be an excellent field to become a part of for any geologist seeking a challenge.

Standard Caveat

J. Robert Oppenheimer on freedom and scientific inquiry

The purpose of my weblog postings is to spark people's curiosity in geology. Don't entirely believe me until you've done your own research and checked the evidence. If I have sparked your curiosity in the subject of this posting, follow up with some of the links provided here. If you want to, go out into the field and examine some rocks on your own with the help of a good field guide. Follow the evidence and make up your own mind.

In science, the only authority is the evidence.