January 5, 2026

News and notes

Lightly falling snow on Crescent Lake, January 1, 2026

This week, before going on to discuss the geology and mineral resources of Morocco, we will first look at some news items I thought were interesting. The picture above is from Crescent Lake on January 1.

If you enjoy my blogs, bookmark the site and check on Mondays rather than relying on social media postings which can get lost in the shuffle. For my news items, I try to stick to open access papers.

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

- There are lots of news reports on the American action in Venezuela.
- Meanwhile: Inside US Plans To Reopen WWII Air Bases for War With China.
- Geopolitical analysis from Alexander Dugin.
- Iran protests enter fourth day as clashes intensify.

Research and News

- Planetary Geology: Photochemistry of Fe (II) and carbonate-bearing waters and the influence on Greenhouse Gas production in Early Mars.
- January 2026 GSA News.
- Playing with rocks in the lab: Experimental Deformation of Textured Amphibolites in the Semi-Brittle Regime: Microstructural Signatures of Dislocation-Mediated Deformation.
- New Mineral Names!!!
- Eclogite-facies metamorphism of continental crust at the Mesoarchean-to-Neoarchean transition.
- Raman spectroscopy as an alternative approach for prediction of silicate mineral content in sedimentary rocks.
- Pseudomorphs After Titanite to Investigate Ti Mobilization in a Carbohydrothermal Pegmatite at Moose Creek, Ice River Alkaline Complex, Southeastern British Columbia, Canada.
- Zircon diffusion chronometry reveals brief ultrahigh-temperature metamorphism in a prolonged Paleoproterozoic orogen.

Plate Tectonics

- Regional Three-Dimensional Magnetotelluric Electrical Resistivity Model of the Manica Greenstone Belt, Western Mozambique.
- Neotectonic Origins for the Meadow Bank Scarp, Wabash Valley Seismic Zone, USA .
- From the Bottom Up: Calculating Mantle-Derived Magma Flux Using Subduction Parameters and Petrologic Constraints at Oceanic Arcs.
- Development of thermal state and plate tectonics in the North China Craton during Neoarchean–Paleoproterozoic.
- Ancient, buoyant mantle under the Sierra Leone Ridge in the equatorial Atlantic.

Paleontology

- Ancient African bedrock reveals the violent beginnings of life on our blue planet.
- Ammonite survival across the Cretaceous–Paleogene boundary confirmed by new data from Denmark.
- Stable Isotope Analysis of *Gryphaea arcuata* Reveals the Prevalence of Humid Tropical Conditions During the Early Sinemurian of Normandy (Fresville), Northwestern France.
- A unique snake assemblage from the Early Miocene locality of Wintershof-West, Germany, with comments on the transitional period in the evolution of European snake fauna.

- *Verrocaris kerrymatti* n. gen. n. sp., a new "misfit" anomalocaridid radiodont (Euarthropoda) from the Kinzers Formation (Cambrian, Series 2, Stage 4) of Pennsylvania and its implications.

- Rewind evolution and get a different result, The variability of evolvability: Properties of dynamic fitness landscapes determine how phenotypic variability evolves; Science Daily summary here.

Ore Deposit Geology

- Complex carbonate ore mineralogy in the Mountain Pass carbonatite rare earth element deposit, U.S.A.

- 3D Multi-Layer Geological Modeling of the Allou Kagne Attapulgite Deposit (Senegal, West Africa).

Mining and Energy

- Bad boys: Ganfeng Lithium says it may face insider-trading charges; cue the music.

- Africa's Emerging LNG Corridor Is Taking Shape South Of The Sahara.

- Suriname's Oil Dreams Collide With Geological Reality.

- Coal Remains King in India While Exports Optimize Domestic Stock.

- Ivanhoe Mines begins copper anode production at new Congo smelter.

- 'People are wrestling with the burden': Japan pivots to focus on nuclear power 'maximisation' alongside renewables.

- Rare Earths: A Strategic Agreement Enables the United States to Produce 540,000 Tons per Year and Challenge China.

- Video: Why Silver Is Breaking New Records | Risky Business.

- Platinum price set for biggest monthly gain in 39 years on EU auto policy boost.

- Vaca Muerta Shale: Argentina's Shale Boom Propels It Past Colombia in Oil Output.

- China's CNOOC Discovers Massive Oilfield in Bohai Sea.

- Commodity and Financial Market Linkages: Granger Causality Insights from Rare Earths, Crude Oil, and Equities; Rare Earth Exchanges summary here.

Environmental Geology and Hydrogeology

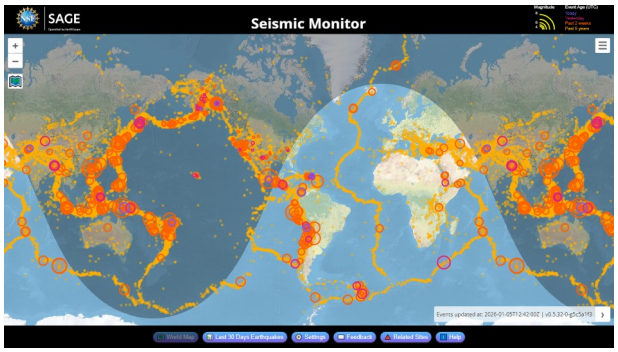
- NGWA Submits Comments on Coal Combustion Residuals Disposal Extension.

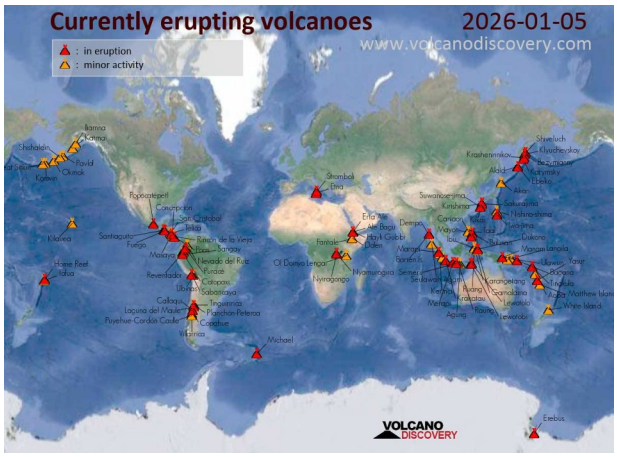
- Whiskey's for drinking, water's for fighting over:

    - Hungary's 'water guardian' farmers fight back against desertification.

    - 'There's no water any more': How palm oil plantations drained a Guatemalan rainforest community.

Volcanoes, Earthquakes and Geohazards





Seismic Monitor | **Active Volcano Map**

Volcanoes

- Smithsonian / USGS Weekly Volcanic Activity Report.
- United States Geological Survey (USGS) Volcano Observatories:
  - Yellowstone Caldera Chronicles: The top Yellowstone geological stories of 2025.
  - Cascades Volcano Observatory Weekly Update.
  - Volcano Watch – Hauʻoli Makahiki Hou: a round-up of fireworks from Kīlauea's fountains.
- Deciphering chemical complexity in monogenetic eruptions: Xitle Volcano, Mexico.
- Imaging of Magma Intrusion Below La Palma During a Strong Effusive Eruption in 2021 Inferred From Repeated Seismic Tomography.
- Video: The Golden Volcanic Glass Only Formed from 1,000+ Ft Lava Fountains.
- December 31, 2025 - Well ... Axial Seamount did NOT erupt in 2025. It's time to try a new forecast method!
- What's inside Mexico's Popocatépetl? Scientists obtain first 3D images of the whole volcano.

Earthquakes

- Euro-Mediterranean Seismological Centre (EMSC).
- Earthquakes Monitoring Live Worldwide.
- M6.5 subduction earthquake strikes near Acapulco, Mexico; USGS summary here.
- Rapid Characterization of the 2025 M*w* 8.8 Kamchatka, Russia Earthquake.

- Fluid-Induced Earthquake Nucleation on Aging Rate-and-State Faults: Influence of Hydraulic Diffusivity and Injection Rate Under Different Nucleation Regimes.
- Monitoring-Induced Seismicity in Urban Environment Using Low-Cost Stations: Lessons Learned from the Strasbourg Dense Semipermanent Seismic Network, France.
- Seismic hazard analysis: Improving High-Frequency Spectral Estimates in Spectral Ratio Analysis Using Between-Event PGA Differences.
- Mantle Earthquakes: Deep Quakes Beneath the Moho in the Wyoming Craton

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 together with free online courses, listed here.
- Free Groundwater Modeling Courses from the HydroGeoCenter.
- From Western Australia: Carbonatite, lamprophyre and host rocks in the northern Aileron Province.
- The Geology of Indonesia: Volume 1 and Volume 2.
- 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

- January 14, 2026 from 9am to 4:30pm GMT, IAH (Irish Group) CPD Course: Groundwater, Hydrology and Climate Change.
- Feb. 16-18, 2026, Inaugural Mineralogical Society of America Annual Meeting, Tuscon AZ
- GAC-MAC 2026 St. John's NL, St. John's Convention Center, May 25-28, 2026.
- PEG2026: 11th International Symposium on Granitic Pegmatites; 16th–19th August 2026, in Perth, Western Australia.
- 14-18 September 2026 , IAH 2026, 53rd Congress of the International Association of Hydrogeologists; Budapest Congress Center.
- Society of Petroleum Engineers Distinguished Lecturer Schedule.
- American Geophysical Union List of Upcoming Meetings.
- The Geological Society: Events & Courses.

January 5, 2026

Geology and Mineral Resources – Morocco

Introduction

Figure 1a – Morocco
Credit: CIA World Factbook, public domain

Figure 1b – Location of Morocco
Credit: CIA World Factbook, public domain

The Kingdom of Morocco is a country of 37,387,585 people in the Maghreb region of North Africa. The country has a total area of 716,550 square kilometres (km^2) of which 270,000 km^2 is the Western Sahara occupied by Morocco since 1975 and the remaining 446,550 km^2 is Morocco proper. Morocco has coastlines on the Mediterranean Sea, to the north, and the Atlantic Ocean, to the west. Morocco's land borders are with Algeria, to the east, and Mauritania, to the south. Morocco's occupation of the Western Sahara is still in dispute. Also in dispute are Morocco's claim to the the Spanish exclaves of Ceuta, Melilla and Peñón de Vélez de la Gomera, and several small Spanish-controlled islands off its coast. These disputes are a function of the complicated history of Morocco and especially the French and Spanish "protectorates" established during the 20th Century.

Moroccans are moderately well off with a modest per capita GDP (PPP) of $11,270 and a high Human Development Index of 0.710. The major industries of Morocco are: automotive parts, phosphate mining and processing, aerospace, food processing, leather goods, textiles, construction, energy, tourism. The main trading partners are: China, France, Germany, Italy, Spain, the United Kingdom, and the United States with Spain leading in imports and exports.

For more details on the country, check out the CIA World Factbook on Morocco as well as the Wikipedia article.

Geology

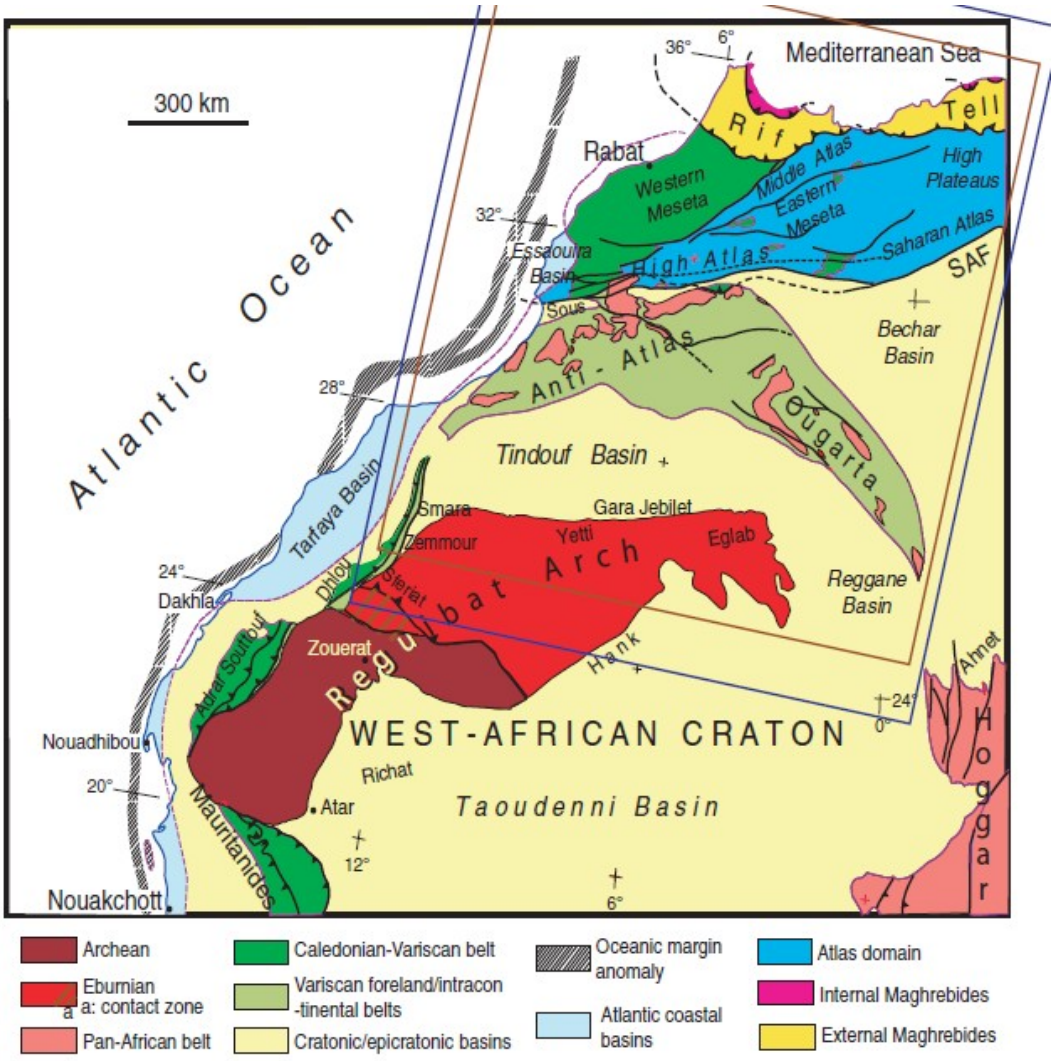


Figure 2 – Tectonic Map of Northwest Africa
Credit: Figure 1.11 in Michard et al, 2008

The geology of Morocco reveals a complex geological history. Morocco sits on the West African Craton and its current form is result of a succession of orogenies.

The oldest rocks in Morocco are Archean in age and include the rocks of the of the Reguibat Shield. The Reguibat Shield also includes the next oldest rocks in Morocco, those of the Proterozoic aged Eburnian formations. Also Proterozoic in age are the rocks formed during the Pan-African Orogeny which extended from the Neoproterozoic into the Early Paleozoic eras.

Next oldest are the rocks formed during the Caledonian and Variscan orogenies during the Paleozoic Era. During these orogenies, the land that is now Morocco was pushed up against what is now North America into the supercontinent of Pangea. The Atlas Mountains in Morocco formed as the result of the Caledonian and Variscan orogenies.

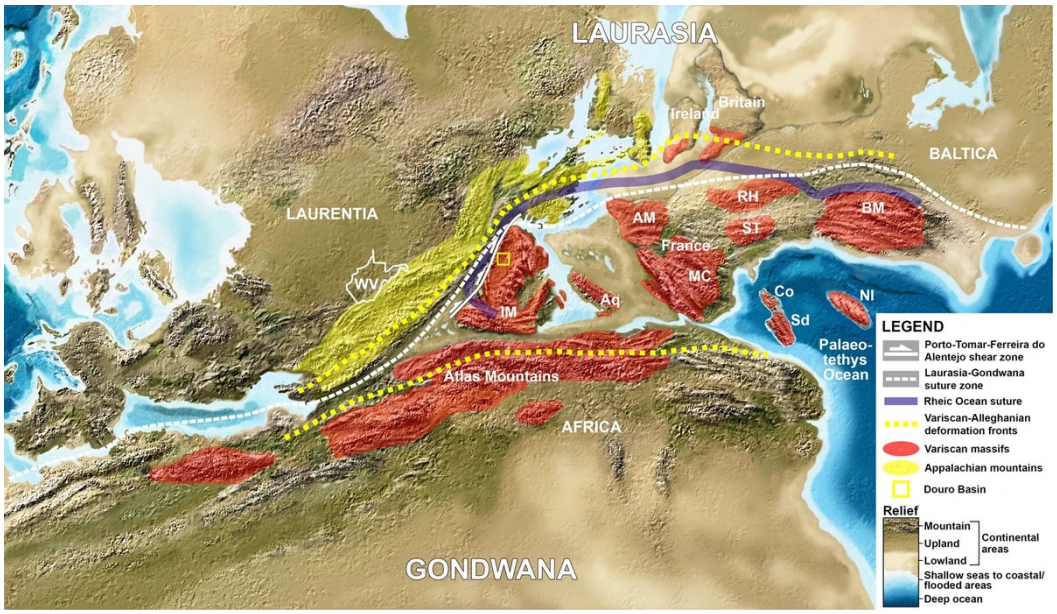


Figure 3 – Trans-Pangaea Mountains
Credit: Figure 5 in Correia & Murphy, 2020.
Creative Commons Attribution 4.0 International license

The breakup of Pangea began during the Permian Period and continued into the Mesozoic Era, leading to the creation of the Atlantic Ocean. The final orogeny affecting Morocco is the Alpine Orogeny, where Africa is moving northward into Eurasia, this orogeny began in the Late Mesozoic and continues to this day.

Figure 4, below, shows a more detailed geologic map of Morocco.

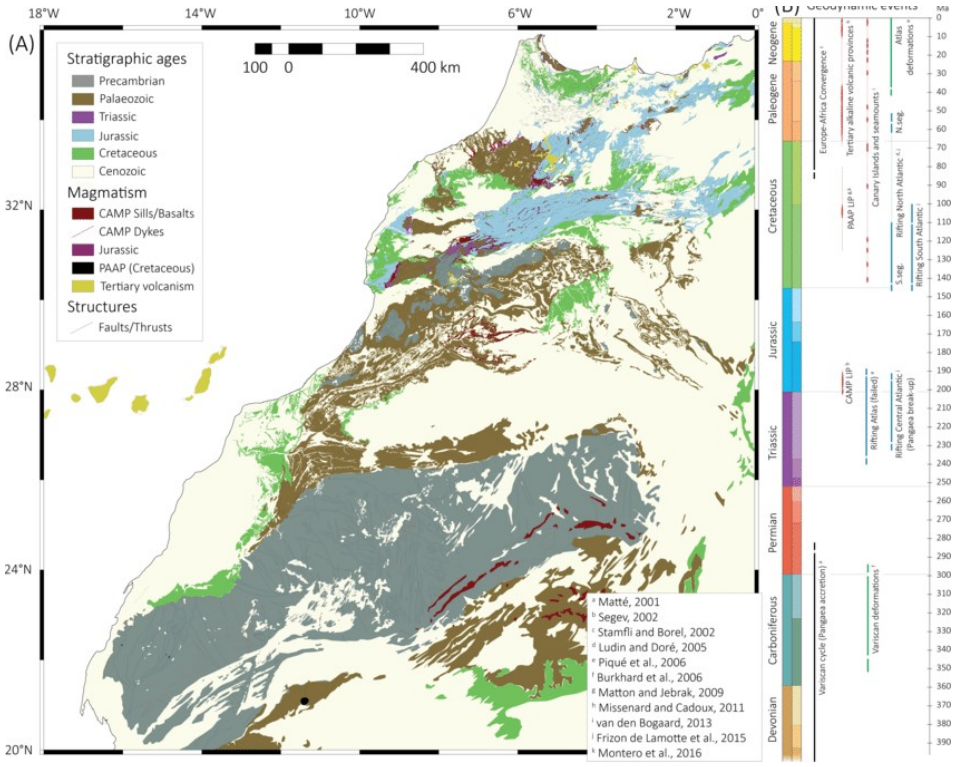


Figure 4 - Geological map of Morocco
Credit: Figure 02 in Charton et al, 2020, Creative Commons Attribution 4.0 International license

So what kinds of rocks are found among the various aged formations in Morocco? Starting with the suite of Precambrian deposits, the Archean rocks of Morocco are predominantly supracrustal rocks and include gneiss, granite, metagabbro, serpentinite, quartzite, chert, and impure marble. The Paleoproterozoic rocks of the Kerdous, Bas Drâa, Tagragra and Zenaga regions in the Anti-Atlas Mountains include schist, migmatite, and granitic intrusions. The Neoproterozoic rocks in Morocco include high-grade metamorphic rocks, granitic intrusions, and mafic to ultramafic dykes in the nappes of the Adrar Souttouf Massif. Other Neoproterozoic rocks in Morocco include ophiolites, parts of oceanic crust that are now exposed.

Paleozoic aged (Cambrian to Permian periods) in the High Atlas Mountains and Meseta include metamorphosed tillite, arenite, schist, limestone, sandstone, and granite. The Cambrian to Carboniferous aged rocks of the Anti-Atlas Mountains are mostly the result of shallow marine sedimentation and includes tillite, arenite, schist, limestone and sandstone. The Ordovician to Carboniferous aged units of the Dhlou, Zemmour, and Tindouf basins include tillite, arenite, shale, and limestone.

The Triassic aged rocks of the High and Middle Atlas Mountains are siltstone, sandstone, and evaporite together with some basalt related to the rifting the of the Atlantic Ocean. The Jurassic aged rocks in the Atlas Mountains are predominately carbonate platform rocks, often forming karst topography. Late Jurassic to Early Cretaceous deposits in the Atlas Mountains include red-bed sandstone, marine marl, and fluvial conglomeratic calcarenite.

The Early Cretaceous deposits of the Rif Belt of northern Morocco is made up of flysch, associated with tectonic activity including the opening of the Atlantic Ocean. The Rif also includes Cretaceous, Paleogene, and Neogene aged limestone as well as older ophiolites and metamorphic basement.

Along the Atlantic coast, the Tarfaya-Dakhla Basin is made up of Cretaceous to Neogene aged sediments including marine to lagoonal sediments with organic-rich black shales and sandy marls. Other basins include the Phosphate Plateau north of Marrakesh, made up of limestone, marl, and (as you might guess) phosphorite. There are also Paleogene, and Neogene aged calcareous lacustrine deposits in northeastern Morocco.

The youngest deposits in Morocco are Paleogene to Quaternary aged including alluvial and coastal sand deposits; sand dunes in the deserts; the Souss Basin near Agadir; and the Saïs Basin from Rabat to Fez.

Mineral Resources

Figure 5 – Barite Sample from Jebel Ouichane Credit: Lech Darski, Creative Commons Attribution 4.0 International license

According to the USGS Minerals Yearbook for Morocco, the country's mineral industry includes the production of metallic minerals, industrial minerals and a modest amount of fuel minerals, including:

- Arsenic trioxide from the hydro-metallurgy complex at Managem.
- Barite from artisanal producers in the Draa-Tafilalet Region as well from at least 10 industrial mines including those run by ADO Barite Morocco and SMBM - Minière des Barites et Minéraux.
- Cement, lime, and pozzolan for construction is produced at numerous locations.
- Bentonite and montmorillonite clay is mined at six mines.
- Cobalt is mined at the Bou-Azzer Mine.
- Copper is mined at the Ousdiden copper deposit, the AKA mine, the Ouansimi Copper Mine, the Bleida Mine, the Bouskour Mine, the Oumjrane Mine, and the Douar Hajar Mine.
- Fluorspar is mined at a mine in Taourirt Province at a facility owned by Gujarat Fluorochemicals Limited.
- Gold is mined in the Guemassa Massif at a facility operated by Managem Group.
- Iron ore is mined at the Mines Del Rif Nador Mine.
- Lead is mined by artisanal miners as well as a mines at Fez - Boulemane, Marrakech - Tensift - Al Haouz, Meknes - Tafilalet, and Oriental.
- Manganese is mined at the IMINI mine in Ouarzazate.
- Natural gas is produced at the Sebou and Oulad N'Zala Field and is supposed to begin soon at the Tendrara field. Gas condensate is also produced at the Sebou field.
- Phosphate rock is mined at Khouribga, Ganntour, the Youssofia Mine, and the Boucraa Mine.
- Salt is produced from brine at Lake Zima and rock salt is mined at Ain Tekki.
- Silver, lead and zinc is produced at the Tighza Mining Center and the Guemassa Mine; silver and copper at the Tirzet Mine; and gold and silver at the Zgounder Mine.
- Pyrophyllite is produced at a mine near Khenifra; talc is mined near Tinjdad and Taliouine.
- Zinc is produced by artisanal miners from mines at Errachidia, Figuig, and Tafilate in the Draa-Tafilalet Region.

The latest mineral production statistics from the USGS can be found here. Figure 6 links to an interactive mineral occurrence map of Morocco from Mindat.org.

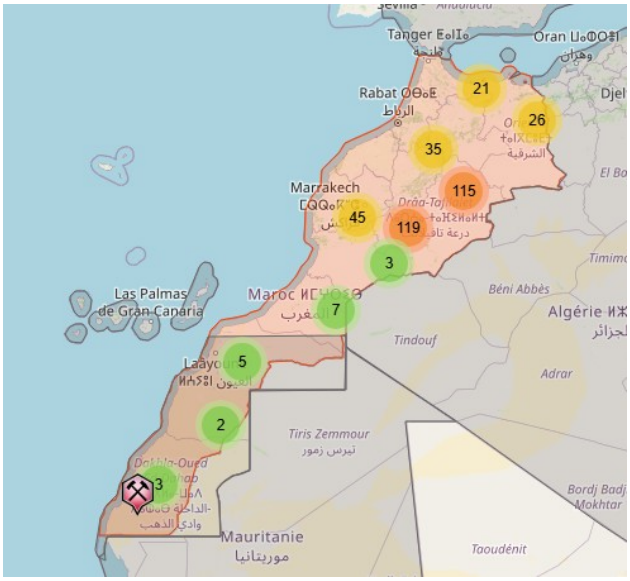


Figure 6 – Interactive Mineral Occurrence Map of Morocco, [Credit: Mindat.org]

Summary

Figure 7 – Sunset over Jamaa El Fna, Morocco
[Credit]: MoroccanPixels, [Creative Commons] [Attribution 4.0 International] license

Morocco has been a [favourite tourist destination] for a long time, so if you go, take the usual precautions ahead of time, For geologists, the complex geology of Morocco suggests that it is a promising place for [mineral exploration]. It helps that the government is [relatively stable]. As well as the on shore prospects in a variety of metallic and industrial minerals, there may be opportunities for off shore oil and gas development in the future.

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.