# The Catoctin Iron Furnace Supplemental Trip Guide
# Roadside Chemical Engineering

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In addition to the tour provided by the Catoctin Furnace Historical Society, this supplement highlights some of the "chemical engineering" items of interest. All photographs and illustrations by the author. See associated articles at LinkedIn: Roadside Iron Furnaces & The Bowen Reaction Series: https://www.linkedin.com/groups/13007402/

**Summary of a Generic Pig Iron Smelting Process and Main Reaction Equations**

The Catoctin Iron Furnace at Thurmont, Maryland, originally dates from 1714, and was rebuilt in the 19th century. Iron Ore (essentially Iron Oxide) under goes a reduction process called smelting. Carbon is used to remove the oxygen from the iron ore to produce pig iron.

The Iron Ore, limestone and carbon (e.g., coke or charcoal) are put into the top of the furnace. At the same time, hot air is blown inside the furnace at the bottom. The process is known as blasting. The carbon ignites and creates carbon monoxide because there is not enough oxygen to make carbon dioxide. The carbon monoxide then reduces the ore to iron. The limestone forms a slag with the rock part of the ore.

The silica in the ore reacts with calcium oxide (burned limestone) and forms silicates, which float to the surface of the molten pig iron as slag. The slag can be made into bricks or mixed with concrete, among other uses. Charcoal is made by heating wood above 750° F in an oxygen deprived environment. Coke is a gray, hard, and porous coal-based fuel with a high carbon content and few impurities, made by heating coal or oil in the absence of air.

The main chemical reaction producing the molten iron is:

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

The preheated air blown into the furnace reacts with the carbon to produce carbon monoxide:

$$2\ C_{(s)} + O_{2(g)} \rightarrow 2\ CO_{(g)}$$

Limestone is decomposed calcium oxide and carbon dioxide:

$$CaCO_{3(s)} \rightarrow CaO_{(s)} + CO_{2(g)}$$

The calcium oxide formed by decomposition reacts with various impurities in the iron ore (notably silica), to form a slag which is essentially calcium silicate, CaSiO.

$$SiO_2 + CaO \rightarrow CaSiO_3$$

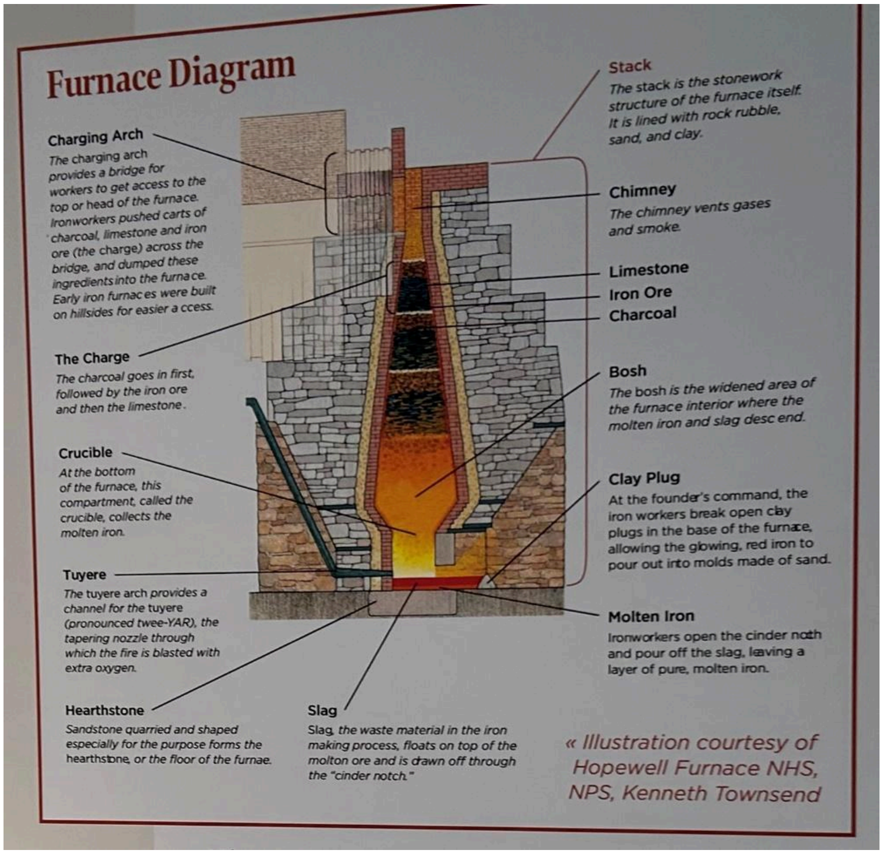
**The Furnace and Furnace Casting Shed Area**

The rocks of Catoctin Mountain Park include those from volcanic eruptions. About 500 million years ago molten lava rose up through fissures on the Earth's surface creating an igneous rock called basalt. Through metamorphic processes that occurred afterwards, this rock was transformed into metabasalt greenstone. Green minerals such as epidote and chlorite give the rock its green hue. See the Catoctin Mountain Geology brochure and the Roadside Chemical Engineering article of natural distillation.

**Photograph: The Furnace and Covered Furnace Casting Area**


Wealth is originally derived from growing and mining. All other wealth is an associated product of this original wealth. Hence, iron smelting is a fundamental chemical engineering process.

**Photograph: The Furnace Diagram inside the Museum of the Iron Worker**




**Photograph: Furnace Casting Shed Area.**

Ingredients for the iron production source were large deposits of hematite ore which were readily accessible. Around 300 million years ago the continents of North America and Africa collided creating the Catoctin Mountains. During this time a fault formed along what is now Route 15. West of the fault, the mountains rose higher. East of the fault low lying basin rocks slid down to create a valley. In the area where the mountains and valley met, iron ore formed. Nearby deposits of limestone provided flux, and thick forests of American chestnut trees provided charcoal to create iron at the furnace. While the iron ore and limestone are no longer present in any large extent to visit as a field trip stop, there are pebbles and grains remaining on the on the property to inspect. However, other roadside furnace locations may still have the limestone quarries and hematite ore that fed these furnaces still present in the vicinities.

**Left Photograph:** Magnetic Iron/Ore Block

**Right Photograph:** A magnet on a stick attracts magnetic pulverized ore around the block.

Get the Catoctin Furnace brochure.

**Photograph: Furnace Casting Shed Area Edge & Close-up**

**Left Photograph:** Look for limestone or limestone/dolomite rock. Dolomite is composed of calcium magnesium carbonate, $CaMg(CO_3)_2$.

**Right Photograph:** A magnet on a stick attracts magnetic iron ore chips.

**The Slag Pile/Heap Trail**

**Photograph: Iron Trail Remnants of Slag Heaps**

Walking along the Iron Trail between Route 806 and Route 15 and to the north of the Catoctin Furnace are several slag heaps. Crossing over the Route 15 pedestrian bridge and following the Little Hunting Creek path, one finds additional slag piles. The slag heaps your see around you are the furnace's waste product called slag.  The molten iron sinks to the bottom, while the impurities and limestone residue rise to the surface, where they were slimmed and discarded. They harden into slag and they looked like volcanic glass or lava rock.  They were used to fill holes and surface roads.

**Photograph: The Iron Trail**

**Transportation of Resources**

Transportation related to the iron furnace manufacturing was accomplished by mule in early days to nearest canal about 10 miles away. This later improved to rail driven cargo by mule. Afterwards the coming of a steam engine railroad near the end of the $19^{th}$ century improved the transportation situation.

The Construction of the Chesapeake and Ohio (C&O) Canal began in 1828. The furnace was not far from the canal. Just south of the furnace is the Monocacy Aqueduct, the largest of the eleven aqueducts erected along the C&O Canal. The Monocacy Aqueduct was completed in 1833.

On the east side of Maryland Route 806, you will see power lines that go along what looks like an old railroad bed. This is the old railroad bed of the Monocacy Vally Railroad. The railroad paralleled present day Maryland Route 806.

**Photograph:** Ore Cart, from the Museum of the Iron Worker.

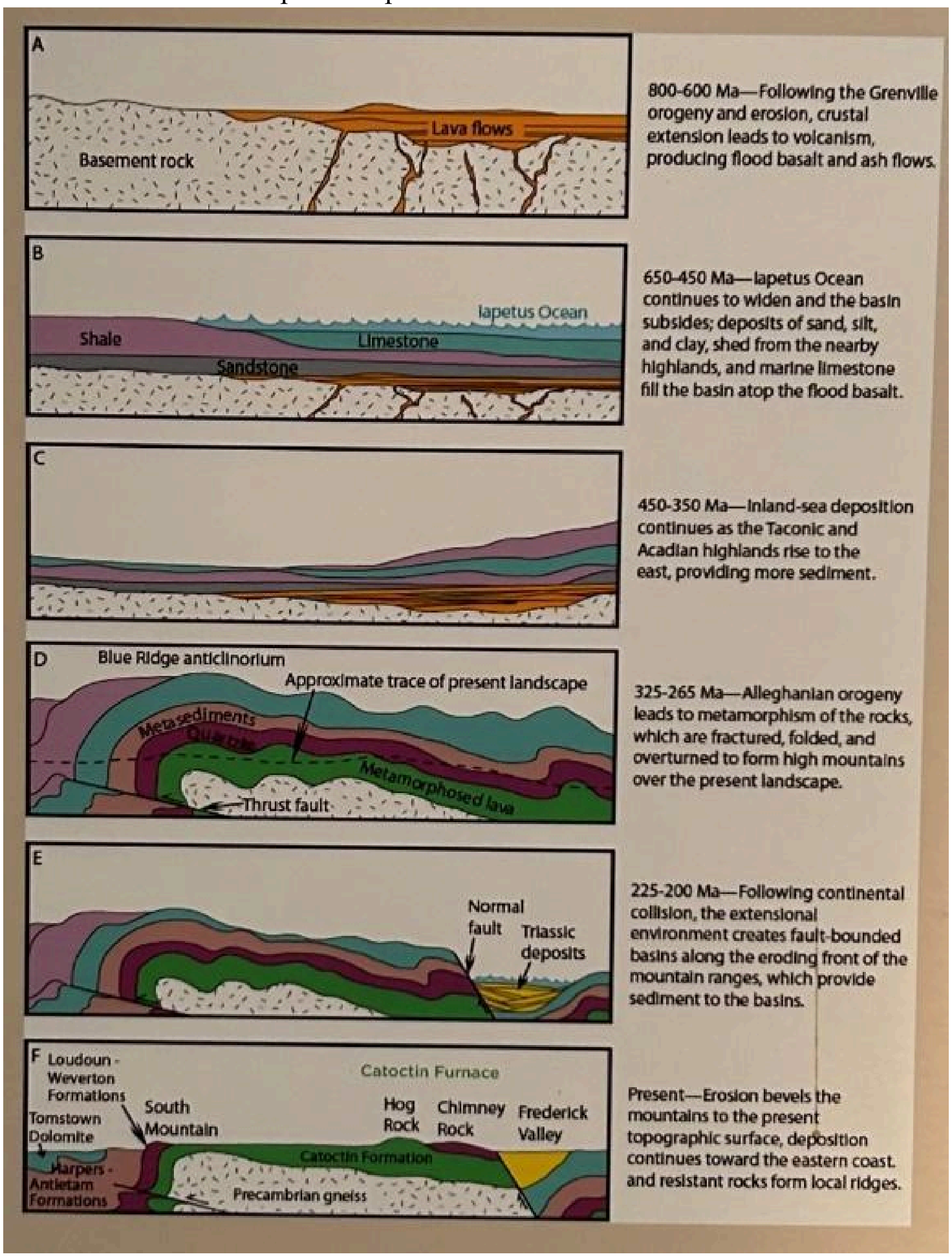
**The Museum of the Iron Worker**
12610 Catoctin Furnace Road.

This small but interesting museum is a stop on this tour and is located with a short walk from the iron furnace.  Pictured below are iron ore artifacts.

**Geological History of the Catoctin Iron Furnace Area**

**Geologic Mountain Building (Orogeny)**

**Photograph:** From the Museum of the Iron Worker, a chart on the geological history that made the iron furnace operation possible.




- Grenville orogeny: about 1.15 billion years ago.
- Taconic orogeny: about 435 million years ago.

- Acadian orogeny: about 370 million years ago.
- Alleghanian orogeny: about 320 million years ago

**Optional: The Charcoal Trail & Bowen Reaction Series**

- Getting Here: Route 77 closure, use Catoctin Hollow Road from Route 806 and Route 15 near the Catoctin Furnace.
- Safety: Be mindful of snakes, ticks, gnats, tripping hazards, roadside traffic. Speak to a park ranger on all the potential hazards if you are concerned. ticks spiders snakes
- Get the Catoctin Mountain Park brochure for the Charcoal Trail.

**The Charcoal Trail**

Length: .6-mile loop
Time: 20 minutes
Difficulty: Easy with a couple negligible hills

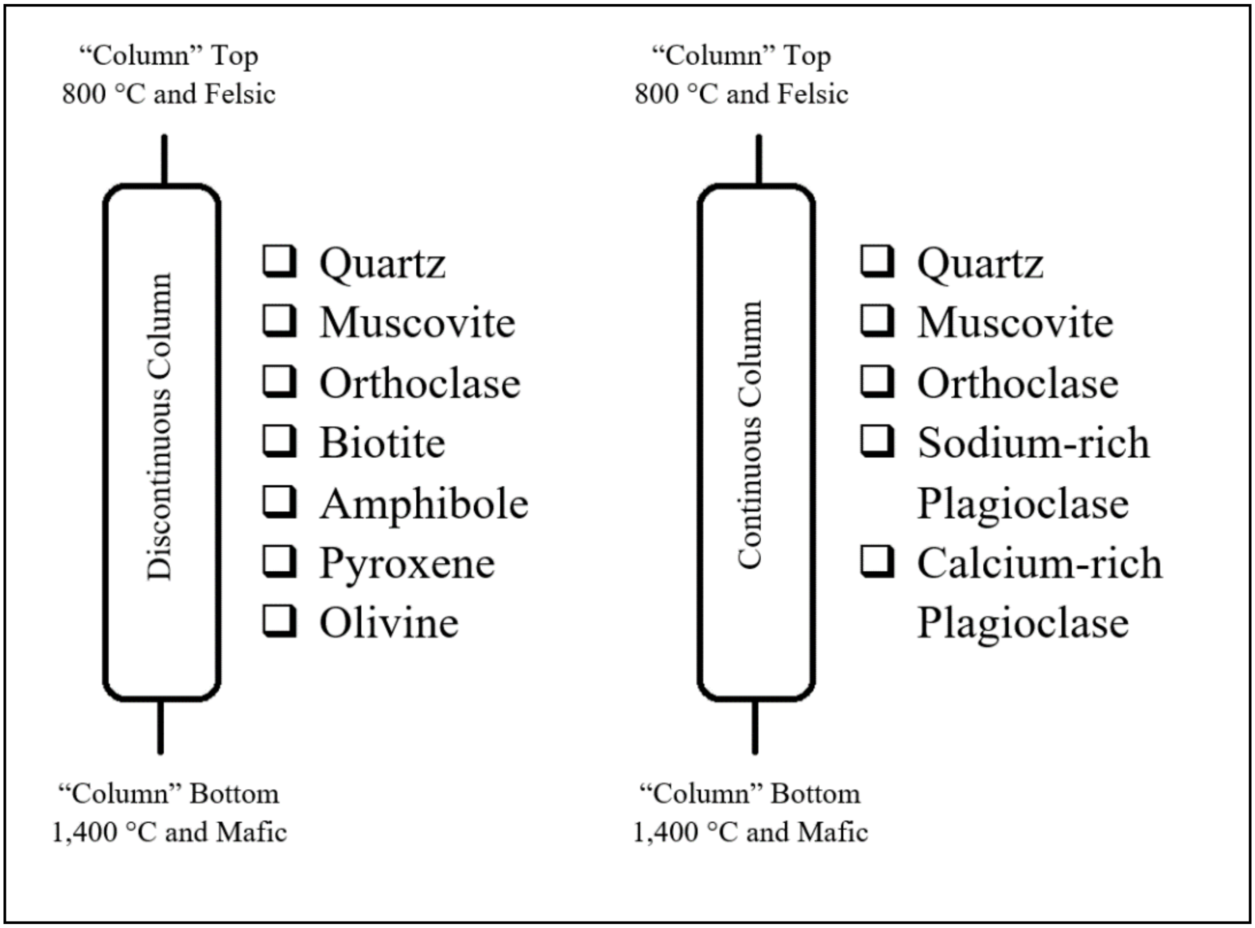
The Charcoal Trail at Catoctin Mountain Park is a short loop trail that passes through an area where charcoal was once made. Charcoal was needed to fuel the nearby Catoctin Iron Furnace. The furnace operated until 1903 (it is a historic site today). Charcoal production required an enormous amount of wood. The Catoctin Iron Furnace burned charcoal up until 1873, at which time it switched over to coal.

The Charcoal Trail starts at the Thurmont Vista / Charcoal Exhibit Parking Lot, the second parking lot north of the Catoctin Mountain Park Visitor Center. Look for the Charcoal Trail wayside exhibit at the trailhead. The trail is relatively flat for most of the way.


**Bowen Reaction Series At Catoctin Mountain Park**

The Greenstone you will see all around you is a result of a “natural distillation” process called the Bowen Reaction Series.

A mafic mineral or rock is a silicate mineral or igneous rock rich in magnesium and iron. Most mafic minerals are dark in color, and common rock-forming mafic minerals include olivine, pyroxene, amphibole, and biotite. Common mafic rocks include basalt, diabase and gabbro. Mafic rocks often also contain calcium-rich varieties of plagioclase feldspar. Mafic materials can also be described as ferromagnesian, because of their main composition of minerals composed of magnesium and iron. The term Mafic comes from "magnesium" and "ferric" (iron).  Felsic rocks, such as granite, are high in light-colored minerals, including feldspar and quartz.  Feldspar is a group of rock-forming aluminum tectosilicate minerals, also containing other cations such as sodium, calcium, potassium, or barium.  Felsic and mafic rocks are two main types of igneous rocks, which are rocks that are formed from the cooling and solidification of magma or lava. Felsic rocks are high in silica ($SiO_2$), while mafic rocks are low in silica. This difference in silica content gives the two types of rocks different physical and chemical properties. Felsic is a term used to describe silicate minerals, magma, and igneous rocks which are enriched in the lighter elements such as silicon, oxygen, aluminum, sodium, and potassium. The term "felsic" comes from the words "feldspar" and "silica".




**Geology At the Charcoal Trail**

**Charcoal Trail**

**Photographs (below):** Outcrop of Greenstone at the Charcoal Trail parking lot (40 spaces) and some smaller rock samples found on the ground. The color is grayish-green. Mineralogy includes chlorite, actinolite, albite, epidote, titanite, quartz, and magnetite.


The Catoctin Formation is a formation of metabasalt, metarhyolite, and porphyritic rocks. Evidence for past volcanic activity includes columnar basalts and greenstone dikes. These dikes of greenstone can be found cutting across the Catoctin Formation. They are composed of pyroxene and plagioclase with chlorite and small amounts of calcite, quartz, and epidote, as well as other green-hued minerals.

Basalt erupted as mafic lava onto or near Earth's surface, cooling rapidly to make a fine-grained igneous rock. Mafic igneous rocks (such as olivine and pyroxene) include basalt (extrusive) and gabbro (intrusive). Extrusive rock refers to the mode of igneous volcanic rock formation in which hot magma from inside the Earth flows out onto the surface as lava or explodes violently into the atmosphere to fall back as pyroclastics. In contrast, intrusive rock refers to rocks formed by magma which cools below the surface. Metabasalt is a metamorphic rock that forms when altered from igneous basalt. Igneous rocks form from the cooling of magma and metamorphic rocks form from existing rocks over time through heat and pressure. This metamorphism happened in the Catoctin area when the continents collided from 540 million years ago all the way back to the back to the Grenville Orogeny and beyond.

Greenstone is common in the Catoctin Mountain Park and can be seen also at Wolf Rock and Hog Rock if you hike there.

**Geology at Wolf Rock and at Hog Rock**

**Geology at Wolf Rock:** This is quartzite that 500 million years ago was sea bottom sand. Tremendous earth forces compressed and crystallized it into hard rock, when the Appalachian Mountains uplifted 200 million years ago. Tough quartzite erodes slowly so it often forms ridges like Catoctin Mountain. Where erosion has worn away the quartzite layer there are older sediments and ancient lava flow beneath it (Catoctin Metabasalt or Greenstone).

**Geology at Hog Rock:** At Hog Rock, located in the center of the Catoctin Mountain Park, the Catoctin metabasalt formation is the bedrock. This bedrock is dark greenish-gray metamorphosed igneous rock, which is highly resistant to weathering. It is known as Catoctin Greenstone. This type of rock can be found throughout the Blue Ridge Mountains in what is known as the Catoctin Formation. Hog Rock Parking has 50 spaces.

**Optional: The Catoctin Mountain Park Visitor Center and Museum**

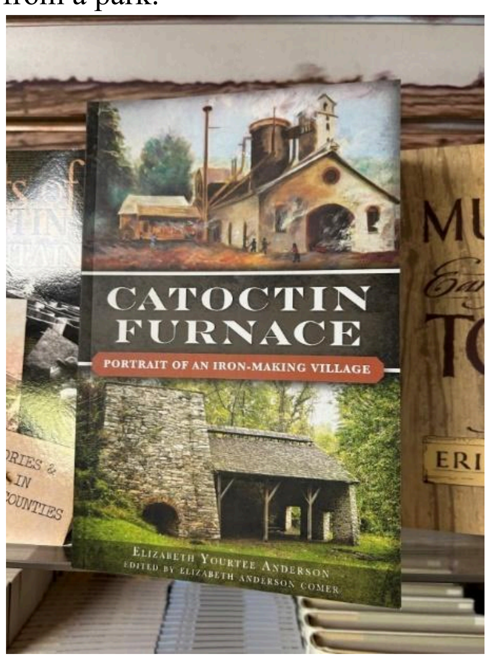
Catoctin Mountain Park Visitor center has a museum with iron furnace related displays. There is a main road closure to Catoctin Mountain Park Visitor Center due to a broken sewer line. Repairs are anticipated through June, 2024. Use alternate road Catoctin Hollow Road from Catoctin Furnace.

**Photograph:** The Catoctin Mountain Park Visitor Center and Museum


**Photograph:** The Catoctin Mountain Park Visitor Center and Museum


**The Catoctin Mountain Park Visitor Center and Museum**

Sample souvenirs: Check with the parks. Many will indicate it is illegal to remove anything from a park.



**Useful References**

Get the Iron Road Driving Tour brochure for a history of iron furnaces in our area including the Catoctin Furnace. https://catoctinfurnace.org/ironroad/

Get the Museum of the Iron Worker brochure. This will be visited on our Catoctin Furnace Roadside Chemical Engineering tour. https://catoctinfurnace.org/ironworker/

Get the 2023 Explore Cunningham Falls and Gambrill State Parks brochure for the segment on the annual Maple Syrup Festival (early Chemical engineering food processing) and the annual Iron Festival.
https://issuu.com/fredericknews-post/docs/cunninghamgambrillrecguide-2023

Get the Catoctin Furnace Archeological Mitigation Project Final Report of the 1979 Excavation, for detailed information on the whole engineering operation including: the furnace complex, water power, furnace fuels, mines and quarries (raw materials iron ore and limestone), hydraulic systems, the charcoal sources, and limestone kiln.

https://apps.jefpat.maryland.gov/NEH/Assets/Collections/images/18fr321/PDFs/final_report.pdf

**Useful Links**

https://rockd.org/

https://www.usgs.gov/faqs/what-difference-between-rock-and-mineral

https://vgfc.blogs.wm.edu/

https://www.ganj.org/index.php

https://www.nysga-online.org/

https://courses.vccs.edu/colleges/nova/courses/GOL135-FieldStudiesinGeology

https://www.energy.virginia.gov/geology/Symposium.shtml

https://csmgeo.csm.jmu.edu/geollab/vageol/vahist/index.html

https://www.geosociety.org/

https://www.sandatlas.org/sand-types/

https://en.wikipedia.org/wiki/Iron_ore