EARTHQUAKE
e-Newsletter about what's movin' and shakin' at the Earth Science Museum

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ESM OUTREACH UPDATE

Mardy Zimmermann, Outreach Coordinator

Late February Outreach

On February 26, 2024, Lynne and Terry Dyer taught 6 Webelos cub scouts and 5 adult leaders at Chandler Heights United Methodist Church.

Celebrating the 250th Anniversary of the Discovery of Oxygen

By Harvey Jong

Oxygen was discovered about 250 years ago, and its identification represents a major scientific milestone that revolutionized chemistry. But some controversy surrounds who actually made the discovery. We'll explore the different claims and how oxygen introduced inconsistencies with prevailing theories about chemical composition. In addition, we'll take a look at some minerals containing oxygen, specifically the class of minerals known as oxides.

Chemical Understanding Prior to the Discovery of Oxygen

Three philosophies about chemical composition were popular in the 18th century. These theories included:

1. Aristotle's theory of the four elements: air, earth, fire, and water
2. Paracelsus' three primes (tria prima) of alchemy: sulfur, mercury, and salt
3. Phlogiston theory which hypothesized that fire was a constituent of combustible materials

Working within this framework, natural philosophers/scientists studied the heating of materials and the process of combustion. They noted phenomena, such as a gas being released during heating and some metals gaining weight after they burned, which would set the stage for oxygen's discovery.

Oxygen's Principal Investigators

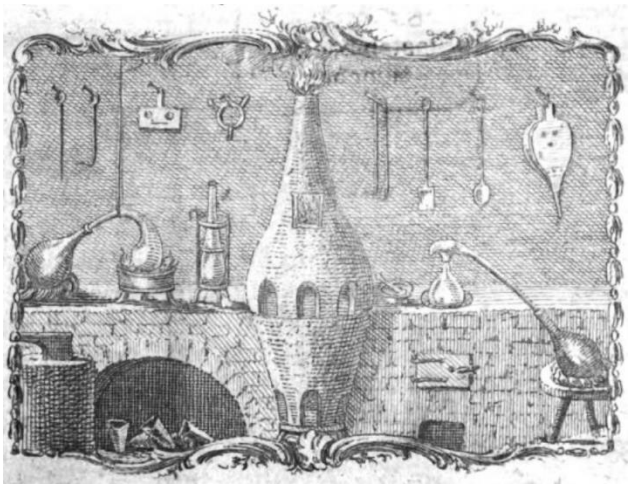
The discovery of oxygen is associated with three different scientists:

1. Carl Wilhelm Scheele (1742-1786)
2. Joseph Priestley (1733-1804)
3. Antoine Laurent de Lavoisier (1743–1794)

Carl Wilhelm Scheele

Engraving by unknown author, - CC_BY_SA-4.0 International, via Wikimedia Commons
Date 1780

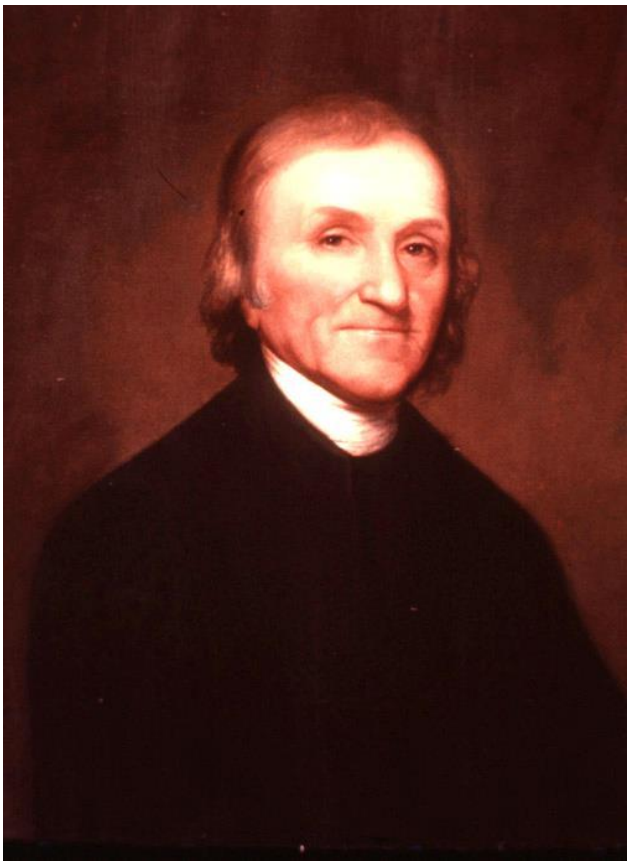
Carl Wilhelm Scheele (1742-1786) was a Swedish-German pharmaceutical chemist who experimented extensively with metals, gases, organic compounds, and acids. He used simple instruments that were borrowed or improvised from equipment in his pharmacy.



Scheele's Laboratory
Engraving from the title page of Scheele's, *Chemische Abhandlung von der Luft und dem Feuer (Chemical Treatise on Air and Fire)* (1777), - PD, via Wikimedia Commons

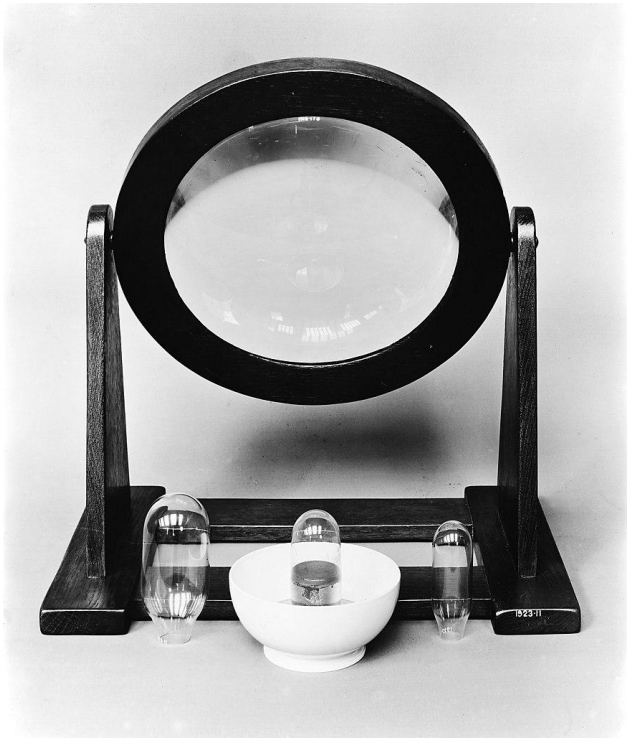
Scheele achieved the distinction of not only being the first person to prepare oxygen (1771), but he also identified several other chemical elements: barium (1772), chlorine (1774), manganese (1774), molybdenum (1779), and tungsten (1781). He produced oxygen by heating a variety of substances that included mercuric oxide, potassium nitrate, silver carbonate, manganese nitrate, and manganese oxide. He named the gas "Feuerluft" (fire-air) since it produced sparks when it came into contact with charcoal dust.

Unfortunately, Scheele was slow to report these results which appeared in his book, *Chemische Abhandlung von der Luft und dem Feuer (Chemical Treatise on Air and Fire), published in 1777*.



Joseph Priestley
Rembrandt Peale (1779-1860) painting, - PD, via Wikimedia Commons
Portrait circa 1801, Courtesy of the American Philosophical Society Library

In 1774, English chemist Joseph Priestley (1733-1804) independently discovered that a gas was released by heating red mercuric oxide.



Priestley's Apparatus for Producing Oxygen
Wellcome Library, London photo, - copyrighted work available under CC_BY_SA-4.-0 International, via Wikimedia Commons
Priestley used a large lens to focus sunlight and heat an enclosed sample of mercuric oxide.

Priestley noted that this gas caused a candle to burn more intensely and called it "dephlogisticated air". He was the first person to publish the discovery which appeared in the second volume of his work, *Experiments and Observations on Different Kinds of Air* (1776). As a result, Priestley is widely recognized as the discoverer of oxygen.

Antoine-Laurent de Lavoisier
Engraving by unknown author, - PD, via Wikimedia Commons
Date 1877

Antoine-Laurent de Lavoisier (1743-1794) was a French chemist who studied combustion and the weight changes association with calcination. Lavoisier is credited for naming the element "oxygen" (1778) which is derived from the Greek words for "acid-former". (Note that he also named hydrogen, recognizing its role as the "water-former" and challenging the view of water as an element.)

It should be noted that he was aware of the research efforts of Scheele and Priestley. In September 1774, Scheele wrote a letter to Lavoisier explaining how he in 1771 had generated a new gas by heating certain metallic compounds. Scheele indicated that

he was unable to reconcile this finding with phlogiston theory and asked Lavoisier to repeat the experiment and help him explain it. Lavoisier never answered his letter, but the evidence of the correspondence was uncovered in 1993 (Severinghaus, 2016).

While visiting Paris in October 1774, Priestley described his method of preparing oxygen to Lavoisier. Later, in the spring of 1775, Lavoisier began experimenting with the new gas.

In 1789, Lavoisier published his ground-breaking work, *Traité élémentaire de chimie* (*Elementary Treatise on Chemistry*), which is considered the first modern chemistry textbook. The book described 33 substances as elements (23 correspond to modern elements), but it also included the statement:

"This species of air was discovered almost at the same time by Mr. Priestley, Mr. Scheele, and myself"

Priestley and others accused Lavoisier of plagiarism in claiming discoveries that were made by other scientists. (Severinghuas, 2016).

Oxide Minerals

Shifting from the history of oxygen's discovery, we'll now examine the mineralogy of oxygen. As shown in the following chart, oxygen is the most abundant element in the Earth's crust:

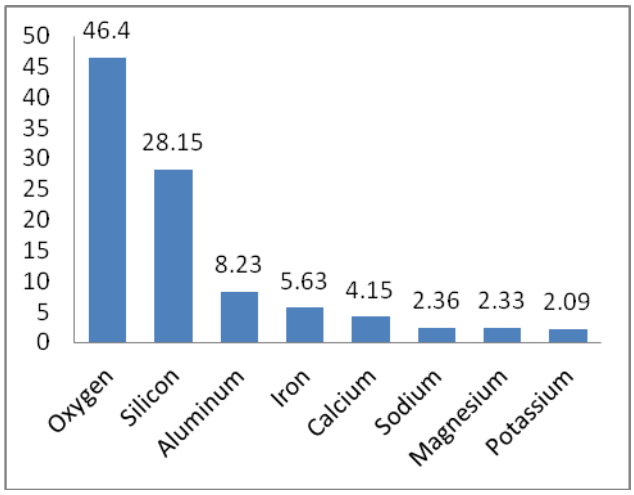


Figure 1 Major Chemical Elements in the Earth's Crust (Weight %)[1]

This abundance is reflected in the composition of minerals. Of the 6,006 minerals currently approved by the International Mineralogical Association (IMA), oxygen is present in 4,874 species.

Minerals have traditionally been classified by their chemical composition. The major classes along with their key elements are listed in the table below.

Mineral Class	Key Elements	Number of IMA-approved Minerals
Native elements	Single elements	35
Arsenates	(AsO_4)	398
Borates	(BO_3) or (BO_4)	98
Carbonates	(CO_3)	383
Chromates	(CrO_4)	23
Halides	F, Cl, Br, I	900
Hydroxides	(OH)	2,261

[1] Based on Table 17. CRC Practical Handbook of Physical Properties of Rocks and Minerals. R.S. Carmichael (ed.), 1989, p. 30.

Molybdates	(MoO_4)	22
Nitrates	(NO_3)	20
Phosphates	(PO_4)	655
Silicates	Si, O	1,633
Sulfates	(SO_4)	617
Sulfides	S	444
Sulfosalts	As, Sb	64
Tungstates	(WO_4)	14
Vanadates	(VO_4)	85
Oxides	**O**	**687**

Note that some minerals may be counted in several classes since their composition includes several key elements while dominant anions or anionic groups were not considered. The oxides, however represent minerals that involve the oxygen anion (O^{2-}) bonded to one or more metallic elements, but exclude complex anion groups, such as CO_3 or SO_4.

Oxide minerals may be divided into simple oxides, which contain a single metal cation, and binary oxides, which include two different cations. Depending on the valence states of the cations, the chemical formulas of simple oxides may have the forms, XO, XO_2, or X_2O_3, while many binary oxides may be expressed by forms, such as XYO_3 and XY_2O_4. (X and Y denote cations involving either different elements or an element with different valence states.) Some notable examples of the different forms will be presented in the following section.

Oxide minerals may also be considered as ionic crystals where oxygen anions and metal cations are held together primarily by ionic bonds. The oxygen atoms are arranged in frameworks that involve either cubic or hexagonal close packing. The cations occupy either octahedral or tetrahedral sites within these frameworks. This leads to cubic or rhombohedral crystals as shown in the examples.

XO Form

Many oxide minerals have the XO form since a wide variety of divalent cations bond with oxygen.

- Periclase (MgO)
  Periclase is a rare occurrence in the Earth's crust, but since the mineral is stable at high temperature and pressure it is a major constituent of the lower mantle (approximately 25% by volume) (Cordier et al., 2023). Since its magnesium cations occupy only octahedral lattice sites, the monoxide has a cubic crystal structure similar to that of halite. The type locality is Monte Somma of Italy's famous Somma-Vesuvius volcanic complex. Italian mineralogist Arcangelo Scacchi (1810-1893), who studied the lava flows of Mount Somma, described the magnesium oxide in 1841. The name is derived from the Greek words *peri* for "around" and *klasis* for "fracture" and refers to the mineral's perfect cleavage.

Periclase Var. Ferropericlase
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
San Vito quarry, Monte Somma, Somma-Vesuvius Complex, Naples Province, Campania, Italy
8.2 x 6.4 x 2.4 cm

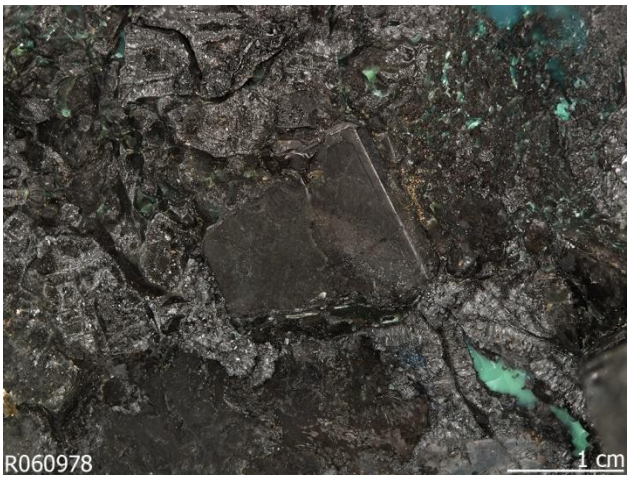
This sample features tiny, lustrous, grayish-green crystals of ferropericlase, an iron-rich variety. Note that periclase forms a solid solution series with wüstite (FeO).

- Montroydite (HgO)
  Montroydite is the mineral form of mercuric oxide which played a key role in the discovery of oxygen. The mineral may have a deep red to brown color and has an orthorhombic crystal structure. It was found in 1903 in the Terlingua Mining District, Texas and named in honor of Montroyd Sharpe (1861-), an owner of the Terlingua mercury deposit.

Montroydite
Marko Burkhardt photo, - CC_BY_SA-3.0, via Wikimedia Commons
Socrates Mine, Castle Rock Springs area, Sonoma County, California
Field of view: 5.6 mm

- Tenorite (CuO)
  Tenorite is one of three copper oxides. It forms monoclinic crystals that may be gray or black. The cupric oxide was originally called melaconite, but in 1962 the IMA changed the name to tenorite to honor Michele Tenore (1780-1861), an Italian botanist at the University of Naples, Naples, Italy. Mount Vesuvius is the type locality, and a description of the mineral was first published in 1842 by Italian botanist M. S. Semmola.

Tenorite Labeled As "Melaconite"
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Copper Harbor, Keweenaw County, Michigan
26.3 x 23.9 x 6.0 cm
This basketball-sized hemispherical specimen reflects the rich deposits that were found in the Copper Harbor area. Over 23 metric tons of "black oxide" copper ore were produced after the 1832 discovery of some boulders containing tenorite.



Tenorite with Chrysocolla
RRUFF project specimen and photo
Algomah, Michigan

- Zincite (ZnO)
  Zincite was originally found at the well-known Franklin and Sterling Mines in New Jersey. The mineral occurs in a variety of colors ranging from red, orange, yellow, white, and green. Crystals are hexagonal.
  The zinc oxide was called a variety of names until it was renamed zincite in 1845 by Austrian mineralogist Wilhelm Karl von Haidinger (1795-1871).

Zincite
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Sterling Mine, Sterling Hill, Ogdensburg, New Jersey
2.1 x 1.3 x 0.7 cm

X_2O Form

Since the X_2O form involves bonding with monovalent cations, there are only two known minerals – cuprite and ice.

- Cuprite (Cu_2O)
  Cuprite is a secondary mineral which forms in the oxidized zone of copper sulfide deposits. Due to internal reflections, the mineral may appear dark red and is known as "ruby copper". It forms isometric crystals. Wilhelm Karl von Haidinger described the copper oxide in 1845, and its name is based on the Latin word *cuprum* for "copper".

Cuprite
Parent Géry photo, - CC_BY_SA-3.0, via Wikimedia Commons
Ray Mine, Pinal County, Arizona
This specimen features both cubic and octahedral cuprite crystals.

Cuprite Var. Chalcotrichite
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Cole Mine, Bisbee, Warren District, Cochise County, Arizona
11.4 x 10.1 x 5.6 cm

Cuprite exhibiting an acicular habit is called a varietal name, chalcotrichite.

- Ice (H_2O)
  Ice forms colorless to white hexagonal crystals. The name is from Old English, *īs*, for "ice".

Ice Crystals
W. Carter photo, - CC_BY_SA-4.0 International, via Wikimedia Commons
Tuntorp, Brastad, Lysekil Municipality, Sweden

XO_2 Form

Oxide minerals with the XO_2 form involve bonding with tetravalent cations. These minerals represent important sources of tin, manganese, and uranium.

- Cassiterite (SnO_2)
  Cassiterite is a primary ore of tin that occurs in hydrothermal veins and pegmatites and as alluvial deposits. It may be black, yellow, brown, red, or white and forms tetragonal crystals. The origin of the name may be from *Cassiterides* referring to islands off the western coast of Europe; from the Greek word *kassiteros* for "tin"; or from *Kassites*, an ethnic group originating in west and central Iran. Although known since the early Bronze Age, the mineral was formally described by French mineralogist François Beudant (1787-1850) in 1832.

Cassiterite
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Vilocao Mine, Loayza Province, La Paz, Bolivia
4.9 x 3.4 x 3.4 cm

Cassiterite Var. "Wood Tin"

Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Durango, Mexico
5.0 x 4.9 x 3.3 cm
The botryoidal form of cassiterite with concentric banding may be called the varietal name, “wood tin”.

- Pyrolusite (MnO_2)
  Pyrolusite is a common manganese mineral, but its tetragonal crystals are uncommon. The manganese oxide usually occurs as black or dark gray powdery to fibrous crusts or as botryoidal aggregates. It forms under highly oxidizing conditions in manganese-bearing hydrothermal deposits and under shallow marine conditions. Haidinger named the mineral in 1827 based on the Greek for “fire” and “to wash” due to use in removing tints in glass making.

Pyrolusite
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Dona Ana County, New Mexico
4.3 x 2.8 x 1.5 cm

Pyrolusite
Aram Dulyan photo, - PD, via Wikimedia Commons
Tres Cruzes, Brazil
Natural History Museum, London specimen

- Ramsdellite (MnO_2)
  Ramsdellite is an orthorhombic polymorph of manganese dioxide. It is a secondary mineral found in manganese deposits and has a steel-gray to iron-black color. The mineral may occur as crystals, plates, fibers, or massive aggregates. The type locality is Lake Valley Mining District, Sierra County, New Mexico. Ramsdellite is named in honor of American mineralogist and University of Michigan professor Lewis S. Ramsdell (1895-1975) who first described the mineral in 1932.

Ramsdellite
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Mistake Mine, Box Canyon District, Yavapai County, Arizona

3.2 x 2.6 x 1.6 cm

- Rutile (TiO_2)
  Rutile is an accessory mineral that forms under high pressure and temperature in igneous and metamorphic rocks. It has a tetragonal crystal structure and is the most common form of naturally occurring titanium dioxide. The range of colors includes blood red, brownish yellow, brown-red, yellow, greyish-black, brown, bluish, or violet. The name is from the Latin word *rutilus* for "red", and was introduced by German geologist Abraham Gottlob Werner (1749-1817) in 1803. The type locality Horcajuelo de la Sierra, Community of Madrid, Spain.

Rutile
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Diamantina, Minas Gerais, Brazil
2.5 x 2 x 0.3 cm

Rutile
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Graves Mountain, Lincoln County, Georgia
4.6 x 4.6 x 2.7 cm

Rutile and Hematite
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Novo Horizonte, Bahia, Brazil
5.9 x 4.5 x 0.6 cm

- Uraninite (UO_2)
  Uraninite is a major ore of uranium. Its isometric crystals have a structure similar to fluorite. The mineral occurs in granite and syenite pegmatites, in hydrothermal veins, and in sandstone and

conglomerates. Colors vary from steel-black to velvet black, brownish-black, pale gray, pale green, pale yellow, and deep brown. The mineral has been known since the 15th century and called various names, such as pitchblende. It was renamed in 1845 by Wilhelm Karl von Haidinger for its uranium-bearing composition.

Uraninite
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Swamp #1 quarry, Topsham, Sagadahoc County, Maine
2.7 x 2.4 x 1.4 cm

Uraninite
Weirdmeister photo, - CC_BY_SA-4.0 International, via Wikimedia Commons
Uranium Mine No. 4 (Shaft No. 4), Příbram, Central Bohemian Region, Czech Republic
Approximately 4.5 cm across

X_2O_3 Form

The X_2O_3 form involves trivalent cations combining with oxygen.

- Corundum (Al_2O_3)
  Corundum is a rock-forming mineral and has two primary gem varieties – ruby and sapphire. Ruby's red color is due to the presence of chromium, while iron and titanium produce the color of sapphire. Crystals belong to the trigonal crystal system. The mineral has been known in ancient times and by many names. In 1725, English naturalist and geologist John Woodward (1665-1728) introduced the name "corinvindum" which is derived from the Sanskrit word *kuruvinda* for "ruby". Irish geologist and chemist Richard Kirwan (1733-1812) used the current spelling "corundum" in 1794 edition of his book *Elements of Mineralogy*.

Corundum Var. Ruby
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Mogok, Mandalay Division, Myanmar
3.9 x 2.7 x 2.6 cm, crystal 1.0 cm

Corundum Var. Sapphire

Sri Lanka

1.3 x 0.4 x 0.3 cm

Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons

Hematite

Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons

Bouse, Plomosa District, La Paz County, Arizona

2.4 x 1.3 x 1.3 cm

- Hematite (Fe_2O_3)
  Hematite is an important iron ore with widespread deposits. It occurs in various forms that include silver-gray to black complex prismatic crystals; thin, tabular platy groups, often as rosettes; reddish brown botryoidal masses, and earthy concretions. Its crystals have a trigonal structure. Greek philosopher Theophratus (371-287 BCE) originally named the mineral *aematitis lithos* for "blood stone". This was later translated by Roman author and naturalist Pliny the Elder (23-79 AD) as *haematite*, "bloodlike".

Hematite

Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons

Wessels Mine, Hotazel, Kalahari manganese fields. Northern Cape Province, South Africa

4.4 x 3.5 x 2.6 cm

Hematite "Rose"
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Serra das Éguas, Brumado, Bahia, Brazil
4.1 x 3.2 x 1.3 cm

Ilmenite
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Froland, Aust-Agder, Norway
4.1 x 4.1 x 3.8 cm

Binary Oxides

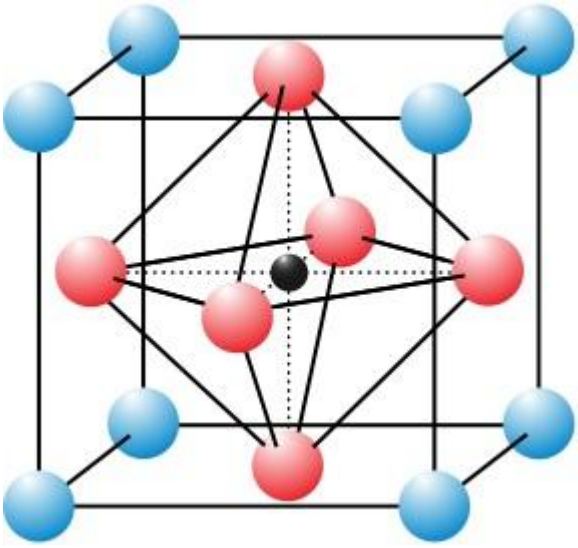
Binary oxides may involve two different cations with different valence states occupying tetrahedral or octahedral lattice sites. This complexity leads to several mineral groups that exhibit special properties of interest to researchers in the Earth sciences, electronics, and energy technology.

XYO_3 Form

- Ilmenite ($FeTiO_3$)
  Ilmenite is a common accessory mineral found in igneous rocks, such as granites, gabbros, and kimberlites, and in high-grade metamorphic rocks. The color may be iron black or gray, while crystals have a trigonal structure. German chemist and physicist Adolph Theodor Kupffer (1799-1865) named the mineral in 1827 after its type locality in the Ilmen Mountains, Russia.

- Perovskite ($CaTiO_3$)
  Perovskite is an accessory mineral found in alkaline mafic rocks. It forms orthorhombic crystals that may have an iron-black, brown, or reddish-brown to yellow color. The mineral was discovered by German mineralogist Gustav Rose (1798-1873) in 1839. It is named in honor of Count Lev Alekseevich Perovskii (1982-1856), a Russian minister and mineral collector.

  Perovskite's cubooctahedral crystal structure is occurs in a variety of other minerals and synthetic materials. This structure is the focus of research in a number of areas, such as the composition of the Earth's mantle, photovoltaic cells, and high temperature superconductors.



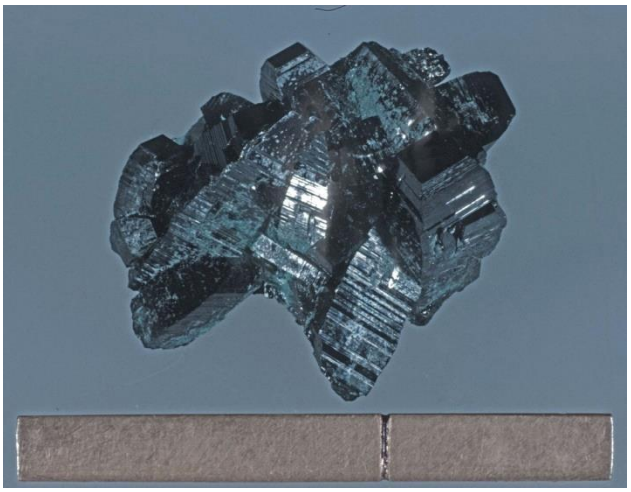
Perovskite Crystal Structure
Korjus diagram, - CC_BY_SA-3.0, via Wikimedia Commons
Cations are represented by blue and black spheres, while the red spheres correspond to oxygen atoms.

Perovskite
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Magnet Cove, Hot Spring County, Arkansas
2.3 x 2.1 x 2.0 cm, crystals 6-7 mm

Perovskite
Leon Hupperichs photo, - CC_BY_SA-3.0, via Wikimedia Commons
Rocca Sella, Almese, Susa Valley, Torino Province, Piedmont, Italy
Field of view 7 mm

$X_2Y_2O_3$ Form

- Paramelaconite ($Cu^{1+}{}_2Cu^{2+}{}_2O_3$)
  Paramelaconite is a very rare copper oxide that occurs in hydrothermal deposits. The black to purplish-black mineral has a tetragonal crystal structure. The Copper Queen Mine in Bisbee is the type locality. German mineralogist and professor George Augustus Koenig (1844-1913) described the mineral in 1891, and the name refers to its composition as being near “melaconite” (tenorite).



Paramelaconite
Rock Currier photo, - CC_BY_SA-3.0, via Wikimedia Commons
Copper Queen Mine, Bisbee, Warren District, Cochise County, Arizona
Scale is one inch with a ruling at one cm

XY_2O_4 Form

- Chromite ($Fe^{2+}Cr^{3+}{}_2O_4$)
  Chromite is the only commercial source of chromium. The color may be black to brownish black, and its crystals have a cubic structure. The mineral was originally named in 1798 *fer chromate alumina* by the discoverer of the element chromium, Louis Nicolas Vauquelin (1763-1829). In 1845, Wilhelm Haidinger renamed it chromite, alluding to its composition.

Chromite
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Hangha, Kenema District, Eastern Province, Sierra Leone
1.8 x 1.7 x 1.2 cm

- Chrysoberyl ($BeAl_2O_4$)
  Chrysoberyl occurs in some granite pegmatites and in ultramafic rocks. It may assume various shades of green, yellow, brownish to greenish black, or colorless. Crystals have an orthorhombic structure, but cyclic twinning is common which is called a trilling. The mineral was described and named by German geologist Abraham Gottlob Werner (1750-1817) in 1790. The name is derived from the Greek words *χρυσό* for "golden" and *βήρυλλος* for "beryl". The green, chromium-bearing gem variety that exhibits a strong color change from blue-green to red is known as alexandrite.

Chrysoberyl
Matteo Chinellato photo of D. Preite specimen, - CC_BY_SA-3.0, via Wikimedia Commons
Governador Valadares, Doce Valley, Minas Gerais, Brazil
7.33 mm diameter

- Magnetite ($Fe^{2+}Fe^{3+}{}_2O_4$)
  Magnetite is a common accessory mineral in igneous and metamorphic rocks and is found in extensive deposits in sedimentary banded iron formations. The mineral may be grayish black or iron black and forms isometric crystals. It was originally known as lodestone and by other names, but was renamed magnetite by Wilhelm Karl von Haidinger in 1845.

The name refers to Magnesia, Greece where lodestone was found.

Magnetite
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Cerro Huañaquino, Potosi Department, Bolivia
5.9 x 4.0 x 3.3 cm, largest crystal 1.5 cm

Magnetite
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
ZCA Mine No. 4, Balmat, St. Lawrence County, New York
11.5 x 4.6 x 4.5 cm, crystal 1.5 cm

-

- Spinel ($MgAl_2O_4$)
  Spinel forms at a high temperature and may be found in igneous rocks and metamorphosed schists or limestones. Crystals belong to the cubic system and colors range from colorless, brown, black, red, orange, yellow, green, blue, indigo, and violet. The mineral was named in 1779 by Belgian physician, geologist, and mineralogist Jean Démeste who alluded to the sharp octahedral crystals with the Latin word *spinella* for "little thorn".

Spinel
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Lu Yen, Yenbai Province, Vietnam
3.4 x 3.3 x 3.1 cm

Spinel
Rob Lavinsky, iRocks.com photo, - CC_BY_SA-3.0, via Wikimedia Commons
Kaiiado District, Rift Valley Province, Kenya
5.9 x 4.5 x 3.8 cm, largest crystal 0.6 cm

References:

Cordier, P., K. Gouriet, T. Weidner, J. Van Orman, O. Castelnau, J.M. Jackson, and P. Carrez (2023) Periclase deforms more slowly than bridgmanite under mantle conditions. *Nature* 613: 303-307.

Severinghaus, J.W. (2016) Eight sages over five centuries share oxygen's discovery. *Advances in Physiology Education* 40: 370-376.

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Photosynthesis
From Wikipedia

Jan Ingenhousz (Fellowship of the Royal Society) (Born 8 December 1730 – Died 7 September 1799) was a Dutch-born British physiologist, biologist and chemist.

He is best known for discovering photosynthesis by showing that light is essential to the process by which green plants absorb carbon dioxide and release oxygen. In the 1770s Ingenhousz became interested in gaseous exchanges of plants. He did this after meeting the scientist Joseph Priestley (1733–1804) at his house in Birstall, West Yorkshire, on 23 May 1771. Priestley had found out that plants make and absorb gases.

Facts about Oxygen

Who knew?
By Stephanie Pappas, Live Science Contributor

- As a gas, oxygen is clear. But as a liquid, it's pale blue.
- If you've ever wondered what swimming in a pool of liquid oxygen would be like, the answer is: very, very cold, according to Carl Zorn of the Thomas Jefferson National Accelerator Facility. Oxygen must get down to minus 297.3 F (minus 183.0 C) to liquefy, so frostbite would be a problem.
- Too little oxygen is problematic. So is too much. Breathing 80 percent oxygen for more than 12 hours irritates the respiratory tract and can eventually cause deadly fluid build-up, or edema, according to the University of Florida and the company Air Products.
- Oxygen is one tough cookie: A 2012 study published in the journal Physical Review Letters found than an oxygen molecule (O2) can survive pressures 19 million times higher than atmospheric pressure.
- The lowest levels of oxygen ever recorded in human blood were measured near the summit of Mount Everest in 2009. Climbers had arterial oxygen levels of 3.28 kilopascals on average. Compare that to the normal value of 12 to 14 kilopascals, and the mountaineering term "death zone" makes plenty of sense. The findings were published in the New England Journal of Medicine.
- Thank goodness for an atmosphere of 21 percent oxygen. About 300 million years ago, when oxygen levels reached 35 percent, insects were able to grow super-large: Think dragonflies with the wingspans of hawks.

Arizona Rocks 130

Text by Ray Grant
Photos by Jeff Scovil

One of the minerals found in the oxide zones discussed in the last month's Arizona Rocks is copper, sometimes referred to as native copper. It is somewhat unusual to find it in the oxide zone since it is not an oxide mineral. It is found low in the oxide zone near the water table and it is deposited when the copper bearing solutions react with iron and the more chemically active iron displaces copper from solution causing it to precipitate in elemental form. There is a commercial use of this process where copper rich solutions are put in a vat with steel cans and the copper forms from the solutions.

Because Arizona is the nation's leading producer of copper, it is appropriate that copper is the Arizona State Metal. Many of the very best copper specimens found in the world are from Arizona.

Copper crystals, Ray Mine, Pinal County, Arizona

Copper in Gypsum. Mission Mine, Santa Cruz County, Arizona

Campbellite, a lapidary material named after the Campbell Mine in Bisbee, It is a mixture of copper, cuprite, and other copper minerals.

AZ Mining, Mineral & Natural Resources Education Museum Update March 2024

https://ammnre.arizona.edu/

Catie Carter Sandoval
cscarter@email.arizona.edu
703.577.6449

Help support the museum at:
http://tinyurl.com/SupportMM-NREMuseum

Our museum's new Executive Director Marta Bones has been rapidly getting up to speed over the past few weeks. Marta is learning everything she needs to know about the museum's history and wealth of assets, including the building, mineral collection, and network of supporters. She has met with several members of our Governor-Appointed Advisory Council as well as volunteers and stakeholders. Both Catie and Marta recently attended 'Mining Day at the Capitol,' hosted by the Arizona Mining Association, which is a fun event that connects the public to mining companies and individuals in the industry. Mining Day is a fantastic opportunity to learn more about Arizona's mining history as well as technological advances in modern-day mining. We had a great time and look forward to next year.

Meanwhile, we were invited to give a presentation about the museum to the Sun City Rockhound Club at their March meeting. Thank you to the Rockhound Club for their generous fundraising support during the meeting. The club hosted a silent auction and donated the profits to our University of Arizona Foundation account. Thank you Sun City Rockhounds!

April is a busy month with school outreach activities, Advisory Council meetings, and continued strategic planning under new Director Marta. Thank you all for your continued support of the museum.

Catie and Marta in front of an Empire CAT 988 XE Wheel Loader at the 2024 Mining Day at the Capitol

Silent Auction (left) at the Sun City Rockhound Club meeting, raising funds for the museum.

Sun City Rockhounds President Cheryl (left) and Vice President Carol (right) in front of our guest display at the Sun City Rockhound Mineral Museum, located at the Sundial Recreation Center.

Pinal Museum and Society News

351 N. Arizona Blvd., Coolidge, AZ

Pinal Geology and Mineral Society next meeting

April 17, 2024

Meetings are the third Wednesday at 7pm, doors open at 6:30

Everyone is welcome!

www.pinalgeologymuseum.org

Ray Grant ray@pinalgeologymuseum.org

Through May, we will have our hours of 10 to 4 Wednesday through Saturday, admission is free.

The Pinal Geology and Mineral Society's April 17th meeting program will be presented by Richard Sichling, vice president.

"Geology and Unusual Mineral Pseudomorphs of the Verde Valley"

This will be followed by a Saturday trip to collect the pseudomorphs.

Sun City Rockhound Mineral Museum
Sundial Recreation Center
14801 N. 103RD Ave.
Sun City, AZ 85351
scrockmuseum@gmail.com
623-428-6442

C. Sandoval photo

Winter Hours
October – April
10 am to 1 pm
Closed Thurs., & Sunday
Summer Hours
May-September 10am-1pm
Saturdays only

Sun City Rockhound Club Support of Local Organization

By: Carol Bankert-George, Sun City Rockhound Club & Museum Vice President

As part of our mission statement, to provide educational opportunities through our club and museum, a recent donation was made to a local organization. The board unanimously voted to donate from the Sun City Mineral Museum unidentified stones (possibly tools), pottery and possible arrowheads that had been donated over the years to the club.

Peter Huegel a frequent guest speaker at Rockhound monthly meetings is a board member of Study of Ancient Lifeways and Technologies organization. The group is known as SALT for short. He has been interacting with the Sun City Rockhounds through guest presentations in recent years on local petroglyphs, (including tours of the Deer Valley Petroglyph Preserve), native plants and native animals. The SALT group's primary focus is to understand, practice and share life skills and arts of the ancient world. They accomplish these goals through educational public events and skills meetings.

The Rockhound club and museum have forged a kinship through Peter, with the SALT organization. Over the last few months Rockhound board members have attended SALT meetings to ensure the proposed donation would go to an organization that aligns with our educational mission. They will also be able to correctly identify and use these items in education programs and have a committee already in place to do so. The SALT group will soon be celebrating 25 years. Monthly they meet at the S'edav Va'aki Museum (formally known as the Pueblo Grande Museum) in downtown Phoenix, on the 3rd Saturday of the Month. We highly recommend attending one of their informative and interactive monthly meeting.

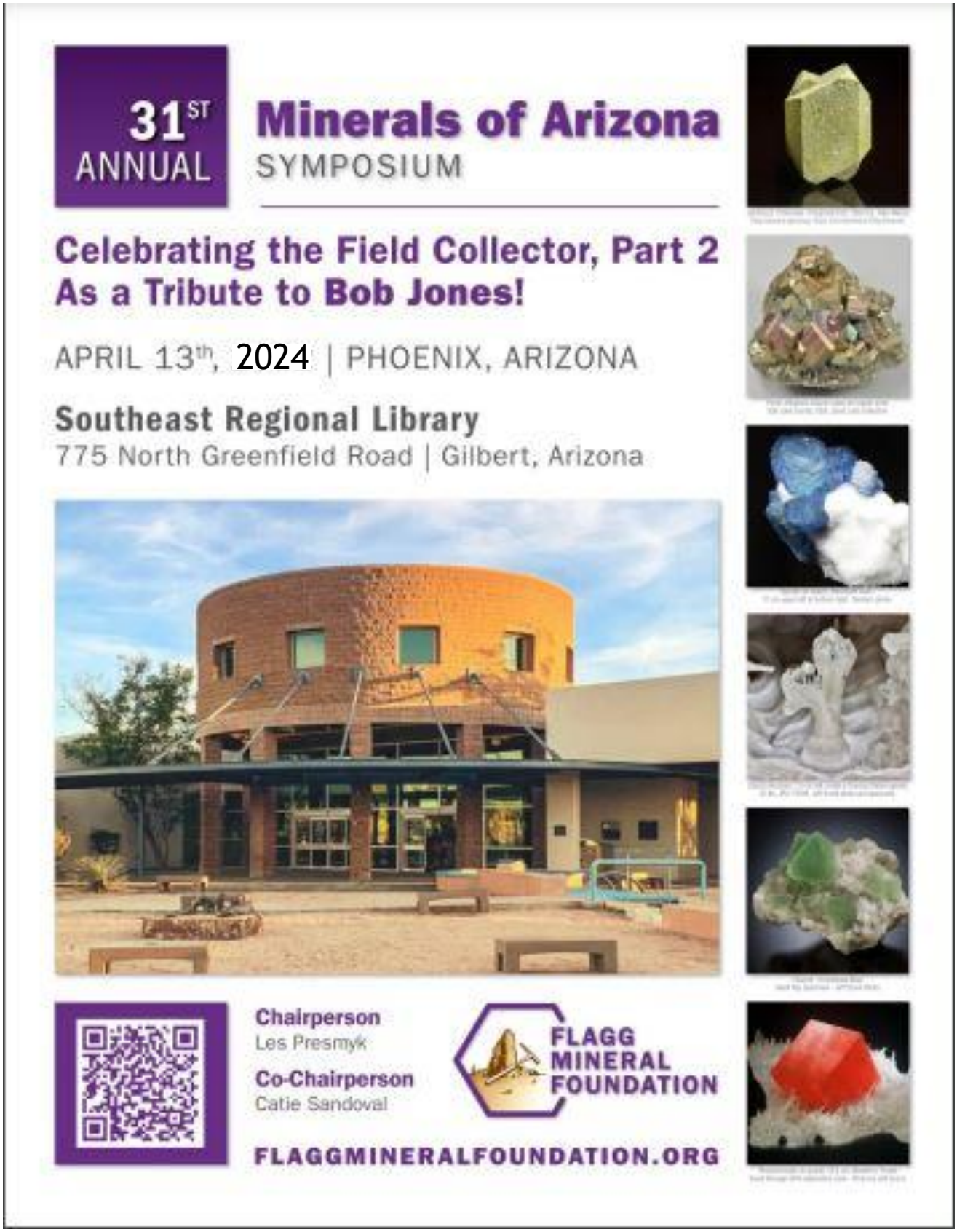
SCRC, Board Members Carol Bankert-George, Debra Carlone and club member Sue Treadwell presented the donated items on Saturday February 17th, at SALT's monthly board meeting. For more information on the SALT organization check them out at www.saltskills.com.

SALT Board Members Charlie and Tamara Tadano, Bob and Carol Sizemore, Jennifer Ahumada, Laura Robins, Gary Alves and Peter Huegel

Deb Carlone, Carol Bankert-George, Susan Treadwell pictured with SALT Board Member Peter Huegel

Find us on: Facebook: Sun City Rockhounds

Arizona Rock and Gem Shows




The 4th
PHOENIX HERITAGE
MINERAL SHOW
Largest, Quality
Mineral Show in
the Phoenix Area!
FLUORITE with Barite
Ana Mine, Berbes, Ribadesella, Asturias, Spain
6.5cm – Nick McClure Collection – Jeff Scovil Photo
MINERALOGICAL SOCIETY OF ARIZONA
Café & Bar: Open - 4pm
Admission:
CASH ONLY – ATM Available
• $5.00 Adults
• $3.00 MSA Members
• FREE 12 years & younger with paying adult
• FREE Parking during show
msaaz.org
JUNE 1st & 2nd 2024
PHOENIX SHRINE AUDITORIUM
552 N 40th STREET • PHOENIX, AZ 85008
Saturday 9am - 5pm | Sunday 10am - 4pm
Featuring: Minerals, Competitive and Guest Exhibits
Saturday Night: Dinner, Talk, Awards and Auctions!

Apache Junction Rock & Gem Club
Meetings are on the 2nd Thursday
Next Meeting: April 11, 2024, 6:30 pm
www.ajrockclub.com
@ Club Lapidary Shop
2151 W. Superstition Blvd., Apache Jct.

Daisy Mountain Rock & Mineral Club
Meetings are on the 1st Tuesday
(unless a Holiday then 2nd Tuesday)
Next Meeting: April 2, 2024, 6:30 p.m.
Please go to their website for more info
www.dmrmc.com
@ Anthem Civic Building
3701 W. Anthem Way, Anthem, AZ

Maricopa Lapidary Society, Inc
Note: New meeting day
Meetings are on the 3rd Tuesday
Next Meeting: April 16, 2024, 7:00 pm
www.maricopalapidarysociety.com
@ North Mountain Visitor Center
12950 N. 7th St., Phoenix, AZ

Mineralogical Society of Arizona
Meetings are on the 3rd Thursday
(Except December & June)
April 18, 2024, 7:30 pm
Franciscan Renewal Center, (Piper Hall)
5802 E. Lincoln Drive, Scottsdale
www.msaaz.org

Pinal Geology & Mineral Society
Meetings are on the 3rd Wednesday
Next Meeting: April 17, 2024, 7:00 pm
In person meeting
www.pinalgeologymuseum.org
351 N. Arizona Blvd., Coolidge

West Valley Rock & Mineral Club
Meetings are on the 2nd Tuesday
Next Meeting: April 9, 2024, 6:30 pm
www.westvalleyrockandmineralclub.com
@ Buckeye Community Veterans Service Center
402 E. Narramore Avenue, Buckeye, AZ

Gila County Gem & Mineral Society
Meetings are on the 1st Thursday
(unless a Holiday then the next Thursday)
Next Meeting: April 4, 2024, 6:30 pm
www.gilagem.org
Club Building
413 Live Oak St, Miami, AZ

Wickenburg Gem & Mineral Society
Meetings are on the 2nd Friday
(February & December on the 1st Friday)
Next Meeting: April 12, 2024, 7:00 pm
www.wickenburggms.org
@ Coffinger Park Banquet Room
175 E. Swilling St., Wickenburg

ESM's Meeting Notice

ESM's next meeting will be at North Mountain Visitor Center, 12950 N. 7th St., Phoenix, on Tuesday, TBA 2024, at 6:30 p.m.

BECOME A MEMBER!
Join the Earth Science Museum's

esi: Earth Science Investigation team

IS IT TIME TO RENEW YOUR MEMBERSHIP?
Please renew today! ☺☺☺

MANY THANKS TO OUR MAJOR DONORS!

AZ Leaverite Rock & Gem Society

Flagg Mineral Foundation
www.flaggmineralfoundation.org

Friends of the AZ Mining & Mineral Museum

Maricopa Lapidary Society
http://maricopalapidarysociety.com/

Mineralogical Society of AZ
www.msaaz.org

Payson Rimstones Rock Club

Sossaman Middle School

White Mountain Gem & Mineral Club
www.whitemountain-azrockclub.org

Wickenburg Gem & Mineral Society
http://www.wickenburggms.org
www.facebook.com/pages/Wickenburg-Gem-and-Mineral-Society/111216602326438

West Valley Rock and Mineral Club
http://www.westvalleyrockandmineralclub.com/

Staples Foundation
www.staplesfoundation.org

Anita Aiston
Peter & Judy Ambelang
Stan & Susan Celestian
Russ Hart
Will & Carol McDonald
Debbie Michalowski
Janet Stoeppelmann
Dennis & Georgia Zeutenhorst

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ESM Earth Science Investigation Team Membership Form

_____ New Member _____ Renewal

Membership levels:

_____ ESI Family $20

_____ ESI Individual $10

Membership benefits:

- Monthly e-newsletter *Earthquake*
- Official team membership card
- Knowledge that your contribution is making a difference in earth science education.

_ _ _ _ _ _ _ _ cut here _ _ _ _ _ _ _ _ _

Name: _____

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Phone:
602-973-4291

Editor E-Mail:
scote@earthsciencemuseum.org

We're on the Web!

Visit us at:

www.earthsciencemuseum.org

Mission
Our Mission is to excite and inspire all generations about earth sciences through educational outreach.

Vision
We envision a community where students and the general public have curiosity about, passion for, and understanding of the underlying principles of earth sciences.

For more information about the ESM, how to become a member or how to arrange for a school visit or Community function, go to: www.earthsciencemuseum.org.

NOTICE:
ESM's next meeting will be at North Mountain Visitor Center, 12950 N 7th St, Phoenix, on Tuesday, TBA 2024, at 6:30 p.m.

THANK YOU FOR YOUR CONTINUING INTEREST & SUPPORT!!!

Earth Science Museum
3215 W. Bethany Home Rd.
Phoenix, AZ 85017