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

I have been working with Dr. Ray Grant to have ESM support the egg carton program at the Pinal Geology and Mineral Museum. The in-house set-up with bowls of attractive rocks, minerals, and crystals allows for groups and individuals to make their own egg-carton collection for $1:00 as part of their visit to the museum.

The initial trial was very successful and I am now going through my material and filling jars. In addition, I will be giving their program some needed egg cartons. The in-house egg carton program is already a success and ESM will have Ray and Cynthia visit my rock shop in Apache Junction to identify any other materials they could use.

While at the museum, check out their new exhibits on geologic time covering Precambrian, Paleozoic, Mesozoic and Cenozoic; and one on crystal systems.

A couple of the geologic time displays

A sampling of the crystal systems display

Year of Mineralogy Starts in 2022

By Harvey Jong

The International Mineralogical Association (IMA) announced that a yearlong celebration of mineralogy will start in 2022. The event will be officially launched at the IMA's 23rd General Meeting in July 2022 in Lyon, France. Some goals of the worldwide celebration include:

- to generate public interest for the science of matter and how it underpins most innovations and developments in modern society
- to attract young people to science through the fascination of natural crystals
- to illustrate the universality of science
- to intensify the emergence of mineralogical societies in developing countries
- to foster international collaboration between scientists worldwide
- to promote education and research in mineralogy, crystallography and their links to other sciences
- to increase public awareness of the importance of natural resources

In addition to highlighting the importance of mineralogy, the event will honor the bicentennial of two key mineralogical milestones - the death of the famous French mineralogist René Just Haüy (1743-1822) and the publication of his *Traité de cristallographie (Treatise on Crystallography)*.

René Just Haüy (1743-1822)

Portrait by Ambroise Tardieu (1788-1841) – PD, via Wikimedia Commons

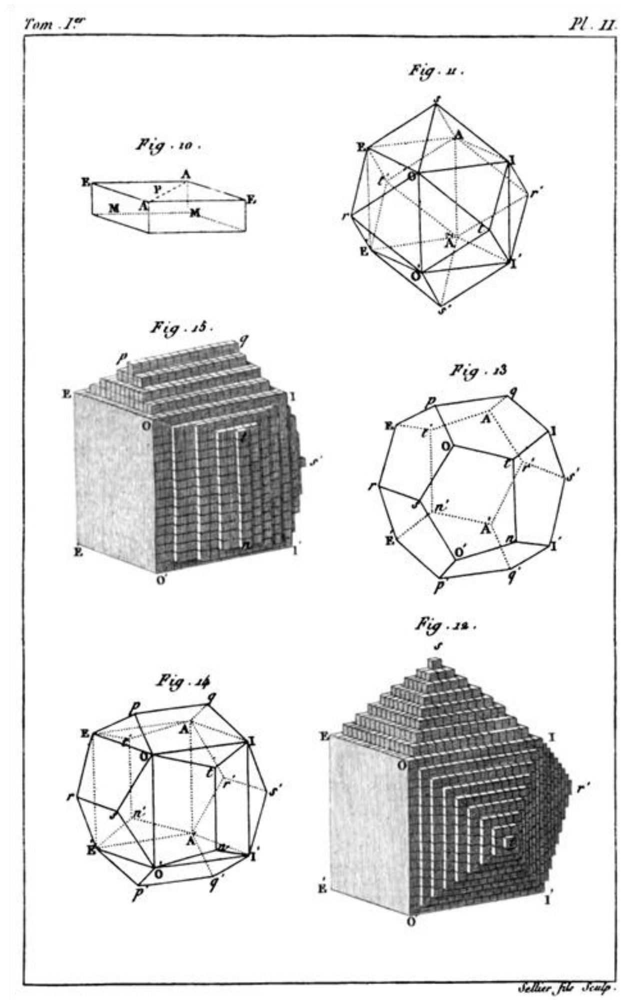
For his theories on crystal structure and formation, René Just Haüy is often referred to as the "father of modern crystallography". Haüy was a French priest and mineralogist born in 1743 at Saint-Just-en-Chaussée in the province of Île-de-France. He studied theology at the Collège de Navarre in Paris and was ordained as a Roman Catholic priest in 1770. He was a teacher at the Collège du Cardinal-Lemonine, but in 1793 he decided to focus on mineralogical studies. In 1795, Haüy was appointed an instructor of physics and mineralogy at the École des Mines (School of Mines). He would later assume the post of professor of mineralogy (1802) at the Muséum d'Historie Naturelle (Musuem of Natural History) and chair of mineralogy

(1809) at the Sorbonne. He served in these positions until his death in 1822.

Haüy's interest in crystallography apparently started when he examined a broken calcite crystal in the collection of Jacques de France de Croisset. (Some accounts indicate that Haüy dropped the specimen and caused it to break.) He was intrigued by the perfect cleavage and later wrote in his *Traité de minéralogie (Treatise of Mineralogy)*:

"The observation I have just noted is that which has served to develop my ideas on the structure of crystals. It presented itself in the case of a crystal that the citizen Defrance was kind enough to give me just after it had broken off from a group this enlightened amateur was showing me, and which formed part of his mineralogical collection. The prism had a single fracture along one of the edges of the base, by which it had been attached to the rest of the group. Instead of placing it in the collection I was then forming, I tried to divide it in other directions, and I succeeded, after several attempts, in extracting its rhomboid nucleus."

Haüy found that every mineral has a unique crystal structure that can be used in its identification and classification. He deduced that the shape of crystals involved a basic "unit cell" (which he called an integral molecule) and how these unit cells stacked together to form larger crystals. Haüy proposed that the stacking is governed by a law of rational indices (or intercepts) which states that a mineral's crystal face along a crystallographic axis will be intercepted by a simple, constant whole number of unit cells.



Haüy's Crystal Diagrams
Diagrams from Haüy's *Traité* élémentaire de physique, 1803, Vol. 1 – PD, via Wikimedia Commons
The diagrams show the stacking of "integral molecules" to form crystals.

As part of his *Treatise on Mineralogy*, he assembled an atlas with almost 600 diagrams of various crystal structures that he identified. In addition, he commissioned a set of pearwood models to depict the three-dimensional form of each crystal. With the publication of his treatise, Haüy announced that the wooden models would also be sold. He didn't, however, realize the time and effort involved in producing the models. A goniometer had to be used in carving the precise angles that Haüy insisted for each model. Only six sets were made in two and a half years, and only two of these collections have survived.

Quartz Crystal Model
Photo by Teylers Museum – CC-BY-SA-3.0 Netherlands, via Wikimedia Commons
One of the 597 pearwood crystal models commissioned by René Haüy.

New Mineral Discoveries Over Time

One of the key contributions of mineralogy involves the discovery of new mineral species. As of March 2022, the number of official IMA-approved mineral species stands at 5,794. To celebrate the year of mineralogy, I thought it might be interesting to explore how the number of minerals has increased from Haüy's time to the present day.

The starting point for this analysis is the IMA's master list of approved and grandfathered (i.e. inherited from before 1960) minerals which can be downloaded from the following web address:

http://cnmnc.main.jp/imalist.htm

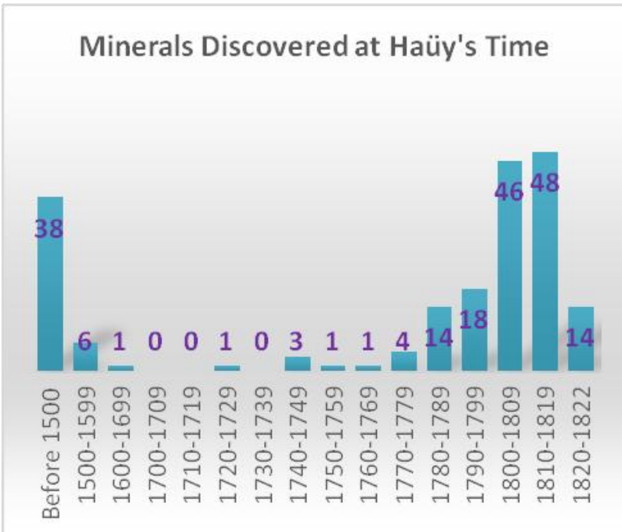
This list is also available as an online database at the rruff.info website:

https://rruff.info/ima/

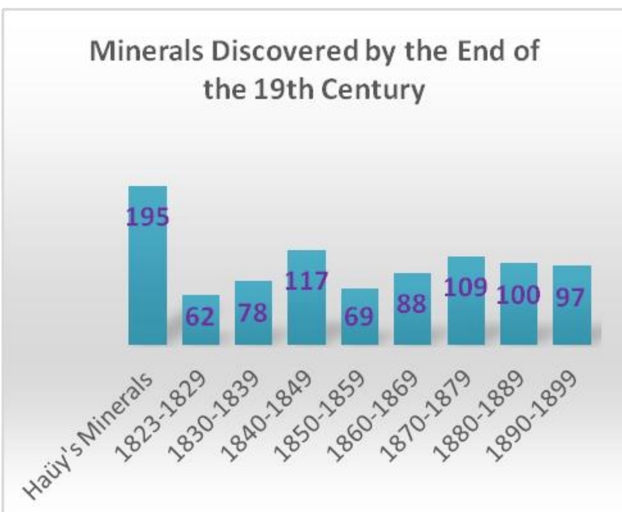
This database currently indicates that there are 5,780 IMA approved minerals and provides a variety of export options (Note that the discrepancy [5,780 vs 5,794] is due to referencing the earlier January 2022 master list). One option involves the "year first published" which will be treated as the date of a mineral's discovery. It should be noted that the IMA has rather strict requirements about publishing the description of approved minerals (Nickel and Grice, 1998). Many of the "grandfathered" minerals may not have a known reference with complete information, so either no year or the year of a publication deemed to have most of the necessary details may be associated with these species.

Minerals have been studied since ancient times by Greek, Chinese, Persian, and other philosophers. The scientific study in a modern sense, however, is attributed to the early 16th century writings of German scientist Georgius Agricola. His works, *De veteribus et novis metallis* (1546) and *De re metallica* (1556), along with instruments, such as the microscope, provided the foundation for finding new minerals.

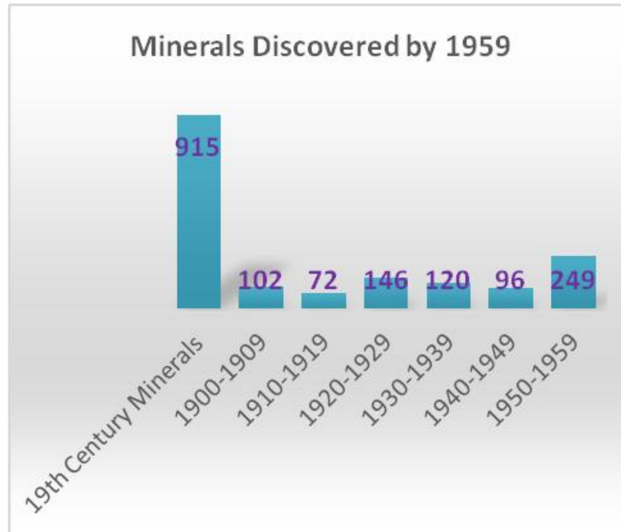
By Haüy's time, the number of valid mineral species had reached 195. As depicted in the following chart, a significant number of these minerals were discovered during his lifetime when interest in mineralogical studies started to develop.



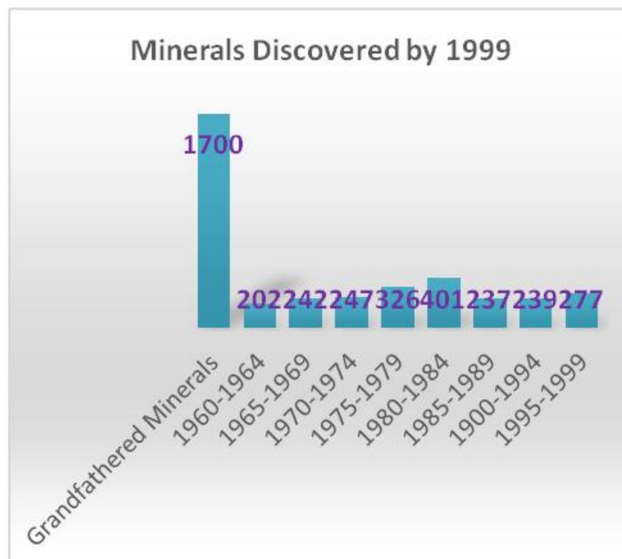
Driven by the Industrial Revolution and associated mining activity, steady progress in finding new minerals occurred. By the end of the 19th century, the number of valid minerals had increased to 915.



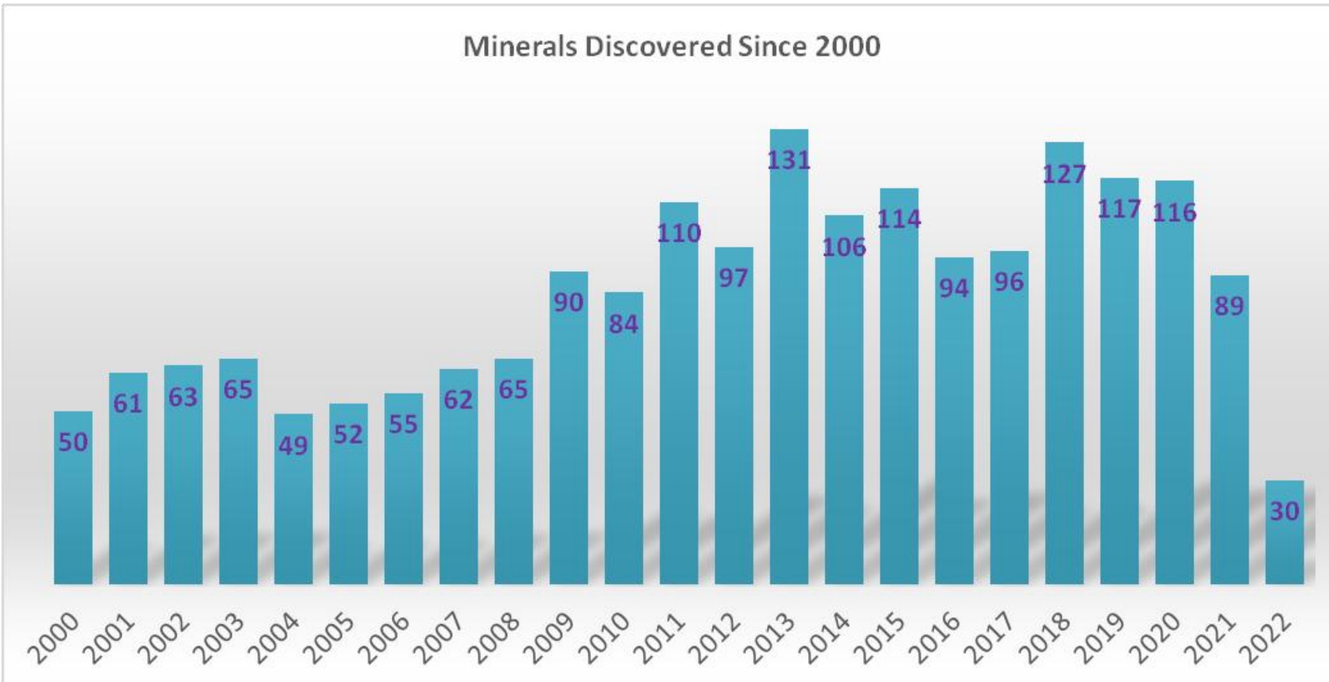
The pace of mineral discoveries continued through the first half of the 20th century, but the rate started to accelerate in the 1950s. The number of valid minerals expanded to 1,700. These minerals are assigned a "grandfathered" approval status since they predate the founding of the IMA.



The rate of mineral discoveries has been boosted by advances in analytical tools. At the end of the 20th century, the list of valid minerals more than doubled reaching 3,871.



Current mineralogical research seems to lead to the discovery of about a hundred new minerals each year. An additional 1,923 minerals have been found since the year 2000 which brings the total number of approved minerals to 5,794.



References:

Nickel, E.H. and J.D. Grice (1998) The IMA commission on new minerals and mineral names: procedures and guidelines on mineral nomenclature, 1998. *The Canadian Mineralogist* 36: 913-926.

Haüyne

Haüyne is a rare aluminosilicate sulfate that usually occurs in low-silica igneous rocks, such as lava flows. The mineral was first found in 1803 at Lake Nemi in the Italian Latium region and tentatively named latialite by Carlo Giuseppe Gismondi. Gismondi, however, did not formally publish his findings, and in 1807 Danish mineralogist Tønnes Christian Bruun de Neergaard named the mineral, haüyne, in honor of René Just Haüy.

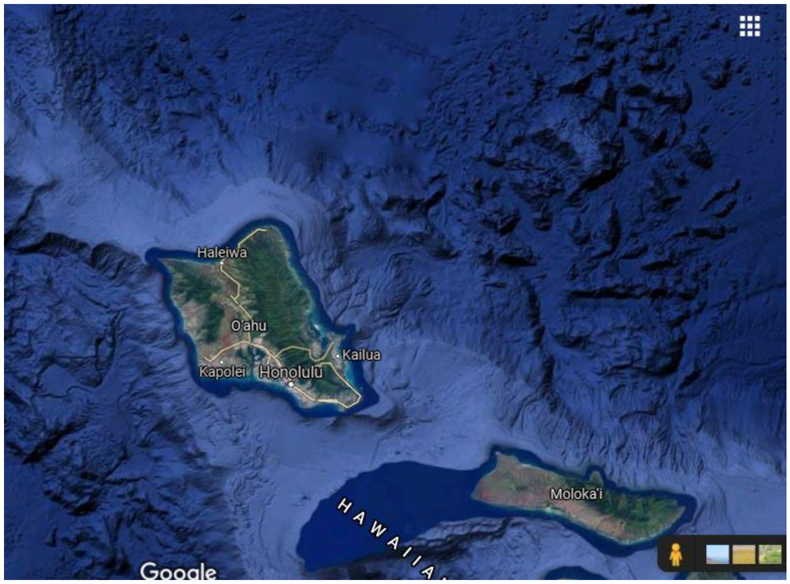
Haüyne is a member of the sodalite mineral group and has been mentioned as forming a solid solution series with lazurite. Haüyne is defined as a sulfate dominant end member, while lazurite is the sulfide-rich member.

The analysis of many lazurite specimens, however, indicates that they are just sulfide-bearing haüyne. Haüyne is noted for its vibrant blue color and has been used as a gemstone.

Haüyne
Photo by Rob Lavinsky, iRocks.com – CC-BY-SA-3.0, via Wikimedia Commons
Mayen, Mayen-Koblenz District, Germany
Dimensions: 1.1 x 0.9 x 0.8 cm

MBARI Monterey Bay Aquarium Research Institute
A nonprofit oceanographic research center

Hawaiian landslides



Hawaiian landslides have been catastrophic

Volcanic activity and gentle erosion have not been the only forces to shape the Hawaiian Islands. Landslide debris has now been mapped off of all the islands. Enormous amounts of material have traveled great distances, indicating that the slides were truly catastrophic. The Nuuanu and Wailau landslides, shown in the map, tore the volcanoes forming eastern Oahu and northern Molokai, respectively, in half, and deposited blocks large enough to have been given names as seamounts. Tsunamis generated during these slides would have been devastating around the entire Pacific Basin. (See the coral reefs page for evidence that an enormous tsunami hit the shores of Lanai.)

IMPROVEMENTS IN MAPPING LANDSLIDES

OAHU, MOLOKAI – The development of ideas on the giant Hawaiian landslides parallels improvements in the technology of bathymetric mapping and navigation. The landslides were first recognized in the 1960s in a relatively detailed U.S. Navy single-beam sonar survey utilizing an improved radio navigation system. The GLORIA multibeam side-scan sonar system (1980s) imaged unprecedented detail in the known landslides and revealed numerous other undiscovered ones. The JAMSTEC multibeam surveys (late 1990s), utilizing GPS navigation, produced detailed maps of the entire landslide area for the first time.

Reference: J.G. Moore and D.A. Clague (2002) Mapping the Nuuanu and Wailau landslides in Hawaii, In: *Hawaiian Volcanoes: Deep Underwater Perspectives*, E. Takahashi, P.W. Lipman, M.O. Garcia, J. Naka, and S. Aramaki (eds), *Geophysical Monograph 128*, American Geophysical Union, 223-244.

Our research on Hawaiian landslides

MAUNA LOA'S UNSTABLE WESTERN FLANK

MAUNA LOA – Four new remotely operated vehicle dives carried out by Monterey Bay Aquarium Research Institute (MBARI) reveal a heterogeneous distribution of lithologies and compositions along a transect across the submarine west flank of Mauna Loa, from the outer scarp of the frontal bench to the upper flank. The frontal bench is composed predominantly of volcaniclastic sediments, ranging from very fine-grained monomictic hyaloclastites to coarse-grained, compositionally mixed volcaniclastic breccias. The predominance of subaerially derived clasts suggests accumulations of landslide deposits, probably emplaced along a regional shear plane preserved in cataclastic breccias with local foliations and grain trails. Repeated packages of inversely graded strata are interpreted to reflect thrust imbrication of the resulting volcaniclastic apron during volcanic spreading of Mauna Loa's western flank, similar to that now documented along Kilauea's south flank. Many of the rocks from the bench show evidence for alteration, ranging from low-grade burial diagenesis to higher-grade hydrothermal alteration, including phases never before observed in submarine Hawaiian rocks, including epidote, talc, sphene, and corrensite. Alteration is concentrated in deformed zones, denoting pathways for fluid flow into or out of the volcanic edifice. Formed at depth, the altered rocks were subsequently transported along low-angle thrust faults into the bench and exposed along high-angle fractures and faults. The upper submarine flanks are draped by subaerially erupted, submarine emplaced pillow lavas and interbedded hyaloclastites, generated by shoreline-crossing lava flows. Basalt glasses indicate Mauna Loa origin but imply earlier compositions than present-day lavas, consistent with Ar-Ar ages suggesting eruption 0.28 ± 0.10 Ma. Late stage detachment of a near shore slump produced the ʻĀlika 2 debris avalanche that broke through the frontal bench, perhaps portending the evolution of the active Hilina slump now present on Kilauea volcano's south flank.

Reference: Morgan, J.K., D.A. Clague, D.C. Borchers, A.S. Davis, and K.L. Milliken (2007) Mauna Loa's submarine western flank: Landsliding, deep volcanic spreading, and hydrothermal alteration, *Geochem. Geophys. Geosyst.*, 8, Q05002, doi:10.1029/2006GC001420.

SPREADING OF MAUNA LOA'S FLANK

MAUNA LOA – A transect of four ROV *Tiburon* dives across the submarine west flank of Mauna Loa volcano yields compelling evidence for volcanic spreading and associated hydrothermal circulation during volcano growth. A frontal bench at the toe of the flank, formerly thought to be a down dropped block of Mauna Loa, contains a mix of volcaniclastic lithologies, including distally derived siltstone, mudstone, and hyaloclastite. The bench is overlain by bedded gravels and subaerially erupted pillow flows derived from local shoreline-crossing lava flows. The volcaniclastic strata in the bench were off scraped, uplifted, and accreted to the edge of the flank, as it plowed seaward into the surrounding moat. The accreted strata underwent significant diagenesis, through deep burial and circulation of hydrothermal fluids expelled from porous sediments beneath the volcano. Timing constraints for bench growth and breakup suggest that catastrophic failure of the subaerial edifice ca. 250–200 ka triggered volcanic spreading by reducing stresses resisting basal sliding and rift-zone inflation. Increased eruptive activity, and westward migration of Mauna Loa's southwest rift zone, gradually rebuilt the massive flank, arresting slip prior to detachment of the Alika 2 debris avalanche ca. 120 ka.

Reference: J.K. Morgan and D.A. Clague (2003) Volcanic spreading on Mauna Loa volcano, Hawaii: Evidence from accretion, alteration, and exhumation of volcaniclastic sediments. *Geology:* Vol. 31, No. 5, pp. 411-414. doi: Geologic history of Wai'anae Volcano

OAHU – Wai'anae Volcano comprises the western half of O'ahu Island, but until recently little was known about the submarine portion of this volcano. Seven submersible dives conducted in 2001 and 2002, and multibeam bathymetry offshore of Wai'anae provide evidence pertaining to the overall growth of the volcano's edifice as well as the timing of collapses that formed the Wai'anae slump complex.

A prominent slope break at ~1400 meters below sea level marks the paleoshoreline of Wai'anae at the end of its shield-building stage and wraps around Ka'ena Ridge, suggesting that this may have been an extension of Wai'anae's northwest rift zone. Subaerially erupted tholeiitic lavas were collected from a small shield along the crest of Ka'ena Ridge now submerged. To the south, tholeiitic pillow lavas have been recovered 65 km from the volcano's center, indicating the south rift zone extended at least this distance. Sediment cores collected from north of Ka'ena Ridge contain pelagic sediment with volcaniclastic grains and volcanic glass that originated from Wai'anae's post shield stage and eastern Oahu's Ko'olau Volcano's shield stage, respectively.

Multiple collapses and deformation events occurred during and after the shield stage, resulting in compound mass wasting features on the volcano's southwest flank, the Wai'anae slump complex. This slump complex is the largest in Hawai'i, covering an area of ~5500 km^2. It is composed of several distinct sections based on morphology and lithologies of collected samples. The outer bench of the slump complex contains tholeiites that correlate with subaerial lavas erupted early during the volcano's shield stage, from 3.9 to 3.5 million years ago (Ma), and probably formed during and shortly after the early shield stage. To the southwest of the outer bench lies a broad debris field of subaerially derived volcaniclastic rocks containing tholeiites with early shield compositions, interpreted to have formed by a catastrophic collapse event that breached the outer bench. The breach may have then been filled by slumping material from the main volcanic edifice. Finally, on top of the northern main body of the slump is a rotated landslide block that detached from the proximal part of the Ka'ena Ridge after the volcano's late shield stage (3.2 to 3.0 Ma), containing higher alkali rocks that correlate with late shield-stage subaerial lavas. None of the slump complex samples correlate with alkalic subaerial post shield lavas.

Reference: M.L. Coombs, D.A. Clague, G.F. Moore, B.L. Cousens (2004) Growth and collapse of Waianae Volcano, Hawaii, as revealed by exploration of its submarine flanks, *Geochemistry*, *Geophysics*, *Geosystems*, 5(8), Q08006. doi: 10.1029/2004GC000717.

SLOPE FAILURE ON KILAUEA'S SUBMARINE SOUTH FLANK

KILAUEA – Observations along the submarine south flank of Kilauea volcano have revealed the subsurface structure of active submarine slope failure and the remnants of an ancient landslide. New multichannel reflection data and high-resolution bathymetry provide this evidence, and suggest a dynamic interplay among slope failure, regrowth, and volcanic spreading. Disrupted strata along the upper reaches of Kilauea's flank denote a coherent slump, correlated with the active Hilina fault zone on land. The slump comprises mostly slope sediments, underlain by a detachment 3-5 km (1.8 – 3.1 mi) deep. Extension and subsidence along the upper flank is compensated by uplift and folding of the slump toe, which surfaces about midway down the submarine flank. Uplift of strata forming Papa'u seamount and offset of surface features along the western boundary of Kilauea indicate that the slump has been displaced ~3km in a south-southeast direction. This trajectory matches coseismic and continuous ground displacements for the Hilina slump block on land, and contrasts with the southeast vergence of the rest of the creeping south flank. To the northeast, slope sediments are thinned and disrupted within a recessed region of the central flank due to catastrophic slope failure in the recent past. Debris from the collapsed flank was shed into the moat in front of Kilauea, building an extensive apron. Seaward sliding of Kilauea's flank off scraped these deposits to build an extensive frontal bench. A broad basin formed behind the bench and above the embayed flank. Uplift and back tilting of young basin fill indicate recent, and possibly ongoing, bench growth. The Hilina slump now impinges upon the frontal bench; this buttress may tend to reduce the likelihood of future catastrophic detachment.

Reference: J.K. Morgan, G.F. Moore, and D.A. Clague (2003) Slope failure and volcanic spreading along the submarine south flank of Kilauea volcano, Hawaii, *Journal of Geophysical Research*, 108(B9): 2415.

CONDITIONS FOR LANDSLIDES AND CANYON FORMATION

MOLOKAI – The main break-in-slope on the northern submarine flank of Molokai at 1500 to 1250m depth is a shoreline feature that has been slightly modified by the Wailau landslide. Submarine canyons above the break-in-slope were subaerially carved. Where such canyons cross the break-in-slope, plunge pools may form by erosion from bedload carried down the canyons.

West Molokai Volcano's continued infrequent eruptions formed a series of small coastal sea cliffs, now submerged, as the island subsided. Lavas exposed at the break-in-slope are subaerially erupted and emplaced tholeiitic shield lavas. Submarine rejuvenated-stage volcanic cones formed after the landslide took place and following at least 400-500m of subsidence after the main break-in-slope had formed. The sea cliff on east Molokai is not the headwall of the landslide, nor did it form entirely by erosion. It may mark the location of a listric fault similar to the Hilina faults on present-day Kilauea Volcano. The Wailau landslide occurred about 1.5 Ma and the Kalaupapa Peninsula most likely formed 330 ±5ka. At their peak, West and East Molokai stood 1.6 and 3 km above sea level.

High rainfall causes high surface runoff and formation of canyons, and increases groundwater pressure that during dike intrusions may lead to flank failure. Active shield or postshield volcanism (with dikes injected along rift zones) and high rainfall appear to be two components needed to trigger the deep-seated giant Hawaiian landslides.

Reference: D.A. Clague and J.G. Moore (2002) The proximal part of the giant submarine Wailau landslide, Molokai, Hawaii, *Journal of Volcanology and Geothermal Research*, 113: 259-287.
doi: 10.1016/S0377-0273(01)00261-X.

VOLCANICLASTIC ROCKS ON THE FLANKS OF LANDSLIDE BLOCKS

OAHU, MOLOKAI – The rocks exposed on the steep slopes of giant landslide blocks in the Nuuanu and Wailau landslides are fragmental rocks: hyaloclastite and volcaniclastic breccias. They form as 1) secondary slope mantling of unlithified breccia consisting of clasts in a mud matrix; 2) hyaloclastite and breccia, all with zeolite cement, that form downslope of the shoreline where lava flows enter the sea and fragment; and 3) breccia formed by tectonic fragmentation of glassy submarine-erupted pillow basalt. Lavas erupted from single volcanoes are highly variable in major-element composition, even during their tholeiitic shield stage, making it difficult to identify which landslide block was derived from which volcano. Low-temperature fluids circulate through the fragmental deposits on the flanks of the volcanoes, partially altering the glass to palagonite and cementing the volcaniclastic rocks with Na- and K-rich zeolites. Spreading of the volcano early in its history along low-angle thrust faults laterally transports deep submarine pillow lava into the flank of the volcano where it crops out as tectonic breccia. The faults underlying the landslide blocks are within this tectonized core of the volcano, not simply within the shallow slope deposits of hyaloclastite and breccia. The Nuuanu landslide predates the 1.5 Ma Wailau landslide.

Reference: D.A. Clague, J.G. Moore, and A.S. Davis (2002) Volcanic breccia and hyaloclastite in blocks from the Nuuanu and Wailau landslides, Hawaii, In: *Hawaiian Volcanoes: Deep Underwater Perspectives*, E. Takahashi, P.W. Lipman, M.O. Garcia, J. Naka, and S. Aramaki (eds), *Geophysical Monograph 128*, American Geophysical Union, 279-296.

AZ Mining, Mineral & Natural Resources Education Museum Update April 2022

https://ammnre.arizona.edu/

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

On Tuesday, March 1st, Monday Crew leader and stamp millman Charlie Connell passed away. For decades, Charlie led volunteer groups at the AZ Mining and Mineral Museum and later the AMMNRE Museum. He is responsible for acquiring, maintaining, and restoring much of the museum's outdoor mining equipment, including the Swallow Mine 5-Stamp Mill and the Boras Headframe. Charlie put in thousands of hours of volunteer time at the museum, in addition to his efforts at other Arizona museums and around the country. His blog, 'Restoring Historical Mining Equipment,' reached readers across the world, sparking interest in restoring their own stamp mills. While he was an expert in historical mining equipment, Charlie was always willing to help in any way possible and be a positive force for the museum and its supporters.

On April 2nd, the millmen, led by Bill Yedowitz, ran a full demonstration of the museum's mining equipment in Charlie's honor for attendees at the Flagg Mineral Foundation's Minerals of Arizona Symposium. The demonstration was accompanied by a display of Charlie's artifacts and awards inside the Copper Gallery, on loan from his wife Kathy.

Charlie's knowledge, generosity and work ethic were unmatched and we will miss him terribly. We are so very thankful for Charlie's many years of service and friendship. The museum will continue to honor his legacy through our Monday Crew volunteer program.

Below is Charlie's official biography, courtesy of Kathy Connell.

Charlie was born on July 29, 1947 in Albany, NY. His family home was in Voorheesville, NY. Charlie's father was a sheet metal worker for the railroad and at a very young age Charlie began working with tools which lead him to learn about sandblasting, metal and wood working, painting, staining, and wood preservation. He also developed a love for chemistry which led to performing adventurous experiments in the basement of the family home and worrying family members about him blowing up the house.

Charlie graduated high school in 1965 and went on to attend the Junior College of Albany, graduating in 1967. During this time Charlie needed a car to get to school. Being Chevy people, the family went to a local Chevy dealer where his mother saw a car that she thought would be a good size car for young Charlie and bought it. Charlie was very lucky that his mother was only worried about the size of the car, so Charlie became the proud owner of a 1967 Camaro.

Charlie then went on to a four-year college but dropped out a few months later because he could not concentrate on his studies due to the activities of fellow students in the dormitory. Charlie went on to join the Navy as they offered him the ability to work with chemistry. Charlie was claustrophobic but ended up serving as a submariner. After his 6 years in the Navy, he began working at the

Indian Point Nuclear Generating Station in Peekskill, NY. While working at the station, he earned his B.A. degree from Iona College.

Charlie and his daughter suffered from allergy problems, and he decided to move to Arizona for a better climate. He was offered a job at Palo Verde Nuclear Generating Station by Arizona Public Service where he worked in Start-Up, Fire Protection, and Quality Assurance.

Charlie joined the Arizona Prospectors Association which met at the Arizona Mining and Mineral Museum. When the museum moved to 1502 W. Washington, Charlie began volunteering in 1993. Soon members from APA joined Charlie in volunteering and they became the Monday Crew. One day while in the basement of the museum Charlie saw various machine parts and did not know what they were used for. He inquired about them and learned that they were the parts of a historic stamp mill. For Charlie, a future Millman and Millwright was born and for all of us, the rest is history.

Charlie was the heart and soul of the mining equipment displays at the Arizona Mining, Mineral and Natural Resources Education Museum and other mining museums around Arizona and other states. His knowledge of historic mining and milling equipment was extraordinary and he was an exceptional teacher to all.

Charlie with the Swallow Mine 5-Stamp Mill

Charlie presenting an award to a volunteer

Part of Charlie's memorial display, includes his signature 'MILLMAN' license plate

Charlie's memorial display in the Copper Gallery

Arizona Rocks 107

Text and photos by Ray Grant

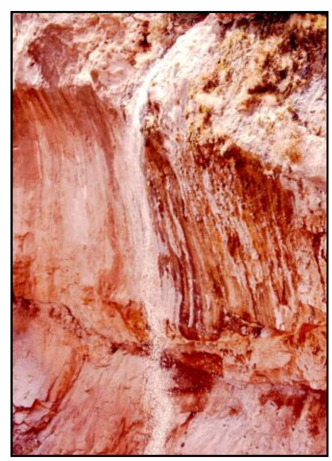
It's getting hotter in southern Arizona and if you are headed for cooler temperatures, make a stop at the Tonto Natural Bridge State Park. It is on Route 260 about 12 miles north of Payson on the way to Pine. It has been in the Earthquake newsletter previously but not in Arizona Rocks. The bridge is unique as it is made of travertine, calcium carbonate (calcite) deposited by a spring.

Ground water flowing through limestone dissolves the calcite and when it gets to the surface and evaporates, the calcite is deposited as travertine. In the past especially during the ice age it was much wetter in Arizona and the increased volume of water is responsible for the large travertine deposit. The travertine filled in the canyon and made a dam on Pine Creek. Eventually the creek eroded a tunnel under the travertine dam forming the bridge.

The Tonto Natural Bridge is claimed to be the largest travertine bridge in the world. It is 183 feet high, and the tunnel underneath is 400 feet long and 150 feet wide. For more information about trails, hours, and cost go to the website: https://azstateparks.com/tonto/.

The top of the travertine dam filling in Pine Creek Canyon, the bridge is under this flat surface.

When I made my first trip to the park there was a series of ladders that you could climb to a small cave at the top. Of course such things are too dangerous now. Note people at bottom of big ladder for scale.



Tunnel under the travertine, you can see the flow lines formed when the travertine was deposited.

There is still a small flow of spring water over the top of the bridge, but it does not appear to be depositing any travertine.

Pinal Museum and Society News

351 N. Arizona Blvd., Coolidge, AZ

Pinal Geology and Mineral Society meeting

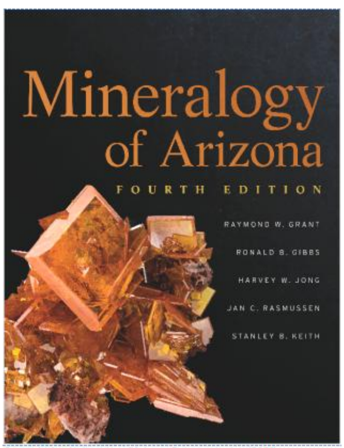
May 18 2022

www.pinalgeologymuseum.org

Ray Grant raycyn@cox.net.

The Pinal Geology & Mineral Museum will be open from 10 to 3 on Friday for June, July, and August.

Masks are now optional at the Museum. Please bring your own mask if you wish to wear one. We will have some masks on hand at the Museum, but cannot guarantee to provide them.



Cover design University of Arizona Press, copyright 2021

The University of Arizona Alfie Norville Gem & Mineral Museum, and the University of Arizona Press invite you to celebrate the publication of *Mineralogy of Arizona, Fourth Edition*.

When: Saturday, June 25, 11 a.m.-3 p.m. at the Alfie Norville Gem & Mineral Museum, 115 N Church Ave., Ste 121, Tucson.

Authors will be in the museum auditorium to answer all your mineralogy questions, and sign books, which will be available for purchase.

This fourth edition covers the 992 minerals found in Arizona, showcased with breathtaking new color photographs throughout the book. The new edition includes more than 200 new species not reported in the third edition and previously unknown in Arizona. Chapters cover gemstones and lapidary materials, fluorescent minerals, and an impressive catalog of mineral species. The authors also discuss mineral districts, including information about the geology, mineralogy, and age of mineral occurrences throughout the state. The book includes detailed maps of each county, showing the boundaries and characteristics of the mineral districts present in the state.

Parent/Teacher Resource Pages

HTTPS://WWW.EARTHSCIWEEK.ORG/NEWSLETTER

EARTH SCIENCE WEEK UPDATE
April 2022

Earth Science Week 2022 Contests Spark Education

For this year's Earth Science Week (October 9-15, 2022), AGI is sponsoring four contests focusing on the theme of this year's celebration, "Earth Science for a Sustainable World." The 2022 competitions will feature video, photography, visual arts, and essay contests:

- Teams and individuals of any age are invited to submit brief videos that tell viewers about "Striving for Sustainability Globally."
- The photo contest, also open to all ages, asks participants to show "Sustainability in Action" in their communities.
- Open to students in grades K-5, the visual arts contest encourages children to depict "Our Sustainable World."
- Finally, students in grades 6-9 are eligible to enter the essay contest, "Geoscience for Sustainable Development Goals."

For all contests, entries may be submitted any time from now to the Friday of Earth Science Week, October 14, 2022. These contests allow both students and the general public to participate in the celebration, learn about Earth science, and compete for prizes. The first-place prize for each contest is $300 and an AGI publication. Learn more at Earth Science Week Contests.

GLOBE Observer: Link to Oceans, Soil, Air, More

Want to get involved in a global citizen science project? Through the Global Learning and Observations to Benefit the Environment (GLOBE) program, you can take part in GLOBE Observer, an international network of professional scientists and citizen scientists collaborating to promote education about environment and climate.

On the GLOBE Observer website, you'll find teaching activities and resources on soil, air, oceans, weather, and other topics. For example, Mosquito Habitat Mapper provides materials on mosquito prevention and control, such as a guide to retrieving precipitation data, an educational activity, and lists of resources to learn more about properly identifying and eliminating potential mosquito breeding sites.

GLOBE Observer invites you to make environmental observations that complement NASA satellite observations to help scientists studying Earth and the global environment. By using the GLOBE Observer app, you are joining the GLOBE community and contributing important scientific data to NASA and GLOBE, your local community, and students and scientists worldwide.

To begin, all you need to do is download the GLOBE Observer app and use it to observe the environment wherever you are. Visit GLOBE online for more information.

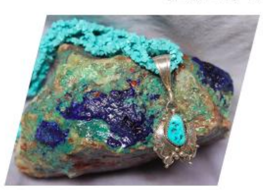
knowledge by reading GSA publications or attending a GSA Annual Meeting or Section Meeting. Watch for opportunities both online and in-person at the October 2022 GSA Annual Meeting.

Mohave County Gemstoners
Annual Gem and Mineral Show
May 7-8, 2022
Sat. 9-5, Sun. 9-4
Kingman Academy of Learning
3420 N. Burbank St. 86409
Kingman, AZ
Free Admission
Plenty of Parking

White Mountain Gem
and Mineral Annual Show
July 9-10, 2022
Sat. 9-5, Sun. 10-
Adults $2.00
Juniors 18 and under with Student ID
Free when accompanied by an adult
Elks Lodge
805 E. Whipple Street
Show Low, Arizona
www.whitemountain-azrockclub.com

48th ANNUAL HUACHUCA MINERAL, GEM, AND JEWELRY SHOW

8th AND 9th OCTOBER 2022
2200 EL MERCADO LOOP,
SIERRA VISTA, AZ
For Information;
Contact Maudie Bailey, gmbailey@msn.com,
520 249-1541



ALL ARIZONA CLUB MEETINGS MAY BE CANCELED DUE TO HEALTH CONCERNS!

Apache Junction Rock & Gem Club
Meetings are on the 2nd Thursday
Next Meeting: May 12, 2022, 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: May 3, 2022, 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
Meetings are on the 1st Monday
(unless a Holiday then 2nd Monday)
Next Meeting: May 2, 2022, 7:00 pm
www.maricopalapidarysociety.com
@ North Mountain Visitor Center
12950 N. 7th St., Phoenix

Mineralogical Society of Arizona
Meetings are on the 3rd Thursday
Next Meeting: May 19, 2022, 7:30 pm
Please go to their website for more info
www.msaaz.org
@ Franciscan Renewal Center
Room: Padre Serra
5802 E. Lincoln Dr., Scottsdale

Pinal Geology & Mineral Society
Meetings are on the 3rd Wednesday
Next Meeting: May 18, 2022, 7:00 pm
On YouTube until further notice
www.pinalgeologymuseum.org
@ Artisan Village
351 N. Arizona Blvd., Coolidge

West Valley Rock & Mineral Club
Meetings are on the 2nd Tuesday
Next Meeting: May 10, 2022, 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: May 5, 2022, 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: May 13, 2022, 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 2022, at 6:30 p.m.

BECOME A MEMBER!
Join the Earth Science Museum's

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

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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.

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

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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Name: ______________________________

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Mail form & payment to: Earth Science Museum
3215 W. Bethany Home Rd., Phoenix, AZ 85017

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

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 2022, at 6:30 p.m.

THANK YOU FOR YOUR CONTINUING INTEREST & SUPPORT!!!

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