

June 2011 Mineral of the Month: Aegirine

This month we shine the spotlight on aegirine, a single-chain inosilicate from a classic locality in Africa's Great Rift Valley. Our write-up explains the mineralogy of aegirine, the geology of rifts, and why the source of our specimens may be the world's most dangerous collecting locality!

OVERVIEW

PHYSICAL PROPERTIES

Chemistry: $\text{NaFeSi}_2\text{O}_6$ Sodium Iron Silicate, usually containing varying amounts of aluminum, titanium, vanadium, and chromium.

Class: Silicates

Subclass: Inosilicates (Single-chain Inosilicates)

Group: Jadeite

Crystal System: Monoclinic

Crystal Habits: Usually as tapered, prismatic crystals with prominent, longitudinal striations and blunt-to-steep, pointed, pyramidal terminations; often as sprays of needle-like crystals, radial concretions, and haystack-like aggregates; also granular, compact, and fibrous.

Color: Usually black, greenish-black, or brownish-black; occasionally reddish-brown.

Luster: Vitreous, sometimes slightly resinous.

Transparency: Usually opaque, occasionally translucent on thin edges.

Streak: Gray to yellowish-gray

Cleavage: Perfect in two directions at nearly right angles

Fracture: Hackly and uneven; brittle.

Hardness: 6.0-6.5

Specific Gravity: 3.5-3.6

Luminescence: None

Refractive Index: 1.778-1.839

Distinctive Features and Tests: Best field marks are black, greenish-black, and brownish-black colors; tapered, prismatic crystals with pointed, pyramidal terminations; and frequent occurrence in nepheline syenite pegmatites. Can be confused with augite [calcium sodium magnesium iron aluminum titanium oxysilicate, $[\text{Ca},\text{Na}](\text{Mg},\text{Fe},\text{Al},\text{Ti})(\text{Si},\text{Al})_2\text{O}_6$], which is softer and forms shorter prisms; and with schorl [tourmaline group, basic sodium aluminum iron borosilicate, $\text{NaFe}_3\text{Al}_6(\text{BO}_3)_3(\text{Si}_6\text{O}_{18})(\text{OH})_4$], which is softer and forms hexagonal crystals.

Dana Classification Number: 65.1.3c.2

NAME The name "aegirine," pronounced AGE-er-een, is derived from Ægir, god of the sea and king of all sea creatures in Norse mythology. Until 1988, the names "aegirine" and "acmite" were used interchangeably. Aegirine has also been known as "achmite," "acnite," "aegerine," "agirine," "aegerite," "aegirite," "jadeite-aegirine," and "soda-aegirine." A titanium-rich variety is called "titanoan aegirine"; "vanadian aegirine" is a vanadium-rich variety. In European mineralogical literature, aegirine appears as *Aegrin* and *egirina*.

COMPOSITION: Aegirine, chemical formula $\text{NaFeSi}_2\text{O}_6$, contains the elements sodium (Na), iron (Fe), silicon (Si), and oxygen (O) in the proportions of 9.95 percent sodium, 24.18 percent iron, 24.32 percent silicon, and 41.55 percent oxygen. Aegirine is a member of the silicates, the largest mineral class, in which silicon and oxygen combine with one or more metals. It is classified as a single-chain inosilicate, a major group of rock-forming minerals also known as pyroxenes that consist of single chains of silica tetrahedra. Aegirine crystallizes in the monoclinic system, in which crystals have three axes of different lengths, two of which are perpendicular. Aegirine has a substantial density (specific gravity 3.5-3.6) because it consists of

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24.18 percent of the relatively heavy element iron (atomic weight 56.85). As an idiochromatic (self-colored) mineral, aegirine's characteristic black, greenish-black, or brownish-black colors are caused by the essential element iron and the nature of its crystal lattice. Aegirine occurs primarily in basic (alkaline, low-silica) igneous rocks, most notably in nepheline syenite pegmatites, and also in altered schist and gneiss formations. In conditions of long-term, atmospheric oxidation, aegirine will alter into riebeckite.

COLLECTING LOCALITIES: The finest aegirine specimens come from the Zomba District, Malawi; the Khibiny Massif on Russia's Kola Peninsula; Rundemyr, Buskerud, Norway; the Llimaussaq igneous complex in Kitaa Province, Greenland; Mont-St-Hilaire, Québec, Canada; and Magnet Cove, Hot Spring County, Arkansas, in the United States. Other localities are in Brazil, Bolivia, Japan, Kenya, Namibia, Pakistan, and South Africa. In the United States, aegirine occurs in California, Colorado, Oregon, Massachusetts, New Jersey, New Mexico, Texas, Washington, Utah, and Wisconsin.

HISTORY, LORE, & GEMSTONE/TECHNOLOGICAL USES: Aegirine was recognized as a new mineral species and named in 1835. Its atomic structure was defined by X-ray diffraction in 1927. Modern metaphysical practitioners believe that aegirine protects against negative energy, enhances the ability to cope with group pressure, and strengthens personal integrity and convictions. It is also said to enhance the healing energies of other mineral crystals. Aegirine's use in jewelry is limited. Nicely formed crystals are sometimes wrapped in silver wire for wear as pendants for metaphysical purposes. Collectors value aegirine crystals for their rarity, distinctive shape, and associations with rare and unusual minerals. Apart from serving as the mineralogical model for its own laboratory synthesis, aegirine has no technological uses.

ABOUT OUR SPECIMENS: Our specimens were collected at a recently recognized, classic locality for aegirine—Zomba Mountain in the Chilwa Alkaline Province in the Zomba District of the Southern Region of the southeastern African nation of Malawi. The origin of our specimens is linked to the formation of the East African Rift System, a series of long, narrow, north-south-oriented depressions in the Earth's surface and Africa's most prominent geological feature. When the rift began to form some 65 million years ago, crustal fracturing was accompanied by the emplacement of numerous igneous intrusions and widespread extrusive (volcanic) activity. At present-day Zomba, Malawi, these intrusions consisted of nepheline syenite, a granite-like, igneous rock that solidified from alkaline (silica-poor) magma. The final sections of these intrusions to solidify were zones of residual magma that were enriched with quartz and unusual and rare elements. This residual magma eventually formed dikes that solidified into nepheline syenite pegmatites containing pockets of well-developed mineral crystals. Today, these pegmatite dikes outcrop on the faces of sheer, 2,000-foot-high cliffs. After these cliffs yielded their first specimens in the late 1980s, they were quickly recognized as a classic locality for aegirine. Collecting specimens from these cliffs poses extreme physical danger. Nevertheless, about 50 Malawian miners are now licensed by the government to collect specimens on the cliffs. These brave collectors then sell their finds to African mineral dealers who offer them at gem and mineral shows worldwide.

10 YEARS AGO IN OUR CLUB: Trona, Owens Lake, Inyo County, California. We were particularly happy in June 2001, as we sent Club members these outstanding specimens shortly after they were written up in the "What's New in Tucson 2011"! The *Mineral News* Tucson Report said: "Trona, known as an ugly mineral, has improved its image at this show . . . These translucent crystals can be called best of species for trona: up to 4 cm long and about 2-3 cm wide." During the Tucson Gem & Mineral Show that February, we saw one high-end dealer offering specimens for \$200 and more that were similar to what we sent Gold-Level members then! (In 2001, we called our Gold-level membership the "Deluxe Membership.") Our trona write-up, which we will reformat and put on our web site for you to read, went into the history of the diverting of water from Owens Lake to the city of Los Angeles. Interesting reading!

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COMPREHENSIVE WRITE-UP

COMPOSITION

Aegirine, chemical formula $\text{NaFeSi}_2\text{O}_6$, contains the elements sodium (Na), iron (Fe), silicon (Si), and oxygen (O) in the proportions of 9.95 percent sodium, 24.18 percent iron, 24.32 percent silicon, and 41.55 percent oxygen. Like all molecules, those of aegirine are composed of positively charged cations and negatively charged anions. Aegirine's compound cation consists of one sodium ion Na^{1+} with its +1 charge and one trivalent (ferric) iron ion Fe^{3+} with its +3 charge, which provide a total cationic charge of +4. The aegirine anion is a radical, a bonded group of ions of different atoms that behaves as an entity in chemical reactions. The aegirine anion is the silica radical $(\text{Si}_2\text{O}_6)^{4-}$, in which the two silicon ions 2Si^{4+} have a collective +8 charge and the six oxygen ions 6O^{2-} have a collective -12 charge. This provides a total anionic charge of -4 to balance the total cationic charge of +4 and impart electrical stability to the aegirine molecule.

Aegirine is a member of the silicates, the largest mineral class, in which silicon and oxygen combine with one or more metals. The basic silicate structural unit is the silica tetrahedron $(\text{SiO}_4)^{4-}$, in which a silicon ion is surrounded by four equally spaced oxygen ions that are positioned at the four corners of a tetrahedron (a four-faced polyhedron). In the silicates, silica anions and metal cations join together in repeating chains to form seven types of structures: independent tetrahedral silicates (nesosilicates); double tetrahedral silicates (sorosilicates); ring silicates (cyclosilicates); sheet silicates (phyllosilicates); framework silicates (tectosilicates); and single- and double-chain silicates (inosilicates).

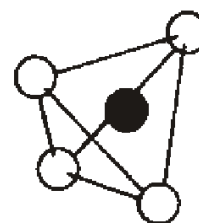


Figure 1. Silica tetrahedron.

As a single-chain inosilicate, aegirine is a member of a major group of rock-forming minerals known as pyroxenes that consist of single chains of silica tetrahedra, in which silica tetrahedra bond together by sharing two of their oxygen ions with adjacent tetrahedra. This reduces the number of oxygen ions per tetrahedron by one, resulting in groups of $(\text{SiO}_3)^{2-}$ units. Although these single chains are often diagrammed as being straight, they are actually twisted or helical in a manner that provides space to accommodate other ions between them. The two negative charges on each unit, which are carried by the two unshared oxygen ions, must be balanced by positive ions. In aegirine, these positive ions are sodium ion Na^{1+} and the trivalent (ferric) iron ion Fe^{3+} , which bond ionically to the negatively charged oxygen ions. Aegirine forms single-width, unbranched chains of molecular units, each unit consisting of two bonded $(\text{SiO}_3)^{2-}$ radicals, an arrangement that is reflected in the $(\text{Si}_2\text{O}_6)^{4-}$ radical of its chemical formula $\text{NaFeSi}_2\text{O}_6$.

Within the aegirine lattice, these single chains form planes of closely packed oxygen ions that alternate with planes of silicon ions and those of sodium and iron ions. Because the ionic bonds in the two directions *between* the chains are much weaker than the covalent oxygen-oxygen bonds *within* the chains, cleavage planes exist in two directions that are nearly perpendicular to the long axes of the chains. If the aegirine lattice had only strong, covalent, oxygen-oxygen bonding, it would have the approximate hardness of quartz (Mohs 7.0). But because it also has weak ionic bonding, aegirine has a hardness of Mohs 6.0-6.5, substantially less than that of quartz. Aegirine crystallizes in the monoclinic system, which is characterized by three axes of different lengths, two of which are mutually perpendicular. The third is not perpendicular to either of the other two, but intersects at an angle that creates crystals similar to orthorhombic crystals that are deformed in one direction. Aegirine's substantial density (specific gravity 3.5-3.6) is due to the relatively heavy element iron (atomic weight 56.85) that makes up 24.18 percent of its composition.

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The Dana mineral-classification number 65.1.3c.2 first identifies aegirine as an inosilicate with single-width, unbranched chains (65). The subclassification (1) defines it in structural terms as consisting of chains of double-silica units $[(\text{Si}_2\text{O}_6)^{4-}]$. Aegirine is then assigned to the jadeite group of sodium clinopyroxenes (3c) as the second (2) of six members, all of which share the same $(\text{Si}_2\text{O}_6)^{4-}$ silica anion and lattice structure. Their different chemistries are due to cationic substitution that occurs mainly when trivalent ions of aluminum, manganese, chromium, and vanadium replace those of iron, as shown in the following list:

Jadeite	$\text{Na}(\text{Al},\text{Fe})\text{Si}_2\text{O}_6$, sodium aluminum iron silicate
Aegirine	$\text{NaFeSi}_2\text{O}_6$, sodium iron silicate
Namansilitite	$\text{NaMnSi}_2\text{O}_6$, sodium manganese silicate
Kosmochlor	$\text{NaCrSi}_2\text{O}_6$, sodium chromium silicate
Natalyite	$\text{Na}(\text{V},\text{Cr})\text{Si}_2\text{O}_6$, sodium vanadium chromium silicate
Jervisite	$(\text{Na},\text{Ca},\text{Fe})(\text{Sc},\text{Mg},\text{Fe})\text{Si}_2\text{O}_6$, sodium calcium iron scandium magnesium silicate

The recent reclassification of mineral groups, as found in *Fleisher's Glossary of Mineral Species 2008*, places aegirine in the Pyroxene Group of minerals, along with 21 other minerals, including those mentioned above. Other collectible minerals that are part of this group include:

Diopside	$\text{CaMgSi}_2\text{O}_6$, sodium magnesium silicate
Enstatite	$\text{Mg}_2\text{Si}_2\text{O}_6$, magnesium silicate
Hedenbergite	$\text{CaFeSi}_2\text{O}_6$, calcium iron silicate
Spodumene	$\text{LiAlSi}_2\text{O}_6$, lithium aluminum silicate

Enstatite includes the variety known as hypersthene, while spodumene includes two gemstones: kunzite, which is pink spodumene, and hiddenite, which is green spodumene from North Carolina.

As mentioned under "Physical Properties," crystals of aegirine can be difficult to differentiate from the closely related mineral augite [calcium sodium magnesium iron aluminum titanium oxysilicate, $[\text{Ca},\text{Na}](\text{Mg},\text{Fe},\text{Al},\text{Ti})(\text{Si},\text{Al})_2\text{O}_6$]. In fact, an intermediate mineral is recognized as part of this series: Aegirine-augite, $(\text{Ca},\text{Na})(\text{Mg},\text{Fe}^{2+},\text{Fe}^{3+})\text{Si}_2\text{O}_6$, calcium sodium iron silicate, but we may have entered the realm of hair-splitting here, and some of us don't have much hair to spare.

As an idiochromatic (self-colored) mineral, aegirine's characteristic black, greenish-black, or brownish-black colors are caused by the essential element iron and the nature of its crystal lattice. The trivalent iron ion Fe^{3+} is a powerful, black chromophore (color-causing agent). Aegirine colors vary somewhat with the amount of aluminum, chromium, titanium, and vanadium that has replaced iron. As the amount of substituted metals increase and iron content decreases, aegirine colors shift from black and greenish-black to brownish-black and reddish brown. The presence of chromium accounts for aegirine's subtle greenish hues.

Although aegirine is a fairly common and widely distributed, rock-forming mineral, well-developed, collectible crystals are quite rare. Aegirine occurs primarily in basic (alkaline, low-silica) igneous rocks, most notably in nepheline syenite pegmatites in association with quartz [silicon dioxide, SiO_2]; microcline [potash-feldspar group, potassium aluminum silicate, KAlSi_3O_8]; zircon [zirconium silicate, ZrSiO_4]; and goethite [basic iron oxide, $\text{FeO}(\text{OH})$]. Aegirine also occurs with andradite [garnet group, calcium iron silicate, $\text{Ca}_3\text{Fe}_2(\text{SiO}_4)_3$] and albite [sodium aluminum silicate, $\text{NaAlSi}_3\text{O}_8$] in carbonatites (carbonate-bearing igneous rocks), and in altered schist and gneiss formations. In conditions of long-term, atmospheric oxidation, aegirine will alter into riebeckite [basic sodium iron silicate, $\square\text{Na}_2(\text{Fe}^{2+}_3\text{Fe}^{3+}_2\text{Si}_8\text{O}_{22}(\text{OH})_2$].

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COLLECTING LOCALITIES

Although widely distributed, collectible specimens of aegirine are rare, with large, well-developed crystals found only at a half-dozen localities worldwide. Our specimens were collected at a recently discovered, classic locality for aegirine—Zomba Mountain in the Chilwa Alkaline Province, Zomba District, in the southern African nation of Malawi. Before this site began yielding specimens in the late 1980s, collectible aegirine specimens came mainly from the Khibiny Massif on the Kola Peninsula, Murmanskaya Oblast', Northern Region, Russia; the type locality at Rundemyr near Øvre Eiker, Kongsberg, Buskerud, Norway; the Llimausaq igneous complex at Narsaq, Kitaa (West Greenland) Province, Greenland; the Poudrette Quarry at Mont-St-Hilaire, Rouville, Montérégie; Québec, Canada; and the Jones quarries at Magnet Cove, Hot Spring County, Arkansas, United States.

Other localities in the United States include the Glen Ellen amphibole-pyroxene occurrence in the Sonoma Valley, Sonoma County, California; the Cripple Creek district in Teller County, Colorado; the Quincy granite quarries in Norfolk County, Massachusetts; Sterling Hill at Ogdensburg in the Franklin district, Sussex County, New Jersey; Point of Rocks near Springer in Colfax County, New Mexico; Summit Rock in Klamath County, Oregon; Rattlesnake Mountain in Big Bend National Park, Brewster County, Texas; Washington Pass in the Golden Horn Batholith, Okanogan County, Washington; the 3M Quarry at Little Rock, Pulaski County, Arkansas; outcrops of the Green River Formation in Uintah County, Utah; and the nepheline syenite of the Stetin Pluton in Marathon County, Wisconsin.

Aegirine is also found at the Prefeitura and Bortolan quarries at Poços de Caldas, Minas Gerais, Brazil; the Alto Chapare District in Chapare Province, Cochabamba Department, Bolivia; the Shiromaru Mine at Okutama, Tokyo Prefecture, Kanto Region, Honshu Island, Japan; the Olkaria Volcano in Hell's Gate National Park, Rift Valley Province, Kenya; the Kombat Mine at Kombat, Grootfontein District, Otjozondjupa Region, Namibia; Zagi Mountain at Hameed Abad Kafoor Dheri near Peshawar, North-West Frontier Province, Pakistan; and the Wessels Mine at Hotazel in the Kalahari Manganese Fields, Northern Cape Province, South Africa.

JEWELRY & DECORATIVE USES

Aegirine has few jewelry or decorative uses. Nicely formed crystals are sometimes wrapped in silver wire for wear as pendants for metaphysical purposes. Collectors value aegirine crystals for their rarity, distinctive shape, and associations with rare and unusual minerals.

HISTORY & LORE

Aegirine was first studied in southern Norway about 1780, but an inability to determine its chemical composition precluded its recognition as a distinct mineral species. The mineral was first known as "achmite" or "acmite," from the Greek word *akmē*, meaning "point," alluding to the pointed shape of its crystals. In 1821, P. Ström (vita uncertain), a supervisor at Norway's famed Kongsberg silver-mining district, collected "acmite" specimens from Rundemyr near Øvre Eiker, Kongsberg, Buskerud, and sent them to the prominent Swedish chemist Jöns Jacob Berzelius (1779-1848) in Stockholm, Sweden. In 1829, the bishop of Brevik, Hans Morten Thrane Esmark (1801-1882), collected specimens at Låven Island in Langesundsford on Norway's southern coast. An amateur earth scientist, Esmark also sent these new specimens to Berzelius, who correctly determined their composition as sodium iron silicate and realized that they and the original Rundemyr specimens represented a new mineral species. The European mineralogical community accepted both Rundemyr and Låven Island as co-type localities and proposed naming the new mineral in honor of Berzelius. But in 1835, the humble Swedish chemist refused

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the honor and instead suggested the name “aegirine,” after Ægir, god of the sea and king of all sea creatures in Norse mythology. Nevertheless, the original name “acmite” remained in regular use until being formally discredited in 1988. Interestingly, two minerals were eventually named after Jöns Jacob Berzelius, berzelianite [copper selenide, Cu_2Se] and berzeliite [calcium sodium magnesium manganese arsenate, $(\text{Ca},\text{Na})_3(\text{Mg},\text{Mn})_2(\text{AsO}_4)_3$], but only after death prevented the chemist from refusing these honors. The atomic structure of aegirine was defined by X-ray diffraction in 1927.

Modern metaphysical practitioners believe that aegirine protects against negative energy, enhances the ability to cope with group pressure, strengthens personal integrity and convictions, and enhances the healing energies of other mineral crystals.

THE GREAT RIFT VALLEY

Our aegirine specimens were collected in southern Malawi at the southern terminus of the East African Rift System. Geological rifts are separations in the Earth's crust that appear as long, linear, surface depressions. The 2,500-mile-long East African Rift System is actually the southern part of the Great Rift Valley which, with a total, north-south extent of 4,200 miles, is the longest rift on Earth. Recognized and named in 1895 by British geologist and explorer John Walter Gregory (1864-1932), the Great Rift Valley stretches from Syria in the Middle East all the way to southern Malawi in southeast Africa.

The Great Rift Valley must be considered in terms of both geology and geography. Geologically, rifts are formed either by the drifting apart of tectonic plates or by geological uplifts that stretch the rigid crust to its breaking point. Rifts of tectonic origin form at tectonic plate boundaries when plates separate, causing the overlying crust to fracture into long fault systems and pull apart. As plate separation progresses, long, narrow, crustal blocks between the two plates subside to form grabens. Grabens are more-or-less straight depressions which, when interconnected, form rift valleys. Rifts can also develop far from tectonic-plate boundaries through geological uplifting when subterranean upwelling of magma causes regional uplifting or “doming” of large sections of crust. To accommodate doming, the overlying, rigid crust stretches and eventually fractures along its weakest sections to create major fault systems. As doming progresses, the solid crustal sections on both sides of the fault systems slowly move apart, leaving long, narrow center sections to drop, sometimes thousands of feet relative to the adjacent sections of solid crust. With extreme doming and associated faulting and crustal separation, previously solid tectonic plates can actually fragment—as is now happening in the East African Rift System.

Geographically, the Great Rift Valley begins in the north at the common border of Lebanon and Syria as the long, narrow, north-south trending El Baqaa Valley. (This geographical description can be followed on a map of the Middle East and Africa.) Moving south, the Great Rift Valley is the site of the Sea of Galilee, the Jordan River, and the Dead Sea; the latter, at 1,237 feet below sea level (-1,237 feet), is the lowest point on the Earth's surface. Farther south, another long valley, the Wadi al Arabah becomes the Gulf of Aqaba, which flows into the Red Sea. The Red Sea, 1,200 miles long but only 150 miles wide, reflects its rift origin with an astounding maximum depth of nearly 10,000 feet. Along this entire 1,700-mile distance from Syria to the mouth of the Red Sea, the Great Rift Valley marks the boundary between two tectonic plates that are drifting apart—the African Plate to the west and the Arabian Plate to the east.

At the tiny African nation of Djibouti at the mouth of the Red Sea, the Great Rift Valley turns south-southwest into the landmass of the African continent. This region, just east of the Horn of Africa and known as the Afar Triangle, marks the juncture of three tectonic plates. Regional depression features

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include the Afar Depression, the lowest point in Africa with an elevation of -480 feet and the Danakil Desert, elevation -509 feet. The Afar Triangle marks the beginning of the East African Rift System. Continuing south, the rift system divides into two, more-or-less parallel rift structures—the Eastern Rift Valley and Western Rift Valley. The western section, which passes through Ethiopia, Uganda, western Congo, eastern Tanzania, and Zambia, hosts the African “Great Lakes,” a series of long, narrow, very deep lakes, including 4,600-foot-deep Lake Tanganyika. The eastern and western rift sections reconnect in southern Tanzania, where a single rift valley continues south into Malawi and Mozambique. Lake Nyasa—the southern shore of which is near the source of our aegirine specimens—is the southern terminus of the Great Rift Valley. Although Lake Nyasa’s surface elevation is 1,700 feet, the bottom of this 2,200-foot-deep lake is actually well below sea level.

Extensive intrusive and extrusive igneous activity accompanied the formation of the East African Rift System. Rift-associated volcanic activity created many of Africa’s tallest peaks, including its highest, 19,320-foot-high Mt. Kilimanjaro. Extensive seismic and tectonic activity is ongoing today, as the East African Rift System continues to separate at the rate of about 0.6 inches per year—very rapid by tectonic-drifting standards. Over millions of years, this separation has already fragmented the original African Plate into two sections—the Somali African Plate to the west, which comprises the bulk of the African continent, and the smaller Nubian African Plate, which is drifting to the east. Within just five million years, the blink of an eye in geological time, geologists expect the Red Sea to break through into the Afar Depression. And in 10 million years, they expect seawater to inundate most of the East African Rift System, creating a new sea larger than the present-day Red Sea.

Geologists consider the East African Rift System a valuable field laboratory for the study of active tectonic movements and the creation of new tectonic plates. For the last few million years, the rapidly eroding, adjacent highlands have quickly filled the rift valleys with sediments, creating a favorable environment for the preservation of human remains. East Africa’s rift valleys have yielded fossilized, partial skeletons of a number of human ancestors. Some anthropologists now suggest that the East African Rift System altered the paleoclimate, giving the region more extreme wet and dry seasons. Between a spreading rift system, plate fragmentation, and a treasure of early human fossils, it is little wonder that many scientists consider the East African Rift System to be the Earth’s most interesting geological area. This brief overview has certainly whetted our appetites—how we would love to spend months (or years) hiking, examining, and getting to know the many diverse features of this amazing area!

TECHNOLOGICAL USES

Apart from serving as the mineralogical model for its own laboratory synthesis, aegirine has no technological uses.

ABOUT OUR SPECIMENS

Our specimens were collected at a recently recognized, classic locality for aegirine—Zomba Mountain in the Chilwa Alkaline Province, Zomba District, in the Southern Region of the southeastern African nation of Malawi. Malawi, the smallest nation in sub-equatorial Africa, has an area nearly that of the state of Pennsylvania and a population of 12 million. Landlocked Malawi is bordered by Tanzania to the north, Mozambique to the east, south, and southwest, and Zambia to the west. The territory that is now Malawi was first politically administered by Britain in 1891 as part of its Nyasaland District Protectorates (British Nyasaland); in 1893, it became part of Britain’s Central African Protectorates. Malawi gained its independence in 1964. Zomba, the British colonial capital, served as the national capital until 1975, when

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the seat of government was moved to the much larger city of Lilongwe, population one million. Today, Malawi's largest city is Blantyre, population two million. Malawi, one of Africa's poorest nations, has an economy based largely on the small-scale production of cotton, tobacco, and coffee.

Lake Nyasa (also known as Lake Malawi) forms much of Malawi's eastern boundary. Africa's third largest lake, Nyasa is 360 miles long, 25 miles wide, and 2,200 feet deep. It was the improbable site of the first naval battle of World War I when, on August 16, 1914, a British gunboat shelled and disabled a German gunboat (adjacent Tanzania was then German East Africa). This battle is often erroneously believed to have been the inspiration for C. S. Forester's 1935 novel *The African Queen* and the 1951 motion picture of the same name that starred Humphrey Bogart and Katharine Hepburn. A similar battle that *did* inspire the book was actually fought on Lake Tanganyika in 1916.

The origin of our aegirine specimens is tied to the formation of East African Rift System, Africa's most prominent geological feature (see "The Great Rift Valley"). Malawi is located on the southern terminus of the East African Rift System, which is a connected series of long, narrow, north-south-oriented depressions. This rift topography is clearly reflected in the shape and alignment of finger-like Lake Nyasa. The East African Rift System began to form in the late Cretaceous Period some 65 million years ago, when massive magmatic intrusions uplifted (domed) and stretched the crust to create fault systems that initiated crustal separation across much of eastern Africa. This process was accompanied by the emplacement of numerous igneous intrusions and widespread extrusive (volcanic) activity, some of which continues today. The topography of the rift is one of long, narrow depressions (now often filled by deep lakes) bordered on both sides by rugged highlands with steep cliffs. These cliffs, which geologists call scarps, are the exposed, vertical-displacement surfaces of major rift-related faults.

When rifting began, magma was forced upward into the fractured crust. Near what is now Zomba, Malawi, these intrusions consisted of nepheline syenite, a granite-like igneous rock that solidified from alkaline (silica-poor) magma. As these intrusions, now known as the Chilwa Alkaline Province, slowly solidified, they left small zones of residual magma enriched with quartz and unusual and rare elements. Contraction of these intrusions exerted pressure on the zones of residual magma, which fractured and penetrated the surrounding nepheline syenite rock to form networks of pegmatite dikes rich in unusual minerals. Wherever gases were present in this residual magma, the pegmatite dikes contained voids that provided space for unrestricted crystal development. Long after emplacement of these nepheline syenite intrusions, continued faulting along the edges of the developing rift vertically displaced great blocks of crust, dropping the rift floor relative to the adjacent highlands and creating nearly sheer cliffs. At Zomba Mountain in the Zomba-Malosa Mountains 30 miles north of the city of Blantyre, Malawi, and near the former colonial capital of Zomba, the cliff faces were laced with nepheline syenite pegmatites.

When British geologists from the Geological Survey of Nyasaland first surveyed the Zomba-Malosa Mountains in the 1950s, they noted exposures of nepheline syenite pegmatites with large crystals of aegirine and other unusual minerals. But this occurrence received no further attention until the late 1980s, when Malawian collectors, called "miners," began selling superb specimens of aegirine crystals. These specimens came to the attention of South African mineral collectors who recognized their unusual size and degree of development, as well as their commercial potential. In 1991, a brief mention of these remarkable crystals in *The Mineralogical Record* attracted the attention of the international mineral-collecting community. A full article in the same publication in 1994 immediately bestowed classic-locality status on Malawi's Zomba-Malosa Mountains.

But because South African dealers had simply purchased these specimens from an informal "miners' market" near Zomba, their exact source remained unknown. Finally, in 1997, when travel restrictions were

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lifted following a brief Malawi civil war, three Johannesburg, South Africa-based mineral dealers, Karl Messner, Paul Botha, and Eric Farquharson, drove to Zomba (1,500 road miles) to buy aegirine specimens and to precisely locate their source. Guided by Malawian miners and packing sufficient food and supplies for three days, they trekked 10 miles from the nearest road. The narrow trail—in places less than one foot wide—wound around a mountain, descended into a deep valley, then ascended another mountain to end at the brink of 2,000-foot-high, nearly vertical cliffs. The three South African dealers had become the first foreigners to ever reach and document the Zomba Mountain aegirine locality.

The dealers were astounded to learn that the collecting sites—nepheline syenite pegmatite dikes—were all located on the sheer faces of these cliffs. These dikes are between three and five feet thick, with occasional hollow pockets containing mineral crystals. Because they are more quartz-rich and thus more resistant than their nepheline syenite host rock, the exposed pegmatite dikes form narrow ridges or “noses,” which the Malawian miners use to descend the cliffs. The miners work with no technical climbing equipment whatsoever, relying on their bare feet to locate ridges and their fingers to cling to small crevices. The cliffs are composed of soft, weathered nepheline syenite that must be cleared away to fully expose the pegmatite dikes. Digging and extracting specimens is performed manually, using only the simplest iron tools. Falling from the precarious cliffs means certain death. Because the more accessible pegmatite veins have now been depleted, the miners who work the remaining, less accessible pegmatite dikes face extraordinary physical risks. Despite these risks, collecting specimens from the sheer cliffs is one of the few ways to earn an income in a nation that offers otherwise limited economic opportunities.

The 1997 visit of the three South African specimen dealers was important in several respects. First, they determined and documented the precise location (15° 16' 18" south latitude, 35° 18' 05" east longitude) of the Zomba Mountain aegirine locality. Second, they confirmed the presence of other rare, collectible minerals that the Malawian miners had neglected in their search for the readily marketable aegirine specimens. Finally, they taught the Malawian miners how to identify and collect the other rare minerals. The availability of these new specimens has since greatly stimulated international demand for Zomba Mountain minerals, boosted prices, and made collecting even more profitable for the Malawian miners. The Malawian government is now attempting to regulate the specimen trade. To legally collect, each Malawian must obtain a required government mining certificate. Some miners hold government claims to specific sections of the cliffs. In recent years, the Malawian army troops and members of the national police have patrolled the area, checking the required documentation of both miners and foreign buyers. Despite the remoteness and dangers of the Zomba Mountain locality, about 50 Malawians are now licensed to collect mineral specimens on the cliffs.

The nepheline syenite pegmatites at Zomba Mountain consist primarily of quartz and microcline [potash-feldspar group, potassium aluminum silicate, KAlSi_3O_8]. Other familiar minerals within these dikes are gemmy, transparent, brownish-orange crystals of zircon [zirconium silicate, ZrSiO_4] and orange-brown crusts and coatings of goethite [basic iron oxide, $\text{FeO}(\text{OH})$]. Along with aegirine, the more unusual or rare minerals found at Zomba Mountain include:

Arfvedsonite [basic sodium iron silicate, $\text{Na}_3(\text{Fe}^{2+4}\text{Fe}^{3+})\text{Si}_8\text{O}_{22}(\text{OH})_2$], which is chemically similar to aegirine and forms sharp, blackish, prismatic crystals. Needle-like arfvedsonite crystals sometimes form inclusions within quartz crystals to which they impart a greenish color.

Caysichtite-Y [basic hydrous yttrium calcium rare-earth-elements carbonate silicate, $\text{Y}_4(\text{Ca,REE})_4\text{Si}_8\text{O}_{20}(\text{CO}_3)_6(\text{OH})\cdot 7\text{H}_2\text{O}$], as milky-white, pseudotetragonal crystals.

Epididymite [basic sodium beryllium silicate, $\text{NaBeSi}_3\text{O}_7(\text{OH})$], as cream-to-white, prismatic crystals that often form inclusions within quartz crystals.

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Eudialyte [basic hydrous sodium calcium iron manganese zirconium niobium oxychlorosilicate, $\text{Na}_{15}\text{Ca}_6(\text{Fe},\text{Mn})_3\text{Zr}_3(\text{Si},\text{Nb})\text{Si}_{25}\text{O}_{73}(\text{O},\text{OH},\text{H}_2\text{O})_3(\text{Cl},\text{OH})_2$], as tiny, blocky, orange-red crystals.

Eudidymite [basic sodium beryllium silicate, $\text{NaBeSi}_3\text{O}_7(\text{OH})$], as spiky, twinned, pale-yellow crystals.

Fergusonite-Y [yttrium niobium oxide, YNbO_4], as tapering, pale-yellow, prismatic crystals closely associated with aegirine.

Parisite-Ce [calcium cerium lanthanum fluorocarbonate $[\text{Ca}(\text{Ce},\text{La})_2(\text{CO}_3)_3\text{F}_2]$ as tapering yellow prisms.

We will certainly do our best to obtain a few choice specimens of these extremely rare minerals from Mount Malosa for those of you who might like to have one. The only one of these we have ever featured, of course, is eudialyte, in April 2002, when we sent Club members specimens of pinkish-red eudialyte from the now-closed Kipawa Syenite Complex, Villedieu Township, Quebec, Canada. We may still have some available, so let us know if you are interested in obtaining one!

Our aegirine specimens were actually acquired over a period of two years at the Tucson Gem & Mineral Show from South African mineral dealer Paul Botha, one of the three dealers who were the first foreigners to ever visit the Zomba Mountain locality in 1997. In 2009, he provided us with most all the specimens we would need, which we brought home and set aside; but in 2010, he had no new specimens for us to choose from; and finally this year, we met up with him before the shows officially opened and picked out the rest of what we needed! Another importer has also brought in a couple of sizable lots from Mount Malosa, which they were selling quite briskly in Tucson this year. In addition to providing the aegirine crystals we needed, Paul Botha provided us with two more sources of information on collecting activities at Mount Malosa, which you can visit by following these links:

<http://www.edu.uni-klu.ac.at/~mmessner/sites/malawi/zomba.htm>

<http://www.koeln.netsurf.de/~w.steffens/zomba.htm>

As you examine your specimen, first note four properties that are characteristic of aegirine: the bright, vitreous luster; the slightly tapered, long, prismatic shape of the crystals; the coarse, longitudinal striations; and the black opacity that is due to the essential element iron. The relative "heft" of the specimen in your hand reflects a moderately high specific gravity of 3.5-3.6, which is also due to the substantial iron content. A few specimens may also include secondary, identifiable minerals. Small white, hexagonal crystals with pyramidal terminations are quartz; small, cream-colored, blocky crystals are microcline. Rust-colored crusts and coatings are goethite, an iron mineral common to nepheline syenite pegmatites. Besides being a fine example of aegirine, your specimen is also a souvenir of the East African Rift System and of one of the world's most dangerous mineral-collecting localities!

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