

August 2005 Mineral Group of the Month: Purpurite-Heterosite

After completing most of this write-up but still seeking information on the Sandamap locality where our featured specimens were unearthed, we were given an excerpt from a soon-to-be published book on the minerals of Namibia. This new publication list 42 different minerals as found at Sandamap, but not one of them is purpurite! Evidently, recent research indicates that most of what has always been considered purpurite from Sandamap is in fact closer to the composition of heterosite, which forms a series with purpurite, as explained in the write-up. So we thought it would be appropriate to include information on heterosite as well, and renamed the write-up to spotlight these mineral "brothers."

PHYSICAL PROPERTIES (Where they differ, the properties of heterosite are noted in italics.)

Chemistry: $\text{Mn}^{3+}\text{PO}_4$ Manganese Phosphate Usually contains varying amounts of iron.

$\text{Fe}^{3+}\text{PO}_4$ Iron Phosphate Usually contains varying amounts of manganese.

Class: Phosphates, Arsenates, and Vanadates

Subclass: Anhydrous Phosphates

Group: Heterosite

Crystal System: Orthorhombic (theoretical) *Orthorhombic*

Crystal Habits: Does not form crystals. Occurs in massive or granular form, or as coatings or crusts.

Massive.

Color: Bright violet and purple to reddish-purple and purple-brown, sometimes with a black-to-brown tarnish. *Brownish black, violet brown, greenish brown, dark brown, dark pink.*

Luster: Dull, earthy to subvitreous; varies with grain size. *Dull to earthy.*

Transparency: Subtranslucent to opaque

Streak: Deep red to purple. *Pale rose to reddish purple.*

Cleavage: None. *Good in one direction, imperfect in another.*

Fracture: Uneven, brittle

Hardness: 4.0-5.0, varies with grain size and chemical composition. *4.0-4.5.*

Specific Gravity: 3.3-3.4 *3.41*

Luminescence: None

Distinctive Features and Tests: Distinctive purple or violet color, absence of crystals, and occurrence only in lithium-rich, granite pegmatites. *Occurrence only in lithium-rich, granite pegmatites.*

Dana Classification Number: 38.4.1.2 *38.4.1.1*

NAME

Purpurite, correctly pronounced "PURP-uh-rite," is named for its distinctive purple color. The name derives from the Latin *purpureus*, meaning "purple-red." Purpurite has also been known as "purpurit" and "purpurita." Pronounced "HET-er-o-site," its "brother" is named from the Greek *heteros*, meaning "another," because it was the second manganese-containing mineral discovered at the same locality. Other names for heterosite are "heterosit," "heterosita," and "soda-heterosite."

COMPOSITION

The chemical formula MnPO_4 identifies purpurite as manganese phosphate containing the elements manganese (Mn), phosphorus (P), and oxygen (O). The molecular weight of purpurite consists of 36.65 percent manganese, 20.66 percent phosphorus, and 42.69 percent oxygen. Within the purpurite molecule, the +3 charge of the manganese cation (Mn^{3+}) balances the -3 charge of the phosphate anion $[(\text{PO}_4)^{3-}]$ --the same goes for heterosite, except the phosphate ion balances an iron cation. Heterosite's molecular weight consists of 37.03 percent iron, 20.54 phosphorus, and 42.43 percent oxygen, nearly identical, with iron taking the place of manganese.

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Purpurite and heterosite are among the more than 240 members of the Phosphates, Arsenates, and Vanadates class of minerals, most of which, like purpurite, are rare. Purpurite's Dana classification number, 38.4.1.2, first identifies the mineral as an anhydrous phosphate (38). The subclassification (4) next defines it by the general formula AXO_4 , in which A is a trivalent metal cation (a metal ion with a +3 charge) and XO_4 is a phosphate, arsenate, or vanadate anion. Finally, purpurite is assigned to the heterosite group (1), in which it is the second (2) and final member after heterosite, which is 38.4.1.1.

The fundamental building block of the phosphates is the phosphate ion $[(PO_4)^{3-}]$, which consists of a phosphorus ion (P^{5+}) surrounded by four equidistant oxygen ions (O^{2-}) that form a tetrahedron. Within the phosphate ion, the phosphorus ion is bound to the oxygen ions by strong covalent, shared-electron bonds. Because the three negative charges are distributed evenly over the four oxygen ions, the phosphate ion can bond ionically with many metal cations (and combinations of metal cations). This is seen in the purpurite molecule, where the trivalent manganese ion (Mn^{3+}) is ionically bound to the phosphate ion. In turn, purpurite molecules are joined together only by intermediate-strength ionic bonds, linking a repetitive, but disordered, sequence of manganese ions and the oxygen ions of phosphate tetrahedra.

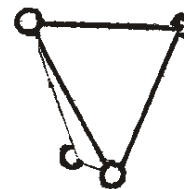


Figure 1.
Phosphate ion, showing 4 equidistant oxygen ions forming a tetrahedron. The phosphorous ion (not shown) is in the center.

Purpurite is the manganese-rich end member of a solid-solution series with heterosite, the iron-rich member. Solid-solution series occur when two cationic elements (or anionic radicals) substitute for each other in a mineral. Solid-solution series have continuously graded compositions with proportional gradation of such properties as color, density, and hardness. In the purpurite-heterosite solid-solution series, the cationic manganese in purpurite is replaced by the cationic iron in heterosite and vice-versa. Because of the generally similar sizes of ionic radii, manganese and iron ions easily replace each other in numerous solid-solution series. In the purpurite-heterosite series, when the amount of manganese exceeds that of iron, the mineral technically is purpurite; when the amount of iron exceeds that of manganese, it becomes heterosite. Evidently, the latest research indicates that specimens found at Sandamap Pegmatite may have higher amounts of iron than manganese, and should rightly be called heterosite.

Both purpurite and heterosite are secondary minerals that occur only in a specific mineralogical environment—lithium-rich granite pegmatites. The term “granite pegmatite” refers to coarse-grained granite or to an emplaced body of coarse-grained granite. Pegmatites form from residual pockets of intruded magma that retain heat, and thus cool and solidify very slowly. Rather than quickly “freezing” into common, uniform granite with tiny, well-dispersed, crystalline mineral components, residual magma crystallizes on a fractional or mineral-by-mineral basis to form horizontal pods and lenses and irregular veins and dikes. Because residual magma, the last of a magmatic intrusion to solidify, is often enriched with concentrations of accessory and rare elements, pegmatites tend to contain uncommon and unusual minerals, often of exceptional size, quality and clarity with well-formed, distinct faces and terminations.

Purpurite is very unusual because it does not form crystals. Purpurite originates as the alteration product of the chemical weathering of lithiophilite (lithium magnesium phosphate, $LiMn^{2+}PO_4$), a rare mineral that sometimes forms in lithium-rich, granite pegmatites. Lithiophilite and triphylite (lithium iron phosphate, $LiFe^{2+}PO_4$) are end members in a solid-solution series in which manganese and iron substitute for each other, just as in the purpurite-heterosite series. The chemistry, however, is slightly different. In the lithiophilite-triphylite series, manganese and iron are present as the divalent ions Mn^{2+} and Fe^{2+} . Under proper conditions, lithiophilite undergoes oxidative chemical weathering and alters to purpurite. During this process, the covalently bonded phosphate ions remain stable, but the divalent manganese (Mn^{2+}) oxidizes to trivalent manganese (Mn^{3+}), a conversion which displaces the lithium ion, changes that are readily seen in the combined ionic and chemical formulas of lithiophilite ($LiMn^{2+}PO_4$) and purpurite ($Mn^{3+}PO_4$). The

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same chemical weathering process can alter triphylite ($\text{LiFe}^{2+}\text{PO}_4$) to heterosite ($\text{Fe}^{3+}\text{PO}_4$). Thus, oxidative chemical weathering can alter the complete lithiophilite-triphylite solid-solution series to the purpurite-heterosite solid-solution series.

Although lithiophilite forms crystals, its alteration product, purpurite, does not. The reason is that the oxidation of divalent manganese to trivalent manganese, together with the displacement of the lithium ion, disrupts the structure of the original orthorhombic crystal lattice, so weakening the intermolecular ionic bonds that purpurite occurs only in massive or granular form. Interestingly, heterosite, the iron-rich end member of the purpurite-heterosite series, *does* form crystals, although it too is only found in masses. This is because the ionic radius of the trivalent iron ion (Fe^{3+}) is slightly smaller than that of the trivalent manganese ion (Mn^{3+}) and does not disrupt the original orthorhombic crystal lattice.

There are several reasons why some purpurite specimens can appear to be crystalline. First, the oxidative chemical weathering process may not be complete, thus leaving behind some tiny, brownish-purple, orthorhombic crystals of unaltered heterosite. Second, the specimen can be an intermediate member of the purpurite-heterosite series with enough iron present to produce the crystalline form of heterosite. Finally, because the alteration of heterosite to purpurite takes place on an atom-by-atom basis, pseudomorphs often result. Pseudomorphs, literally “false forms,” develop when a different mineral replaces a previously deposited mineral in a manner that precisely retains the original mineral’s crystal form. Although the external shape of the pseudomorph is identical to the original crystal, the internal crystal structure has been altered. Externally, a purpurite pseudomorph of heterosite, properly called “purpurite-after-heterosite,” will have an orthorhombic shape. Internally, however, the pseudomorph is massive or granular and lacking in true crystal structure.

Purpurite is an idiochromatic, or self-colored, mineral. Its color is due to one of its essential components—manganese, which is a powerful chromophore, or coloring agent. The manganese minerals that make popular collectibles because of their colors include blood-red rhodochrosite (manganese carbonate, MnCO_3), which we featured both in October 1997 and as our 100th featured mineral in June 2004, and pink-red rhodonite (manganese silicate, MnSiO_3), which we featured in July 2003. When pure or nearly pure, manganese-rich purpurite is an eye-catching, brilliant violet or purple. On the other hand, pure or nearly pure, iron-rich heterosite is usually an unremarkable brownish-black. Intermediate phases of this solid-solution series exhibit graded colors that reflect the graded chemical composition.

COLLECTING LOCALITIES

Purpurite is a rare mineral with collecting localities limited to certain lithium-rich granite pegmatites. In Austria, purpurite specimens have been collected at the Brandrücken spodumene pegmatite in Carinthia’s Koralpe Mountains. Fine Portuguese specimens have come from the Bandada Mine at Sabugal in the Guarda District. The Hagendorf pegmatite at Oberfäizer Wald in Bavaria, Germany, has yielded brightly colored purpurite. Australian sources include the Wodgina pegmatites in the Pilbara region of Western Australia. In Africa, excellent purpurite-heterosite specimens are found at the Sandamap pegmatite in Namibia’s Karibib District, as we will see, and in South Africa’s Northern Cape Province at the Strausheim pegmatite near Kenhardt and the Blesberg pegmatite near Steinkopf.

In the United States, purpurite sources are, as expected, limited to those states known for pegmatite mines. Purpurite is collected in Maine at the Mt. Mica Mine, BB No. 7 Mine, Dunton Quarry, Emmons Mine, and Bennett Quarry in Oxford County; the Starrett Mine in Knox County; and the Pulsifer, Maine Feldspar, Hole-in-the-Ground, and Keith mines in Androscoggin County. New Hampshire sources include the G. E. Smith and Sargent mines in Sullivan County; the Palermo No. 1, Ruggles, and E. E. Smith mines in Grafton County; and the Chickering Mine in Cheshire County. In Massachusetts, purpurite occurs at the

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Blandford mica mine in Hampden County, the Walnut Hill pegmatite in Hampshire County, and at Pine and Long hills in Worcester County. Fine specimens have also come from North Carolina, notably from the Ray Mica Mine in Yancey County; and from the Foote Lithium Mine and the type locality at the Faires Mine, both in Cleveland County. Moving west, purpurite is collected in South Dakota at the Ross Hannibal Mine in Lawrence County and the Ross Mine in Custer County; in Colorado at the Krystal Canyon, King's Canyon, and Big Boulder pegmatite mines in Larimer County; and in California at the Stewart pegmatite mine in San Diego County.

Heterosite, as you may imagine, comes from many of these same sites. It was first discovered at Huréaux, St. Sylvestre, Haute-Vienne, France, in 1825. Other outstanding heterosite localities include Varuträsk, Sweden; Telírio mine, Lavra Do Ênio, Galiléia, Minas Gerais, Brazil; and Angarf Süd, Tazenakht Plain, Morocco. In Namibia, heterosite is found at Okatjimukju Farm pegmatite, Karibib, and in the nearby Erongo Mountains.

JEWELRY & DECORATIVE USES

Were it not for its rarity, purpurite, with its brilliant purple colors, would certainly enjoy great popularity as a semiprecious gemstone. Nevertheless, small quantities of purpurite are tumbled and made into beads for stringing in necklaces and bracelets, and occasionally into cabochons for non-abrasive wear, such as in pendants or bola ties. Pieces of massive purpurite are occasionally cut into small figurines. Because of their rarity, bright colors, and unusual tendency to not form crystals, purpurite specimens are valued highly by mineral collectors and make striking display pieces. The information here as well as that presented under *Technological Uses* can also apply to rose-colored heterosite and intermediate mixtures of the two.

HISTORY & LORE, TECHNOLOGICAL USES

Because of its eye-catching color, purpurite was probably collected in antiquity from exposed, weathered pegmatites. Despite its rarity, purpurite saw limited use as a pigment for canvas and fresco paints in Europe during the 15th, 16th, and 17th centuries. Finely ground purpurite has limited use as a lavender-colored specialty pigment for water- and oil-based art paints. Prepared purpurite-based paints are understandably expensive, currently selling for about \$10 per one-half ounce.

Purpurite was identified as a distinct mineral species in 1905 by Harvard University geologist Louis C. Graton (1880-1970) and United States Geological Survey mineralogist Waldemar T. Schaller (1882-1967) after studying specimens obtained from the type locality at the Faires Mine in Cleveland County, North Carolina. Graton and Schaller published their purpurite findings that same year in *The American Journal of Science* in an article titled "Purpurite: A New Mineral." Heterosite was first recognized in 1826.

According to metaphysical belief, purpurite helps its wearers to speak with confidence, promotes spirituality and inner growth, enhances the insight and understanding, and aids in avoidance of self-destructive or self-limiting patterns. Similarly, heterosite is said to assist in expressing oneself with both assurance and autonomy, provide freedom from the material world, and rid one of undue modesty.

ABOUT OUR SPECIMENS

For the second time this year, and the third time in the last eleven months, we are featuring a phosphate class mineral, actually two this month, if you count heterosite. Other phosphates we have featured are apatite from Canada (October 1996) and from Russia (May 2003), pyromorphite from a new find in China (July 2002), vanadinite from the classic locality in Morocco (November 2001), Utah variscite (April

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2000), Bolivian vivianite from a new find (November 2004), and Yukon augelite (April 2005.)

Our specimens come from Sandamap pegmatite, near Usakos, in the Karibib district of Namibia. (Sandamap also may be spelled Sandamab.) Pegmatites and the unusually fine quality crystals that develop in them are abundant in this region, and mining for lithium minerals, mica, quartz, tourmaline, and granite for building materials has been ongoing in the district since at least the early twentieth century. Other well known sites in the vicinity include the Erongo Mountains, home of the beautiful jet-black tourmaline crystals we sent to Club members in August 2003, also known for exceptional aquamarine and world-class jeremejevite, an extremely rare aluminum borate fluoride highly prized by collectors; Klein Spitzkoppe, which produces exceptional topaz crystals and was the subject of a recent *Mineralogical Record* article; Otjua pegmatite, which produces faceted tourmalines in a variety of colors and, a few years ago, enormous clusters of fine smoky quartz crystals; and two producers of exceptional tourmaline, Neu Schwaben and the Usakos tourmaline mine, with bright blue-to-green facet rough coming from both. Who else is up for a trip to Karibib?

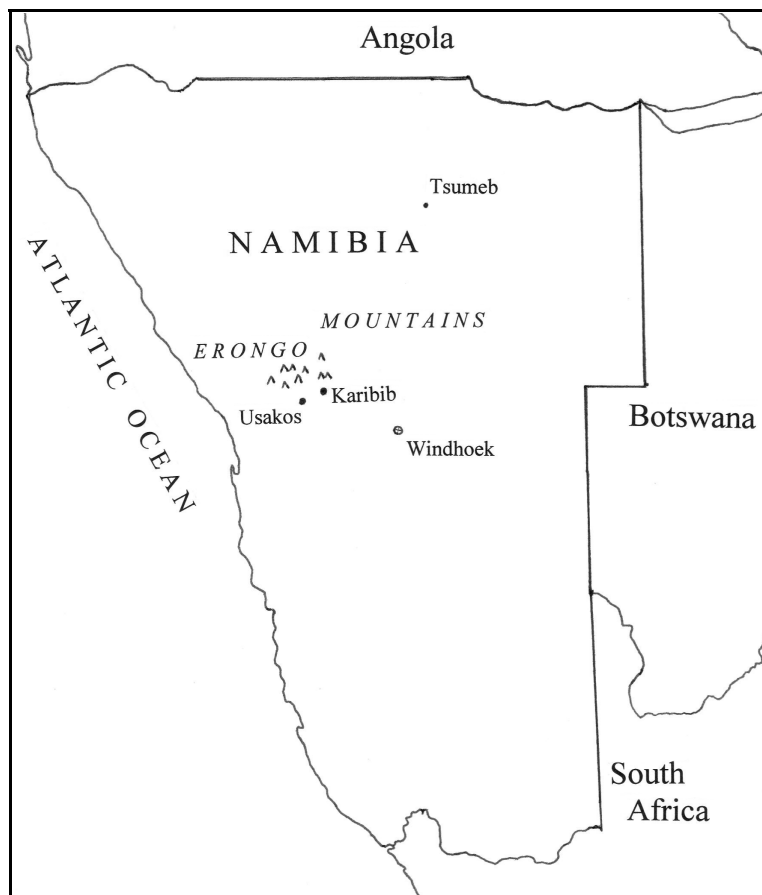


Figure 2 Map of Namibia.

The district lies roughly 100 kilometers west and slight north of Windhoek, the capital of Namibia, formerly known as South-West Africa. This mineral-rich country was colonized by Germany, then captured by South Africa during World War I. Namibia won independence in 1988 after twenty-three years of bloody guerilla fighting. With a population of 1.6 million, a life expectancy of 41 years, and principal occupations of livestock raising and subsistence agriculture, life is difficult for most Namibians. Some are involved in working the previously mentioned mineral localities, and can earn additional income from doing so. Namibia is also well-known in the gem and mineral world for having some of the world's richest, highest-quality diamond fields, and for being home to what many consider the world's greatest mineral locality, Tsumeb. Other Namibian mines produce uranium, copper, tin, lead, silver, vanadium, tungsten, and salt.

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We are fortunate to have been provided the following information on Sandamap, from the manuscript of an upcoming book by Dr. Ludi von Bezing (information in brackets inserted by us):

"The Sandamap pegmatite is situated on Sandamap North 115, just east of the Usakos-Uis road, and it stands out in the surrounding landscape as a white quartz hill. The farmstead is known as Sandamab, and in some of the literature the pegmatite is also written as "Sandamab." To the north is a second hill, the Sandamap Northern pegmatite, that was mined as a tourmaline prospect. Across the dry stream to the east is another smaller pegmatite, known as 'Klein Sandamap'.

"Initial mining started in the 1920's when cassiterite was mined and this mine was one of the first tin mines in the area. Mining was haphazard, following the tin-rich areas and the mine changed hands many times. The last epoch of mining was mainly for petalite [$\text{LiAlSi}_4\text{O}_{10}$, found in Namibia as pink crystals suitable for faceting]. There are large dilapidated excavations on the hill with dumps scattered over the hill slope. Mining ceased many years ago.

"The main pegmatite is a 90m by 20m, highly fractionated, zoned rare metal pegmatite emplaced in schists, with irregular outlines. It has become known to the micromount collectors as a locality with excellent secondary phosphate minerals and is the type locality for giniite [$\text{Fe}^{2+}\text{Fe}^{3+}_4(\text{PO}_4)_4(\text{OH})_2 \cdot 2\text{H}_2\text{O}$]. The phosphates occur as both dendritic growths of primary triphylite and black nodules scattered in the intermediate zone."

Dr. von Bezing also lists the following minerals as found at Sandamap: albite, cassiterite, columbite, goethite, microcline-perthite, microlite, muscovite (including lithian muscovite), natrojarosite, orthoclase, petalite, pyrite, quartz, schorl, and the phosphate minerals apatite, triphylite, heterosite, ferrisicklerite, alluaudite, barboselite, cyrilovite, dufrenite, eosphorite-childrenite, frondelite, giniite, hureaulite, jahnsite, kidwellite, laueite, leucophosphite, lipscombite, melonjosephite, monetite, montgomeryite, phosphosiderite, robertsite-mitridatite, rockbridgeite, scorzalite, stanekite, strengite, tavorite, variscite, and whitlockite. Several may sound familiar from our April 2005 write-up on augelite, where many rare phosphate minerals are also found.

One Sandamap reference mentions purpurite, or let's just call it purpurite-heterosite forming on the rim of the pegmatite, due to weathering of lithiophilite-triphylite, as explained under *Composition*. Many of our specimens are composed primarily of purpurite-heterosite, with zones of other minerals. We recognize some mica, and perhaps some lithiophilite-triphylite, the former described as bluish gray or greenish gray in color, the latter as clove-brown, yellowish-brown to honey-yellow, salmon, with exposed surfaces often brown, dark gray to black due to alteration. We did not observe any reaction to either shortwave or longwave ultraviolet light. It seems that a number of scientists and geologists are giving attention to the many minerals of Sandamap, and more information may be available in the future. Perhaps in ten or twenty years, we will again feature purpurite-heterosite—and who knows what more will have been learned by then?

References: *Minerals of Namibia*, Dr. Ludi von Bezing; *Dana's New Mineralogy*, Eighth Edition; *Encyclopedia of Minerals*, Second Edition, Roberts, et al, Van Nostrand Reinhold; *2004 Fleischer's Glossary of Mineral Species*, The Mineralogical Record Company, Joseph Mandarino and Malcolm Back; *Mineralogy*, John Sinkankas, Van Nostrand Reinhold; *Minerals of the World*, Walter Schumann, Sterling Publishing Company; *Mineralogy of Maine: Vol. 1, Descriptive Mineralogy*, V. T. King and E. E. Foord, Maine Geological Survey, 1994; "Kings Canyon Lithium Pegmatites, Crystal Mountain District, Larimer County, Colorado," Mark Jacobson, *Rocks & Minerals*, January-February 1986; "Gem and Rare-Element Pegmatites of Southern California," Jesse Fisher, *The Mineralogical Record*, September-October 2002; "Famous Mineral Localities: The Pulsifer Quarry, Androscoggin; "From Paris in America to Amerika in Saxony," Max Glas and friends, *extraLapis English* No. 3; "A Plethora of P's," Frederick H. Pough, Ph.D., *Lapidary Journal*, November 1997; "Update on Some Namibian Gem Localities," Brendan Laurs, *Gems & Gemology*, Fall 2002