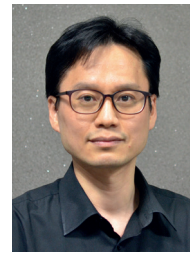
Flowers Blooming on Rocks; Cheongsong Flowerstone of Korea
石上開花：韓國青松郡之花石


YoungMin Kim


JooSeong Moon

YoungMin Kim & JooSeong Moon
Wooshin Gemological Institute of Korea (WGK)
Website: www.wooshinlab.com Email: syracus@naver.com

作者簡述南韓慶尚北道青松郡之帶花狀岩石的地質成因、產出、岩相定義和分類，其流紋岩的形成及晶粒流紋岩的形態分類，並簡介其開採、首飾製作和一些產品。

Introduction

We call rare minerals that have excellent lustre, a beautiful colour, and transparency *gemstones*. Some may also be particularly loved because of their varied and unique patterns such as stripes and orbicules. In particular, the patterns of snowflake obsidian (Bakken 1977) or petrified corals resemble flowers and are therefore sometimes called "flowerstones" (Fig. 1). There are such stones in Cheongsong County, North Gyeongsang Province, South Korea, called "flowerstones" because they look like beautiful flowers. The flowerstone from Cheongsong County attracts a lot of interest because its flower pattern is more pronounced than most (Fig. 2). It may be up to several millimeters in size and appears in a variety of attractive patterns. Recently, the district where this Cheongsong flowerstone occurs has been registered as a World Geological Park and Cheongsong County is currently exploring whether the academic value of such flowerstones might make it possible for it to be listed as a World Natural Heritage Site.

Fig. 1 Examples of flowerstones: Snowflake Obsidian (left) and Petrified Coral (right). *Photo by WGK*
花形石的例子：雪花黑曜岩（左），石化珊瑚（右）

The aim of this paper is to introduce the unique properties of the Korean flowerstone based on information gleaned from a visit researchers from the Wooshin Gemological Institute of Korea made to Cheongsong's Stone and Flowerstone Museum, the Flowerstone Experience Learning Site within the UNESCO Global Geopark, the Flowerstone Production Workroom, and the exhibition/sales offices. This trip was under the guidance of the Cheongsong Flowerstone Association.

Fig. 2 The Chrysanthemum shaped "flowers" on a Cheongsong Flowerstone (spherulitic rhyolite). *Photo by WGK*
青松花石（球粒流紋岩）上的菊花形"花朵"

Petrographic Definition and Classification of the Flowerstone

The mineralogical name of the Cheongsong flowerstone is spherulitic rhyolite. Spherulitic rhyolite grows as quartz mixed with small crystals of orthoclase and plagioclase. (Oh, Kim et al, 2004). The spherulite is classified by the textures of rocks. They are small, rounded mineral aggregate bodies grown in a radial formation. A rhyolite is a rock formed from quickly cooled magma with a high silicic acid content. In other words, it is rhyolitic magma that, when it cooled and hardened, formed a spherulitic structure which is called spherulitic rhyolite. In general, orbicular rocks consist of alternate dark and bright strata around a central core composed of particular minerals or captured materials. The rocks that show these structures are called orbicular rocks, and since they were first mentioned by Von Buch in 1802, they have become

of interest to geologists because of their rare and aesthetic value. Currently, varieties of spherulite have been reported in more than 100 locations including Finland, South Africa, Chile, New Zealand, Sweden, the United States and India. Most of them are developed in igneous rocks such as diorite, gabbro and metamorphic granitic gneiss. Spherical structures develop very rarely in volcanic rocks. The volcanic rocks of the Juwangsan Mountains in Cheongsong, South Korea, are unusual volcanic rhyolites, and spherulite is developed here in shape of the spheroids more generally developed. Spherulitic rhyolites are also found internationally but rarely in a variety of forms.

Formation of Rhyolite and Morphological Classification of Spherulitic Rhyolite

Rhyolite is a volcanic rock created by the rapid cooling of magma (Fink, 1983). An acidic magma with a silicate content of 69-wt% or more, it cools rapidly near the surface. It shows an amorphous and semi-crystalline structure. Obsidian, a well-known gem material, can be said to be a volcanic glass that solidified rapidly at the edge of this rhyolite magma.

Rhyolite consists mainly of quartz, alkali feldspar, and plagioclase minerals. The subcomponent minerals include biotite, amphibole, and hexagonal pyroxene. Rhyolitic magma has low iron and magnesium content and is rich in silicon dioxide, forming magma with high viscosity. When the magma cools slowly, crystals are made to match the temperature of each step, but when rapidly cooled, the crystals are not formed or they are cooled to a state where they cannot make enough crystals. This cooling is called supercooling, in which case the magma component is supersaturated. As a result, some supersaturated minerals grow at a rapid rate in the direction of supply, forming fibrous minerals. In particular, if crystals or rocks form in the magma, new minerals grow rapidly in a radial form with these as nuclei, so a pattern is formed that extends around one point. In the case of snowflake obsidian, the silica in the obsidian crystallises as cristobalite and produces white "skeleton crystals", whereas the spherulitic rhyolite grows as quartz mixed with small crystals of orthoclase and plagioclase. That makes the difference in the representation of various floral patterns. These spherulite morphologies are characterised by fibrous minerals in the dyke that generate the spherulitic rhyolite, which accelerate the rapid cooling of the dykes and vary according to the rate of cooling. These spherulitic rhyolites are divided into simple spherulite, which is a one-step growth, and multiple spherulite, which is a continuous multi-step growth. The spherulite rhyolite from the Juwangsan (mountain) area in Cheongsong is subdivided into a variety of shapes according to the flower types that they resemble; chrysanthemum, dandelion, plum, carnation, peony, rose, sunflower and dahlia types (Fig. 3). The spherulitic rhyolites come from the Jangsan area in Busan, but there is a difference in the radial arrangement in the simple spherulite, as unlike the Cheongsong spherulitic rhyolite, they do not show various orbital structures.

Morphological Classification of the Cheongsong Flowerstone

The chrysanthemum type and dandelion type of flowerstones show the typical texture of fibrous spherulites. Bright colour grows radially from nuclei that are developed at the spherical centre with a dark coloured spherical base. These are classified as simple spherulite. The peony type shows repeating bright and dark spherical cells, and can be classified as a layered multiple spherulite. The carnation type is divided into radial spherulite

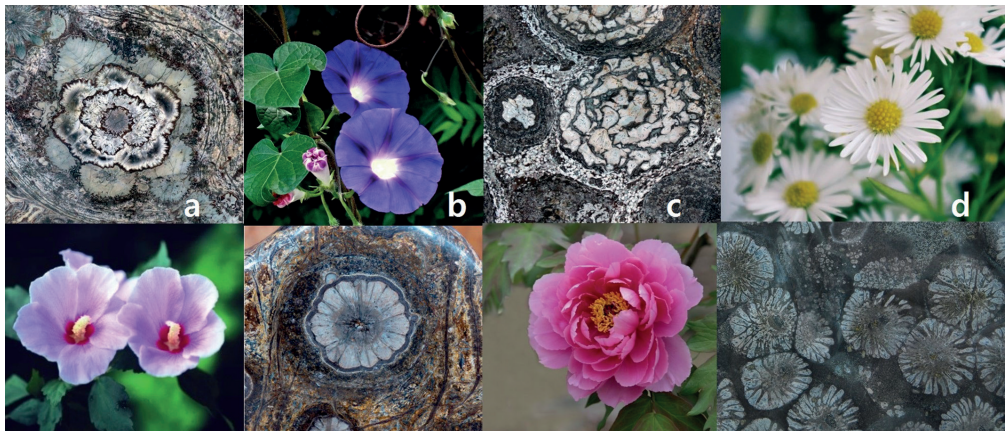


Fig. 3 a) Rose of Sharon, b) Morning glory, c) Peony, d) Chrysanthemum. *Photos by WGK*
a) 沙龍玫瑰，b) 牽牛花，c) 牡丹，d) 菊花

Table 1. The origin and classification of spherulitic rhyolites in Cheongsong 青松郡球粒流紋岩的成因及分類

	Classification of origin	Description	Morphological classification of spherulitic rhyolites
Simple	Radiating simple spherulite	formed by diffusion current caused by supercooling related to very fast cooling	Chrysanthemum and dandelion types
	Layered simple spherulite	formed by supercooling related to medium cooling	Apricot flower type
Multiple	Layered multiple spherulite	formed by relatively slow diffusion as a Liesegang ring* during relatively slow cooling	Peony, Rose, and Amorphous types
	Radiating-layered multiple spherulite	formed by mixed Radiating simple spherulite and supercooling with gas outflow	Carnation type
	Radiating-layered multiple spherulite	formed by relatively fast repetitive supercooling	Dahlia and Sunflower types

inside with layered multiple spherulites outside. The peony and rose types, which again show a repeating pattern of bright and dark spherical cells, can also be classified as layered multiple spherulites. In the case of the rose type, the stratum of bright colour is well connected and has developed into a perfect concentric sphere, but in the peony type, the bright stratum is frequently cut off, showing irregular concentric spheres. Like the flowerstones mentioned above, there are several other types of spherulites that appear to have been formed by irregular mix. However, in some cases, specific spherulites located at the centre of the dykes, surrounding or upper & lower parts show a regular form. In some spherulitic rhyolite, many small dykes and pores appear together and sometimes, bright and dark strata of zonal shapes other than the sphere shape appear repeatedly, and spherulites appear inside these strata. Table 1 shows the origin and classification of Cheongsong flowerstones.

Suiseki and Flowerstone Museum

The museum was established to promote the value of suiseki within our culture. Beautiful rocks and Flowerstones that occur in nature are on display there so that visitors may experience the serene beauty of the mysterious flowers within the flowerstones. The Museum has flowerstones in a variety of colours and shapes on display, explaining the origins and history of the Cheongsong flowerstone at a glance (Fig. 4).

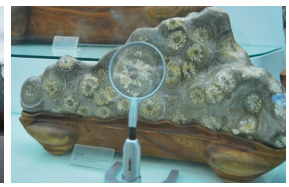


Fig. 4 (L) A panoramic view of the Suiseki and Flowerstone Museum, (R) A yellow chrysanthemum-shaped flowerstone on display in the museum. *Photo by WGK*
(左) 水石及花石博物館的全景圖，(右) 在博物館展出的黃色菊花形狀花石

Flowerstones in the UNESCO Global Geopark

The UNESCO World Geopark is a geological heritage site of scientific importance, The UNESCO assessors, after seeing the Cheongsong flowerstone here, observed that "nature in its most beautiful state is carved on these stones."

In Jinbo-myeon, Cheongsong County, a Flowerstone Experience Centre has been set up in a former spherulitic rhyolites quarry with tableaux reproducing the original mining experience. Flowerstone is easily visible where the dyke has been penetrated, and both the history of flowerstone and the processing of the flowerstone (Fig. 5) are clearly explained. A walkway is currently being constructed there, which will give a closer and much clearer view of the flowerstone's dykes, by processing the outcrops of various forms of flowerstone. When this work is completed, a truly fine geological site will have been created.

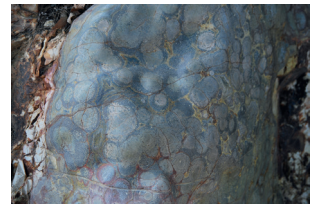


Fig. 5 The outcrop and collection of flowerstone rough; with tableaux showing how the seam is worked. *Photo by WGK*
找尋和收集露出表面的花石原石

Flowerstone processing workshop

Not far from the Geopark, there is a flowerstone village, where we visited one of the workshops where the quarried flowerstone is processed. Flowerstone is not a gemstone in its raw form, but it becomes a true ornamental gem after processing. The flowerstone, once cut from the outcrop (Fig. 6), is transported to workshops where, after it is cut, ground and polished, it is ready to be put on

display. In order to cut the stone to the proper size in the factory, large, medium and small cutters are used on the stones according to need.

Fig. 6 Sectional aspect of spherulitic rhyolite. *Photo by WGK*
球粒流紋岩的切面

Flowerstone has slightly different properties depending on the dyke from which it is mined. In flowerstone that is quarried in yellow and white dykes, the spherulite and the host material are easily separated. However this is not the case in flowerstone that is quarried in blue dykes, so it is less likely to crack during processing and can be carved into vases, sculptures and tables.

The Flowerstone Gallery and Shop

Our last stop on our tour of the Cheongsong Flowerstone Association was at the Flowerstone gallery and shop. Actually you can see many small shops and galleries selling or exhibiting flowerstone products In Cheongsong County. Each shop has its own distinctive style, all charming in different ways even though the colour and pattern may be the same. We saw flowerstone cut to a toad shape, as table or interior ware, even as a picture in a frame. There was also flowerstone furniture on display for everyday use, such as tables and desks, as well as jewellery such as necklaces and pendants (Fig. 7).

Fig. 7 a) Rose pendant, b) Red plum necklace, c) Red plum pendant. *Photos by Cheongsong Flowerstone Association*
a) 玫瑰吊墜，b) 紅梅花項鍊，c) 紅梅花吊墜

Uniqueness and Scarcity of the Cheongsong Flowerstone

As we have seen, Cheongsong's spherulitic rhyolite is characterised by a larger, more vivid floral pattern than is seen in spherulite with simple repetition of concentric circles or spherulitic rhyolite from other regions. Due to its unique beauty, Cheongsong Flowerstone was mined in large quantities in the 90's and freely exported, but later, this became regulated so that mining was restricted to those with official licences, as the authorities recognised the value of Flowerstone to the country. The former mining area has been designated a UNESCO geological park and all mining is now prohibited, which will further increase the scarcity of the Cheongsong Flowerstone.

If you are in Cheongsong, visit the Suiseki and Flowerstone Museum located towards the Juwangsan Mountains and the Flowerstone Experience Centre in Goejeong-ri, Jinbo-myeon, to learn about the unique beauty of Cheongsong Flowerstone. I hope you will recognise the unique beauty of "Cheongsong Flowerstone," the flower made by lava and preserved by rocks for a long time.

Acknowledgement

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