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SYSTEMATIC INCLUSION STUDY ON SOME RARE GEMSTONES OF THE MOGOK AREA, MANDALAY REGION, MYANMAR

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Abstract. *The Mogok area is situated in Mogok Township, Mandalay Region. It is bounded by Latitude* 22°52′-23°00′ *N and Longitude* 96°10′-96°33′ *E. The rock sequence of the study area consists of medium to high grade metamorphic rocks; marble, gneiss, and intrusive igneous rocks; Kabaing granite, leucogranite and syenite. It is famous for presence of ruby and sapphire. Exceptionally some rare gemstones also are discovered. The present work is especially intended to explain systematically the inclusions of some rare gemstones from the Mogok area. Liquid feather inclusions present in jeremejevite. Two-phase inclusions occur in morganite and petalite. In petalite, tube-like inclusions also present. Opaque inclusion and solid inclusion occur in rutile and treacle granular inclusion and finger print inclusion observe in sinhalite.*
Keywords: Mogok area, Rare gemstones, Inclusion

1. **Introduction.** The Mogok area is found about 545 miles N from Yangon and situated within the Mogok Township, Mandalay Region. It is bounded by Latitude 22°52′ to 23°00′ N and Longitude 96°10′ to 96°33′ E. The study area has rugged terrain and hard accessible territories of the hilly regions [1-3]. Automobiles can access the study area from the Yangon through Mandalay. This area is especially composed of igneous and metamorphic rocks namely Kabaing granite, leucogranite, syenite, marble and gneiss [4-6].

Defined broadly, an inclusion is a foreign chemical that appears as a clear solid, liquid, or gas contaminant inside a mineral crystal. Under this definition of inclusion, water is the commonest one to be found in crystals, often having bubbles of gases (such as carbon dioxide) in it. Sometimes suspended crystal inclusions are floating in water inclusions: solid inclusions within liquid inclusions within the host mineral. Air or CO_2 bubbles are found in liquid inclusions (mostly water) in calcite, fluorite, halite, and quartz crystals, for example [7].

The present research is mainly intended to carry out laboratory works including systematic inclusions study of some rare gemstones from the Mogok area. Therefore, the stereo zoom gemmolite, refractometer, polariscope, spectroscope, and other available gem testing instruments were used to identify the various sorts of inclusions in rare gemstones.

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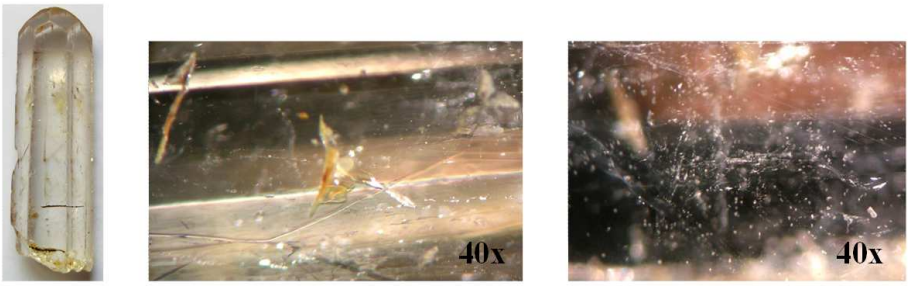
2. **Methods of Study.** Some rare gemstones sampling for detailed gemmological studies was conducted [8]. Identification of gemstones was carried out with the aid of stereo zoom gemmolite, refractometer, polariscope, spectroscope and other available gem testing instruments.

Systematic Mineralogical Analysis of Some Rare Gemstones

Jeremejevite

Chemical composition	$Al_6B_3O_{15}(OH)_3$ (Aluminium borate)
Crystal system and habits	Hexagonal (blue), Orthorhombic (yellow or colorless). Elongated prismatic crystals and tapering (Figure 1(a))
Cleavage	None
Fracture	Iron oxide stained fractures (Figure 1(b))
Hardness	6.5
Specific gravity	3.28
Colour and transparency	Pale yellowish brown: transparent to translucent
Refractive index	1.639-1.648
Occurrence	Jeremejevite occurs in loose granitic debris.
Locality	Kyauksin, Painpyit
Inclusion	Liquid feather inclusion (Figure 1(c))

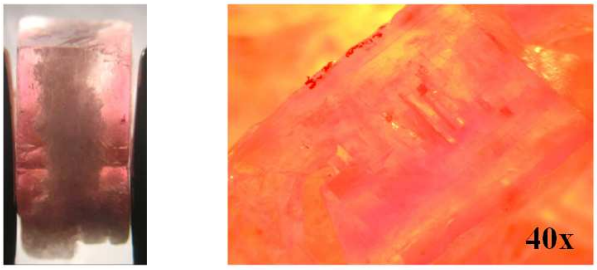


(a) (b) (c)

FIGURE 1. (a) Elongated prismatic Jeremejevite crystal, (b) iron oxide stained fractures and (c) liquid feather inclusions

Morganite

Chemical composition	$Be_3Al_2Si_6O_{18}$ (Beryllium aluminium silicate)
Crystal system and habits	Hexagonal. Prismatic often with striations parallel to their lengths; also, massive (Figure 2(a))
Cleavage	Basal, poor
Hardness	7.5-8
Specific gravity	2.8
Colour and transparency	Transparent gem quality beryl may be pink (morganite): transparent to translucent
Refractive index	1.586-1.594
Occurrence	Accessory mineral in granite, and pegmatite. It is usually found in cavities. It also occurs in schist and gneiss in association with phenakite, rutile and chrysoberyl.
Locality	Momeik
Inclusion	Two-phase inclusions (Figure 2(b))

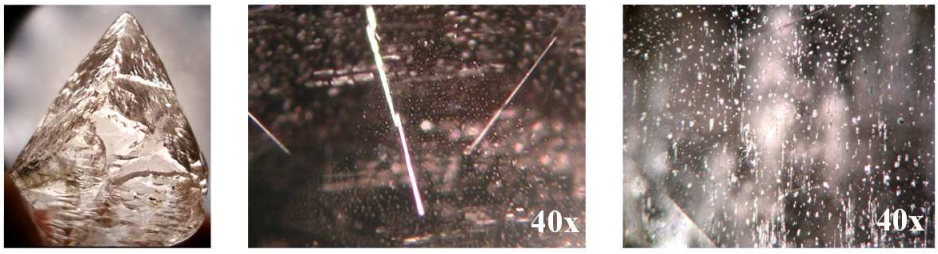


(a) (b)

FIGURE 2. (a) Prismatic morganite crystal and (b) two-phase inclusions

Petalite

Chemical composition	$LiAlSi_4O_{10}$ (Lithium aluminium silicate)
Crystal system and habits	Monoclinic. Crystal rare. Usually as masses showing cleavage (Figure 3(a))
Cleavage	One set, perfect
Fracture	Subconcoidal
Hardness	6-6.5
Specific gravity	2.4
Colour and transparency	Whitish gregyg, sometimes colorless: transparent to translucent
Lustre	Vitreous, pearly on cleavage surface
Refractive index	1.504-1.516
Occurrence	Typically occur in lithium-bearing granite and pegmatite along with minerals spodumene, tourmaline, lepidolite and feldspar.
Locality	Molo (about 32 miles NE of Momeik)
Inclusion	Tube-like inclusion, and two-phase inclusions (Figures 3(b) and 3(c))



(a) (b) (c)

FIGURE 3. (a) Petalite crystal, (b) tube-like inclusions and (c) two-phase inclusions

Rutile

Chemical composition	TiO_2 (Titanium oxide)
Crystal system and habit	Tetragonal. Prismatic and terminated by bipyramids. Prism faces often striated; also massive (Figure 4(a))
Cleavage	Prismatic, distinct
Fracture	Uneven

Hardness	6-6.5
Specific gravity	4.25
Colour and transparency	Usually reddish brown; can be yellowish red or black. Transparent when thin, usually sub translucent, occasionally nearly opaque.
Refractive index	2.616-2.903
Occurrence	Accessory mineral in a variety of igneous rocks, and in schist, gneiss, metamorphosed limestone, and quartzite. It often occurs as acicular crystal in quartz (rutilated quartz). It is also concentrated in alluvial deposits and beach sands.
Locality	Sinkwa, Bawlongyi, Pyaunggaung
Inclusion	Opaque inclusion, solid inclusion (Figures 4(b) and 4(c))

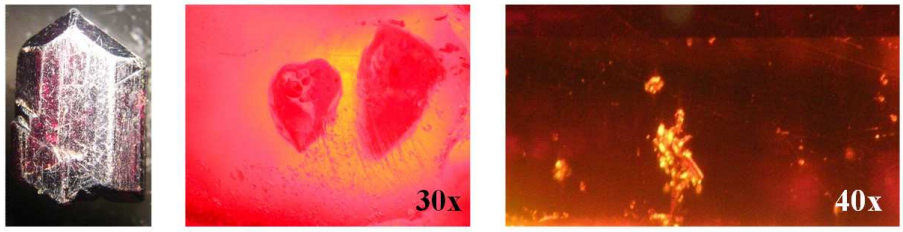


FIGURE 4. (a) Prismatic rutile crystal, (b) opaque inclusion and (c) solid inclusion

Sinhalite

Chemical composition	$Mg(Al,Fe)BO_4$
Crystal system and habit	Orthorhombic. Found only as grains and rolled pebbles (Figure 5(a))
Cleavage	Distinct in two directions
Fracture	Conchoidal
Hardness	6.5-7
Specific gravity	3.47-3.50
Colour and transparency	Yellowish, greenish brown: transparent to translucent
Refractive index	1.670-1.707
Occurrence	A contact metamorphic mineral in limestone at granitecontact; alluvil.
Locality	Kyauksin, Ohn Gaing
Inclusion	Treacle granular inclusion and finger print inclusions (Figures 5(b) and 5(c))

3. **Results of Inclusion Study of Gemstones.** The study of inclusions is extremely important. Inclusions can help gemmologists to

1) Identify gemstone species. Some types of inclusions are typical for certain gem species, for example, liquid feather inclusions in jeremejevite, tube-like inclusions in petalite, and treacle granular inclusion and finger print inclusion in sinhalite.

2) Distinguish between natural and synthetic materials, for example curved striations in synthetic stones.

3) Detect treatments, for example dye in the cracks of stained materials.

4) Assess the 'cleanness' of the stone, for example the clarity of Mogok ruby. This will affect the quality of the stone and therefore the price.

5) Assess the likelihood of future damage to the stone from fractures and cleavages. This is of great importance when receiving stones for setting and repair, or when selling stones which may suffer from a lack of durability.

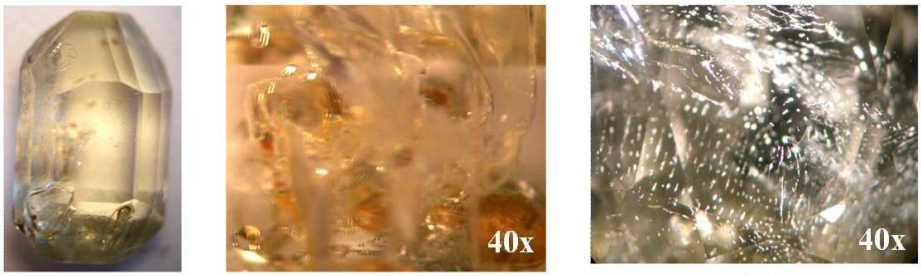


FIGURE 5. (a) Sinhalite crystal, (b) treacle granular inclusion and (c) finger print inclusion

6) Understand how gemstones were formed and the nature of their environments during formation. This information can be used to gain information that can be used when prospecting for new localities.

4. **Discussion.** A gemstone may also vary from the normal physical property values due to inclusions which can, if present in sufficient quantities, reduce or increase the specific gravity. This is true of many gemstones, so allowances must be made when assessing the SG of any particular specimen. Some gemstones rely upon large numbers of inclusions for visual appeal, as with star, cat's-eye and aventurine stones.

Inclusions may be

1) Solid, liquid and gas. For example, a solid inclusion may be a crystal or a needle-like inclusion. Solids may also occur in cavities along with liquids and gases. These are of three types:

a) Monophase inclusions of liquid, gas or solid

b) Two-phase inclusions which contain liquid and gas, gas and solid, or liquid and solid

c) Three-phase inclusions which contain liquid, gas and solid

2) Zoning, including colour distribution;

3) Twinning;

4) Internal fractures and cleavages;

5) Treatments such as laser drill holes.

The previous mentioned inclusions are clearly seen by stereo zoom gemmolite. If the crystal is highly transparent, the inclusions may be observed clearly under magnification. Sometimes, if the inclusions are very small and transparency of host mineral is not good, stones are immersed in water or some immersion liquids under the gemmolite. However, some crystals do not have inclusions.

5. **Conclusions.** All gem varieties from the Mogok area are mainly recovered from secondary deposits (gravels). Most gemstones contain inclusions and each gemstone possesses the unique inclusions. Some inclusions may be used to identify the gem species or variety and occasionally the source locality. Inclusions are also important in helping to distinguish many types of artificial and treated gem materials. The present research describes the occurrences of liquid feather inclusions in jeremejevite, two-phase inclusions in morganite and petalite, tube-like inclusions in petalite, opaque inclusion and solid inclusions in rutile and treacle granular inclusion and finger print inclusion in sinhalite. In conclusion, this research work is not the end of the story of rare gemstone's inclusions of the Mogok area. Some more concealed rare gemstones could be discovered in the near future and then classified genetically.

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