The Republic of the Union of Myanmar

Ministry of Natural Resources and Environmental Conservation

Myanma Gems Enterprise

# Gemmological Accounts Of Ruby From Shwe Pyi Aye- Shwe Daing-Dattaw Pyant Area, Mogok Township, Mandalay Region, Myanmar

Jue Jue Htin

Gem Sorter - 1

February, 2024

**Contents**

**Gemmological Accounts Of Ruby From Shwe Pyi Aye- Shwe Daing- Dattaw Pyant Area, Mogok Township, Mandalay Region, Myanmar**

## 1. Introduction

Mogok area is well known for many centuries as the source of the world's finest rubies, sapphires and other precious stones.The study area is contained in the Mogok Stone Tract of Iyer (1953), Mogok Belt of Searl and Haq (1964). The metamorphic are regionally metamorphosed high grade para – and ortho- gneisses, calc- silicates rocks and marbles and igneous rocks include syenitic rock and leucogranite. Itis situated within Mogok Township, Mandalay Region, Myanmar. It also lies between N. Lat 22° 55′ 30″ to 22° 57′ 30″ and E Lon 96° 29′ 30″ to 96° 31′ 30″, is a part in UTM map 2296-05 and 2296-09. The area is approximately 3 square miles. Mogok can reach from Mandalay by car with two highway roads. Location map of the study area is shown in (Figure 1).

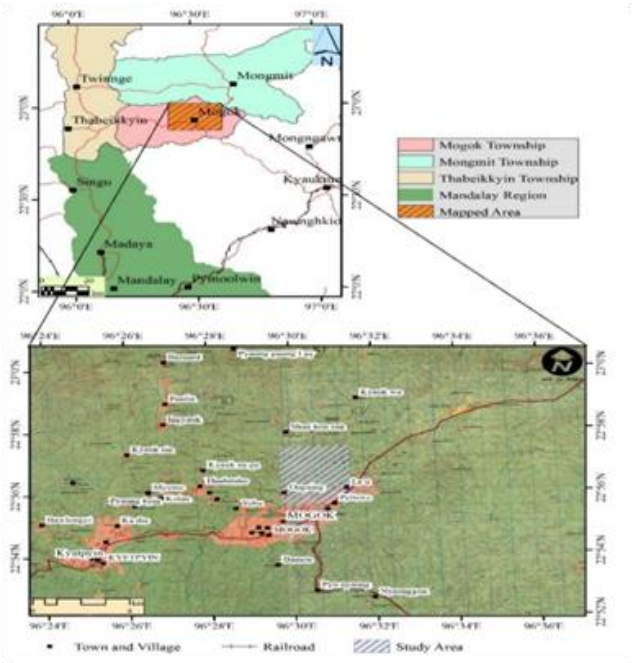


Figure 1. Location map of the study area (source: MIMU, 2010)

## 2. Objective

The main objectives of this study have three-fold:

1. To ascertain the ruby association of the study area.
2. To investigate the gemmological accounts and inclusions of ruby by using advanced laboratory techniques.
3. To describe the origin of ruby in the investigated area.

## 3. Laboratory methods

1. Using gemmological microscope was used to examine the inclusion which is useful for genetic interpretation.
2. Identifying the refractive indices with the Rayner's refractometer.
3. Fluorescence test was determined by using LW (365nm) and SW(253.7nm) UV illumination for some gemstones.
4. Specific gravity was determined by hydrostatic method with electronic balance.

5. Trace element concentration of Rubies fromthe study area was determined by X-Ray Guide Tube (XGT).
6. FTIR (Fourier Transform Infrared) Spectroscope was used for identify unknown inclusion minerals in Ruby.
7. Raman spectroscope was used for determining thehost minerals and inclusions of mineral species.

## 4. Nature and Occurrences of Ruby

The study area is a rugged and mountainous region with steep sloped covered by dense forests forming the western border of Shan Plateau. Good exposures of marble are also widely distributed all over the study area. Various types of marbles include pure marbles, spinel, graphite, phlogopite -bearing marbles, forsterite, chondrodite, diopside-bearing marbles and ruby-bearing diopside marble.Primarily ruby occurs in coarsely crystalline marble and skarn deposits. Primary ruby worksites are situated around the study area.

## 5. Gemmological accounts of Ruby

Ruby is a gem variety of corundum which is a crystalline form of aluminum oxide ($Al_2O_3$) typically containing traces of chromium, titanium, vanadium and iron. It is also a naturally transparent material, but can have different colours depending on the presence of transition element impurities in its crystalline structure.The red (Cr-bearing) gem variety is called Ruby. It is a very hard (hardness 9 on the Mohs' scale), tough and stable mineral. It is also unaffected by acids and most environments. Ruby usually forms in metamorphic rocks like marble which are rich in aluminium.

Mogok area is well-known for its corundum deposits.The mining area at Shwe Pyi Aye has a centuries-old history of gem mining. It is famous for its highest quality ruby. Shwe Daing mine is well-known for its fine quality rubies, but of small size. Dattaw Pyant area is famous for large, fine quality ruby crystals. Some rubies found in the marble matrix are of a fine red colour and high luster, making them exquisite mineral specimens.

### 5.1. Forms and Habits

Rubies of the study area are short prismatic terminated by a basal pinacoid and rhombohedron faces (Figure2). Octahedron like forms is rarely observed, due to a large development of rhombohedron faces and waterworn.

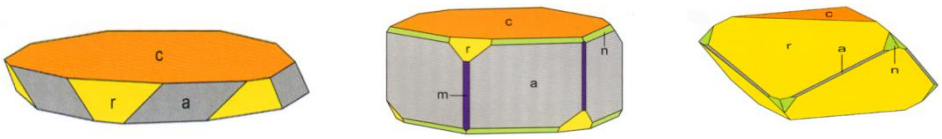


Figure 2. Common crystal forms and habits of ruby from the study areaC = basal pinacoid, m = 1st order hexagonal prism, a = 2nd order hexagonal prism,r = positive rhombohedron, n= 2nd order hexagonal dipyramid

### 5.2. Basic GemmologicalProperties and Characteristics of Ruby

| | |
|---|---|
| Name | -Ruby |
| Chemical Composition | -$Al_2O_3$ (Aluminium oxide) |
| Crystal system | -Hexagonal (Trigonal) |
| Forms and Habits | -Tabular, short prismatic terminated by a basal pinacoid and rhombohedron faces. |

| | |
|---|---|
| Colour | - Light pale pinkish, red to very dark red |
| Hardness | -9 |
| Streak | -White |
| Transparency | -Transparentto Opaque |
| Specific Gravity | -3.99- 4.01 |
| Refractive Index | -1.76-1.77 |
| Double Refraction | -0.008 |
| Dispersion | -Medium (0.018) |
| Pleochroism | -Distinct pleochroism, showing orange red to puplish red. |
| Fluorescence(UV) | - Strong red (LW) and Moderate red(SW) |
| Spectrum | - Two fine,dark lines in the blue at 468 nm and 476 nm, fine lines in the orange-red at 659 nm,668 nm, and 693 nm |
| Mode of Occurrence/ Environment | -In altered metamorphic rocks such as marble and hornfels, in nepheline syenite pegmatites and in placer deposits. |

Table 1. Gemmological properties of Rubies from the study area

| No | Sample No. | Photo | Colour | Weight | R.I | S.G | Measurements (L-W-D) | Fluorescence UV | Dichroism |
|---|---|---|---|---|---|---|---|---|---|
| 1 | R 1 |  | Purplish Red | 0.36Ct | 1.762 - 1.770 | 3.95 | 4.16 x 3.75 x 2.46 mm | LW - Strong red , SW - Moderate red | Orangy red and purplish red |
| 2 | R 2 |  | Purplish Red | 0.35Ct | 1.760 - 1.770 | 4.01 | 4.25 x 3.89 x 1.94 mm | LW - Strong red , SW - Moderate red | Orangy red and purplish red |
| 3 | R 3 |  | Purplish Red | 1.15Ct | 1.762 - 1.770 | 3.99 | 6.66 x 5.25 x 3.75 mm | LW - Strong red , SW – Moderate red | Orangy red and purplish red |
| 4 | R 4 |  | Purplish Red | 0.42Ct | 1.762 - 1.770 | 4.01 | 4.89 x 3.57 x 2.56 mm | LW – Strong red , SW - Moderate red | Orangy red and purplish red |
| 5 | R 5 |  | Purplish Red | 0.53Ct | 1.760 – 1.770 | 3.87 | 5.11 x 3.95 x 2.70 mm | LW– Strong red , SW - Moderate red | Orangy red and purplish red |
| 6 | R 6 |  | Purplish Red | 1.55Ct | 1.762 - 1.770 | 3.95 | 7.83 x 6.19 x 3.49 mm | LW - Strong red , SW - Moderate red | Orangy red and purplish red |

## 6. Chemical Characteristics of Mogok Ruby

Trace element analysis data (XGT results) of Mogok rubies (Shwe Pyi Aye- Shwe Daing-Dattaw Pyant)are presented in Table 2 respectively. Trace element distribution diagrams of Mogok rubies from the study area are shown as graphical form in (Figures 3).

The trace element present in Mogok rubies are Cr, Fe, V, Ti, Ga and Mn. Cr is the dominant one. It is also noted that V concentration of Mogok ruby is rather high.

Table 2. XGT Trace element analysis result of rubies from the study area

| Sample No. | Worksite | Cr (ppm) | Ti (ppm) | Fe (ppm) | V (ppm) | Ga (ppm) | Mn (ppm) |
|---|---|---|---|---|---|---|---|
| R1 | Shwe Pyi Aye | 5600 | 100 | 100 | 2400 | 0 | 100 |
| R2 | | 9700 | 700 | 100 | 300 | 0 | 200 |
| R3 | | 23000 | 2000 | 500 | 4800 | 0 | 200 |
| R4 | | 53900 | 1100 | 1200 | 3800 | 600 | 800 |
| R5 | | 22900 | 800 | 500 | 1600 | 200 | 200 |
| R6 | Shwe Daing | 53900 | 800 | 8000 | 2400 | 0 | 2600 |
| R7 | | 4700 | 1500 | 15800 | 600 | 3500 | 0 |
| R8 | | 4100 | 900 | 400 | 1000 | 100 | 0 |
| R9 | | 9700 | 1400 | 0 | 2100 | 500 | 8000 |
| R10 | | 11800 | 2000 | 15200 | 3700 | 400 | 500 |
| R11 | Dattaw Pyant | 41600 | 1500 | 500 | 2200 | 0 | 600 |
| R12 | | 16400 | 0 | 300 | 500 | 2100 | 100 |
| R13 | | 34600 | 900 | 400 | 4500 | 300 | 400 |
| R14 | | 40900 | 100 | 10900 | 1100 | 0 | 600 |
| R15 | | 39800 | 500 | 800 | 3800 | 200 | 3400 |

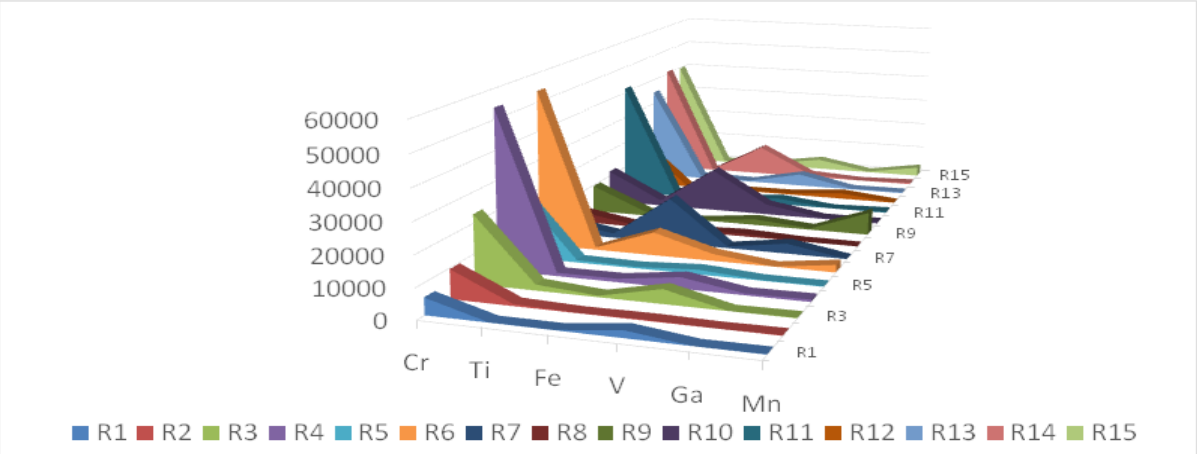


Figure 3. Trace element distribution diagram of Mogok Rubies from the study area

## 7. Inclusion of Ruby

Threetypes of inclusions are found in ruby from the study area. They are–

(a) Protogenetic inclusions (e.g- quartz, zircon, spinel, calcite and apatite)

(b) Syngenetic inclusions(e.g- solid or as cavities or 'bubbles'of gas or liquid encapsulated in the host mineral)

(c) Epigenetic inclusions(e.g- rutile needles)

Inclusions in rubies are studied by using gemmolite microscope which has been examined under 10x,20x,25x magnification. And also, host minerals and inclusions of mineral species were identified by FTIR (Fourier Transform Infrared) Spectroscope and Raman Spectroscope. Crystalline solids of various minerals along with dense cloud of rutile silk are characteristic of rubies from the study area.

### Rutile

Rutile is often found as an inclusion inside Ruby. Intersecting needles of the mineral rutile create a common ruby inclusion called silk which is found to consist of long crystals of rutile, straight and needle like in appearance and arranged in 3 sets of parallel threads, which intersect each other at 60˚-120° angles (Figure 4(d)). Properly arranged rutile needles in a cabochon cut ruby may produce asterism. These rutile silks are epigenetic as they are formed by exsolution.

### Calcite

It is the common inclusion in rubies in the study area. It occurs as both rounded and angular rhombs, recognized by its cleavage and twin bands. Sub rounded plates of calcite are often seen. It may appear as a single crystal or as groups.

### Apatite

Euhedral prismatic or rounded low relief crystals of apatite are found in ruby.

### Mica

It is found as hexagonal shiny platelets in ruby. It may be colourless to brown.

Apart from these solid inclusions, very prominent straight anglular growth zoning is common in ruby. Pronounced polysynthetic twinning is also observed in ruby. Swirly colour pattern, known as treacle is seen in ruby. Liquid inclusion in the form of feather and fingerprints is rare in ruby. All these internal features are syngenetic.

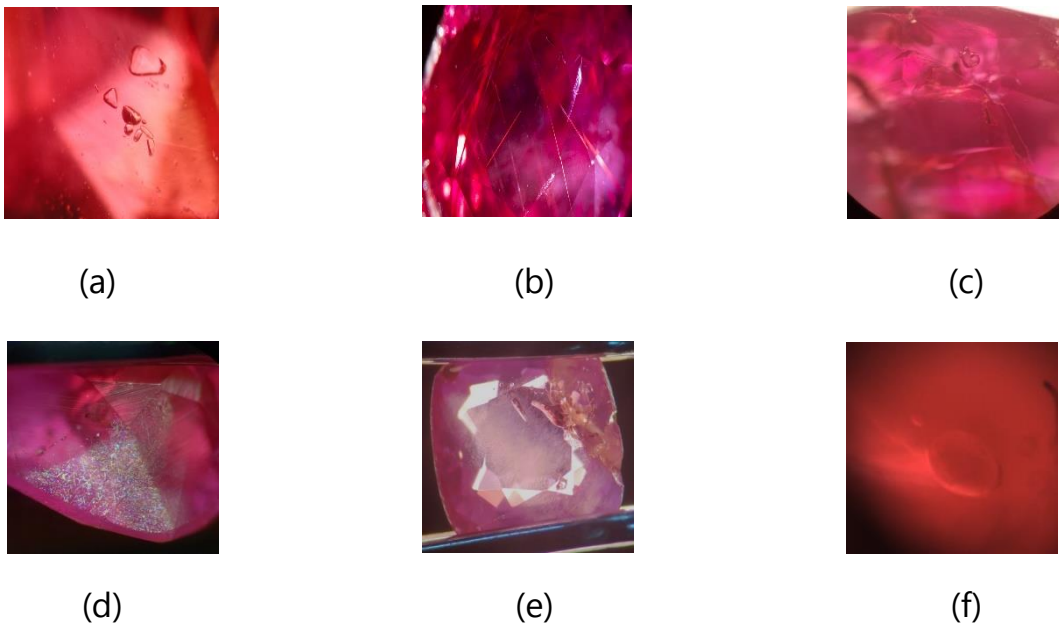


Figure 4. Inclusions of ruby in the study area

(a)Solid calcite crystal inclusion in ruby (R-5)10x (b)Long rutile needles inclusion in ruby (R-5)20x (c)Solid calcite crystal inclusion in ruby(R-2). 20x (d) 3 set of short rutileneedlesin ruby (R-1)20x (e)Solid calcite crystals and 3 set of short rutile needles in ruby (R-2)10x (f) Solid apatite crystal inclusion in ruby (R-6)40x

Table 3. Inclusions of Ruby Samples

| NO. | Sample No. | Magnification |
|---|---|---|
| 1 | R(1)– S P A | Solid calcite crystals, 3 set of rutile needles. |
| 2 | R(2)– S P A | Solid calcite crystals, 3 set of rutile needles. |
| 3 | R(3)– S D | Long rutile needles, Fingerprint, Solid crystals, Many fractures. |
| 4 | R(4)– S D | Long rutile needles, 3 set of short rutile needles |
| 5 | R(5)– Dattaw pyant | Solid calcite crystals,Long rutile needles, short rutile needles and fingerprint. |
| 6 | R(6)– Dattaw pyant | Solid calcite and apatite crystals, Long rutile needles, 3 set of rutile needles, Many fractures, Large cavity. |

### 7.1. Inclusions Study of Ruby with FTIR Spectra and Raman Spectrometer

The inclusions that contained in the studied ruby samples were analysed by Fourier Transform Infrared Spectrometer. The analysed spectra shows that the included inclusions are mostly calcite which may probably be protogenetic (Figure 5). Moreover, Raman analyses also proof that the Raman spectrum of ruby sample (R-5) with the primary inclusion consisted of a calcite crystal with a peak at 1086cm $^{-1}$ (Figure 6) and sample (R-6) with the primary inclusion consisted of an apatite crystal with a peak at 965 cm $^{-1}$ (Figure 7). The Raman spectra were collected with a 785 nm laser.

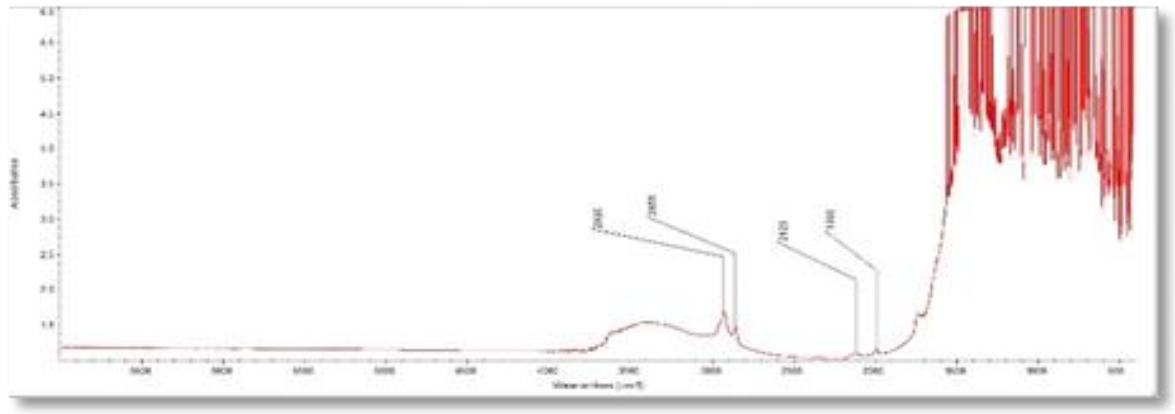

Figure 5. FTIR spectra of the ruby (R-1) displayed calcite peaks at 2855, and 2920cm$^{-1}$and diaspore 1990, 2120cm$^{-1}$ peaks.

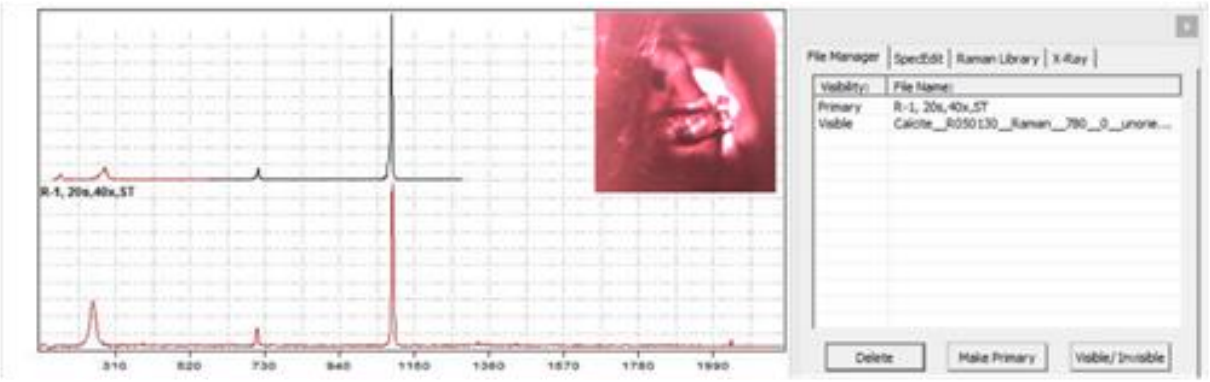


Figure 6.Raman spectrum of ruby sample (R-5) displayed round shaped crystal-calcite(1086cm-1)

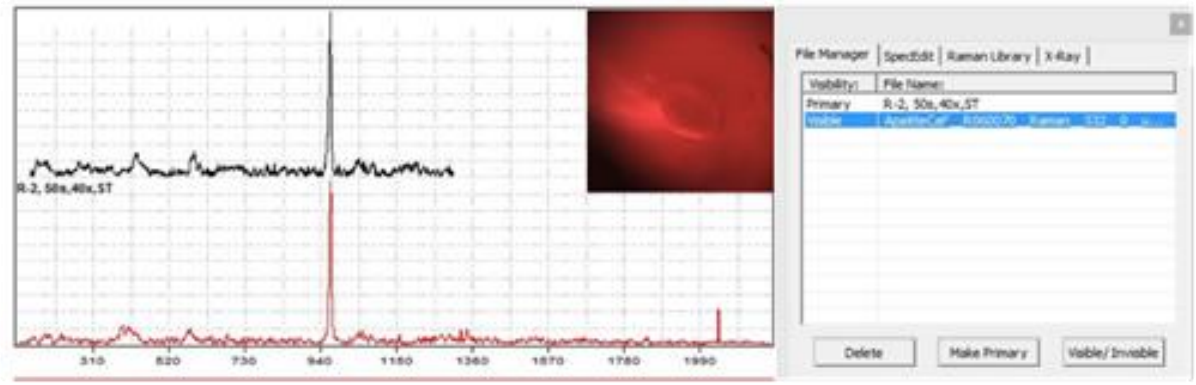


Figure 7.Raman spectrum of ruby sample (R-6) displayed round shaped crystal-apatite(965cm-1)

## 8. Origin of Ruby

Ruby samples can be assigned to either a "basaltic" or "metamorphic" origin based on their trace element composition. XGT Trace element analysis data of the rubies from the study area fall within metamorphic field which comprises regional and contact metamorphic rocks (Figure 8).

The origin of ruby deposits in the study area are indicated by trace element distribution pattern of $Fe_2O_3/TiO_2$ vs $Cr_2O_3/Ga_2O_3$ in which the trace element ratio of ruby in this area is plotted in (Figure 8). The regional metamorphic and magmatic field demarcations are modified after Sutherland et al., (1998) and Than Than Nu (2003). The Cr contents are highly variable in ruby grains and correspond with colour variation from deep red to pink. High Cr contents are also known in some unusual ruby associations.

The field for contact metamorphic and regional metamorphic type corundum's have high $Cr_2O_3/Ga_2O_3$ (10-700 ppm) ratio. Though $Cr_2O_3/Ga_2O_3$ ratios are similar, but $Fe_2O_3/TiO_2$ ratios are quite different. Regional metamorphic type rubies display high $Fe_2O_3/TiO_2$ (1-100ppm) ratios. The field for contact metamorphic type rubies falls between these two fields. Some plots of rubies from study area fall in hydrothermal metamorphic field which may probably be formed at the contact zone from deeper level.

Twodimensional plot of trace element distribution diagram $TiO_2/ Ga_2O_3$ vs $Fe_2O_3/Cr_2O_3$ of this area is shown in (Figure 9). It is clearly seen that most ruby fall in the metamorphic field except only one in magmatic field which may probably be formed at the contact metamorphic zone. Judging from the results of figure, rubies from the study area are mainly formed regional metamorphism.

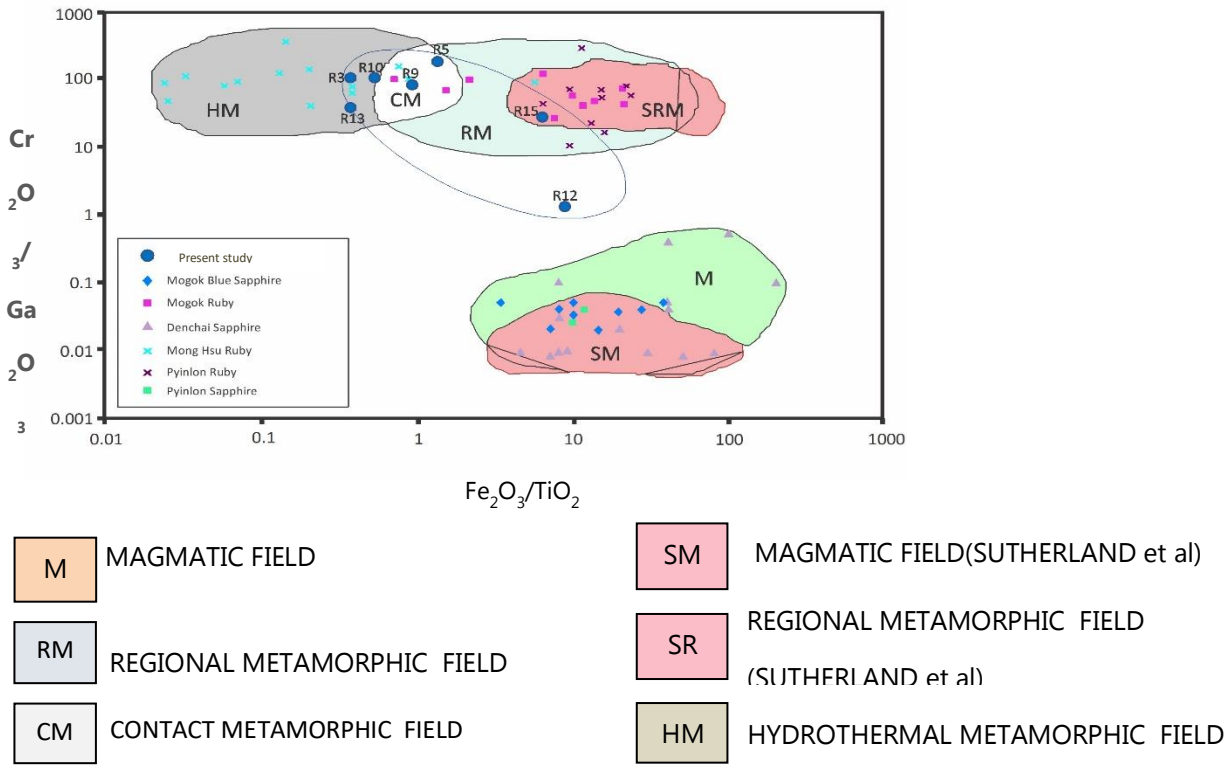


Figure 8.The different modes of origin of primary corundum deposits in Mogok, Pyinlon,Möng Hsu and Denchai(Thai)area, as indicated by trace element distribution pattern $Fe_2O_3/TiO_2$ vs $Cr_2O_3/Ga_2O_3$ : HM=Hydrothermal Metamorphic ruby deposit (Möng Hsu),CM= contact metamorphic ruby deposit (Mogok),RM = Regional Metamorphic ruby deposit(Mogok Pyinlon),and M=Magmatic sapphire deposit(Mogok, Pyinlon, Denchai "Thai" ):(based on classification of Sutherland et al., 1998.AndThan Than Nu, 2003)

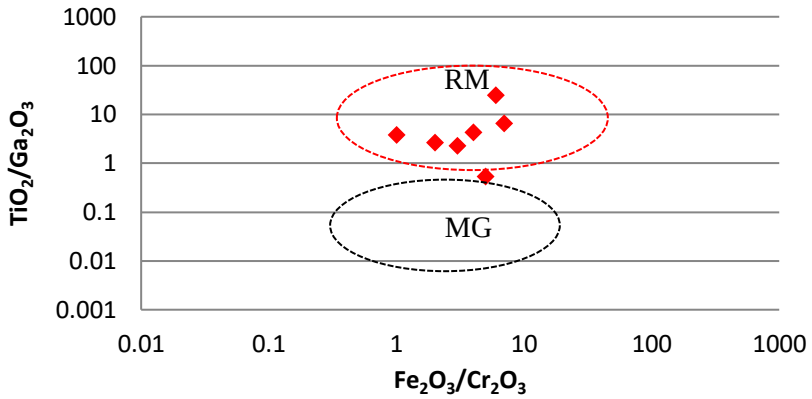


Figure 9. Two dimensional plot of trace element distribution diagram Fe2O3/Cr2O3 vs TiO2/Ga2O3 of the study area; RM= regional metamorphic field, MG= magmatic field (from Sutherland et. al., 1998).

## 9. Conclusion

The colour of ruby found *in situ* in marble is depend on the colouring trace element in the original aluminous layer in limestoneand trace element nearby. Fine quality, large rubies from the study area are mainly formed in regional metamorphic rock which is pure coarse-grained, ruby-bearing crystalline marble with a minor amount of pyrite, sphene and phlogopite. Subordinate amount of rubies are together with diopside, scapolite and hornblende are also found in contact zone between marble and syenitic intrusion. At Shwe Pyi Ayeworksite fine quality rubies are found in the yellow stained brecciated marble in contact zone (between yellow marble and intrusive rocks). Small size fine quality rubies from Shwe Daing are recovered from the alluvium in several fracture filled deposits. Dattaw pyant ruby has slightly higher glow under short wave ultraviolet light than others. Common solid inclusions are rutile, spinel, calcite and sphene. Rutile mainly occurs as oriented needles, which sometimes may develop into star form. Liquid feather inclusion is very rare.

**Acknowledgement**

I would like to express many thanks to my supervisor Dr.Than Than Nu, Professor and Head of the Geololgy Department, Mandalay University and Dr.Thet Tin Nyunt, Director General, Department of Geological Survey and Mineral Exploration for their valuable advice, comments and suggestions in chemical data of my study area. I want to express thanks to Managing Director and responsible personnel of the Myanmar Gem Enterprise. I also want to express our gratitude to everyone who provided assistance in performing this study.

## References


Iyer,L.A.N.,(1953). The geology and gemstones of the Mogok Stone Tract, Burma: Mem.Geol. Surv. India, v. 82., p.100

Jue Jue Htin., (2019).Gem Corundum Mineralization in Shwe Pyi Aye – Shwe Daing- Dattaw Pyant, Mogok Township, Mandalay Region. Unpublished,M.Sc Thesis, University of Mandalay.

Sutherland, F.L., Schwarrz, D., Jobbins, E.A; Coenraads, R.R., and Webb, G., (1998b). Distinctive gem 2corundum suites from discrete basalt fields: a comparative study of Barrington, Australlia, and West Pailin Combodia, gem fields. Journal of Gemmology, 26, 65-85.

Than Than Nu (2003); A comparative study of the origin of ruby and sapphire in the Mogok, Pyinlon and Mong Hsu Areas, Unpublished, Ph.D Thesis, Mandalay University.