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EXPERIMENTAL DISSERTATION

Characteristic inclusions of Herkimer quartz and Pakimer quartz

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INTRODUCTION

Rock crystal is a variety of quartz. Because of clarity and transparency of crystal with distinguished inclusions, its beauty attracts a lot of mineral collectors. Even though I have known several trade names such as tourmalinate quartz – tourmaline crystal inclusion, rutilated quartz – rutile crystal inclusion and rainbow quartz – fracture inclusion with interference color. Nevertheless I had never heard the name of Herkimer and Pakimer quartz before. The special characteristic of all stone are luminescence under the ultraviolet light which is spectacular and interesting. AIGS Labs brought the stones from 2017 Tucson Gem Show and allowed for this research. There are two parcels of them. One is Herkimer Quartz which was collected from New York. Another is Pakimer Quartz which was collected from Pakistan. All stones are rough and show hexagonal crystal form. (Figure 1)

Figure 1: Herkimer Quartz (left) and Pakimer Quartz (right)

1. NEW YORK AND PAKISTAN GEOLOGY

Hyršl (2006) classified the genetic type of inclusion in quartz which related with geological environments – alpine fissures, granitic pegmatites, alkaline pegmatites, tungsten deposits, ore veins, monomineralic quartz veins with amethyst, amethyst geodes in basalts and dolomitic carbonates.

1.1 NEW YORK GEOLOGY AND MINES

Herkimer quartz or “Herkimer Diamonds” is found in Herkimer Country, New York and surrounding area. Others name of Herkimer quartz are called their names followed location where they were found like "Little Falls Diamond" or "Middleville Diamond". Herkimer quartz

occurred in hexagonal crystal form in cavities of dolostone (Figure 2). There are numerous commercial mines where allow gem collectors go and collect the stones. They are on New York State Routes 28 and 29 – Ace of Diamonds Mine, Herkimer Diamond Mines and Crystal Grove Diamond Mine and Campground. (Hobart, 2018)

Figure 2: Dolostone with Herkimer Quartz (Hobart, 2018)

1.2 PAKISTAN GELOGY

Pakimer quartz has a few information in the research report. They classified in dolomitic carbonate type and found in Baluchistan, Pakistan (Hyršl, 2006)

2. SAMPLING

Herkimer quartz and Pakimer quartz (Figure 3) were selected to display various inclusion of them. All of the stone are very water-clear, rough and formed hexagonal crystal habits. They are quite large and approximately 2 to 6 carats.

Figure 3: Three of Herkimer quartz and three of Pakimer quartz (from left to right)

Sample	Picture	Width (mm)	Length (mm)	Depth (mm)	Weight (ct)	Localities
CK01		7.95	12.21	6.01	3.43	New York
CK02		7.03	10.60	6.48	2.54	New York
CK03		6.65	10.26	6.20	2.29	New York
CK04		10.27	9.95	7.94	3.12	Pakistan
CK05		11.06	12.94	9.83	6.22	Pakistan
CK06		9.42	12.50	9.14	4.69	Pakistan

Table 1: Description of the samples used in this study

The material obtained for this study proprietary AIGS Labs. They was bought in 2017 Tucson Gem Show from a trusted seller. I was assured that all stones are collected from their localities.

3. EXPERIMENTAL METHODS

To perform tests on the sapphires different equipment were used from the simplest to more sophisticated machines.

3.1 BASIC INSTRUMENT

First of all, the basic instruments of gemmology were used. They include, the use of microscope, refractometer and ultra-violet cabinet (long wave ultra-violet – LWUV – at 365 nm, and short wave ultra-violet – SWUV – at 254 nm; the gems were placed on a dark background at approximately 7 centimeters (cm) from the bulbs).

3.2 SPECTROSCOPY

Spectroscopy for this study used Fourier transform infrared (FTIR) spectrometer, Micro-Raman spectrometers.

3.2.1 FTIR

FTIR spectroscopy has been used to determine the hydrocarbon inclusions. Background and spectra were performed at room temperature using Bruker Vertex 70. Spectra were recorded in absorbance mode in the range 7,000 to 400 cm^{-1}. The spectral resolution chosen was 4 cm^{-1}. Spectra were later manually set in absorption coefficient to allow comparison between samples. All of spectra were done using 100 scans.

3.2.2 RAMAN

Raman spectroscopy has been used to determine the organic inclusion. Background and spectra were performed at room temperature using micro-Raman Horiba T64000 with laser 514.532 nm. Spectra were recorded in absorbance mode in range 3500 to 150 cm^{-1}. The spectral acquisitions chosen were 3 scans for 30 seconds. All of spectra were done using 3 averaging. Spectra were later manually set in absorption coefficient to allow comparison between samples.

4. RESULTS

4.1 BASIC GEMMOLOGY

4.1.1 TEST SUMMARY

Basic gemmological test revealed that all stones are quartz. Refractive indices of the ordinary ray (n_o) was 1.54 and refractive indices of the extraordinary ray (n_e) was 1.55. The birefringence (DR) of all quartz was 0.01. Quartz was inert under ultraviolet light. Most of

luminescence came from their inclusions which reacted under ultraviolet light in SWUV stronger than LWUV. (Figure 4) The result are summarized in table 2.

Figure 4: Herkimer quartz and Pakimer quartz react under LWUV (left) and SWUV (right)

Sample	Picture	n_o	n_e	DR	LWUV	SWUV
CK01		1.54	1.55	0.01	weak blue	moderate blue
CK02		1.54	1.55	0.01	weak blue	weak blue
CK03		1.54	1.55	0.01	weak blue	moderate blue
CK04		1.54	1.55	0.01	weak blue	very strong blue
CK05		1.54	1.55	0.01	weak blue	strong blue
CK06		1.54	1.55	0.01	weak blue	very strong blue

Table 2: Basic gemmological result

4.1.2 MICROSCOPE OBSERVATION

The stones are very water-clear. It is easy to observe inclusions under microscope. The most obvious clarity characteristics were fractures, healed fissures, negative crystal, two-phase inclusion and black inclusion.

I. Herkimer quartz

Herkimer quartz found crystals inclusion with orange, yellow and blue luminescence under LWUV and SWUV (Figure 5). Other inclusions were negative crystal and black inclusion. (Figure 6, 7)

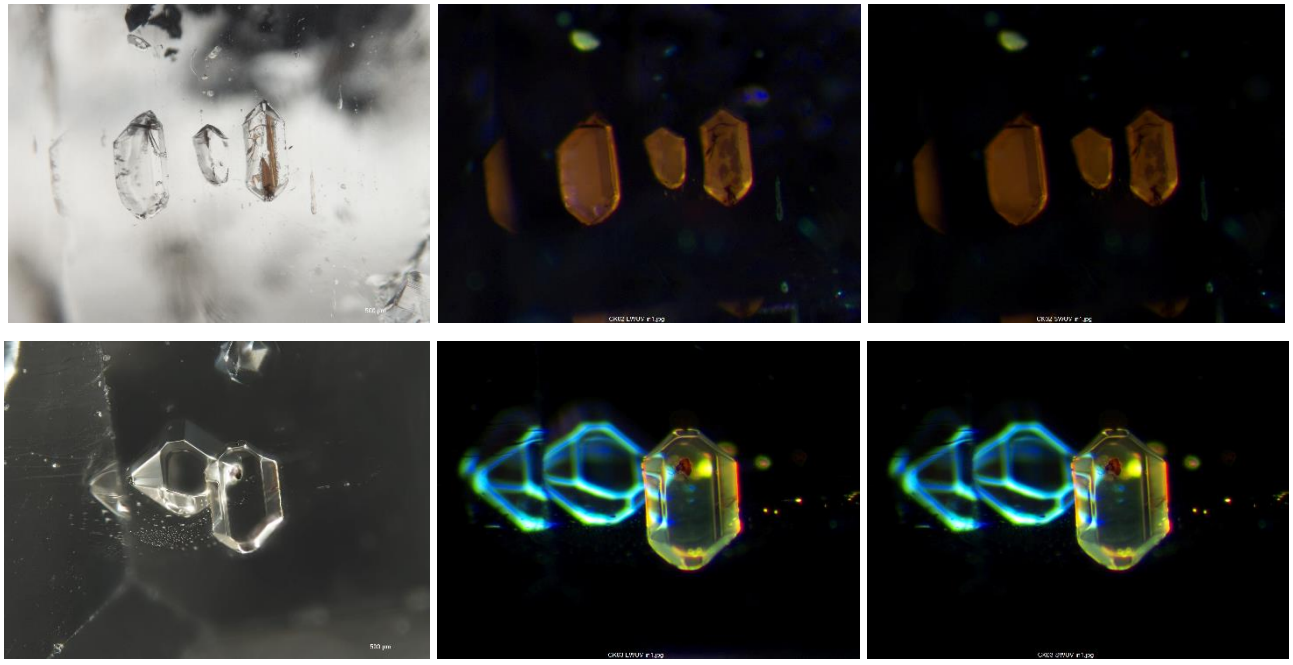

Figure 5: Rounded euhedral crystal displayed colourful luminescence under LWUV (centre) and SWUV (right) in samples CK02 (top) and CK03 (bottom)

Figure 6: Negative crystal with brown stain under transmitted light found in sample CK02

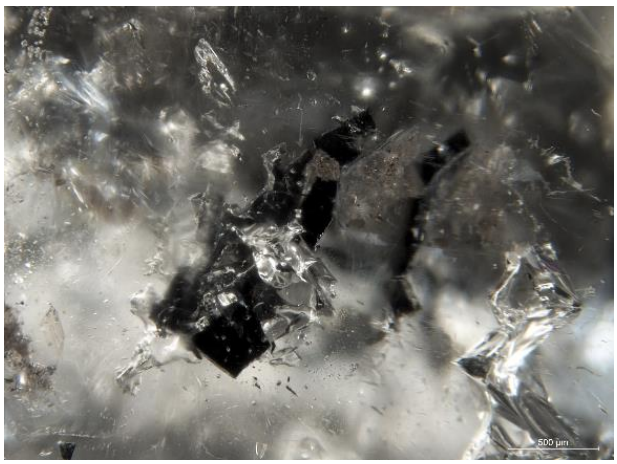

Figure 7: Negative crystal and black inclusion under darkfield in sample CK02

II. Pakimer quartz

Pakimer quartz found a number of negative crystals consist yellow fluid inclusion with gas bubbles and some black inclusion (Figure 8). They are reacted blue luminescence under LWUV and SWUV (Figure 9). Negative crystal with brown stain also found.

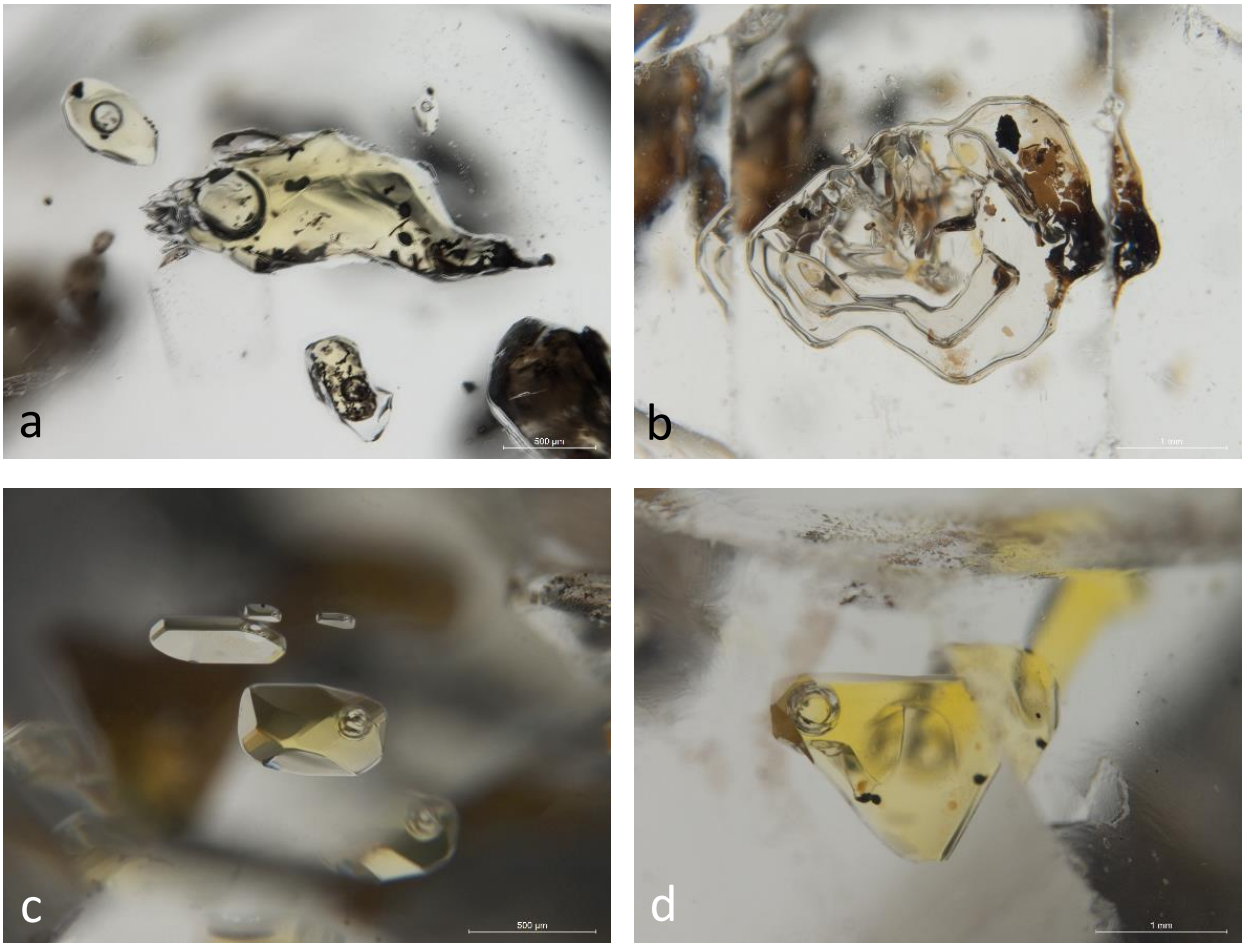

Figure 8: Negative crystals consists yellow fluid inclusion with gas bubble and some black inclusion in samples CK04 (a) – CK05 (b, c) – CK06 (d)

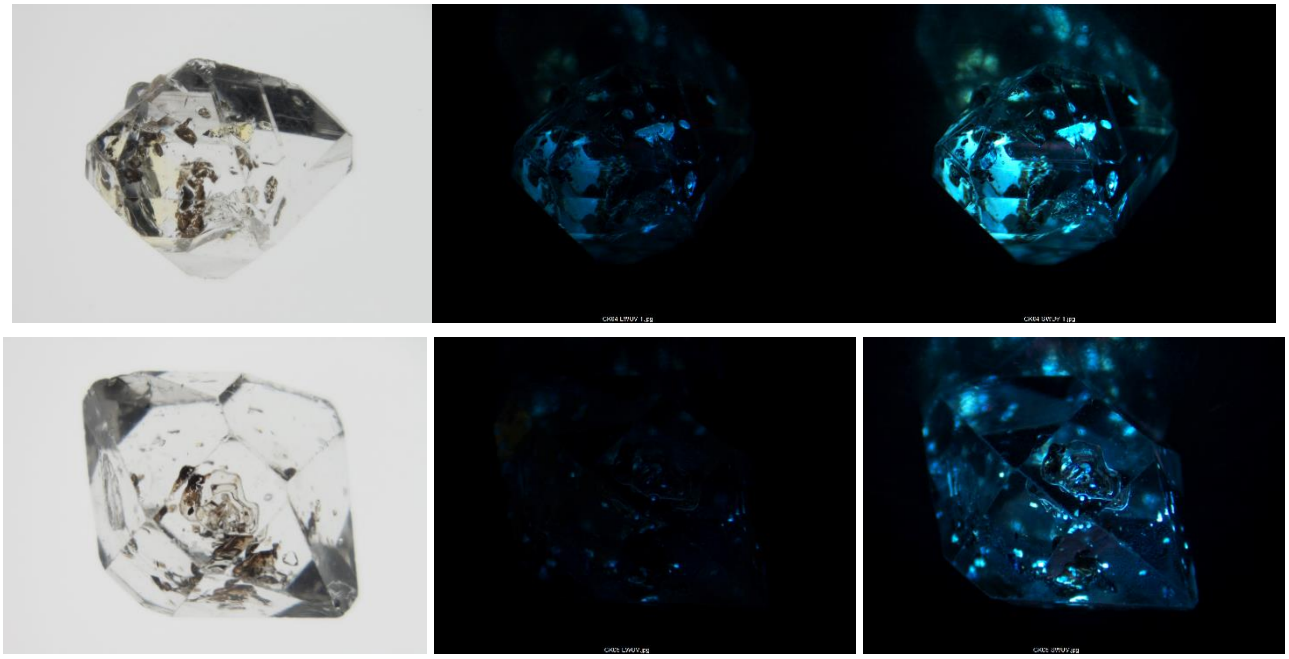

Figure 8: Samples CK04 (top) and CK05 (bottom) presented blue luminescence inclusion under LWUV (centre) and SWUV (right)

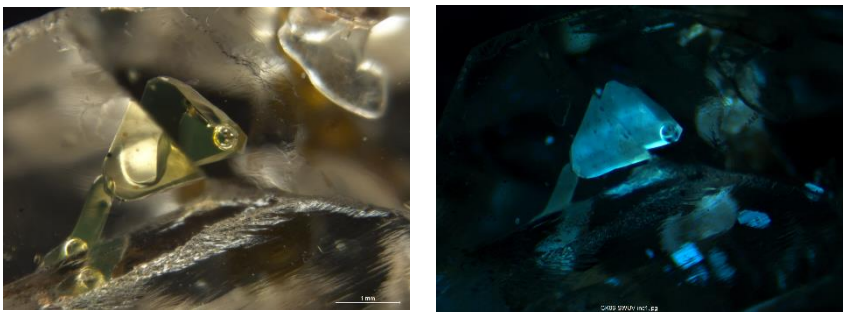

Figure 9: Negative crystals consists yellow fluid inclusion with gas bubble showed blue luminescence under SWUV (left) in sample CK06

4.2 SPECTROSCOPY

4.2.1 FTIR

Most of inclusion of Herkimer quartz are negative crystal, quartz crystal and black inclusion. Nevertheless collected spectra show characteristic the same as quartz (Figure 10). Whereas most of inclusion of Pakimer quartz are negative crystal consists yellow fluid inclusion with gas bubble. The inclusion spectra are different from quartz in range 7000 to 3500 cm^{-1} (Figure 11).

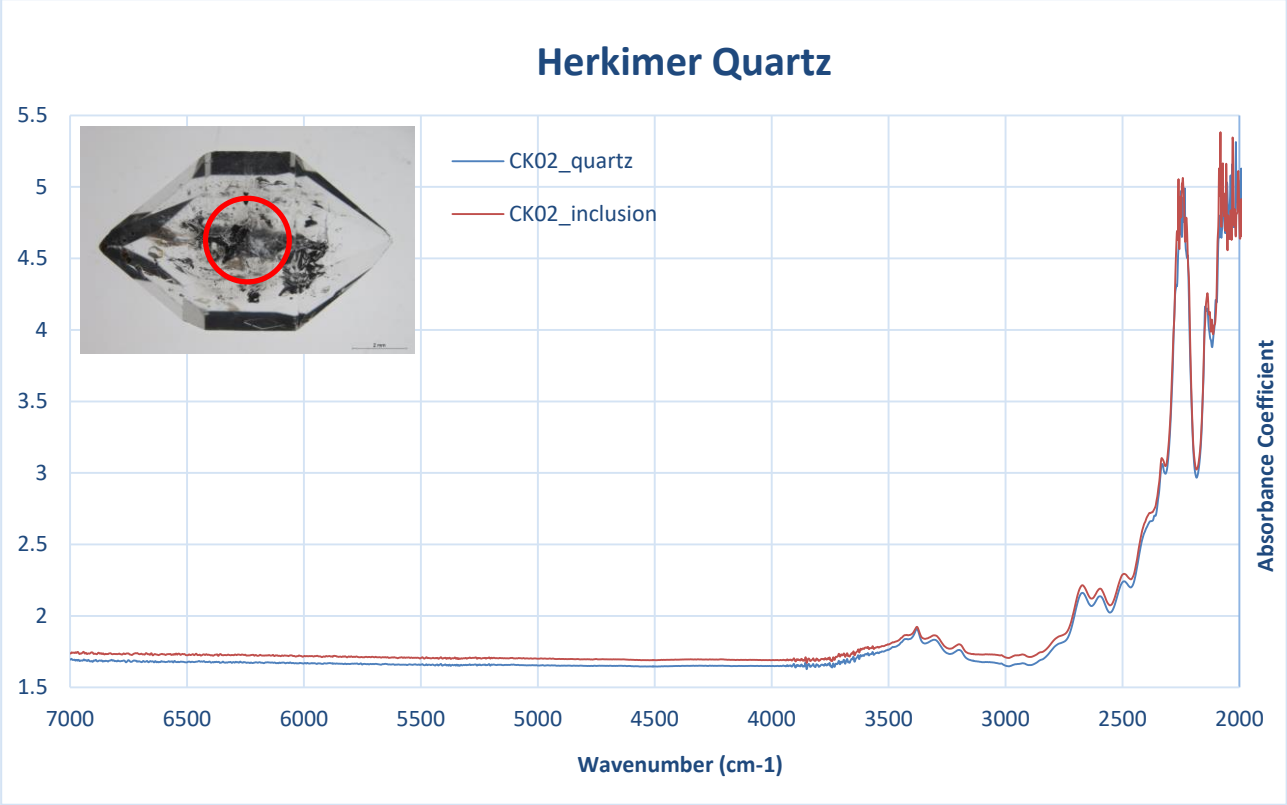

Figure 10: The spectra show no different from quartz and inclusion (red circle is target area) in sample CK02

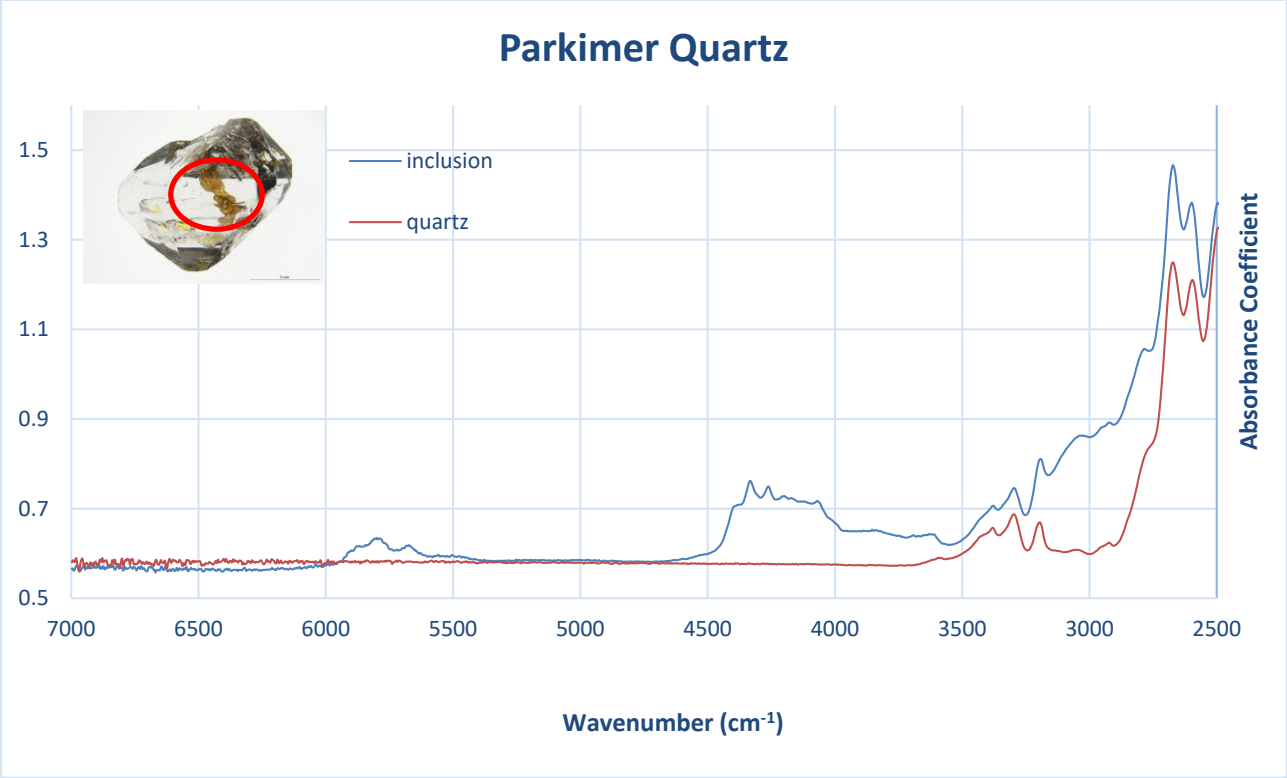

Figure 11: The yellow inclusion spectra show different peak from pure quartz in range 7000 to 3500 cm^{-1}

4.2.2 MICRO-RAMAN

Black inclusion in both of Herkimer quartz and Pakimer quartz show the same Raman spectra in range 150 to 4000 cm^{-1} (Figure 12). Luminescence inclusion spectra show nothing useful to analyse. (Figure 13)

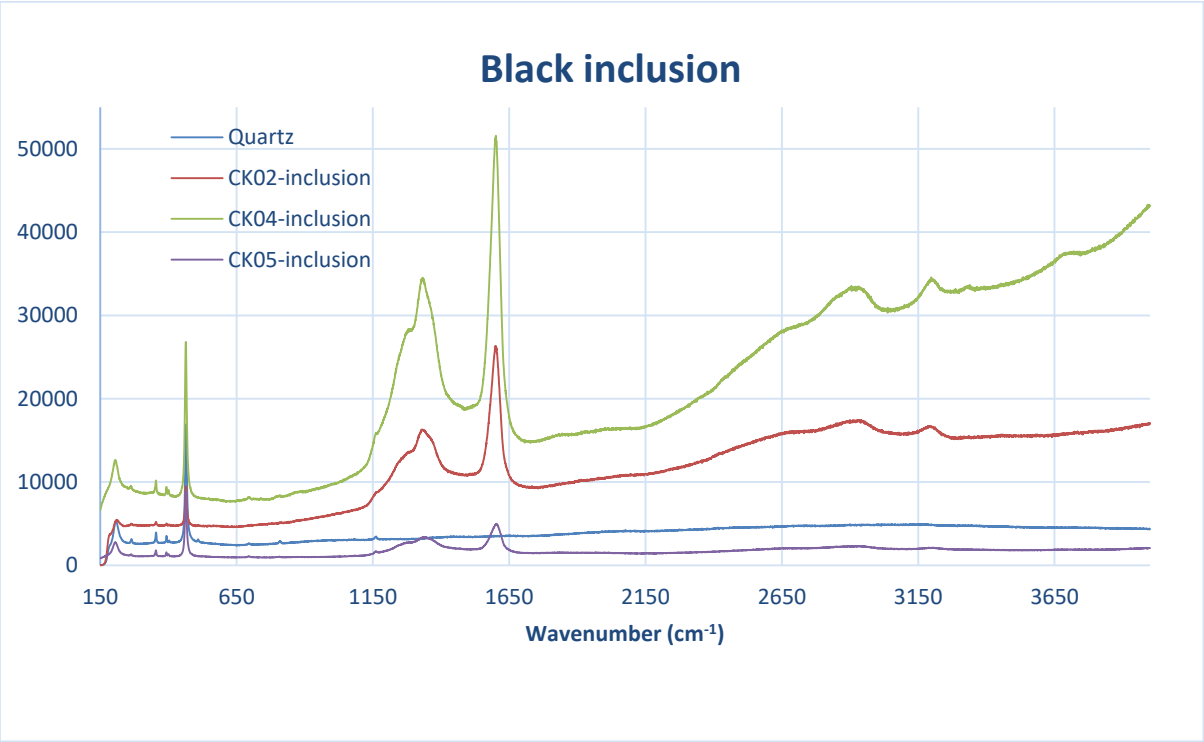

Figure 12: Black inclusion in both Herkimer quartz and Pakimer quartz present the same spectra in range 150 to 4000 cm^{-1}

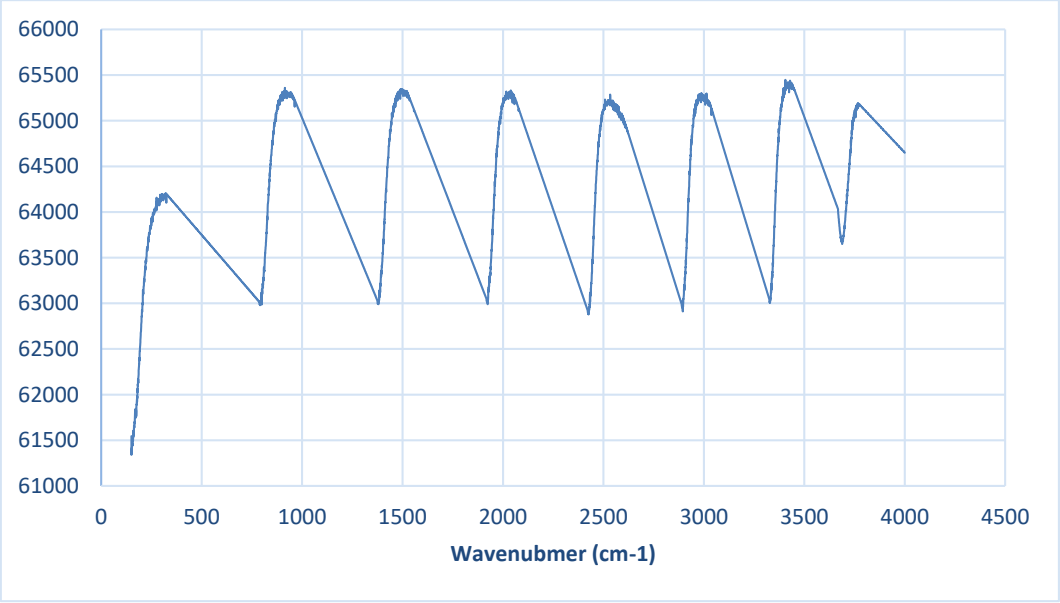

Figure 13: Raman spectra of luminescence inclusion

5. DISCUSSION

Most inclusion of Herkimer quartz and Pakimer quartz are negative crystal, quartz crystal and black inclusion. In this study Pakimer quartz has a number of yellow fluid inclusions with gas bubble. Their spectra show no information because of their luminescence. Therefore cannot analyse. Black inclusions are organic inclusions which detected by FTIR spectrometers.

CONCLUSION

Characteristic inclusion both of Herkimer quartz and Pakimer quartz are hydrocarbon and carbon that were detected by FTIR and Raman spectroscopy. Inclusions are no different between two localities for distinguishing. Quartz with inclusions are interested including quartz from other localities. It is important to use advanced instrument to confirm what inclusion it is. Moreover the database of spectra are also necessary.

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ANNEX