The characteristics of amber from Indonesia

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Introduction

Amber is a popular organic gem material that has been made into a variety of decorative objects sold in the gem market. Its history can be traced back to the Neolithic times. The so-called "Ambers" are, in fact, tree resins that were fossilized during earlier geologic times. Their accepted ages generally range from Mesozoic (about 250 million years) to lower Cenozoic (about 23 million years). Most known ambers are the fossil resins of two main plant groups, *Agathis* and *Hymenaea*. (Kosmowska, 2006).

Amber has been found in many localities worldwide but only a few countries are considered as major suppliers such as countries surrounding the Baltic sea including Poland, Ukraine, Lithuania, along with the Dominican Republic and Myanmar (Grimaldi, 1996).

Beside those countries, Indonesia, the largest country in the Southeast Asia region and consisting of tens of thousands of islands, is endowed with many gem species such as opal, chrysocolla, chalcedony as well as amber. The Indonesian amber can be found in several localities including the islands of Papua, Sulawesi, Kalimantan, Sumatra and Java (Wikipedia, 2013).

They reportedly occur in association with Tertiary (Miocene, about 23 million years) coal formations. The ambers from Indonesian sources have been considered as a non-commercial gem material for a long time. Recently, these ambers have appeared in major gem shows worldwide.

Materials and Methods

All together ten samples of Indonesian amber were used for this study. Of those, three cabochon stones, claimed to be from Sumatra weighing 14.45, 12.31 and 10.70 carats, respectively, were provided by a co-author (SP), four pieces sold as Sumatran amber weighing 5.39, 4.02, 3.70 and 1.92 carats, were bought from a gem dealer at the 2013 JCK fair in Las Vegas USA by the first author (TL), and three rough specimens believed to be from Aceh and Palembang areas of Sumatra Island (see Figure 1) weighing 62.58, 45.95 and 40.05 carats were provided by Terry Coldham (see Figure 2).

From the rough stones, seven cabochons were cut in various sizes, their colours ranging from yellow to brownish yellow to brownish red. A bluish sheen can be observed in some samples when viewed in strong daylight, thus making the amber from this source appear very similar to the famous blue amber from Dominican Republic.

Basic gemmological properties, such as Refractive Indices (RI), Specific Gravity (SG), LW/SW UV fluorescence effect, were recorded using standard gemmological equipment (Table 1 and Figure 3).

In addition, advanced analyses were also carried out using a Laser Raman spectroscope (Renishaw Invia equipped with 785 nm laser) and an Attenuate Total Reflection (ATR) -FTIR spectroscope (Thermo-Nicolet In10 attached with germanium tip for ATR analysis). All of these measurements were performed at the GIT-Gem Testing Laboratory.

Figure 1. A map of Indonesia showing Sumatra Island and location of Aceh and Palembang.

Figure 2. Ten samples of amber reportedly from Sumatra Island, Indonesia; the three cabochon pieces on the lower left weigh 14.45, 12.31 and 10.70 carats; the four cabochon stones on the lower right weigh 5.39, 4.02, 3.70 and 1.92 carats; and three rough specimens on the upper center weigh 62.58, 45.95 and 40.05 carats.

Figure 3. Strong bluish fluorescence displayed by these Indonesian amber samples under LWUV.

Table1. Summary of the basic gemmological properties of the seven cabochon samples from Indonesia

Sample no.	Wt.	RI	SG	LW/SW UV fluorescence
1	12.31	1.50	1.00	Strong chalky blue in LW and weaker in SW
2	14.45	1.51	1.02	Strong chalky blue in LW and weaker in SW
3	10.70	1.54	1.01	Strong chalky blue in LW and weaker in SW
4	3.70	1.52	1.00	Strong chalky blue in LW and weaker in SW
5	1.92	1.52	1.02	Strong chalky blue in LW and weaker in SW
6	4.02	1.51	1.01	Strong chalky blue in LW and weaker in SW
7	5.39	1.52	1.05	Strong chalky blue in LW and weaker in SW

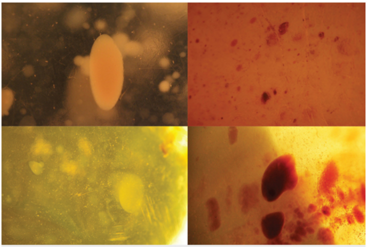

Figure 5. Close-up view of several round-to-oval-shaped droplet inclusions.

Under the microscope, the most striking feature observed in most samples was the presence of numerous round-to-oval-shaped droplet inclusions that appear in various sizes and colours from white, reddish brown to brown. These droplet inclusions are often oriented in a zonal pattern or distributed throughout the whole piece. Some black swirly inclusions can also be seen in some samples (Figures 4 and 5).

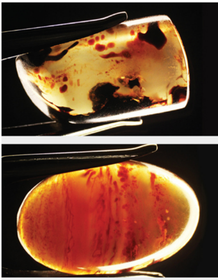

Figure 4. Top: Black swirly inclusions in sample No.3. Bottom: Brown droplets aligned in zonal pattern in sample No.4.

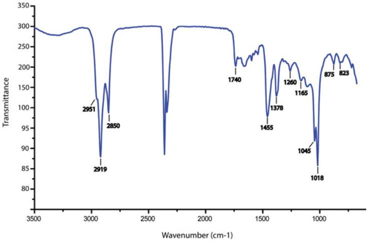

Figure 6. Representative Mid-IR spectrum of Indonesian amber.

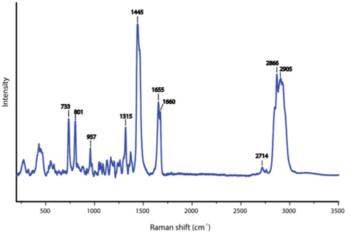

Figure 7. Representative Raman spectrum of Indonesian amber.

Advanced Testing

The Mid-IR spectra, in the range of 4,000-650 cm^{-1}, of all the studied samples were collected by ATR technique. The spectra show two regions of absorption; the first region between 1800-650 cm^{-1} showed many characteristic absorption peaks and bands at around 823, 875, 1018, 1045, 1165, 1260, 1378, 1455 and 1740 cm^{-1} together with several low-intensity absorption peaks and bands in the range below 800 cm^{-1}. The second region, between 3,000-2,800 cm^{-1} showed distinct peak positions at around 2852, 2920 and 2950 cm^{-1} (Figure 6).

The Raman spectroscopic analyses of all samples, using 785nm laser, also show nearly identical spectra with major Raman shift peaks at 733, 801,957, 1315, 1445,1655, 1660 cm^{-1} together with broader peaks around 2800-3000 cm^{-1} (Figure 7).

Comparison with amber from other localities

The data collected from these samples were compared with amber specimens collected from other major sources such as the Baltic region, Dominican Republic and Myanmar. All the studied samples were drawn from the amber reference collection of the GIT Gem Testing Laboratory.

In contrast to Indonesian amber that shows prominent characteristic numerous round-to-oval-shaped droplet inclusions, in amber from other sources such inclusion features were less obvious. However, some similar looking droplet inclusions were observed in some of our reference samples but the droplets usually had irregular shapes. No evidence of insect or plant fossils were observed in these studied samples.

The Mid-IR and Raman spectra of Indonesian amber, obtained from the aforementioned three different sources, show clearly defined identical patterns. This suggests that they may be derived from the same plant species. In contrast, amber from other localities also possess their own characteristic IR and Raman Spectral patterns. This indicates that, at each locality, the amber could have been derived from different species of resin-producing trees found in differing geological ages (Figures 8 and 9).

Conclusions and Discussions

Even though, the exact localities of these Indonesian amber samples are still not disclosed, it can be assumed that these materials are found mainly in Sumatra Island and the origin of these ambers seems to be associated with tertiary coal formation (about 23 million years ago).

Based on basic gemmological properties, these Indonesian fossilized resins show characteristic properties such as RI and SG values that are consistent with properties of amber. The abundant presence of rounded-circular-to-oval-shaped droplet inclusions appeared in various sizes seems to be the most common characteristic found. In contrast, such rounded droplet inclusions are less common in amber from other localities such as Myanmar, Dominican Republic and the Baltic region, where they tend to be more irregular in shape. Furthermore, because of the presence of very strong chalky blue fluorescence in LW/UV in the Indonesian amber, this could explain the bluish sheen observed under strong daylight of such material.

The Raman spectra and Mid-IR spectra of the studied samples also show identical patterns. The low-intensity absorption peaks and bands in the range below 800 cm^{-1} in the Mid-IR spectrum is commonly used as characteristic of true amber. The absorption peaks and bands in this range are directly related to the lower content of unsaturated single carbon-hydrogen bonds involving carbons in the hexagonal rings that are characteristic for young resin (Abduriyim, 2009). However, by comparison, the IR spectral pattern of amber from this locality is clearly different from the spectrum of amber from other important sources such as the Baltic region, Domini-

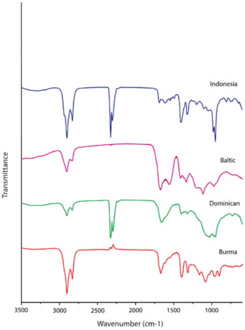

Figure 8. Comparison of Mid-IR spectra of Indonesian amber with amber from other sources.

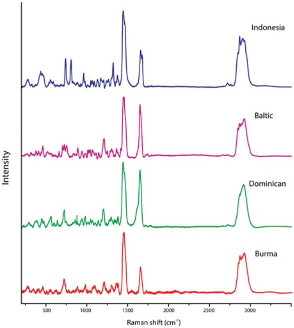

Figure 9. Comparison of Raman spectra of Indonesian amber with amber from other sources.

can Republic and Myanmar (Figure 7). This may be due to amber from different localities originating from differing plant species in different geological ages. It is concluded that the amber from this locality in Indonesia can be distinguished from amber of other sources using both distinct inclusion features and IR spectrum, which are unique enough to be used as the key locality specific properties.

Acknowledgements

The authors would like to thank Mr. Terry Coldham for supplying some samples used in this study as well as their locality information. Assoc. Prof. Dr. Visut Pisutha-Anond kindly helped in reviewing the manuscript and GIT's junior gemologists including Mr. Tasnara Sriooonjan, Mr. Saengthip Saengbuangamlam and Ms. Warithip Krajaejan assisted in preparing photos and spectrums for this study.

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