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Editorial

Editorial for the Special Issue “Gem Characterisation”

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Gem characterisation is an ever-increasing challenge, especially with hard-to-detect treatments and new demands regarding origin determination. For this purpose, only non- (or micro-) destructive methods can be used [1–3]. This Special Issue includes 14 articles published by around 50 different researchers from about 20 different institutions situated in different continents.

Luminescence has largely been used for the characterisation of minerals and gems during the last decade [4–6]. In the present issue, a review on fluorescence and phosphorescence spectroscopies and their application in gem characterisation is presented by Zhang and Shen [7]. This article briefly summarises luminescence spectroscopy and illustrates the experiments that the authors performed on diamonds, fluorite, jadeite jade, hauyne and amber. Vigier et al. [8] review blue shortwave-excited luminescence (BSL) in natural minerals as well as synthetic materials. These authors also describe the BSL of several minerals and gems such as beryl (morganite), dumortierite, hydrozincite, pezzotaite, tourmaline (elbaite), some silicates glasses, and synthetic opals. They conclude that the BSL of these minerals is caused by titanate groups (TiO₆). A luminescence study using a 405 nm laser on Cr-containing samples such as alexandrite and spinel is published in an article authored by Xu et al. [9]. It is demonstrated that the photoluminescence lifetime displayed notable differences between natural, heated, and synthetic versions of these materials.

Treatments to improve the colour, appearance and/or durability of gems have been used for several years; over recent decades, these have increased and become more sophisticated [10–13]. In the present issue, four studies on the treatment of gems are published [14–17]. Zhou et al. [14] present the results of the method they developed for the high-temperature copper diffusion process for the surface recolouring of faceted labradorites. In parallel, they describe their gemmological and spectroscopic characteristics. The heat treatment of pink zoisite is presented by Schwarzinger [15]. This paper describes the heat treatment of zoisites under pure oxygen which allowed the manganese to remain oxidized, while the brownish yellow colour component was still successfully removed. Detection of this treatment is not easy as the temperature is relatively low and induces little change in internal features, but a combination of UV-Vis-NIR spectroscopy and trace element chemistry provided by LA-ICP-MS might give evidence of such treatment. Two papers on the detection of the low-temperature heat treatment (i.e., below 1200 °C) of corundum by studying inclusions are also published in this Special Issue [16,17]. Krzemnicki et al. [16] present a study on rubies and sapphires containing diaspore and goethite inclusions. Based on their experiments and in agreement with the literature, the dehydration of diaspore in corundum occurs between 525 and 550 °C, whereas goethite transforms to hematite between 300 and 325 °C. As both diaspore and goethite might be present as inclusions in gem-quality corundum, these dehydration reactions and phase transformations can be considered important criteria to separate unheated from heated stones. Karampelas et al. [17] focus on the analysis of zircon inclusions found in pink to purple sapphires from Ilakaka (Madagascar). It is found that by using Raman spectroscopy, the full width at half



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maximum (FWHM) of the main Raman band of zircon inclusions in the unheated samples from Ilakaka (Madagascar) is slightly larger than in heated samples.

The origin determination of gems using non-destructive methods is of increasing importance in gemmology [18–21]. Three studies on emeralds from different mining areas are published in this Special Issue [22–24]. Chen et al. [22] present results on emeralds from the Panjshir Valley in Afghanistan. In terms of inclusions, these might be confused with those from Colombia, some from China as well as from a small mine in Zambia (Musakashi). It is suggested that these emeralds might be separated by using chemical plots. A study on rough emerald single crystals and rough emeralds in the host rock from the ruins of Alexandria and from Mount Zabargad in Egypt, preserved in the collection of the museum of the Ecole des Mines (Mines Paris—PSL) since the late 19th or early 20th century, is presented by Nikopoulou et al. [23]. Tube-like inclusions as well as mineral inclusions of quartz, calcite, dolomite, albite and phlogopite, among others, are observed. Moreover, high concentrations of alkali elements but low amounts of caesium (below 200 ppm) are measured, and it is further confirmed that iron together with chromium contribute to their colour. Gao et al. [24] publish an update regarding emeralds from Kagem mine in Zambia. This is nowadays one of the most important mines in terms of economic value and market share in the world. The most common inclusions in Kagem emeralds are two-phase inclusions of prism shape as well as mineral inclusions which typically include actinolite, graphite, magnetite, and dolomite. These emeralds present a high amount of alkali elements as well as a relatively high amount of caesium (average amount above 500 ppm). This article adds information to the extensive studies already published on samples from the same area [25,26]. In another article relevant to the origin determination of gems, the results on purple-violet spinels from Tanzania and Myanmar are presented [27]. The samples found in these two countries differ in terms of inclusions as well as some spectroscopic characteristics.

Quartz and other silica minerals are some of the most abundant minerals in the Earth's crust [28,29]. These minerals have been used as gems since the antiquity. In this Special Issue, three studies on quartz and chalcedony are published [30–32]. Caucia et al. [30] present the characteristics of grey to black quartz from the Burano Formation situated in the province of Reggio Emilia in Italy. They demonstrate, among other things, that the colour of these samples is linked to inclusions of disordered graphite. The characteristics and the possible geological origin of agates from Mesoproterozoic volcanics situated in Pasha-Ladoga Basin (NW Russia) are presented in one of the published articles in this Special Issue [31]. It is revealed that two different phases of agate formation took place, which were most likely controlled by two different fluids and/or their mixture. Finally, Svetova et al. [32] present a study of amethyst-bearing agate from the Tevunskoye deposit situated in the Northern Kamchatka (Russia). Agate mineralization is found to occur in lavas and tuffs, as amygdales, geodes, lenses and veins present similarities with those from Ijevan (Armenia) and Ametista do Sul (Brazil). Amethysts in these agates formed at relatively low temperatures (100 °C) from low-salinity fluids under an oxidizing environment.

Overall, this present Special Issue confirms that a growing number of scientists are working on various aspects of gemmology around the globe. Hopefully, this series of articles will contribute to a better understanding of the characteristics of some gems.

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