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Editorial

Editorial for Special Issue "Mineralogy and Geochemistry of Gems"

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Gems are materials used for adornment or decoration that must satisfy several criteria where they must be aesthetic and visually appealing; relatively rare; hard and tough enough to resist "normal" wear; and able to withstand corrosion by skin contact and cosmetics [1]. Gems have been used since antiquity thus, gemology, the science dealing with gems, is positioned between academia and industry. As an applied science, in gemology, the instruments used should be non- or micro-destructive and their cost should be reasonable (both in terms of equipment and time consumption [2,3]). Gemology can also contribute to the development of pure science and in some cases, destructive techniques may have to be used [1–3]. This special issue presents recent advances on the study of various types of gems based on a variety of research (e.g., geology, trace element geochemistry, inclusion studies, geochronology, spectroscopy). It includes 20 articles by around 100 researchers from over 30 different institutions situated in 20 countries from around the globe. These articles will hopefully contribute to our better understanding of the formation of gems.

Pegmatites are known to be a source of several (>50) gem-quality minerals [4,5]; and in the present Special Issue, three works related to gems and pegmatites are published [6–8]. The first work by Strmić Palinkaš et al. [6] is concerned with a detailed analysis of the economically important gem-bearing Boqueirão granitic pegmatite situated in the Borborema Pegmatitic Province (BPP) from Rio Grande do Norte in Northeast Brazil. The Boqueirao granitic pegmatite is classified as a member of the Lithium-Caesium-Tantalum (LCT) pegmatite family and was emplaced during a late stage of magmatic activity in the late Cambrian. The second work by Huong et al. [7] presents a comparison of the trace element geochemistry of danburite, a gem mineral commonly formed within transition zones of metacarbonates and pegmatites as a late magmatic accessory phase from Mexico, Tanzania, and Vietnam. Differences in the rare earth elements (REE) concentrations of danburite from the different localities were observed and these show that trace element variations reflect different degrees of involvement of metacarbonates and pegmatites among different locations. The third work by Diella et al. [8] is a study of the first gem-quality multicoloured tourmalines found in the Alps hosted in LCT pegmatites of the Adamello massif, Italy. Tourmaline is considered as an important recorder of its geological formation [9,10] and the results of the study may contribute to understanding the evolution of the pegmatites in this massif.

Giuliani et al. [11] and Karampelas et al. [12] present studies on emeralds; the bluish-green to green to yellowish-green variety of beryl coloured by chromium and sometimes vanadium. The first group of authors in their review proposed an enhanced classification for emerald deposits based on the geological environment (magmatic or metamorphic), host-rock types (mafic-ultramafic rocks, sedimentary rocks, and granitoids), degree of metamorphism, styles of mineralization (veins, pods, metasomatites, shear zone) as well as the type of gem-forming fluids and their temperature, pressure, and composition [11]. Karampelas et al. [12] present an applied study that provides a chemical and spectroscopic analysis of gem-quality emeralds from the most important sources (i.e., Afghanistan (Panjsher Valley), Brazil (Itabira), Colombia (Coscuez), Ethiopia (Shakisso), Madagascar (Mananjary), Russia (Ural mountains), Zambia (Kafubu) and Zimbabwe (Sandawana)). Their study demonstrates how these different analyses can collectively be used to distinguish them from one another (i.e., geographic gem determination).

Rubies and sapphires are coloured gem varieties of corundum and can be found in various places around the globe. Ruby is the red variety and sapphire is the blue variety, while all other coloured corundums are called fancy sapphires and need a colour prefix (e.g., pink sapphire, yellow sapphire). A comparative study of ruby chemistry and inclusions between Myanmar and eastern Australia is presented by Sutherland et al. [13] and clearly shows that although having formed in different parts of the world, at different times and under different tectonic settings, unusual Ga-rich rubies occur in both regions, indicating primary generation involving magmatic processes. Sorokina et al. [14] focus on the genesis of gem-quality sapphires from the Ilmen Mountains (South Urals, Russia) found in situ within ultramafites. These sapphires were formed together with a spinel–chlorite–muscovite rock during the metasomatic alteration of orthopyroxenites at a temperature around 700–750 °C and pressure of about 1.8–3.5 kbar. Despite their metasomatic genesis, Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry (LA-ICP-MS) analyses of these blue sapphires showed that they clearly fall into the range of "metamorphic" sapphires (e.g., Ga/Mg < 2.7). Filina et al. [15] presented data on another occurrence of sapphires in the same region of the South Urals occurring in anorthosites (kyshtymites). Syngenetic zircon inclusions of magmatic origin were found in these sapphires; however, a few of the measured elements using LA-ICP-MS show that some of these sapphires also fall into the range for "metamorphic" sapphires (e.g., Ga/Mg < 0.8). Formation of anorthosites (kyshtymites) is still debatable and two possible scenarios (magmatic and metamorphic-metasomatic) are proposed. Voudouris et al. [16] give an overview of gem corundum deposits from Greece where they occur within clearly diverse geological settings. For instance, pink sapphires to rubies from Paranesti (Drama area; found in boudinaged lenses of Al-rich metapyroxenites alternating with amphibolites and gneisses), pink to purple to blue sapphires from Gorgona (Xanthi area; occurring within marble layers alternating with amphibolites), and sapphires from the central part of Naxos Island (associated with desilicated granite pegmatites intruding ultamafic lithologies, a.k.a. plumasites) can be classified as metamorphic in origin. On the other hand, blue sapphires from the southern part of the Naxos and Ikaria Islands (both occurring in fissures within metabauxites hosted in marbles) display atypical magmatic signatures, indicating a likely hydrothermal origin. In these four papers [13–16], it is evident that some ratios used to separate gem corundum from different geological environments (e.g., Ga/Mg ratio [17]) should be applied with caution. They possibly need revision using solely data obtained from gem-quality samples, in addition, the data should be grouped carefully according to colour. Corundum oxygen isotope values have been used to determine the likely geological origin of gem-quality corundum as well as to constrain the likely geological environment of samples collected from secondary alluvial deposits [18–22]. There are two contributions on the use of in situ oxygen isotope analysis on gem corundum from a primary and secondary occurrence to help better understand their origin [23,24]. The first by Wang et al. [23] is on fingerprinting rubies from Paranesti in northern Greece and importantly suggests that this method can be used to distinguish between two similar occurrences only 500 metres apart. The second paper by Graham et al. [24] is on the use of in situ oxygen isotopes to help in determining the genesis and evolution of alluvial sapphires from the Orosmayo region (Jujuy Province, NW Argentina) and importantly shows that there is a wide, although systematic, range in oxygen isotope values, which can be explained by differing degrees of interaction between mantle-derived magmas, lower crustal felsic magmas, and, most likely, both mantle- and crustal-derived metasomatic fluids.

Pearls are biogenic gems and are of historic and present-day importance [1,25]. A study of a large number of natural and cultured pearls found in various bivalves from saltwater and freshwater environments using LA-ICP-MS and X-ray luminescence is given by Karampelas et al. [26]. LA-ICP-MS can be used to accurately separate freshwater from saltwater samples using manganese, barium, sodium, magnesium, and strontium ratios, and in some cases, even to identify their host bivalve species. Additionally, X-ray luminescence reactions of the studied samples have confirmed a correlation between yellow-green intensity and manganese content in aragonite. It is suggested that orange luminescence, observed in a few freshwater samples under X-rays, is due to a different coordination of Mn^{2+} in vaterite as compared to aragonite.

Zircon is another important mineral geologically [27,28], which can be of gem-quality. Studies on gem-quality zircons from two occurrences are also included in this Special Issue [29,30]. Data by Piilonen et al. [29] on zircon xenocrysts from alkali basalts in Ratanakiri Province (Cambodia) suggest that their genesis involved zirconium-saturated, aluminium-undersaturated, carbonatitic-influenced, low-degree partial melting (<1%) of peridotitic mantle at ca. 60 km beneath the Indochina terrane. Data by Bui Thi Sinh et al. [30] on zircon crystals (up to 3 cm long) from placer deposits in the Central Highlands of Vietnam suggest a genesis from carbonatite-dominant melts as a result of partial melting of a metasomatized lithospheric mantle source as well as resorption and re-growth processes.

The paper by Dill [31] is an excellent review of gem placer deposits, outlining their processes of formation, controls on deposition, and concludes with a new classification system. Štubňa et al. [32] describe some relatively small (< 0.2 ct) and rare gem-quality demantoid (i.e., yellowish-green to green coloured andradite garnet) from serpentinized harzburgites situated in Dobšiná, Slovakia. Curtis et al. [33] in their work reviewed the current opal classification including additional data on samples from new localities. Classification of opal-A, opal-CT, and opal-C as well as transitional types can use XRD and infrared spectroscopy with the aid of Raman spectroscopy and nuclear magnetic resonance (NMR).

Klemme et al. [34] focus on the genesis of prase (green-coloured quartz) and amethyst from Serifos Island (Cyclades, Greece). The stable oxygen and hydrogen isotopic composition of both quartz varieties suggest a mixing of magmatic and meteoric (and/or marine) fluids. Large (up to several centimetres) and vividly coloured Mn-rich minerals (kyanite, green andalusite, garnet -grossular, and spessartine- and red-epidote) of "near" gem-quality from Thassos Island (Rhodope, Greece) are described by Tarantola et al. [35]. They also show that the orange colour of kyanite from Thassos is due to Mn^{3+}; this is the second reported occurrence (after Loliondo, Tanzania) of such kyanite. Voudouris et al. [36] offer an overview of collector and gem-quality mineral occurrences from Greece, relating them to various geological environments such as regional metamorphic-metasomatic, alpine-type fissures, plutonic-subvolcanic intrusions and pegmatites, zones of contact metamorphism, and peripheral volcanic rocks.

This Special Issue is a good example of the growing number of scientists working and collaborating on various gem-related topics around the world. We hope that this issue will shed light on various aspects of gemology, enhance scientific debate, and attract more scientists from various disciplines to become involved in this field of research.

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