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Gem-quality blue sapphires (Al2O3-corundum variety) from the Milas-Yatağan region, Muğla, Turkey

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The aim of this short paper is to announce the existence of gem-quality blue sapphire crystals in southwestern Turkey and to state their geological-mineralogical occurrences as well as gemological properties.

The Menderes Massif is an important metamorphic complex, composed of a series of Alpine and partly Pan-African metamorphic, igneous, and structural history, and it spreads over a wide area (from İzmir to Fethiye) in the western Anatolian of Turkey (Van Hinsbergen, 2010, Candan et al., 2011). The metamorphic rock succession of the Menderes Massif separates into two main units, such as Pan-African basement (core series) and Palaeozoic -Early Tertiary meta-sedimentary rocks (cover series) (Hatipoğlu et al., 2010c; Candan et al., 2011). the schists are Permian and/or Permo-Triassic in age, whereas the overlying marbles are Upper Cretaceous–Palaeogene in age. Thus, the Jurassic aged rocks are not found in Muğla region, more the schists and marbles in the cover series are separated by an unconformity. In order to explain this unconformity, it would be necessary to determine the depositional ages of the shales and/or mudstones (now schists) and limestones (now marbles). This complex also contains many gem materials (Hatipoğlu et al., 2010a, 2010b, and 2010c). In the Milas-Yatağan (Muğla/Turkey) region, there are blue sapphire (the mineral corundum Al2O3- variety) crystals that may be of gemological importance. These crystals are in the karst-type diasporic meta-bauxite and emery deposits located at an altitude of 1,500 m in overturned metamorphic zone called the Lycian Nappes (Van Hinsbergen, 2010, Candan et al., 2011). Three types of bauxite deposits are found in Turkey: bauxite (main constituents: gibbsite and boehmite) in non-metamorphosed regions, and diasporite (main constituent: diaspore) and emery (main constituent: corundum) in metamorphosed regions (Wippern, 1965; MTA, 1965; Özlü, 1983).

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In southwestern Turkey, diasporite and emery meta-bauxite deposits are found in the Muğla region between the Menteşe Mountains to the east and the İlbir Mountains to the west, in the western Tauride Mountains (Wippern, 1965; MTA, 1965). Bauxite is not a mineral species (*Roberts et al., 1990)*, but a colloidal mixture of hydrous oxides of aluminum, iron, and titanium, as well as silica (Bardossy, 1982; Petrascheck, 1989). The largest known reserves are found in Jamaica, Guinea, and Australia (more than 5 billion tons of high-grade ore). Lateritic bauxite ores are soft and earthy, containing 55% Al2O3 and 0–5% SiO2+Fe2O3 (Comer, 1974). Ideally, a quality bauxite ore should contain over 50% Al2O3, less than 5% SiO2, and 5–10% Fe2O3 (Bardossy, 1982).

Because the meta-bauxite and emery horizons are of karst origin, and are metamorphosed, their physical characteristics are significantly different from those of the more common lateritic bauxite ore. The color of fresh karstic bauxite ore is either uniform dark gray, blackish, or mottled, with a leopard-skin appearance. Upon weathering, the color changes to dark yellow or dark brown. Moreover, these bauxites are tough and compact.

The karst-type diasporic and emery bauxite deposits in the region, including the gem-quality blue sapphires called Muğla blue sapphires, are mainly hosted in the white marbles. Sapphires in the deposits are surrounded with translucent and transparent white calcite (CaCO3) crystals. In addition, gem-quality diaspore, chloritoid, margarite, spinel, rutile, goethite, hematite, siderite, ilmenite, chalcopyrite, pyrite, bornite, magnetite mineralization is present (2010c). The ore formation and mineral crystallization in the deposits of the Milas-Yatağan (Muğla) region can be attributed to the Alpine-type multi crack-filling after the hydrothermal alteration and circulation during the tectono-metamorphism of the Lycian Nappes. Thick, white to light gray and dark gray limestone beds were deposited in the region during the Cretaceous (146–65 Ma), and contain many stratigraphically distinct karst-fill bauxite and emery horizons. Al-, Fe-, Si- Cu-, Cr-, and Ti-rich solutions that infiltrated the karstified limestone probably originated from altered schist and gneiss that surround the basin. The limestone beds (> 2000 m thick) were subjected to burial metamorphism, forming marble. Subsequently, the marble blocks were folded during the Nappe emplacement toward the SSW as part of late Alpine constructional deformation during the Paleogene (65–23.8 Ma) (Hatipoğlu at al., 2010b and c). These minerals formed via a series of chemical processes, including extraction, mobilization, migration, and re-crystallization of original diasporic bauxite and emery constituents in an aqueous complex from the ore bodies into fracture zones that cross-cut the bauxite horizons (Misantoni, 2007).

Fourier Transform Infrared (FT-IR) spectra of the Muğla blue sapphire samples are obtained and it seen that the sapphires have strong absorptions from the Al-O bonds near 1450-1480 cm-1, and also a small peaks in the infrared spectra near 3310 cm-1 that corresponds to

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the O-H stretching mode of residual water.

The sapphire crystals in the Muğla district are generally from opaque to translucent, but there are even fully transparent saturated sky-blue ones. Some places in the deposit, blue sapphires alter to the opaque bluish-black spinel crystals. Its dimensions are between 0.4-12 cm, and they are gemologically worthless. Therefore, they are not cut as gems. Instead, they are ideal for collectors to display in their rough form. Others are dark blue. Their size in the range of 0.3-6 cm. They are very suitable for cutting cabochons (facet if desired) due to the attractiveness of their colors and the smoothness of their shape in discrete pieces. Of these, the weight of the facet cuts can reach 90 ct, and the cabochon cuts can reach up to 200 Ct. The high weight of the facet cut translucent and transparent samples (especially the fact that they can go up 20 Ct) makes them have great economic value. The translucent and transparent ones of the sapphire crystals are in different tones from dark blue, and also some of them are ancient Thai Lotus-cornflowers blue (twice blue). They can reach up to 8 cm in rough crystal size.

Similar corundum (Al2O3) occurrences of the Muğla blue sapphires in the Menderes massif are reported to have been observed in the Aegean Sea Islands (Greece), such as Xanthi–Drama areas (Rhodope massif), Naxos-Ikaria Islands and Andros Island (Alttico-Cycladic massif) (Voundouris et al, 2019).

As a result, most of the Muğla blue sapphires have a very low degree of transparency and clarity, unfortunately. In general, solid and liquid inclusions are observed in them. Although this situation reduces the gemological values of the sapphires, they are still suitable for cutting as facet and cabochon. Considering the scarcity of natural worldwide blue sapphire deposits, the Milas-Yatağan region (Muğla / Turkey) can be taken as a rich sapphire production area.

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