Geological and geochemical investigation on Andalusite and Chiastolite deposit at Balanthota, Ginigathhena, Sri Lanka

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Introduction

Out of the Al_2SiO_5 chemical composition bearing aluminosilicate trimorphs including sillimanite and kyanite, andalusite is the low-temperature, low-pressure mineral phase [1]. Also, andalusite is crystallized under the orthorhombic crystal system following the orthorhombic dipyramidal symmetry class with vertically striated prismatic habit crystals [1]. When carbon is trapped into the andalusite structure, it may give rise to form distinctive cross-shaped dark region on the perpendicular plane to the c axis of a crystal called 'Chiastolite'[1]. Andalusite principally found in Brazil but Canada, Sri Lanka, France, Chile, Myanmar, Australia, Bolivia, America and Russia are also famous countries for andalusite occurrences [1]. Since andalusite and chiastolite are semi-precious gemstones, it has been worn as amulets, charms and other piece of costume jewelleries [1]. Also, it has been believed as a curio stone with healing power [2].

Large number of gem varieties are found mainly in three major gem fields of Sri Lanka restricted to a narrow zone of the Highland complex which laid across the most central part of the island with Precambrian granulite facies metamorphic rocks [3]. Sillimanite is the abundant aluminosilicate mineral phase within the pelitic granulites of the Highland complex [3]. Therefore, a gem variety of sillimanite which is called fibrolite is the common gem constituent especially among alluvial gem beds of Sri Lanka [4]. Although it is controversial concerning regional geology, andalusite gemstones are also found in alluvial gem beds of the Rathnapura gemming region [5]. Local gem miners and merchants used to name it as "*Giniboku thora*" [4].

Ginigathhena which is a small town at Nuwaraeliya district in the central province of Sri Lanka is well-known place for gemstones including andalusite [4]. Although, occurrence of andalusite and chiastolite have been reported by several researchers around the Balanthota village [3,4], geological and geochemical characteristics of it has not been reported yet. Geological and geochemical characteristics of this mineral occurrence are prime important when appraise and interpret its economic potential. Therefore, the main objective of this study was to investigate the geological and geochemical characteristics of Balanthota andalusite and chiastolite occurrence to facilitate future prospecting activities.

Methodology

Initially, reconnaissance field survey was carried out to identify the location and approachability for the localized andalusite and chiastolite occurrence at Balanthota village. Then, the recognized area was perused in satellite images to demarcate the extent and distribution of this mineral deposit. Successively, the structure and geological setting of this deposit were inspected on exposed soil successions in the field. During these field investigations, a chiastolite sample and four small fragments of andalusite samples were collected after a careful examination through exposed soil successions of shallow gem mining pits for further laboratory analysis.

Collected samples were thoroughly cleaned using diluted hydrochloric acid and excess

distilled water to remove their surface blemishes. Then, refractive indices, hardness and specific gravity were measured. Also, basic gemological properties and inclusion characteristics were investigated using a gemological microscope. Then, a chiastolite sample and three andalusite samples were powdered. These powdered andalusite and chiastolite samples were analyzed using X-ray Fluorescence (XRF) spectroscopy for major elemental concentrations. Moreover, the powdered chiastolite sample was analyzed using X-Ray Diffraction analysis (XRD) to characterize and confirm the mineral constituents in the inclusions. Finally, major elemental concentrations, mineralogical constituents and physical and gemological properties were correlated.

Results and Discussion

According to the field observations, these Andalusite and Chiastolite fragments are embedded within a thick Colluvium deposit which is lying on Garnet sillimanite graphite granulite basement rock at Balanthota village (Figure 1).

Figure 1. (A) - Andalusite and chiastolite fragments embedded thick colluvium at Balanthota village. (B) Underlying garnet sillimanite graphite granulite basement rock.

Small size of transparent gem-quality andalusite and relatively large size translucent to opaque chiastolite are found within this deposit (Figure 2).

Figure 2. (A) - A translucent to opaque chiastolite specimen (B) - Small size of transparent gem-quality andalusite found in Balanthota deposit.

Both Andalusite and Chiastolite varieties are brown in colour. The transparent verity shows pleochroism from brown to light green. Measured refractive indices are 1.63 (±0.005) and 1.64 (±0.005). Therefore, birefringence is 0.01 (±0.005). Measured hardness is around 7 as per the Mohs hardness scale. Also, measured specific gravity is around 3.2 (±0.05). At a glance, transparent andalusite found in this deposit are eye clean but acicular sillimanite inclusions (1mm) can be identified under the 10× loop magnification power through polished surfaces (Figure 3).

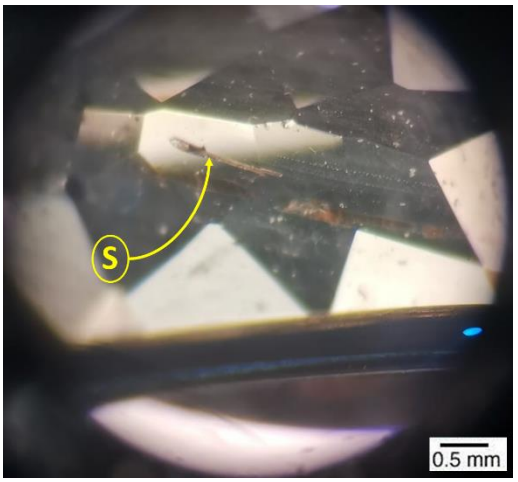

Figure 3. 1mm length acicular sillimanite inclusion (S) within Balanthota andalusite fragment under 10× loop magnification power.

Based on the results of XRF analysis, Al_2O_3 and SiO_2 are the major chemical constituents since andalusite is an aluminosilicate mineral. Furthermore, MnO, Fe_2O_3, Cr_2O_3, TiO_2, MgO and K_2O oxides were detected as trace element oxides (Table 1).

Table 1. Chemical composition of analyzed Andalusite and Chiastolite found in the Balanthota deposit.

	Concentration (wt %)								
Sample No.	**Al_2O_3**	**SiO_2**	**TiO_2**	**Cr_2O_3**	**MnO**	**Fe_2O_3**	**MgO**	**K_2O**	**Total**
And-01	61.95	37.27	0.06	0.01	0.45	0.08	0.08	0.00	99.90
And-02	62.00	37.01	0.10	0.02	0.62	0.11	0.09	0.01	99.96
And-03	61.95	37.19	0.08	0.03	0.56	0.09	0.10	0.01	100.01
Chi-04	61.22	36.99	0.98	0.02	0.56	0.08	0.11	0.00	99.96

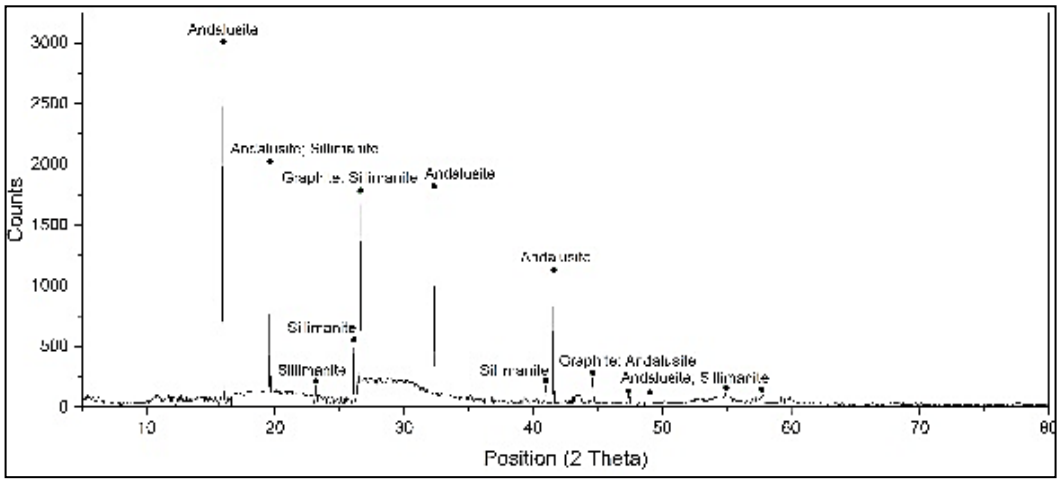

Figure 4. Detected minerals by powder XRD analysis of sample No. Chi-04. Andalusite (ICDD 39-376), Sillimanite (ICDD 38-471) and Graphite (ICDD 75-1621).

Also, the prevalence of Andalusite in this deposit has been further validated by 2.77 Å, 5.55 Å, 2.17 Å and 4.53 Å characteristic *d* spacing values of XRD analysis (Fig. 4). Further XRD analysis shows the presence of carbon as graphite (*d* spacing 3.35 Å, 2.03 Å, 1.67 Å) forming a distinctive cross-shaped dark region. Also, the existence of sillimanite mineral phase within these andalusite and chiastolite fragments of Balanthota deposit has been further confirmed by 3.84 Å, 3.42 Å, 3.37 Å and 2.20 Å *d* spacing values of the XRD analysis (Figure 4).

It is evident that Andalusite and Chiastolite deposit at Balanthota village is a colluvial type of gem occurrence lying on the Garnet sillimanite graphite granulite basement rock. It contains small size of fine quality andalusite fragments and relatively large size of chiastolite assorted with other colluvial debris. Based on the results of physical and chemical analyses executed on collected samples, prevalence of andalusite in this deposit has been further confirmed. Acicular sillimanite can be identified as inclusions within the andalusite fragments under high magnification. Furthermore, carbonaceous cruciform of chiastolite found in this deposit bedecked by graphite.

Conclusion

Geologically, Balanthota Andalusite and Chiastolite deposit can be identified as a colluvial type gem occurrence. Owing to physical and geochemical characteristics of analyzed samples, it contains fine gem quality small size of Andalusite and large size of Chiastolite fragments as disseminated grains. Sillimanite and graphite can be found as inclusions within the andalusite and chiastolite fragments. Further studies needed to be carried out considering extend of this gem occurrence to check its economic feasibility.

Acknowledgement

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