

SHORT COMMUNICATION

Gemmological Characteristics of Gemstone Varieties Found in the Pegmatite of Haramosh Area, Gilgit-Baltistan

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Introduction

Haramosh valley is located in eastern side of Gilgit city (Fig. 1). Geographically it is located between 74°44' 17.37 " E and 35° 51 '8.97 " N. The area is a sub range of Karakoram in the south-central region of the Rakaposhi–Haramosh mountains. Haramosh valley is famous for its gemstones which are well known in the world. The first gem mine was discovered in 1951 in the area of Haramosh valley in Gilgit. The prominent four localities of gem-bearing pegmatites occur in the vicinity of the Haramosh peak, Shengus along Indus river, Haramosh Bulachi village, and the setting of Khaltoro pasture. Along with glaciers, Hindukush Karakorum and Himalayan ranges host a variety of precious stones (Agheem et al., 2014). In recent decade Haramosh valley received more attention because of the occurrence of a variety of gems in pegmatite veins. Gemstone varieties related to pegmatites are also found in other parts of Gilgit Baltistan, like Shigar, Shengus, and Stuk Nala (Kazmi et al., Laurs et al., 1998). Pegmatites are found widely in Gilgit-Baltistan Pakistan within the mountain ranges of Karakoram (Laurs et al. 1998). These macrolitic pegmatite's are mainly associated with leucogranites in Haramosh Massif, which is famous for recent rapid uplift (Laurs et al., 1998; Zeitler 1985). Various crystals of topaz, tourmaline, beryl, and quartz are being mined from these macrolitic pegmatite's (Laurs et al., 1998). Famous tourmaline crystal (10cm) of Pakistan is found in Stuk Nala of Nanga Parbat Haramosh Massif (Laurs et al., 1998).

Geology of the Area

Haramosh Valley which is a part of Kohistan island arc and two main fault lines separating Kohistan Island Arc from Indian and Eurasian plates known as Main Mantle Thrust (MMT) in the south and Main Karakoram Thrust (MKT) in the north. The area is mostly composed of metamorphic rocks with subordinate igneous rocks. The rocks are highly metamorphosed and the valley is surrounded by high steep mountains. The area is under the Nanga-Parbat Haramosh Massif. In most of the regions, banded

gneisses occur. The geological features of the field site include dikes, sills, joints, fault, contacts, folds, striation, etc., along with geomorphologic features like river terraces, alluvial fans, etc., are existed in the area (Fig. 2). There are approximately 200 active mines in the Haramosh valley, but the local people are not extracting the gems by modern mining methods and use primitive methods like excavating mouse bores. As a result, about 50% gems pockets are ruined due to blasting.

Several other areas of the world are famous for pegmatite gems (London 1986; Peretyazhko et al., 2004; Rosenberg 1972; Shearer et al., 1984; Viana et al., 2002). Various types of other gemstones are also reported from different localities of Gilgit –Baltistan like Shigar valley, (Blauwet, Smith, and Smith 1997). Almost all gem bearing pegmatites are of granitic origin rarely few pegmatites are reported having the primary or alkaline source, which contains gems (Simmons et al., 2012). Historically granitic pegmatites are found in Brazil, Madagascar, the United States in large amounts but presently gemstone varieties are found mainly in Africa and Asia (Simmons et al., 2012; Simmons and Groat 2007).

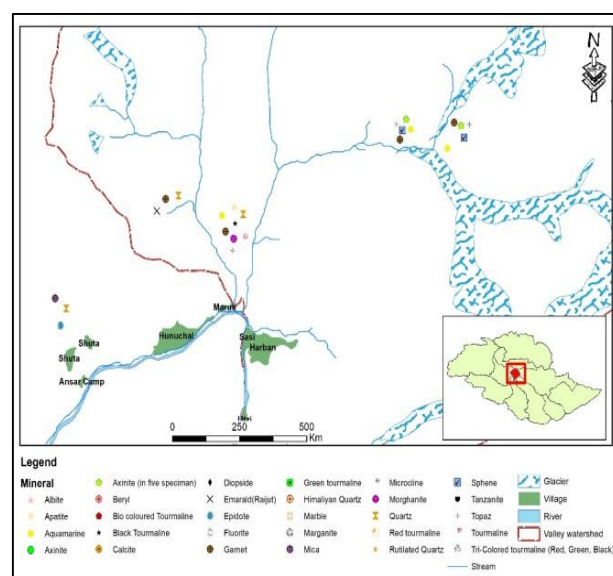


Fig. 1 Location map of study area.

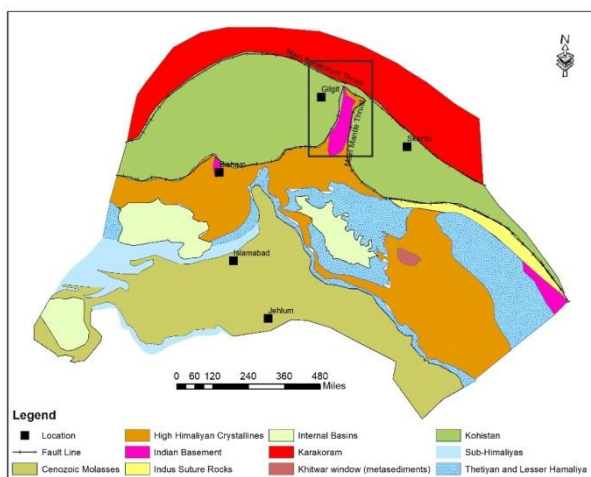


Fig. 2 Geological map of study area (after Searle, M. P., and Treloar, P. J. (2010).

Regional Geology

Himalayan tectonic/ orogenesis plays a vital role in the formation of pegmatite's of Haramosh and adjacent areas. The rocks of Indian plate are subducting beneath the Kohistan-Ladakh Island Arc in Paleocene. Subsequently, the thick crustal wedge of Nanga Parbat Haramosh Massif starts thinning by faulting and begins to uplift rapidly (Zeitler, 1985).



Fig. 2 Photographs of various gemstones of Haramosh pegmatites. (a) quartz, (b) garnet, (c) fluorite, (d) emerald, (e) topaz, (f) tourmaline (schorl), (g) amethyst, (h) aquamarine, (i) tourmaline (rubellite)

Local fluid decompression occurs due to rapid uplift, which helps in the breakdown of biotite due to which volatile-rich leucogranites melt was formed (Kleinhesselink and Rosa, 1991). Leucogranites melt was emplaced by sills of pegmatite during extension and uplift of Nanga Parbat Haramosh Massif (Laurs et al., 1998). Still, Haramosh Massif is uplifting rapidly. In the northern end of Nanga Parbat, Haramosh Massif normal movements along faults up to Indus Suture Zone commenced 11Ma and this is concluded from $40\text{Ar}/39\text{Ar}$ dating from rocks of Khaltaro region (Laurs et al., 1998), and since 5 Ma this is continued in Stak Nala area.

Geochemical and mineralogical characteristics play a vital role in knowing the petrogenesis of any rock and

gem type. Granitic pegmatite have complex properties and internal structure (Cerny, 1982, 1992). The granitic pegmatite of the Haramosh area are Li-Cs-Ta with the transition in characteristics between lepidolite and albite subtypes (Cerny, 1992; Novák and Povondra 1995). Mineralogically, these pegmatites contain coarse-grained K feldspars, schorl, quartz, and sodic plagioclase with minor traces of muscovite and garnet (Laurs et al., 1998). The core of the gem pocket contains tourmaline, topaz and fluorite, and a minor amount of several other minerals (Laurs, 1998). The mineralization of the gem pocket of the Haramosh area is similar to southern California (Foord and EE 1976; Jahns and Wright 1951; London, 1986). Conversely, the internal zonation of both is different. Haramosh pegmatites are symmetrically zoned, while Californian pegmatites are asymmetrical (Jahns, 1953). The pegmatites of the Haramosh area form different sills, which are about 0.3 to 1.2m thick while up to 120m long. These sills are dipping 5° southward (Laurs et al., 1998).

Materials and Methods

Different analytical techniques were used to determine the physical and optical properties of the gems found in the study area. Total nine samples (Fig. 2) for determining their properties and identified in the laboratory of Pakistan Gems and Jewelry Development Corporation (PGJDC), Gilgit using different instruments, e.g., Refractometer, polarize scope, lopes, specific gravity weighing balance, spectroscope and gemological microscope. These properties include color, cut, shape, transparency, weight, hardness, crystal system, specific gravity, chemical formula, optical characteristics, refractive index, pleochroism, and inclusions. Inclusions may be in the form of liquid, concrete, and gas. The type of inclusion provides a strong clue about the origin of stone (Viana et al., 2002). Firstly, the samples were collected and washed, and then different experiments were conducted to know the physical and optical properties of collected gemstone samples from the study area.

Results and Discussion

By studying different physical and optical properties, we can identify the gem quality and variety of the mineral specimens found in the Haramosh area.

Like physical properties, we also did an optical analysis of gemstone varieties of Haramosh Pegmatites. Each sample has different optical properties, which are mentioned in table 2.

The study reveals that pegmatite's contain different varieties of garnet, beryl, and quartz. Almandine, which is a variety of garnet, occurs in large amounts while pyrope, almandine, and spessartine are in a minor amount (Laurs et al. 1998). A large amount of garnet is present in the form of fine-grained subhedral crystals. Two varieties of tourmaline were sampled

Table 1 Physical properties of different gem varieties of Haramosh pegmatites.

Sample ID	Name	Color	Cutting style	Shape	Transparency	Weight	Hardness	Crystal System	Specific gravity	Chemical Formula
Sample 1	Quartz	Colorless	round brilliant	Irregular	Transparent	6.0754g	7	Trigonal (Hexagonal)	2.65	SiO ₂
Sample 2	Garnet	brownish red	rough polished	Trapezohedron	semi-transparent to opaque	1.3618g	7	Cubic	4.103	Mg ₃ Al ₂ (SiO ₄) ₃
Sample 3	Fluorite	Purple	rough polished	Irregular	Transparent	0.5568g	4	Cubic (Isometric)	3.16	CaF ₂
Sample 4	Emerald	Green	Rough Polished	Irregular	Transparent	0.1862g	8	Hexagonal	2.4893	Al ₂ Be ₃ Si ₆ O ₁₈
Sample 5	Topaz	Colorless	Rough	orthorhombic	Transparent	6.229g	8	orthorhombic	3.4927	Al ₂ SiO ₄ (F,OH) ₂
Sample 6	Tourmaline	Black	Rough Polished	Irregular	Opaque	0.7638g	7	Trigonal	3.199	NaMg ₃ Al ₆ (BO ₃) ₃ Al ₆ O ₁₈ (F,OH) ₄
Sample 7	Amethyst	Purple	rough Crystal	hexagonal prism	Transparent	11.23g	7	Trigonal	2.644	SiO ₂
Sample 8	Aquamarine	Light Sky blue	Rough	Hexagonal Crystal	Transparent	0.7870g	8	Hexagonal	2.6569	Al ₂ Be ₃ Si ₆ O ₁₈
sample 9	Tourmaline	Pink	Rough	Irregular	Transparent	3.3581g	7	Trigonal	2.992	N/A

during this study and the color of each sample was different. One was black while the other was pink. The black color tourmaline is known as schorl, while rubellite is pinkish. The schorl is found in the main mine area, which contains more Ti and Mg than schorl, which occurs in pegmatites containing a significant amount of Al and Fe (Laurs et al., 1998).

veins in amphibolite's and granites are found in Khaltoro area of Haramosh. Moreover, slight or no deformation is occurred in the gem bearing pegmatites, indicating these gemstones were formed after the times of Cretaceous-Tertiary tectono-metamorphism.

Table 2 Optical properties and variety of gems of Haramosh pegmatites.

Sample ID	Name	Optical Characteristics	Refractive Index	Pleochroism	Inclusions	Specie	Variety
Sample 1	Quartz	Double refractive	1.544-1.553	N/A	N/A	Crystalline Quartz	Colorless quartz
Sample 2	Garnet	Single refractive	over the limit	N/A	Spots, Blemishes, and inclusions	Garnet	Pyrope garnet
Sample 3	Fluorite	Double refractive	1.432-1.434	N/A	Spots and Inclusions	Fluorite	purple florite
Sample 4	Emerald	Double refractive	1.56-1.59	N/A	Inclusions	Beryl	Green emerald
Sample 5	Topaz	Double refractive	1.609-1.643	N/A	none	Topaz	Colorless topaz
Sample 6	Tourmaline	Double refractive	1.615-1.655	N/A	none	Tourmaline	Schorl
Sample 7	Amethyst	Double refractive	1.542-1.550	N/A	white stripes	Quartz	Amethyst
Sample 8	Aquamarine	Double refractive	1.570-1.592	N/A	small spots	Beryl	Aquamarine
Sample 9	Tourmaline	Double refractive	1.612-1.643	N/A	blemishes	Tourmaline	Rubellite

Conclusion

Initially, gemstone mining started in the Haramosh area by the villagers using primitive techniques. The formation of the gemstones and minerals are caused by extensive magmatism and metamorphism after the collision of Karakorum plate to the Kohistan magmatic arc along Shayok suture in late Cretaceous and the Indian plate to the Karakoram Kohistan collision during Paleocene-Eocene age. The high-grade metamorphism occurs at the southern edge of the Karakoram and Northern edge of Indian plate. Most of the pegmatites are accompanying quartz-feldspar veins with tourmaline, aquamarine, topaz, quartz, amethyst, fluorite, moonstone, sphene, rutile, apatite, morganite, beryllonite, hamburgite, herderite, zoisite-epidote, Mn-rich garnet, zircon, axinite, and many other minerals. Pegmatite mainly occur on the eastern side of Gilgit-Baltistan. Emerald beryl in pegmatites while quartz-albite bearing tourmaline

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