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GEOLOGICAL RECONNAISSANCE OF THE GRIZZLY CREEK GEMSTONE DEPOSIT, LARAMIE MOUNTAINS, WYOMING – Potential Source for Iolite, Sapphire, Ruby & Kyanite

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Abstract

Following the discovery of the Palmer Canyon iolite-sapphire-ruby-kyanite deposit (Hausel, 1998, 2002b), similar geological conditions were noted to exist at a number of other localities in Wyoming and it was postulated that additional gemstone occurrences should be found in some of these areas (Hausel, 2002a, 2003). Some notable areas include Owen Creek, Grizzly Creek, Cooney Hills and some other localities in this region.

One area to the south of Palmer Canyon was recently examined by W. Dan Hausel and Wayne Sutherland of the Wyoming State Geological Survey (WSGS). This deposit, known as Grizzly Creek, exhibits similar rocks to those found at Palmer Canyon. Notable is the presence of cordierite schist and gneiss, corundum schist and kyanite schist.

This report describes the results of geological reconnaissance conducted at Grizzly Creek leading to the discovery of giant gem iolite occurrences along with minor white and pink sapphire, ruby and considerable gem kyanite.

INTRODUCTION

Iolite, pink sapphire, white sapphire, ruby, industrial kyanite and gem-quality kyanite were all found at Grizzly Creek during reconnaissance by the WSGS in 2004. The iolite, in particular, is impressive and considerable gem-quality material may be present. Both the Grizzly Creek and Palmer Canyon deposits may represent two of the larger *in situ* deposits of gem-quality cordierite (iolite) in the world. Even so, both deposits are relatively small, but host considerable gem material.

Iolite is a little known gemstone in the geological community, even so iolite (gem-quality cordierite) is a very attractive gemstone that has been recovered from few localities in the world. Most notable are the gem placers of Sri Lanka (Hausel, in preparation).

MINERALOGY

Introduction

Iolite is a term used by gemologists to describe gem-quality cordierite, which often occurs with other alumino-silicates such as andalusite, kyanite, and/or sillimanite. These minerals are typically hosted by amphibolite-grade alumina-rich mica schists (metapelites). Cordierite is primarily metamorphogenic; however, it is has also been described as a replacement mineral in some alumina-rich syenites and shales.

Sinkankas (1959) indicates that the terms cordierite and iolite can be used interchangeably and that iolite, which was coined at an earlier date, should have preference over the term cordierite. The term *iolite* is derived from the Greek word for violet. *Cordierite* was named after the mineralogist who initially described the mineral. However, gemologists typically use the term *iolite*, while geologists and mineralogists prefer the term *cordierite.* The mineral has also been periodically referred to as *dichorite* and *water sapphire* although these terms are less common in the literature. The authors suggest that the term *cordierite* should be used for the mineral, and a restriction of the term *iolite* for the gem-variety of cordierite.

Crystal Habit

Cordierite is an orthorhombic mineral that typically forms short prismatic pseudohexagonal crystals with rectangular cross sections, as well as massive, compact grains, porphyroblasts, and/or nodules in various shades of blue, bluish-violet, grey, or brown. According to Sinkankas (1964), the repeated twining on *m*{110} produces cordierite crystals of nearly hexagonal cross section.

Some researchers report that iolite exhibits poor cleavage on the side pinacoid *b*{010} (Schumann, undated). However, Bauer (1968) reports that there is no definite cleavage contrary to Dana and Ford (1949) who describe distinct *b*{010} and indistinct *a*{100}, *c*{001} cleavage. Some researchers describe parting parallel to *c*{001}.

Cordierite may exhibit simple, polysynthetic, parallel, interpenetrating or cyclic twinning with radial, stellate or concentric twins. Both twins and the compositional planes of simple twins may lie parallel to {110} or {130}. Twin crystals may be common in magmatic or thermally metamorphosed rocks, however, untwined crystals are more common in regional metamorphic rocks (Spry, 1969).

Cordierite is brittle producing uneven to conchoidal fracture and may occur with, or as replacements of, other alumino-silicate minerals such as andalusite, sillimanite, and/or kyanite. Unaltered cordierite exhibits a hardness of 7 to 7.5 (very close to quartz). Thus polishing will produce attractive gemstones. Its low specific gravity of 2.55 to 2.75 (the specific gravity increases with increasing iron content) is unfavorable to concentration in placers. Sinkankas (1964) reports that the specific gravity for transparent gem-quality cordierite typically lies within the range of 2.57 to 2.61.

Cordierite has oily to vitreous luster. Transparent iolite gems will exhibit strong and distinct pleochroism ranging from dark violet-blue, light sapphire blue, to light gray. Pleochroism is pronounced and distinctive in iolite gems such that the mineral will appear deepest blue when the stone is viewed down the c-axis, and light blue to light gray in other orientations. This phenomenon, known as dichroism, is essentially the difference in color shown by the same stone when viewed in different directions.

Iron in iolite occurs as ferrous oxide, which is thought to be the primary coloring agent for the mineral. A chemical analysis of iolite gave the following result (Bauer, 1968):

SiO_2	43.6%
Al_2O_3	37.6
Fe_2O_3	5.2
MgO	9.7
CaO	3.1
H_2O	1.0

Artificial cordierite will crystallize above 950°C. When tests conducted on natural specimens were heated to 1440°C, they altered to a mixture of sillimanite and glass (Dana and Ford, 1949). Cordierite (iolite) may exhibit pinite alteration assemblages that commonly include muscovite or biotite and chlorite.

GEOLOGY & GENESIS

Sharp cordierite crystals are rare and the mineral is typically found as granular material or rounded porphyroblastic nodules in aluminum-rich schists (metapelites) in amphibolite grade regional metamorphics. The cordierite schist and gneiss may be found intercalated with other pelitic metasedimentary rocks that can include kyanite, corundum, sillimanite, and/or andalusite. Cordierite is also reported as a high-temperature replacement mineral related to thermal metamorphism.

The cordierite often shows porphyroblastic development in schists in a groundmass that often consists of quartz and muscovite. In high-grade metamorphic rocks and pegmatites, cordierite may show well-developed pseudohexagonal habit. Gem-quality material has been reported from India, Burma, Canada, Madagascar, Sri Lanka, Tanzania and the US. The most important source is the Ratnapura district, Sri Lanka, where pebbles of iolite are recovered from streams with other gemstones.

Regional Metamorphism

Much cordierite appears to have formed as a result of recrystallization in response to increase temperature and pressure during regional metamorphism of metapelite. Since there is little change in the bulk chemical composition of the original rock, the chemistry of the original rock along with changes in pressure and temperature are the controlling factors in rock mineralogy. If aluminum is present in impurities in limestone or a similar silica-poor rock, some ruby and sapphire may be produced during metamorphism. However, if the original rock is shale (consisting of clays and other alumino-silicates), as the intensity of metamorphism increases, the primary minerals will be replaced by new minerals of greater grain size. As the rock changes from shale to slate to schist and/or gneiss, a suite of alumino-silicates may be produced such as garnet, staurolite, andalusite, kyanite, sillimanite, chrysoberyl and cordierite (iolite).

Deer and others (1972) indicate that cordierite formed during regional metamorphism may only occur in high grade gneiss. Where found, the cordierite gneiss will typically lack garnet, since garnet and muscovite will be replaced by cordierite, potassium feldspar and spinel.

DEPOSITS

Iolite is found in Canada, India, Sri Lanka and Madagascar and is also described from Brazil, Tanzania and the United States. Irregular masses with a pleasing blue color and transparency are reported in gneiss at Arendal, Kragero, Tvedestand and other places in Norway. It is also described at Orijarfvi near Abo, Finland. Fine stones are reported in granite gneiss at Haddam, Connecticut and reported to occur with blue and white topaz in the Minas Novas district, Brazil (Bauer, 1968).

Some of the better transparent crystals are found as finely colored stones that occur as pebbles recovered from drainages in Sri Lanka. High-grade metamorphic rocks are believed to be the source of many of these gems (Keller, 1990).

Large areas of British Columbia are underlain by high-grade metamorphic rocks; gemstones found to date in this region include star-sapphire, zircon and red garnet, and these rocks could potentially host, ruby, spinel, garnet, cordierite (iolite), tourmaline, scapolite and kyanite.

Wyoming

Two of the better iolite deposits in the world have recently been identified in the Laramie Mountains of eastern Wyoming by the WSGS. These iolite deposits are multi-gemstone occurrences and include some ruby, sapphire and kyanite. Based on the metamorphic grade of the Precambrian basement (primarily almandine amphibolite grade) and the presence of abundant metapelite, this region provides excellent hunting ground for similar alumino-silicate and oxide deposits and others are expected to be found in the future. The known iolite deposits are located at Palmer Canyon and Grizzly Creek in the central Laramie Mountains 15 to 20 miles west of Wheatland with another occurrence identified further south in the vicinity of Sherman Mountain in the anorthosite complex. This latter deposit is essentially unexplored for gemstones and only minor granular iolite has been identified by the WSGS, to date.

The size of the deposits appears to be relatively restricted, but enrichment of iolite in the Palmer Canyon and Grizzly Creek deposits can best be described as extraordinary. It is not uncommon to find iolite gemstones weighing more than 1000 carats in both deposits, with some masses potentially weighing considerably more. Unfortunately, due to the brittle nature of the stone and effects of deformation, much of the iolite has well-formed cleavage and fractures limiting the size of the facetable gem material. Even so, with the presence of such large nodular iolite, considerable material is available for gemstones, and in particular, for the production of large iolite gems.

To date, three iolite gemstone deposits have been identified in Wyoming – in addition, Sinkankas (1959) reports iolite is a widespread constituent of schists and gneisses in Wyoming. In describing one deposit at an undisclosed location in the Laramie Mountains of southeastern Wyoming, Sinkankas writes, *"...one estimate has placed the quantity available at thousands of tons. Specimens at this locality* (location not provided by Sinkankas) *examined by the author are glassy broken fragments of rather light blue color, verging towards grayish, small sections are clear and suitable for faceted gems. It is entirely possible that important amounts of gem quality material will be produced from this locality in the future."* It is very unfortunate that a legal description of this locality was not made available as it could refer to any of the three deposits recently identified by the WSGS, or potentially refer to fourth unrecognized deposit.

Sherman Mountains. The Sherman Mountain deposit is located along the north fork of Horse Creek near Ragged Top Mountain northeast of Laramie and more than 15 miles south of Palmer Canyon. In this region, Proterozoic (1.4 Ga) age metanorite, syenite, and syenite-diorite gneiss in the Laramie anorthosite complex are described as having high cordierite content. The cordierite is scattered over several square miles and occurs as lenticular to tabular masses in metanorite. It is found in low ridges in an area about 5 miles long and 0.25 to 1 mile wide. The principal occurrences are described to include some exposures with 60 to 80% cordierite! It was estimated that the combined deposits of 100 feet or more in length contained a total of more than 500,000 tons of cordierite (no mention as to whether this material is gem or industrial quality). Possibly, this is the deposit described by Sinkankas (1959) however, further investigations are needed. The cordierite is interpreted to have formed by replacement of metanorite during emplacement of diorite gneiss (Newhouse and Hagner, 1949). In contrast, Subbarayuda (1975) describes the cordierite deposits within cordierite-hypersthene gneiss that he interprets as contact metamorphosed sedimentary rocks.

Unfortunately, physical descriptions of the cordierite are notably lacking and it remains to be seen how much of the material is gem quality. Howard (1952) described the rock to be foliated and the cordierite to exhibit weathered dark brown surfaces with blue and bluish gray fresh fractured surfaces - suggestive of gem material. Reconnaissance samples collected by the WSGS in the vicinity of Sherman Mountain during 2004 show the syenitic rocks to contain minor disseminated cordierite. The massive deposits were inaccessible at the time of field reconnaissance. However, some disseminated cordierite was gemmy with excellent transparency and light-blue to violet color; however, the material was relatively small (<1 carat). Only a very tiny portion of the cordierite deposit has been examined to date for gemstones and investigations of the massive cordierite as well as placer potential are warranted and highly recommended.

Owen Creek. (Sections 9 and 10, T25N, R71W). Located north of Palmer Canyon. Snyder and others (1989) report kyanite, sillimanite, cordierite and relict staurolite in pelitic schist. A similar occurrence was also reported further north. Unfortunately there were no descriptions of the cordierite, but based on the presence of two gem-quality deposits to the south (Palmer Canyon and Grizzly Creek), this deposit should be considered for future field reconnaissance (Hausel and Sutherland, 2000).

Palmer Canyon. (N/2 section 18, T24N, R70W). Granitic gneiss at Palmer Canyon contains small intercalated lenses of quartzofeldspathic gneiss, metapelite and vermiculite. The quartzofeldspathic gneiss, granite gneiss, pelitic schist, and biotite-chlorite-vermiculite schist have a general N80°W trend and 65°SW dip.

The vermiculite schist locally contains biotite, chlorite, kyanite, and corundum. The quartzofeldspathic gneiss is the primary host for the cordierite, much of which is gem-quality (iolite). Nearby, kyanite schist contains excellent, light to sky blue kyanite (a significant portion of which is also gem-quality), and the vermiculite schist contains considerable corundum (white, pink, and red) and is a source for ruby and sapphire. The iolite discovered at Palmer Canyon by W.D. Hausel is best described as a significant discovery. In total, eight types of gemstones, near-gems and ornamental stones were identified. These include:

(1) Violet to blue, transparent iolite,
(2) Dark-gray transparent cordierite,
(3) Gray to bluish translucent to opaque iolite with excellent parting,
(4) Reddish transparent to translucent corundum (ruby),
(5) White to light pink to dark pink translucent corundum (sapphire),
(6) White to pink translucent to opaque corundum,
(7) Sky-blue translucent kyanite, and
(8) Low quality, dark gray, translucent to cloudy cordierite.

There is also some corundum with well-developed rhombohedral parting that tends to crumble. The latter two stones have little value as gems although some cloudy cordierite can be used as faceted low-quality ornamental stones or as lower-quality cabochons (Hausel, 2002a,b).

Metapelites at Palmer Canyon include cordierite quartzofeldspathic gneiss, corundum-kyanite mica schist, and corundum vermiculite schist. The vermiculite is locally enriched in corundum with hexagonal porphyroblasts up to 25 carats in weight. The corundum includes white and pink sapphire with some ruby, and the percentage of gem-quality material has not been estimated, but could be as much as 10 to 20% of the corundum. Some of the vermiculite locally contains as much as 20% corundum by volume, but the tonnage of high-grade rock is restricted to a small area. It also appears that significant portions of the gem-bearing schist and gneiss lie under a thin soil cover.

Very little subsurface exploration has taken place even though a good part of the property is buried by a thin soil layer. None of the corundum has yet been heat-treated to determine if it can be upgraded. This is important as approximately 95% of the world's gem corundum is heat treated to improve both clarity and color (Hausel, in preparation).

The transparent blue iolite forms large porphyroblasts, nodules and disseminated grains in quartzofeldspathic gneiss adjacent to corundum schist. The iolite-bearing gneiss was traced over a strike length of 500 feet but is buried under a thin soil layer and is undoubtedly more extensive. A handful of large nodules were initially found including a raw gem known as the 'Palmer Canyon Blue Star' which weighs 342.8 grams (1,714 carats). Exploration of the deposit in 2003 included minor trenching and several thousand carats of fractured iolite were exposed in the initial backhoe cut. An estimated >100,000 carats of gem quality material were exposed in approximately one cubic yard of material. In addition to the clear, transparent, violet blue gem-quality cordierite, some black translucent cordierite ('Palmer Canyon Black') was recovered. The Palmer Canyon Black is used in cabs, whereas the transparent iolite is facetable grade.

The first faceted iolite gems from the property included a group of flawless to nearly flawless gemstones weighing 0.2 to >3 carats. Although porphyroblasts of material from the property weigh several thousand carats, much of the raw material is fractured, even so, much larger faceted stones will undoubtedly be cut from the raw material in the future. The iolite is primarily anhedral and fractured although some with pseudohexagonal habit is recognizable.

Grizzly Creek. Grizzly Creek is located 4 miles south-southwest of Palmer Canyon immediately south of Collins Peak about 15 to 20 miles west of Wheatland (Figure 1). The property is accessed from the Palmer Canyon road at the base of the Laramie Range. The unimproved 4-wheel drive road runs westerly to southwesterly for a few miles prior to reaching the deposit through private property. Permission for access is required.

The geology of Grizzly Creek is similar to Palmer Canyon. Both are located within the Wyoming craton in an area mapped as undifferentiated Archean granite-gneiss (Graff and others, 1982). This craton was established by 2.7 Ga (Eggler and others, 1988). The gneiss at Grizzly Creek is deformed exhibiting at least one episode of isoclinal folding. Archean pelitic gneiss and schist are intercalated in the granite gneiss and the pelitic rocks are localized in a small outcrop on the east side of Grizzly Creek in the center of NE section 35, T24N, R71W.

During field reconnaissance, gem-quality cordierite was identified in quartzofeldspathic gneiss. Minor amounts of corundum along with pink and white sapphire were also identified in biotite (vermiculite) schist at Grizzly Creek, but the amount of corundum found to date has been minor compared to Palmer Canyon. Even so, the Grizzly Creek occurrence appears to have greater concentrations of both kyanite and iolite. Considerable kyanite was found in pelitic schist adjacent to the iolite gneiss and some of the kyanite is sky blue and found as porphyroblasts of 3 to 5 inches in length.

The deposit is very similar to Palmer Canyon and is relatively unexplored; however, considerable gem material is exposed on the surface and the authors were able to collect masses of gem-quality iolite that weighed a few thousand carats. Much of the iolite is granular or occurs as large masses (nodules) in the gneiss.

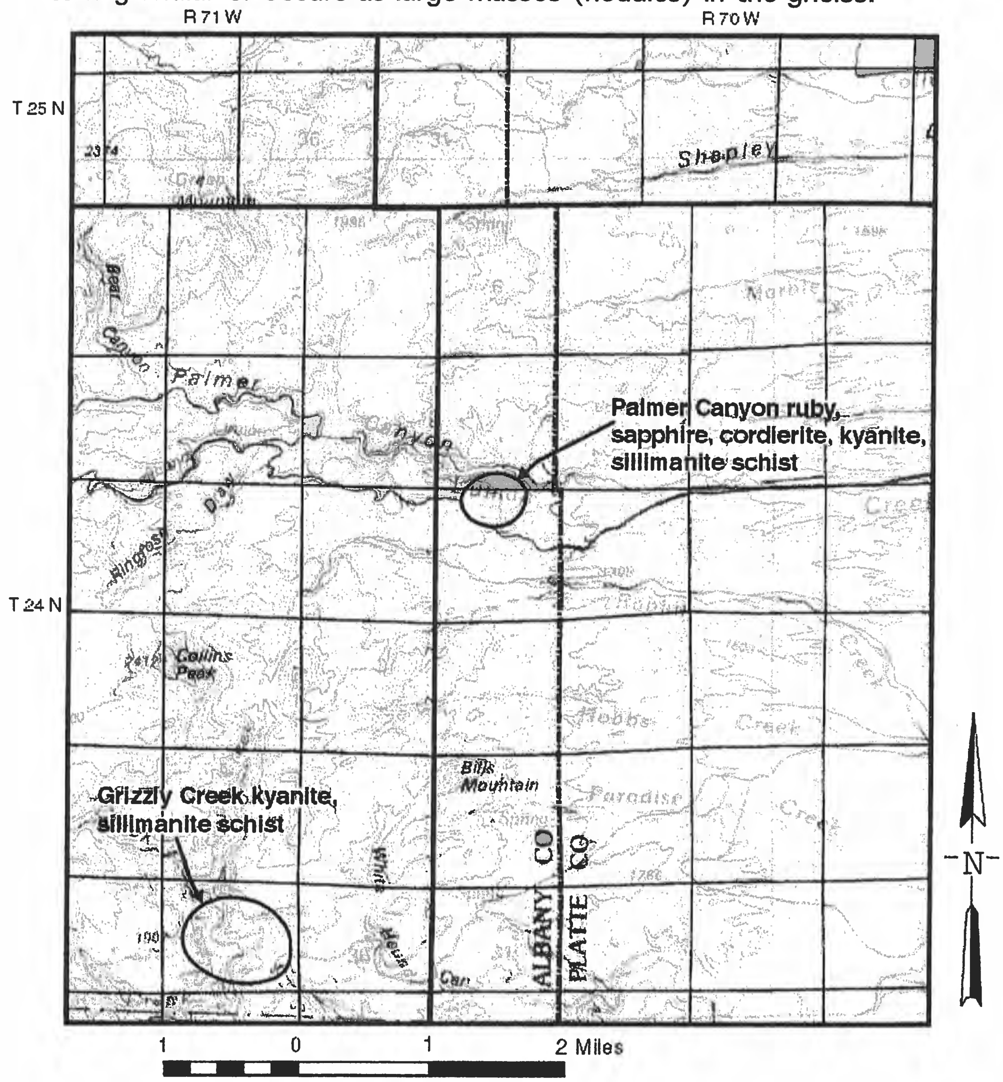

Figure 1. Location map of the Palmer Canyon and Grizzly Creek deposits.

CONCLUSIONS

Prior to the gemstone investigations by the WSGS, Wyoming was little known for gemstones other than jade and a few geological curiosities of diamond. However, the results of the WSGS's gemstone research program over the past two or more decades have been one of the more successful in the world. To date, the WSGS has found and identified several colored gemstone deposits as well as several diamondiferous kimberlites. Known gemstones and decorative stones in Wyoming now include many varieties of agate and jasper, some aquamarine, green beryl, pyrope (cape rubies), chromian diopside, chromian enstatite, peridot, ruby, sapphire, diamond and iolite. Continued investigations will undoubtedly lead to many more gemstone discoveries in Wyoming.

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