



PRECIOUS OPAL IN THE WHITESAIL RANGE, WEST-CENTRAL BRITISH COLUMBIA, CANADA (NTS 93E/10W AND 93E/11E)

By G. J. Simandl (B.C. Geological Survey), S. Paradis (Geological Survey of Canada),
L. J. Diakow, P.J.Wojdak and A. J. Hartley (B.C. Geological Survey)

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INTRODUCTION

The search for gemstone deposits in British Columbia has attracted very limited attention in the past. For example, precious opal deposits were not known in B.C. before the discovery of the Klinker deposit near Vernon in 1991 (Simandl *et al.*, 1996). This despite the fact that common opal occurrences are relatively widespread within Tertiary volcanic rocks (Leaming, 1973; Church and Hora, 1996). Another precious opal occurrence has been recently discovered in the Whitesail Range and is described in this article. The senior author is aware of two other new and confirmed precious opal localities in British Columbia that are not yet being made public. The Eagle Creek occurrence, located 6.5 kilometres from Burns Lake, is also reported to contain precious opal, however we were not able to confirm this information (Paradis and Simandl, 1998). The discovery of more precious opal localities since 1992 underlines the importance of the initial discovery and dissemination of information on how to look for more. This report is based on a two day property visit by the senior author, in combination with limited laboratory work and bibliographic research. The main objective of this study is to contribute to the systematic documentation of the precious opal deposits in the province and to develop a deposit model and exploration guidelines for prospectors.

WHAT IS OPAL?

Opal is a hydrated amorphous silica with between 3 and 20 percent water and a lattice structure of ordered or disordered α -cristobalite

microcrystallites. Electron microscope studies show that the precious opal consists of close packed silica spheres ($\text{SiO}_2 \cdot n\text{H}_2\text{O}$) and interstitial silica, water or CO_2 gas-vapour air. Opal is characterized by a conchoidal fracture, and it occurs in a variety of background colours. It is transparent to nearly opaque, and may be distinguished from chalcedony and cryptocrystalline varieties of quartz by its higher water content and lower hardness. Opal is brittle, sensitive to heat, and easily scratched. Furthermore, opal from some localities, is “unstable” and may craze or self-destruct through the loss of water. Despite these faults, opal’s beauty is supreme, and it has been recognized for the past thousand years as a “highly prized” gemstone.

The terminology currently used to describe opal for lapidary applications is quite complex. The three most commonly used terms are “precious”, “common”, and “fire” opal. Precious opal is defined as opal with a bright, internal play of colours that may be red, orange, green or blue. This play of colours is caused by diffraction of white light by the regular packing of silica microspheres within the mineral structure. The diameter and spacing of the microspheres control the colour range of an opal (Darragh *et al.*, 1966). Precious opal may be subdivided further by colour modifiers, white, black, pink, and blue, which describe the body colour of the opal. Australia is famous for its white and black precious opal. The term “common opal” groups all opals without a play of color (including the fire opal). The lack of a play of colours may be due to a less ordered packing of the silica microspheres. Fire opal is defined as a solid opal with transparent orange to red-orange base colour. It belongs to the precious opal variety if it shows a play of colour, or to the common one if it lacks play of colour. Some of the best fire opal comes from Mexico.

The opal may be deposited by silica-bearing hydrothermal solutions in hot spring or geyser environments, from meteoric waters, or as the accumulation of tests of silica-secreting organisms called diatoms. These organisms live in marine or lacustrine environments.

Deposits that contain precious opal are divided into sediment or volcanic-hosted deposits (Simandl and Paradis, 1998 and Paradis *et al.* 1998). Most of the world's gem opals are from the Australian deposits of the Coober Pedy, Andamooka, and Mintabie areas, which are excellent examples of sediment-hosted fields. These deposits are believed to have formed by descending silica-bearing meteoric waters. The silica is derived from the intense and deep weathering of the sediments overlying the opal deposits. Silica in the meteoric water is concentrated by evaporation, resulting in the formation of colloidal silica gel and ultimately opal. The remaining opal production comes from volcanic-hosted deposits such as those of the Querétaro region of Mexico, Gracias à Dios area in Honduras, and the Spencer deposit in Idaho, USA. The volcanic-hosted opal deposits are believed to be genetically associated with hydrothermal activity.

REGIONAL GEOLOGY

The Whitesail Range is located near the boundary of the Coast and Intermontane belts (Van der Heyden, 1982). The Mesozoic through Tertiary Coast Belt is mainly composed of granitic rocks with variably metamorphosed and deformed peninsular and slivers of island arc terranes. The Intermontane Belt at the latitude of the study area is underlain by island and continental margin arc strata and comagmatic plutons that vary in age from Late Triassic to Paleogene. Block faults are numerous, juxtaposing rocks of contrasting age and tilting layered sequences (Diakow and Mihalyuk, 1987a,b).

A regional geologic synthesis of the Whitesail Lake map area was first published by Duffell (1959). Woodsworth (1978, 1980) remapped this area. Map sheets 93E/10W and 93E/11E, which contain the opal deposits, were mapped at 1:25,000 scale by Diakow and Mihalyuk (1987a) and the results were published at 1:50,000 scale by Diakow and

Mihalyuk (1987b). Stratigraphy of the Ootsa Lake Group (Figure 2) in the region between the Whitesail Range and Whitesail Lake map area is described in Diakow and Mihalyuk (1987a) and Drobe (1991). Radiometric dating of the Eocene rocks that host the opal are given in Diakow and Koyanagi (1988) and Drobe (1991).

NORTHERN LIGHTS OPAL OCCURRENCES

Location

The newly discovered opal showings are located in west central British Columbia in the Whitesail Range, north of Whitesail Lake (Figure 1). Access is either by helicopter or by surface transportation and hiking. By air, the property is approximately 130 kilometres from Smithers and 90 kilometres from Houston. One travels west by road from Prince George to Burns Lake and then southwest to the west end of Francois Lake. From there, a set of logging roads lead to Tahtsa Reach, where a private barge operated by Houston Forest Products affords passage to the few logging roads south of the Reach. From the nearest logging road, it is approximately a 12 kilometre walk southwest along the valley of Slide Creek towards Troitsa Peak to get to the Northern Lights claims. The claims are located well above the tree-line on the eastern spur of the Troitsa Peak.



Figure 1. Location of the precious opal occurrences, Northern Lights claims, Troitsa Peak area, Whitesail Range.

Geological Setting

The precious and common opal showings on the Northern Lights claims are hosted by Ootsa Lake Group volcanics (Figure 2). These volcanics were described by Drobe (1991) as well-layered, coarsely plagioclase- and pyroxene-phyric andesite flows, approximately 130 to 200 metres thick, that conformably overlie flows of rhyodacitic composition. The andesite flows are characterized by abundant plagioclase and pyroxene phenocrysts. In the area of the opal occurrences the andesite flows are subhorizontal and sheet-like, each of which range from 1 to about ten metres thick (Drobe, 1991). These flows resemble near-source compound lavas, consisting of a number of relatively thin lens-shaped flows separated by poorly sorted, debris flow deposits. Individual flows are typically massive at their base and grade upwards into oxidized and strongly vesicular tops (over 50% vesicles in the uppermost 20-40 cm). Vesicles are scarce in the center of the larger flows, but in some thinner flows the vesicular texture may persist throughout. Vesicles are filled with a variety of minerals that generally include a combination of chalcedonic quartz, celadonite, zeolites, and carbonates. Chabazite may occur locally (Diakow and Milhalynuk, 1987a). Volcanic rocks of the Ootsa Lake Group, with the exception of one sample, can be classified as subalkaline using the $(\text{Na}_2\text{O}+\text{K}_2\text{O})$ versus SiO_2 plot of Irvine and Baragar (1971). These rocks also belong to the calcalkaline field on an AFM diagram. Based upon the K_2O - SiO_2 plot of Ewart (1982), they are classified as high-K andesites and basaltic andesites (Drobe, 1991).

The debris flows are commonly up to two metres thick and interfinger with the compound flows (Drobe, 1991). These deposits are lenticular and composed of unsorted, subrounded to subangular clasts of andesite that locally may average 20 to 30 centimetres in diameter.

A broad zone of pervasive alteration developed in volcanic rocks assigned to the Lower Jurassic Hazelton Group is situated to the south of the opal-bearing area (Diakow and Mihalynuk, 1987a). The zone was not examined during this study and was not specifically described by Diakow and Mihalynuk. It is one of several broad areas they mapped with clay minerals, fine grained silica, pyrite, and in places barite, that replaces both underlying sedimenta-

ry rocks of the Smithers Formation (Hazelton Group) and unconformably overlying volcanic strata of the Ootsa Lake Group. It is not known if the precious opal on the Northern Lights claims is genetically linked to this zone of silicification. These silicification zones are probably due to hydrothermal alteration associated with high-level intrusions (Diakow and Mihalynuk, 1987a). No precious opal was found within this zone by the prospectors.

Opal-bearing lithologies

The dominant opal-bearing lithologies in the area are the debris flows. Less abundant opal-bearing lithologies are massive lava flows and associated flow top breccias and minor, possibly waterlain, ashfall tuffs. Massive flows are commonly dark green and mostly porphyritic, although aphyric flows were also observed. The phenocrysts are predominantly plagioclase (up to 2 cm) and pyroxene (<6 mm). Most of the flows are either strongly vesicular or amygdaloidal. The debris flows consist of subangular to subrounded, vesicular, amygdaloidal or massive clasts that typically vary in size from 2 to 100 centimetres, but some may be several metres in size. The flows are matrix- or clast-supported (Figure 3b). Some of the debris flows are polymictic, others are oligomictic. The colour of the clasts varies from dark green, brown, and beige to deep brick-red, a feature that is probably related to the degree of oxidation, and possibly permeability. The scoraceous clasts appear most oxidized. The colour of the matrix varies from yellow to red to gray. Reworking of the debris flows is common, as seen by the rounded heterolithic clasts making up the flows. Some of the flows are truncated by thin bedded, possibly waterlain tuffs, but more commonly by younger debris flows. In thin section most of the opal-bearing rocks consist of 10 to 30 percent plagioclase phenocrysts (up to 15 millimetres in length), amphiboles (0-2%), pyroxene (<2%), opaque oxides (<2%), apatite and opaques (trace). Vesicles may account for more than 20 volume percent of some rocks. The vesicles may be partially or completely filled by common and precious opal or agate and coated by celadonite or zeolites.

Locally, shallowly inclined compound flows and debris flows, including the opal-bearing

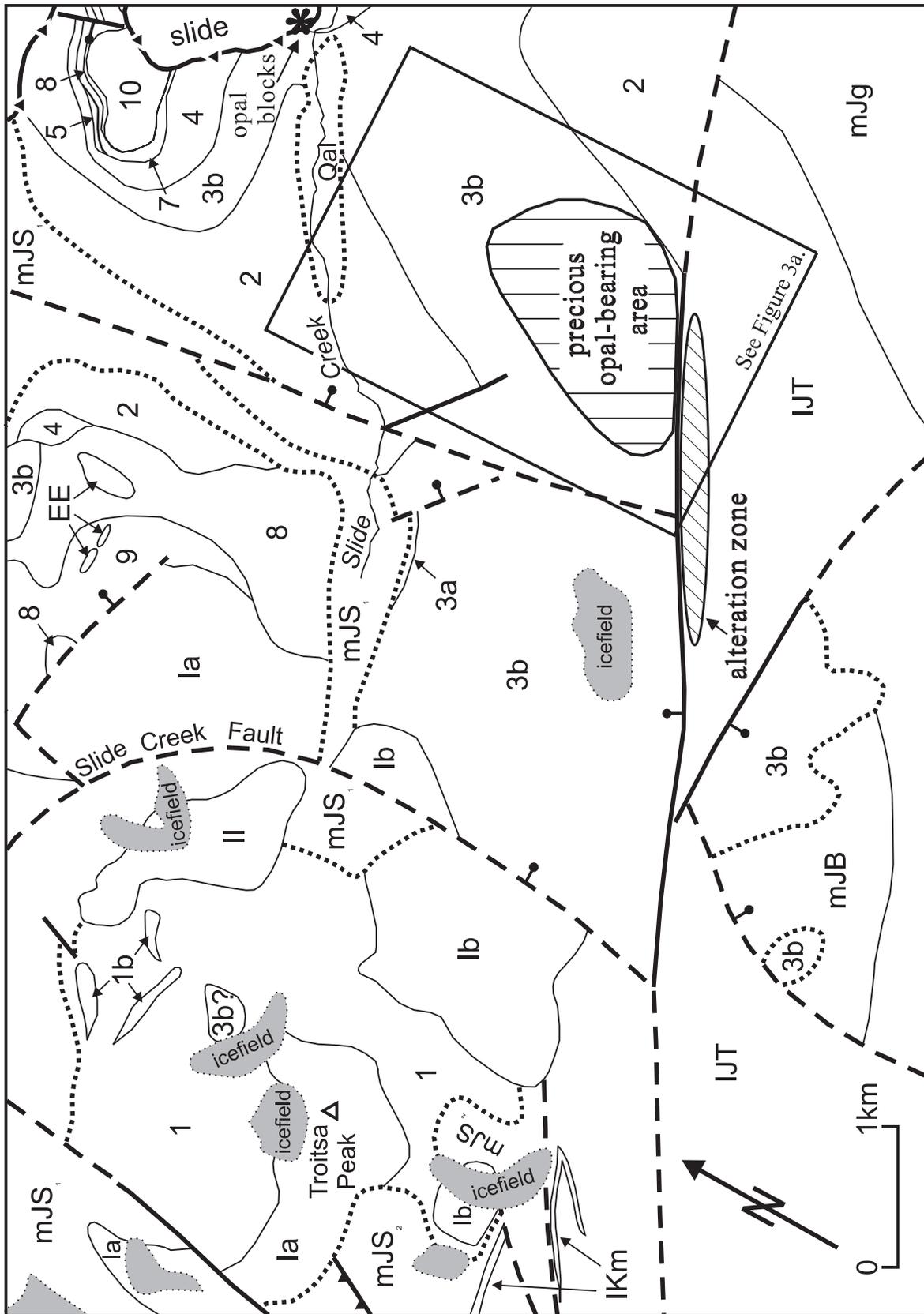


Figure 2. Geological setting of precious opal occurrences in the Whitesail Range (modified from Diakow and Mihalnyuk, 1987a,b and Drobe, 1991).

VOLCANIC AND SEDIMENTARY ROCKS

QUATERNARY

Qal Glacial till and alluvium

EOCENE

EE ENDAKO GROUP: Plagioclase and olivine phyric basalt

10 OOTSA LAKE GROUP: Plagioclase and biotite phyric rhyodacite flows, mauve and grey

9 Coarse plagioclase and pyroxene phyric well-layered andesite flows

8 Buff to tan airfall tuff

7 Intensely welded and minor weakly welded maroon devitrified and black vitrophyric ashflow tuff

6 Stratified and graded thickly bedded debris flows (not present)

5 Plagioclase and pyroxene phyric andesite

4 Sparsely plagioclase phyric dacite flows and debris

3b Coarse plagioclase and pyroxene phyric, well-layered basaltic andesite and andesite flows

3a Crystal lapilli air-fall tuff

2 Plagioclase-biotite-hornblende phyric rhyodacite flows

1 Intensely welded dacitic ash-flow tuff, minor weakly welded block and lapilli tuff, dacite lava flows

MIDDLE JURASSIC

mJB BOWSER LAKE GROUP
Ashman Formation: Siltstone, shale, feldspathic sandstone, lithic arkose; medium to thickly bedded; fossiliferous

LOWER AND MIDDLE JURASSIC

mJS₂ HAZELTON GROUP
Smithers Formation: Lapilli tuff, accretionary lapilli tuff, brownish-red to dark grey

mJS₁ Siltstone, feldspathic sandstone, lithic arkose, greyish-green, minor shale, chert, limestone

IJT TELKWA FORMATION: Maroon and green andesitic to basaltic tuffs and flows; rhyolitic flows, lapilli tuff and tuff breccia

INTRUSIVE ROCKS

TERTIARY

II Equigranular and quartz-biotite-feldspar porphyry granodiorite and quartz monzonite stocks

Ia Plagioclase porphyry diorite sills, plugs, and dykes

Ib Hypidiomorphic-granular diorite plugs and dykes

MESOZOIC

IKm Equigranular diorite and negmatitic monzonite

mJg Middle Jurassic equigranular granite and quartz monzonite stock

SYMBOLS

..... unconformity

▲▲▲▲▲ landslide

—●— fault (solid circle on downthrown block)

▲▲▲▲▲ thrust or reverse fault

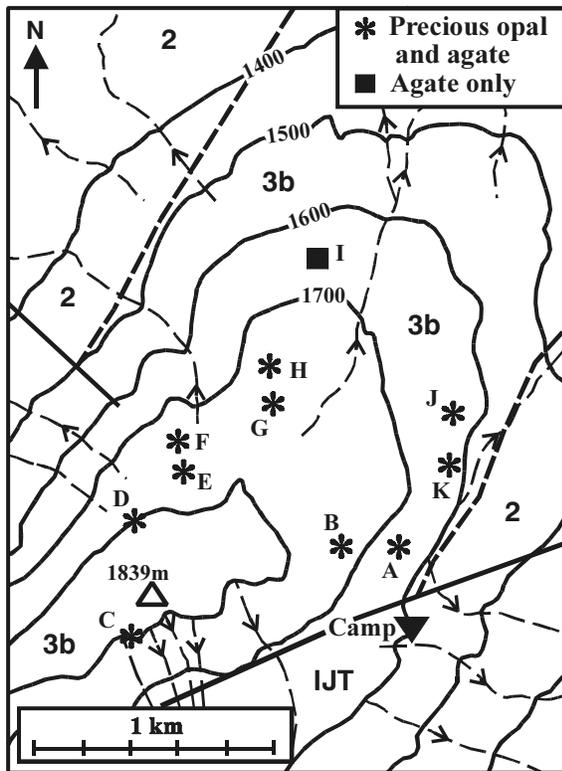


Figure 3a: Distribution of precious opal and agate occurrences on the Northern Lights claims situated on a ridge extending east-northeast from the Troitsa Peak. For geological legend see Figure 2. Star - precious opal and common opal ± agate; square - agate occurrence; A-Zona Rosa, B- Northern Lights, C- Great Wall, D-Bright Lights, E-Ptarmigan, F-New Lights, G-New Lights (East), H-Side Lights, I-No Lights, J-Agate Alley (North), and K-Agate Alley (South); Inverted triangle - camp. Contours are in metres.



Figure 3b: Typical debris flow, Agate Alley showing. Hammer for scale.

ones, may be repeated by displacement along recent, crescent shaped, steeply dipping slump planes in the southern part of the opal-bearing area. A mica-bearing, subvertical dike oriented N65E, cuts the opalized country rocks. The dike is about 60 centimetres wide and is traceable for 2000 metres as a distinctive positive weathered spine that protrudes as much as 6 metres above the surface. According to the prospectors, the dike itself contains a small amount of precious opal and was the initial opal discovery on the property. Common opal can be seen as thin fracture filling along the intrusive contact with the country rock. Prospectors refer to this dike as the Great Wall (Figure 3a). Chemical analysis would be required to determine if this dike is a feeder to the biotite-bearing rhyodacite unit described by

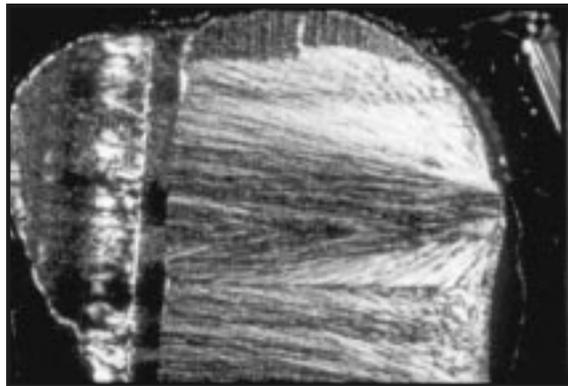


Figure 3c: Agate-filled vesicle in polarized light, showing multiple nucleation sites and nature of horizontal layering. The longest dimension of the photograph is approximately 4mm.

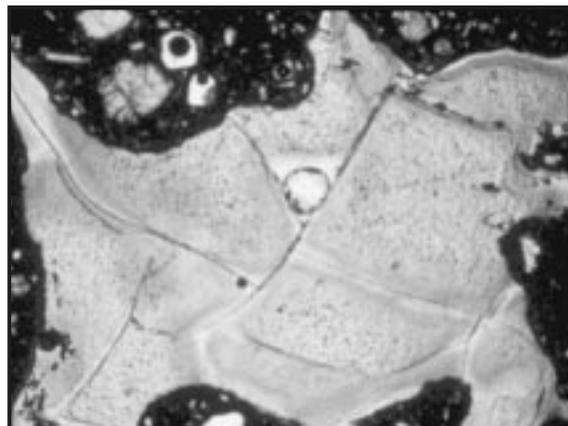


Figure 3d: Precious opal-filled vesicle in plain light. The center of the amygdule is more cloudy and greenish. Edges of the amygdule are slightly brownish, as well as salvages along the desiccation cracks. The longest dimension of the photograph is approximately 4mm.

Drobe (1991). The dike's mafic content appears too low to be described as a lamprophyre.

Opal and Agate Occurrences

The opal occurrences are located near the brim of a flat-topped ridge within an area 1200 by 2000 metres. (Figures 2 and 3a). There are at least 10 precious opal occurrences. Most of the precious opal extracted for testing purposes by the prospectors was from the Zona Rosa and Ptarmigan occurrences.

In general, opal and agate occur most commonly as open space fillings in the matrix and vesicles of clasts and rarely as thin films along fractures in debris flows and flow top breccias. It occurs also as amygdules in massive flows. Due to the complex history of some of the reworked flows, agate may be present only in the vesicles of individual clasts. In such flows only one clast out of fifty may contain agate fillings. Geopetal indicators generally suggest that the agate and opal formed when the lithological units acquired their present orientation. However, in rare cases they suggest that the strata has been tilted approximately 15 degrees south since the agate was formed. Celadonite, a soft, green, earthy mineral of the mica group, is present throughout the area as a vesicle filling and in some places it is so abundant that it gives the rocks a bright green colour. Celadonite commonly forms the rims of empty or agate filled vesicles, suggesting that celadonite predated agate.

Two of the metre-scale clasts within the same debris flow at the Agate Alley showing, display concentric layering (zoning) in terms of the vesicle fillings. The vesicles within the core zone (central portion) of these clasts are empty (silica-free). The core is surrounded by 10 to 15 centimetres thick zone containing individual vesicles coated by a one millimetre thick celadonite layer. This is in turn surrounded by an outer zone characterized by agate partially or completely filling the vesicles, suggesting that the fluids that deposited the celadonite and agate were penetrating the clast from the more porous matrix and moving inward. The high concentrations of celadonite on the property do not appear to coincide geographically with the high opal concentrations. As at the Klinker deposit, the presence of zeolites within the area indicates a favorable geological environment for opal

preservation. The opal stability field is similar to that of clinoptilolite and chabasite.

Most of the agate is colorless, gray or white. The largest agate eggs observed at the site measured up to 15 centimetres in longest dimension. The agate deposition may be in layers or it may form from several nucleation sites simultaneously (Figure 3c).

Precious opal occurs as irregular zones filling individual vesicles or fractures in some of the common opal and agate-bearing debris and compound flows. The size of the opal-bearing zones is difficult to evaluate, but the best exposed occurrence is Ptarmigan. At this location the opal occurs within a trench at least one metre deep, 2 metres wide and 5 metres in length. It appears genetically unrelated to the degree of oxidation, filling vesicles in both hematized and unoxidized lava flows. In most cases, vesicle fillings result in small flecks of opal being densely distributed throughout the rock, similar to examples of Honduran opal. Where the vesicles are large, solid opal recovery is possible. In places, the host volcanic material appears fresh and hard, and will probably take a good polish if polished simultaneously with the matrix opal. In other areas it appears porous and soft and may not give adequate support for the opal during processing. Uncommonly thin (<1mm) fractures filled by precious opal have also been observed. Some of these appear suitable for production of assembled stones as doublets and triplets.

The typical precious opal body colours observed at the sites are white, brown and honey yellow, although black is present but scarce. Most of the opal is opaque to translucent (semi-crystal). The play of colours within the precious opal are green, red, blue and yellow (no systematic study was attempted). The stones appear average or better than average in terms of brightness, although, the detailed evaluation is typically done on individual stones and it will commonly vary within a deposit. In general, the bright play of colour remained after the samples were extracted. The brightness of the samples from the "Bright Lights" locality (Figure 3a) appears strongly enhanced in humid or wet environments. The opal from this occurrence is probably hydrophane, a variety of common opal with a change in opacity and indirectly, intensity of colour, with a corresponding change in water

content. Under transmitted light the precious opal typically appears cloudy brownish or greenish in the central portions of the vesicles and it may contain some dehydration fractures (Figure 3d). It appears isotropic under polarized light.

Economic Potential

Based upon field observations, most of the stones extracted by the prospectors in 1998 may be described as matrix opal of specimen or gem quality. Some of the opal may be suitable for doublets and triplets. Material suitable for "solid opal" cabochon-making is relatively rare. The stability of the opal from the Northern Lights claim remains to be assessed. Some of the opal is hydrophane, however, the owners of the claims indicate that precious opal cut two or three years ago did not craze or undergo other undesirable changes. The appraisal of rough or finished stone from the Northern Lights claims is beyond the scope of this study. Test marketing of the precious opal jewelry from this deposit is in progress and several artists are determining if the opal is suitable for carving purposes. The Whitesail area has many similarities with the Klinker deposit in terms of lithologies, age of the host rocks, mineralogy of vesicle fillings, and the presence of zeolites and celadonite.

The precious opal exploration potential of the area is not limited to the Northern Lights claim. For example, slide scree on the north side of Slide Creek, approximately 3 kilometres north of the camp site (Figure 2), contains angular blocks up to 30 centimetres across consisting of cream colored, translucent, common opal crosscut by black opal veinlets. On the weathered surface these blocks are white. Although no precious opal was observed at this location, there is no doubt that more precious opal will be found in the Whitesail Range.

CONCLUSIONS

- ♦ Northern Lights precious opal is an important discovery that warrants more detailed evaluation.
- ♦ Ootsa Lake volcanic rocks in the Whitesail Range, and possibly even further afield in central B.C., have good exploration potential in terms of precious opal.

- ♦ Permeable lithological units such as debris flows are the most favourable host rocks.
- ♦ Known common opal- and agate-bearing areas in the above described geological settings should be carefully reexamined for the presence of precious opal.
- ♦ More precious opal will likely be located in other areas of British Columbia in similar geological settings as more prospectors and rockhounds are introduced to this type of deposit.

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