NOTES
· AND ·
NEW TECHNIQUES

OPALS FROM OPAL BUTTE, OREGON

By Kevin Lane Smith

Recent mining at Opal Butte in northeastern Oregon has produced a wide variety of large flawless opals. The most common gem-quality varieties are hyalite and rainbow opal, but the less common play-of-color varieties contra luz, hydrophane, and crystal opal are economically more important. Fire, blue, and dendritic opal are also found. The opal occurs in rhyolite geodes embedded in decomposed perlite. More than 100 kg of material was uncovered from November 1987 through November 1988. The opal varies greatly in stability, but the finest stable material makes excellent carvings, cabochons, and even faceted stones.

The northeastern Oregon deposit of precious opal at Opal Butte has been known to collectors since at least 1892 (Kunz, 1893), but because of the inconsistency with which opal was found and the highly variable stability of the gem material itself, it was not considered to have significant commercial potential. Recent exploratory work, however, has established that there is enough stable gem-quality opal (figure 1) to make commercial mining feasible. In November 1987, West Coast Gemstones began the first systematic mining of this deposit.

LOCATION AND ACCESS

The mine is located on privately owned land in Morrow County, 35 miles (56 km) south of the town of Heppner. It lies on the western slope of Opal Butte, at an elevation of 4700 ft (1400 m). Opal Butte is part of the Blue Mountain Range, which covers much of northeastern Oregon. Snowy winters make mining possible only from May through November. Summers are quite dry, however, and temperatures up to 90°F (32°C) are common in July and August.

GEOLOGY AND OCCURRENCE

The dominant geologic features of northeastern Oregon are the extensive and voluminous Columbia River basalt flows. Erosional dissection of a northeast-trending anticline in this area has exposed an underlying series of early Tertiary (60–65 million years old) rhyolitic volcanic flows (Walker, 1977). The rhyolite geodes (popularly known as "thunder eggs") in which opal is found occur in perlite, the glassy basal vitrophyre of the rhyolite.

ABOUT THE AUTHOR

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All of the stones illustrated in this article were cut or carved by the author, who also designed and manufactured the two pieces of jewelry shown. Photos that are not otherwise credited are by the author.

Figure 1. This faceted 105-ct contra luz opal represents some of the finest play-of color material found at Opal Butte, in northeastern Oregon, during the 1987–1988 mining season. Unlike the "normal" play-of-color typically seen in Australian opal, contra luz play-of-color is visible only with transmitted light. Photo by Stan Thompson.

Locally, the perlite, a dark green, silica-rich rock, has been altered to a pastel clay. Opal-bearing geodes are found exclusively in the clay zones. This suggests that the hydrothermal alteration of the perlite to clay minerals is related to the opal deposition (Staples, 1965). No reports have been found of any other opal deposits in this area.

The geodes may contain one or more of the following: agate stalactites, quartz crystals (rarely), banded agate, common opal, or various types of gem-quality opal. Approximately 70% of the geodes contain no opal, 20% contain common opal, and 10% contain some gem-quality opal; less than 1% contain opal with prominent play-of-color. The play-of-color opal most commonly occurs in a 0.5–2.5 cm layer near the top of a partially filled geode (figure 2). The occurrence of opal in Oregon most closely resembles that of Querétaro, Mexico (Koivula et al., 1983).

The fact that the geodes differ greatly in content suggests that the temperature and/or composition of the mineralizing solutions varied considerably over time (Renton, 1936; Staples, 1965). About half of the geodes are lined with botryoidal agate and/or agate stalactites. On top of this agate layer in some geodes are alternate horizontal layers of agate and common opal. There was at least one major episode of common-opal deposition which completely filled many geodes. Almost every other geode, however, contains a unique sequence of layering. Some geodes contain convergent layers that indicate a tilt in the original beds of up to 10° during the mineralization sequence.

The geodes also vary greatly in size, from a few centimeters to well over a meter in diameter. Most of the smaller geodes have little or no empty space, whereas the larger geodes have cavities comprising up to 75% of their total volume. There is little correlation between the size of a geode and its opal content. We have observed, however, that the smaller geodes may contain all gem-quality opal, whereas the giant geodes contain mostly common opal.

MINING

Mining is by open-pit excavation with a backhoe. To the best of the author's knowledge, the West Coast Gemstones operation represents the first use of mechanized mining at this locality. At the present time, only two people do the actual min-

Figure 2. A layer of opal with some play-of-color is evident in this typical partially filled geode (10 in.—25 cm—in diameter) from Opal Butte.

Figure 3. Two people currently mine at Opal Butte: One operates the backhoe, while the other retrieves the geodes that have been dug out. This is believed to be the first mechanized mining ever conducted at this locality.

ing: One person operates the backhoe while the other retrieves the geodes (figure 3). After a few dozen geodes have been accumulated, they are carefully split to determine if they contain any opal. Most of the geodes contain natural fractures and can be opened easily without damaging much of the opal inside. Because so few of the geodes actually contain opal, it would not be economically feasible to saw each one open.

From November 1987, when mechanized mining first began, through November 1988, the mine produced a total of 100 kg of gem-quality material. Of this, 10 kg show definite play-of-color. Play-of-color opal is so rare that sometimes the miners may go as long as two weeks without finding any. The word that characterizes this deposit most succinctly is *unpredictable*. For this reason, it is difficult to assess its future potential. However, mining is planned for at least the next five years.

STABILITY OF OREGON OPAL

The opals found at Opal Butte vary tremendously in stability. Some of the material can safely be left in the sun immediately after being mined; other pieces craze thoroughly within a few minutes of being exposed to dry air. Most of the geodes are layered, and some contain one or more layers that craze badly while the adjacent layers remain intact.

Crazing occurs when stress is created due to shrinkage from uneven loss of water. If a freshly dug water-saturated opal is exposed to dry air, the surface may begin to dry and shrink. We routinely test the stability of the opal by taking one of the many pieces that may be found in a single geode and placing it outside (the balance of the material is wrapped in wet paper towels and sealed in plastic buckets). If after several days the test piece has not crazed, the rest of the opal from that geode is unwrapped and left at room temperature and dryness. If these pieces do not craze after two months, they are deemed stable. Of the opals that were stable after two months, more than 95% remained uncracked a year later.

Crazing can be prevented in some opals by carefully controlled or extremely slow drying, to avoid a steep moisture gradient between the surface and the interior by promoting even shrinkage. For example, if the initial test piece from a geode does craze, the remaining material is usually allowed to dry out slowly, at room temperature, over the course of eight or more months. This slow curing stabilizes about half of the material that initially crazed readily. The author has developed another method whereby some of the unstable material is packed in wet sand in covered Pyrex containers. These containers are then placed in an oven at 200°F. After the sand dries out, approximately two days later, the stones are left in the dry heat an additional 12 hours to firmly establish the outcome. Approximately 25% of the material treated by this method emerges uncrazed.*

**Tests still underway indicate that approximately 20% of the opals that do not make it through the oven without cracking would have become stable if put through the much longer room-temperature curing process.*

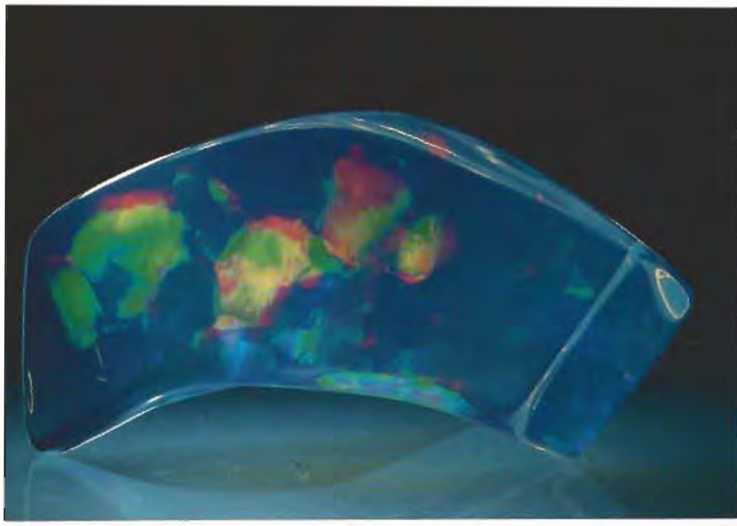

Figure 4. This 135-ct contra luz opal was found at Opal Butte in 1972. Note the large "harlequin" patches of color. Photo by Stan Thompson.

These methods will usually work as long as the opal is homogeneous in terms of water affinity. If some layer or zone in an opal holds water less tightly than another, however, differential shrinkage will cause cracking no matter how carefully it is cured. Even very stable opal may crack some if left on the matrix, because cracks may form near the interface between the opal (which may shrink some) and the rhyolite matrix (which will not shrink). Cracks near the opal/geode boundary generally do not propagate deeply into an otherwise solid opal, so matrix pieces can still be very attractive mineral specimens.

Considerable work remains to thoroughly evaluate the various techniques for stabilizing opal that at first appears to be unstable, but the assessment of the opal that is stable from the start appears to be very good. The author knows of three private collections with opals collected from this locality over 15 years ago that have remained stable. The flawless 135-ct contra luz opal in figure 4 was found in 1972.

It is not possible to predict with great certainty which opals will crack, and which will not, based on macroscopic appearance. However, some generalizations are made in the following description of the different types of opal found at Opal Butte.

VISUAL APPEARANCE AND GEMOLOGICAL PROPERTIES OF THE DIFFERENT OPAL TYPES

Several varieties of gem-quality opal have been recovered at Opal Butte. The rarest, those with distinct play-of-color, are referred to as contra luz, hydrophane, and crystal. The most common varieties are rainbow and hyalite, but fire and blue opal also occur, as well as a dendritic variety. Table 1 provides approximate figures on the relative abundance and stability of the various types of gem opal found at Opal Butte. Table 2 lists the refractive indices (flat facet readings) for the different types as well as their reaction to long- and short-wave U.V. radiation. In general, the opals vary in specific gravity from 1.3 for the lightest (dry) hydro-

TABLE 1. Approximate relative abundance and overall stability of the different types of gem-quality opal mined at Opal Butte from November 1987 to November 1988.

Type	Abundance[a] (%)	Stability[b] (%)
Contra luz	5	70
Crystal	2	60
Hydrophane	2	90
Contra luz/crystal	1	80
Rainbow	25	90
Hyalite	43	70
Fire	6	20
Blue	12	90
Dendritic	1	75

[a]Percentage of the 100-kg of gem-quality opal mined during this period. The remaining 3% include hydrophane with no play-of-color.
[b]The percentage of the material of this type found that was stable when mined and has remained so over time.

TABLE 2. Refractive index and reaction to ultraviolet radiation of the different types of Opal Butte opal.

		Reaction to U.V. radiation[a]	
Type	R.I.	Long-wave	Short-wave
Contra luz	1.44–1.45	Weak green	Very strong green
Crystal	1.45	Very weak green	Medium green
Hydrophane	1.43–1.45	Strong chalky bluish white	Very weak white
Contra luz and crystal play-of-color	1.44–1.45	Chalky white	Weak green
Rainbow	1.44	Weak green	Very strong green
Hyalite	1.45	Weak green	Very strong green
Fire	1.42–1.43	None	None to weak green
Blue	1.47	None	None to weak green

[a]No phosphorescence was observed in any of the pieces tested.

phane to 2.2 for the heaviest (wet) clear material. Similarly, they vary in hardness from 4 on the Mohs scale for the chalky hydrophane to 6 1/2 for the clear pieces. All show a conchoidal fracture, pearly to vitreous in luster. No reaction was visible with either the polariscope or the Chelsea color filter. The most distinctive properties of each type found at Opal Butte are described below.

Opal with Play-of-Color: Contra Luz, Crystal, and Hydrophane. About 10% of the gem-quality opal found at Opal Butte shows distinct play-of-color. Half of this material is similar in appearance to Mexican contra luz opal (Leechman, 1984). The play-of-color is only apparent in transmitted light and most commonly occurs in a pinfire pattern, but harlequin (again, see figure 4) and other types (see figure 1) are also observed. Most of the contra luz opal is clear or very nearly clear, but white, orange, and yellow opal with contra luz play-of-color is also found. About 70% of the contra luz opal is stable to spontaneous crazing.

Almost half of the opal with "normal" play-of-color (i.e., that which is apparent with reflected light, as with most Australian opal), is clear or almost clear, and is referred to as crystal opal (figure 5). Sixty percent of this material is stable. Some pieces show both contra luz and "normal" (crystal) play-of-color.

Figure 5. The finest piece found at Opal Butte in 1988 is this 315-ct crystal opal. Photo by Stan Thompson.

The remaining half of the opal with "normal" play-of-color is referred to as hydrophane; that is, it is exceptionally porous and does not hold water tightly. Hydrophane may be either clear or white when saturated with water, but the clear material turns white when dry (figure 6). Unlike the hydro-

Figure 6. This 145-ct hydrophane opal is clear when wet (here, having been soaked in glycerin), as evident on the left, and white when dry, as photographed on the right. Good play-of-color is seen in both conditions. The photo on the left is © Tino Hammid; the one on the right is by Robert Weldon.

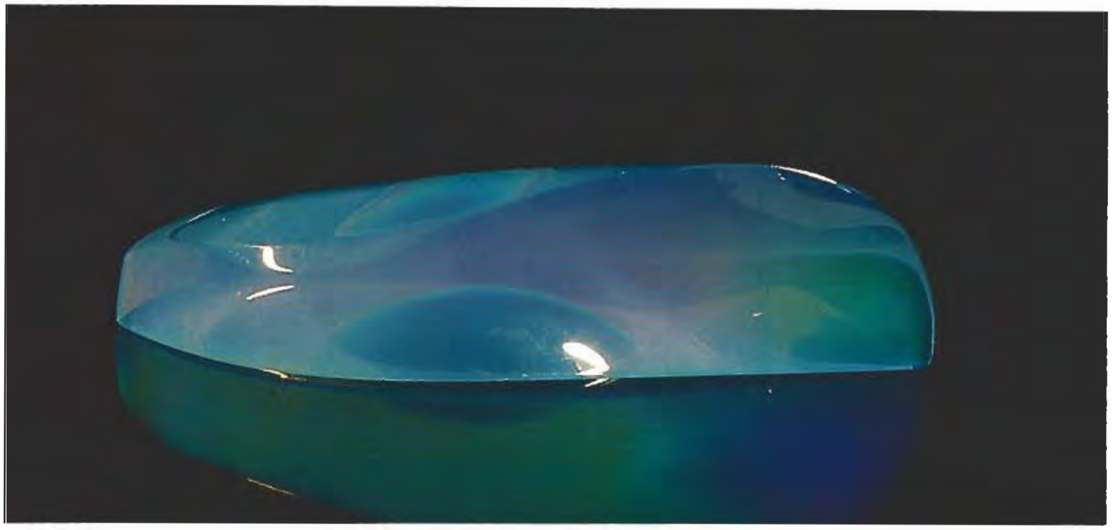

Figure 7. Rainbow opal represents 25% of the gem-quality opal mined at Opal Butte. This material glows soft hues as light passes through it. Note the different colors in the reflected image of the 62-ct rainbow opal carving as compared to the actual stone. Photo by Stan Thompson.

phane described in Bauer (1969), this material has good play-of-color both when clear and when white. The hydrophane that is white when wet is not only more porous and softer than the clear hydrophane, but it is also less likely to crack when it dries. Some of the clear hydrophane is unstable when wet but becomes stable when it dries out. Conversely, some white hydrophane may crack if suddenly immersed in water. Resorption of water occurs quite readily: A dry stone takes only a few hours to become completely saturated. You can distinguish most hydrophane from other opals by touching it with the tip of your tongue, which will stick to dry hydrophane.

The play-of-color in white hydrophane opal is usually stronger when the material is dry. Some of the clear hydrophane, however, has more brilliant play-of-color when it is wet. Thus far we have found no hydrophane at Opal Butte that has play-of-color when in water but none when dry. Over 90% of the hydrophane opal from this locality is stable.

Figure 8. Rainbow opal is particularly well suited to faceting, as evidenced by this 27-ct stone. Stone courtesy of Harold Johnston; photo by Robert Weldon.

Rainbow Opal. This material has a type of color play that makes the stone glow soft shades of the spectrum as light passes through it (figure 7). The colors change as the angle of illumination changes, with red light being bent more than blue light. Rainbow opal is about five times more plentiful than contra luz at Opal Butte, but the two types commonly are closely associated. In most geodes that contain contra luz opal, the contra luz overlies a layer of rainbow opal.

Rainbow opal has been the most consistently stable type of opal found at Opal Butte, and represents the largest flawless pieces (some more than 500 grams) found to date. Rainbow opal also lends itself well to faceting (figure 8).

Hyalite Opal. Hyalite is clear opal with no fire. This is the most abundant type of opal (other than common opal) found at Opal Butte. The best is a light ethereal blue that is well suited for faceting and carving (figure 9). When faceted, it reflects yellow light off the pavilion faces even though the body of the stone is light blue. Much of the hyalite opal contains zones or layers of orange. Several flawless pieces of blue hyalite weighing 300–500 grams were found in 1987 when mining began, but only one piece this size was uncovered in 1988. Most of the hyalite opal is stable.

Fire Opal. Orange and red opal similar to Mexican fire opal is also found at Opal Butte (figure 10). Unfortunately, most of the orange opal is unstable, crazing within minutes of exposure to air. The dark red material tends to be much more stable.

Blue Opal. A few geodes have been found to contain nearly opaque, dark blue opal. Although these geodes are rare, thus far they have been quite large. Most of this "blue" opal has a greenish tint, but some is pure blue. We found approximately 100 grams of this material that at first appeared to be opaque, but when backlit proved to be very translucent.

Dendritic Opal. Another rare feature in Oregon opal is the presence of manganese oxide dendrites. These dramatic inclusions may form as dense black spots or as delicately branching dendrites.

DISTRIBUTION AND CUTTING

Most of the high-grade play-of-color material from Opal Butte has been worked into finished jewelry or stone carvings by the author. Although some adjustments have to be made for the softness of the dry white hydrophane, the rest of the opal works very much like opal from other localities. High-dome cabochons are the most effective cut for

Figure 9. The best hyalite is light blue and makes excellent carvings and faceted stones. This 44-ct hyalite is mounted in a 14k gold pendant.

Figure 10. A small percentage of the gem-quality material found at Opal Butte strongly resembles Mexican fire opal. Although most of this material is not stable, this 113-ct dark reddish orange carving has proved to be.

displaying the contra luz play-of-color in jewelry (figure 11). Much of the material is suitable for doublets. Specimens on matrix as well as cutting-grade rough and cut stones are also marketed.

CONCLUSION

Although it does not occur in large quantities, the quality and diversity of Oregon opal gives it special gemological significance. Many interesting geologic and gemological questions concerning the physical properties and mode of occurrence of these opals remain to be addressed.

Figure 11. High-dome cabochons best reveal the play-of-color of contra luz opal in jewelry. This cabochon weighs 22 ct.

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