

Electric Opal: Green daylight-luminescing hyalite opal from Zacatecas, Mexico

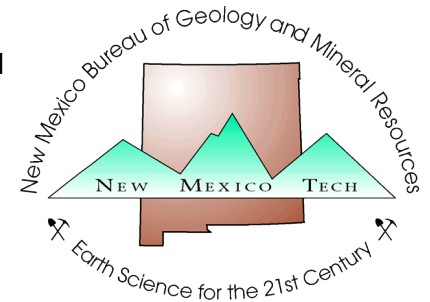
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The symposium is organized each year by the [Mineral Museum](#) at the [New Mexico Bureau of Geology & Mineral Resources](#).



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“Electric Opal”: Green daylight-luminescing hyalite opal from Zacatecas, Mexico

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Weathered specimens of botryoidal opal rough exhibiting a distinctive color-change phenomenon, appearing near-colorless or pale-to-moderate yellow in incandescent light; changing to chartreuse green in indirect sunlight first appeared in 2013. Not surprisingly, reaction by specimen collectors to this luminescence phenomenon was immediate and very positive, so reconnaissance prospecting was undertaken to determine quality and quantity of material available. This found that strongly-colored specimen material was sparsely distributed but did turn up a number of specimens composed of transparent lustrous *druplets* and blobs that showed strong color change, some of which appeared facetable. The specimens and initial cut gems attracted considerable attention, so long-term exclusive access was secured. The site lies at the top of a steep 250-meter-high mesa so mining was exclusively manual and lasted about a year until production dropped off and the project was abandoned.



The drupelets are about 5 mm across, shot in incandescent light and shaded sunlight. *Peter Megaw specimens and photo by author.*

The hyalite occurs in mid-Tertiary caldera-related rhyolitic rocks typical of the Sierra Madre Occidental Volcanic Province in the northwestern part of Zacatecas State, Mexico. Devitrification of these units liberated silica, uranium, iron and other constituents from the decomposing volcanic glass, which initially went into volcanic vapors emanating from the cooling pile and circulating heated groundwaters that emerged as hot-springs. Devitrification continued more slowly after the volcanic pile cooled off; releasing constituents into descending surface waters. Silica liberated at higher temperatures tended to precipitate as chalcedony or fine-grained quartz, whereas at lower temperatures opal was deposited. Uranium and other liberated elements were also redeposited, in some cases as discrete species and in others within the framework structure of the chalcedony or opal. Several acicular uranium-containing minerals are found with and within the opal. Where encapsulated in opal, the uranium minerals are largely leached out leaving elongate tubes, some of which are marked by linear arrays of minute purple fluorite cubes that presumably crystallized on the elongate uranium minerals before they were covered and leached out. The most prominent uranium species were identified with X-ray diffraction and include meta-autunite ($\text{Ca}(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 6-8\text{H}_2\text{O}$), haiweeite ($\text{Ca}(\text{UO}_2)_2[\text{Si}_5\text{O}_{12}(\text{OH})_2] \cdot 6\text{H}_2\text{O}$), uranophane ($\text{Ca}(\text{UO}_2)_2(\text{HSiO}_4) \cdot 5\text{H}_2\text{O}$), meta-uranospinite ($\text{Ca}(\text{UO}_2)_2(\text{AsO}_4)_2 \cdot 8\text{H}_2\text{O}$) and boltwoodite [$(\text{K},\text{Na})(\text{UO}_2)(\text{SiO}_3\text{OH}) \cdot 1.5\text{H}_2\text{O}$].

Marketed as Electric Opal™ in allusion to the color change phenomenon, free-standing lustrous botryoids make the most attractive specimens with individual drupelets making stand-alone jewelry pieces. The material facets beautifully and the faceted, color-changing opals captured the immediate attention of the gemstone world. Research to characterize the material in detail was swiftly undertaken, led by Emmanuel Fritsch of France. This work showed them to be Opal-AN, the amorphous (A), glass-like opal variety consisting of hydrated silica molecules that are network-forming (N). Also known as *hyalite*, **Opal-AN** does not have a regular array of spheres or any specific microstructure, so it is always ‘common’ opal and does not exhibit play-of-color like the familiar Australian or Ethiopian opals. Electric opal’s luminescence is due to dispersed uranyl ions, and although it may locally contain up to 0.3% wt. % UO_2 where uranium species are visible, detailed radiation measurements recorded very low levels of emitted radioactivity from the opal itself: most “granite” kitchen countertops are more radioactive than this hyalite opal.



The trillion is 5 ct, shot in filtered sunlight. Smithsonian specimen, photo by Peter Megaw.



The vertical specimen is 4 cm tall shot under filtered sunlight. Peter Megaw specimen, photo by Jeff Scovil.



Hyalite covering a 3 cm ball of boltwoodite. shot under filtered sunlight. *Peter Megaw specimen, photo by Jeff Scovil.*

The main interest in this hyalite is its daylight-induced luminescence and why it is observed in this opal and in almost no other opals or other minerals. Several phenomena compete and combine for the perception of a color from an object: transmitted light (body color), reflected light (gloss) and scattered light ('haze' in colorimetric terms), which is commonly seen in milky gems (e.g. white diamond, jade or opal) or the blue adularescence of moonstone—luminescence is also a scattering phenomenon. Like most hyalite, Electric Opal is highly glossy, ranges from colorless to pallid yellow-green in daylight and fluoresces violently chartreuse under UV. What makes it different appears to be luminescence stimulated by uranyl ions dispersed in the opal that cause excitation in both the UV and the visible range with a maximum emission at 524 nm—in the visible range. It appears that perception of the green daylight luminescence stems from how this light is scattered before encountering the eye. The studies also indicate the influence of several other key factors: 1) Transparency—cloudy botryoids on the same samples do not fluoresce in daylight, 2) Absence of any sort of luminescence quencher, such as Fe^{3+} , and 3) The uranyl ions must be present within a certain range of concentration—if there is not enough, the luminescence is too weak, and if there is too much, the molecules absorb one another's emission through a process called *concentration quenching* or *self quenching*, which reduces the overall luminescence. In summary, it appears that this kind of daylight fluorescence is exceedingly rare because all of these conditions must be met for the phenomenon to occur.