Plastic Impregnated Gem Opal

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Introduction

The "play of color" shown by gem opal is a beautiful and distinctive characteristic such that fine opal has over long periods of time kept its position as an appreciated and popular stone in the gem markets of the world. In the late 1960's, the unique structural characteristics of opal were determined, leading to an understanding of the cause of play of color in gem opal. Inevitably, researchers began experimenting with the reproduction of this phenomenon in synthetic materials. The most successful of these efforts became apparent with the introduction by Pierre Gilson of his spectacular synthetic milky and black opal in the early 1970's. To a variable degree, both natural opal and this synthetic material have a tendency to develop cracks and also, in some instances, to lose their beautiful translucency as they lose water. Many individuals have made numerous efforts of one kind or another to overcome these problems by stabilization processes. Their intent was to seal the opal from drying out and/or to neutralize or remove any strain within the stone.

Recently, such efforts have resulted in a new material appearing in the market place. It consists of Brazilian opal in which the interstitial voids have been inpregnated with a plastic resin. In some specimens, the addition of a dark dye-like material gives an appearance closely resembling Australian black opal. The description of this material is the principal subject of this report.

Gem Opal

The special characteristics of gem opal have long been admired. With the attractive and characteristic "play of color," it is unique among gemstones and better specimens will show flashes of color of pure hues from all portions of the spectrum.

In the late 1960's, with the availability of electron microscopes to research mineralogists, almost simultaneous inquiries in Germany and Australia revealed the distinctive nature of gem opal. At magnifications of approximately 15,000 times, appropriately prepared specimens revealed gem opal to be characterized by regularly stacked arrays of uniform-sized, sphere-shaped particles of colloidal silica. When the size of the spheres lies between certain specific limits, these regular arrays, or more particularly, the combination of spheres and their interstitial voids, provide for a three-dimensional structure which serves as a diffraction grating, if the colloidal silica spheres are transparent to light. Depending on the angle of incidence and the distance between parallel layers in the array, white light falling on the opal will be diffracted, such that for any one position of observation patches of pure spectral colors will reach the eye *(Figure 1)*. The colors can pass progressively through the entire range of the spectrum as either the source of light, the specimen or the observer change their relative position and the requirements for diffraction are satisfied for light of a different wavelength.

Depending on the domain within the opal over which a regular array of the spheres prevails, as also on the mosaic-like arrangement among these arrays, it is possible for the play of color to have a quite varied appearance. These variations are distinguished by descriptive terminology and range from the so called "pin fire" to the checkerboard appearance characteristic of "harlequin," to the broad flashes of "flash fire," and all conceivable combinations in between.

Gem opals from numerous localities have been examined in this study and with minor variations, all show the validity of these observations.

Synthetic Opal and Opal Simulants

The original studies which led to this understanding were well documented and soon led to numerous attempts to reproduce the structure of opal and the development of a synthetic opal gemstone. (See Darragh, P.J., Gaskin, R.J. and Sanders, J.V.) In the early 1970's, the rather remarkable milky and black synthetic opals produced by Pierre Gilson appeared and received acceptance. In 1976, another man-made material became available. Called Slocum Stone, it emulates the appearance of opal, although not exactly duplicating the effect of "play of color" in gem opal. (See Darragh, P.J. and Sanders, J.V.; and also Dunn, P.J.) Scanning electron microscopy reveals that Slocum Stone, an artificial glass with an irregular granularity, contains thin film or plate-like areas randomly distributed within the glass. These provide for a light diffraction effect which produces the distinctive Slocum Stone phenomenon.

Most recently, an opal simulant manufactured entirely of plastic has been developed. Samples of material from Australia and Japan have been examined. Infrared spectroscopy identifies the Australian material to consist solely of a plastic, the co-polymer of styrene and methyl methacrylate. Preliminary examination under the scanning electron microscope shows that the plastic duplicates the geometrical arrangement of three-dimensionally stacked arrays of spherical particles comparable in size to those present in

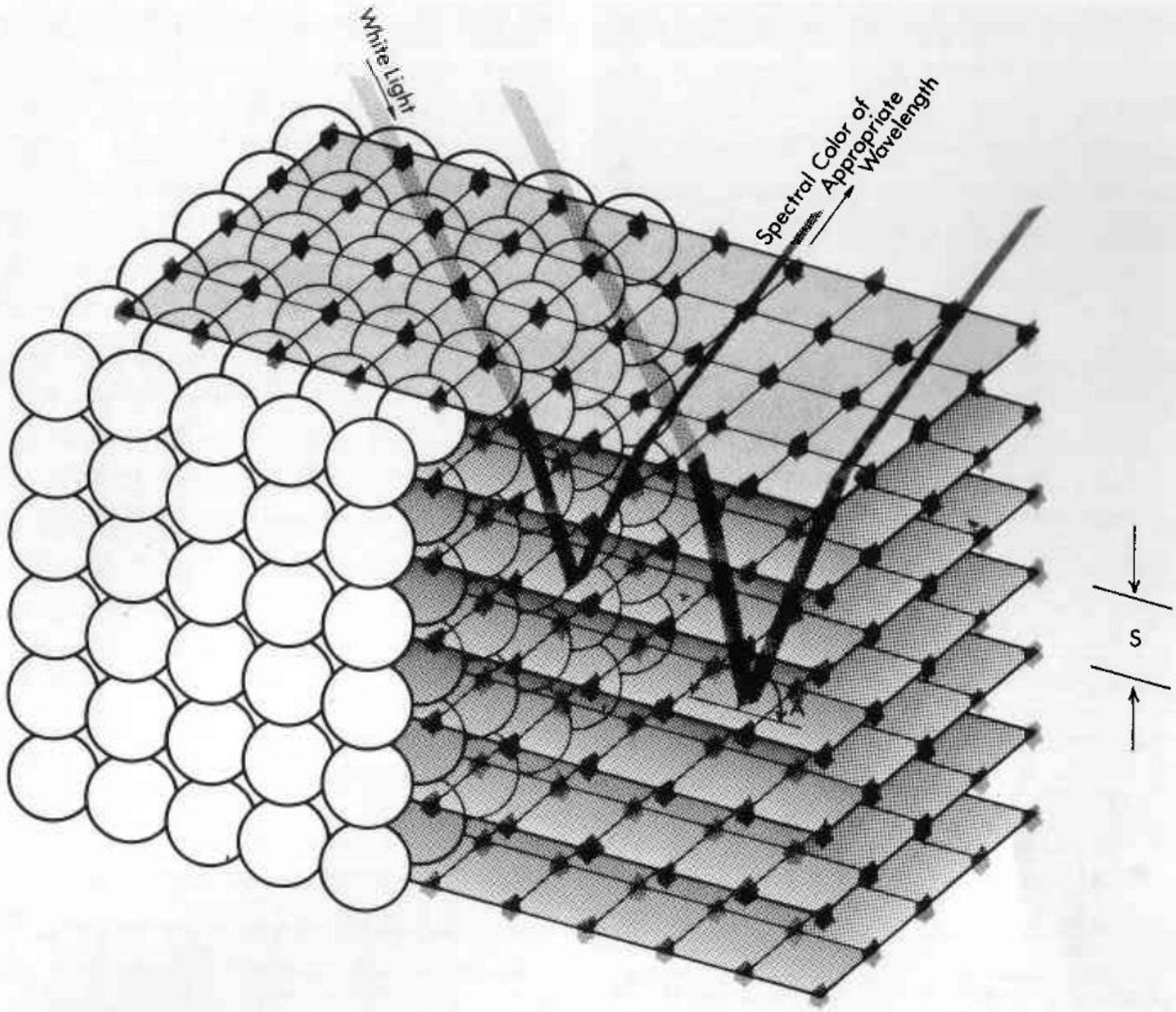


Figure 1. Patches of color are produced in gem opal when white light is diffracted by the ordered structure of silica spheres and interstitial voids. The particular spectral color observed is related to the distance S between adjacent arrays of spheres in the structure and varies with A, the angle of incidence and reflection.

natural gem opal. This material has a light milky appearance and is similar to lower quality Brazilian and Australian gem opal, with a play of color resembling pin fire. A sample examined had a refractive index of 1.465. The composition of plastic in the simulant from Japan has not yet been identified. In the single sample of this material seen to date, it has a very pleasing appearance duplicating the "play of color" in fine gem opal. A refractive index of 1.48 was measured. The specific gravity of this sample was determined to be 1.17. It is interesting to note that the sample was mounted in an 18-karat gold setting.

Numerous assembled materials with some of the characteristics of play of color in gem opal have been produced. These include the well known doublets and triplets in which a thin layer of natural gem opal is covered or sandwiched between other suitable natural or synthetic materials. Another approach has been to embed fragmented opal pieces within a plastic binding agent. This can provide for a resemblance to opal, but the material is readily distinguished by close examination.

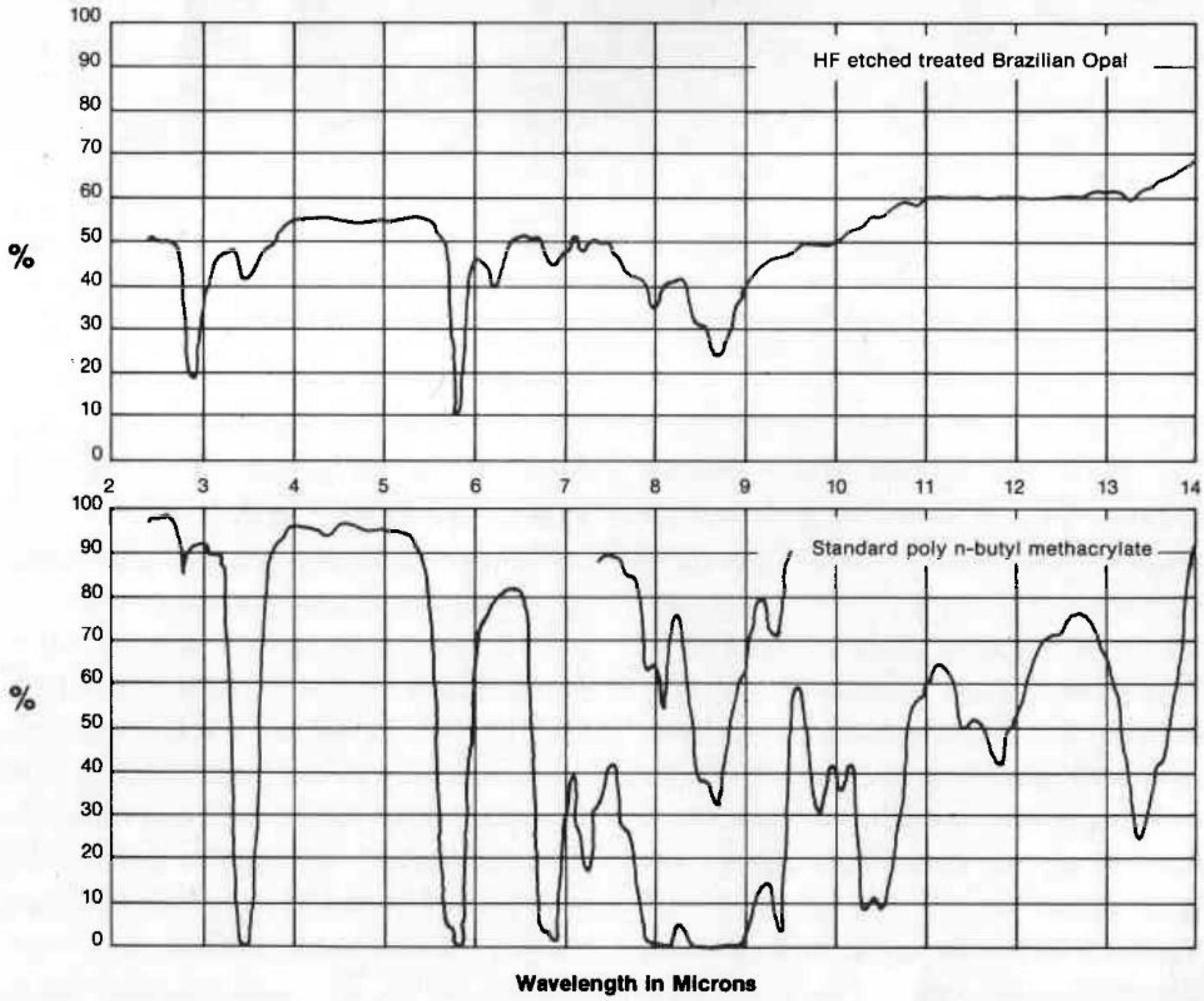
Another material which to the untrained eye may be confused with gem opal, is the assembled stone called Calcentine. The iridescent nacre layer of fossil ammonites and baculites from deposits of Permian Age is cemented to a suitable matrix and most often also capped by a quartz crystal cabochon. This provides for an attractive stone showing the effects of diffraction of light, but is quite distinct in appearance from the play of color in opal.

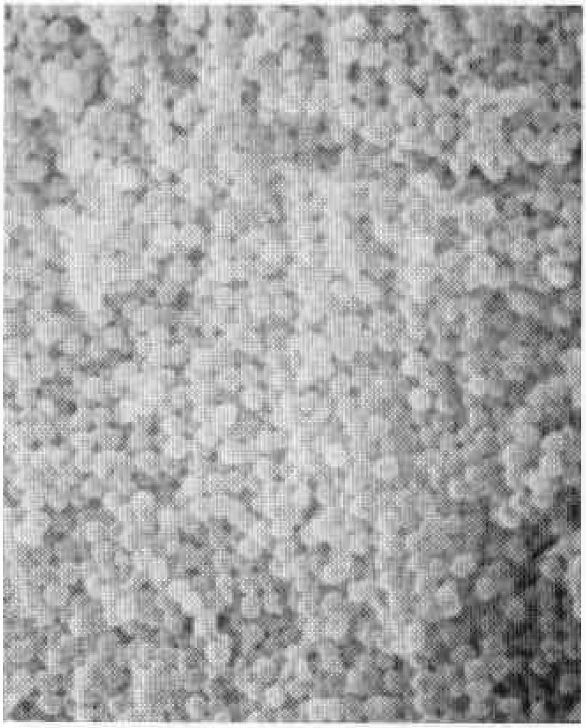
Plastic Impregnated Gem Opal

The first samples of this material seen had an appearance suggestive of poorer quality black opal from Australia. A slightly dull or smoky blue appearance in the body of the stone together with wisp-like veils of a deep blue-black color associated with some of the natural fractures in the stone were noted. This unusual appearance together with values for refractive index of 1.45 and specific gravity of 1.85, raised our suspicions with regard to the natural origin of this sample. Examination under the scanning electron microscope was most informative.

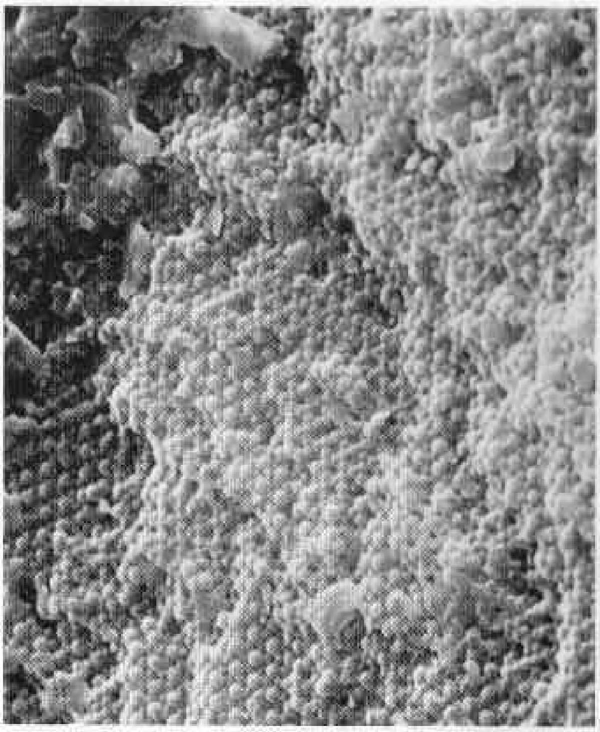
Figure 2.

INFRARED TRANSMITTANCE SPECTRA





Scanning electron microscope view of etched surface natural Australian opal magnified 14,000xs



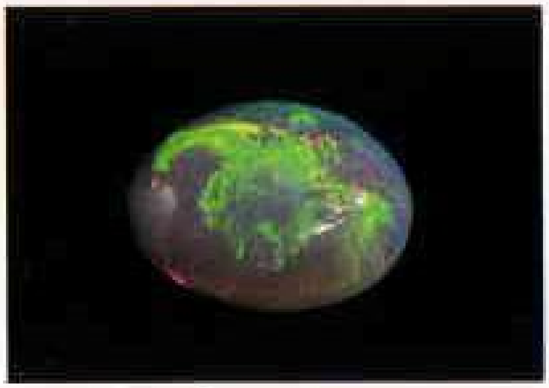
Fracture surface of plastic treated Brazilian opal magnified 9,000xs

A natural fracture surface exposed when the stone was broken revealed under high magnification the typical stacked arrays of silica spheres. These spheres, however, appeared to be embedded in a matrix of material filling the interstitial voids. This surface was etched with a 10% solution of hydrofluoric acid in water, for approximately forty seconds. On reexamination under the scanning electron microscope, the silica spheres had been dissolved but the interstitial matrix was untouched leaving a distinctive three-dimensional mesh work which was, in fact, a negative form of the normal silica spheres in gem opal. A small cabochon of this material was placed in hydrofluoric acid for an extended period. All the silica spheres were dissolved in this way, leaving a cabochon consisting only of the matrix material which had been used to impregnate the voids in the original opal. The composition of this strange cabochon, which still showed a polished surface and a diminished but distinctive play of color, was determined by infrared spectroscopy to consist solely of the plastic polymer n-butyl methacrylate *(Figure 2)*.

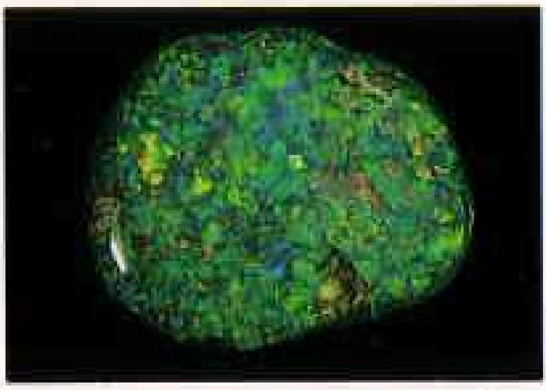
Numerous samples of similar plastic-impregnated gem opal have now been encountered. They include some very fine samples that resemble the best quality "crystal" opal from Australia and pieces with an appearance ranging from poor to excellent quality black opal, apparently as a result of a dye incorporated with the resin during impregnation. It is possible, however, that some natural opals

Natural Australian opal, pinfire type play of color.

Natural Australian opal, harlequin type play of color.



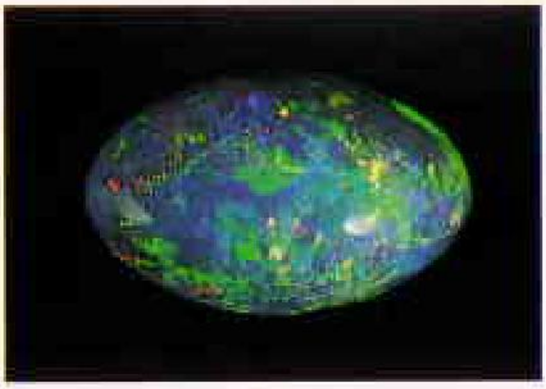
Natural Australian opal, broad flash type play of color.



Natural Australian black opal, mosaic type play of color.

Natural Brazilian opal, banded milky appearance.

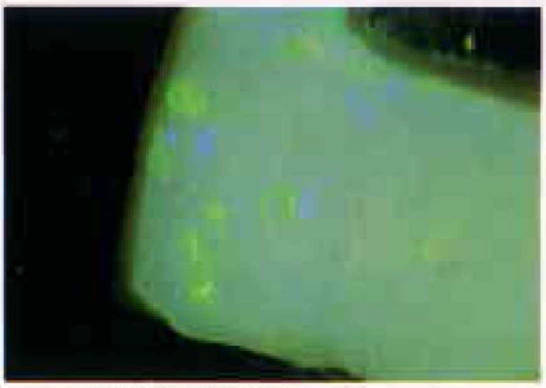
Plastic treated Brazilian opal resembling Australian crystal.



Natural Australian black opal, crystal type.

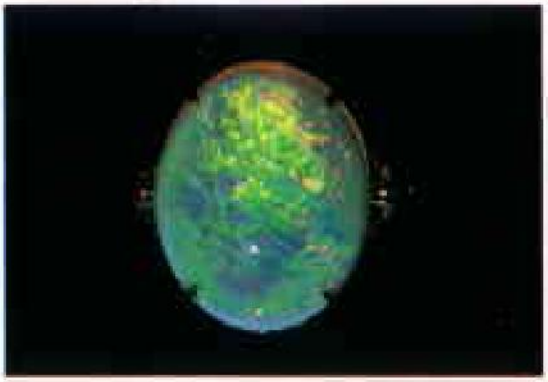
Plastic treated and dyed Brazilian opal showing hydrofluoric acid etch mark.

Plastic treated and dyed Brazilian opal showing detail of wisp-like veil of dye along crack and removal of dye in etched area.



Portion of cabochon showing play of color in plastic "negative opal."

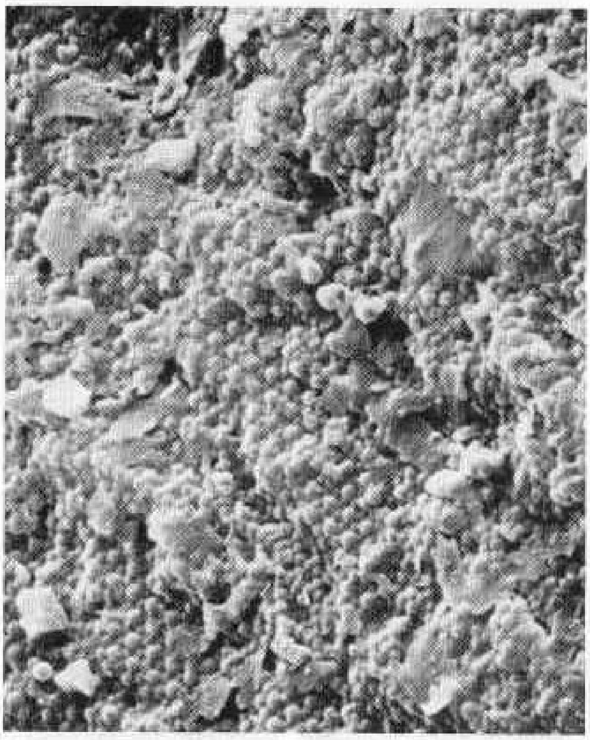
Gilson synthetic black opal.



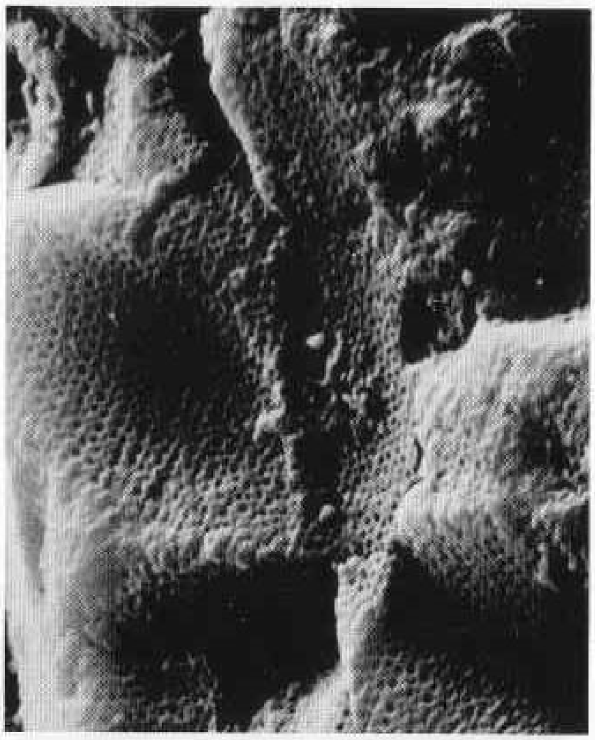
Japanese plastic cabochon simulating opal.

Plastic embedded opal fragments.

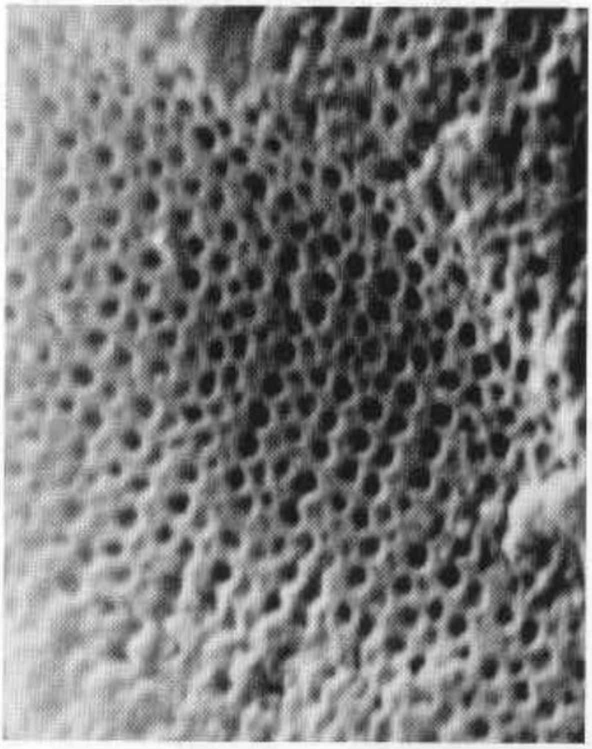
'Slocum Stone' opal simulant.



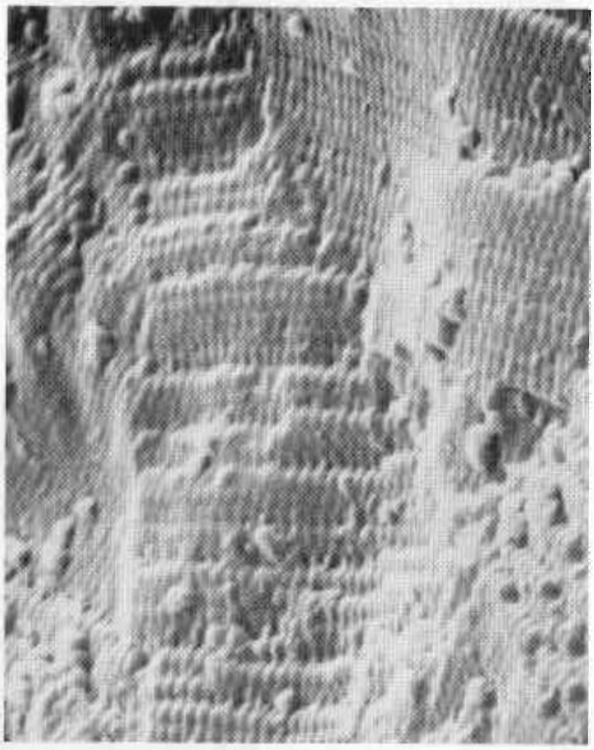
Plastic embedded silica spheres on fracture surface of plastic treated Brazilian opal magnified 9,000xs



Etched fracture surface of plastic treated Brazilian opal magnified 6,500xs



Etched fracture surface of plastic treated Brazilian opal magnified 16,000xs



Fractured surface of Australian plastic opal simulant magnified 15,000xs with a color due to naturally included dark particles have also been impregnated.

The refractive index of this impregnated material appears to be consistently in the range of 1.410–1.460, while the specific gravity falls between 1.85 and 2.01. Recently, it has been reported (personal communication Dag Johnson) that a few samples of Mexican and Idaho opal have also been successfully treated.

The wide variety of sources, the variation in quality and also the variation in the value for specific gravity suggests that more than one source exists for this material. Further, it is considered that a variety of polymer plastics may be used for impregnation with or without a dye used to impart a body color suggestive of black opal.

At the present time, the only positive identification of this material is dependent upon the discovery of the mesh work structure in the plastic as revealed under high magnification by the scanning electron microscope following etching with a small drop of diluted hydrofluoric acid. It is hoped that a simple spectroscopic examination in the infrared will be perfected in the near future whereby a characteristic signature may be used for rapid distinction of this treatment procedure in gem opal.

It is important that recognition of the treatment of this material be readily available. While the treatment process appears to provide an interesting and useful source of a stable and quality gem product, there is a need for its distinction from natural untreated and presumably more desirable gem opal.

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