Fire Opal/Precious Opal versus Common Opal in Infrared

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We get from mindat.org the following statement definitively declaring the composition of precious opal and common opal:

> **"**X-Ray amorphous opal (hydrous silica), sometimes divided into two subtypes: ——— Opal-AG: (Amorphous-Gel) (contains closely packed amorphous silica spheres, which at times form a diffraction grating to create precious opal). Since the packing of the spheres is similar to the structure of a gel, the subscript G ("gel-like") has been added (Flörke et al, 1991; Graetsch, 1994). ——— Opal-AN: (Amorphous-Network (commonly found as hyalite). It still contains spheres, but much smaller (Lee et al., 2022) and lacks a play of colours. In the study of Lee et al. (2022) opal-AN was shown to mainly comprise aggregates of differently-sized nanospheres."

Their declaration of all opal definitions is:

> "Opal is structurally classified into three main types, though they grade into one another (Jones & Segnit, 1971; Curtis et al, 2019):
> - Opal-CT: originally considered to contain cristobalite and tridymite but probably contains mostly poorly crystalline tridymite plus amorphous silica and sometimes poorly crystalline cristobalite
> - Opal-C: contains poorly crystalline cristobalite-like material
> - Opal-A: X-Ray amorphous, sometimes divided into two subtypes:
> ——— Opal-AG: (<u>A</u>morphous-<u>G</u>el) (contains closely packed amorphous silica spheres, which at times form a diffraction grating to create precious opal). Since the packing of the spheres is similar to the structure of a gel, the subscript G ("gel-like") has been added (Flörke et al, 1991; Graetsch, 1994).
> ——— Opal-AN: (<u>A</u>morphous-<u>N</u>etwork (commonly found as hyalite). It still contains spheres, but much smaller (Lee et al., 2022) and lacks a play of colours."

They do go on to say that precious opal:

> "Opal with a play of colours ("precious opal") is most commonly opal-AG but some is opal-CT (Curtis et al, 2019). The diffracting structure and the resulting opalescence may be preserved to some degree when opal-AG transforms to opal-CT by crystallization (Sanders, 1975)."

Given all this, we have a terminology problem to start with. "Precious" opal is a mining term that changes with region such that it is used by Australians for the "play of colors" and is used by Mexicans to mean a rich opalescent body color, often orange. In the US, we use the term "fire opal" that means "play of color," the former used by collectors and the latter used by gemmologists.

If we study opals in infrared and develop a classification scheme to define them, we get many more opal species, but will focus here mainly on these three and introduce two more.

The problem caused by opal-AN and AG terms is that this is the case where two minerals are defined by microscopy structure, not a method of spectroscopy. The standard method of spectroscopy for mineral study is X-ray spectroscopy, but there is also Raman and Infrared spectroscopy methods. The author uses Infrared spectroscopy. If we try to use all these examples of AN and AG and apply them to infrared spectra, there is no consistent correlation. "Gel" has no meaning in infrared at all, but "glass" does, so when we use examples of glass spectra, hyalite, and fire opal/precious opal from well collected locales we get the following:

Fire opal/precious opal examples:

Welo, Ethiopia fire opal	opal-AN, and opal-AG
Mexican orange precious opal	opal-CT
Mexican white body color fire opal	opal-AN
Red Rock Canyon, CA fire opal	opal-CT
Honduras black fire opal	opal-AG
Cooper Pedy, Australia fire opal	opal-AN

For common opals we get these as examples:

Slovakia brown opal	opal-AN
Boron, CA milky opal	opal-BC (beta-cristobalite)
Dendritic common opal	opal-CTQ-calcite (opal-CT, granular quartz, calcite)
Opal Mtn (Barstow, CA) salmon opal	opal-CTQ
NM opal wood	opal-CT
Kramer, CA opalite	opal-Q (microquartz, a mixed quartz and opal IR spectrum)
Carlin, NV opal	opal-Q, bentonite (clay)
Sheep Rock (Northern CA) opal in basalt	opal-CT
Brazilian amygdule shell	opal-CTA (transitional between CT and A)
Alpine, TX black agate on white plumes	opal-Q
Blue translucent opal in geode	opal-CT
Fallen Tree Claim, OR blue opal in geode	opal-C
Baker Claim, NM blue opal in geode	opal-C
Tehachapi, CA green opal	opal-Q
Dugway, UT geode banding	opal-BCQ (beta-cristobalite, quartz)
Peru pink opal	opal-Q, sepiolite (clay)
BB Mine, NV myrickite pink opal	opal-Q, moganite
Libyan desert “glass”	opal-AN, opal-CT (varies)
Trinitite glass	opal-AG
Moldavite glass	opal-AG
Gyongyossolymos Hungary Hyalite	opal-AN

It is not possible to reconcile all specimen identifications of AG and AN as the nomenclature is based on defective use of microscopy, not composition, but infrared sees composition and lattice structure. The author calls opal-AG a glass, not gel, and opal-AN is non-glass based on two specific spectra for opal A that exists mapped to glasses and hyalite. We know the spectrum for a glass and for a hyalite, and they are different, and once we go with that, matches to the literature don’t consistently occur again. This is the mangled legacy Flörke and Graetsch created.

Conclusions:

What the author finds is the most common opal is microquartz (opal-Q), an infrared spectrum of mixed quartz and opal, which is not an opal-A, C, or CT. Opal-C is only found continentally in geodes. Common opal can be any species of opal. Precious opal is AG, AN, and CT. At a site, precious opal specimens can be AN and others AG. In effect, we got gibberish from Flörke and Graetsch, repeated commonly online at sites like mindat, as minerals are not identified by a look, but by a method of spectroscopy and when we use the latter, their segregation scheme falls apart. It is possible to distinguish quartz, glass, and the AN and AG species in infrared, and mixed specimens of the opal species occur all the time. The author claims an opal-beta-cristobalite can be found and that most opal-C is actually opal-BC when you separate them. As opal-C is only found in volcanic rocks, it is presumed to be the highest temperature opal formed, followed by opal-BC whose transition from cristobalite to beta-cristobalite is found in lab studies to convert at 220C.

Lastly, in infrared, cristobalite has a clearly understood marker band to define it in the literature, allowing us to see opal-C, and when we do that, we note opal-CT never has this cristobalite marker band but the author recalls someone in one paper proclaiming to have found it with X-ray spectroscopy. That method is exceptionally poor at identifying the opal species which is why its use missed opal-BC and cannot see hybrid opal forms and missed microquartz (opal-Q). Opals also occur commonly with carbonates and clays. Opal-Q and moganite is a common combination.

We can now see why fire opal can be opal-CT as it is actually opal-T (tridymite). Opal-A has no meaning and is a placeholder in X-ray spectroscopy meaning amorphous (no X-ray response), which is not the identification of anything. However, in infrared it is not amorphous, it acts like tridymite, which several authors in the literature have noted before. So, we have all tridymite for fire opal. The understanding has just been hidden in outdated nomenclature which no standards body cleans up.