THE JADE ENIGMA

By Jill M. Hobbs

Jade is one of the most misunderstood gemstones. It is actually two separate materials: jadeite and nephrite. Together, these materials have more simulants than most other gems. Thus, it is important to know the various simulants, and to understand how to separate them from jade. This article examines the key identifying properties of green jade (jadeite and nephrite) and contrasts them with the properties of the 10 most common green jade simulants. Simple visual techniques are emphasized as well as the appropriate gemological tests.

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It is easy to understand why jade has been considered a "piece of heaven" for centuries. The rich color and soft texture of fine jade have made it a favorite of gem connoisseurs everywhere. It is also easy to understand why many materials have been represented as jade. It is curious, however, that the names for jade are still a subject of controversy and that so much misinformation, myth, and superstition surrounds this gem, especially the treasured green material (see figure 1).

This article will try to remove some of the confusion that often accompanies the purchase of jade jewelry or carvings. By introducing the common trade names and misnomers for green jade and its simulants, and by explaining how these materials can be separated from one another, the following text will serve as a guide to the gemology of jade.

WHAT IS JADE?

Civilizations of all ages have prized this material. In his widely read book on jade, Gump (1962) captures the spell of this gemstone:

> The Central Asians placed a huge slab of jade before the tomb of Tamerlane to make it inviolate. The pre-Columbians made sacrificial knives from it. Aladdin expressed wonder at the fabulous trees of the jade in the underground cavern. The Russians carved a whole sarcophagus, for Czar Alexander III, of jade. In both New Zealand and New Calcedonia a jade mere or war club was the chief's symbol of authority. Fathers in the Loyalty Islands once bartered their daughters for jade. China built a civilization around the stone.

All races and ages that encountered jade valued it. Prehistoric civilizations recognized jade for its toughness. In China, in the Swiss Lake area in Europe, and in Central America (especially Guatemala and Mexico), prehistoric cultures used jade for functional articles. In the Swiss

Figure 1. An attractive example of green jadeite used in jewelry (the jadeite measures 6.3 × 5.6 × 0.4 cm). A wide variety of simulants attempt to duplicate the unique beauty and appearance of jadeite. It is enigmatic that although jadeite (and nephrite, which is also known as jade) have been worked and admired by many civilizations, the true nature of the material is still misunderstood, and its simulants are often misidentified as the original. Brooch courtesy of Mason-Kay, Inc.

Lake area in particular, archaeologists have documented that early dwellers used jade for axe heads, scrapers, and instruments of war; they eventually treasured it for aesthetic and symbolic value as well (Foshag, 1957).

Curiously, the scientific nature of jade was not fully understood until the 19th century, when Professor A. Damour proved that the gemstone that is commonly called jade is actually two separate and distinct materials: jadeite and nephrite. The former is usually the more valued of the two for jewelry and carvings, because fine-quality jadeite is an intense medium green, whereas even the best nephrite tends to be a darker, more blackish green. Interestingly, the distinction was made in another culture long before Damour published his scientific findings. When the intense-green jadeite began to enter China from Burma in the middle of the 18th century, the Chinese called it *fei-ts'ui* instead of *yu*, which had been the standard name for jade (Hardinge, 1953). In addition, while most early writings purportedly described nephrite, a few of them were said to describe material that would fall under the modern mineralogical classification of jadeite (Foshag, 1957).

Although A. G. Werner, in 1788, was the first to apply the mineralogical name *nephrite*, Damour was the first to determine the chemical composition of this material. In his 1846 publication, Damour established that nephrite is a compact variety of the amphibole minerals tremolite and actinolite. Then, in 1863, Damour reported the very important discovery that jadeite is a separate and distinct species. A member of the pyroxene group of minerals, jadeite is very different from nephrite in both chemistry and internal structure (see box). Thus, it has different properties and a different appearance.

These findings revolutionized jade nomenclature, and they should have simplified the identification, evaluation, and marketing of jadeite and nephrite. Yet jade remains an enigma to most buyers. The tradition of myth and misinformation continues today. In addition to the accepted trade names for jade (see table 1), many misleading terms such as "Mexican jade," "Japanese jade," "jasper jade," and "Transvaal jade" are used to market gem materials other than jadeite and nephrite (table 2). With so many materials touted as jade, the buyer must be aware of the names of these simulants as well as their key identifying characteristics.

This article examines both the identification of jadeite or nephrite and the separation of these

THE QUESTION OF JADE NOMENCLATURE

The term *jade* encompasses two tough, compact, fine-grained materials: jadeite and nephrite. The definition of these two materials is difficult, at best.

Strictly speaking, jadeite is a distinct monoclinic mineral belonging to the pyroxene group and having an ideal chemical composition of $NaAl(SiO_3)_2$. However, jadeite may be an intimate intergrowth of jadeite with at least one of two closely related pyroxenes: acmite $[NaFe(SiO_3)_2]$, or diopside $[CaMg(SiO_3)_2]$. The three minerals can form a continuous isomorphic substitution series. The variations in the properties of jadeite are therefore dependent on the proportions of each pyroxene present.

If enough diopside is present that the material's chemical composition is intermediate between diopside and jadeite, the material is sometimes called diopside-jadeite. The optical and physical properties of this material are normally so close to those of pure jadeite that a distinction is impractical. However, if the material's chemical composition is intermediate between acmite and jadeite—or acmite, diopside, and jadeite—its properties and appearance are distinct from pure jadeite and it is commonly known as chloromelanite. This material is typically blackish green to nearly black; the presence of a significant amount of iron produces a slightly higher refractive index and specific gravity as well.

The definition of nephrite is even more controversial. Mineralogy texts have traditionally listed nephrite as a variety of actinolite, a monoclinic member of the amphibole group. As in the case of jadeite, however, actinolite is very closely related chemically and structurally to other members of its group. Actinolite $[Ca(Mg,Fe)_3(SiO_3)_4]$ is so closely related to tremolite $[CaMg_3(SiO_3)_4]$ that their optical and physical properties may be indistinguishable. The magnesium in tremolite is commonly replaced by iron, and the two minerals do, in fact, grade into one another. The color of the material, however, indicates the amount of iron present: the iron in actinolite imparts a green to grayish-green color, whereas the iron-poor tremolite is normally white to gray. The fact that nephrite is, in reality, a variety of two mineral species recently led the International Mineralogical Association (I.M.A.) to discredit nephrite as a valid mineralogical variety.

In defining both jadeite and nephrite, texture is as important as mineralogical composition. The material must be tough, compact, and fine-grained. In the case of nephrite, it must also consist of interlocking fibers. If the fibers are not interlocking, but simply parallel or subparallel, the material lacks the necessary toughness and therefore cannot be considered nephrite. This author defines jade as any member of the pyroxene or amphibole group that possesses the necessary textural characteristics to impart toughness, as well as the commonly accepted refractive index and specific gravity of jadeite or nephrite.

Note how different this late-19th century jadeite vase is from the jadeite illustrated in figure 1. This difference in appearance reflects variations in chemical make-up. Such variations in materials classified both mineralogically and gemologically as jadeite contribute greatly to the nomenclature problem. Vase courtesy of Crystalite Corp. Photo ©1981 Harold & Erica Van Pelt.

TABLE 1. Common trade names for green jade.

Type of jade	Trade name	Standard color/appearance
Jadeite	Apple	Intense, medium yellowish green.
	Chicken or Tomb	Iron oxidized causing a yellowish or brown color.
	Emerald Gem Imperial	Intense, medium green resembling fine emerald. Considered by most to be top quality.
	Kingfisher (Chinese word, *fei-ts'ui*)	Intense, medium green. The Chinese named the material after the brilliant green plumage of the bird by the same name.
	Moss in the Snow	White jadeite with green streaks that are called streamers.
	Yunan or Yunnan	Intense, medium green, nearly opaque. When cut in thin sections, it appears translucent.
Nephrite	Axe[a]	In reference to the use of jade as a tool.
	B.C. jade Canadian	Dark green to blackish green.
	Kidney[a]	In reference to the belief that jade would cure kidney trouble if worn.
	Maori stone	Dark green material from New Zealand, often carved into items of adornment; mainly prehistoric.
	New Zealand New Zealand greenstone Spinach jade	Medium to dark grayish green.
	Siberian	Medium green, fine quality.
	Taiwanese	Medium green, fine quality.

[a]*This name is now obsolete.*

TABLE 2. Misleading terms for jade simulants.

Simulant	Misleading term
Calcite	Oriental alabaster (trade name)
dyed	"Mexican jade"
Chalcedony	
Chrysoprase	"Queensland jade"
dyed jasper	"Swiss jade"
Jasper	"Jasper jade" "Oregon jade"
Glass (partially devitrified) also known as Imori or Iimori stone	"Metajade"
Idocrase	"Vesuvianite jade"
Californite	"American jade" "California jade"
Malachite	"Silver Peak jadeite"
Microcline, amazonite	"Amazon jade" "Colorado jade"
Pectolite	"Alaska jade" "Pectolite jade"
Prehnite	"Japanese jade"
Pseudophite	"Styrian jade"
Quartz	
Aventurine	"Regal jade" "Indian jade" "Imperial yu"
Serpentine (Antigorite)	"Korean jade"
Bowenite	"Soochow jade" (may also refer to talc) "New jade"
Verd-antique (mixed with marble)	Verdite (trade name)
Talc also known as steatite or "soapstone"	"Fukien jade" "Honan jade" "Manchurian jade" "Shanghai jade"
TI grossularite	"Transvaal jade" "South African jade" "Garnet jade" "White jade"

two forms of jade from their 10 most common simulants (see table 3 for a list of other materials occasionally used to simulate jade). For the purposes of this article, jadeite and nephrite will be cited individually when appropriate and together under the term *jade* when the discussion applies to both.

THE IDENTIFICATION OF GREEN JADE

With practice and an understanding of the techniques involved, jadeite and nephrite can be readily separated both from each other and from their simulants. The best method is first to look at the material, since your eyes can reveal a great deal about a gemstone's composition and properties, and then to perform those gemological tests that will effectively lead to an identification.

Visual examination of a jade-appearing material may yield significant identifying clues such as texture, surface luster, and fracture, as well as characteristic inclusions, evidence of dye, the presence of phenomena, and possibly other distinguishing characteristics. All these visual characteristics contribute to the typical appearance of a gemstone, thus allowing the gemologist with a well-trained eye to limit the range of possibilities quickly after an initial examination of the material.

But even experts support the suppositions they make after a visual examination with standard gemological tests. The two tests that provide the most diagnostic results are those that use the refractometer and the spectroscope. Specific gravity determinations and hardness points may also provide useful supplemental data.

The rare cases that require additional instrumentation usually involve mixtures of materials or materials that contain impurities. If green jade and its simulants mix with other minerals such that their appearance and properties deviate noticeably from normal, an identification often can be obtained by X-ray diffraction.

The recommended approach to the identification of jade is summarized in the property chart. After jadeite and nephrite, the 10 most problematic green jade simulants are listed from top to bottom in order of descending refractive index. From left to right, the properties are arranged according to the steps to be followed in the suggested approach; that is, visual characteristics are listed first, followed by properties that are determined by standard gemological tests. Distinctive absorption patterns are illustrated separately, in the section on spectroscopy.

TABLE 3. Other jade simulants.

Aragonite (may be dyed)
Agalmatolite (pagodite), also known as pagoda stone
Beryl, green nontransparent
Fluorite
Malachite
Maw-sit-sit (mixture of ureyite and natrolite, and possibly albite)
Microcline, amazonite
Opal, prase
Pinite
Pectolite
Plastic
Pseudophite (chlorite group)
Pyrophyllite
Serpentine mixed with zoisite
Sillimanite (fibrolite)
Smaragdite (near actinolite in composition)
Smithsonite, also known as bonamite

VISUAL CHARACTERISTICS

To a discerning eye, jade is different in appearance from its simulants. The ancient Chinese philosopher Confucius (551–479 B.C.) recognized the unique visual traits of jade when he likened them to worldly virtues:

> Its polish and brilliancy represent the white of purity, its perfect compactness and extreme hardness represent the sureness of intelligence; its angles, which do not cut, although they seem sharp, represent justice; the pure and prolonged sound which it gives forth when one strikes it represents music. Its color represents loyalty; its interior flaws, always showing themselves through the transparency, call to mind sincerity; its iridescent brightness represents heaven. . . .

The alluring appearance of fine jade is created by certain optical and physical properties, some of which can be detected by an experienced eye. The visual factors that contribute to jade's unique appearance are the stone's texture, surface luster, fracture surface, inclusions, and distinctive surface features. While the net visual effect is not enough to identify the gem material conclusively, it renders clues that are invaluable in the identification process.

Texture. This relates to the "perfect compactness" of jade noted by Confucius. It is that quality of jade which makes it the toughest of gem materials. The toughness of a gem material is not the same as its hardness: toughness is the resistance to breaking, chipping, or cracking, while hardness is the resistance to scratching or abrading.

Toughness helps to explain why, when a major earthquake struck Southern California recently and shook various art objects off the shelves of a store in Santa Barbara, most of the jade pieces did not break (GIA, 1980). Jade is not an extremely hard material: jadeite is listed as 6½–7 on the Mohs scale of hardness and nephrite as 6–6½. The toughness of jade, however, is unsurpassed, and of the two jades, nephrite is somewhat tougher. Prehistoric peoples recognized this attribute of nephrite as evidenced by its use in early tools and functional implements.

The toughness of a material is related to its internal structure, which is different for nephrite and jadeite. The internal structure, in turn, is often reflected in the texture of the stone. Thus, by looking at texture, the difference between jadeite and nephrite—and between these stones and their simulants—may become apparent.

PROPERTY CHART: GREEN JADE AND SIMULANTS

Gem Material	Visual Characteristics					Gemological Properties		
	Texture	Surface Luster	Fracture Surface	Inclusions/Dye	Other Distinguishing Features	Refractive Index	Specific Gravity	Hardness
Jadeite	Interlocking granular structure	Vitreous-greasy	Granular, possibly splintery	May be dyed	Grainy, or dimpled surface; color mottling	1.660–1.680[a] + 0.10[b] Spot: 1.66	3.34 +0.11[b]	6½–7
Nephrite (Actinolite/tremolite)	Interwoven fibrous structure	Greasy-vitreous	Splintery, possibly granular	May have black inclusions (chromite, diopside), may show brown iron oxidation; rarely dyed	Chatoyancy	1.606–1.632[a] Spot: 1.61–1.62	2.95 ± 0.05	6–6½
TI Grossularite	Not apparent	Vitreous	Conchoidal	Usually dotted with black inclusions (magnetite, chromite)		1.720–1.730[c] Spot: 1.72	3.47 + 0.03 – 0.32[c]	7
Idocrase Californite	Not apparent	Vitreous, possibly resinous	Uneven to subconchoidal			1.713–1.718[a] Spot: 1.71	3.40 ± 0.10	6½
Zoisite Saussurite	May appear somewhat fibrous	Vitreous	Uneven to subconchoidal		Often variegated colors	1.691–1.704[a] Spot: 1.68–1.71 (1.52–1.57)[d]	2.95–3.40 2.60–2.75[d]	6½–7
Prehnite		Vitreous-waxy	Uneven to conchoidal		Usually pale yellowish green	1.616–1.649[a] Spot: 1.63 Bire blink: 0.020–0.033	2.88 ± 0.06	6–6½
Serpentine (Antigorite) Bowenite	May appear somewhat fibrous	Subresinous, greasy, pearly, resinous, waxy	Splintery to conchoidal	May have black, chromite inclusions, may be dyed	Color mottling may be present	1.560–1.570 (–0.07)[a] Spot: 1.56	2.57 ± 0.06	2½–4 5–6
Talc Steatite or "Soapstone"	May appear somewhat fibrous	Pearly-greasy	Uneven	May be dyed	Soapy feeling	1.540–1.590[a] Spot: 1.55	2.75 + 0.05 – 0.20	1–2½
Quartz Aventurine Dyed	Appears crystalline	Vitreous	Conchoidal	Chromium mica platelets (fuchsite) May have dye in fractures	Aventurescence	1.544–1.553[a] Spot: 1.54, 1.55	2.66 ± 0.01	7
Chalcedony Chrysoprase	Not apparent	Vitreous-greasy	Conchoidal	May be dyed	Even color	1.535–1.539[a] Spot: 1.53	2.60 ± 0.05	7
"Metajade" Glass	Not apparent	Vitreous	Uneven to splintery to conchoidal	Fern-like structure, gas bubbles	Warm to touch	1.510	2.65	5½–6
Calcite	Appears crystalline	Vitreous	Uneven to splintery	May be dyed	Cleavage may be noted (3 distinct directions)	1.486–1.658[a] Bire blink: 0.172	2.70 ± 0.01	3

[a] *Doubly refractive.*
[b] *Increase due to diopside and acmite impurities, e.g., chloromelanite.*
[c] *Hydrogrossular as low as 1.690.*
[d] *Two different readings possible.*

Figure 2. A thin section of jadeite shows many interlocking granular crystals. Magnified 100×. Photograph courtesy of the Smithsonian Institution, NMNH 94303.

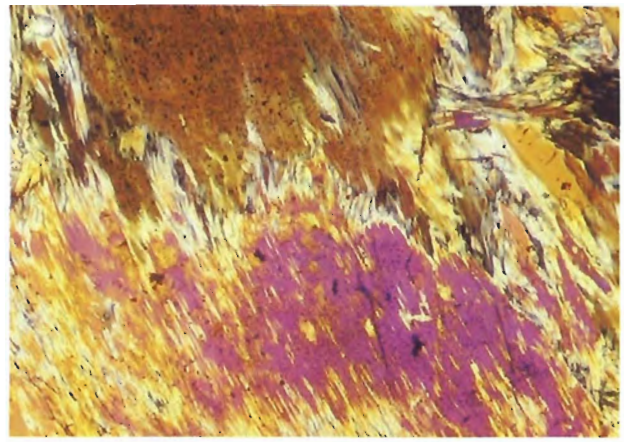


Figure 3. A thin section of nephrite shows interwoven, fibrous crystals. Magnified 100×. Photograph courtesy of the Smithsonian Institution, NMNH R6775.

Jadeite and nephrite are aggregates; that is, they are made up of a number of individual crystals. Aggregates are usually distinguished by the size of the individual crystals, but in the case of jadeite and nephrite it is the nature of the individual components that is distinctive. Magnification of a thin section from each of the materials provides a dramatic comparison: in jadeite (figure 2), the crystals appear as separate entities even though they are intergrown; whereas in nephrite (figure 3), the crystals take on a rope-like, fibrous appearance and seem to be inextricably woven together. This difference in structure is reflected in the visual appearance of the two materials: jadeite normally looks granular while nephrite looks fibrous.

None of the jade simulants has the tightly bound structure of either jadeite or nephrite, although aventurine quartz and calcite often appear to have the same degree of crystallinity as jadeite. None of the common jade simulants possesses a texture similar to that of nephrite; nephrite's interwoven structure qualifies it for a unique rating of exceptional toughness. Of all the jade simulants, saussurite, talc (also called steatite), and a few types of serpentine may appear fibrous.

Surface Luster. When Confucius notes that jade's "polish and brilliancy represent the whole of its purity," he touches on the significance of the stone's surface appearance, especially its ability to take a high polish. Luster is the appearance of a material's surface in reflected light, as determined by the quality and quantity of light reflected. For example, a beam of sunlight will show a much sharper reflection off a freshly waxed car than off a car in need of wax. In order to evaluate luster on a polished gemstone surface, simply note the sharpness of the image that the light source creates and the brightness of the area surrounding that image.

The refractive index of the stone and the quality of its surface (which is determined by the polish) are the two main factors that affect how much light is reflected. Texture may also affect luster. In the case of jade, it is almost impossible to achieve an optically flat, planar surface upon polishing because the random orientation of minute crystals causes undercutting during the sanding operation. As a result, the quality of light reflected from the surface is affected, so that the surface of most polished jadeite and nephrite has a slightly "greasy" luster. Because of its structure, polished dark-green nephrite usually has a greasier appearance than jadeite. Even the best-polished nephrite often looks as though someone left fingerprints on it, or smudged its shine. As evidenced in figure 4, the reflection of the light source is dim, and the area surrounding the reflection is blurry.

The luster of a gemstone often varies from one sample to the next, and there are no sharp divisions between types of luster. Yet, the jade simulants can be grouped into basic luster categories. Aventurine quartz, glass, and calcite are, like some jadeite, usually vitreous (the most common type of luster on transparent gemstones, like the surface of most window glass in reflected light; see figure 5). These materials reflect much of the light off their surfaces.

Figure 4. Nephrite usually exhibits a greasy surface luster.

The surface luster of grossularite, chalcedony (cryptocrystalline quartz), saussurite, idocrase, prehnite, and serpentine may range from vitreous to greasy, but usually it lies somewhere in between. Talc generally has the poorest luster of all. At best it is greasy; but because of talc's extreme softness and inability to take a good polish, it is usually waxy or pearly.

Fracture Surface. A break in any direction other than along a cleavage plane is called a fracture, and the surface of that break differs in appearance depending on the nature of the material. Crystalline aggregates such as jadeite and nephrite may show the same type of fracture, but usually they differ. A granular fracture is characteristic of jadeite (figure 6). The surface of a granular fracture looks like that of a lump of sugar; that is, it shows the fine, individual crystals of the material.

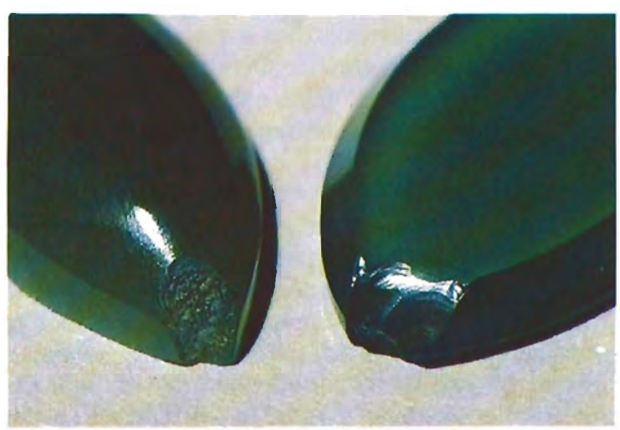
Jade, though, may also exhibit a splintery fracture, which looks like the surface of a broken piece of wood. The splintery, or fibrous, appearance of a fracture is most often seen on nephrite, reflecting its fibrous structure. A splintery fracture is characteristic not only of jade, but also of common jade substitutes such as serpentine, "metajade" glass, and calcite.

A conchoidal fracture may be as helpful as a granular fracture when separating jade from its substitutes. A conchoidal fracture has curved ridges similar to the outside markings on a shell (again, see figure 6). While a granular fracture may suggest jade, a conchoidal fracture usually suggests a jade simulant. As indicated in the property chart, many jade simulants show conchoidal fractures on a broken surface.

Figure 5. Jadeite usually exhibits a vitreous surface luster.

Several of the jade substitutes exhibit an uneven fracture surface, that is, a break that does not have any regular pattern although it often appears jagged. Because it is nondescript and may be seen in many of the jade simulants (and possibly jade), an uneven fracture is not as helpful in jade identification as a granular or a conchoidal fracture.

Figure 6. A granular fracture on a broken surface is often characteristic of jade (in this case nephrite, illustrated on the left). Many jade simulants (such as dyed chalcedony, illustrated here on the right) show a conchoidal fracture on a broken surface.



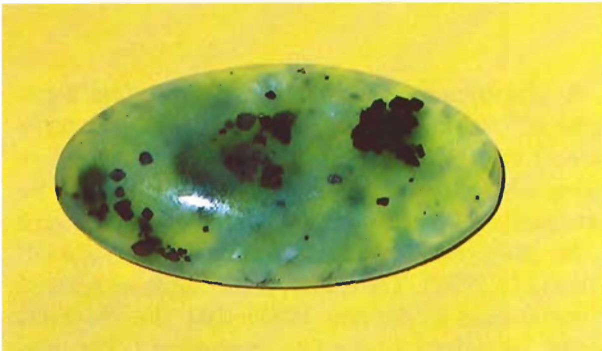


Figure 7. Black inclusions, such as the chromite in serpentine shown here, may suggest that the stone is a jade simulant.

Figure 9. "Metajade" glass often shows a fern-leaf pattern under magnification. Here, magnified 5×.

Inclusions/Dye. Jade and its substitutes often contain the same types of inclusions. When combined with the color and typical appearance of the stone, though, the inclusions may aid in the identification of the material. For example, grossularite and serpentine (figure 7), as well as nephrite, often contain black chromite inclusions. Yet, if the chromite inclusions are scattered throughout a medium bluish-green, semitranslucent to opaque material, the gemologist suspects grossularite (or hydrogrossular, i.e., grossularite with a high water content). The types of nephrite and serpentine that most often contain chromite are generally a darker green (Bergsten, 1964). Do not assume, however, that all black inclusions are chromite; often, they are magnetite or diopside.

Some inclusions in jade simulants can serve to identify the material. Round green platelets that are so densely packed that they give the gemstone color strongly suggest aventurine quartz. The platelets are fuchsite, a green chromium mica, and prove that the material is not jade. These disc-like inclusions, pictured in figure 8, can be detected with the unaided eye if the material is examined under good lighting.

"Metajade" glass, also called Imori or Iimori stone, is an excellent imitation that is made by Iimori Laboratory in Japan. This material can be detected by its inclusions as well as by its other optical and physical properties. Because the material is partially crystallized, it exhibits a fern-leaf pattern that is easily seen under magnification, as illustrated in figure 9 (Crowningshield, 1973). Patterns such as these, which are the result of devitrification (the partial change from an amorphous to a crystalline structure), suggest glass. Gas bubbles may also be present.

Dyed green quartzite can also be mistaken for jadeite. Green dye hides the "non-gemmy" quality of this massive, metamorphosed sandstone, and may provide a believable jadeite color. The dye can be detected under magnification in the form of heavy concentrations of color in the breaks or fractures that usually occur throughout the stone (figure 10).

Green organic dyes have also been used to im-

Figure 8. Green chromium mica (fuchsite) inclusions, as shown in these 8-mm beads, suggest aventurine quartz.

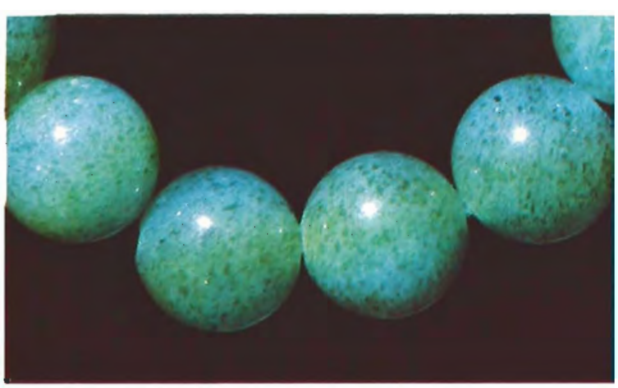
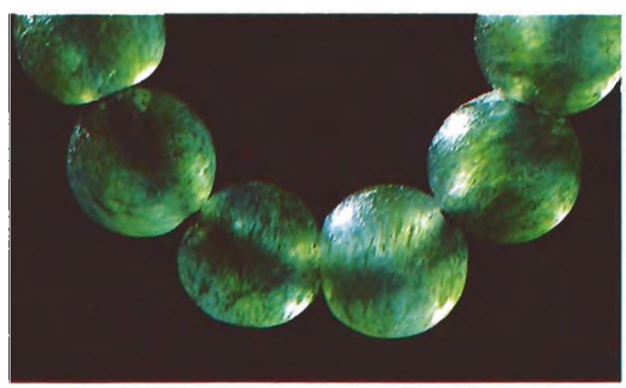


Figure 10. Green dye is evident in the fractures, or cracks, of these 8-mm quartz beads.



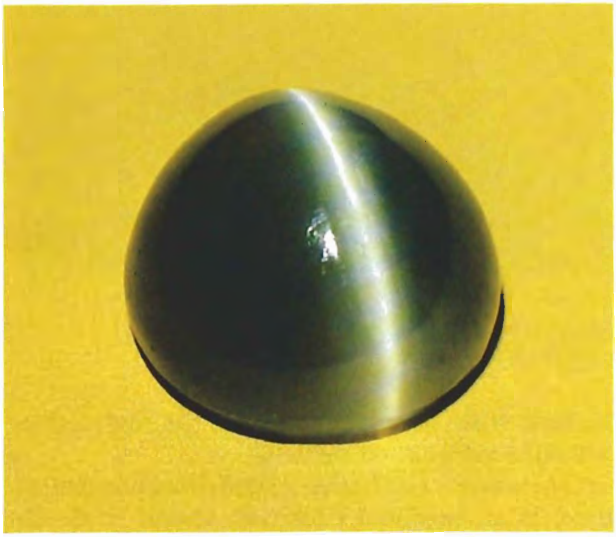


Figure 11. Actinolite, a major constituent of nephrite, often exhibits chatoyancy. Stone (9.4 × 5.9 mm) courtesy of Robert E. Kane.

part color to jadeite, serpentine, calcite, talc, and—in rare instances—nephrite (Liddicoat, 1965). The ease with which the dye is detected depends on the nature of the material and the dye used. In the case of jadeite, the granular structure of the stone may cause the uneven distribution of the dye and thus a heavier concentration in some areas. Concentrations of dye may be detected under the microscope, but the gemologist must be careful not to confuse this characteristic with the color mottling of untreated jadeite. Positive proof of green dye in jadeite and serpentine can be determined with the spectroscope, which will be discussed later. Magnification is usually sufficient to detect dye in calcite and talc.

Other Distinguishing Features. As previously noted under surface luster, the structure of jadeite may cause undercutting during the sanding process, which results in a grainy or dimpled surface appearance. This dimpled surface, the result of minute, randomly oriented crystals, is not found in the common jade simulants.

Phenomena, or unusual optical effects, may also help in the identification of a jadeite simulant. The fuchsite inclusions in aventurine quartz set up a glittery effect as the stone is turned in light. Aventurine quartz is the only jadeite simulant that exhibits this effect, known as aventurescence.

A chatoyant material known as "cat's-eye nephrite" surfaces occasionally in the jewelry trade. It belongs to the tremolite-actinolite series of amphiboles, of which nephrite is a variety. The chatoyancy is due "to the fibrous structure and to the preferred orientation of tremolite fibers" (Tan et al., 1978). Therefore, it has been suggested by some (see Anderson, 1980) that the material should be called "cat's-eye tremolite." Yet, the material is more apt to be actinolite than tremolite (figure 11). Using X-ray diffraction, Fryer confirmed that a sample of the cat's-eye nephrite was in fact cat's-eye actinolite (Crowningshield, 1972). In any event, either tremolite or actinolite cat's-eye is more appropriate than "cat's-eye nephrite," because the chatoyancy is due to the reflection of light off parallel fibers, and by definition nephrite consists of randomly oriented, interlocking fibers. Regardless of the nomenclature question, chatoyancy is important in identification because it is most common in the tremolite-actinolite series and is rarely seen in the jade simulants.

A true jade *aficionado* may develop a sense for the feel of jade. In an article on the "Art of Feeling Jade" (1961), it was stated that jade fishers of Khotan, who wade the rivers in search of jade, find it by the touch of the foot. Also, Chu Hsi, the last Empress Dowager of China, was said to have trained her fingers to recognize jade and some of its different quality grades. The family of Richard Gump, a renowned jade dealer, claim that he was able to identify jade by feel after losing his eyesight in later years. In addition, when jadeite was first introduced into China, the Chinese apparently knew "it wasn't the same (as nephrite) as soon as they handled it, it didn't feel the same" (Gump, 1962).

Identification of jade by feel is extremely difficult. In centuries past, there were not as many recognized jade simulants, or methods to distinguish jadeite from nephrite. The feel of jade, therefore, is best left as a questionable means of detection.

While we are on the subject of tactile sensations, it is interesting to note that glass and plastic are warm to the touch, while crystalline materials are cold. Thus, all jade and jade simulants other than glass and plastic should feel cold to the touch initially. Also, talc can be easily identified by its slippery, or soapy, feel. It is often called "soapstone" for this reason.

In short, a visual examination of a gem material can limit the field of possibilities. It can help to separate nephrite and jadeite. Gump (1962) attempts to pinpoint the difference in the appearance of most green nephrite and jadeite:

> For the brightness and clarity of jadeite's tones contrast sharply with the soapy, almost aged-looking hues of most pieces of nephrite. Jadeite comes closer to being, and sometimes is, translucent. In general, one might say that the colors of jadeite turn toward vividness and translucency, while the hues of nephrite are greasier, denser, and heavier.

Visual characteristics can provide some valuable indications to the identification of jadeite and nephrite, but they usually lead only to suppositions that should be backed by positive gemological tests. Several key tests in the separation of jadeite from nephrite and the two jade materials from their simulants are described below.

Figure 12. Dyed calcite such as this may look like jadeite, and its refractive index may be confused with that of jadeite. The birefringence blink technique is suggested for this material.

GEMOLOGICAL TESTS

Standard tests used to verify the identity of jade-appearing materials include refractive index readings, specific gravity determinations, and spectroscopic analysis. Less frequently, careful hardness tests are conducted. Sophisticated laboratories may also use X-ray diffraction to analyze jade-appearing specimens.

Refractive Index Readings. The refractometer is one of the most helpful instruments in the separation of jade from its simulants. Almost all of the jade simulants have refractive indices well above or below that of jadeite and nephrite. The only difficulty lies in using the refractometer on the surface that is usually accessible.

Normally, that is, with faceted gemstones, a flat facet of the stone in question is placed directly on the refractometer hemicylinder with a small amount of liquid. Since jadeite, nephrite, and their simulants are generally cut with rounded or curved surfaces, a "spot" or "distant vision method" must be used to read the refractive index. The spot technique requires that a portion of the curved surface be placed or held on the refractometer with a small drop of liquid, the size of which is reduced until the image that is seen without the eyepiece magnifier is only two or three scale increments. By reducing the stone's image to a very small spot, the gemologist can obtain a meaningful refractive index that should serve to separate jade from most of its simulants. (Note: in taking a spot reading, it is only possible to judge the refractive index accurately to the hundredths place, e.g.,1.66.)

Using the spot technique and a little ingenuity, one of the GIA lab experts was able to take a refractive index reading on a large jade carving. An associate held a light source to the refractometer porthole as the gemologist held the refractometer hemicylinder on the gemstone surface rather than the gemstone on the hemicylinder.

Jadeite and nephrite are easily separated from one another by their refractive indices. Although both are doubly refractive, it is rare to see the full spread of refractive indices listed on the property chart because both are crystalline aggregates. Also, only one refractive index is easily resolved with the spot technique. The refractive index obtained, however, is usually sufficient to distinguish the two materials, since jadeite's reading tends to be around 1.66 and nephrite's is around 1.61.

The jade simulants can be divided into three groups on the basis of refractive index: (1) those with refractive indices higher than that of jade, (2) those with refractive indices lower than that of jade, and (3) those with refractive indices that could be confused with jade (see figure 12).

Grossularite, idocrase, and saussurite have refractive indices that are usually higher than that of jadeite. Saussurite's refractive index (R.I.) may

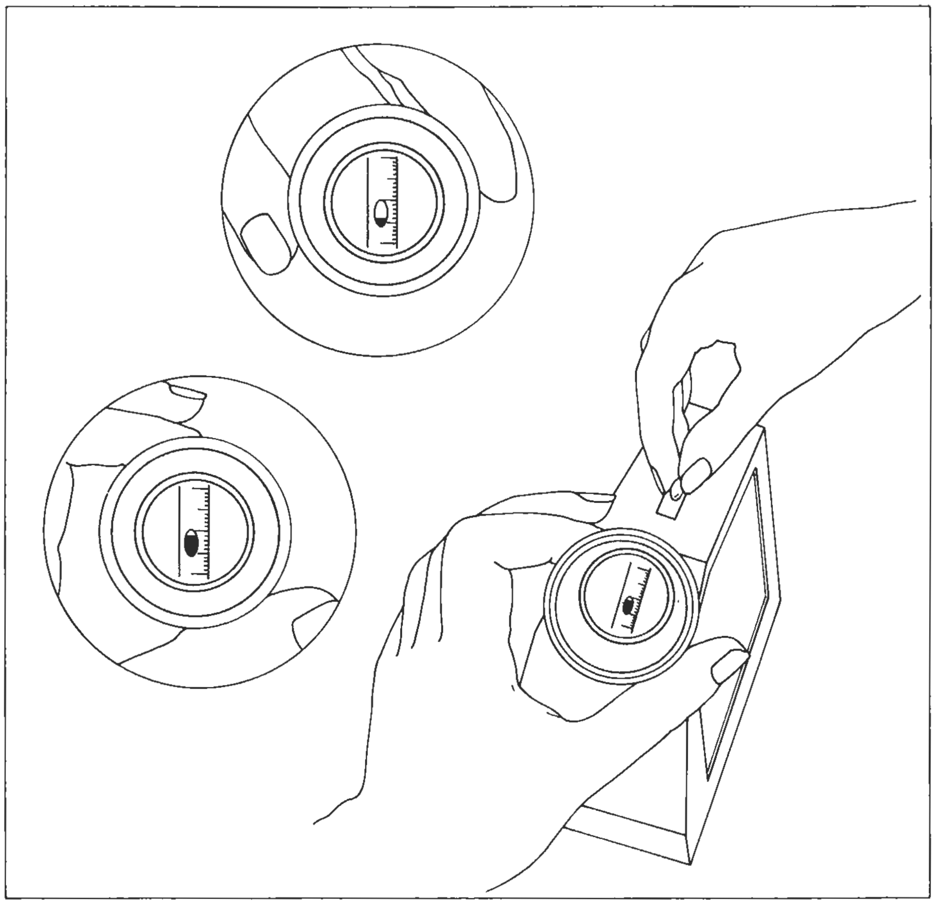


Figure 13. The birefringence blink technique involves rotating a polaroid plate in front of the refractometer (magnifier removed). If the stone is placed in the approximate direction of maximum birefringence, the R.I. shadow will jump within the spot image. Birefringence is estimated as the amount of movement seen. As illustrated in the two circular diagrams, prehnite will show a maximum birefringence of 0.030 as the polaroid plate is turned.

vary because it is a rock. If it mixes with feldspar or serpentine, its R.I. may be as low as 1.55; more often, saussurite shows a much higher R.I., around 1.68–1.70, due to the presence of idocrase or zoisite. Such a reading is too high for pure jadeite, but could indicate chloromelanite, which is a very dark green to almost opaque type of jadeite (again, see box). Saussurite can be separated from chloromelanite by spectroscopic analysis, X-ray diffraction, or possibly the presence in saussurite of two widely different refractive indices (which reflects the presence of different minerals).

Most jade simulants fall into the second category, that is, materials that have lower refractive indices than jadeite or nephrite. Quartz, chalcedony (cryptocrystalline quartz), serpentine, talc, and most types of glass or plastic used as simulants can be easily separated from jadeite with the use of the refractometer.

Using the regular spot refractive index technique, the gemologist might mistake calcite and prehnite for jade. Both of these materials can, however, be identified by employing the "birefringence blink" technique. Birefringence is a measurement of the difference between two refractive indices in a doubly refractive material. Although jadeite and nephrite are doubly refractive, they rarely show any birefringence; whereas prehnite may show a birefringence of 0.020 to 0.033, and calcite one of 0.172. The birefringence blink technique uses the standard spot-reading procedure, which requires white light and no magnification. A slightly larger amount of liquid may be needed. Rotate a polaroid plate in front of the refractometer eyepiece and note the extent to which the shadowed lines (which represent refractive index) jump inside the spot, or stone image (figure 13). Provided that the stone is lying in the direction of the greatest birefringence, there is a slight but noticeable shadow movement in prehnite, and in calcite shadows appear to leap between the different refractive indices and may even blink from red to green.

Specific Gravity Determinations. Specific gravity (S.G.) determinations are not as conclusive as refractive index readings because (1) many of the jade simulants have specific gravities close to those of jadeite and nephrite, and (2) the measurements are not constant in most of the jade simulants because they often mix with other minerals. Specific gravity is defined as the ratio of the weight of a substance to the weight of an equal volume of water at 4°C. Specific gravity can be estimated by the use of heavy liquids, and precise measurements are obtained on a hydrostatic balance.

The specific gravity liquid that is most useful in separating jadeite from nephrite and from most other jade simulants is methylene iodide (3.32 liquid). When nephrite or most jade simulants are immersed just slightly under the surface of the liquid, they will bob to the top, while jadeite will remain suspended or sink very slowly to the bottom.

For large pieces, an accurate specific-gravity measurement can be obtained on a balance that has been adapted for hydrostatic measurements. The material is weighed first in air and then in water to determine the weight lost in water. The specific gravity is found by dividing the material's weight in air by the loss of weight in water.

On property charts, the specific gravity of jadeite is usually listed near 3.34, although it may vary depending on the presence of impurities. Chloromelanite may have a specific gravity as high as 3.45, and a rock-like form of jadeite that has a high albite content may be as low as 2.90 (Foshag, 1957). If we take this range into account, nephrite and three of the common jade simulants have S.G. values that could be confused with jadeite: grossularite, zoisite, and idocrase. However, all of these gemstones could be identified by their refractive index readings. All the other common jade simulants have S.G. values far lower than that of jadeite.

The specific gravity of nephrite usually ranges between 2.90 and 3.00. Nine of the 10 jade simulants discussed here have specific gravity values that are significantly different from nephrite: those of grossularite, zoisite, and idocrase are normally higher, and those of quartz, chalcedony, "meta-jade" glass, bowenite, talc, and calcite are normally lower. Only prehnite could be confused with nephrite on the basis of specific gravity, in which case the refractometer would make the distinction.

In short, specific gravity should be used as a supplemental test in the separation of jade from jade simulants. Jadeite, and many jade-like materials, may contain impurities that will cause the specific gravity to vary. Also, specific-gravity determinations can be helpful only if the results are noticeably higher or lower than that of jadeite or nephrite. Two other tests provide more consistent results: refractive index readings (as discussed above) will positively identify jadeite and nephrite, and spectroscopic analysis (as described below) can provide conclusive proof of jadeite.

Spectroscopic Analysis. The spectroscope may provide positive identification of jadeite, although it is not helpful with nephrite (which usually does not show absorption lines in the spectroscope). Jadeite and some of its simulants show absorption that correlates with the presence of certain coloring agents, so their absorption patterns are distinctive. For example, pure jadeite is white; the various colors in which jadeite appears are due to the presence of such impurities as iron, manganese, and/or chromium. Green jadeite owes its coloration primarily to chromium, even though some iron may also be present. The higher the chromium content in jadeite, the stronger and more distinct the absorption pattern is in the red part of the spectrum. Some of the jade simulants also have characteristic absorption patterns that, when used in conjunction with refractive index readings, definitely identify these materials (figure 14).

The spectroscope is helpful in that both cut and rough, as well as mounted or loose, materials can be tested. In order to assure accurate results, the maximum amount of light must be sent through the material, and the slit of the spectroscope must be adjusted correctly. Since jadeite and its simulants are normally translucent to opaque, the transmitted light that passes through the material may not be sufficient for the absorption pattern to be seen by the spectroscope. Reflected light will usually resolve the absorption lines on a more opaque material. When using reflected light, make sure that the spectroscope picks up the maximum amount of light reflected from the stone (figure 15).

To achieve optimum results, the slit of the spectroscope must be opened the correct amount. Specifically, the more light absorbed by the stone, the more the slit must be opened to pick up absorption lines. However, the slit should not be opened beyond the first point at which the absorption pattern is seen or else too much light

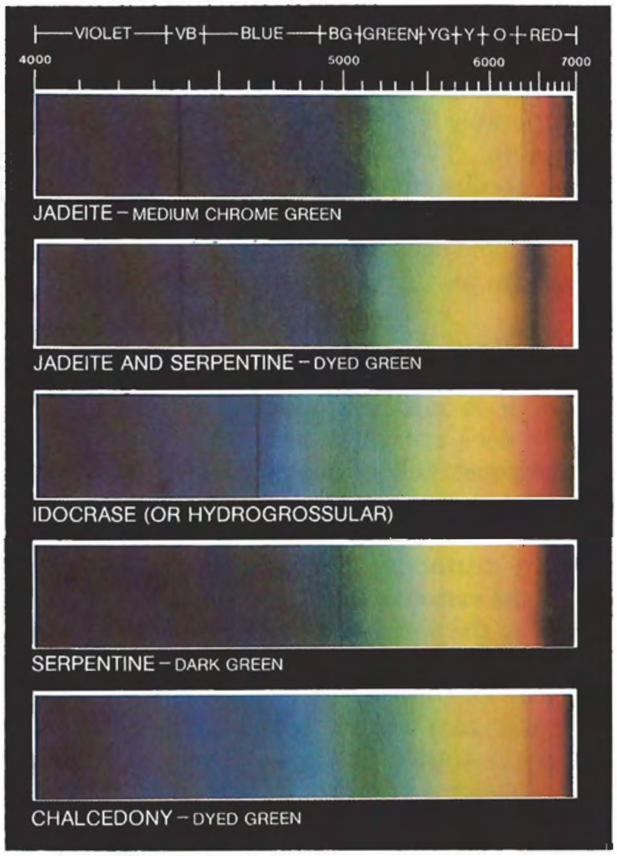


Figure 14. Green jadeite and some of its simulants have identifying absorption patterns. Water-color spectra by Misha Merrill.

will enter and the lines will not appear distinctly. Special attention must also be paid to the position of the drawtube to obtain proper color resolution (see the caption to figure 15).

Two color areas of the spectrum are particularly important to the identification of jadeite: the violet and the red. In the violet end of the spectrum, jadeite often shows a line around 4370 Å that appears in only one of its simulants (again, see figure 14). It is most easily seen in jadeite that is pale green; in darker green material, the line may be obscured by general absorption in the violet-blue area. If difficulties are encountered, Anderson (1980) suggests that a flask of copper sulphate be placed in front of the light source in order to eliminate the glare from the red and yellow sections of the spectrum. Prehnite is the only gemstone that may show an absorption line in the same area (4380 Å). Green jadeite, however, normally has additional lines in the red that prehnite does not have.

A band seen near 4640 Å in the blue area of the spectrum signifies idocrase (or hydrogrossular, which is a type of grossularite that grades into idocrase). Broad absorption in the violet-blue region that cuts off in the area between 4800 and 5200 Å indicates serpentine. Bowenite, the hardest variety of serpentine, may even show a line around 5000 Å (Liddicoat, 1981). If idocrase or zoisite is present in saussurite, this material may show a line around 4600 Å.

The red area of the spectroscope is also important in the identification of jadeite. Spectral absorption in the red may indicate dye in jade, serpentine, or chalcedony; may signal a triplet; or may indicate the presence of chromium, a primary coloring agent in some green gem materials.

Medium-green jadeite characteristically shows three distinct bands in the red, near 6300, 6600, and 6900 Å (Anderson, 1980). These bands usually have absorption shading in between them, and the shading darkens near 7000 Å. Lighter tones of green jadeite usually will not exhibit all three lines; instead, they will exhibit one or two lines (usually 6600 and 6900 Å) and dark shading near 7000 Å.

Dyed green chalcedony, and rare chrome-colored chalcedony, may exhibit somewhat similar narrow bands in the red, but there is no subtle shading between the bands as in jadeite. Refractive index will also suffice to separate these materials.

A piece of "metajade" glass was tested by the GIA Gem Trade Laboratory and found to have a spectrum "identical to that of a naturally colored green jadeite" (Liddicoat, 1975). Most pieces of "metajade" do not show this spectrum and are easily identified by their visual characteristics, refractive index, and specific gravity; the latter two values are considerably lower for "metajade" glass than for jadeite.

A broad band in the red, extending from approximately 6300 to 6700 Å, is proof of dye in green jadeite. The novice spectroscopist often cannot tell the difference between the broad dye band and the shaded bands of untreated jadeite. However, if the spectra are compared side by side, it is apparent that a light area exists between the high numeric edge of the dye band and 7000 Å. In an untreated piece of green jadeite, the immediate area near 7000 Å is quite dark.

The broad band in the red area also proves dye in serpentine, once the material has been identi-

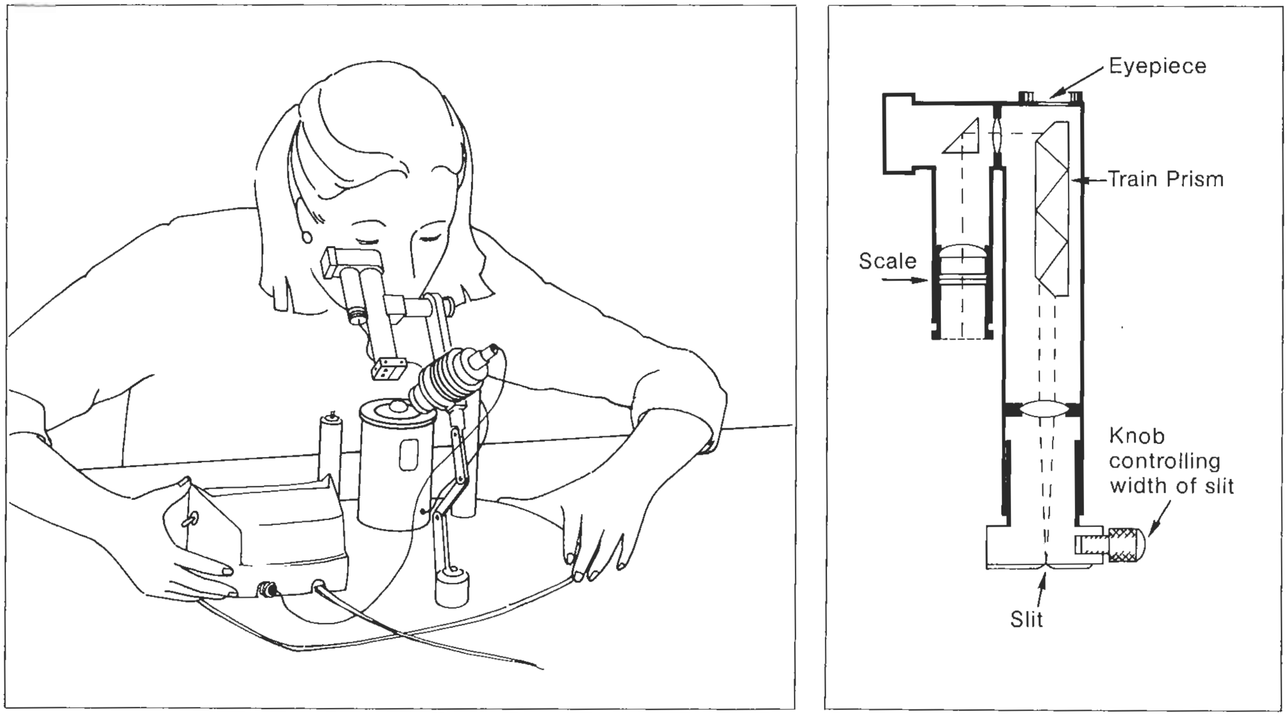


Figure 15. Reflected light is most often used to resolve absorption lines on translucent-to-opaque materials such as jade and its simulants. The spectroscope and light source should be positioned so that the maximum amount of light reflected from the specimen is seen by the spectroscope. The slit and drawtube of the spectroscope must then be adjusted properly in order to obtain the most distinct absorption lines. The slit should not be opened beyond the first point at which the absorption pattern is seen. When looking for absorption in the violet region, push the drawtube up until the lines are in focus; for absorption in the red region, pull the drawtube down until the lines are distinct. In general, follow the drawtube role, Blue (violet)–Up, Red–Down, perhaps best remembered by the acronym BURD.

fied by refractive index. The band appears in green jadeite triplets as well, because of the dye in the cement layer.

Many gem materials that are colored by chromium show absorption lines in the red area of the spectrum. Aventurine quartz may show lines in the red because of the presence of chrome mica. Even though aventurine's lines, near 6500 and 6800 Å, are close to that of jadeite, the overall absorption pattern is different. Like other jade simulants that show lines in the red, aventurine quartz can be verified by refractive index and specific gravity. Characteristic inclusions, as discussed above, are also helpful in the identification of this material.

In short, the spectroscope is a key test in the identification of jadeite. It can provide quick, positive proof of green jadeite, dyed green jadeite, and many green jade simulants if the spectroscope results are analyzed in conjunction with refractive index readings.

Hardness Tests. Hardness tests are rarely used in gemology because, if improperly done, they can easily mar or even break a gem material. Moreover, other gemological tests are just as quick and are usually more useful in identification. Although hardness tests should never be performed on transparent gemstones, the tests may have some application in the case of a translucent to opaque material such as jade.

Hardness is the ability of one material to scratch another. The hardness of gem materials is rated from 1 to 10 on a scale developed by Mohs (it is a relative scale in that the numbers do not represent equal increments of hardness). A set of hardness points is most commonly used for this test. Each of the small metal tubes in the set usually holds a piece of a mineral of known hardness that has been ground to a point and centered into one end of the tube. Common minerals include diamond, synthetic corundum, topaz, quartz, and feldspar.

The material should be observed under the microscope while a hardness point is drawn firmly across an extremely small, inconspicuous area. Then, the test surface should be wiped and examined to see whether the point has powdered itself or actually scratched the test surface. Always start with a low hardness point and then try increasingly harder points until a scratch is made.

Jadeite cannot be separated from nephrite using this test because their relative hardness values are too close. Hardness tests would only help separate materials that have a hardness value that is significantly lower than jade, such as serpentine, calcite, and talc. The other common simulants are of the same hardness as, or slightly harder than, jade. Although most serpentine is between 2½ and 4 on the hardness scale, the variety bowenite may have a hardness value as high as 6. Because the hardness of jade is between 6 and 7, bowenite cannot be separated from jade on the basis of a hardness test.

Calcite has a hardness of 3 on the Mohs scale, which makes it easy to distinguish from jade. However, other gemological tests, such as for birefringence, are recommended in the identification of calcite.

Perhaps the best application of the hardness test lies with the identification of talc. Since talc has a hardness of 1–2½, even a fingernail (which has a hardness of 2½ or lower) will cut into it. Its low hardness may also be evidenced by a low luster and by surface scratches resulting from wear or contact with other materials.

When using hardness points to separate jadeite from its simulants, you should remember that many jade-like materials contain impurities that have hardness values different from the main mass. Therefore, it is advisable to avoid testing areas that differ in color or texture from the basic material.

In short, hardness tests will determine that a gem material is too soft to be jadeite. They will not identify the material, and the results help in the detection of only a few jade simulants.

X-ray Diffraction. The most precise test in jade identification involves X-ray diffraction by the powder method. Not only can this test identify most crystalline materials, but it can also detect variations in their mineralogical compositions. Unfortunately, X-ray diffraction is feasible only for sophisticated laboratories. It takes more time than other gemological procedures, requires costly equipment, and a skilled laboratory technician must set up the test and interpret the results.

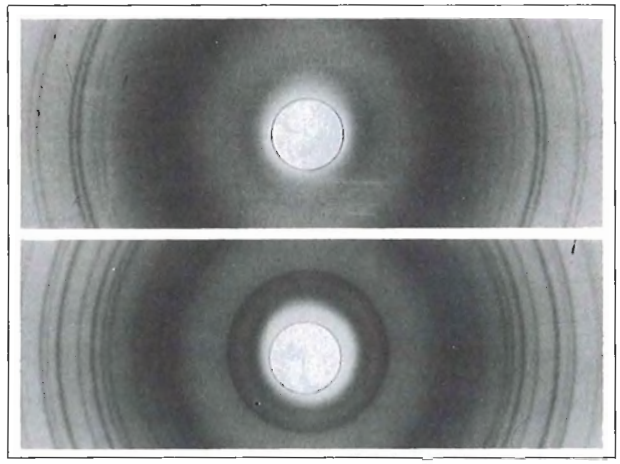


Figure 16. An X-ray diffraction pattern will identify jadeite from nephrite and both from their simulants. Top, jadeite; bottom, nephrite.

The powder method works best in gemstone analysis because only a small amount of material is required. Chuck Fryer (personal communication) has devised a technique in which a very minute scraping from the girdle is sufficient for the test. The crystalline particles can be picked up and cemented to a very fine glass spindle. The spindle is mounted in the center of a cylindrical camera that has a small hole that will allow X-rays to pass through to the material. A filmstrip fits snugly around the inside wall, and when X-rays strike the material, the atomic planes of that material show up by reflection of the X-rays as a certain diffraction pattern that is recorded on the filmstrip (figure 16). The diffraction pattern on the filmstrip appears as curved lines, the spacing and intensity of which are characteristic for the specific crystalline substance (Hurlbut and Switzer, 1979). By applying mathematical formulas, or by comparing the filmstrip patterns against standard patterns of known materials, most gem materials can be positively identified. This is true for jade and jade simulants as well as for any other single-crystal mineral.

CONCLUSION

Much of the enigma surrounding the identification of jade is based on the long-time propagation of misnomers, misinformation, and tenuous nomenclature. This confusion can be greatly reduced if the correct information is circulated among buyers and sellers alike.

Visual characteristics provide the first indication that a gem material may or may not be jade. The granular texture of jadeite and the fibrous texture of nephrite are often distinctive, just as the surface luster of these materials may be. A granular fracture, too, indicates a crystalline aggregate such as jadeite. Certain other features, such as a dimpled surface, may also suggest the unique structure of jadeite.

Since visual characteristics are rarely sufficient proof, assumptions made from visual inspection need to be supported by appropriate gemological tests. Refractive index readings and absorption spectra lines provide the most accurate information. Specific gravity measurements and hardness tests should be considered as supplemental data. If any problems arise in the testing of jadeite, nephrite, or any of the jade simulants, the material can be sent to a laboratory for X-ray diffraction analysis.

Thus, the identification of jade requires an awareness of its appearance, skill in instrumentation, and sound deductive reasoning. The nomenclature may change in the future as these minerals are more clearly defined and separated, but good gem identification skills will always be needed to separate jade from its simulants.

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