Gemology

- **Gemology or gemmology is the science dealing with natural and artificial gemstone materials. It is considered a geoscience and a branch of mineralogy**

- **National Association of Goldsmiths (NAG) set up committee for qualifying "Gemologists" in 1908. This NAG Committee matured to "Gen-A" an accredited awarding body with its courses taught worldwide**

- **The first US graduate of Gem-A's Diploma Course, in 1929, was Robert Shipley, who later established both the Gemological Institute of America (GIA) and the American Gem Society**

GIA - Colored Stone Course Summary

- Learning from the Course (3 Main Sections)
  - 1 – Gem formation, properties, valuation (2-6)
  - 2 – Gem color, cut, clarity, and carat weight (7-11)
  - 3 – Major commercial Gems (12-27)
- Questionnaire
  - At the end of each assignment, 70% needed to advance to next assignment
- Final Examination
  - Proctored final exam, 70% or better to pass course

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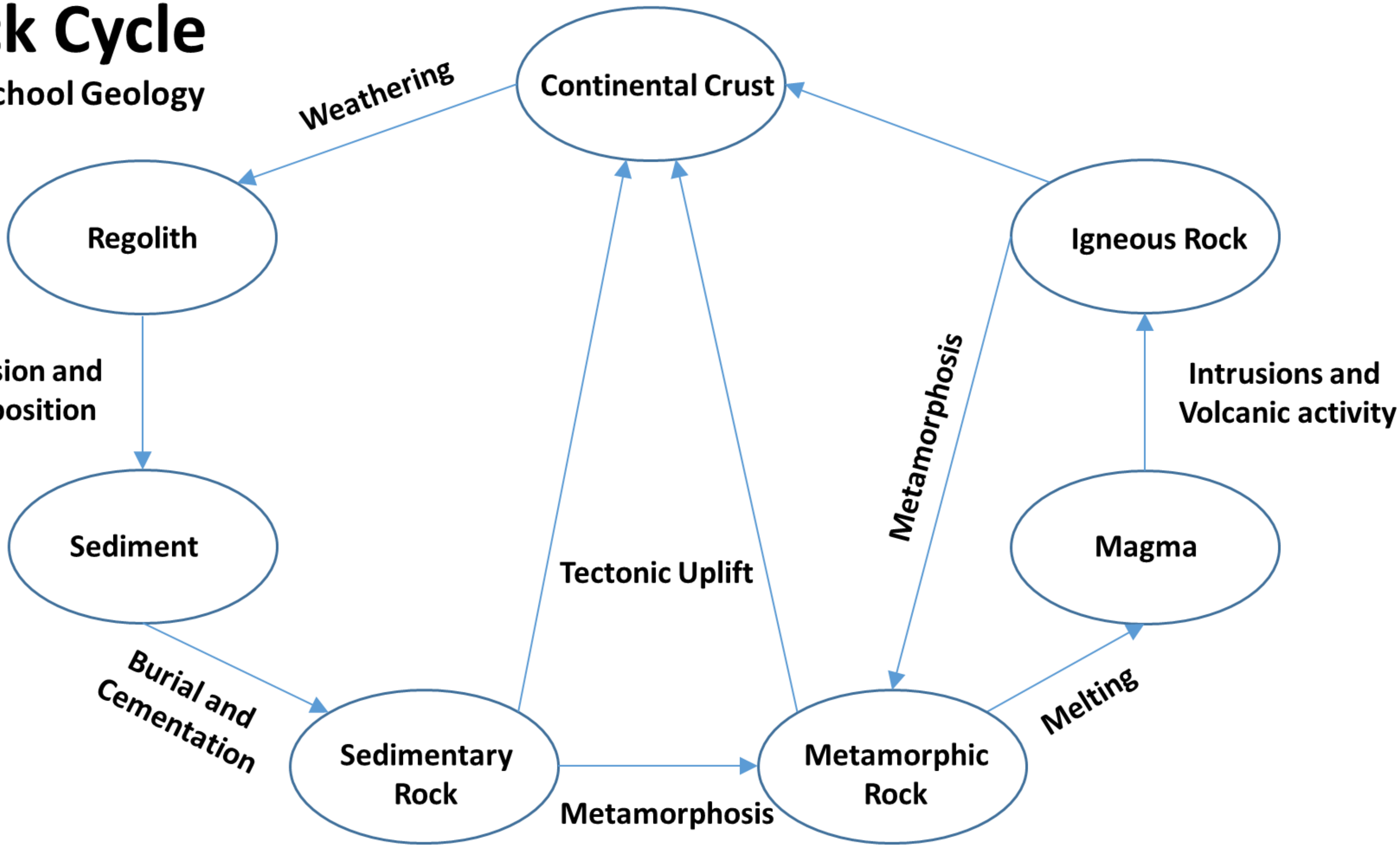
Rock Cycle

High School Geology



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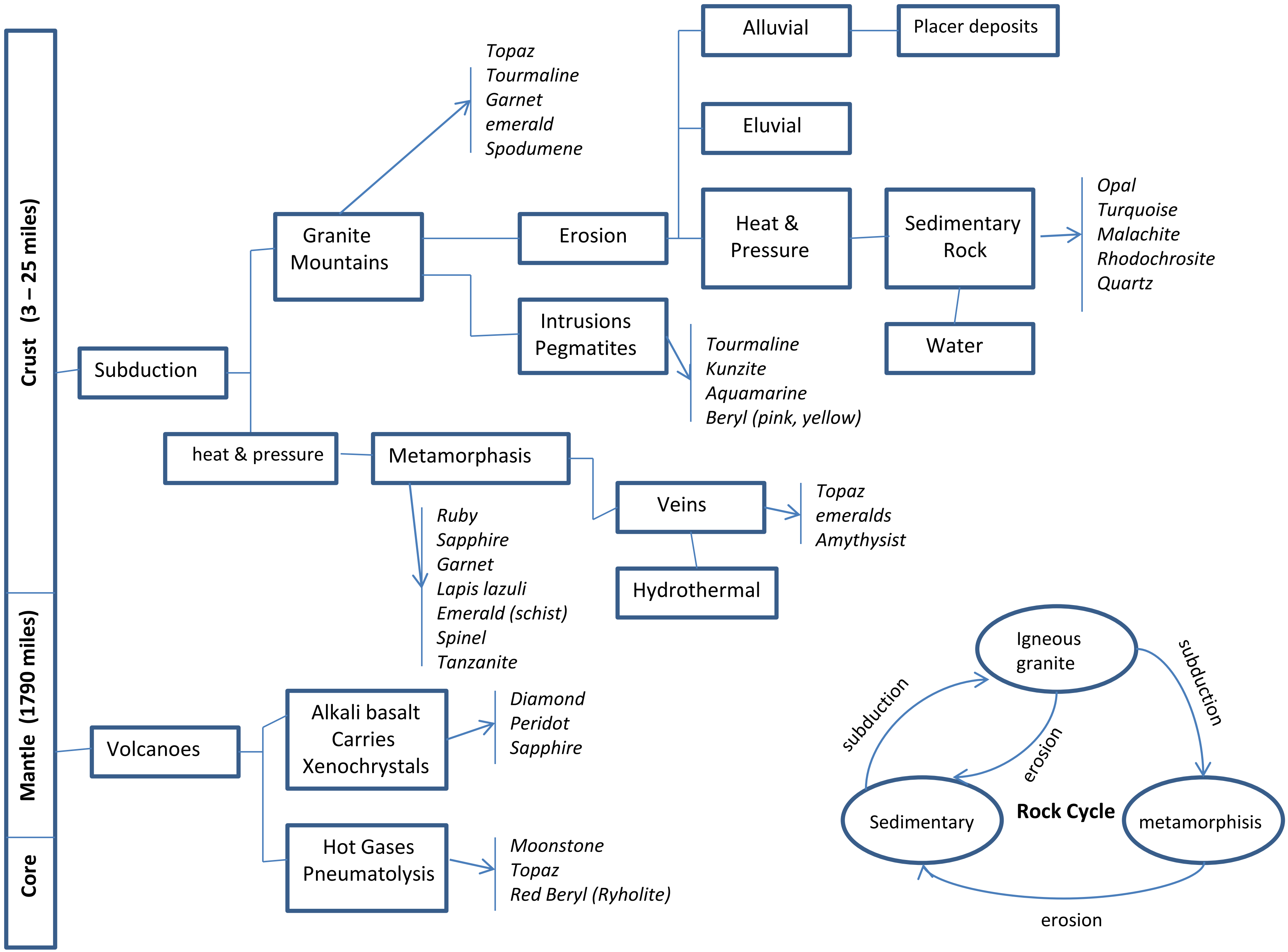
Assignment 2 - Summary



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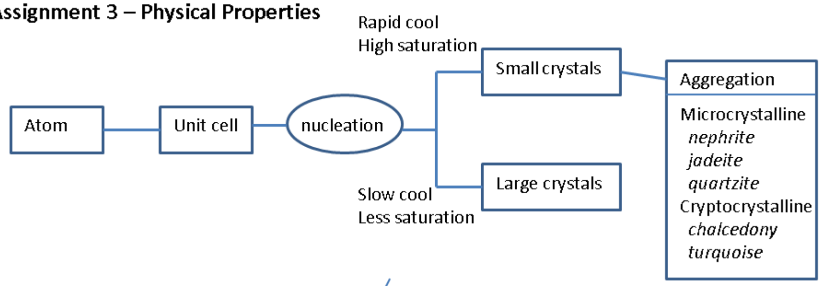
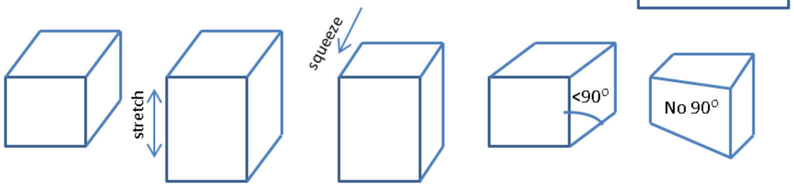
Assignment 3 – Physical Properties





Cubic
garnet
diamond
spinel
fluorite

Tetragonal
zircon

Orthorhombic
topaz
peridot
iolite
tanzanite
chrysoberyl

Monoclinic
kunzite (spodumne)
moonstone
orthoclase feldspar

Triclinic
amazonite
microcline feldspar
rhodonite
kyanite

Hexagonal
beryl
apatite

Trigonal (rhombohedral)
corundum
tourmaline
quartz

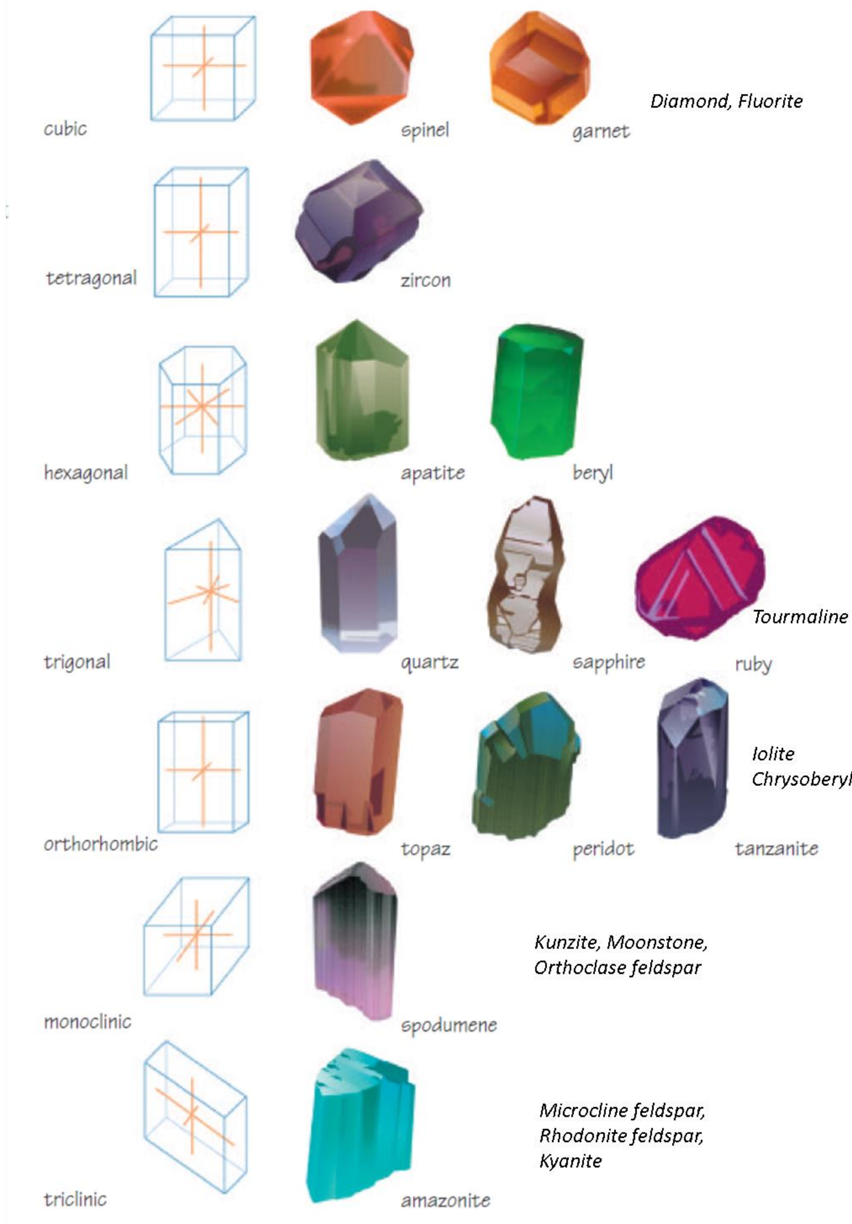
MOHS Scale
10 – diamond
9 – corundum
8 – topaz
7 – quartz
6 – orthoclase feldspare
5 – apatite
4 – fluorite
3 – calcite
2 – gypsum
1 – talc

Crystal Characteristics
Tabular – squat and flat
Prismatic – (3, 4, 6, 8 or 12) parallel faces
Euhedral – well formed with sharp crystal faces
Anhedral – lacking obvious crystal faces
Striations – horizontal or vertical growth marks
Pyramid – equal triangular faces meeting at a point
Bipyramid – two pyramids back to back

Density – weight in relation to size
Sp gr – ration of weight to equal volume of water
Durability – combination or hardness, toughness and stability
Hardness – resistance to scratching
Toughness – resistance to breaking and chipping
- exceptional – jade and nephrite
- excellent – corundum
- good - quartz and spinel
- fair – tourmaline
- poor – feldspare and topaz

Stability - susceptability to heat, light and chemicals

Breakage
- Cleavage – along lines of fewer atomic bonds (diamond)
- Parting – along twinning planes (corundum)
- Conchoidal – (glass, opal, quartz, peridot)
- Granular – occurs in aggregates (jadite, nephrite)



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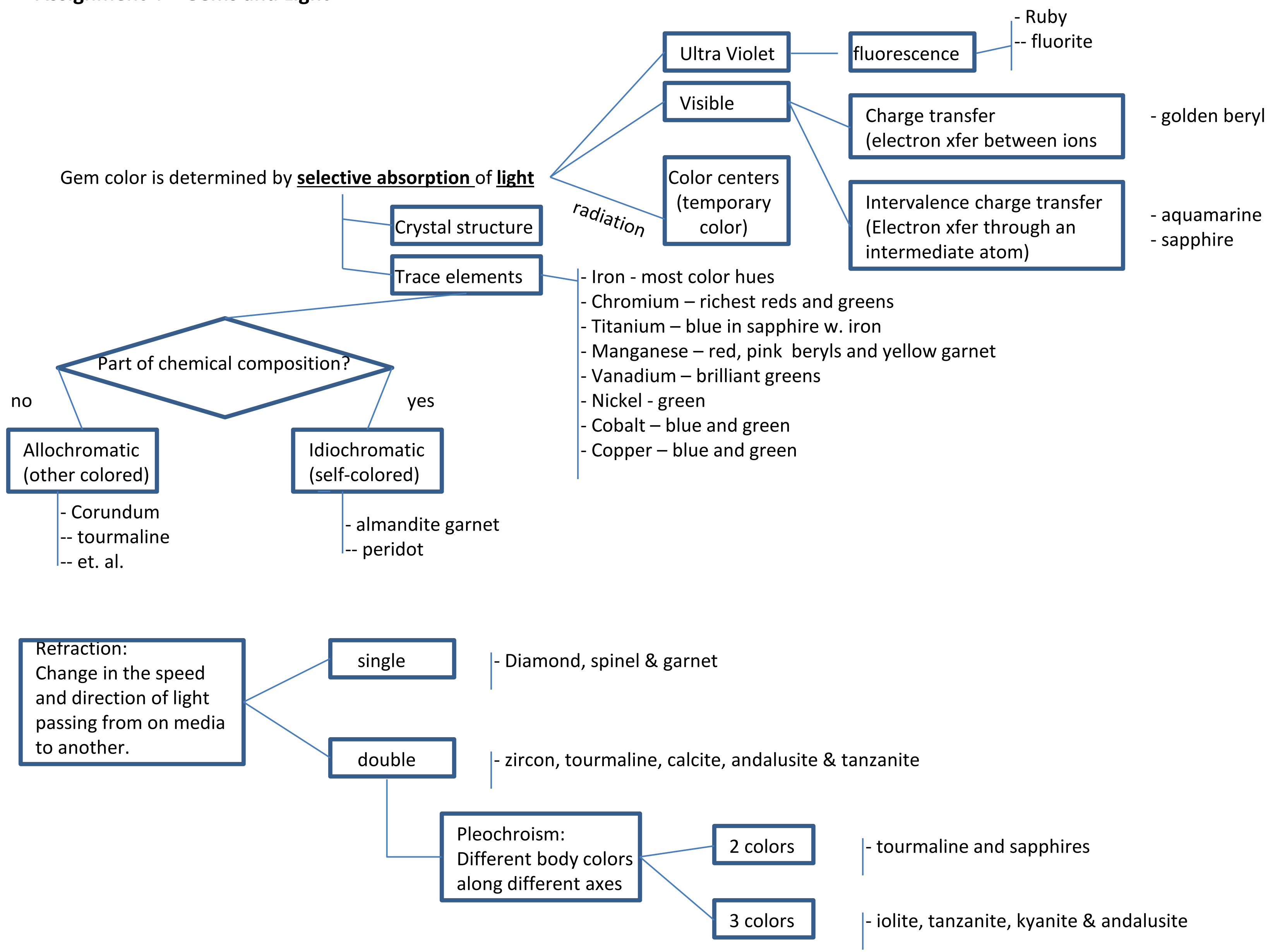
Assignment 4 – Gems and Light



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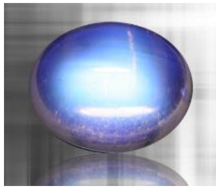
Gem Phenomenon

Adularesence: Adularescence is the phenomenon of blue sheen reflecting on the domed cabochon surface of Moonstone. The phenomenon of shimmer is created by the interaction of light with layer of little “albite” crystals in the moonstones. The quality of blue shimmer is determined by the thickness of layer of these tiny crystals, thinner the layer, better the blue flash. This usually appears as a billowy light effect. Moonstone is orthoclase feldspars and are also known as Selenite. The Romans called them Astrion. (moonstone from India and Afghanistan)



Asterism: The gem material that is low on clarity is often cut as cabochon. In such gems and stones when the light falls on the domed surface and makes star - like rays, the phenomenon is called asterism. There are 4 ray and 6 ray stars observed normally. This happens when the orientation of the needle like inclusions or silk within the crystal is on more than one axis. (rose quartz and Garnet)

Aventurescence: The gem exhibiting this phenomenon appear to have sparkles that sparkle in the light .The glittery effect is created by the presence of plate-like or leaf-like inclusions interspersed throughout the gem. Light encountering these myriad inclusions are reflected back to the viewer. Aventurine quartz and orthoclase feldspar (sunstone) are examples. (quartz and sunstone)

Chatoyancy: Chat in French means Cat and chatoyancy refers to a phenomenon akin to opening and shutting of cat’s eye. This phenomenon can be seen in Chrysoberyl cat’s eye gem with great clarity. Cat eye gems have a single sharp band (sometimes two or three bands)running across the domed cabochon surface. The rutile silk in this case is aligned perpendicular to the crystal. So when light falls on it, the sharp band can be seen. In the best cases, the chatoyant Chrysoberyl cats eye visually separates the surface into two halves creating the **milk and honey effect** as the stone is moved under light. (Tiger eye and Hawk’s eye)

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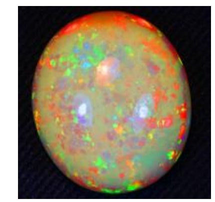
Gem Phenomenon cont.

Iridescence: Iridescence is also known as *goniochromism*, a phenomenon where the surface of a material displays several colors as the angle of viewing changes. The irregularity of surface and large interstitial spaces allow light to pass and reflect back from multiple surfaces (diffraction) causing the multi color visual effect. Combined with interference, the result is dramatic. Natural pearls display iridescence that is very different from its body color. Tahitian pearls display great iridescence. (fire agate)

Play of color: The wonderful gem called opal displays a beautiful color. The fire opals from **Lightening Ridge, Australia** (showing shifting patches of luminous spectral colors against black) are famous for this phenomenon. While this phenomenon- play of color is a type of iridescence, it is wrongly called fire. Fire is actually a term used for the brilliant flashes of color in a diamond which is caused by dispersion of light. In case of opals it isn't dispersion and hence cannot be called fire.(opal)



Pleochroism: Pleochroism is a phenomenon where a gemstone appears to have a different color when viewed from a different direction. Iolite, also known as dichroite displays exceptional pleochroism where the usual violet blue color changes to a grayish-yellow. Kunzite, kyanite and unheated tanzanite among others are also pleochroic. These gems are all doubly refractive gemstones.

IOLITE (BLUE ASPECT) IOLITE (COLORLESS ASPECT)

Color change: The most famous example that can be taken in reference to color change is the alexandrite. These gems and stones appear very different in incandescent light compared to natural day light. This is largely due to the gems chemical composition as well as strong selective absorption. The alexandrite appears green in daylight and appears red in incandescent light. The phenomenon of color change can be found in sapphires and tourmaline also.

Labradorescence: Labradorescence is iridescence but is highly directional because of twinning of crystals. It is found in the gemstone called labradorite.

Assignment 5 Synthetics and Imitations

Melt Processes – faster and less expensive

Flame Fusion
Powdered chemicals released to a flame and fused into a boule

corundum
spinel
rutile

Pulling (Czochralski)
A seed is placed on the surface of melted material and pulled slowly to form a boule

alexandrite
corundum
crysoberyl
YAG – garnet
GGG - garnet

Floating Zone
A heated coil is passed over a sintered rod to melt and cool into a crystal.

alexandrite
corundum
crysoberyl

Skull
Ziconium oxide is melted in a vessel that is cooled, but induction heated to form CZ crystals

CZ

Solution Processes – slower and more expensive

Flux
Gem nutrients are dissolved in flux in a corrosion resistant crucible, cooled to form crystals. Seeded or spontaneous nucleation

emerald
corundum
alexandrite
spinel

Hydrothermal
Crushed material is placed in the bottom of an autoclave with water above. Dissolved material floats up to build on seed crystals.

quartz
rose auartz
citrine
emerald

Other Processes

Gilson
3 step process
1 – precipitate silica spheres
2 – settle & compress
3 – add silica to fill cracks
(result in snake skin appearance)

opal

Ceramic
Compress & heat finely ground material to make a fine grained solid

tourquoise
lapis lazuli

Sublimation
Vaporize silicon carbide and cool to recrystallize

moissanite

Natural vs. Synthetic	
2 phase inclusions	gas bubbles
More variety inclusions	less variety inclusions
Straight or angle growth	curved growth

Natural vs. Synthetic	
Ruby	red spinel
Tanzanite	amethyst, syn corundum, YAG, forsterite
Aquamarine	syn spinel or CZ

<u>Imitatations</u>
Diamond simulants
CZ, YAG, GGG, moissonite
Plastic
Glass

<u>Assembled Stones</u> (2 or more joined pieces)
- doublet *opal*
- triplet (3 stones or 2 stones and cement)

Assignment 6 - Treatments

Gemstone Enhancement Codes*

N = NOT ENHANCED	F = FILLING	O = OILING/RESIN
E = ROUTINELY ENHANCED**	H = HEATING	R = IRRADIATION
B = BLEACHING	HP = HEAT & PRESSURE	U = DIFFUSION
C = COATING	I = IMPREGNATING	W = WAXING/OILING IN OPAQUE STONES
D = DYEING	L = LASERING	

* Codes must appear in a column next to all gemstone descriptions, with a noticeable reference or label, at the bottom or back of invoices and memorandums. Codes and type of treatments must only be used as directed in the *Gemstone Information Manual (GIM)*, 7th Edition, available from the American Gem Trade Association (AGTA), Box 420643, Dallas, TX 75342-0643. Phone: 800-972-1162 • 214-742-4367

** The "E" code must only be used according to *Gemstone Information Manual (GIM)* instructions.

Heat Treatment
- Can destroy color centers
- Oxidizing environment can lighten
- Reducing environment can deepen

-corundum — Can remove silk
  sapphire
  ruby — In borax to remove blue & fill fractures
-tanzanite — zoisite brown to tanzanite blue
-zircon — brown to blue
-topaz
-aquamarine
-amber

Lattice diffusion (atomic penetration of the crystal lattice)
-titanium, chromium and beryllium
-can penetrate the entire stone
-very high heat yields a .01mm to .05mm color surface layer
-can be patchy

Fracture filling (common in beryls (emerald in particular))
-oils, polymers, waxes, resins, hardners, , ,
-should have RI close to stones RI

Dyeing (best on porous surfaces like lapis, chalcedony, jadite, coral, turquoise and pearl)
-quench-cracklng may be used to treat surface

Surface Modification (backings, coatings, or coloring agents (like paint))
-gold on quarts or topaz to make "aqua aura"

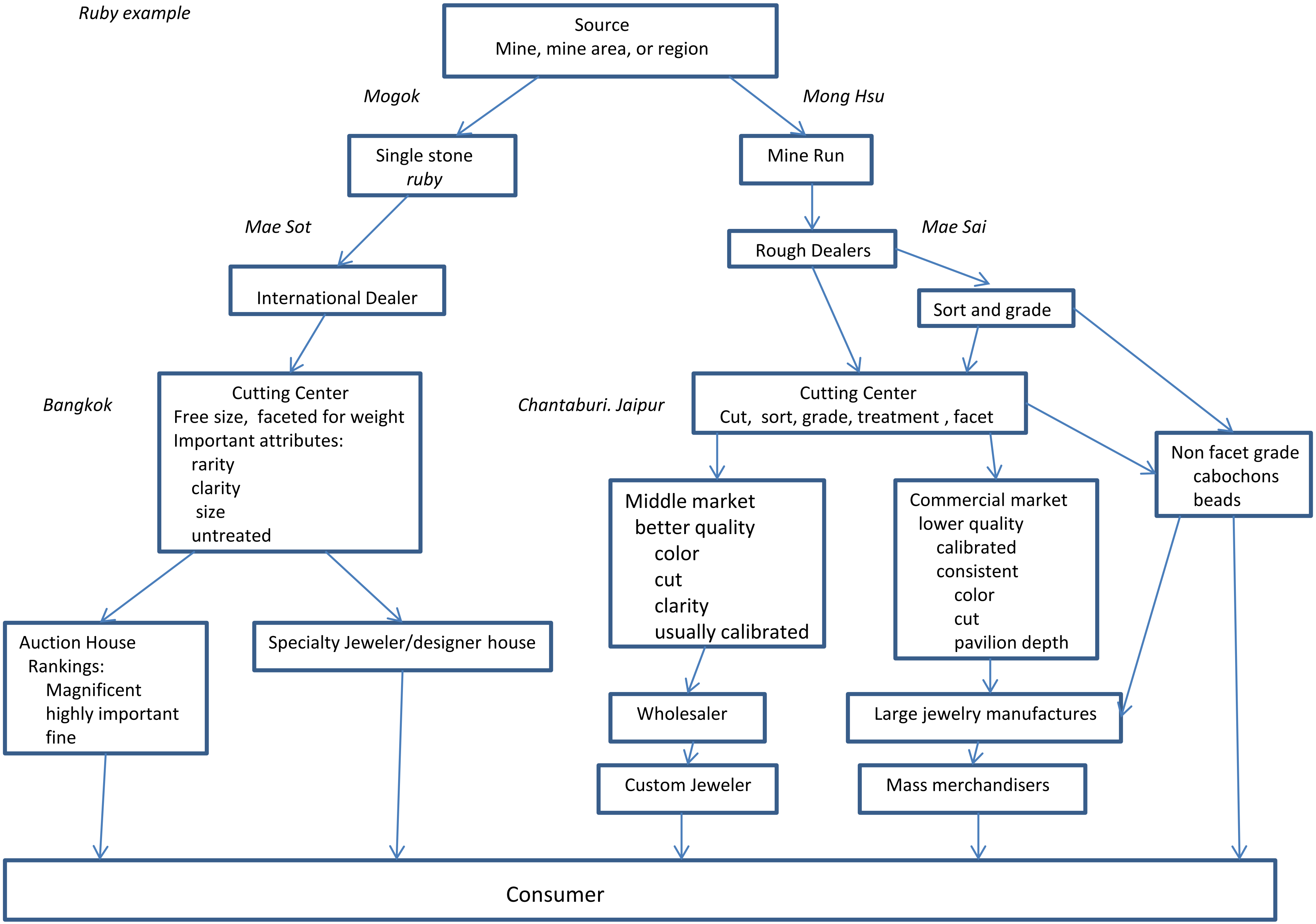
Irradiation (almost all topaz, colorless to various stable blues)
-Xrays, gamma rays, neutrons, electrons
-not always stable to light or heat

Bleaching and colorless impregnation (pearls, jadeite, turquoise, , ,)
-chemicals
-melted waxes, resin, polymers, plastics, , ,
turquoise → Zachary method

Smoke and Sugar treatments (used on opal)
-soak in hot sugar and then in sulfuric acid
-wrap in paper or similar and cook until smoke or ash penetrate opal

Assignment 7 - Market

Ruby example



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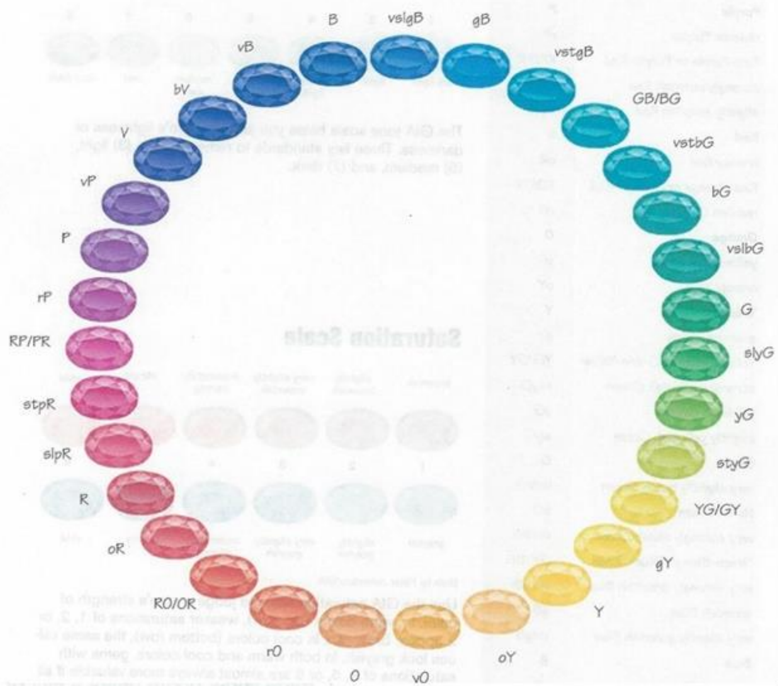
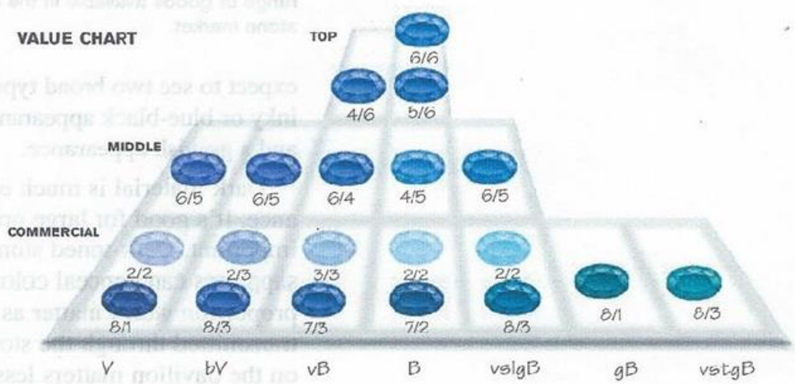
GIA Gem Grading System

Assignment 8 Color

Hue Wheel



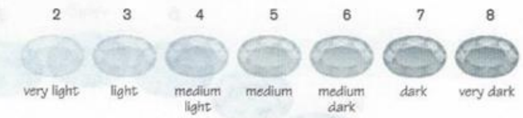


Peter Johnston/GIA

Variations in hue, tone, and saturation decide a gem's value. For example, although blue sapphires occur in a range of hues from violet to strongly greenish blue, dealers set the highest value on pure blue or violetish blue gems with strong to vivid saturation and medium-dark tones. Dark tones and greenish blue hues reduce a sapphire's value most dramatically.

HUES	ABBREVIATION
Purple	P
reddish Purple	rP
Red-Purple or Purple-Red	RP/PR
strongly purplish Red	stpR
slightly purplish Red	slpR
Red	R
orangy Red	oR
Red-Orange or Orange-Red	RO/OR
reddish Orange	rO
Orange	O
yellowish Orange	yO
orangy Yellow	oY
Yellow	Y
greenish Yellow	gY
Yellow-Green or Green-Yellow	YG/GY
strongly yellowish Green	styG
yellowish Green	yG
slightly yellowish Green	slyG
Green	G
very slightly bluish Green	vslbG
bluish Green	bG
very strongly bluish Green	vstbG
Green-Blue or Blue-Green	GB/BG
very strongly greenish Blue	vstgB
greenish Blue	gB
very slightly greenish Blue	vslgB
Blue	B
violetish Blue	vB
bluish Violet	bV
Violet	V
violetish Purple	vP

Tone Scale



The GIA tone scale helps you judge a gem's lightness or darkness. Three key standards to remember are (3) light, (5) medium, and (7) dark.

Saturation Scale

Both by Peter Johnston/GIA

Use the GIA saturation scale to judge a gem's strength of color. In warm colors (top row), weaker saturations of 1, 2, or 3 appear brownish. In cool colors (bottom row), the same values look grayish. In both warm and cool colors, gems with saturations of 4, 5, or 6 are almost always more valuable if all other factors are equal.

Grading Procedure

1. Determine TONE
2. Determine HUE
3. Determine SATURATION

Format: HUE, TONE/SATURATION

example: vslbG 5/6

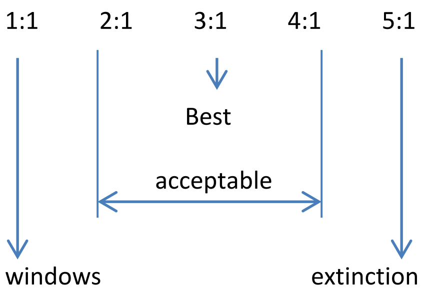
Assignment 9 - Cut

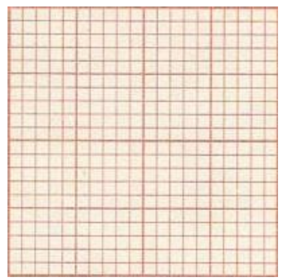
Style:
Brilliant   Step   Mixed

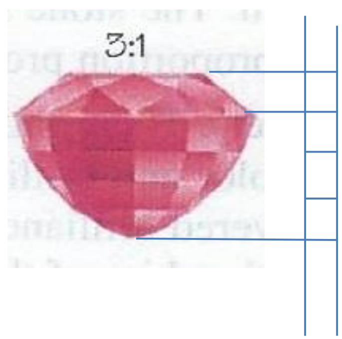
Proportions:

Length to Width Ration
Length / width
example: 12X6 = 2:! baguette
7X5 = 1.4:1 standard size

Crown height to Pavilion







Brilliance:
(ratio of light return to the face up area of the stone,
total area minus the area due to windows and extinction)

75% +	Excellent
60% - 75%	Very Good
40% - 60%	Good
25% - 40%	Fair
> 25%	Poor

Cut Grading Summary

EXCELLENT: No variations that reduce beauty or practicality

- Brilliance (light return) 75 percent or greater in the face-up position
- Minute variations in face-up and profile symmetry that don't make the gem less attractive or cause serious light leakage
- Attractive face-up outline (good curves and symmetry)
- Length-to-width ratio conforms to trade preferences
- Acceptable bulge, girdle thickness, and table size
- Excellent polish and facet placement

GOOD: Minor variations that have some effect on face-up brilliance and symmetry

- Brilliance (light return) 40 to 75 percent in the face-up position. Give the gem a "very good" rating if it's between 60 and 75 percent.
- Minor variations in crown-height to pavilion-depth ratio causing some light leakage
- Minor variations in face-up symmetry that diminish attractiveness a little
- Bulge, girdle thickness, and table size more noticeable
- Some noticeable imperfections in facet arrangement and polish

FAIR: Noticeable variations (easily seen)

- Brilliance (light return) 25 to 40 percent in the face-up position
- Uneven pavilion facets might be visible through the crown
- Noticeable variations from optimum crown-height to pavilion-depth ratio and pavilion symmetry, resulting in considerable light leakage
- Length-to-width ratio more extreme

POOR: Obvious variations (very easy to see)

- Brilliance (light return) less than 25 percent in the face-up position
- Face-up outline might be uneven or not symmetrical
- Profile might reveal extreme shallowness or extreme depth, resulting in very obvious light leakage
- Poor finish, facets might be unsymmetrical, polish lines and abrasions possibly visible

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Assignment 10 - Clarity

Value Characteristics
- Transparency
- Brilliance
- Durability

Inclusion Phases
- Phase I – one of gas bubble, liquid, or crystal
- Phase II – two of gas, liquid, or crystal
- Phase III – all three, gas, liquid, and crystal

Internal

Negative crystal – an angular hollow space that resembles a crystal

Needle – a long thin crystal or tube with gas or liquid
Group of Needles may form "silk"

Finger print – pattern of dots that resemble a finger print

Feather – a general term for a break or fracture

Cloud – a hazy or milky area

Pinpoint – a minute inclusion

Cavity – opening that goes to the surface

External

Chip – on surface, usually near girdle
Scratch – linear mark, straight or curved
Abrasion – wear marks, nicks or pits, usually on facet edges
Polish Lines – tiny parallel groves

Five Marketability Factors
1. Nature – What is it?
2. Size – How big is it?
3. Number – How many are there?
4. Position – Where is it (or are they)?
5. Relief – How much contrast with the body color?

Clarity Categories

TYPES	GRADES				
		Included?			
	Eye Clean	Slightly	Moderately	heavily	Severely
I Eye Clean					
II Eye Visible		*See chart*			
III Almost Always Included					

<u>Judging Tips</u>
Individual stones
take time
use loupe
use reflected light for surface blemishes
Parcels
look for consistency in color, weight, clarity, and size

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Assignment 10 - Clarity 2

CLARITY CATEGORIES

	EYE-CLEAN	SLIGHTLY INCLUDED	MODERATELY INCLUDED	HEAVILY INCLUDED	SEVERELY INCLUDED
TYPE I	The stone appears clean to the unaided eye.	Minute inclusions difficult to see with the unaided eye.	Minor inclusions somewhat easy to see with the unaided eye.	Inclusions are prominent and have a negative effect on appearance or durability.	Inclusions are prominent and have a severe effect on appearance, durability, or both.
Typical inclusions		• Included crystals • Liquid inclusions • Needles • Fingerprints	• Included crystals • Fingerprints • Feathers • Color zoning • Clouds	• Large, prominent inclusions that cause durability problems or loss of transparency	• Stones contain large and very prominent inclusions that affect durability, or numerous inclusions that substantially affect transparency. Stones often lack both beauty and durability.
TYPE II	The stone appears clean to the unaided eye.	Minor inclusions somewhat easy to see with the unaided eye.	Noticeable inclusions apparent to the unaided eye.	Inclusions are prominent and have a negative effect on appearance or durability.	Inclusions are prominent and have a severe effect on appearance, durability, or both.
Typical inclusions		• Included crystals • Liquid inclusions • Needles • Fingerprints	• Included crystals • Fingerprints • Feathers • Color zoning • Clouds	• Large, prominent inclusions that cause durability problems or loss of transparency	• Stones contain large and very prominent inclusions that affect durability, or numerous inclusions that substantially affect transparency, or both. Stones often lack both beauty and durability.
TYPE III	The stone appears clean to the unaided eye.	Noticeable inclusions apparent to the unaided eye.	Obvious inclusions very apparent to the unaided eye.	Inclusions are prominent and have a negative effect on appearance or durability.	Inclusions are prominent and have a severe effect on appearance, durability, or both.
Typical inclusions		• Included crystals • Liquid inclusions • Needles • Fingerprints	• Included crystals • Fingerprints • Feathers • Color zoning • Clouds	• Large, prominent inclusions that cause durability problems or loss of transparency	• Stones contain large and very prominent inclusions that affect durability, or numerous inclusions that substantially affect transparency, or both. Stones often lack both beauty and durability.

Assignment 11 – Carat Weight and the Gem Business

Weigh colored stones to .001. round to .01
Measure stones to .01mm

Calibrated Cuts:

Rounds:

	- +
1.00mm incr	
	- 5.00mm
.50mm incr	
	- 3.50mm
.25mm incr	
	- 1.50mm, 1.75mm

Ovals:

4x3, 5x3, ***6x4****, ***7x5****, ***8x6****, 9x7, 10x8, 12x10
**most widely used*

Squares:

2x2, 2.5x2.5, 3x3, 4x4

Pears:

5x3, 6x4, 7x5, 8x5, 9x6, 10x7

Hearts:

4x4, 5x5, 6x6

Judging Gems

Ask yourself these questions about a gem's color:
- Is the color attractive?
- Is the tone light, medium, or dark?
- Is the hue pure,or is it a combination of hues?
- Is the hue saturated or de-saturated—how much color is there?
- Is the color even or uneven? If it's uneven, is it distracting?

Ask yourself these questions about a gem's cut:
- How much of the crown area shows brilliance?
- Are there any significant light areas of low color intensity (windows) on the crown?
- Are there any significant dark areas of low color intensity (extinction) on the crown?
- Are there light or dark areas concentrated in one part of the stone?
- Is the pavilion off center, too deep, or too shallow?
- Is the face-up outline symmetrical and attractive?
- Is the polish good?

Ask yourself these questions about a gem's size:
- How large is the gem?
- Is it calibrated?

Consignment – A selection of goods loaned to a dealer by another wholesaler of gem cutter

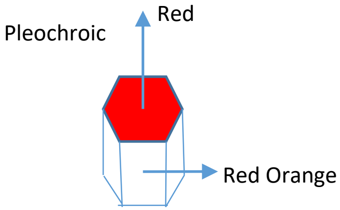
Memo – A buying agreement where a dealer entrusts merchandise to a client for inspection and approval without requiring immediate payment

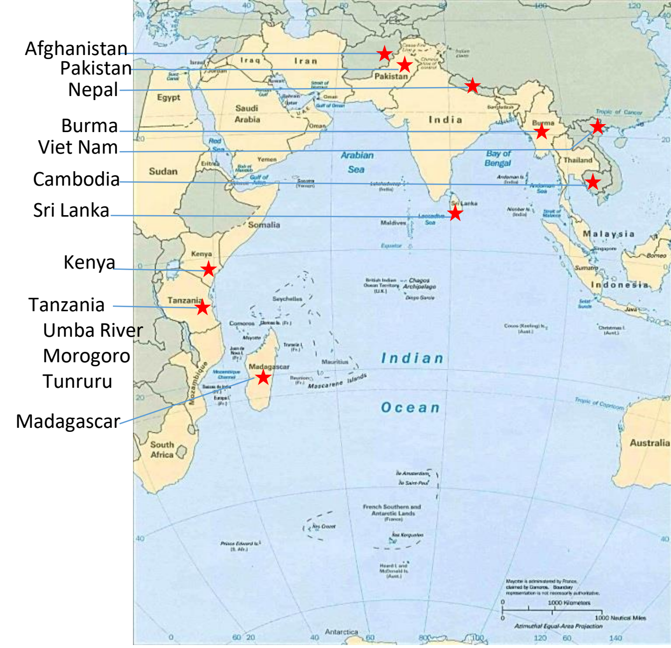
Assignment 12 - Ruby

Hue: Red to SlpR
Hardness: 9
Spgr: 3.99 – 4.00
Crystal: Trigonal
R.I.: 1.761 – 1.769

Four Ruby Descriptions

1. Natural and not enhanced
2. Heated, but no residue
3. Heated, but with residue
4. Evidence of fracture fill





Sources

Metamorphic Marble (florescent)	Volcanic Basalt (no florescence)	Metasomatic (desiication)
- Mogok	- Thailand	- Kenya
- N. Viet Man	- Cambodia	- Sri Lanka
- Himalayas		- Tanzania
		- Central Viet Nam

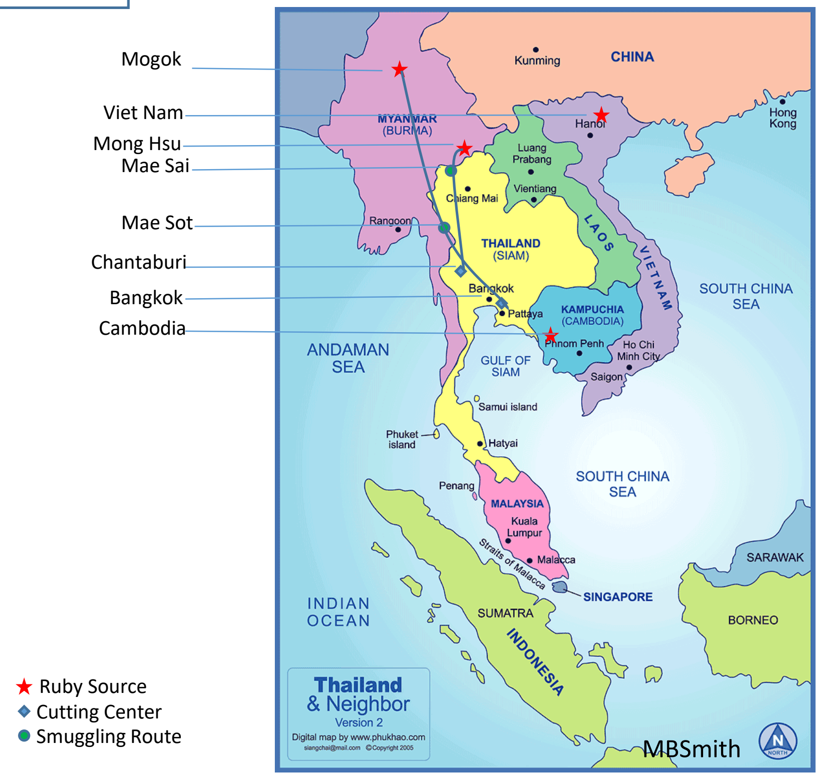
Treatments

<u>Heating</u>
- improve color
- decrease banding & zoning
- remove inclusions
- Thai rubies to drop brownish tones
- Sri Lanka rubies to more intense red
- Mong Hsu to lose color centers

<u>Fracture fill</u>
- Flux fill
- glass fil

Market

- commercial, Mong Hsu
- Good
- Fine Quality, Mogok



Imitations

- Glass
- Spinel
- CZ
- Garnet
- Dyed corundum
- Quartz

Synthetics

- Flame fusion, quick and inexpensive
- Flux, slower but better quality (Chatham Inc and J.O. Crystal are suppliers)
- Pulling, industrial uses
- Hydrothermal, expensive and slow (Russia is major supplier)

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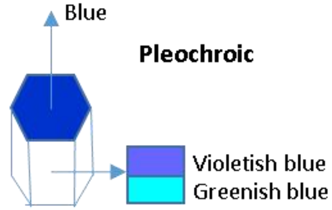
Assignment 13 – Blue Sapphire

Hue: violet to very slightly green Blue
Hardness: 9
Spgr: 3.99 – 4.00
Crystal: Trigonal
R.I.: 1.761 – 1.780

Pleochroic



Market
- commercial, Mong Hsu
- Good
- Fine Quality, Mogok

Treatments

Heating
- improve color
- decrease banding & zoning
- remove inclusions
- Thai rubies to drop brownish tones
- Sri Lanka rubies to more intense red
- Mong Hsu to lose color centers

Fracture fill
- Flux fill
- glass fil

Imitations
- Glass
- Spinel
- CZ
- Garnet
- Dyed corundum
- Quartz

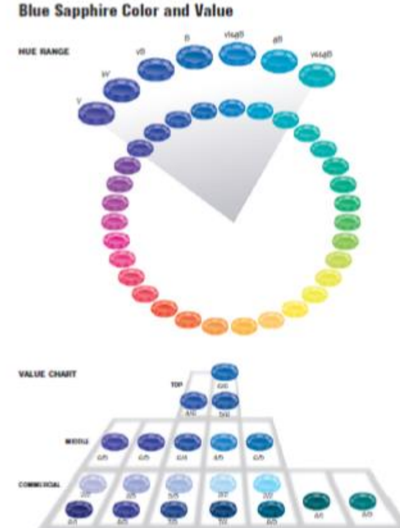
Synthetics
- Flame fusion, quick and inexpensive
- Flux, slower but better quality (Chatham Inc and J.O. Crystal are suppliers)
- Pulling, industrial uses
- Hydrothermal, expensive and slow (Russia is major supplier)

Kashmir	Pure blue to violetish Blue	B - vB
Burmese	Blue to slightly violetish Blue	B - slvB
Sri Lankan	Blue to violetish Blue	B - vB
Palin	Violetish Blue to very slightly green Blue	vB - vslgB
Kahchanaburi	Blue to slightly green Blue	B - slgB
Thai	Violetish Blue to slightly green Blue	vB - slgB
Australian	Violetish Blue to strongly green Blue	vB - stgB
Montana	Blue to violetish Blue	B - vB

Sources

Peter Johnston/GIA
Sapphire sources are located worldwide, from the United States to China. Major producers are found in Southeast Asia, Africa, and Australia.

Blue Sapphire Color and Value



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Assignment 14 – Fancy Sapphires

Hue: all colors
Hardness: 9
Spgr: 3.99 – 4.00
Crystal: Trigonal
R.I.: 1.761 – 1.780

Coloring Agents
- Pink – chromium
- Yellow and Orange – iron and some chromium
- Green – iron for yellow and iron & titanium for blue

Phenomenon
- Color Change via vanadium
- Star via asterism from rutile, hematite or both (black)

Treatments

Heating
- improve color
- decrease banding & zoning
- remove inclusions

Lattice Diffusion
- with beryllium for Padparadscha
- with titanium or hematite for Stars

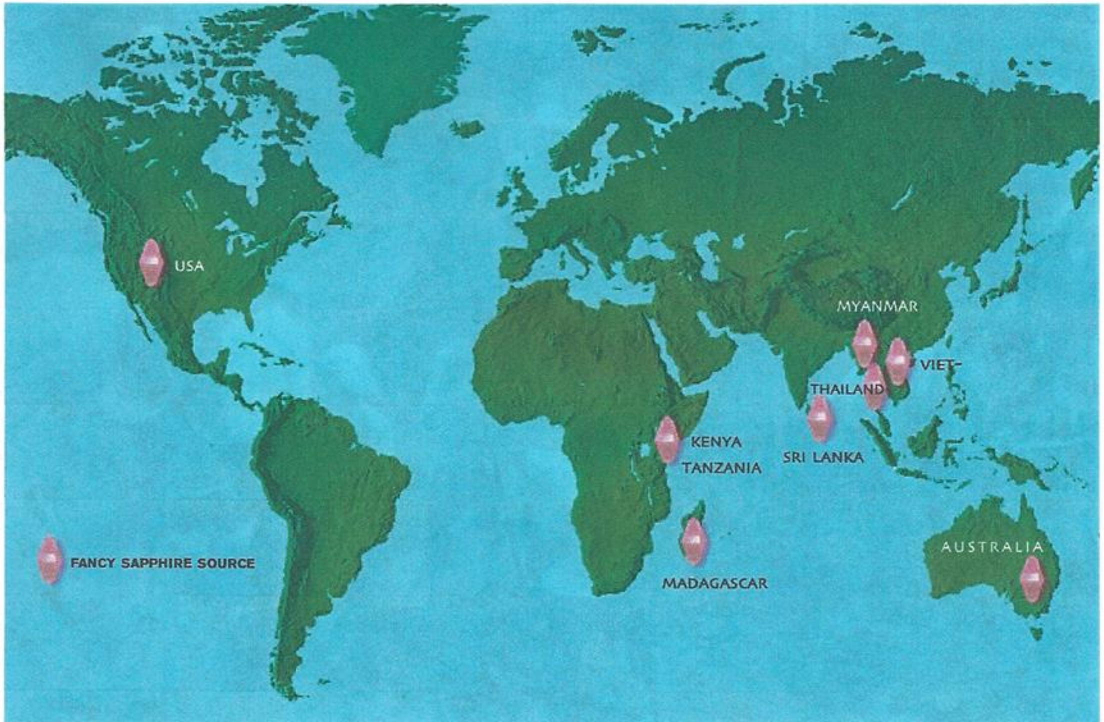
Irradiation
- turn yellow to orange (unstable)

Fracture fill
- Flux fill
- glass fill

Imitations
- Glass
- Spinel
- CZ
- Garnet
- Dyed corundum
- Quartz
- doublets, green on top, synthetic pavilion

Synthetics
- Flame fusion, quick and inexpensive, and most used (Linde 1947)
- Flux, slower but better quality (Chatham Inc and J.O. Crystal are suppliers)
- Pulling, industrial uses
- Hydrothermal, expensive and slow (Russia is major supplier)
- floating zone

Sources



Peter Johnston/GIA

Sources of fancy sapphire and phenomenal corundum are scattered across the globe. The stones are mined in many of the same places as blue sapphire and ruby.

Sri Lanka
- primary source of Padparadscha
- 60% Blue
- 15% Red, Pink and Purple
- 25% Orange and Yellow
- also 90% of the Stars

Africa
- Tanzania, some Padparadscha
- Malawi
- Kenya
- Madagascar, good Pink

Myanmar, Mogok for Pink, star ruby and sapphire
Thailand, black stars
Australia, black stars
USA, Montana

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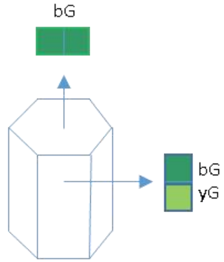
Assignment 15 - Emeralds

Hue: bluish Green to Green (slbG – G)
Hardness: 7.5 – 8.0
Spgr: 2.67 – 2.78
Crystal: hexagonal
R.I. : 1.565 – 1.602



Coloring Agents
- Green, chromium and vanadium
- Blue, iron

Trade Terms for Emerald Color
- Colombian; slbG, medium to medium dark tone strong to vivid saturation
- Zambian; slightly darker and more bluish than Colombian, higher clarity & irregular crystals
- Sandawana (Zimbabwe); bright intense green and smaller size
- Brazilian; lighter tone than Colombian

Treatments
- almost all emeralds show inclusions to the naked eye and require treatment for filling fractures
- cedarwood oil (not permanent)
- resins (sometimes with hardners)(sometimes w. dye)
- New proprietary (ExCel)

Imitations
- glass
- CZ
- YAG
- beryl triplet

Peter Johnston/GIA

The most economically important emerald sources are in South America and sub-Saharan Africa.

Synthetics
- Fluz; Chatham & Kyocera
- Hydrothermal; Lecheitner, Tairus (Russian and Thai)

Colombian
- Mining Areas
  - Muzo
  - Coscuez
  - La Pita
  - Chivor
- Cutting and Sales
  - Bogata
    - Emerald Trade Ctr

Brazil
- Mining Areas
  - Bahia
  - Goias
  - Minas Gerias
- Cutting and Sales
  - Sao Palo
  - Teofilo Otoni

Zambia
- Government owned
  - Kagem
  - Grizzly

Zimbabwe
- Mining Area
  - Sandawana

Madagascar

Major Cutting Centers
- India (Jaipur)
- Israel

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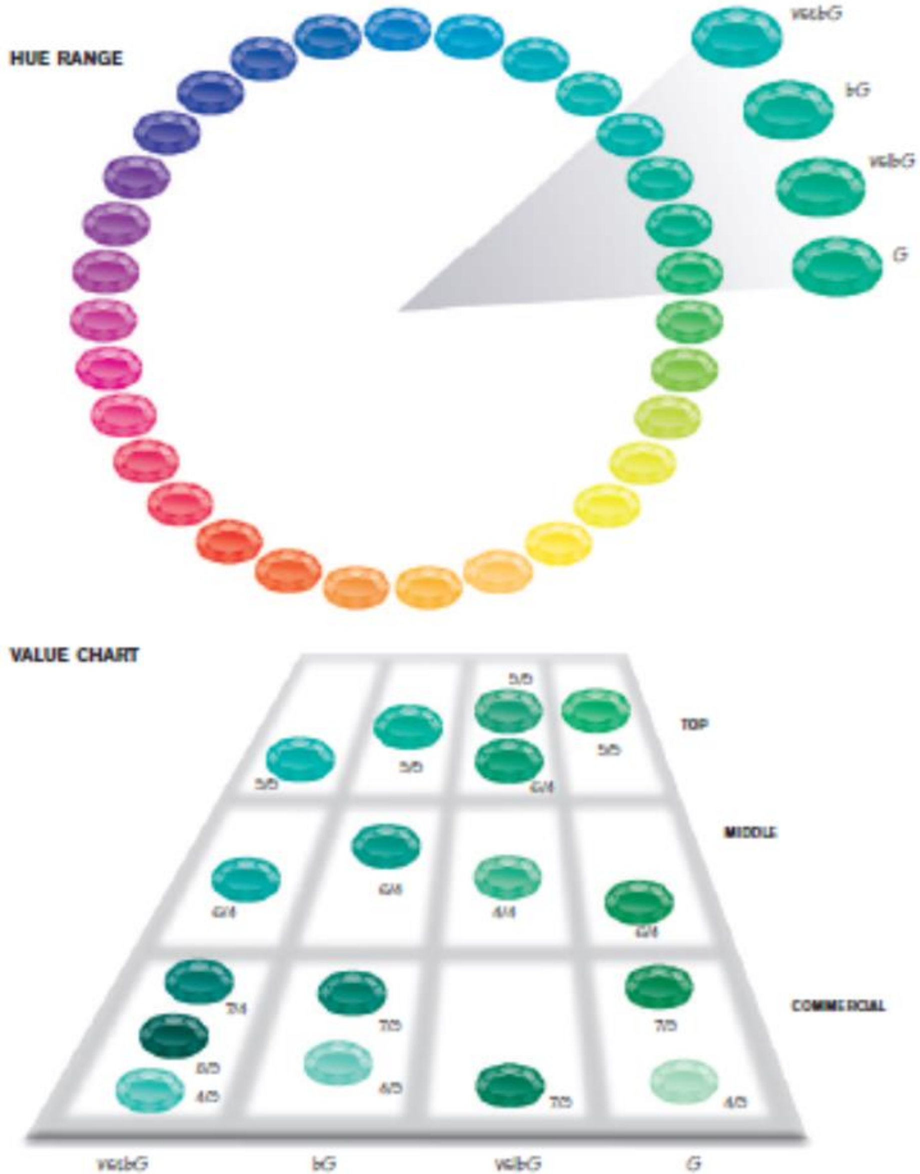
Emerald Color and Value



Peter Johnston/GIA

The four colors outside the hue wheel show the range for emerald. The value chart arranges

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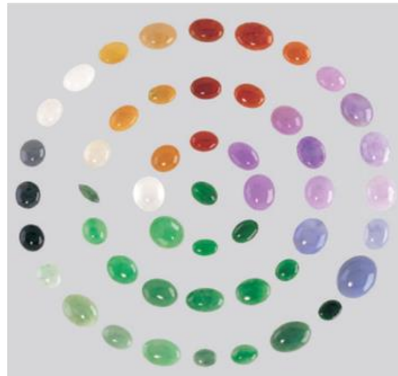
Assignment 18 - Jade

Jadeite (pyroxene)	**Nephrite (amphibole)**
Sodium Aluminum Silicate	Calcium, Magnesium, iron Silicate
[$NaAl(Si_2O_6)$]	$Ca_2(Mg,Fe)_5(Si_4O_{11})_2(OH)_2$
Crystal System: monoclinic	Crystal System: monoclinic
Spgr: 3.30 – 3.36	Spgr: 2.90 – 3.02
Hardness: 7	Hardness: 6.5
RI: 1.654 – 1.667	RI: 1.600 – 1.641
Florescence: green	Florescence: none
Transparency: opaque to semi transparent	Transparency: Opaque

Imitations
Synthetic jadeite produced by GE
Doublets, w. green dye or glue
Assembled stones
Glass
Plastic

Substitutes
Maw Sit Sit, aggregate stone w. jadeite
Serpentine, Korea, New Zealand (greenstone)
Chryophase Chalcedony, Australia
California Idocrase, vesuvianite, Chico California
Hydroglossular garnet, Mexico et.el.

Treatments
Type A – natural with only surface wax
Type B – natural, bleached with acid and impregnated with wax or polymer
Type C – natural, bleached with acid dyed and impregnated with wax or polymer



Colors of Jadeite (Imperial Jade in center)
Green – chromium
Lavender – ion transfer between Fe & O_2
Red – iron?
Black - ?
White - ?
mottled – white and green (moss on snow)

Textures
finest – Old Mine
medium – Relatively Old Mine
coarsest – New Mine

Buying and Judging
Show points – spots of color near the surface also called "pine flowers'
(wet the boulder to see color)
River Jade – weathered with thin skin
Mountain Jade – thick skinned
hololith – item carved from a single piece of rough

Cutting styles
beads
rings
bangles
cabochons
carvings

Value scale*
1 – Imperial
2 – grassy or apple green
3 – green with gray or black overtone
* lavender can come after Imperial

Peter Johnston/GIA

British Columbia
old mine – nephrite
3 mines in NW, 110 mi E. of Juneau AK
Polar jade, hi quality semi transparent

Guatemala
jadite from Motagua Valley

China
mines in NW
Main global polishing center
Hong Kong is the major trade center

Myanmar
Hpakan jadite
tract runs from Maw Sit to Kanai following the Uru and Hwe rivers

New Zealand
S. Island, nephrite
serpentine (bowenite)
[both called 'green stone')

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Opal (Precious and Common)

Composition: Hydrated silica gel
Hardness: 5.5 – 6.5
Spgr: 1.98 – 2.20
RI: 1.44 – 1.46
Crystal: amorphous
Formed: 15 – 30 million years ago
Water: 3% to 10%

Peter Johnston/GIA

Opal Types

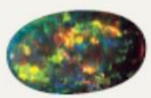
BLACK OPAL
Background color ranges from translucent to opaque black to dark gray, but should appear black in reflected light; shows play-of-color

Categories
gray base color
semi black
crystal

WHITE OPAL
Background color ranges from translucent white to medium gray; shows play-of-color

Bulk of commercial mkt

CRYSTAL OPAL
Background color ranges from transparent to semitransparent; shows exceptional play-of-color



WATER OPAL
Background color ranges from transparent to translucent; shows faint play-of-color or no play-of-color at all

jelly

BOULDER OPAL
Includes host-rock fragments, or matrix, as part of the finished gem; shows play-of-color

Host matrix
sandstone
ironstone

FIRE OPAL
Background color ranges from reds and oranges to yellows; might or might not show play-of-color

Red fm iron

ASSEMBLED OPAL
Precious opal layers, or layers of precious opal and other material, cemented together to improve durability and appearance

Treatments
Sugar and acid
Smoked with paper

Synthetics
Gilson
impregnated with plastic

Imitations
glass (Slocum stone)
Plastic, Japanese '80s

Evaluation Procedure

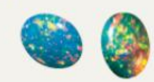
1- Place opal face up on flat surface
2- rotate 360⁰
ck play of color, symmetry, and polish
3- Hold to light, determine ratio 'play of color' to background color
4- rotate against dark background for visibility of 'play of color' and brilliance
5- check thickness
6- Determine dominant phenomenal color
7- Determine pattern, pinfire, flash, or harlequin
8- Determine relationship of colors, red is best, red followed by blue, etc.
9- Determine transparency
10- determine surface quality, crazing, pits, abrasion

How to Evaluate an Opal

Opal evaluation consists of five steps, which should be done under controlled lighting on a dark background. Rotating the opal against the background helps when you're determining its type and evaluating its play-of-color and cut.

TYPE
Determine the type of opal
- Black
- White
- Crystal, etc.

PLAY-OF-COLOR
Determine the ratio and quality of the play-of-color
- Percentage compared to background
- Intensity
- Dominant hues
- Range of color
- Pattern



TRANSPARENCY
Determine the opal's transparency
- Transparent, opaque, etc.

CLARITY
Determine the opal's clarity
- Presence of matrix, crazing, pits, etc.

CUT
Evaluate the cut
- Symmetry
- Thickness
- Polish
- Sizing and calibration

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Assignment 20 – Quartz and Chalcedony

Composition: Silicon dioxide (SiO_2)
Hardness: 7
Spgr: 2.65
RI: 1.544 – 1.553
Crystal: trigonal

Amethyst
- best is reddish purple to purple with no color zoning
- color is from irradiated iron impurities
- Grades: AAA – high saturation
  - AA – less saturation, minor inclusions
  - B – lighter tone
  - C – lighter still, grayish to pale purple
- Major sources, Zambia (best), Brazil (commercial)
- Cutting – Germany, Thailand, India, China, *(Russia)*
- Treatments – heating and dyeing
- Synthetics – hydrothermal process (industrial uses)
- Prices – xtra fine = $15/ct, commercial = $1 to $3/ct

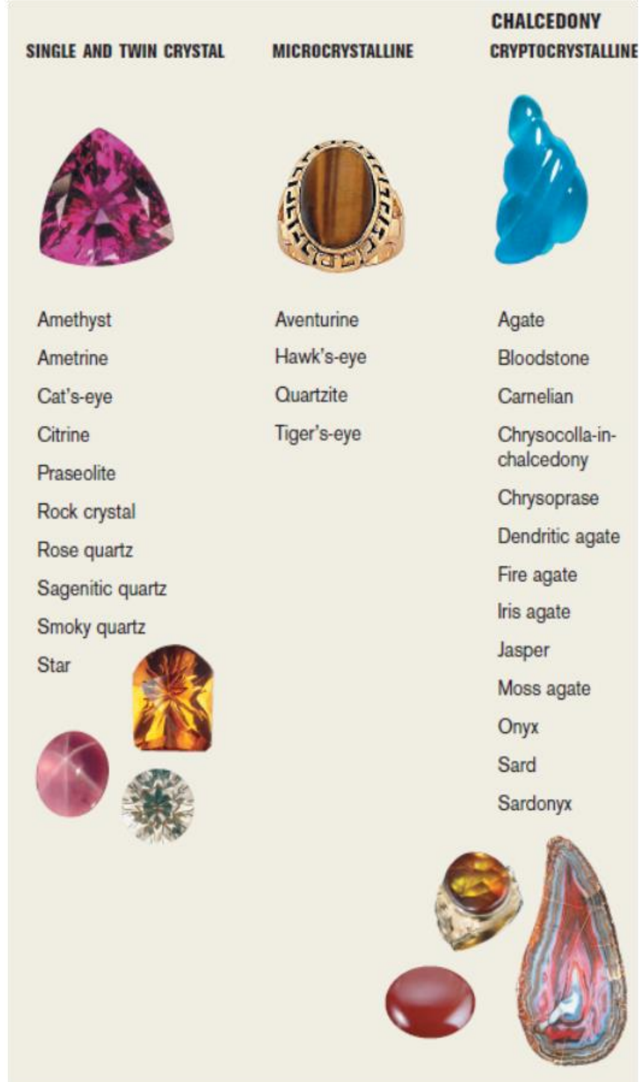
Ametrine
- color is zoned yellow and purple
- source - Bolivia
- Prices - xtra fine = $8 to $10/ct, commercial = $1 to $3/ct

Citrine
- color, pale yellow to brownish orange
- sources – Bolivia, Uruguay, Mexico, Spain, Madagascar (most citrine on market is heated amethyst)
- Prices – xtra fine = $15/ct, commercial = $1 to $3/ct

Rose Quartz
- color, very light pink to medium-dark pink
- asterism occasionally
- sources – Brazil (best), India, Madagascar, Sri Lanka

Rock Crystal
- color, clear or with Sagenitic inclusions of rutiles or tourmaline
- quench crackled and dyed to imitate orher stones

Smoky Quartz
- color, light yellowish brown to almost black, from natural radiation that creates color centers involving aluminum
- sources – Brazil (best), Switzerland, US



Chatoyant Quartzes
- Tiger eye
  - color, yellow and brown bands variegated grayish blue and brown is “zebra tiger'seye
- Hawk's eye
  - color grayish blue quartz
- Cat's eye
  - color, brownish yellow/green, y/grn
  - sources – India, Sri Lanka, S. Africa Myanmar, W. Australia

Quartzite
- Aventurine is gem quality quartzite color from green mica inclusions
- Aventurine sources – Brazil, Russia, Tanzania
- quartzite is often dyed
- Sources, India, Brazil, Russia, Tanzania

Chalcedony
- used in jewelry for over 3000 years
- botryoidal = crystal growth habit, like bunch of grapes

Chryophase
- color, medium yellow green from nickel silicate can be bluish green if colored by chromium
- Sources – Queensland (best), Brazil (olive green), Tanzania (lighter yellowish green), India, Czech, Slovakia, and the US
- Substitute – soak gray chalcedony in acid, chromium, and nickel

Chrysolla in Chalcedony
- color, best is evenly distributed translucent blue hue
- sources – Globe,AZ, Mexico
- Substitute – dyed chalcedony

Carnelian and Sard
- color, yellowish orange to brownish orange semi-transparent to translucent
- sources – Brazil, India, Uruguay
- Substitute – heat treated pale brown chalcedony
- Sard – darker and less saturated color

Onyx and Sardonyx
- color, white, black and reddish bands
- Sources – Brazil, Madagascar, US, Uruguay

Jasper and Bloodstone
Sources – Australia, Brazil, China, India, US

Fire Agate
- color, brown with botryoidal phenomenal iridescence
- Sources – San Luis Potosi, Jalisco MX
- Prices – Xtra fine $10 to $20/ct

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Assignment 21 – Tanzanite, Iolite, Chrysoberyl, and Andalusite

Zoisite

Tanzanite

Composition: $Ca_2Al_3(O/OH/SiO_4/Si_2O_7)$
Hardness: 6
Spgr: 3.10 – 3.38
RI: 1.692 – 1.702
Critical Angle:
Crystal: Orthorhombic

Color: blue to blue-violet
most are brown and heat treated for blue
Pleochroic colors: violet blue to brown
Imitations: Synthetic Fosterite, YAG(Tanavyte), bluish synthetic corundum (coranite), glass, synthetic garnet

Ruby in Zoisite, aggregate with red corundum, usually carved

Thulite, opaque pink zoisite, maybe streaked or mottled gray or white

Various colors of zoisite

Iolite

Composition: $Mg_2Al_3(AlSi_5O_{18})$
Hardness: 7 – 7.5
Spgr: 2.57 – 2.66 (all), 2.57 – 2.61 (gem)
RI: 1.53 – 1.55
Critical Angle:
Crystal: Orthorhombic

Color: violetish blue (from iron)
Pleochroic colors: violet blue to yellow/clear
Iolite is not heat treated
Sources: Sri Lanka, Kenya, Tanzania, Brazil, Africa, Madagascar, Norway, Finland

Andalusite

Composition: $Al(AlSiO_6)$
Hardness: 7.5
Spgr: 3.15 – 3.17
RI: 1.634 – 1.648
Critical Angle:
Crystal: Orthorhombic

Color: brownish or yellowish green to orangy brown, best is yellowish green and orange. Can be pink, brown, green or violet

Pleochroic colors: reds, greens, and oranges; pleochroism can be so strong all colors are visible from the top

Sources: Brazil, Sri Lanka, and Spain

With a special filter, you can see each of andalusite's pleochroic colors. Cutters orient the stone to show its most valuable reddish brown pleochroic color face-up.

Variety: Chiastolite, brown with dark cross resulting from carbon
Sources for Chiastolite are Siberia, S. Australia, Myanmar, Zimbabwe, Arizona and California

Maha Tannous/GIA

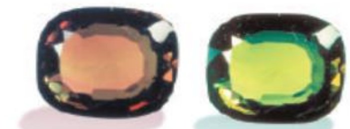
This 148.50-ct. sphere is a little-known andalusite variety called chiastolite. Inclusions cause the distinctive cross-shaped pattern on its surface.

Chrysoberyl

Composition: $Al_2(BeO_4)$
Hardness: 8.5
Spgr: 3.64 – 3.75
RI: 1.740 – 1.770
Critical Angle:
Crystal: Orthorhombic

Alexandrite

Color change: green in daylight, red in florescent due to chromium
Pleochroic colors: red, green and purple-red



Both by Alan Jobbins

While an alexandrite's hue changes under different lighting, its tone and saturation levels usually remain the same. This color-change alexandrite has low saturation in both its red and green hues.

Sources: Sri Lanka, Brazil, Russia (1830)
Synthetic: Czochralski, floating zone, and flux
Alternates: syn. Corundum and spinel

Cat's eye, chatoyant due to tiny needles or hollow tubes
Color: semi transparent yellow to greenish yellow or brownish yellow
Sources: Sri Lanka, Brazil,

Other (non chatoyant)
Chrysolite – greenish yellow
mint green – due to trace vanadium
yellows and browns

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Assignment 22 – Topaz and Beryl

Topaz

Eric Welch/GIA

Topaz crystals are typically elongated, with grooves parallel to their lengths. For this reason, they're commonly cut into long oval or pear shapes.

Composition: $Al_2(SiO_4)(F,OH)_2$
Hardness: 8
Spgr: 3.53 – 3.56
RI: 1.610 – 1.638
Critical Angle: 38°
Crystal: orthorhombic (basal cleavage a problem)
(cut with table 15° to cleavage direction)

Color: Allochromatic via trace elements and color centers
- Red – best color
- Pink - second best
- Sherry (precious)
- Golden or yellow, least valuable
- Colorless (mostly treated for blue)

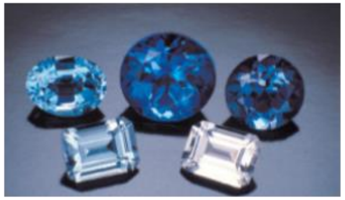
Sources: grows mostly in pegmatites
- Brazil Capao Mine in Ouro Pieto region of Minas Gerais, Brazil
  (Brazil cuts most of their production)
- Pakistan (Katlang)
- Sri Lanka

Treatments:
- heat yellow to get reddish brown
- heat brown to get pink
- irradiate then heat colorless to get blue
- heat with cobalt
- coat with metallic oxide for "mystic topaz"

Imperial Topaz –color medium reddish orange to orange – red

reddish pleochroic color should appear
at tips of finished stones

Colorless and Blue
- Colorless may be fashioned as is
- Colorless irradiated and heated for different durations to obtain various shades of blue
- Colorless may be heated with cobalt compound to get blue



Beryl

Andy Lucas/GIA

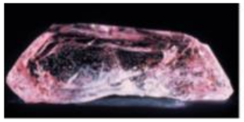
One of beryl's advantages is its wide color range. The crystals (top) show pastel shades: aquamarine's green-blue and blue, and morganite's pink. The golden crystals and gems (bottom) belong to a beryl variety called heliodor.

Composition: $Al_2Be_3(Si_6O_{18})$
Hardness: 7.5 - 8
Spgr: 2.65 – 2.75
RI: 1.570 – 1.600
Critical Angle: 39.5°
Crystal: Hexagonal (trigonal)
grows in pegmatites

Varities

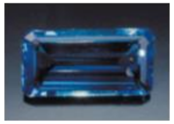
Aquamarine
Color: blue to greenish blue due to iron valence charge transfer
Sources:
Brazil is primary source, Pakistan is secondary, China for small commercial,
others are Australia, Kenya, Madagascar*, Mozambique*, Nigeria*, US, Zambia
Treatments: heat to remove yellow component
Synthetic ; Russia hydrothermally
Imitations: blue topaz, blue spinel, and glass
*best color of blue

Morganite
Color: pink, rose, peach and salmon from traces of manganese
pleochroic, pale pink and deeper bluish pink
Sources: Brazil, Afganistan, Mozambique, Namibia, US
Treatments: heat to improve the pink
Synthetic ; Russia hydrothermally



The 4.11 ct oval morganite from Madagascar is a fine pink color. Most morganite stones are heat treated to produce or improve their color. Since the treatment is undetectable, there's no way to tell if this stone was treated.

Maxixe
Color: Dark blue, but color fades due to light, heat, or irradiation



Red Beryl (Red Emerald) (bixbite), rarest beryl
Color: red due trace manganese
Source: single in rhyolite from Wah Wah mountains of Utah

Heliodor (Yellow or Golden)
Color: yellow from Iron
Sources: Brazil, Namibia, Sri Lanka

Like some other beryl varieties, heliodor can show a cat's-eye when it's properly oriented and cut as a cabochon.

Helidor treatment is generally undetectable. The finest heliodor—like this one—is generally left untreated.

Green
Color: bluish green to yellowish green due to iron and some chromium
Sources: Brazil, Zimbabwe, Australia

Eric Welch/GIA

Green beryl owes its color principally to iron, with possibly a small amount of chromium.

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Assignment 23 – Tourmaline, Peridot and Zircon

Tourmaline

Composition: Aluminum borate silicate
Hardness: 7 – 7.5
Spgr: 3.02 – 3.26
RI: 1.616 – 1.652 double refracting
Critical Angle: 38°
Crystal: Hexagonal (trigonal)

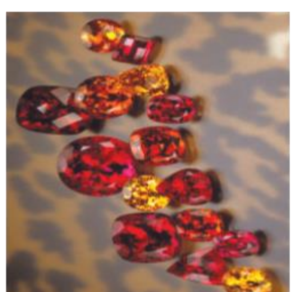
Species
- Elbaite – pegmatite with Al, Li, Na and rarely Cu
- Liddicoatite – pegmatite with Ca, Li, and Al
- Uvite – metamorphized limestone with Ca, Mg and Al
- Dravite - metamorphized limestone with Mg
- Schorl – pegmatite with Fe

Color:
- blue (indicolite), green (verdelite) – iron and titanium
- red, pink and yellow - manganese
- chrome tourmaline – vanadium and maybe chromium
  pure green is best
- pariba tourmaline – copper and manganese
- dravite – brown
- schorl – black

Sources:
- Brazil – major commercial source, rubellite and pariba
- San Diego – pink
- Africa, Afghanistan, Pakistan, Asia, Russia

Treatments:
- Heat to lighten and brighten blue and green
  change brown to rose or pink
- Irradiation – solid green to mix of green and red
  light pink, green and blue from light tones
- Acid – to remove inclusions

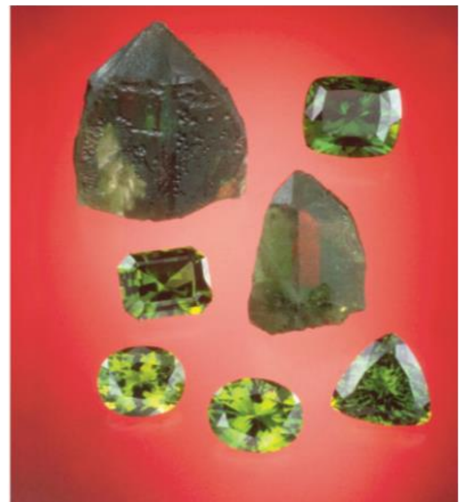
Simulantes: synthetic beryl and apatite



Peridot

Composition: $(Mg, Fe)_2SiO_4$
Hardness: 6.5 - 7
Spgr: 3.25 – 3.27
RI: 1.654 -1.690 double refracting
Critical Angle: 37°
Crystal: orthorhombic

Color: greenish yellow to yellowish green
best color is pure green



Shane McClure/GIA
The peridot crystals that line pockets or veins are generally of higher quality than those found as nodules in basalt. These well-formed crystals and fine fashioned gems are from the far western Himalayas of Pakistan.

Judging:
- A – eye clean, pure yellowish green, no brown
- B – clean, pale, good color, touch of brown

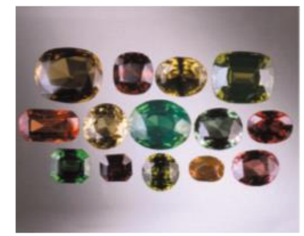
Source:
- Arizona major commercial source
- China is growing commercial source
- Pakistan and Myanmar best stones source

Treatments : none

Zircon

Composition: $Zr(SiO_4)$
Hardness: 6.5 – 7.5
Spgr: 3.90 – 4.71
RI: 1.777 – 1.978
Critical Angle: 31°
Crystal: tetragonal

Color:
- blue, green, yellow, red, brown, et.al.
- green maybe metamict from radiation



Classification Types:
- High – fully crystalline with little or no radiation damage
- Medium – fully crystalline with some radiation damage
- Low – extensive damage to crystal structure

Sources:
- SE Asia, Australia and Madagascar

Treatments:
- Heating to get the best blue
- Heating metamicts restores crystalline structure

Alan Jobbins
Heating zircon under the right conditions turns brownish or yellowish starting material into colorless or blue gems.

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Assignment 24 – Garnet and Spinel

Garnet

Pyrope
Composition: $Mg_3Al_2(SiO_4)_3$
Hardness: 7 – 7.5
Spgr: 3.65 – 3.80
RI: 1.730 – 1.760
Critical Angle: 35°
Crystal: rhombic. Dodecahedron
Color: red with brown tint (chromium)

Almandine
Composition: $Fe_3Al_2(SiO_4)_3$
Hardness: 7.5
Spgr: 3.95 – 4.20
RI: 1.78 – 1.81
Critical Angle: 34.5°
Crystal: rhombic. Dodecahedron
Color: Red with violet tint

Spessartite
Composition: $Mn_3Al_2(SiO_4)_3$
Hardness: 7 – 7.5
Spgr: 4.12 – 4.20
RI: 1.795 – 1.815
Critical Angle: 33.5°
Crystal: rhombic. Dodecahedron
Color: orange to red-brown

Pyrope ↘ Almandine ↙
Isomorphic replacement
↓
Rhodolite
(purplish red)

Isomorphous replacement—Substitution of one chemical element for another in the crystal structure of a mineral.

Found in Idaho

Bart Curren

As with star corundum, tiny needles of rutile cause asterism in some garnets. This 15.60-ct. star rhodolite garnet is a superb example. It features a strong four-rayed star and a fine transparent body.

Glossularite
Composition: $Ca_3Al_2(SiO_4)_3$
Hardness: 7 – 7.5
Spgr: 3.60 – 3.68
RI: 1.795 – 1.815
Critical Angle: 35°
Crystal: rhombic. Dodecahedron
Color: green, yellow, copper brown

Andradite
Composition: $Ca_3Fe_2(SiO_4)_3$
Hardness: 6.5 - 7
Spgr: 3.82 – 3.85
RI: 1.795 – 1.815
Critical Angle: xx°
Crystal: rhombic. Dodecahedron
Color: green. emerald green

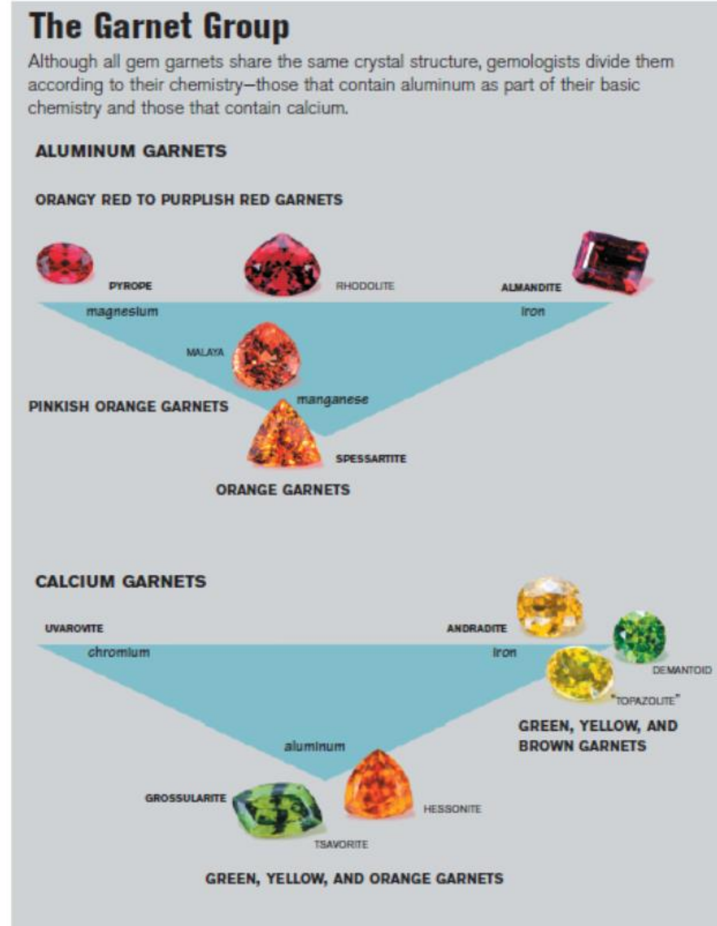
Uvarovite
Composition: $Ca_3Cr_2(SiO_4)_3$
Hardness: 7.5
Spgr: 3.77
RI: 1.795 – 1.815
Critical Angle: xx°
Crystal: rhombic. Dodecahedron
Color: emerald green

Phenomenal Garnets (color change) (vanadium color agent)

Both by Tino Hammid/GIA

Some rare garnets show a striking change of bodycolor when viewed under different light sources. These pyrope-spessartite garnets show a range of violet, brownish, or yellowish hues under fluorescent lighting (left) and more reddish hues under incandescent light (right).

Treatments: rarely treated

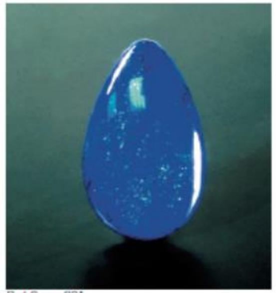


Peter Johnston/GIA

The top triangle represents the aluminum garnets—pyrope, almandite, and spessartite—and the lower the calcium garnets—uvarovite, andradite, and grossularite. At each point of each triangle, there's one garnet species that represents chemical purity. For example, in the top triangle, almandite is a theoretically pure iron-aluminum garnet, and pyrope is a pure magnesium-aluminum garnet. In nature, no garnet is ever pure, and garnet species mix to produce a range of gems with different colors and physical properties.

Stone	Color	Colored by	Source
Malaya	orange	Fe, Mn	E. Africa
Hessonite	orange	Fe, Mn	Mexico
Spessartite	red-Orange	Mn, trace Fe	et. Al.
Demantoid	green	chromium	Russia, E Africa (Mexico)
Tsavorite	green	vanadium	E Africa

Assignment 25 – Lapis lazuli, Turquoise & Other Opaque Gems



Bart Curren/ICA

The most valued lapis contains little or no pyrite, no calcite, and is an intense, uniform, medium-dark, slightly violetish blue. This quality is known in the trade as Afghan.

Peter Johnston/GIA

Lapis lazuli is mined in several locations, but the finest qualities come from the mountains of Afghanistan. The major producer of turquoise is the southwestern United States.

Lapis Lazuli

Composition: $Na_8(Al_6Si_6O_{24})S_2$
[sulfur - sodium aluminum silicate]
Hardness: 5 - 6
Spgr: 2.4 – 2.9
RI: about 1.5
Crystal: isometric (rare)
Color: dark blue from Lazurite
light blue from afghanite
Florescence: strong white

Composition – aggregate rock, lazurite, calcite, pyrite

Color – Best, violetish blue, medium dark, high saturation
Least, dull green, excess pyrite, calcite streaks

Grades – Best, Persian or Afghan
Nili – best blue
Asmani – light blue
Sabzi – greenish
Next, Russian or Siberian, various tones with pyrite and some calcite
Next, Chilean, tinged with green and obvious calcite

Treatments – dyeing and some heating
impregnated with wax or plastic

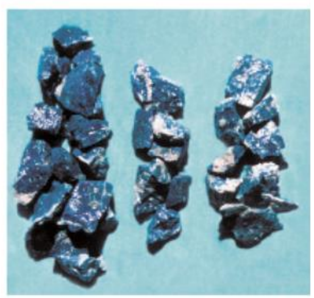
Sources – Afghanistan, Chile, Lake Baikal (Russia)
minor sources, Angola, Canada, Colorado, Pakistan

Cut – carved or cabachon

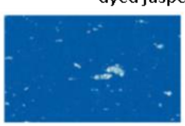
Imitations – glass and plastic
Gilson, porous and dull, soft 3 mhos
dyed jasper chalcedony

Maha Tannous/GIA

Mid-quality light blue lapis, known in Afghanistan as asmani, is also marketed as denim lapis.



The least valuable lapis–often called Chilean i



Gilson imitation lapis has a telltale dullness, and it's softer and more porous than natural lapis. Sometimes it contains small flecks of added pyrite.

Maha Tannous/GIA

Many materials can act as lapis imitations. These were marketed as reconstructed lapis. They're made of various materials bonded by a polymer.

Both by Nicholas DelRe/GIA

Natural materials can be dyed to resemble lapis lazuli. These carved scarabs (left) are dyed feldspar. A magnified view of one of the scarabs reveals dye concentrated in surface fractures (right).

Turquoise

Composition: $CuAl_6((OH)_2/PO_4)_4 \bullet 4H_2O$
[hydrated copper aluminum phosphate]
Hardness: 5 - 6
Spgr: 2.60 – 2.80
RI: 1.61 – 1.65
Crystal: triclinic
Color: blue to green
Florescence: weak green/yellow to blue

A. Ruppenthal KG — Jake Schoellkop/AP Wide World Photos

The intense blue color of this turquoise (left) is due to copper. Turquoise with a stronger greenish color (right) probably gets its color from iron.

Composition – cryptocrystalline aggregate

Color – best is even intense medium blue (sky or Persian blue from Iran)
next, greenish blue from iron
some turquoise color is unstable

Texture – best is fine texture and low porosity
least is high porosity that gives dull luster

Matrix – turquoise forms in limonite and sandstone
limonite gives dark brown markings
sandstone gives tan markings
matrix free and spider web matrix are most valuable

Treatments – melted wax, oil, polymers to stabilize
Zachery, improves color gives dark blue around fracture

Imitations – Gilson (ceramic process), glass, plastic and reconstructed
Howlite, Variscite, Chrysocholla in Chalcedony

Sources – Southwest U.S. largest supplier, China (Hubai) top color

Cut – cabochon

Maha Tannous/GIA

The smooth, waxy texture of high-quality turquoise, like this Persian blue cabochon (top), results from closely grouped crystals that lessen porosity. Coarse-textured turquoise, like this Egyptian cabochon (bottom), has dull luster and low durability.

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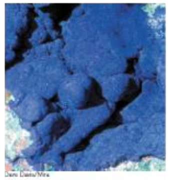
Malachite, Azurite, and Azurmalachite

Composition: $Cu_2((OH)_2CO_3)$ copper carbonate
Hardness: 3.5 - 4
Spgr: 3.75 – 3.95
RI: 1.655 – 1.909
Crystal:
Color: green

Source – Australia, Russia, US, Zaire



Azurite's gorgeous blue is caused by copper, the same metal that causes the green of malachite.

Robert Weldon/GIA
Azurmalachite combines the intense blue of azurite with the green banding of malachite to create a popular ornamental material.

Rhodochrosite

Composition: MnCO3
Hardness: 3.5 - 4
Spgr: 3.30 – 3.70
RI: 1.600 – 1.820
Crystal: hexagonal (trigonal)
Color: rose red to white

Source – Peru, S. Africa

Alan Jobbins
These rhodochrosite (left) and rhodonite (right) bowls share a similar rosy hue, but rhodochrosite has light-colored bands, while rhodonite features dark veins or patches.

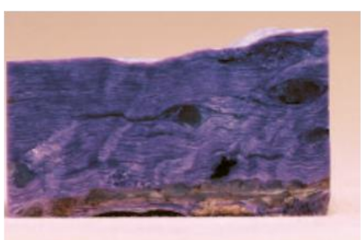
Rhodonite

Composition: $MnSiO_3$
Hardness: 5.5 – 6.5
Spgr: 3.40 – 3.70
RI: 1.733 – 1.744
Crystal:
Color: rose to pink, black inclusions

Charoite

Hardness: 5 – 6

Source - Russia



Violet charoite features attractive swirls, veins, and patches. Russia is the sole source for this unique opaque gem.

Blue John Fluorite

Sugalite

Color: red-purple to to blue purple from manganese

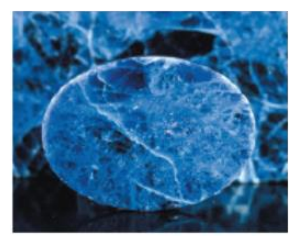
Calcite Onyx Marble

Unakite

Like many other opaque ornamental gems, tumbled pieces of unakite are commonly sold as inexpensive collector gems.

Sodalite

Composition: $Na_8(Cl_2Al_6Si_6O_{24})$ [Chloric sodium aluminum silicate]
Hardness: 5.5 - 6
Spgr: 2.13 – 2.29
RI: over 1.48
Crystal: isometric
Color: blue with white calcite



Royal blue sodalite is often used as an ornamental inlay for decorative objects. The mineral is one of the components of lapis lazuli.

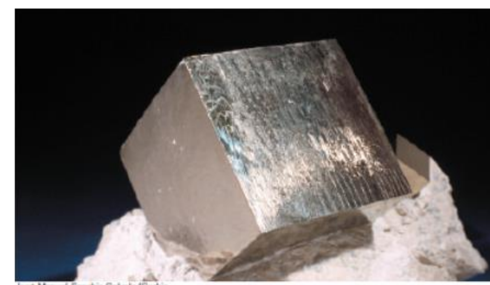
Hematite

Composition: Fe_2O_3
Hardness: 5.5 – 6.5
Spgr: 4.95 – 5.16
RI: 2.94 – 3.22
Crystal: hexagonal
Color: black, black-gray, brown-red

Alan Jobbins
The plentiful mineral hematite has a metallic look when polished. In rough form, its reddish appearance is due to iron oxidation.

Pyrite

Composition: FeS_2
Hardness: 6 – 6.5
Spgr: 5.0 – 5.2
RI: over 1.81
Crystal: isometric
Color: brass-yellow, gray-yellow



José Manuel Sanchis Calvete/Corbis
This glistening pyrite crystal from Spain shows the opaque material's metallic sheen.

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Assignment 26 – Feldspar, Spodumene and Diopside

Feldspar

Amazonite (microcline)
Composition: $K(AlSi_3O_8)$
[potassium aluminum silicate]
Hardness: 6 – 6.5
Spgr: 2.56 – 2.58
RI:1.522 – 1.530
Crystal: triclinic; prismatic
Color: green, blue-green
Florescence: weak olive green

Source: Colorado, Brazil, India

Moonstone (orthoclase)
Composition: $K(AlSi_3O_8)$
[potassium aluminum silicate]
Hardness: 6 – 6.5
Spgr: 2.56 – 2.58
RI: 1.520 – 1.525
Crystal: monoclinic; prismatic
Color: colorless, yellow, pale sheen
Florescence: weak; bluish orange

Source: best from Sri Lanka, India, Australia

Both by Eric Welch/GIA

While not very common, some moonstones show asterism (left), and some show chatoyancy (right).

Labradorite (plagioclase)
Composition: $Na(AlSi_3O_8)$
[sodium aluminum silicate]
Hardness: 6 – 6.5
Spgr: 2.69 – 2.70
RI: 1.560 – 1.568
Crystal: triclinic; rare platy prismatic
Color: dark gray to black with play of color
Florescence: yellow striations

Source: Labrador, Finland (spectrolite), Madagascar (rainbow moonstone)

Both by Robert Weldon/GIA

Rainbow moonstone, mined in Madagascar, is actually labradorite feldspar. Its multi-colored adularescence combines with a light bodycolor (right). When its transparency is high enough, it can be faceted to create a striking gemstone (above).

Aventurine Feldspar (oligoclase) (sunstone)
Composition: $Na(AlSi_3O_8)$
[sodium aluminum silicate]
Hardness: 6 – 6.5
Spgr: 2.62 – 2.65
RI: about 1.522 – 1.530
Crystal: triclinic; very rare
Color: red brown, sparkling
Florescence: dark brown-red

Source: Origoon, India, Canada

Hammid/GIA Robert Weldon/GIA

These fine sunstones display a strong reddish orange bodycolor (above). Transparent labradorites can be yellow, orange, green, or red (left). All of these stones are from the Ponderosa mine in the US state of Oregon.

The feldspar group encompasses a wide variety of minerals. The important species for gemstones are orthoclase, labradorite, oligoclase, and microcline. The most popular varieties for use in jewelry are moonstone and sunstone.

Spodumene

Kunzite

Composition: $LiAl(Si_2O_6)$
Hardness: 6 - 7
Spgr: 3.16 – 3.20
RI: 1.655 – 1.680
Crystal: monoclinic; prismatic tabular
Color: pink-violet, violet
Fluorescence: stong yellow-red, orange

Source: Afganistan, Brazil, Madagascar, California (Elizabeth mine in Pala)

Hiddenite

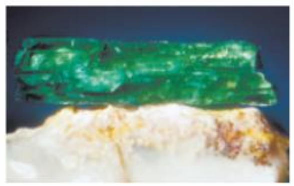
Composition: $LiAl(Si_2O_6)$
Hardness: 6 - 7
Spgr: 3.16 – 3.20
RI: 1.655 – 1.680
Crystal: monoclinic; prismatic tabular
Color: yellow-green, green yellow, emerald green
Fluorescence: very weak red-yellow

Source: Brazil, Malagasy, Burma, California, North Carolina

Triphane

Robert Weldon

Kunzite ranges from pale to intense pink through intense violetish purple. The gem is prized as a collectors' stone.



Green spodumene (top) is named hiddenite, after A. E. Hidden, who discovered it. Yellow spodumene (bottom) is also known as triphane. These colors are not commonly found in jewelry.

Diopside

Composition: $CaMg(Si_2O_6)$
Calsium Magnesium Silacate
Hardness: 5 - 6
Spgr: 3.27 – 3.31
RI: 1.671 – 1.726
Crystal: monoclinic; columnar crystals
Color: light to dark green, bottle green
Fluorescence: strong dark violet

Chrome Diopside colored by chrome or vanadium

Source: Chrome Diopside in Siberia, Russia; Green Diopside in Pakistan and China

Shane McClure/GIA

These diopside crystals range in weight from 4.05 to 59.80 grams.

Van Rossen/Columbia Gem House

The finest chrome diopside has a medium-dark, vivid green color, shown by these three gems. Chrome diopside is a lower-priced alternative to fine green emerald, tsavorite, and chrome tourmaline.

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