

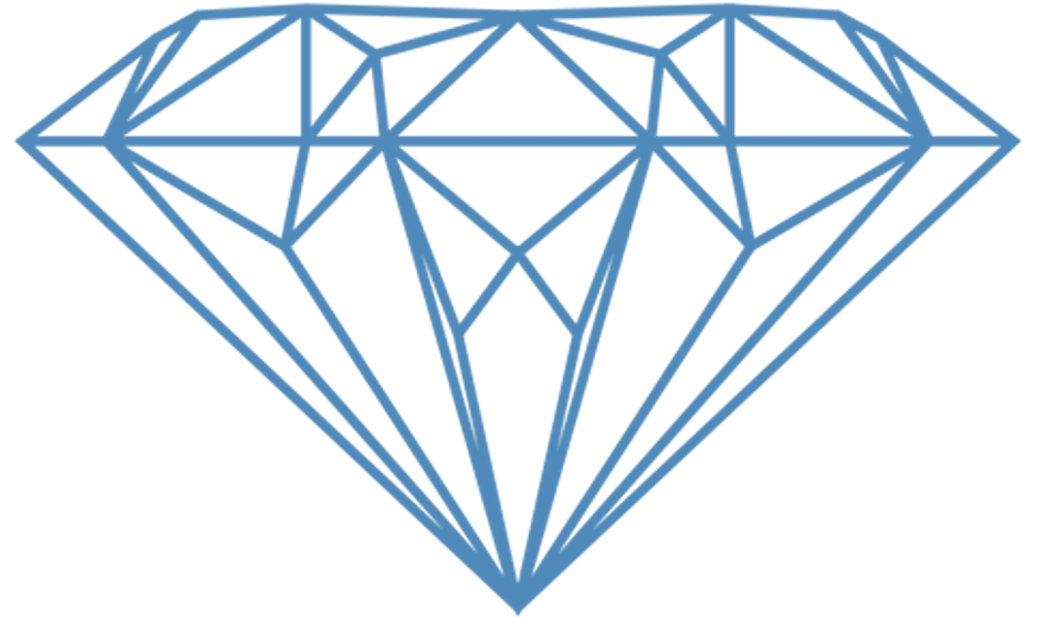
Gemstones

The Precious, the Semi-Precious, and the Ugly

Catherine Barrie

Dogbone of the Week

April 11, 2022



JOHNS HOPKINS
WHITING SCHOOL
of ENGINEERING

Gemstones

a mineral or petrified material that when cut and polished can be used as jewelry – Merriam Webster

- Measured in Carats (200 mg)
- Classification:
 - Precious
 - Semi-Precious



Ruby



Sapphire



Emerald

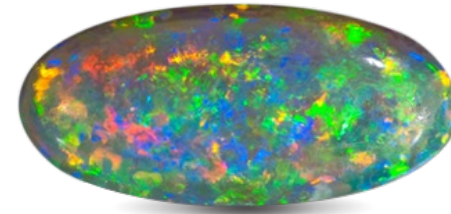


Diamond

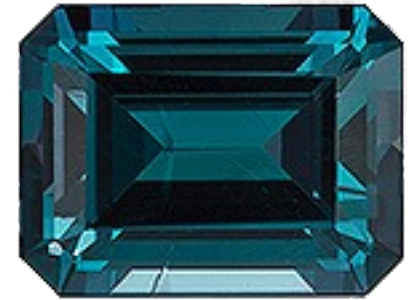
Gemstones

a mineral or petrified material that when cut and polished can be used as jewelry

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Opal



Alexandrite



Topaz

Color

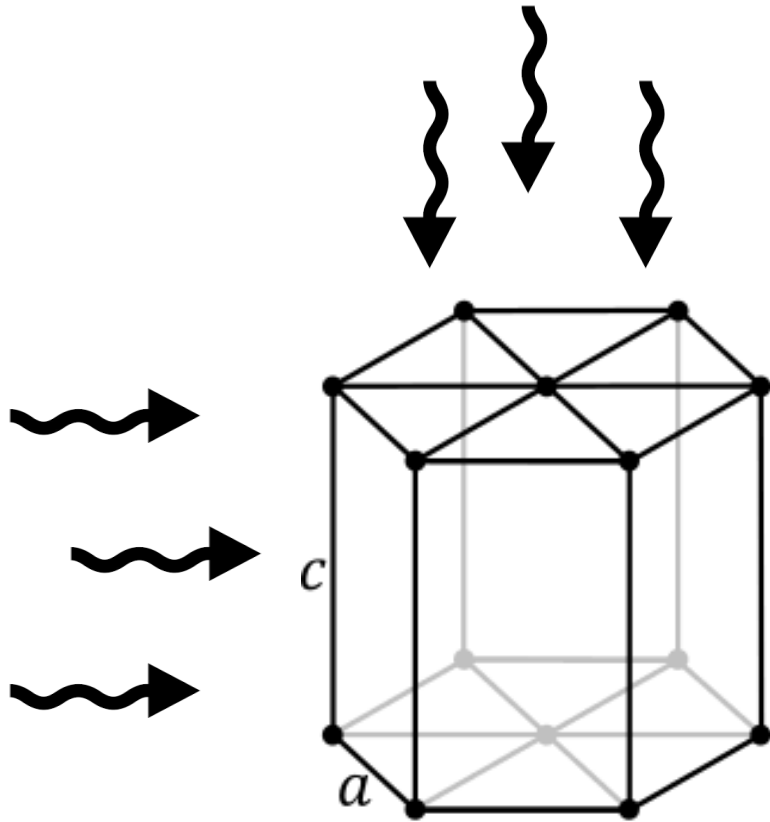
- Structure
- Impurities
- Radiation
- Light Source

ELECTRON TRAVEL

1. The Crystal Field Theory
 - Transition metal compounds (malachite, almandine) - idiochromatic
 - Transition metal impurities (ruby, emerald, citrine, jade) - allochromatic
 - Color centers (amethyst, maxixe-beryl)
2. The Molecular Orbital Theory
 - Charge transfer (sapphire, iolite)
3. The Band Theory
 - Insulators (glass)
 - Conductors (metals)
 - Semiconductors (galena)
 - Doped semiconductors (diamond)
4. The Physical Properties Theory
 - Dispersion (Fire in diamond)
 - Scattering (moonstone, cat's eyes, stars)
 - Interference (iridescence, opal)
 - Diffraction (opal)

Structure

- Anisotropy \rightarrow Pleochroism



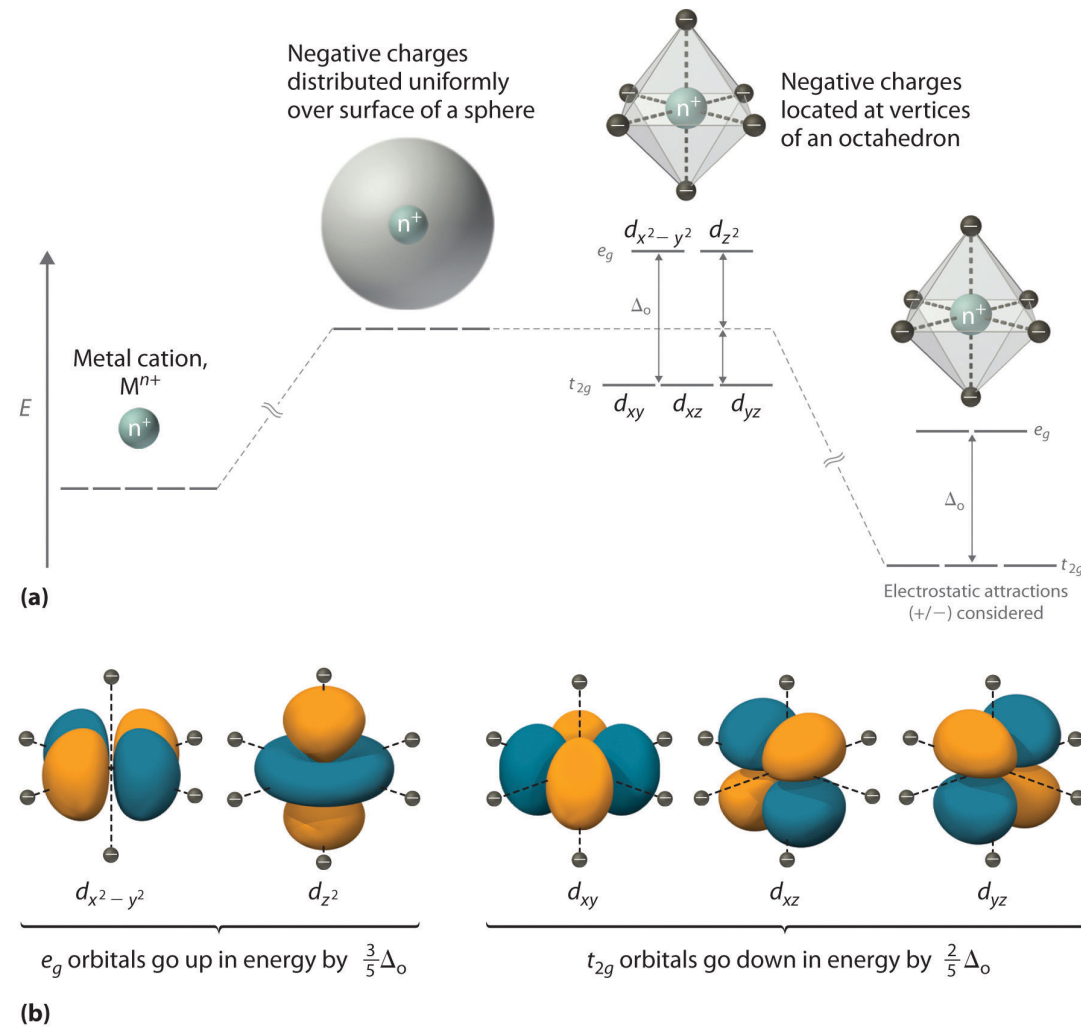
Impurities

- Transition Elements

PERIODIC TABLE OF ELEMENTS																	
1 H Hydrogen																	2 He Helium
3 Li Lithium	4 Be Beryllium											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon
11 Na Sodium	12 Mg Magnesium											13 Al Aluminum	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon
55 Cs Cesium	56 Ba Barium	57 La Lanthanum	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89 Ac Actinium	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson

Gem	Formula	Color	Origin of color
Ruby	Al_2O_3	Red	Cr^{3+} replacing Al^{3+} in octahedral sites
Emerald	$\text{Be}_3\text{Al}_2(\text{SiO}_3)_6$	Green	Cr^{3+} replacing Al^{3+} in octahedral site
Alexandrite	Al_2BeO_4	Red/Green	Cr^{3+} replacing Al^{3+} in octahedral site
Garnet	$\text{Mg}_3\text{Al}_2(\text{SiO}_4)_3$	Red	Fe^{2+} replacing Mg^{2+} in 8-coordinate site

Crystal Field Theory



Impurities

- Color Centers - Wrong Valence
- Radiation also creates this same color phenomenon

PERIODIC TABLE OF ELEMENTS																	
1																	2
H																	He
3	4															10	
Li	Be															Ne	
11	12															18	
Na	Mg															Ar	
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
87	88	89	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og



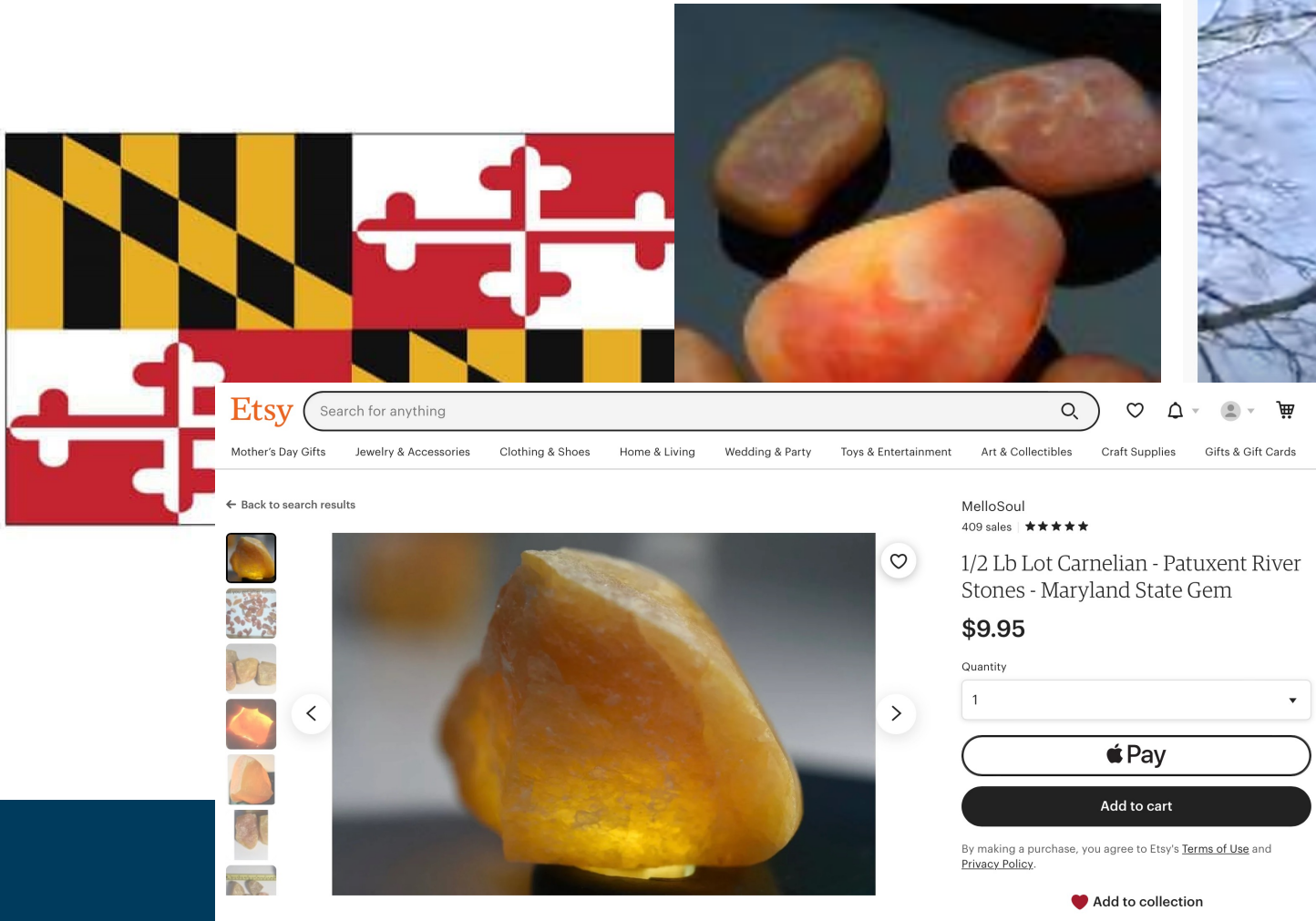
The Hope Diamond

- 45.52 carat blue diamond
 - Surprisingly light
- Owned by prominent figures such as King Louis XIV, XV, XVI
- Cursed
 - Suicide
 - Hanged
 - Thrown from precipice
 - Murdered by lover
 - Torn to pieces by wild dogs
 - Torn to pieces by French mob



State Gemstones - Maryland

Patuxent River Stone



This image shows an Etsy product listing for '1/2 Lb Lot Carnelian - Patuxent River Stones - Maryland State Gem' by the seller MelloSoul. The listing features a large, high-quality photograph of a single, smooth, yellowish-orange stone. To the left of the main image is a vertical strip of smaller thumbnail images showing various stones. The product title and price, \$9.95, are prominently displayed. Below the price, there is a quantity selector set to '1' and two buttons: 'Apple Pay' and 'Add to cart'. At the bottom, there is a link to the seller's terms of use and privacy policy, and an 'Add to collection' button. The Etsy interface includes a search bar at the top and a navigation menu with categories like 'Mother's Day Gifts', 'Jewelry & Accessories', etc. The Maryland state flag is visible in the top left corner of the listing area.

Etsy Search for anything

← Back to search results

1/2 Lb Lot Carnelian - Patuxent River Stones - Maryland State Gem

\$9.95

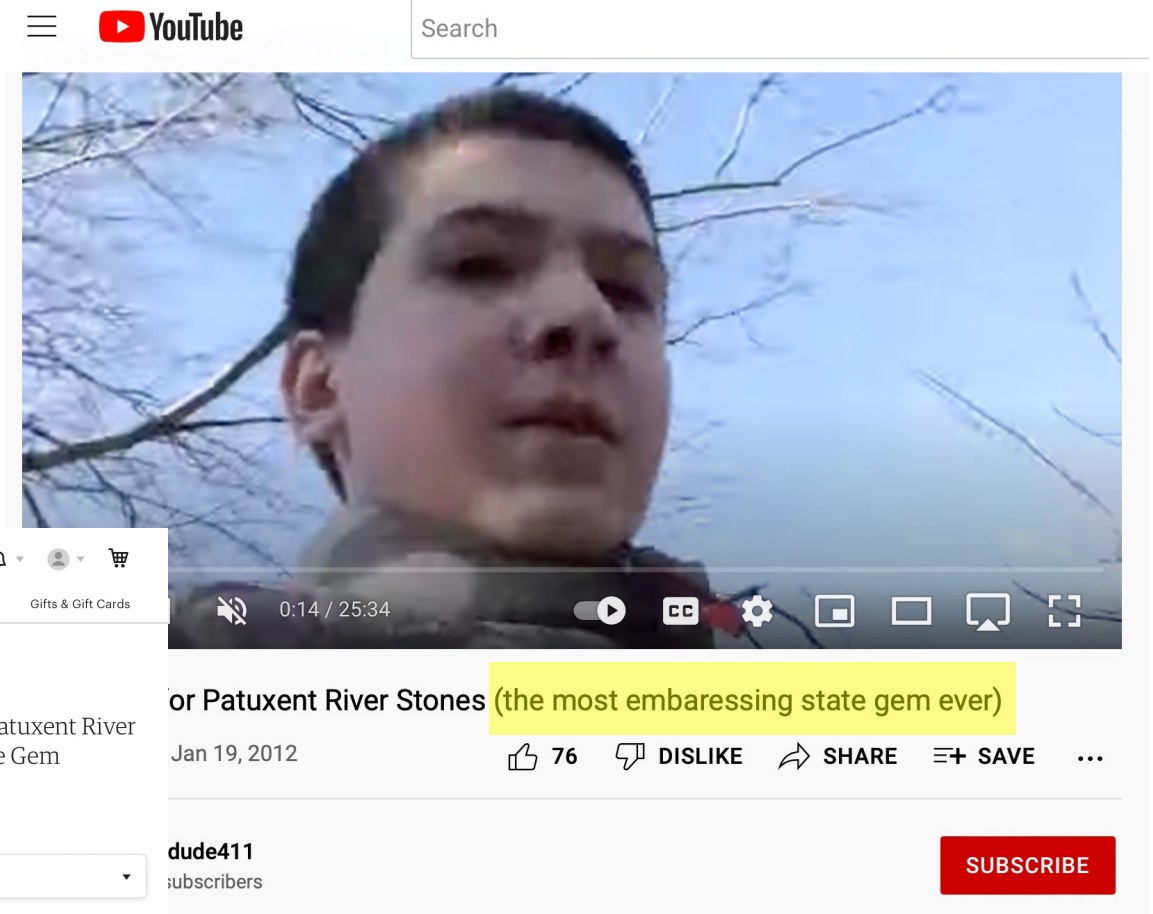
Quantity: 1

Apple Pay

Add to cart

By making a purchase, you agree to Etsy's [Terms of Use](#) and [Privacy Policy](#).

♥ Add to collection



This image shows a YouTube video player interface. The video title is 'or Patuxent River Stones (the most embaessing state gem ever)'. The video was uploaded on Jan 19, 2012, and has 76 likes and 0 dislikes. The video player shows a person's face in the video frame. The YouTube interface includes a search bar at the top, a video player with a progress bar, and a video description area. The video title is highlighted in yellow. The video player shows a person's face in the video frame. The YouTube interface includes a search bar at the top, a video player with a progress bar, and a video description area.

or Patuxent River Stones (the most embaessing state gem ever)

Jan 19, 2012

76 DISLIKE SHARE SAVE ...

dude411
subscribers

SUBSCRIBE

State Gemstones - California

- Benitoite - $\text{BaTi}(\text{Si}_3\text{O}_9)$
- Found in San Benito, California
- Only mine to produce gemstone quality
- ~\$7,000/carat



Jeff Scovill photo



Monetary Value

- Blue Diamonds are the most expensive (\$3.93 Million/Carat)
- Painite – 2005 Guinness World Record for “rarest” gemstone on earth
 - Runs for 50 – 60 K PER CARAT
 - Largest stone found is 213.52 Carats
 - THAT’S 10.68 MILLION DOLLARS



x 21



x 42.72
Million



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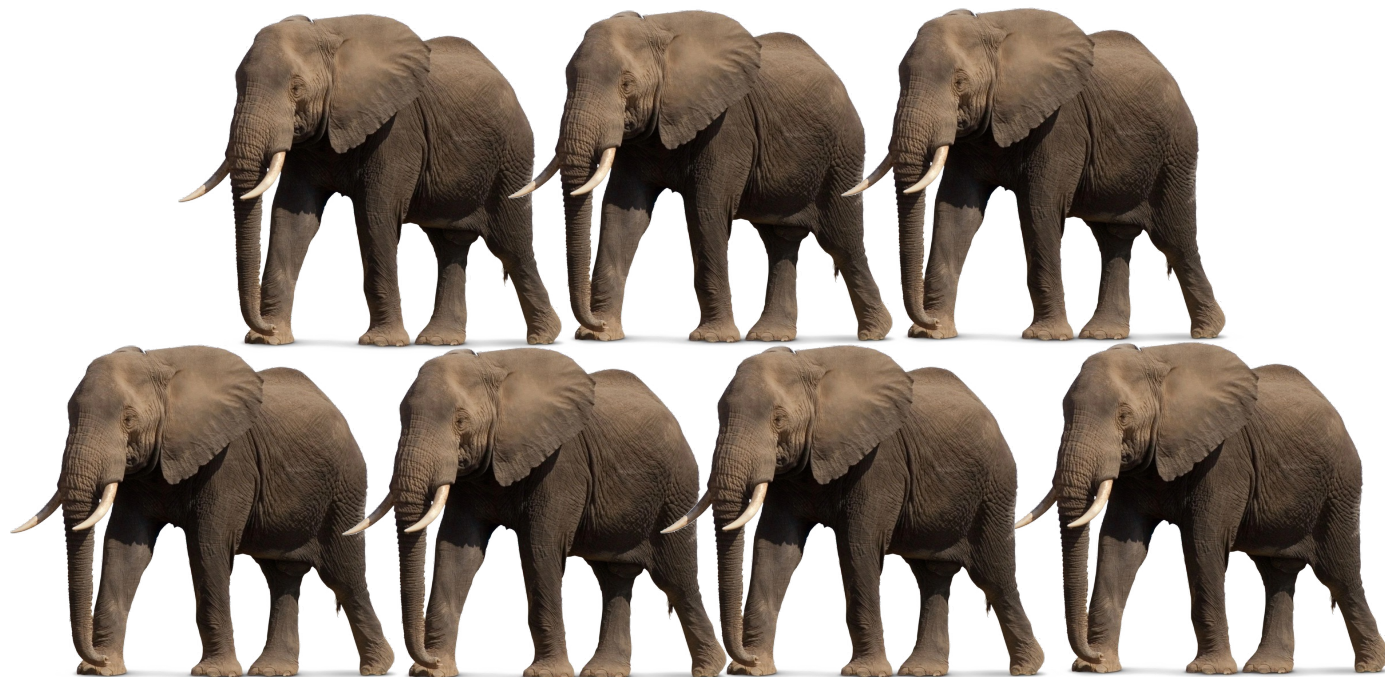
Can we increase monetary value?

- Of *quartz* we can!
- Almost all gems go through “post-processing”

1. Bleaching
2. Surface coating
3. Dyeing
4. Heat Treatment
5. HPHT
6. Irradiation

Heat Treatments

- Diamonds are more valuable colorless!
 - Nitrogen is often an unwanted impurity
 - GE: 1800 C + 50,000 atm – turns the diamond from brown to clear!



+ 180,465 more



Heat Treatments

- Diamonds are more valuable colorless!
 - Nitrogen is often an unwanted impurity
 - GE: 1800 C + 50,000 atm – turns the diamond from brown to clear!
- Corundums are frequently heat treated around ~1500 C
 - There's been “recent” studies of introducing impurities during treatment to further enhance color
- They can distinguish natural vs treated stones via Raman photoluminescence



Conclusions

- Value of gemstones due to rarity and looks
- Natural isn't necessarily better
- Maryland's State Gemstone is “embarresing”

Gemstones ROCK!