Hot Science Cool Talks

UT Environmental Science Institute

5

True Gems: Origins and Identification

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Common questions:

- How are gems different from other minerals?
- How are gems identified?
- Where do they come from and why are they rare?
- How do man-made gems compare to naturals?

What is a gem?

- A natural material that is prized for:
  - Beauty
  - Durability
  - Rarity

Ametrine Quartz, Bolivia

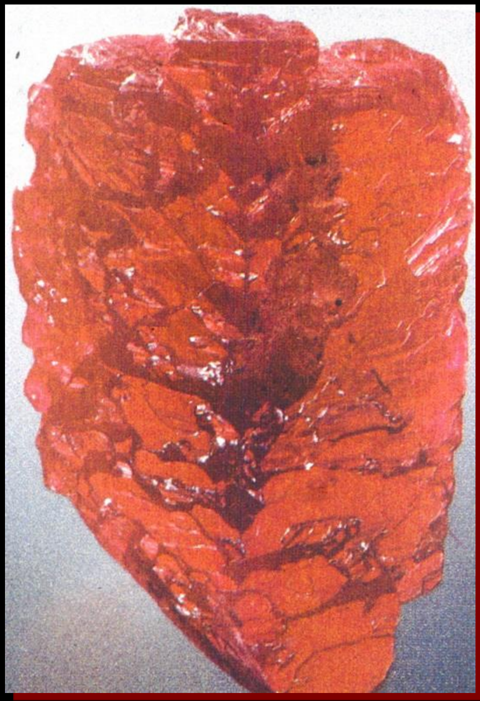
Gems are Beautiful

Outstanding visual qualities:

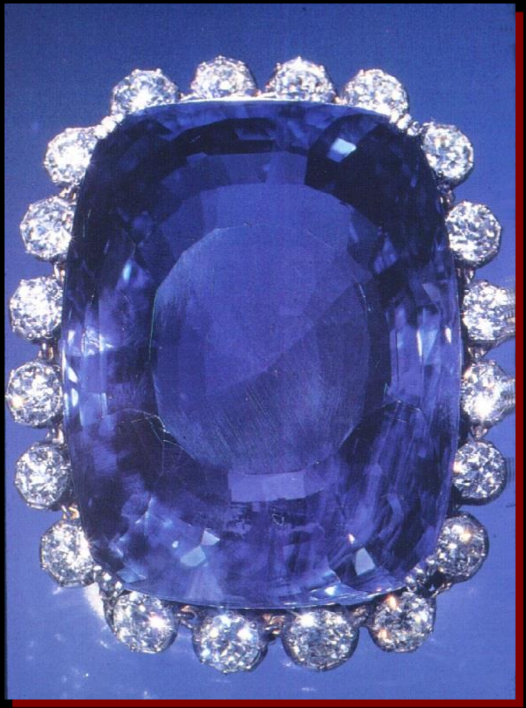
- Color
- Brilliance
- Unusual optical phenomena
  - Stars, cat's eyes
  - Play-of-color

Rose Quartz, Brazil

Beauty:
Color



Hixon Ruby



Logan Sapphire

Hooker Emerald

Beauty:
Brilliance

- Clarity
- Scintillation (sparkle)
- "Fire" prism effect

Synthetic Rutile

Beauty:
Unusual Phenomena

- Reflection of light from something within a gem or diffraction of light by the gem.

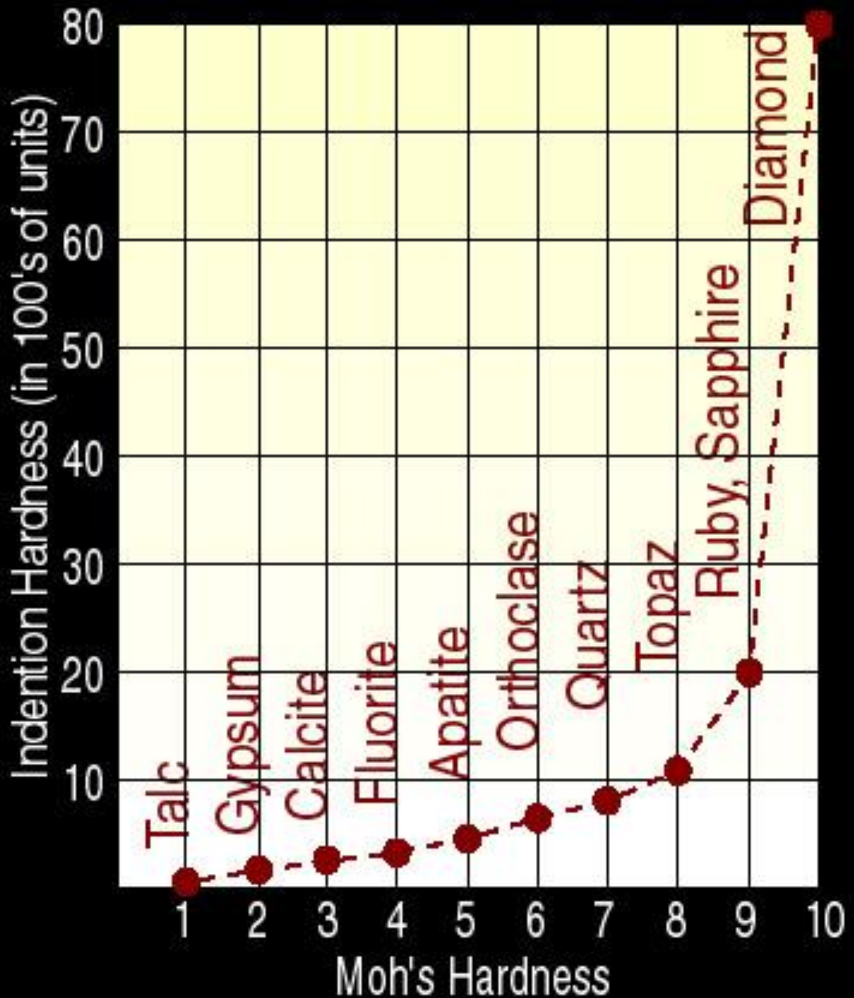
Cat's Eye Gemstones

Opal

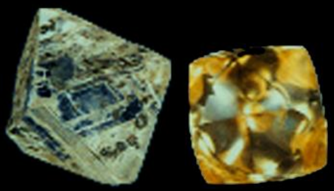
Gems are Durable

- Not easily scratched
  Hard
- Not easily broken
  Tough

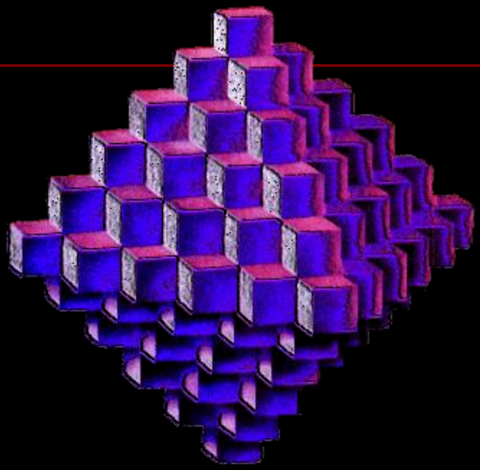
Cleaving a diamond



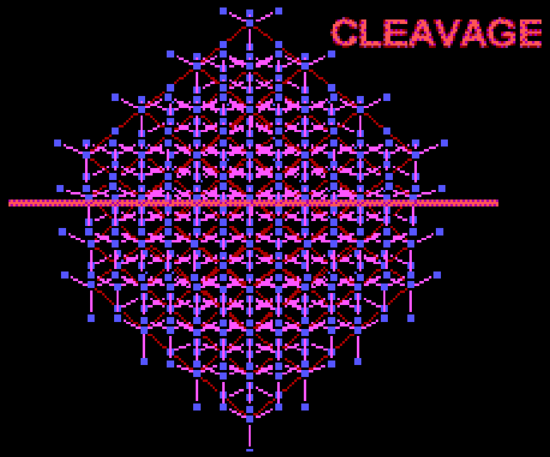
Durability:
Cleavage in diamond



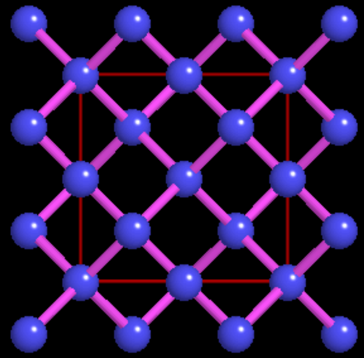
Diamond crystals



Stacked cubes form an octahedron



Planes of fewest bonds are cleavage

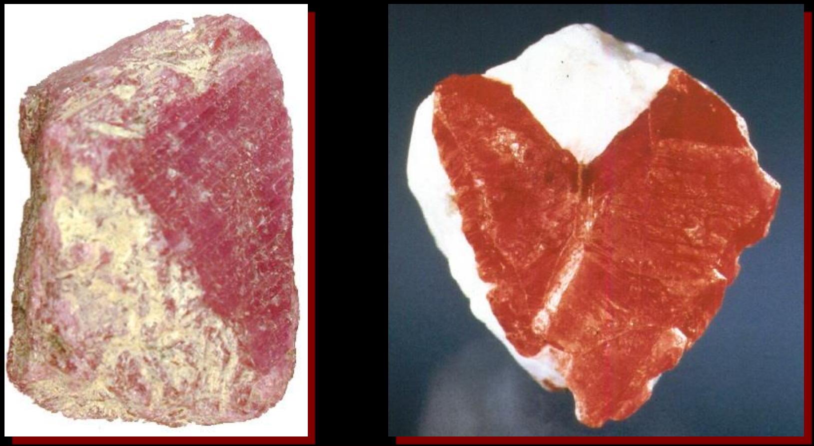


Cube of carbon atoms in diamond

Gems are Rare

- Minerals with properties suitable for gems are rare
- Gem quality specimens are even rarer

Emerald



Ruby

How are gems identified?

- By measuring or observing properties:
  - Hardness
  - Specific Gravity
  - Interactions with light
- Microscopic observation of crystal growth features
- Special techniques

Gem Identification:
Diamond, C.Z. & Specific Gravity

10 mm, 4.1 carats

Diamond

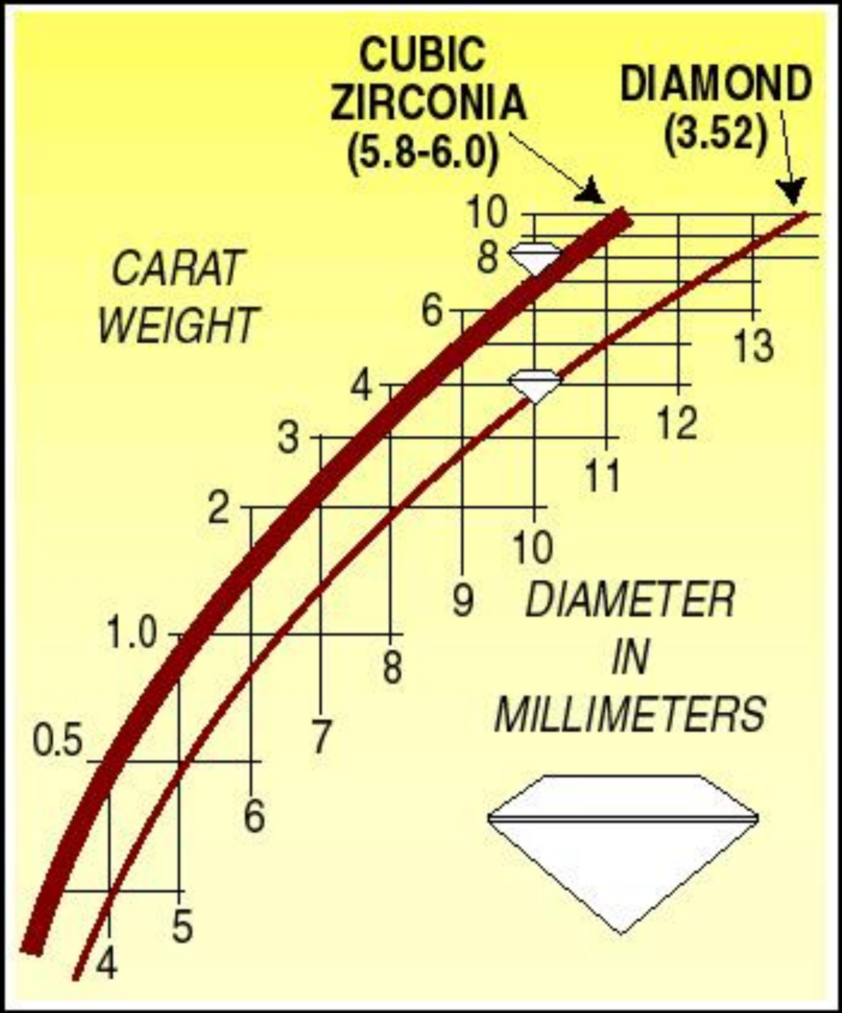
10 mm, 8.0 carats

Cubic Zirconia

Gem Identification:
Specific gravity curves

10 mm, 8.0 cts

10 mm, 4.1 cts

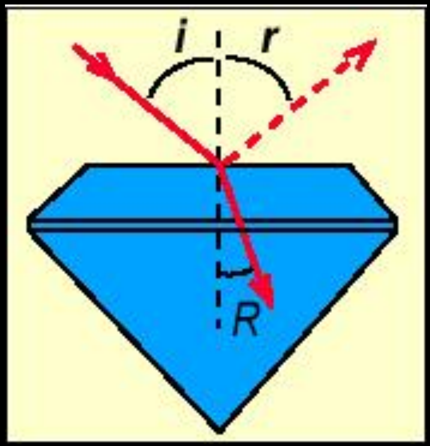


Gem Identification:
Interactions with light

- Refraction – bending
- Dispersion – separation into colors
- Polarization – filtering
- Absorption – produces color

Interactions with light: Refraction

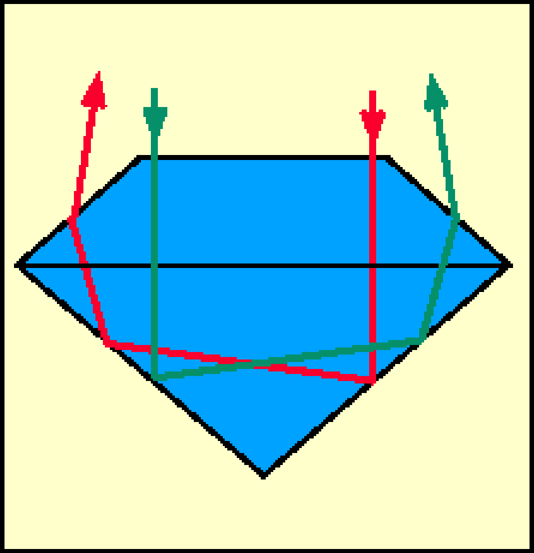
- The speed of light in gems is less than it is in air
- Decrease in speed results in bending of light rays = refraction
- Measure the amount of bending of light to identify gems

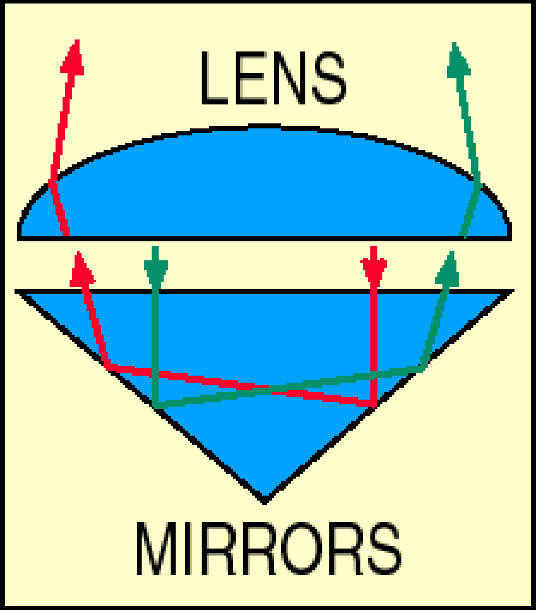


Interactions with light:
How slow is light in gems?

	V (km / sec)	Refractive Index $V_{air} / V_{material}$
Diamond	124,083	2.42
Ruby	169,429	1.77
Emerald	189,803	1.58
Glass	197,349	1.52
Water	225,442	1.33
Air	299,890	1.00

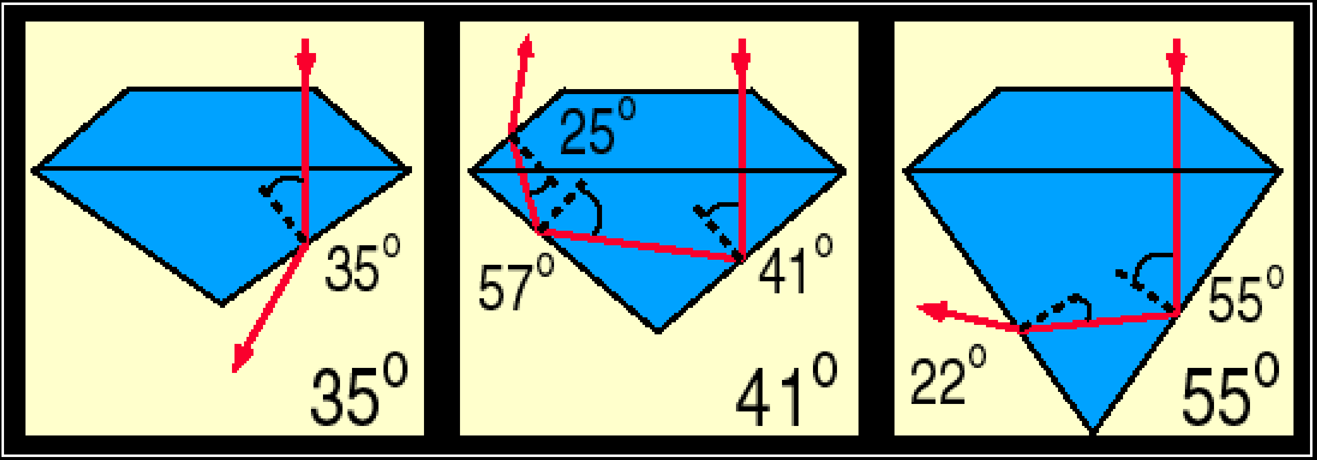
Interactions with light:
Refraction and brilliance





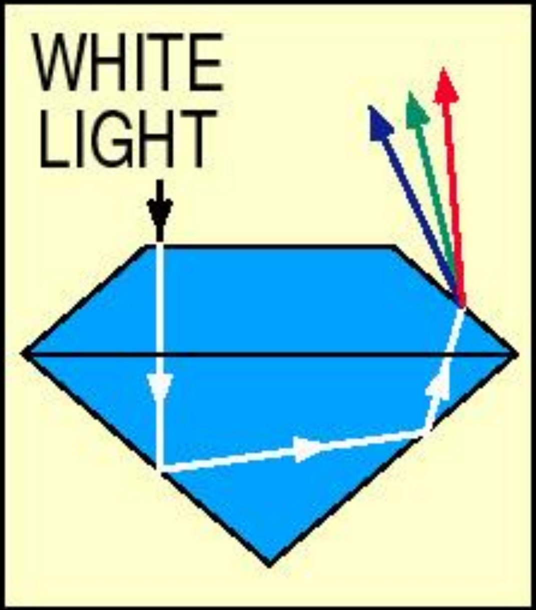
Interactions with light:
Critical angle and brilliance

- For quartz, with a critical angle of 40°:



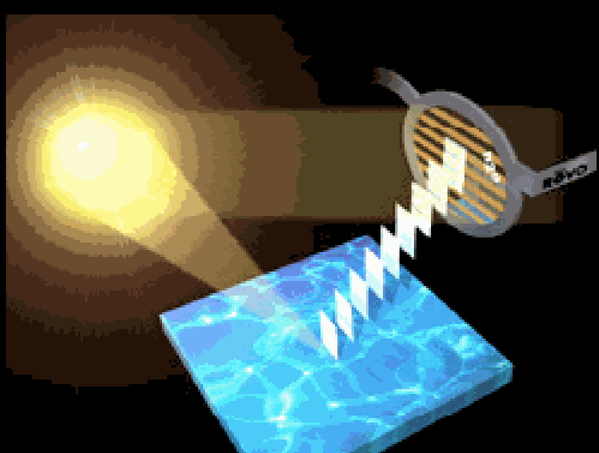
Interactions with light:
Dispersion

- Colors of the spectrum are separated by different amounts of refraction.

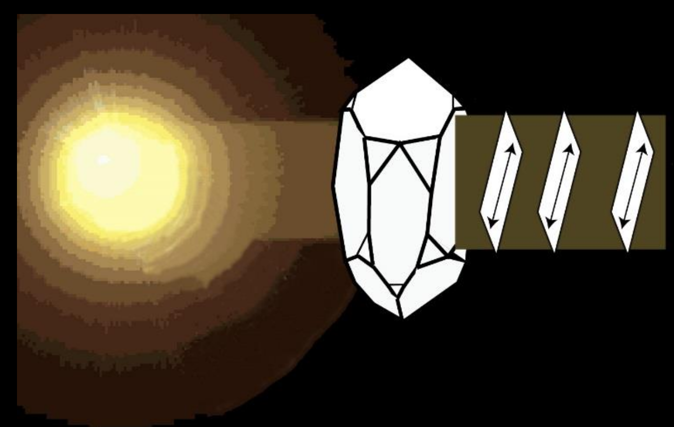


Interactions with light:
Polarization

- Light passing through some minerals emerges as polarized light
- Test whether gem polarizes light



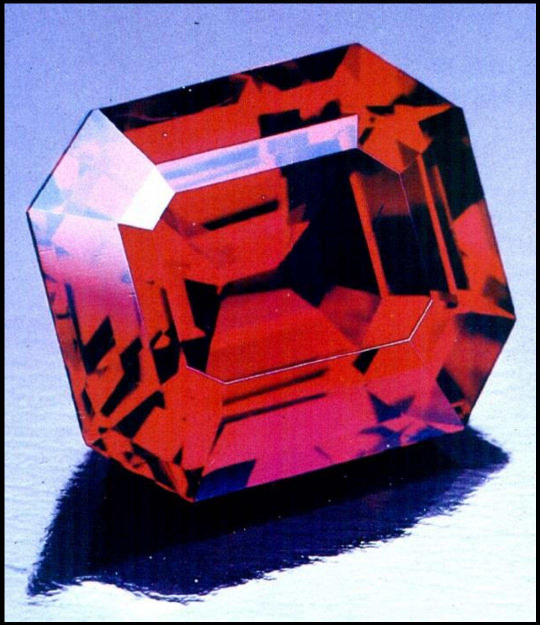
Light polarized by reflection



Light polarized by a mineral

Interactions with light:
Absorption/Color

- Not a distinctive property for most gem minerals



Ruby

Orange Sapphire

Sapphire

CORUNDUM – Al_2O_3

Gem Identification:
Under the Microscope

Natural | Man-made

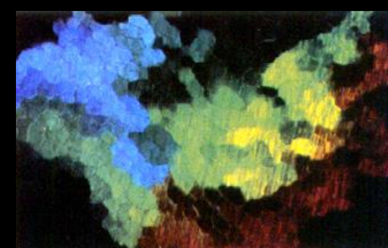
100X

Emerald

40X

20X

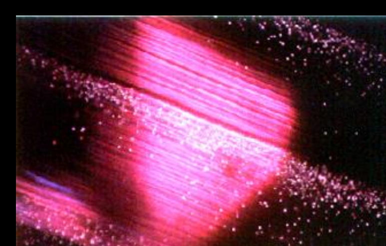
Opal



40X

45X

Ruby



60X

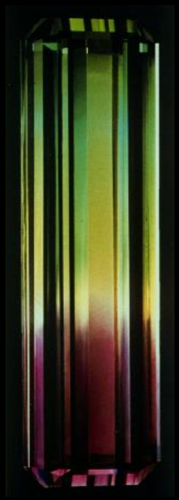
Why are gems rare?

- Contain rare chemical elements
- Get to the surface by unique sequences of geologic events
- Some require unusual conditions for formation

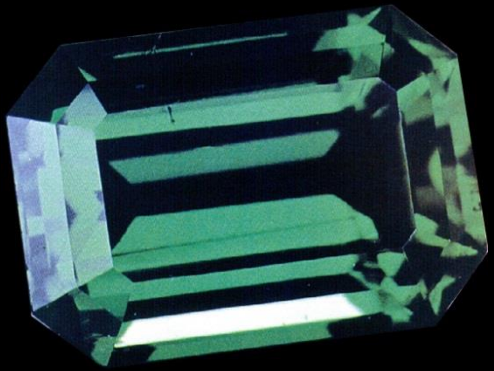
Gem Rarity:
Rare chemical elements

- Emerald – Beryllium & Chromium
- Ruby – Chromium
- Sapphire - Titanium
- Tourmaline – Boron
- Topaz - Fluorine

Star Ruby



Tourmaline

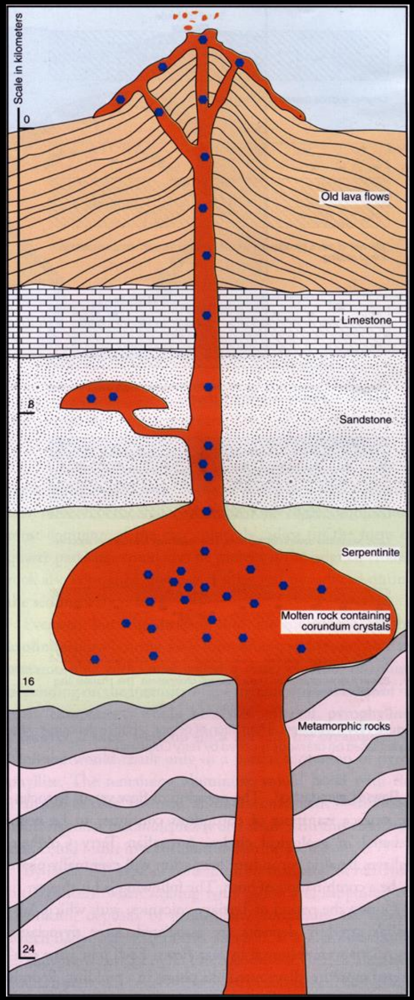


Emerald

Gem Rarity: Transport to the surface

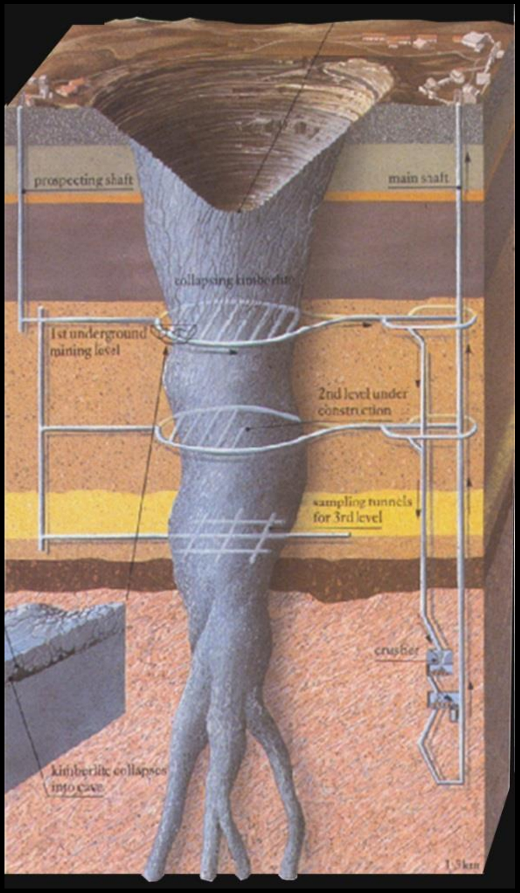
- Many gems form at great depths; need geologic process(es) to get them to the surface
  - Volcanic eruptions
    - Sapphire
    - Diamond
  - Mountain building processes
    - Ruby
    - Emerald
    - Many others

Transport to the surface:
Volcanic eruptions

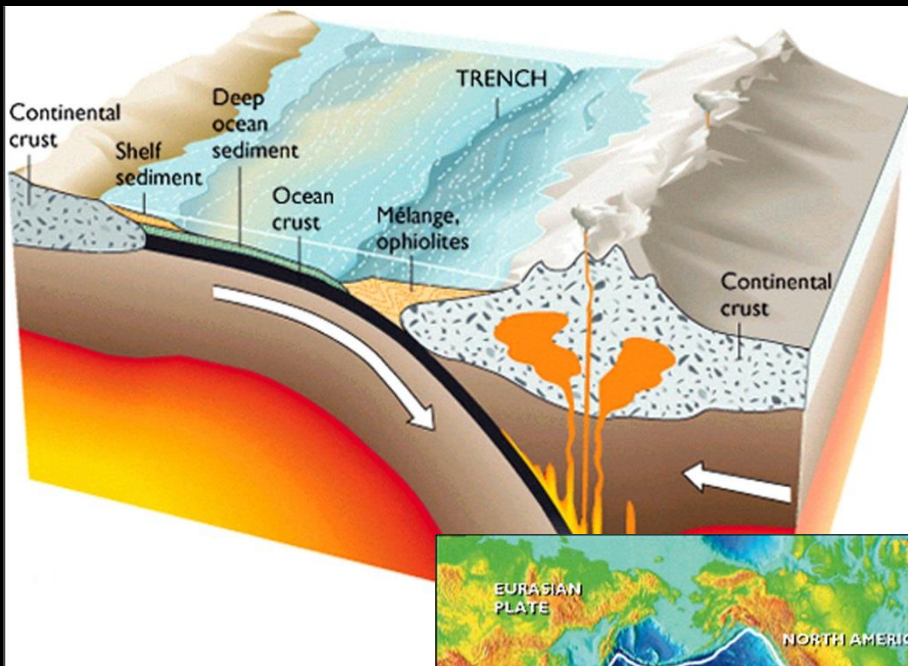


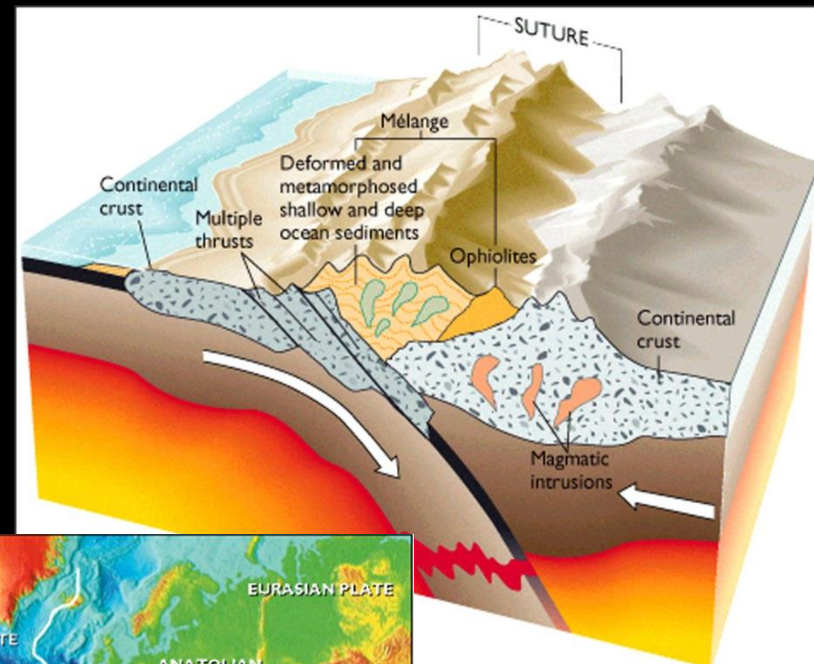
Montana Sapphire

Diamond in kimberlite



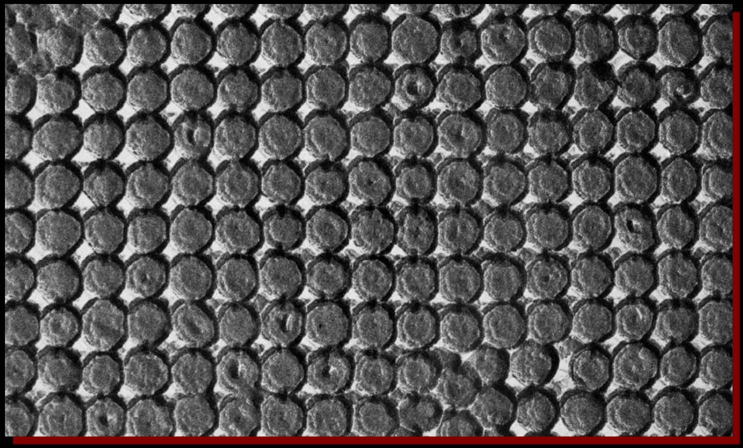
Transport to the surface:
Mountain building





Gem Rarity:
Unique processes of formation

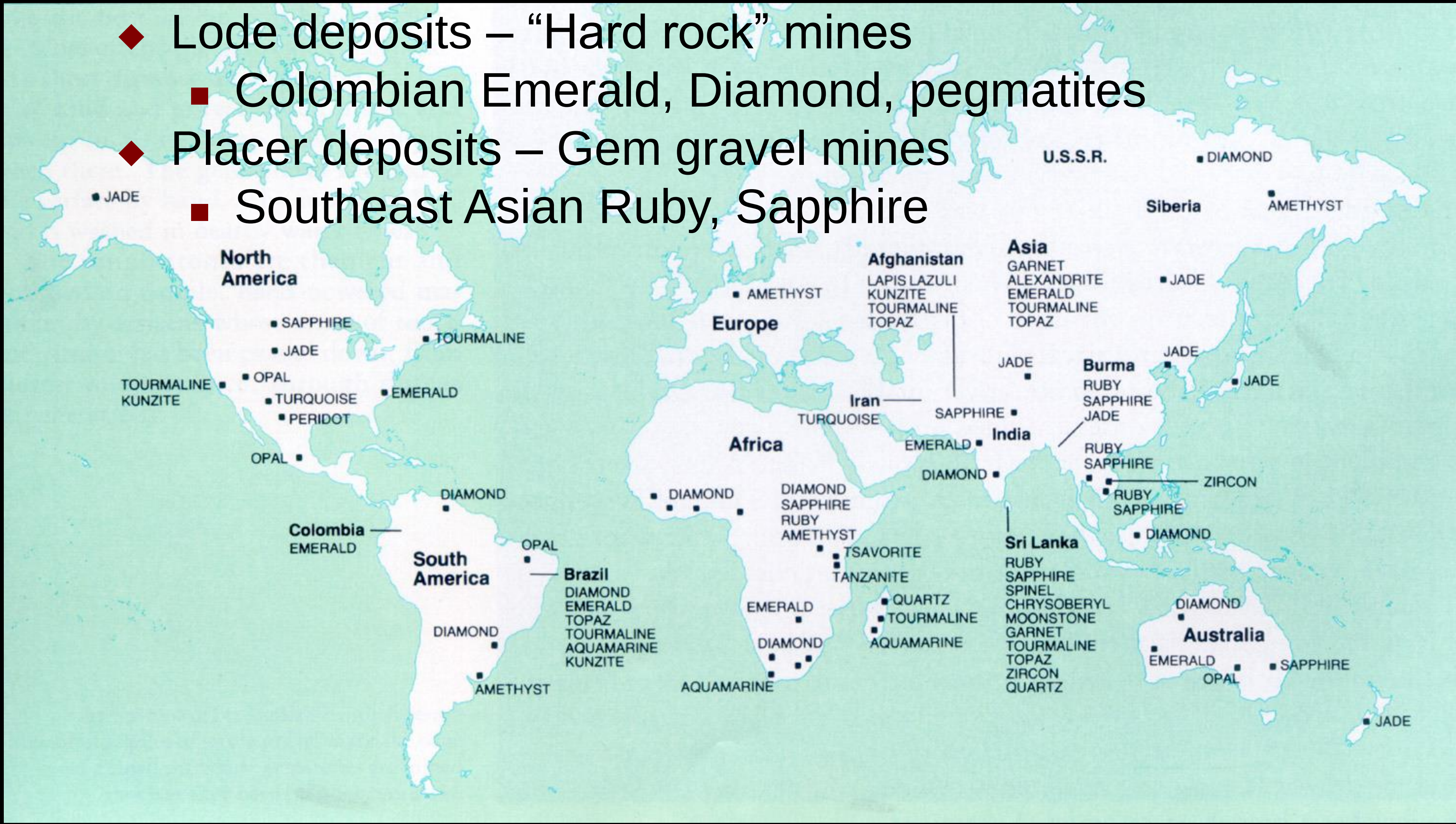
Common Opal at 50,000 X



Precious Opal at 50,000 X

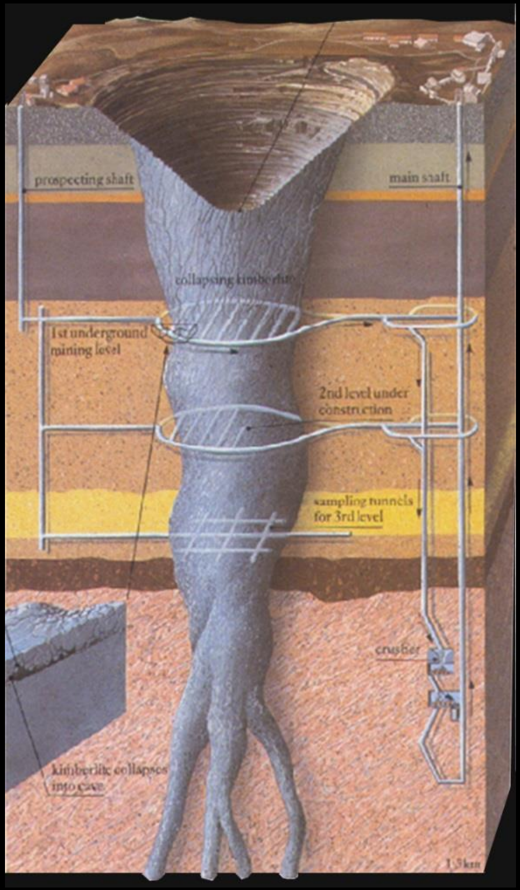
Where do gems come from?

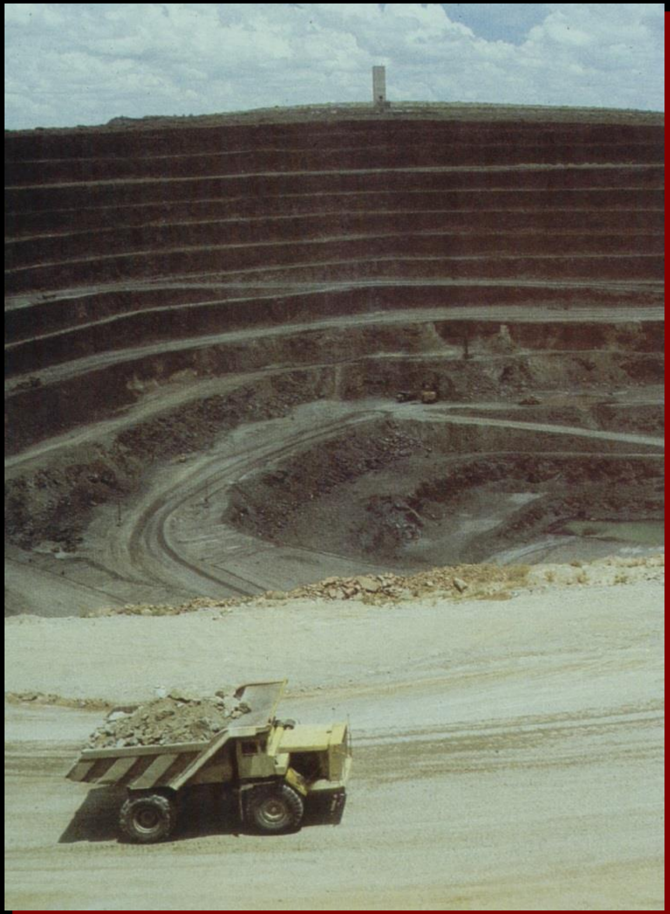
- Lode deposits – “Hard rock” mines
  - Colombian Emerald, Diamond, pegmatites
- Placer deposits – Gem gravel mines
  - Southeast Asian Ruby, Sapphire



Lode Deposits:
Muzo Emerald Mine, Colombia

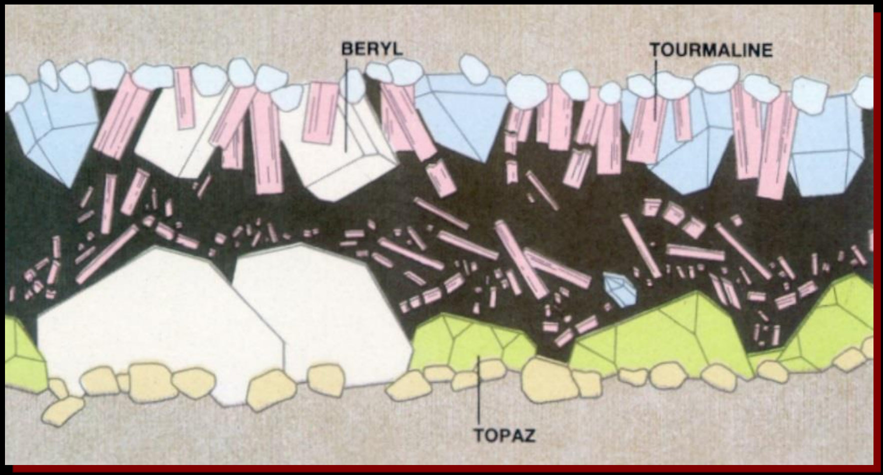
Lode Deposits:
Diamond Mining





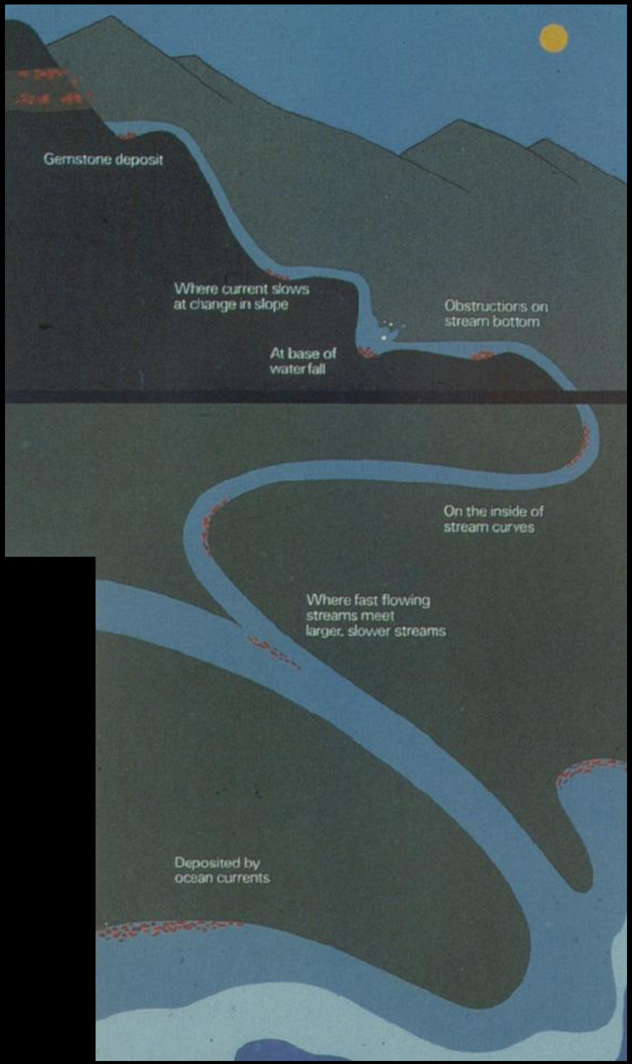
Lode Deposits: Pegmatites

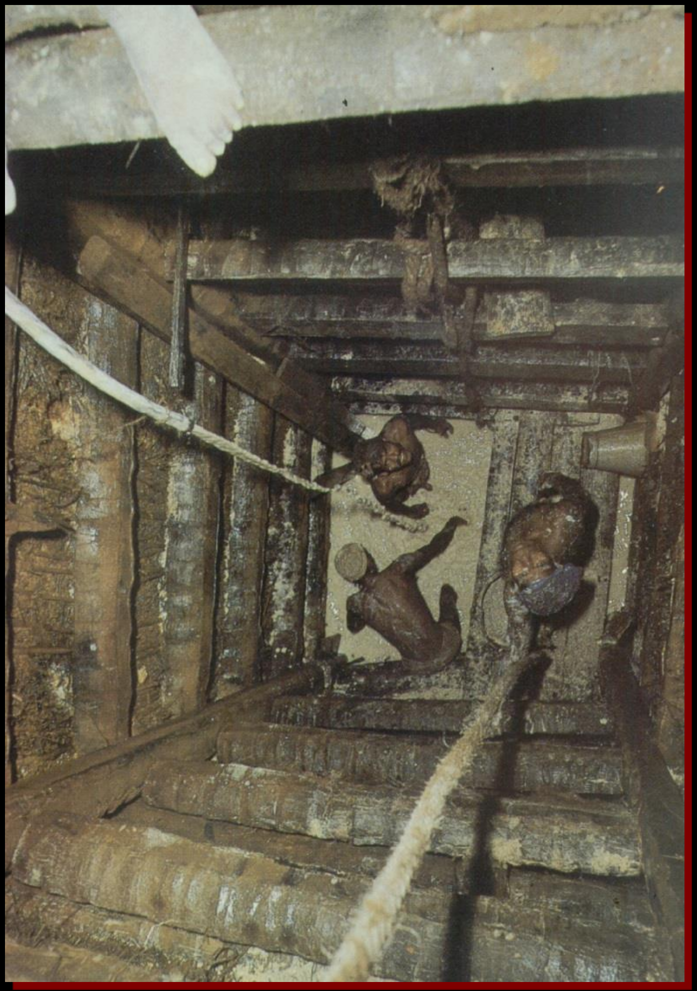
- Unusual, small bodies of igneous rocks containing large crystals
- Sometimes rich in rare elements and minerals



Lode Deposits:
Pegmatites

Gem Gravel Mining, Sri Lanka

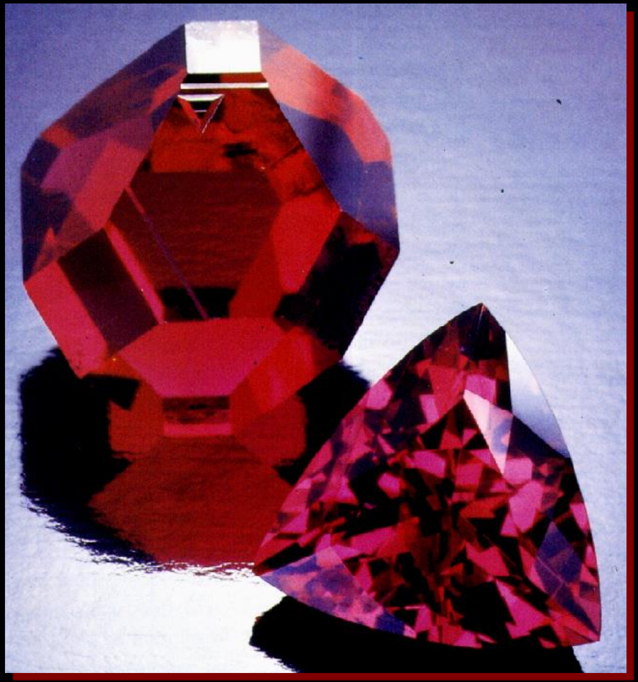




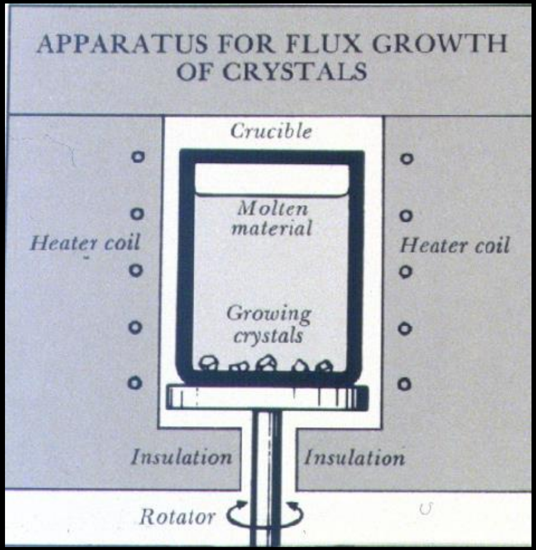
Placer Deposits:
Gem Gravel Mining, Sri Lanka

Man-Made Minerals as Gems

- Technological marvels, beautiful, but lack rarity
- Lab processes do not imitate nature



Ramaura Ruby



Summary

- How are gems different from other minerals?
  - Beautiful, Rare, Durable
- How are gems identified?
  - Physical and Optical Properties
  - Microscopic growth features

Summary

- Why are they rare and where do they come from?
  - Rare chemistry
  - Unique processes of formation and/or transport to the surface
  - Lode and placer deposits

- How do man-made gems compare to naturals?
  - Some are in every way identical, but lack rarity

Dr. Mark Helper

Mark Helper has degrees in Geology from the University of Illinois (BS) and University of Texas at Austin (Ph.D.). As a senior lecturer, he currently teaches classes in Field Geology and Gems and Gem Minerals, serves as director of the Department's summer field geology program, and is curator of the E. M. Barron and G. & M. Vargas gem and mineral collections. His research interests in mountain building processes have led to field studies of portions of the Klamath Mountains in northern California, the Llano uplift of central Texas, the Picuris Mountains of northern New Mexico, and the Shackleton Range and Heimefrontfjella of Antarctica. He has received the Knebel Award for excellence in undergraduate teaching (1995), the Antarctic Service Medal of the U.S. Antarctic Program (1995), the American Federation of Mineralogical Societies Honorary Scholarship Award (1996), and the Miningco.com Award for best World Wide Web mineralogy site (1998).