Gem Identification
Gem Identification

• There are approx. 4000 minerals
• Approx. 100 are classified as gem species. They are found in gem quality. The gem quality has the attributes of a gemstone – beauty, durability, rarity, and portability
• Many of these 100 are found in multiple varieties - by color, by physical properties, and by phenomena
Gem Identification

- E.g. both sapphire and ruby are color varieties of corundum
- Red corundum is ruby
- All the other colors of corundum are sapphire
- Some sapphire, cut in cabochon, shows a six rayed star. The blue variety is called blue star sapphire corundum

Sapphire color suite
Gem Identification

• Gemfoolery is just a game
• GEM IDENTIFICATION IS NOT
• while a few natural gemstone species can be identified by sight from visual clues. Such identification is notoriously unreliable.
• Add to this the fact that synthetic material has the same optical, chemical, and physical characteristics as the natural gemstone
Gem Identification

• Add to this the fact that some natural and synthetic species may be simulants for other species (i.e. look-a-likes)
• Gem identification becomes more important with every advance in technology and with every advance in deceit and fraud
• in the Gemology program at Santiago Canyon College, gem identification is almost half of the colored stones curriculum
Gem Identification

“Black Prince’s Ruby”

• Survived the Battle of Agincourt 1415
• is actually a 170cts spinel
• It is an uncut octahedron 5 cm long with a drill hole (suggesting use as a pendant)
• The hole is now filled with another spinel
• it is mounted in the front of the British Imperial State Crown above the Cullinan II
Gem Identification

The British Imperial State Crown
Gem Identification

The Black Prince’s Ruby
Gem Identification

• Edward of Woodstock received the “Black Prince’s ruby” from Don Pedro the Cruel in 1367, for military services rendered.

• At the time, all red stones were called ruby, green stones emerald, and blue stones sapphire.

• There was no technology available to the owners of gemstones, or to gemstone traders, that could separate species of gemstones which shared the same color.
Gem Identification

• We now know that differences in color may be characteristic of a different species because we can now separate one from the other.

• We now know that the dark blue green color of chrome diopside is not a color of natural emerald because we now know that diopside is a separate species with different chemical, physical, and optical properties.
Gem Identification

• The study of sciences made a quantum leap with Galileo (1564 – 1642) who is known as the father of modern science

• But it wasn’t until 1783 that the French mineralogist Louis Rom de Lisle identified spinel as a separate mineral from ruby.

• Several other “rubies” in Royal/State gem collections were also found to be spinel
Gem Identification

Catherine the Great’s Ruby
Gem Identification

“Catherine the Great’s ruby”

• 398.72cts
• Semi-polished, pear-shaped, blood-red
• Is actually a spinel
Gem Identification

• The “Timur ruby”, in the crown jewels of Great Britain, is worn by Queen Elizabeth II at state banquets
Gem Identification

• the “Timur ruby”, like the Koh-i-Noor diamond, was taken by Nadir Shah when he seized the peacock throne of the Punjab, India in 1739.

• It came to the British in 1849 as war reparations and was given to Queen Victoria.

• It was found to be a spinel.
Gem Identification

Other misnomers

The 52cts Caesar’s Ruby in the Russian Crown Jewels is a red tourmaline (rubelite)
Gem Identification

- the old name for colored gem zircons in Cingalese was "tourmali," colored stones
- In the early 1800s it was discovered that some of the "tourmali" arriving at European gem centers from the far east were actually a previously un-described, unknown mineral
- This new mineral species was named tourmaline
Gem Identification

Before the technology to separate different species, when all red stones were called ruby

• Gemstones of good color and the preferred red were considered fine ruby and expensive

• Off color red gemstones were considered poor quality and cheap

• pale stones were considered unripe fruit of the Earth. Miners often reburied them to give them more time to ripen
Gem Identification

• Most gemstones can be identified using relatively simple procedures and equipment

• the equipment used by in-house jewelry store gemologists usually consists of:
  – Loupe and microscope
  – refractometer and polarizing filter,
  – polariscope,
Gem Identification

– dichroscope,
– Chelsea filter,
– spectroscope,
– u.v. light source,
– interference resolution sphere,
– hydro-static scale and/or specific gravity fluids
Each instrument investigates one or more of the properties of the gemstone
Gem Identification

- A gemstone is identified as to group, species, and variety as the result of a process of elimination and confirmation.
- Observation through the microscope gives the most information about the stone.
- Observations with the refractometer give the most precise information but have some limitations and drawbacks.
Microscope

- the microscope can look into a transparent or semitransparent gemstone. The observer can see and classify inclusions (if there are any)
- if the stone contains any natural inclusions, that is proof of natural origin
- if a double image is seen, known as “doubling of the back facets”, this is proof of double refraction (DR)
Microscope
Refractometer

• the refractometer measures refractive index but has limitations.

• Critical angle is reached in the optically denser medium, which must be the refractometer glass, not in the fluid or the gem

• the practical limit on the RI reading is 1.80

• OTL. There are several species with an RI above the limit - also useful information
Refractometer

• The polarizing filter allows the two rays of a doubly refractive stone to be seen and measured independently

• Measuring and plotting how the refractive index varies with direction can also reveal the birefringence and optical character of the gemstone
Refractometer
Refractometer

Common refractive index readings (approx.)

• quartz (amethyst, citrine, etc.) is 1.54-1.55 DR
• tourmaline is 1.62 - 1.64 DR
• synthetic spinel is 1.73 SR
• corundum (sapphire, ruby) is 1.76 - 1.77 DR
• spessartite and andradite garnet, zircon, diamond, cubic zirconia (and several other diamond simulants) are OTL
Refractometer

• before the refractometer, the procedure for measuring refractive index was to observe and measure the apparent and actual depths of a gemstone

• refractive index  =  \frac{\text{Apparent Depth}}{\text{Actual Depth}}

Synthetic Blue Spinel
12.6mm/7.3mm = 1.73
Polariscope

the Polariscope uses cross polarized filters

• gives reactions for SR, DR, and AGG
• gives an indication of optic axis
• gives an indication of optic character
  isometric (SR) – cubic
  uniaxial (DR) – tetragonal or hexagonal
  biaxial (DR) – orthorhombic, monoclinic, or triclinic
Polariscope
Spectroscope

- scientists analyze the surface of the sun by the wavelengths absorbed from the light emitted
- the spectroscope analyzes the wavelengths absorbed from the spectrum by elements in the gemstone
- The jade merchant tells you the jade has not been dyed. A spectroscope may tell you it has!
Gem Identification

Three types of Spectroscope

Table-top

Hand-held

Table-top

Absorption spectrum for almandite garnet
Measurement of Specific Gravity

- specific gravity is defined as the ratio of the weight of the gemstone divided by the weight of an equal volume of water
- The SG of diamond is 3.52
- SG of cubic zirconia is approx. 5.70 to 6.00
- Easy to measure as a loose stone. Impossible to measure when the gem is mounted in a ring
Hydrostatic Balance

Specific gravity = \text{weight of gemstone in air} / \text{weight in air} - \text{weight in water}
Gem Identification

• the procedure for identifying the gemstone is set out in the “Project Worksheet”
• Measurements and characteristics may give conflicting indications
• Results can be rechecked and confirmation tests performed
• If testing at a higher level of technology is required, the jeweler must be send the gemstone to a lab - for a fee
Gem Identification

• Gemological Institute of America (GIA) operates labs in many countries
• GIA reports can identify the gemstone, its grade, its country/region/mine of origin, undisclosed treatments, presence of foreign matter, natural or synthetic, etc.
• GIA has the high-tech equipment, the expertise, the leading edge research
Gem Identification

• Gemology may be a pseudo-science
• Its instruments and procedures look scientific
• It borrows scientific principles from several scientific disciplines
• the definition of a term in gemology may differ from the definition of the same term in another discipline
Gem Identification

- Gemology seizes on technological advances in physical, chemical and optical disciplines
- Especially in the areas of gem identification, and the revelation of undisclosed gemstone treatments, through spectroscopy and chemical analysis
- E.g. the detection of Beryllium (Be) diffusion in sapphire and ruby

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High Tech Gemology

development of research equipment to non-destructive gem analysis

• infra red and ultra violet spectrometers
• energy-dispersive X-ray fluorescence (EDXRF) and Raman technology

(Raman spectroscopy relies on comparison with a spectral reference library such as the RRUFF project)
High Tech Gemology

chemical analysis

• microprobe analysis
• secondary ion mass spectrometry (SIMS) cost in excess of $1 Million US
• photoluminescence analysis (PL) and luminescence imaging (LI)
• laser induced breakdown spectroscopy (LIBS)
High Tech Gemology

• laser ablation – inductively coupled plasma – mass spectrometer LA-ICP-MS)
• approx. one quarter the purchase cost and operating expense of SIMS instruments
• Laser ablation removes a microscopic amount of material for analysis. It is considered non-destructive because the resulting evidence of removal is too small to be detected at 10x magnification
High Tech Gemology

- A benefit from technological advances is that gemstones can be individually tied to a grading report by an unseen laser inscription.
- Some Canadian diamonds are inscribed with a logo indicating country of origin, the Kimberley Process.
- Gemstones can be branded—De Beers.
- A gift of a gemstone can include a secret massage seen only with a special light source.