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ORIGIN AND OCCURENCE OF GEMS AND GEM MINERALS
OUTLINE

I) Why are gem and gem minerals rare?

A) Composed in part of rare chemical elements
-e. g. Tourmaline (B), Beryl (Be), Topaz (F)

B) Formation requires unusual geologic conditions or mechanisms of exposure.
- e. g. Extreme pressure and temperature for diamond, v. high T for corundum, slow growth in the presence of fluids (pegmatite minerals) for large clear crystals, rapid transport of diamond and corundum via unusual, deep-seated, volcanic eruptions.

II. Origin vs. Occurence

A) Origin - Relating to formation, geologic environment of formation.

B) Occurence - Where the gem or gem mineral is found today. May not be where it formed.

III. Gem deposits

A) Definition - Economic accumulations of gems or gem minerals.

B) Types:
1) Placer - sedimentary accumulation of gems, **gem gravels**, formed by weathering of original gem-bearing rocks. Natural concentration process (winnowing) occurs due to high S.G. of most gem materials. Same true for base and precious metals (gold, platinum, etc.).

2) Load - deposit of gem or gem minerals that occurs where the minerals formed. Usually hard-rock mines. E.g. mining of pegmatites, diamonds. Generally requires greater capital investment, more expertise, and larger-scale operation to be profitable.

IV. Modes of Origin

A) Low T, involving surface and ground water near ambient temperature.

1) Dissolution, leaching and reprecipitation processes

a) Carbonic acid (HCO_3) from rainwater dissolution of limestone leaches and carries metal cations (often from adjacent volcanic rocks) to precipitate:
Malachite ($CuCO_3$)
Rhodochrosite ($MnCO_3$)

Turquoise ($CuAl_6(PO_4)(OH)_8$

b) Sulfuric acid (H_2SO_4) formed by reaction of rainwater or groundwater with pyrite (FeS_2). Acts to leach and dissolve many oxide minerals and transport metals to form supergene ore deposits, some gem minerals.

2) Both produce minerals with botryoidal habits.

3) **Opal**

a) Forms in arid regions underlain by qtz. sandstone or Si-rich volcanic rocks. Need great long term and seasonal fluctuation of the water table.

b) Si carried in solution by groundwater until evaporation causes supersaturation of groundwater with Si. Si then precipitates within cavities in the rock as Si-gel: semisolid spheres of SiO_2*nH_2O. With time and further evaporation, gel hardens to form opal.

B) Heated groundwater - Low temperature hydrothermal processes.

1) Same as above but heat allows groundwater/acids to become: a) more reactive, and b) convectively circulate.

2) Nearly all **agates** form this way, as does most of the worlds **amethyst**, in Si-rich volcanic host rocks that provide both a source and a site for silica dissolution and precipitation.

C) Heated groundwater + Magmatic water - High temperature hydrothermal processes (hot springs analog).

1) Hydothermal veins (50-500^{o}C) form from hot, mineral-rich, solutions that escape from a cooling body of magma and mix with convecting groundwater. Can transport large quantities of Si to produce quartz veins. Also transport volatile elements (Be, F, Cl, etc.) that originate in magma. Fluids can hydrofracture surrounding rock, creating their own pathways. Cooler temperatures and drop in pressure leads to precipitation of **Emerald**, **Amethyst, Imperial Topaz,** some base and precious metals.

2) These are characteristically **vein deposits**.

D) Pegmatites

-Very coarse-grained intrusive rock that forms during the late stages of crystallization of larger masses of magma. Granite magmas are most important for gems.

1) Unique and important gem sources because:
   a) Source of large, clean crystals (due to slow rate of crystallization, high fluid content)
   b) Contain high concentrations of rare elements, allowing crystallization of rare minerals.

2) Can be enriched in elements like Be, Li, B, Mn, P, F leading to formation of: **Aqua., Tourmaline, Chrysoberyl, Topaz, Mn-garnet, Kunzite**, and many other less common minerals.

E) Volcanogenic gems - 3 types:

1) Essential constituents - crystallize from cooling lava. E.g. **Peridot, Moonstone**

2) Gas cavity precipitates - crystallize in gas pockets in cooling lava: **Topaz, some chalcedony (agate)**.

3) Entrained Crystals - crystals that formed in a magma at great depth and were carried to the surface by erupting lava or kimberlite: **Some Peridot, Zircon, Sapphire, Diamond**, **some Garnet**.

F) Metamorphic Gems

-Form during transformation of limestone into marble, sandstone into quartzite, mudstone into schist or gneiss, serpentine into jade. Process requires elevated Temps. and Pressures, **but does not involve melting of rock**.

1) Marbles - **Ruby, some garnets, spinel**

2) Schists and Gneisses- **Sapphire, much garnet, alexandrite**, **tanzanite** (?).

3) Quartzite - **Aventurine**.

4) Serpentinite - **Jade**.