GEM STONES

A. Commodity Summary

The gem stone industry in the United States is extremely small and relies on foreign trade to meet most of its source requirements. The United States has no known large resources of precious gem stones (i.e., diamonds, rubies, sapphires, and emeralds) and reserves are generally limited to semiprecious stones. Several semiprecious gem stone deposits are mined in the United States. In 1992, 91% of the total U.S. gem stone production (by value) was made up by the following states: Arizona, Nevada, Oregon, Maine, California, and Montana. In 1994, domestic natural gem stone production was approximately $51.6 million.[1]

Most gem stone mining appears to be done by hobbyists and amateurs in Mitchell County, NC; Judith Basin County, MT; San Diego County, CA; Oxford County, ME; and Gila County, AZ where gems such as turquoise, tourmaline, kunzite, emerald, and sapphire are found.

Gem stones are formed in nature in one of three ways: (1) from metamorphic processes, (2) by precipitating from aqueous solutions, and (3) by crystallizing from magmas. There are three major compositional groups of gem stones: silicate minerals comprise one-third; alumino-silicates comprise one-fifth; and oxides comprise one-seventh of gem minerals. The remaining groups are sulfides, phosphates, borosilicates, and carbonates.

Some semi-precious stones are produced as by-products of other mining operations. For example, beryl, tourmaline, spodumene, and gem quartz may be coproducts of mica, feldspar, quartz, or other pegmatite minerals. Diamonds may be recovered from gold dredges, turquoise from copper mines, agate and petrified wood from gravel pits, and gem garnet from abrasive garnet mines and mills.

Gem stones are used primarily for decoration. There are, however, some industrial applications for gem stone material. For instance, industrial processes requiring clean homogeneous stones use low-quality diamond. Tourmaline is used in laboratories to demonstrate the polarization of light, to measure the compressibility of fluids, and to measure high pressures. Agate is made into mortar and pestle sets, knife edges for balances, textile rollers, and spatulas. Gem stones are used as jewel bearings in timing devices, gauges, meters, and other applications requiring precision elements.

B. Generalized Process Description

1. Discussion of Typical Production Processes

Gem stone production includes three steps, (1) mining, (2) processing, and (2) enhancement. These steps are discussed in greater detail below.

2. General Process Flow

Mining

Gem stone mining operations vary according to size and complexity. Small shallow deposits are generally mined by a few people with prybars, picks, shovels, and buckets. Drilling, blasting, and timbering may or may not be employed. Mechanized hauling and hoisting are done only at the largest mines.

Processing

In small operations, gem stone ores are broken, crushed, and concentrated by hand picking, washing, screening, or jigging. In larger operations, mechanized processes are employed. For instance, diamond processing involves standard gravity methods, grease belts, electrostatic separation, skin-flotation, magnetic separation, separation by x-ray luminescence, and separation by optical sorting.

Enhancement

Gem materials are cut in four main operations: sawing, grinding, sanding, and polishing. An initial cut is made with a diamond saw or blade to obtain a slice of desired thickness. Grinding of the stone may be done with impregnated-diamond, silicon carbide, aluminum oxide wheels, or coated abrasive disks. Multiple grinding steps ranging from 80 mesh through 600 mesh abrasives are used. Disk and belt sanders use abrasives bonded to cloth or waterproof reinforced

[1] Gordon Austin, "Gemstones," from Mineral Commodity Summaries, U.S. Bureau of Mines, January 1995, pp. 64-65.

paper. Leather laps or hard felt are used with a polishing agent to obtain the final polish.

Polishing agents such as fine diamond compound, tin oxide, tripoli, chromium oxide, cerium oxide, alumina, and rouge are typically used. These polished irregular shapes can then be further polished by tumbling them in a rubber lined drum and using a grinding and polishing medium with or without water.

Finally, many gem stones are further treated to enhance their appearance. Several different chemical and physical processes may be used, including bleaching, oiling, waxing, staining, dyeing, plastic and color impregnation by diffusion or dyeing, surface modification with color coating, lasering, glossing, heat treatment to change color, and irradiation by electromagnetic spectrum and by energetic particles to change color. Interference filters, foil backings, surface decoration, and inscribing are used to alter the surface of gems. The most common method of gem enhancement is heat treatment which can change color, structure, and clarity. A newer method of gem enhancement is diffusion treatment. This involves a chemical heat treatment in a bath of chemicals containing iron and titanium.[2]

3. Identification/Discussion of Novel (or otherwise distinct) Process(es)

Synthesis of materials that can replace rare crystalline materials has been encouraged by industry. Synthetic gem stones may be used in electronics and semiconductors or as frequency controllers, polarizers, transducers, radiation detectors, infrared optics, bearings, strain gages, amplifiers, lasers, lenses, crucibles, and more.[3]

4. Beneficiation/Processing Boundaries

Based on a review of the process, there are no mineral processing operations involved in the production of gem stones.

C. Process Waste Streams

Existing data and engineering judgement suggest that the wastes listed below from gem stone production do not exhibit any characteristics of hazardous waste. Therefore, the Agency did not evaluate these materials further.

1. Extraction/Beneficiation Wastes

The extraction of gem bearing material in mines creates **overburden**. However, land disturbance due to gem stone extraction is minimal since the number of underground mines in operation is minimal.[4] Additional miscellaneous wastes include **spent chemical agents** used to color the gem stones, **spent polishing media**, and **waste minerals**.

2. Mineral Processing Wastes

No wastes are identified.

D. Ancillary Hazardous Wastes

Ancillary wastes may include used chemicals, tires from trucks and large machinery, sanitary sewage, waste oil (may or may not be hazardous), and other lubricants. Small operations may have fewer ancillary wastes.

---

[2] Gordon T. Austin, "Gemstones," from Minerals Yearbook Volume 1. Metals and Minerals, U.S. Bureau of Mines, 1992, pp. 501-519.

[3] Jean W. Pressler, "Gemstones," from Mineral Facts and Problems, U.S. Bureau of Mines, 1985, pp. 305-315.

[4] Ibid.

BIBLIOGRAPHY

Austin, Gordon. "Gemstones." From Mineral Commodity Summaries. U.S. Bureau of Mines. January 1995. pp. 64-65.

Austin, Gordon T. "Garnet." From Industrial Minerals and Rocks. 6th ed. Society for Mining, Metallurgy, and Exploration. 1994. pp. 523-528.

Austin, Gordon. "Gemstones." From Minerals Yearbook Volume 1. Metals and Minerals. U.S. Bureau of Mines. 1992. pp. 501-519.

Pressler, Jean. "Gemstones." From Mineral Facts and Problems. U.S. Bureau of Mines. 1985. pp. 305-315.