

Determining the Source of Gem Emeralds

Emeralds are among the most prized of gemstones. Owners understandably want to know about the source of these valuable gems in specimens and jewelry. Suppose however that the emerald is set in a Gallo-Roman earring, or in a 13th Century French crown, or a sunken Spanish galleon? What clues could one find in order to deduce the gem's history and origin without destroying the priceless object? A newly applied scientific technique from a team of French researchers may hold part of the answer (Giuliani et. al., 2000).

This technique uses oxygen isotopes within the minerals. To give a little "chemistry-lite", most elements, including oxygen, come in several varieties, called isotopes. Isotopes differ from each other in having different numbers of neutrons in the nucleus. Some isotopes are radioactive and break down. Many are not radioactive and are called stable isotopes. The isotopes of oxygen are stable, and behavior mostly alike. You breathe all of them in any one breathe. However the ones that are slightly heavier (another neutron or two in the nucleus) do behave slightly differently from those that are lighter. For example, water that evaporates from the sea has more of the light isotope in it than the heavier stuff left behind. This persists in rain water. So a mineral formed from rain water will have a different mix of oxygen isotopes in it than one that forms from sea water - or groundwater - or volcanic water. Each source of water has a slightly different identifying ratio of these oxygen isotopes in them.

So how does this relate to emeralds? Emeralds from various districts (and even mines within districts) have different oxygen isotope ratios in them - different oxygen "fingerprints". The French geochemists measured these values for many emeralds from known localities, then compared them to emeralds whose origins were not known. Fortunately these tests require only a tiny amount of material, and are not destructive to the gem.

Their tests lead to several surprising results. The emeralds in a 17th century French crown originated from Habachtal emerald mines in Austria. An emerald in a Gallo-Roman ring best matches the emeralds from the Swat-Minguora district in Pakistan. This ring dates back to 500 BC. It was previously thought that emeralds at that time were known only from Egypt and Austria. The new findings show that trade was going to Rome along the Silk Road long ago. An emerald from a Spanish Galleon sunk in 1621 was from the Muzo area in the western emerald district of Columbia., showing how rapidly the mines developed after their discovery. An emerald from a gem treasury in India was also from Columbia, showing an influx of New World gems into Old World collections in the 17th and 18th centuries.

Similar techniques are being developed for rubies and sapphires. As more sources for gem and more artificial gems come on to the market, such analytical tools will be increasingly important as ways to evaluate and validate gems from a variety of sources.

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Reference:

Giuliani, G., et al., 2000, "Oxygen Isotopes and Emerald Trade Routes Since Antiquity", *Science*, vol. 287, p. 631 - 633.