has already managed to make green LEDs simply by adding a little indium to the gallium nitride mix. If the South Carolina team or their competitors can figure out a way to also get red gallium nitride LEDs, it would allow them to integrate both the light emitters and the electronics needed to drive them on the same silicon substrate, which would drastically drop their cost to produce. That promise is enough to keep the lights burning late into the night at semiconductor labs around the globe.

–ROBERT F. SERVICE

GEOLOGY

Discovering the Original Emerald Cities

Emeralds have turned many an eye green with envy. The ancient Egyptians forced slaves to dig for the precious stones, prized as a symbol of immortality. Centuries later, Romans dominated the trade, setting the gems in gold jewelry. And when conquistadors in the 16th century captured mines in Colombia, they shipped back chests full of eye-popping emeralds that were snapped up by royalty, from Indian maharaji to Turkish sultans. Even today, dealers have no trouble spotting the exceptional clarity and intense color of the Colombian gems. But it's been notoriously difficult to track down the birthplaces of the murkier Old World emeralds.

Now on page 631, scientists describe a kind of atomic birth certificate that can peg where emeralds were grubbed from the ground. The technique might help dealers authenticate top-quality stones, and it could clear up the mysterious origins of Old World emeralds, including some famous gems. This new kind of detective work "is just the beginning," says Dietmar Schwarz, a mineralogist with Gübelin Gemmological Laboratory in Lucerne, Switzerland. Indeed, the approach is already providing information on ancient trade routes, and it might someday offer tantalizing hints of long-lost mines.

Emeralds are a kind of beryl, a mineral made when molten granite thrusts up into Earth's crust, cools, and hardens. Normally drab white or pale green, beryl can acquire a striking verdancy if the granite first muscles through rocks bearing chromium and vanadium. Hot water soaks up these and other elements, then crystallizes. Almost all the world's emerald deposits were formed this way.

Except in Colombia. There, hundreds of millions of years ago, black shale containing traces of chromium and vanadium washed off the west coast of South America. As the Caribbean Plate pushed eastward against the Brazilian Plate, it shoved the shale-covered sea floor onto the continent and twice created faults in the shale: first 65 million years ago, then again 38 million years ago. The squeezing and folding acted like a giant squeegee, forcing hot water into the black shales where the fluids picked up chromium, vanadium, and other ingredients of emerald. This brew percolated beneath impermeable shale layers until the pressure grew so great it ripped apart the rocks. The solution shot into the cracks, cooled, and gave birth to clear, blue-green emeralds, according to a scenario developed since the mid-1990s. But as researchers reconstructed this geologic history, they discovered more than a recipe for radiance: Colombian emeralds, it turns out, have unique oxygen isotope ratios that depend on where the stones were mined. So did emeralds from many mines elsewhere in the world.

Intrigued, Gaston Giuliani of the Petrographical and Geochemical Research Center (CRPG)–CNRS in Vandoeuvre-lès-Nancy, France—along with CRPG colleague Marc Chaussidon and Didier Giard and Daniel Piat of the French Association of Gemology—decided to see if they could use this isotopic tag to trace the origins of emeralds in artifacts. First they had to persuade the relics' wardens that they would do no harm. "No one wants you to touch [a precious specimen], no scratching,

Crown jewel. The first isotopic analysis of this 13th century French crown suggests that its central emerald came from Austria—more than 500 years before the mine's documented discovery.

nothing," says Fred Ward, an independent gemologist in Bethesda, Maryland, and author of the book *Emeralds*. But the French group wasn't intending to hack off a piece. To measure oxygen isotopes, the researchers fire a beam of cesium atoms at the emerald, vaporizing a few atoms and leaving a hole a mere 20 micrometers wide and a few angstroms deep.

Reassured that samples weren't visibly marred in a test run, Henri-Jean Schubnel, the director of the National Museum of Natural History in Paris, and curators elsewhere let the team have a crack at a handful of gems spanning the history of emerald trading—from a Gallo-Roman earring to a thumb-sized emerald set on the Holy Crown of France to treasure from a Spanish galleon. "Gems with this pedigree are jealously guarded by museums, so to get access is quite an accomplishment," says Terri Ottaway, a geochemist and gemologist with the Royal Ontario Museum in Toronto, who has worked on Colombian emeralds. As expected, the emeralds from the wrecked galleon bore the isotopic signature of Colombian mines. But surprisingly, the stone in the earring turned out to come from the Swat River in Pakistan, demonstrating that the Romans had access to gems from much farther afield than Egypt. And the 13th century French crown, it turns out, is graced by an emerald from the Austrian alps—one that appears to have been unearthed more than 500 years before the first known description of these deposits.

For gem dealers, isotopes may help tell Colombian emeralds from top Afghani stones, which sometimes resemble each other, says Schwarz, who's working with Giuliani's team to see if oxygen isotopes can pinpoint the origins of rubies and sapphires. Customers care about an emerald's source, Schwarz says, because it helps determine value. Isotopes could also provide an additional tool for spotting synthetic emeralds, which are hard to distinguish from flawless gems. "We have big-time problems with fraud," says Ward.

The technique may offer an important new tool for archaeologists, too. They have a hard time tracing stony emeralds, the opacity of which tends to obscure microscopic drops of fluid or other telltale inclusions of a source region. Oxygen isotopes may lift this veil. "It's a great idea," says Ottaway, "but I'd like to see it tested with more samples." And who knows: If some ancient emerald turns out to be an isotopic orphan, it may point the way to a mine not found on any map.

–ERIK STOKSTAD

CELL BIOLOGY

Generating New Yeast Prions

For a controversy that many insist is settled, the long-running argument over whether abnormal proteins called prions act alone to cause disease has had amazing staying power. The stakes in the debate are high, because prions are implicated in several fatal neurodegenerative diseases, including human Creutzfeldt-Jakob disease and bovine spongiform encephalopathy, or "mad cow disease." But while most researchers now

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