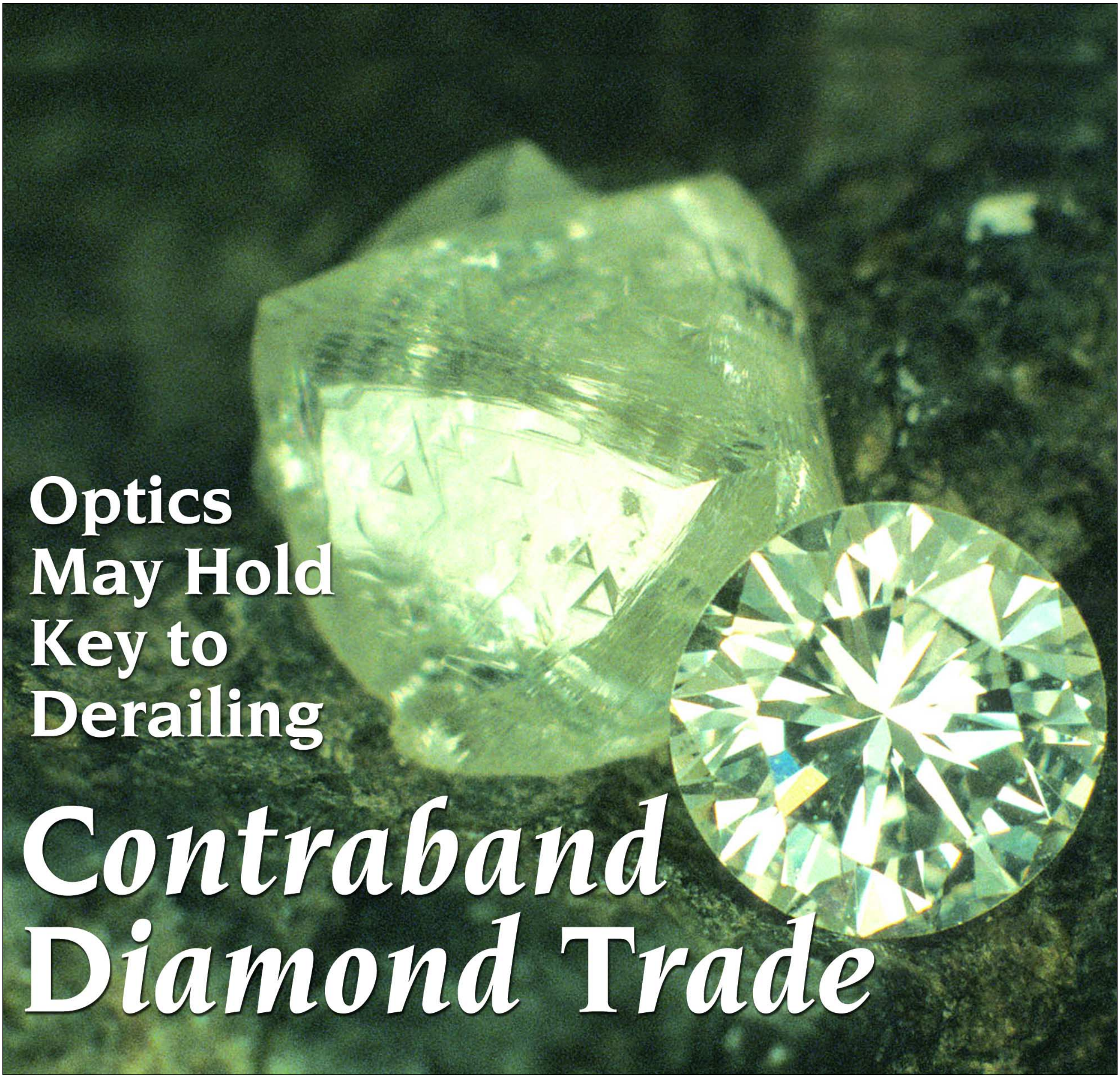

Optics May Hold Key to Derailing Contraband Diamond Trade

Gemological Institute of America. Reprinted by permission.

SUZ REDFEARN

Scientists and law enforcement officials are hoping that optics-based applications may one day help staunch the flow of “blood diamonds.”

Also known as conflict diamonds or rough diamonds, blood diamonds are contraband gems from Africa. After being mined or plundered by rebel groups, the diamonds are sold on the black market to finance the purchase of arms. Traditionally linked to rebel uprisings in countries including Angola, the Congo, and Sierra Leone, today the blood diamond trade is also said to be fueling the operations of the al Qaeda terrorist network, believed responsible for the September 11 attacks.

A highly sensitive mass spectrometer has been used to analyze the surface contaminants of a diamond in an attempt to determine its origin.

Although blood diamonds account for only about 4% of the world diamond market, the value of the transactions overall is high enough to exert a destabilizing influence throughout much of the African continent. Countries like Botswana, which depend on legitimate diamond exports to maintain economic and social stability, are particularly at risk. In Sierra Leone, terrorist activities and armed conflict fueled in part by the blood diamond trade have resulted in the maiming or murders of thousands of innocent victims.

The United Nations banned the export of diamonds from rebel sources in 1998. In 2001, the U.S. House of Representatives

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passed a bill designed to prevent diamond sales in the United States from being used to finance civil wars abroad. But there's a glitch: No commercial technology exists for determining exactly where a diamond has come from—and thus there are no scientific means for keeping illicit diamonds out of the legitimate diamond trade.

At least not yet. A few pioneers are hard at work developing solutions to the country-of-origin problem. George Rossman, professor of minerology in the Division of Geological and Planetary Science at the California Institute of Technology in Pasadena, California, is one such researcher. Rossman is working on a process that employs optics to profile diamonds. "Our philosophy is: it's the surface of the diamond that's important," says Rossman. "The thing that really counts is local dirt, local geography."

Rossman, who presented his research at a White House conference on conflict diamonds in early 2001, explains that when diamonds are fresh out of the ground their microscopic imperfections often harbor minute traces of dirt. Under high magnification, this material can be examined. To Rossman, the trapped soil possesses at least two properties of interest: the composition of the clay minerals, which differs in different parts of the world and, most importantly, the isotopic composition of the soil particles, which varies as well.

Rossman explains that clay minerals are hydrous, containing chemically bound hydrogen in the form of the OH ion and as molecules of water (H_2O). Hydrogen has two common isotopes, normal hydrogen and deuterium, or heavy hydrogen. The isotopic composition of minerals is sensitive to local geography. This, says Rossman, is because the clay minerals equilibrate with the local water. The isotopic composition of the local water varies geographically because the ratio of normal to heavy water in rainfall changes as air masses move inland from the areas in the tropics where the predominance of evaporation occurs. Heavy water tends to rain out first and become increasingly scarse as the air masses move inland. For this reason, Rossman says, diamonds from areas with heavy rainstorms will have the heaviest hydrogen.

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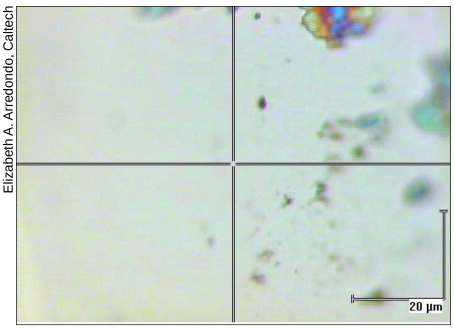
Figure 1. Photomicrograph of the surface of a rough diamond from Angola. The surface is comparatively free of contaminants.

Elizabeth A. Arredondo, Caltech



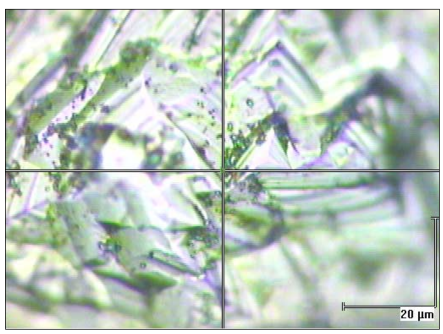


Figure 2. Photomicrograph of the surface of a rough diamond from Sierra Leone. It shows numerous small fragments of contaminants on the surface.

With this mind, Rossman and colleague Professor John Eiler heated an uncut diamond from Orapa, Botswana, collecting the volatile materials that emerged. The water was purified and sent through a highly sensitive mass spectrometer that determined its isotopic composition. From that diamond, says Rossman, three isotopically distinct releases of water were recorded—one was indicative of local contamination (from Pasadena), another was what one would expect from subtropical Africa, and the third remains to be interpreted.

While the concept is promising, Rossman is the first to admit it has a long way to go. "We just have a research idea," he says. "But we have some reason to think we have an idea based on firm principles."

Rossman is seeking funding for further research. A machine dedicated to the process would cost about $100,000. He says a post-doctoral student working on the project full time would be a big plus. "Several hundreds of thousands" of dollars are still needed, he calculates. But what Rossman needs most is a database of conflict diamonds to study. These are exceedingly difficult to obtain. Yet unless the usefulness of the research can be demonstrated on a large scale, progress will be slow.

Others counter that the diamond industry, today a vocal advocate of anticontraband measures since blood diamonds create bad press, wouldn't be impressed enough to provide development funding in any case. For one thing, says James E. Shigley, a geologist and researcher with the Carlsbad, California-based Gemological Institute of America, diamonds—which are almost 100% carbon—are extremely pure chemically speaking. Finding trace elements in them can be more than tough.

Shigley also says that analyzing foreign material on the surface of a diamond requires that the diamond not be cleaned. But when diamonds are extracted from the earth's surface, he says, most often they are immediately sent to India where they are boiled in acid. This removes soil and water nestled in the diamond's crannies, he says, and would leave nothing behind to be analyzed.

According to testimony given by GIA President William Boyajian before a September 2000 House Ways and Means subcommittee hearing on conflict diamonds, diamonds originally lodged in several primary deposits in one or more countries could be weathered out of their original host rock, transported by rivers, and become concentrated in a secondary deposit in another country. Even if identifying characteristics from a particular primary deposit existed, these features might not be retained during the weathering and transport of the diamonds.

Rossman agrees. "Assuming our basic method works reliably—and that is not yet demonstrated on a statistcally meaningful number of samples and localities—we don't know how far apart sources would have to be to be distinguished by our method. We don't know if all 'important' localities can be distinguished by our

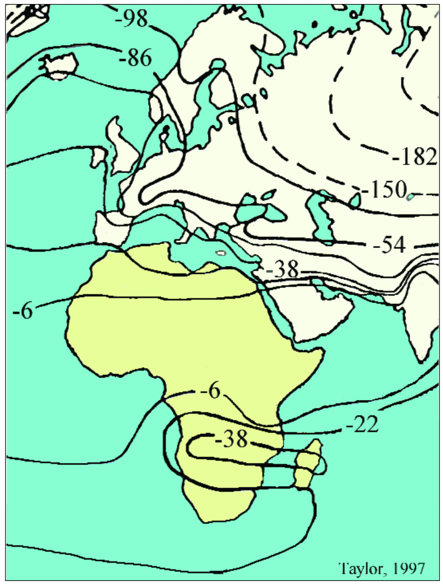
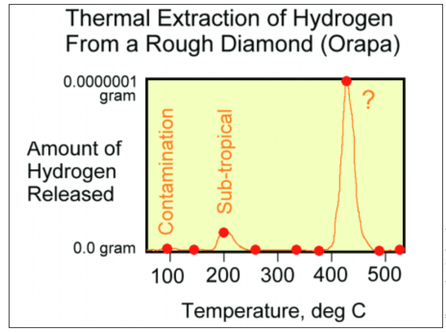


Figure 3. Variation in the isotopic composition of hydrogen in rainwater across Africa, Europe, and parts of Asia. Rainwaters become more depleted in deuterium (heavy hydrogen) as the storm systems travel farther from the tropical areas where most evaporation of the oceans occurs. Hydrogen isotopic compositions are indicated in Δ values, a way of representing the parts per thousand deviation of a water sample from the mean isotopic composition of a standard. Their values on the map are more negative when the water is depleted in heavy hydrogen.[1]

The Royal Canadian Mounted Police are also waging an effort to address the origins of diamonds by examining their impurities.



Eiler Lab, Caltech

Figure 4. Schematic illustration of the system used to liberate hydrous components on a diamond's surface and to determine their isotopic composition.

method. We don't know how much variation may exist in a single locality. And," admits Rossman, "our method would not work on cut and polished diamonds."

He added that he sees the potential of this applicatin as a kind of court of last resort. "Our idea is that a small number of suspect rough diamonds could be tested to verify their origin in cases where the origin was in question."

The Royal Canadian Mounted Police are also waging an effort to address the origins of diamonds by examining their impurities. Sergeant Ray Halwas, in charge of the Mounted Police's diamond protection service, says the police began dabbling in diamond profiling in 1995 when they brought in a chemist from Ottawa. At the time, rough diamonds were making their way into Canada, and to stop them, the police had no one to look to but themselves, said Halwas. "We couldn't opt out of it," he added.

The team began using high-intensity lasers to create a microscopic crater in questionable diamonds. From there, they passed the diamonds through a spectrometer and analyzed the concentration of impure elements. But, like Rossman, when trying to perfect their technology, the Mounted Police ran into sample-group issues. "We had no database to study," said Halwas. "Globally, it just doesn't exist. We need sufficient commitment from industry to move forward with that."

But, also like Rossman, Halwas is very cautious about hype. "We don't want to try and oversell this. There are still a lot of unknowns," he said. "This is largely for exploration purposes."

So, until such exploration is complete, it looks as if the diamond industry and law enforcement officials will have to rely on a process of mandatory audited chains of custody, tough criminal penalties, tamper-proof packaging, and standardized and public record-keeping to keep blood diamonds off the market.

References

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