Features

Hot Rocks - There's a secret to cooking up the perfect fake diamond or emerald. Whatever your brand of alchemy, throw in a few flaws, says Amy Adams, or the gem police will get you **28 Feb 98**

California

IT WAS formed when the Earth's first continent was still unbroken, and is probably older than anything you see around you. It has survived the demise of dinosaurs and the rise and fall of empires. It adorns royalty and movie stars. And it is, apparently, still a girl's best friend.

Few things are as magical or mysterious as a glittering diamond. "Each gem is a piece of history," says George Harlow, curator of the diamond exhibition at the American Museum of Natural History in New York. Something that may have survived for three billion years has got to be special.

But what if the sparkling diamond on your finger wasn't formed in the intense pressures and ferocious heat that pevail miles beneath the Earth? Supposing it came instead from a vat of chemicals in an industrial estate on the outskirts of San Francisco? Could such a fake ever feel as special?

Advances in chemistry have not only made the creation of synthetic gems a reality, but these little fakes are now so good that it is almost impossible to tell the real thing from a crafty copy. That's fine when synthetic gems are clearly labelled, but who do you turn to if you think an unscrupulous dealer has sold you a dud? Enter the Gemological Institute of America (GIA), based in California. Although it has no regulatory role, the GIA helps to monitor the industry and keeps jewellers and gemologists up to date about counterfeiters' latest tricks and techniques. James Shigley, director of research at the GIA, says that most jewellers can usually spot a synthetic gem. And when they are unsure, jewellers often send their hard-to-identify gems his way. But as the gem makers get more skilful, it has become ever harder to be sure what you're looking at. "It is a challenge to recognise some of these things," admits Shigley.

Faking gems has a long history. The first attempts were pretty clumsy, but this changed with the arrival of two revolutionary techniques for cooking up gems. The first was devised at the turn of the century by the French chemist Auguste Victor Louis Verneuil, who created impressive synthetic rubies using a method now called Verneuil flame-fusion ("The fake in the crown",*New Scientist*, 21 December 1991, p 25).

Verneuil knew that real rubies and sapphires were crystals of aluminium oxide, Al_2O_3, and that they gained their colour from contaminants-chromium ions in rubies, and iron and titanium ions in sapphires. His idea was to trickle aluminium oxide powder and the right colour-giving contaminant through a torch-heated chute kept at more than 2000 °C. When the resulting molten liquid hits a pedestal at the bottom, it crystallises. As the crystal builds up, the pedestal is slowly lowered so that the mound, called a boule, is never directly in the flame. When the crystal is several centimetres high, it can be cut into individual stones.

Warts and all

Verneuil gems are easy to identify because they contain bubbles and curved growth lines that are visible under a low power microscope. The lines result from layers of melted aluminium oxide dripping onto the growing boule and trickling down the sides before crystallising. Each drop adds an additional curved cap to the boule.

There are two problems with this technique. First, while the Verneuil process could turn out sapphires or rubies, emeralds proved impossible to grow. Secondly, Verneuil gems have none of the tiny imperfections of natural gems. These have irregularities in the crystal structure that can form unique feather-like patterns, or contain particles of the rock in which the gem formed.

However, improvements in technology have made it possible to produce gems, warts and all. Not only do these synthetic gems have the same chemical composition and crystal structure as natural gems but, most importantly, they mimic the flaws in a natural stone.

The pioneer who made these fakes look almost real was Carroll Chatham. In 1926, the teenaged Chatham decided to grow some diamonds. He dissolved graphite in molten iron and dropped the fiery solution into a vat of liquid nitrogen that he'd placed outside his parents' basement window. He expected that, as the red-hot solution cooled rapidly, the dissolved carbon would crystallise into pure diamond. Instead, the resulting explosion blew out the windows around his San Francisco home.

Urged by his father to find another hobby, Chatham turned his attention to emeralds. When he was 21, Chatham had his first success and by 1938, he had introduced the first lab-grown emeralds to the market.

The key to his process was a special solvent called a flux, a combination of chemicals such as lithium oxide, molybdenum oxide and vanadium oxide that remain liquid at high temperatures. Emeralds are crystals of beryl, $Be_3Al_2Si_6O_{18}$, with some chromium mixed in for colour. Verneuil's technique did not work for emeralds because there is no way to melt all the components together: some of them evaporate before others have even melted. But Chatham's unique and highly secret flux recipe got round this problem. He suspended tiny seed crystals in the hot flux so new crystals had something to grow from, much like providing the first row

of a complicated brick pattern to help place the subsequent rows. After a long wait-it can take over a year to grow marketable stones-out came emeralds.

Chatham's son Tom has carried on his father's business, distributing lab-grown rubies, sapphires and emeralds from his San Francisco office.

With his back to a well-lit case of colourful synthetic gems, Chatham says, without a hint of irony, "luckily, our product is not perfect."

Spot the fake

Although the imperfections he's referring to lower the quality of the stones, they make the jewels more realistic and therefore more expensive than Verneuil gems. They also make flux-grown gems hard to spot by visual inspection alone. It takes a trained eye and a lot of equipment to tell if an eye-catching gem is what it pretends to be. Chatham says that even trained jewellers or gemologists occasionally get it wrong. Crooked dealers can buy synthetic gems and try to sell them overseas as the real thing.

This is where the GIA comes in. Suspect gems might have been labelled correctly when they were first sold, but such information gets lost as gems change hands, says Shigley. "By and large, people who sell treated and synthetic gems attempt to disclose the information." Jewellers are keen to sell honestly because if they make one mistake, their reputation is gone forever. It is partly this fear that makes them send stones to the GIA for analysis.

No single technique can determine a gem's origins. When a suspicious jewel turns up, Shigley first examines its colour, which depends on the light absorbed by tiny amounts of metal ions trapped inside the stone. The differences can be subtle, impossible to distinguish by eye alone. A red stone could be a ruby-synthetic or otherwise-or a similar-looking gem called red spinel. Checking more closely under a microscope, Shigley looks for the curved lines of Verneuil gems or for the dark-coloured platinum inclusions of flux grown jewels. These tell-tale impurities come from the platinum growth chamber where they are grown.

If Shigley is still unsure, he turns to fluorescence for clues. When electrons in a crystal are excited, they fluoresce with a characteristic colour. Although synthetic gems may have the same crystal structure as natural ones, subtle differences in the atomic arrangements create differences in the energy levels that the electrons can occupy. This causes them to fluoresce at slightly different wavelengths. For example, red spinel and ruby fluoresce at different wavelengths when ultraviolet light is shone on them, and a natural emerald gives off a reddish light slightly different from that of its synthetic equivalent.

If such tests are inconclusive, he can also look at the strain patterns in the crystal's structure. Putting a transparent material such as Perspex between a pair of polarising filters reveals the patterns of strain inside the material. In the same way, natural gems show unique strain patterns that are characteristic of the way they grow.

Shigley can also replace the ultraviolet light with high energy X-rays and examine the fluorescence again, this time inside an X-ray spectrometer. Or he can use X-ray crystallography to reveal a gem's exact crystal structure.

Taken together, this battery of tests will usually reveal the synthetic, says Shigley. But sometimes things aren't so tidy and the occasional mystery still pops up.

One such puzzle was a star ruby that had stumped other jewellers. Natural star rubies are highly valued. They contain thin filaments of titanium oxide that reflect light in a beautiful, star-like pattern. But the top of the mystery gem had the gas bubbles and curved lines typical of a Verneuil gem while its middle layer was slightly opaque and seemed to be where the star originated. It turned out that the gem was built from several bits. The synthetic top and unidentifiable bottom gem were fused together and at the join, someone had scored fine lines in three directions, reflecting light in a too-perfect star.

Facet lift

According to Shigley, this sort of assemblage appears regularly at the GIA. Manufacturers often glue an expensive gem on top of a less expensive one. When done honestly, it reduces the cost of a natural-looking gem. However, Shigley has seen a few less than honest versions. And although it's relatively easy to spot a synthetic stone, once it's been fused to a real stone and the whole conglomeration treated in some way, things become far more complicated. One purplish-red stone was being sold as natural spinel. When Shigley examined it, however, he found that the bottom half of the stone was synthetic spinel. Since the synthetic was similar in colour to a natural stone, it is possible that the manufacturers made an honest mistake. Then again, maybe they didn't.

The most difficult fakes to spot are natural gems that have undergone the mineralogical equivalent of a face-lift. These gems look real, but are doctored to make them more expensive. Many gems on the market today fall somewhere between natural and synthetic. They may have originated underground, but it took a little laboratory magic to put them in a jeweller's display case. For instance, emeralds, which are prone to cracking, often have a plastic or oil filler to disguise faults. Diamonds can have dark inclusions removed with a laser knife, or be irradiated to improve colour.

Heat treatment often works wonders. Cook a ruby in the presence of chromium ions and the colour of the gem will improve-at least in the outer few millimetres. Many sapphires are also heated to enhance their natural blue. Such treatment dissolves titanium oxide contaminants, which can make the gem cloudy, and removes an electron from the colour-giving iron contaminant. Iron without the extra electron will steal an electron from a neighbouring titanium ion, changing the stone's colour in the process. This trickery can turn a valueless, murky-grey sapphire into a highly prized deep-blue gem. It can also make its distributors some extra money.

What of the most prized gems, diamonds? General Electric and De Beers have been growing diamonds for industrial use since 1955, but these tend to be yellowish-brown or blue in colour. Officially sold only for industrial use, gemologists have seen a few synthetic diamonds masquerading as real gems. Brown-yellow diamonds have been spotted in Antwerp and London. "Despite the limited numbers of synthetic diamonds seen, the fear that they will enter the marketplace and will not be readily identifiable continues to haunt the trade," says Shigley.

Gems with attraction

Such fears came a step nearer reality when Chatham turned his attention to the diamonds that gave his father such explosive problems. It began when he got a call from some Russian scientists claiming that they could grow "white" diamonds. "I told them that if they could grow them, I could sell them," Chatham recalls. And so he has become the first gem manufacturer to grow white diamonds for jewellery.

The new gems are dismissed by Cheryl Pellegrino of the Diamond Information Center, the marketing arm of diamond giant De Beers. "Diamonds are a gift of love," she says. "We don't think synthetics will ever compete." But not everyone shares her lack of concern. "Someone very high up in the GIA came to me and said: `You just can't do this. It isn't right'," says Chatham.

Though Chatham's white diamonds look like the real thing and are being marketed as jewellery, the GIA says it is easy to spot them. Synthetic white diamonds fluoresce a yellowish-green colour under ultraviolet light while natural diamonds emit either blue or a weak yellow light. The synthetics also contain iron impurities from the growth chamber. The clue is a dark reflective inclusion, which hints at the presence of iron.

And there's a simple test to confirm it, says Shigley. You just dangle the diamond on a string and hold a magnet next to it. If it moves, you've been had.

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