Gemmological intelligence
Short articles

Breaking diamonds

Yoram Finkelstein

Diamond is the hardest of all minerals. Yet the reality is that we are not dealing with 'diamond', but rather diamonds – individual crystals that possess a subtle structure which is exposed during the cutting process. Often the effect of the subtle structure is not subtle at all. There are many stories that could be told.

Figure 1. A partly polished rounded rough diamond measuring 10.8 x 9.9 mm and weighing 9.10 cts.

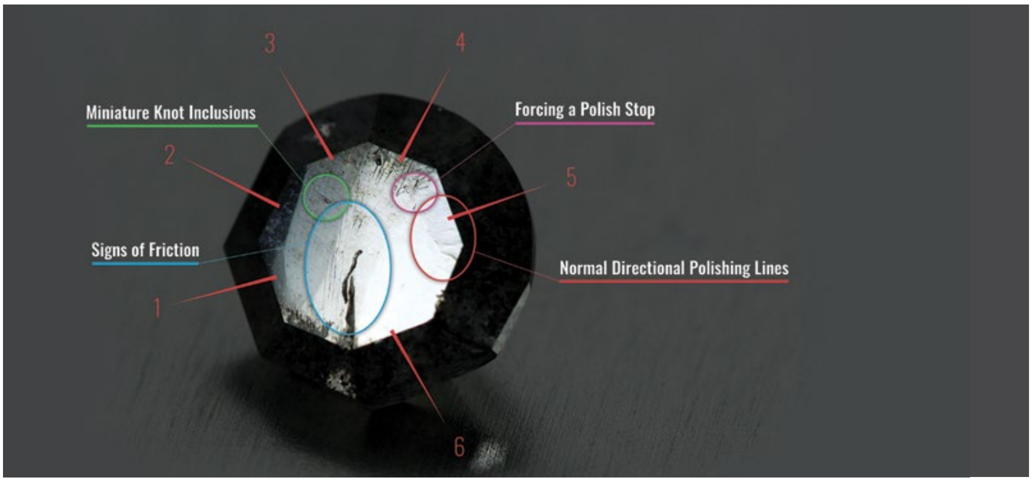

Figure 2a. A diamond which was attempted to be cut around 30 years ago. It has a diameter of 8.2 mm and weighs 2.22 cts.

The tough

We managed to forcibly polish some small areas on this rounded rough diamond by using conventional tools that existed 30 years ago (Figure 1). At that time we did not have the means to further cut this diamond. The white patches in the picture are glare, reflections off a couple of those small, flat polished areas.

There is some question as to how a crystal such as this might have acquired its surprising shape. This rounded rough specimen is a diamond, and may have some unmanageable polycrystalline areas with marked grain boundaries, but it is still considered one coherent rough diamond with plenty of irregularities. Such irregularities in diamond structure make the stone harder – and certainly harder to polish. Strength does come from particular faults.

Some such tough diamonds cannot be cut at all, whilst some might be able to be worked to some extent.

The next picture is of a diamond which my late father attempted to cut around 30 years ago (Figure 2a). Clearly noticeable on the table reflection are the signs of multiple and unsuccessful attempts at cutting and polishing the table facet:

At least six different (but very close) attempted polish angles are visible (numbered 1 to 6 in Figure 2a). On the upper left side of the table are many miniature "knots" or "naats" (within the green circle). These are irregularities in the structure of the diamond related to twinning. They show as pits on the surface and will have different hardness or change in hardness that are impossible to polish. More signs of unwanted friction can be visible as miniature vertical lines (centre, within the blue circle). Close ups of these features are shown in Figure 2b.

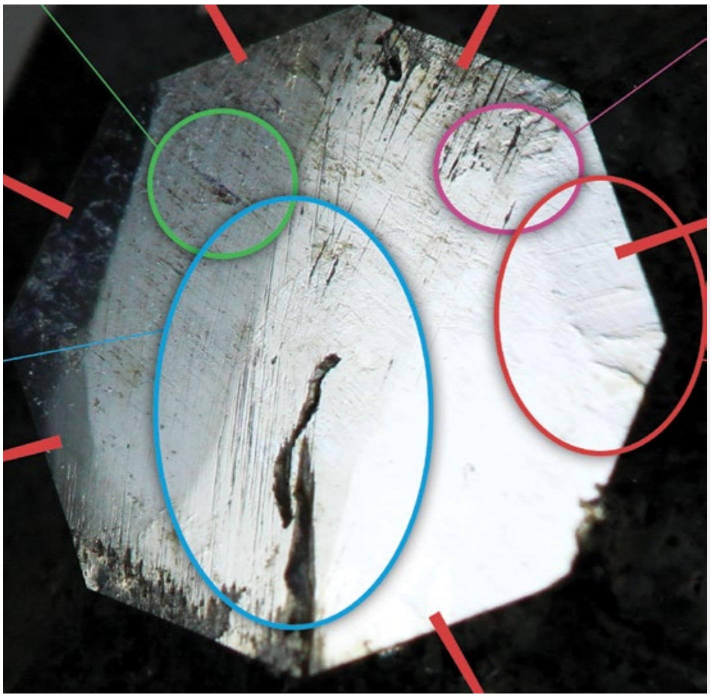

Figure 2b. A close up of the diamond in Figure 2a showing the results of attempted polishing.

You can compare these difficult areas with what a successful polish would look like at this stage. One small area of the diamond did take the polish well – it is in a semi-smooth polished state (in the red circle, no. 5), with the surface wavering a little bit smoother than the others. The smooth polish stops at the border of a rough area (in the purple circle, above the red) containing a knot.

Below is another view of the same diamond (Figure 3). Diamonds such as this are expected to contain zones with different grain directions.

When one grain direction is similar to that of the main diamond, then the worst case scenario can be a simple raised area on the facet; this can be difficult, but not impossible to correct. When substantially different grain directions appear in groups in a diamond, this makes cutting impossible – as it may well be the case with the spherical stone in Figure 1.

Figure 3. The same diamond from Figure 2 under different lighting, with multiple-grain directions.

The tense

Whilst diamond is the hardest of all minerals, with great shock applied along particular directions, they will split or cleave. This property must have been understood very early on, since the oldest technique for shaping diamonds relied on the diamond's ability to cleave along certain directions. This property of diamonds is certainly not obvious: How could one tell how diamonds would break!

In some of the most beautiful stones, clean fault lines open, even if the roughs are not being split along their cleavage direction but cut along other directions.

Some beautiful and rare, rough diamonds such as the famously vivid orangey-yellow diamonds from Zimmi, a small town in Pujehun district of southern Sierra Leone, are known to develop feather inclusions during the various cutting and polishing stages. The price for holding colour!

On account of this reputation of Zimmi diamonds, I had planned the diamond in the next picture to be cut without any sawing (dividing) of the crystal (Figure 4a). Even so, after grinding the top to form the table facet and the four crown facets, numerous feather inclusions developed. The crackle goes deep into the stone, as a grid of great fractures reflecting light the wrong way. This is no longer a transparent diamond.

This is 'grand failure' of a diamond – a result of placing a fragile material within a harsh cutting environment, i.e. being cut on a polishing wheel at 3.750 rpm velocity. The damage caused is not subtle, yet the details of the feathers took several photos to show properly: their depth, their reaching the surface, and the beautiful colour of the stone (Figures 4a, 4b and 5). Each view required different lighting for the camera to capture these features.

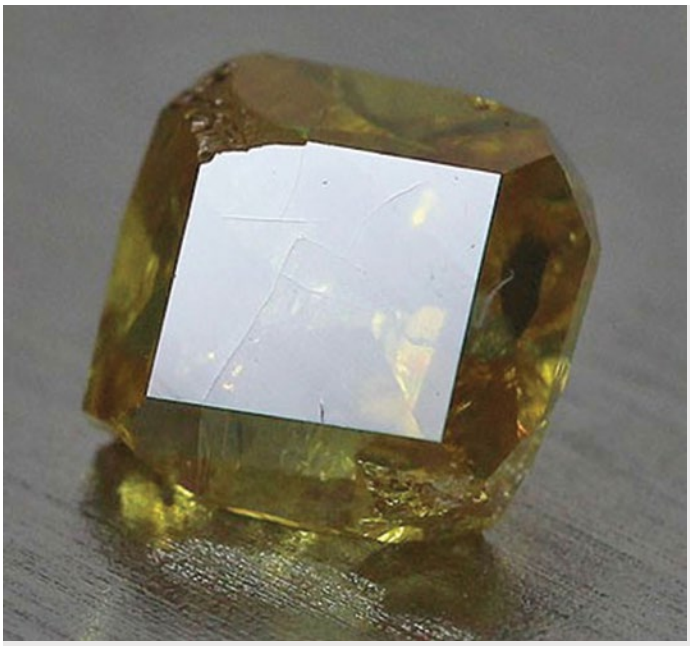

Figure 4a. The development of feather inclusions in a Zimmi diamond after cutting and grinding to form the table facet and four crown facets. The diamond originally weighed 1.00 ct in the rough, and currently weighs 0.65 ct, measuring 4.7 x 4.5 mm.

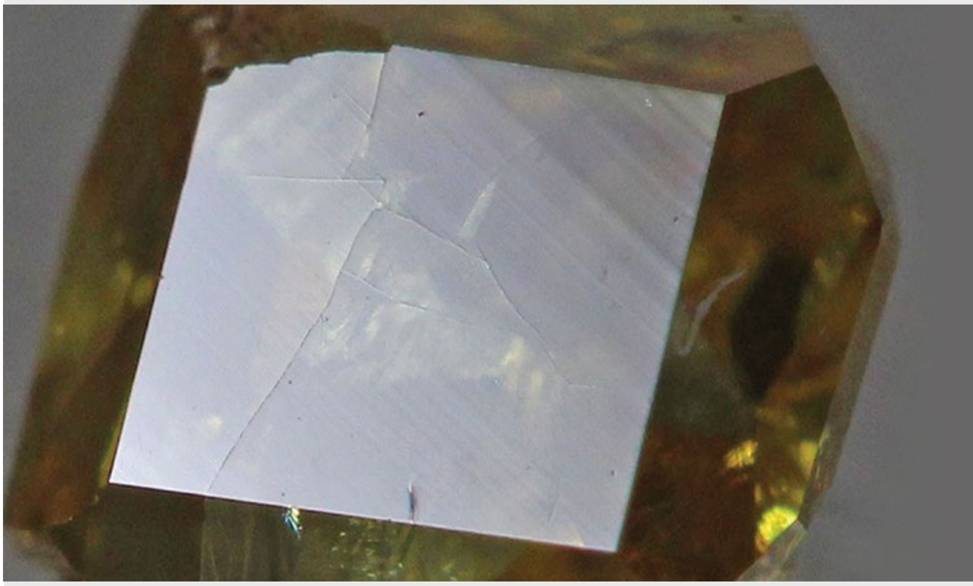

Figure 4b. A close up of the table reflection of the diamond shown in Figure 4a showing how the feather inclusions have reached the surface of the table facet.

The next shot shows a close up of the table reflection of this same diamond (Figure 4b). Looking closely, you will notice the open surface marks showing how the feathers have developed out of one unfortunate site. Bear in mind that this diamond was free of inclusions when it was untouched, prior to cutting.

The last picture of this same diamond shows the colour and the depth of the surface-breaking feathers (Figure 5). Light reflecting off the feathers will no longer play as it should against the cut facets. Even if the cut could be completed, it would not 'work' – a pity for such a great and rare colour.

We can see the undesirable effects of grinding the table and crown facet of this stone. Would laser cutting the table have achieved a better result? No. It fails in the same way – as the next diamond illustrates (Figures 6 and 7).

Figure 5. The diamond shown in Figure 4 under differing lighting which shows its orangey-yellow colour, as well as the depth of the surface-breaking feather inclusions.

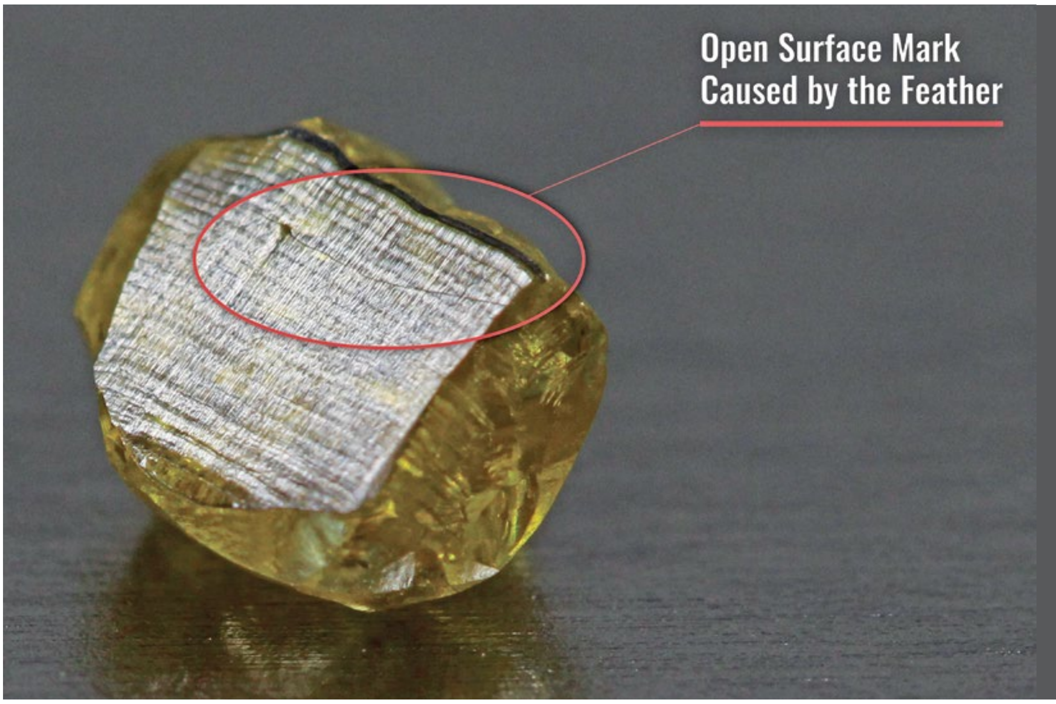

Figure 6. A diamond sawn using a laser. Note the plough-like marks on the surface. The fine horizontal line (circled) on the face of this diamond is the mark of a deep feather reaching the surface. This diamond weighed just under 1.00 ct in the rough, and currently weighs 0.70 ct, measuring 5.2 x 4.2 mm.

The diamond in the next picture was sawn (divided in two) using a laser – hence the tell-tale plough-like marks on the surface (Figure 6). A horizontal fine line is noticeable (circled in red) – the mark of a deep feather inclusion reaching the surface. The depth of the feather is made visible in transmitted light (Figure 7).

These stones split not because of the stress of cutting, but because the cut removed parts of the outer layer of crystals that had contained internal tension.

Figure 7. The same diamond shown in Figure 6 under different lighting, showing the depth of the feather.

Figure 8. A cut diamond that has cleaved along clean planes. It weighs 0.47 ct and has a diameter of 5.1 mm.

Figure 9. Accidental cleaving (large chip) that occurred during the cutting process. The total weight of both pieces of this diamond is 0.36 ct. The diameter was supposed to be 4.6 mm.

The two stones shown in Figures 8 and 9 are cleaved diamond, so to speak, not that the site of the cleavage plane did anyone any good!

The causes for such accidents can be subtle discontinuities in the structure of the crystal that allow splits to become directed along the grain (not unlike the cleaving tools in the past used to do). Such 'subtleties' could be inclusions reaching the surface, boundaries between different grain directions, feathers that met the wheel at an unhappy angle, or just the act of laying the diamond on a 3600 rpm velocity wheel. The diamond shown in Figure 8 was basically completed, but in the final stages of the cutting process, at the end of the brillianteering stage when the upper and lower girdle facets were being polished, this split occurred.

Imagine shaping diamonds, when the only means available was to split them like this, without any of the modern equipment we use today! Yet, this was how many of the earliest diamond cut models were achieved – by splitting the diamond along its cleavage planes, then giving it a slight polish which was very labour-intensive. The facets resulted purely from the natural cleaving of the diamond, responding to the structure of crystals, not to any of the sophisticated cutting equipment we have today. A lost art!

Cleaving is such a lost art that finding reading material on the subject is currently hard to find. I consider myself lucky, as cleaving was my first apprenticeship in the entrance into the diamond cutting arena.

Too much to be said...

Acknowledgements

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All photos are courtesy of GemConcepts Ltd.

About the author

Yoram Finkelstein is the founder of GemConcepts Ltd., a boutique diamond cutting facility that specialises in faceting unique diamonds and is based in Israel. He is a diamond designer and cutter specialising in unique and period cut diamonds using a new approach and philosophy. He designs diamonds that mix the "old world" approach with the newest cutting-edge technologies based on years of research and development on light behavior in diamonds. He has been cutting diamonds for thirty years.

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