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DAMAGE TO CUT GEMSTONES

While many gems are looked upon as durable, there are some factors that make gems prone to damage.

These factors include such things as hardness, toughness, brittleness, fracture, cleavage and parting, thermal stability, chemical resistance, and stability of colour. An example is diamond. Damage to diamonds can and does occur, including damage caused during the cutting and setting process and damage caused during use such as chipped girdle, worn facet edges; abrasion due to rubbing against neighbouring diamonds and even diamond surfaces abraded during sand blasting in the jewellery finishing operations. Even more apparent are similar types of damage on other gems, such as sapphires and garnets, especially when worn or set so that they come in contact with diamonds. An interesting form of damage caused naturally with time, is the expansion of uranium-containing zircon inclusions and uraninite inclusions in sapphire. Such expansion could lead to fractures or even chipping of the gemstone if such inclusions are close to the surface.

TABLE 1

TYPES OF DAMAGE	
Mechanical damage	Breakage, cleavage, chipping, abrasion
Thermal damage	Cracking, decomposing, burning
Chemical damage	Etching, corrosion
Changes of appearance	Due to colour fading, decomposition
Loss of dream	Psychological damage

TABLE 2

OPPORTUNITIES FOR DAMAGE
Geology, tectonics, metamorphosis, weathering
Mining activity, handling of rough
Cutting, polishing, setting
Wear and tear
Soldering (heat, tensions)
Cleaning (ultrasonic, acid, solvents)

The trend towards repairing jewellery with the gems in place also provides opportunities for damage. For example, diamonds in jewellery items that are being torch-repaired are protected from burning by coating them with a borax compound. However, the same compound would attack rubies, sapphires and some other gems. Significant corrosion to rubies set in jewellery is common, when using a borax-compound during soldering. A burned surface on diamonds when borax has not been used is also often seen. Soldering can cause heat stress and even fractures to some set stones. A particularly intriguing instance concerns a chip off a large diamond which was caused by the impact of a soldering laser shot during a repair. Soldering with laser is useful as it does not heat the setting or stone but should be used with caution. Other examples of damage include the removal of the polymer filler in B-Jade when cleaned in an ultrasonic cleaner and serious etching can occur to peridot from acid cleaning of jewellery after soldering.

Damage depends on the different characteristics of gemstones. These could be mechanical resistance, chemical resistance, thermal stability, and stability of colour. All gemstones are subject to damage, from diamond to turquoise, ruby to opal. The popular belief that 'a diamond is forever' can inadvertently lead the wearer to mistreat many a beautiful gem.

Table 1 lists different types of damage together with an analyses of the reason for damage.

This article furnishes some information on how damage could be avoided. A few cases are presented where gemstones suffered accidental damage and there are other situations the reader will be familiar with.

DIAMOND

Diamond has a high scratch hardness, but is very sensitive to percussion and pressure in the situation of daily wear. Because knocking and rubbing with other diamonds, facet edges and corners can appear white after lengthy periods of wear. (Fig. 1). Sharp-edged or thin girdles on diamonds are prone to damage as they will chip during setting or later. (Fig. 2).

Rough usage of diamond cutting tools may also have created pressure or knocking fissures in the cutting factory. Numerous diamonds leave the factory with small percussion marks (fissures) and scratches due to careless dopping procedures during the cutting process (Fig. 3 & Fig. 4).

A burned surface is another type of damage which may occur during the cutting process. The heat produced by the friction on the lap allows carbon atoms from the diamond surface to react with oxygen from the air and form volatile carbon dioxide CO_2. This gas forms at the expense of the diamond surface that is subsequently corroded and shows whitish burn marks. (Fig. 5). Boric acid is usually used to cool the diamond on the dop and coat it with an air-proof flux layer, that inhibits the corrosion.

A common source of damage to diamonds is during repair of mountings when soldering is necessary.

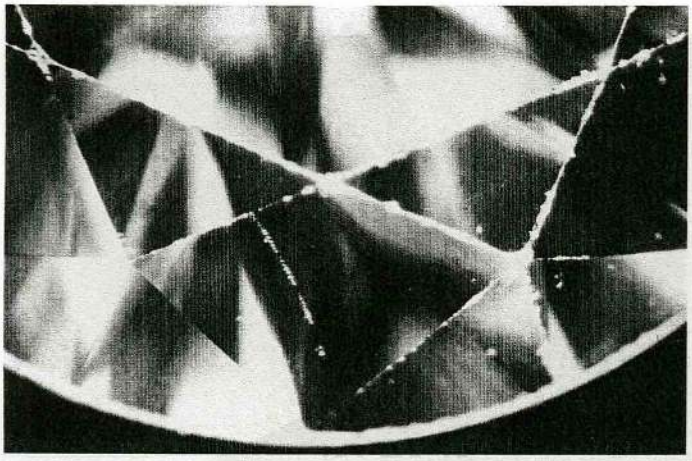

FIG. 1: WORN EDGES AND CORNERS ON A BRILLIANT CUT DIAMOND, WITH A SCRATCH ACROSS A MAIN FACET. DIAMONDS ARE NOT INDESTRUCTIBLE BUT QUITE SENSITIVE TO KNOCKS AND CONTACT WITH OTHER DIAMONDS.

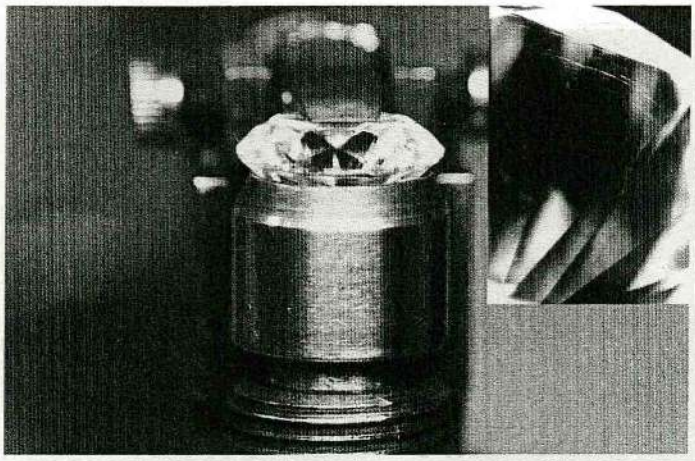

FIG. 3: DIAMOND PARTICLES UNDER THE METAL CLAMP CAUSE SCRATCHES WHEN THE STONE IS TURNED IN THE DOP FOR CROWN FACET CUTTING. SUCH SCRATCHES MAY BE VISIBLE AT 10X AND AVOID A LOUPE CLEAN PURITY GRADE.

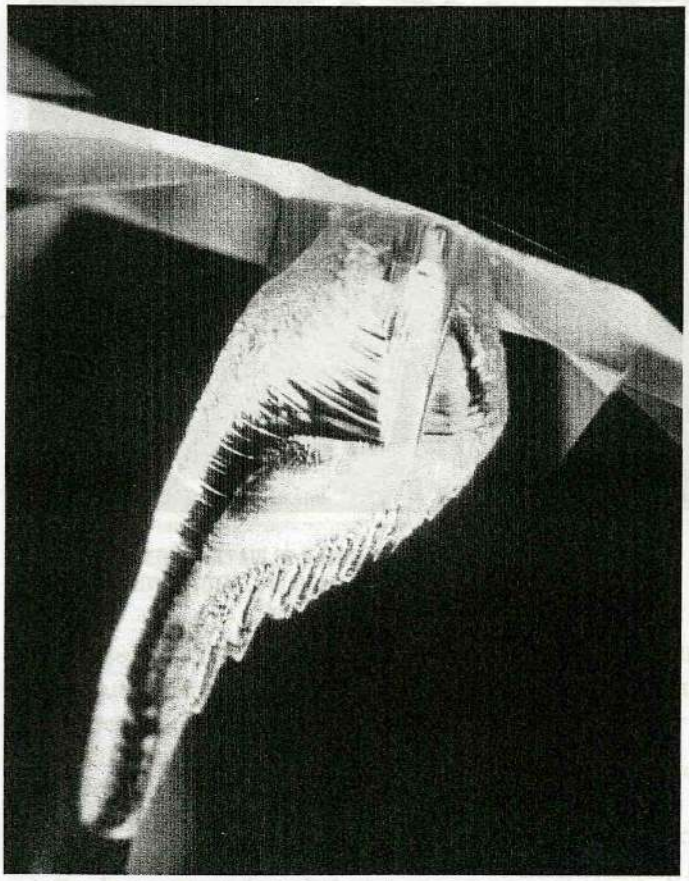

FIG. 2: CHIP ON THE GIRDLE OF A BRILLIANT CUT DIAMOND, SITUATED ON AN AREA WHERE THE GIRDLE IS THIN. THIN OR SHARP EDGED GIRDLES ARE POTENTIAL DAMAGE ZONES.

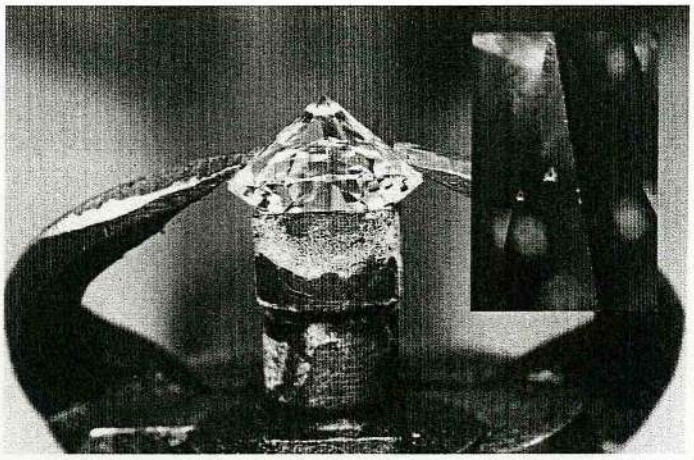

FIG. 4: FORCED CLOSING OF THE CLAWS OF THE DOP FOR PAVILION FACET CUTTING MAY CAUSE PRESSURE MARKS. SUCH FISSURES MAY BE VISIBLE AT 10X AND AVOID A LOUPE CLEAN PURITY GRADE.

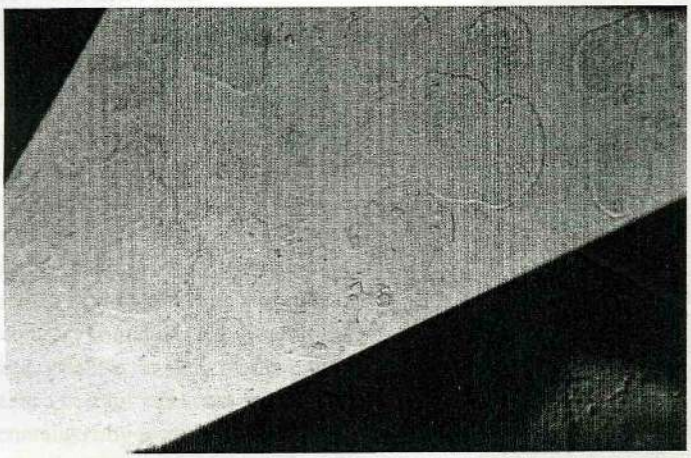

FIG. 5: BURNED SURFACE SPOTS (BURN MARKS) ON A STAR FACET OF A BRILLIANT CUT DIAMOND. MAGN. 30X.

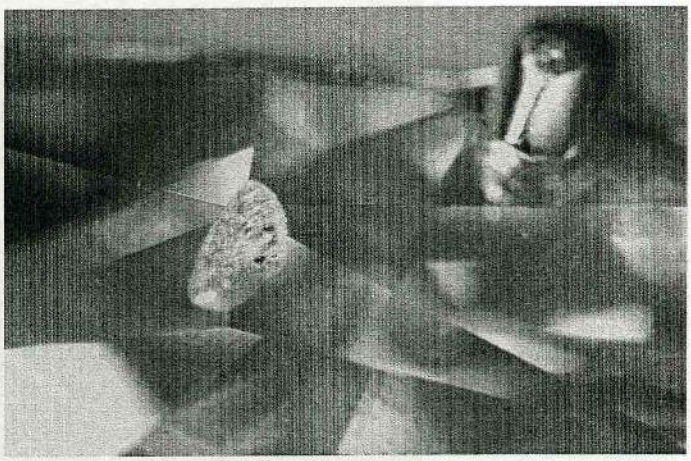

FIG. 7: A STEPPED CHIP ON A CUT DIAMOND, CAUSED BY A LASER SHOT. IN THE CENTRE OF THE CRATER A BLACK PORTION OF GRAPHITE IS VISIBLE.

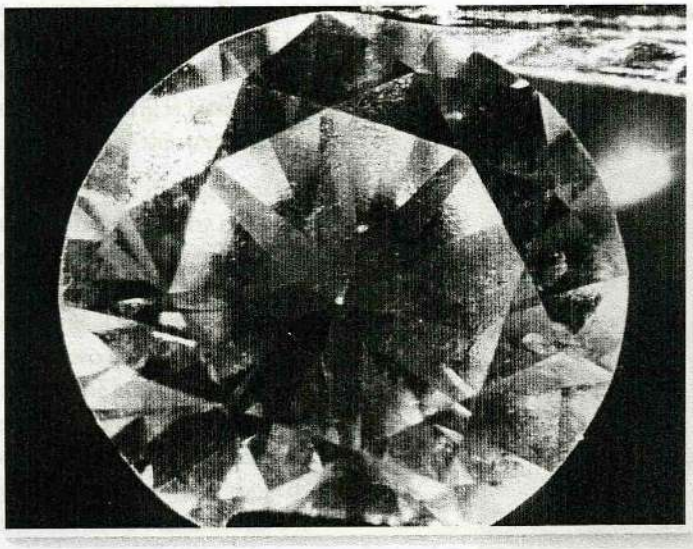

FIG. 6: A SOLDERING REPAIR OF A RING WITH THIS 0.30 CT BRILLIANT LEFT THE STONE WITH A TOTALLY BURNED SURFACE.

The flame of a torch is hot enough to allow the diamond to form CO_2 in the presence of air. A simple remedy against this corrosion is the application of a coating: a borax or boric acid layer protects the diamond and prevents oxygen reaching the surface. Any fat or dirt, however, produces holes in this layer, and corrosion can take place (Fig. 6). Therefore rings etc. must be thoroughly cleaned before soldering. Surfaces of all diamonds must be coated with the protective borax layer when a ring goes under the torch.

Although soldering with a laser does not heat up the mounting or the stone, special precautions also must be taken. Laser soldering may be dangerous for mounted diamonds since the energy of a laser shot may transform diamond into graphite. Either directly shot into the diamond or by reflection on the polished metal, the concentrated energy can, in a very short time transform diamond into graphite. Graphite has a less dense atomic structure, and a transformation from diamond to graphite increases the processed area by 1.6x. If such a phase transition is close under the surface of a diamond, the pressure will burst that spot and a crater will be formed (Fig. 7). Shielding the stone's surface with black ink would be good protection against such unexpected damage (Hänni, 2006).

RUBY AND SAPPHIRE

Corundum is a remarkably tough ring stone and tends to chip much less than diamond with its perfect cleavage. However, wear marks, like rubbed edges and corners, must be expected if ring stones are worn on a hand continually over a long period of time (Fig. 8). Parting along twin planes is a reaction akin to cleavage and may occur. Secondary minerals (e.g. boehmite) may crystallise on twin planes and create a certain weakness in corundum. Generally ruby is much more affected by the formation of thin twin lamellae than sapphire. This also often lessens the transparency of ruby and represents a source of damage when force is applied, for example in setting. Since most of the rubies in the marketplace are heated with additives such as borax, such weakness in respect of parting is lessened due to the gluing effect of this treatment.

A severe case of damage was encountered with an unheated ruby of over 10 ct that was removed from its setting, and re-set using an inappropriate tool for closing the setting. The cushion shaped stone showed two serious chips on opposite corners. The author assumes that tongs were used to bring the claws back in position. Since they reacted to some degree, more force was applied, and the stone shattered within. (Fig. 9).

There have been cases where the older damaged stones have been wax filled to hide or disguise the open fractures. Unfortunately the damage can become noticeable again later in the life of the jewellery. Although the appearance of a fissure was new for the owner of the ring, an insurance company would not consider this fracture as damage.

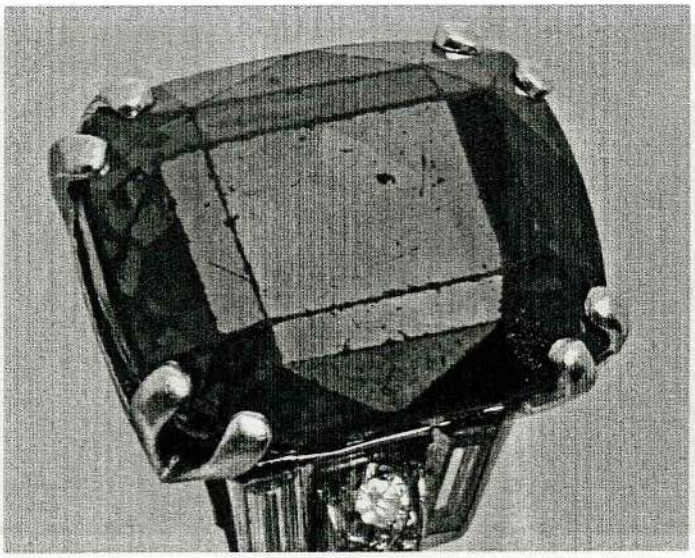

FIG. 8: WEAR MARKS ON A SAPPHIRE MOUNTED IN A RING, WITH ABRASIONS ON FACETS, CORNERS AND EDGES.

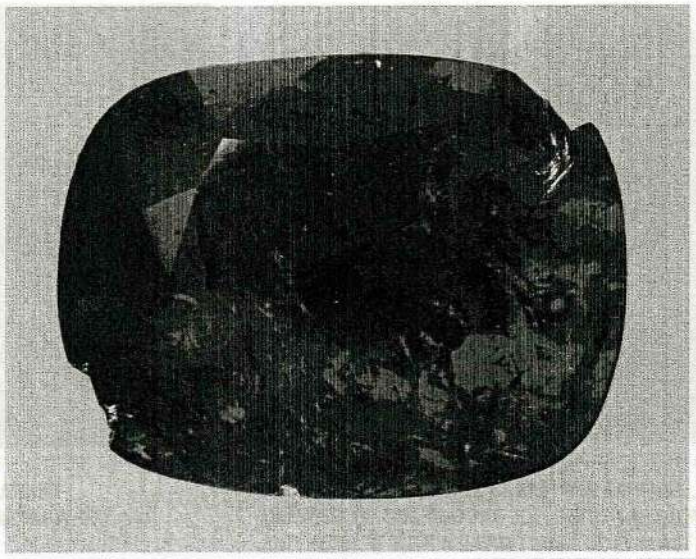

FIG. 9: A RUBY WITH NUMEROUS TWIN LAMELLAE AND NATURAL FISSURES DAMAGED IN AN ATTEMPT TO RE-SET THE STONE WITH TOO MUCH PRESSURE.

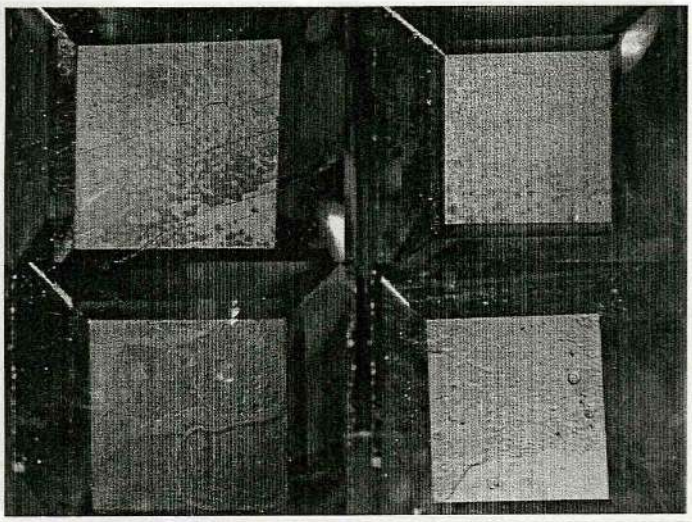

FIG. 10: RUBIES WITH CORRODED SURFACES DUE TO DISSOLUTION BY HOT SOLDERING FLUX.

FIG. 12: THE SETTING TOOL MUST NOT TOUCH THE STONE WHICH IS LOGICAL, BUT DAMAGED STONES QUITE OFTEN HAPPEN WITH THIS TYPE OF BLEMISH.

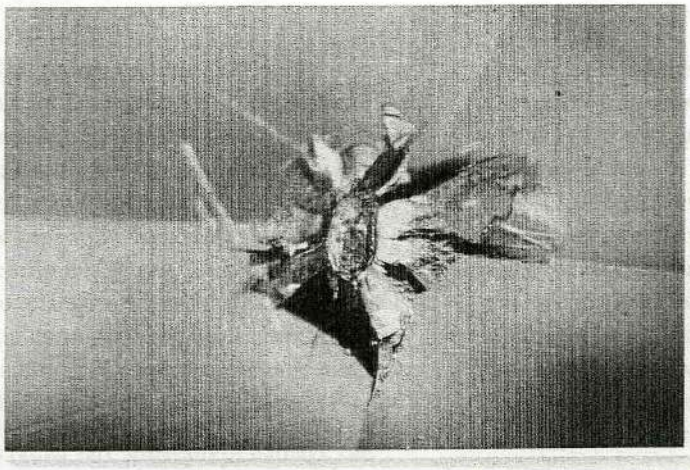

FIG. 11: AN INCLUSION OF ZIRCON WITH TRACES OF URANIUM INCREASE IN SAPPHIRE, WITH TENSION FRACTURES AND BLOW-OFF TOWARDS THE SURFACE. MAGN. 25X.

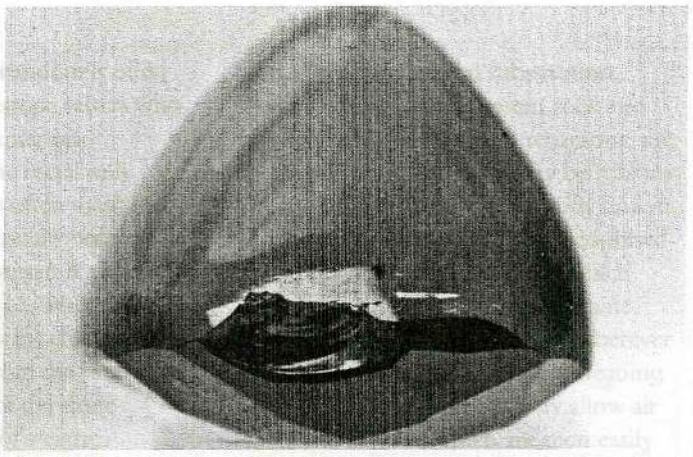

FIG. 13: DAMAGE TO A 12 CT KASHMIR SAPPHIRE, PRODUCED BY A SETTING HAMMER. RE-SHAPING THE OUTLINE OF THE STONE MEANS TOTAL RE-CUTTING, AND RESULTS WITH A WEIGHT LOSS OF AT LEAST ONE CARAT.

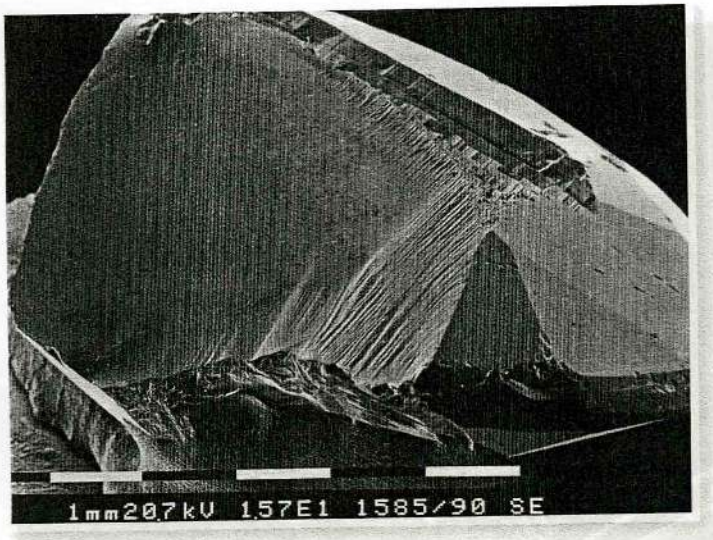

FIG. 14: SEM PICTURE SHOWING THE BREAK STRUCTURE OF A SAPPHIRE DAMAGED DURING ENLARGEMENT OF A RING. THE FORCE TO BREAK THE STONE COMES FROM THE CULET AND AFTER A CONCHOIDAL BREAK IT ENDS IN A STEPPED STRUCTURE NEAR THE TABLE OF THE STONE. LENGTH OF WHITE BAR 1 MM. PHOTO © H.A.HÄNNI, SSEF.

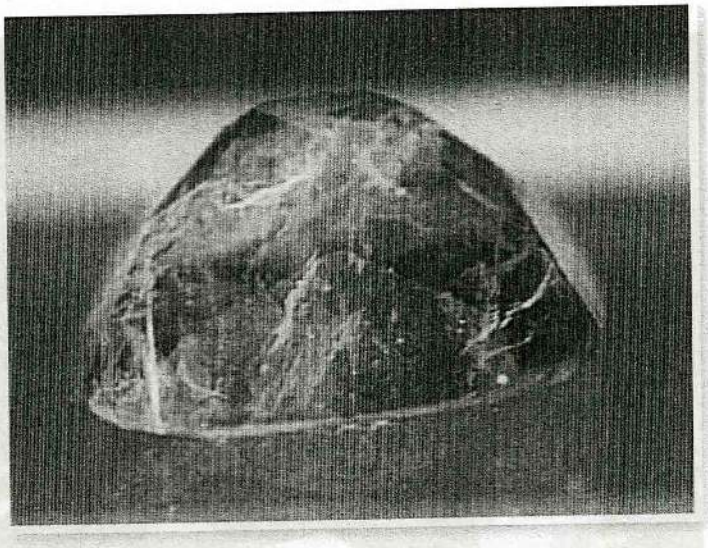

FIG. 15: FISSURE FILLED EMERALD SEEN IN LONG WAVE ULTRAVIOLET ILLUMINATION. THE EXTENDED NETWORK OF BRIGHT LINES SHOWS A SIGNIFICANT DEGREE OF TREATMENT. THE WHITISH FLUORESCENCE OF THE FILLER IS TYPICAL FOR EPOXY RESIN. LENGTH OF THE STONE APPROX. 12 MM.

Using torch soldering on rings incorporating ruby or sapphire can present a problem for the stone despite its usually good reaction to heat. In contrast to diamond, any borax should be kept away from stones when they remain in a setting for soldering. Hot borax melt is a solvent for most minerals and corundum gets heavily etched from such melt. Corrosions can only disappear after a re-polishing of the stone (Fig. 10).

A rather rare situation of damage can be seen in corundum when radioactive included minerals are close to surface. The decay of uranium or thorium in zircon, uraninite or thorianite as an example, increases the volume of such inclusions. This creates stress into the neighbouring host mineral and leads to fractures emanating from the inclusion. When such grains are close to the surface, the tension may blast the overlaying corundum, as seen in Fig. 11.

Despite its toughness, corundum is often damaged by careless gemstone setters who support their setting hammer on the stone instead of on the metal only (Fig. 12). Closed settings often mask such injuries and the damage usually becomes visible when the stone is unset. A typical example is shown in Fig. 13, where the sapphire released a significant chip after the stone was removed from the setting. Re-shaping the contour of the stone means an important loss of weight.

Stones that are deeper than the ring head can cause accidents especially if, on the sizing mandrel the culet touches the metal, subsequent hammering can cause the stone to break. A sizing stick with a groove is highly recommended to escape damage (Fig. 14).

EMERALD

Emeralds are probably the most discussed gemstones in regard to visible or hidden fissures. Tension in the crystal lattice due to chemical substitution, tectonic forces on the parent rock and shocks during mining and separating the crystals from parent rock may be reasons for the fissures that we frequently find in emeralds. They are often not recognised due to effective fracture filling which can start with an oil bath at the mine. Sophisticated filling is standard wherever an open fissure appears. A later cleaning process of just drying out may allow air to fill the fissures, which are then easily visible. Fissures in emeralds are often older than the cutting process, a fact that is visible when the polishing marks that emanate from the fissure openings are studied. Organic fillings are usually visible in a dark room under long wave UV illumination. Oil often appears yellow, but artificial resins (epoxy) appear bluish white (Fig. 15). Cleaning jewellery in solvents or ultrasonic cleaners may remove the filler from the fissures, and the air which takes that space will make the fissures fully visible. The stones

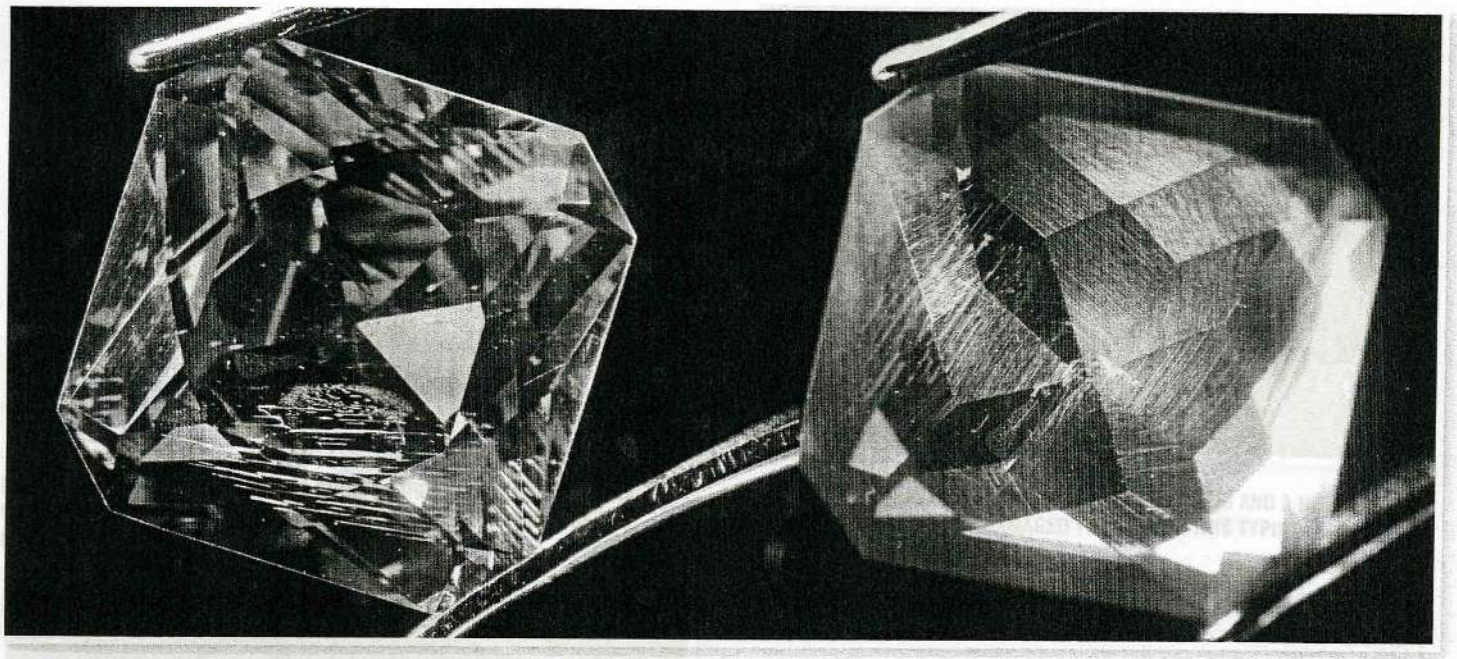

FIG. 16: THE WARM ACID BATH USED AFTER REPAIR SOLDERING ATTACKED THE SURFACE OF PERIDOT. DISTINCT CORROSION IS VISIBLE AFTER 20 MINUTES, MAKING THE SURFACE BLURRED. LEFT SIDE ORIGINAL PERIDOT, RIGHT SIDE AFTER 20 MINUTES IN PICKLING SOLUTION.

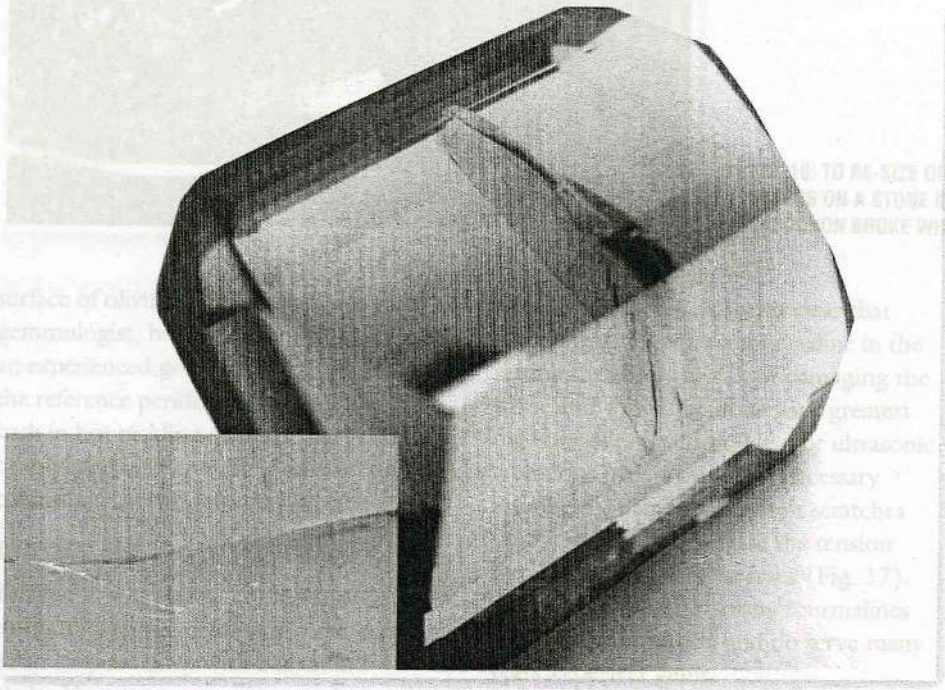

FIG. 17: A TINY SCRATCH (LEFT ON INSET) ON THE SURFACE OF THIS TOURMALINE HAS RELEASED A MAJOR FISSURE.

show their old blemishes, yet a jeweller frequently thinks that the stone has been damaged recently. Polishing marks running out of the fissure, however, indicate that the damage is older than the polishing process.

PERIDOT

When a peridot was sent for analysis of the loss of lustre, the first thought was that the poor polish was disguised with surface waxing or oiling. The client, a goldsmith who bought the peridot from a cutter then polished the stone himself, advised that he had just cleaned a ring after having set the stone. The first thought was that the polish was made by using poorly graded diamond powder, but a reference peridot from the same cutter showed a perfect polish. After some questioning about the method of cleaning the goldsmith mentioned the bath in the pickling solution. A short experiment disclosed evidence that the said solution was able to attack the

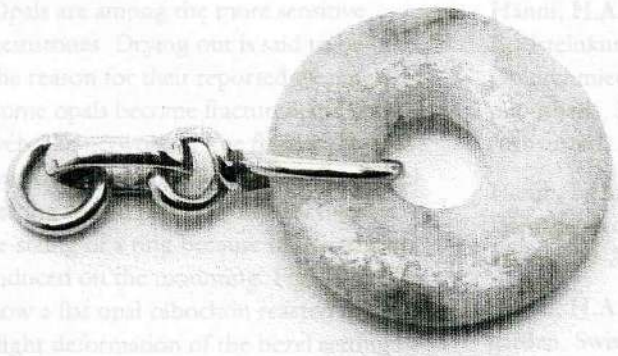

FIG. 18: A B-JADE PENDANT WITH A ROUGH SURFACE AFTER ULTRASONIC CLEANING. THE POROUS STRUCTURE IS DUE TO DISINTEGRATION OF THE IMPREGNATED MATERIAL.

FIG. 20: FRICTION BETWEEN A DIAMOND ETERNITY RING AND A HESSONITE CHANNEL-SET RING BADLY DAMAGED THE RING OF THIS TYPIST.

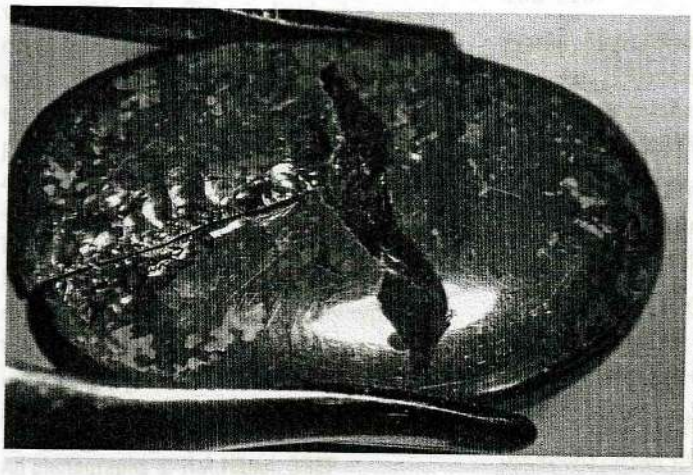

FIG. 19: TO RE-SIZE OR DEFORM A RING MAY PUT CONSIDERABLE STRESS ON A STONE IN A CLOSED SETTING. THIS FLAT BLACK OPAL CABOCHON BROKE WHEN THE GOLDSMITH RE-ADJUSTED THE RING.

surface of olivine, a new experience for a gemmologist, but maybe an old fact for an experienced goldsmith. Fig. 16 shows the reference peridot before and after the bath in hot pickling solution composed of sulphuric acid and nitric acid, as it is commonly used in jewellery workshops.

TOURMALINE

Tension in tourmaline crystals may be so strong that stones crack across the c-axis when they are sawn with a diamond blade. Heat treatment of tourmaline to enhance the colour often ends up with broken stones. Some tourmalines make it to facetted gems but later burst at the slightest stress. It seems clear that soldering a ring with a tourmaline in the setting increases the risk of damaging the stone and should be done with greatest measure of precaution. Heat or ultrasonic vibrations may provide the necessary impulse for damage. Slightest scratches on the surface may release the tension that causes the stone to crack (Fig. 17). However and luckily, many tourmalines are not under tension and do serve many years as perfect gems.

JADEITE

When clients bring gemstones back from their holidays, quite often they are disappointed with the 'bargain' from the local market. A lady decided to have a pendant made from a small jade donut ring. The goldsmith produced a gold mounting and polished the pendant. During the process of cleaning in hot soap water in an ultrasonic cleaner, small parts from the surface broke off so that the surface structure became coarse. In the gemmological laboratory the jade was identified as B-jade, impregnated jadeite jade with an open structure. The filler with some grains of the loose structure had disintegrated and left an item that the client refused to accept. (Fig. 18).

OPAL

Opals are among the more sensitive gemstones. Drying out is said to be the reason for their reported weakness. Some opals become fractured and show a web-like network of fine fissures. It goes without saying that a flat stone in a bezel setting would probably not survive the re-sizing of a ring because of the tension induced on the mounting. Fig. 19 shows how a flat opal cabochon reacted on the slight deformation of the bezel setting.

HESSONITE

Hessonite garnets, being coarsely polycrystalline in their composition possess a quite rough fracture. Intense wear will break off the individual crystallites and the surface will look worse than just rubbed. When a typist presented her ring that she had purchased only 5 weeks previously, she wanted to accuse the jeweller for selling her fake stones. In fact the hessonites were natural gemstones but her new ring was being worn next to a diamond eternity ring. Her daily typing movements caused the diamonds to inflict damage to the hessonites as shown in Fig. 20.

ACKNOWLEDGEMENTS

I thank my goldsmith friends who gave me access to their workshops during the last forty years where I could experience their tools and techniques and discuss accidents and pitfalls when handling gemstones: Daniel Wyttenbach, Peter Gschwind, Alex Schaffner and Jörg Hänni, all in Basel, Switzerland. Most of the cases displayed in this paper concern gemstones that were sent to SSEF Swiss Gemmological Institute for a damage analysis.

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From US correspondents Bear and Cara Williams

GEM WATCH

As a general alert to the gemmological community, Bear Williams of Stone Group Labs has issued a notice regarding a newer treatment being done on ruby. Mining continues in the Madagascar and Mozambique ruby deposits which rough in particular displays the lamellar twinning, numerous internal fissures and basal intergrowth.

It's to be noted that the treatment is not lead-filling type, but the use of fluxes with additives. It differs from that of the heat enhancement done to Mong Hsu ruby, in that recrystalization within fissures and cavities does not occur as the typical minor synthetic corundum combined with borax glasses, but that of a different mineral. This particular mineral was identified by Raman as Iquiqueite in it's synthetic form.

As a relatively low temperature heat is employed, these stones may also exhibit natural looking internal features such as rutile needles. The purpose of the heat then is not solely to burn off colours, but is mainly employed to liquefy the mixture of the borax, fluxes and additives into solution so that it will greatly improve clarity and colour.

There is much yet to be studied here as we are still working on the full chemistry and mechanisms involved. We also look forward to the cooperative efforts of other laboratories working on this issue, so we can come out with full disclosure before the end of the year.