Editor: Evan M. Smith

Raw Brilliance: Nature's Diamond Sculptures

The basic shape of a rough diamond is all around us, from black diamonds on ski slopes to the familiar red diamonds in a standard deck of playing cards. These symbols are the silhouette of an octahedron, which is the archetypal diamond crystal. Indeed, the octahedron appears regularly within parcels of mined diamonds, but accompanying it are many other nuanced shapes, all sculpted by natural processes. GIA scientists recently had the opportunity to examine a suite of 264 rough diamonds handpicked over several years by Pintu Dholakia of Hari Krishna Exports for their unusual or interesting nature. Here we showcase some of these specimens to discuss their morphology and highlight their striking appearances.

Sculpted by Natural Growth, Breakage, and Resorption in the Earth

Diamonds form deep in the mantle when carbon-bearing fluids migrate and interact with solid rocks. Chemical reactions or other changes can decrease the solubility of carbon, forcing it to form solid crystals of diamond. In the simplest case, a growing diamond will take the shape of an octahedron. However, variations in growth conditions can lead to other shapes. By growing diamond crystals in different ways, nature can build diverse rough diamond shapes—as an artist might press clay together to create a masterpiece. Examples include variations of cubes (cuboids, cuboctahedra, re-entrant cubes with concave cube faces and protruding corners), spheres called ballas, and twinned triangular plates called macles (figure 1).

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Despite its status as the hardest natural substance, diamond is not invincible. Natural stresses that squeeze or shear a diamond in the mantle or during transport to Earth's surface in a kimberlite eruption can lead to fracture and cleavage. A diamond has four symmetrical planes within its crystal structure along which it can cleave, meaning that it can break apart with nearly perfect flat, smooth surfaces (see figure 1A). In addition to breakage, the shape and surface of a diamond can be refashioned by a process known as resorption. During resorption, hot fluids or magma in the earth partially etch away a diamond's outer surface. Resorption affects the overall shape, turning sharp-edged octahedral crystals into rounded forms, and can also modify the surface texture through the creation of features including negative trigons, hillocks, and lustrous glossy surfaces (Robinson, 1979; Harris et al., 2022). Removing material from a diamond by breakage and resorption is akin to an artist taking a hammer and chisel to a block of marble. Mother Nature engages in both additive sculpture, by crystal growth, and subtractive sculpture, through breakage and resorption. The incredible array of natural diamond sculptures attests to the dynamic processes occurring deep beneath our feet over millions or billions of years.

Nature's Windows

Geologists sometimes refer to diamonds as metaphorical windows into the mantle, but occasionally diamonds do emerge resembling windowpanes of glass. The transparent plate-like forms shown in figure 2 were created entirely by natural processes. Diamond can form excellent plates by cleavage, breaking along flat planes of weakness in the crystal structure. A single cleave may liberate the face of an octahedral crystal, for example, to make a flat plate shape. The 2.22 ct hexagonal-shaped specimen shown in tweezers in figure 2 was produced in this way. Examination using deep-UV luminescence shows that one side is the original exterior surface of the crystal, while the opposing face represents a cleave crosscutting multiple

Figure 1. Examples of rough diamonds with shapes governed by various combinations of growth, breakage, and resorption: a diamond broken cleanly along a flat plane by cleavage (A); irregular broken fragments smoothed by resorption (B and C); cuboctahedron (D), ballas (E), and re-entrant cuboid (F) shapes produced during diamond growth; two macles resulting from twinned crystal growth, along with two fragments resulting from macle breakage (G); and an elongate fragment representing an edge broken from an octahedron crystal, with the former octahedron corners forming the ends (H). Specimens range from 1.08 to 28.08 ct, with the largest specimen measuring 27 mm in length. Photo by Evan M. Smith.

growth layers. Despite its incredible transparency, small negative trigons (not shown) decorate all sides of this diamond, testifying to its natural unpolished state. In addition to cleavage, twinning can produce flat transparent plates. Macle twinned diamonds tend to grow as flat triangular plates (again, see figure 2, left). Natural transparent diamond plates can therefore form by either growth or breakage.

Figure 2. Left: Transparent plate-shaped rough diamonds ranging from 0.99 to 9.67 ct. Ruled lines have 2.8 mm spacing. Right: The top left specimen (2.22 ct) against the sky. Photos by Evan M. Smith.

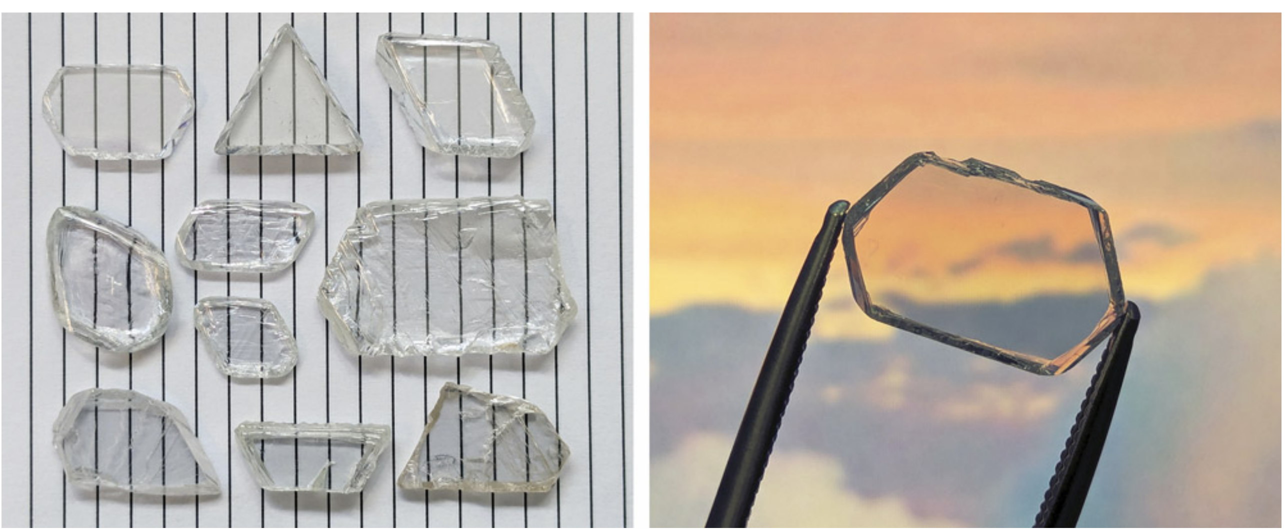


Figure 3. Elongate rough diamonds reminiscent of baguette cuts, ranging from 1.84 to 7.10 ct in weight and 16 to 24 mm in length. Photo by Evan M. Smith.

These shapes are evocative of portrait-cut diamonds, one of the earliest faceting styles, which some jewelers have recently repopularized. Portrait cuts possess two relatively large parallel facets and a thin profile and were originally intended for use as stylish protective covers for painted portraits. In a similar sense, diamond windows serve as transparent yet robust physical barriers in devices such as high-power laser systems and synchrotron beamlines. Diamond windows can have high transmission across the ultraviolet, visible, far-infrared, and microwave regions of the electromagnetic spectrum, which, combined with their thermal and chemical resistance and high strength, make them ideally suited for some modern high-tech applications.

Raw Baguettes

The elongated diamond forms shown in figure 3 are reminiscent of baguettes, both the cut style and the loaves of bread, though their shapes arise through crystal growth or natural breakage in the mantle. Whereas macle twinning provides a viable pathway to grow a natural plate-shaped diamond, there is no such straightforward mechanism to grow an elongate single crystal of diamond. That is not to say that it is impossible for a diamond to crystallize as an elongate rod, but the examples here appear to have been shaped by breakage. In nearly all cases, the direction of elongation is not random but is aligned with the internal crystal structure due to breakage that occurred along cleavage planes. Some are further sculpted by resorption, creating smooth, glossy finishes.

Among the specimens in figure 3, breakage has produced elongate diamonds in at least three distinct ways. The first is depicted in figure 4, with the faces of the octahedron parallel to the four different orientations of cleavage planes within a diamond crystal structure. Cleaving a plate from an octahedron (like those in figure 2) and then cleaving one of the edges off that plate along a cleavage plane of a different orientation can generate a fragment that is elongated in a <110> crystallographic direction.

The second and third ways that natural breakage has produced elongate rough diamonds are less intuitive and involve macle twins, as illustrated in figure 5. In the second mechanism, an edge is broken off a macle (figure 5A). The breakage surface is not planar because of the change in crystal structure orientation across the twin plane. If this break occurs purely by cleavage, the broken surface will be re-entrant, or angled inward, leaving sharp edges that are likely to be rounded off by resorption. Some broken fragments have more irregular or curved breaks (such as the two broken macles in figure 1).

In the third mechanism (figure 5B), the breakage produces a fragment that is elongate in a direction

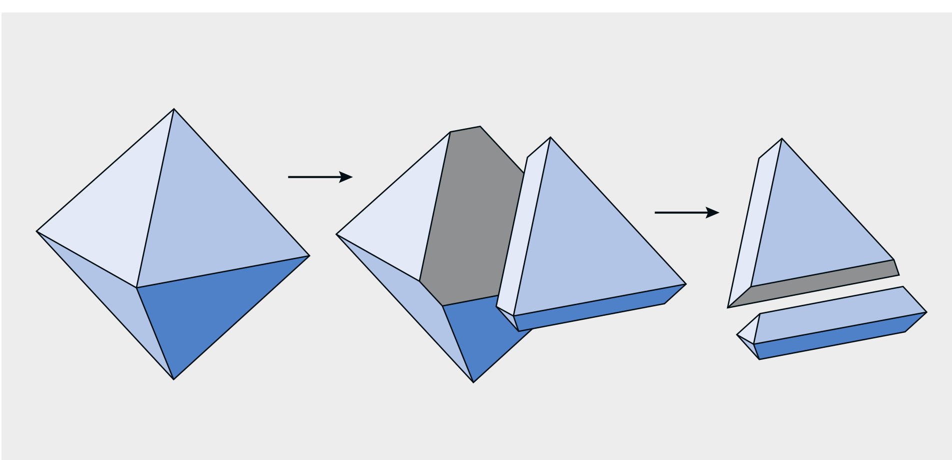


Figure 4. Three-part illustration showing how an octahedron (left) may cleave to yield an elongate parallel-sided fragment. The initial cleave (middle) produces a flat plate-shaped fragment. Cleaving an edge off the plate (right) creates an elongate fragment (as seen in figure 1H).

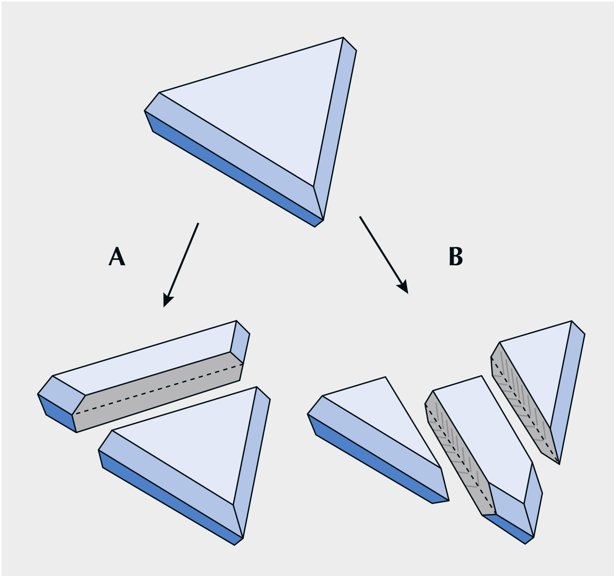


Figure 5. Illustration showing two ways (A and B) that a macle can fracture to yield an elongate parallel-sided fragment. Each fragment will still have a twin plane running through it (dashed line). In B, the breakage surfaces develop a chevron pattern that "points" toward the original point of the macle.

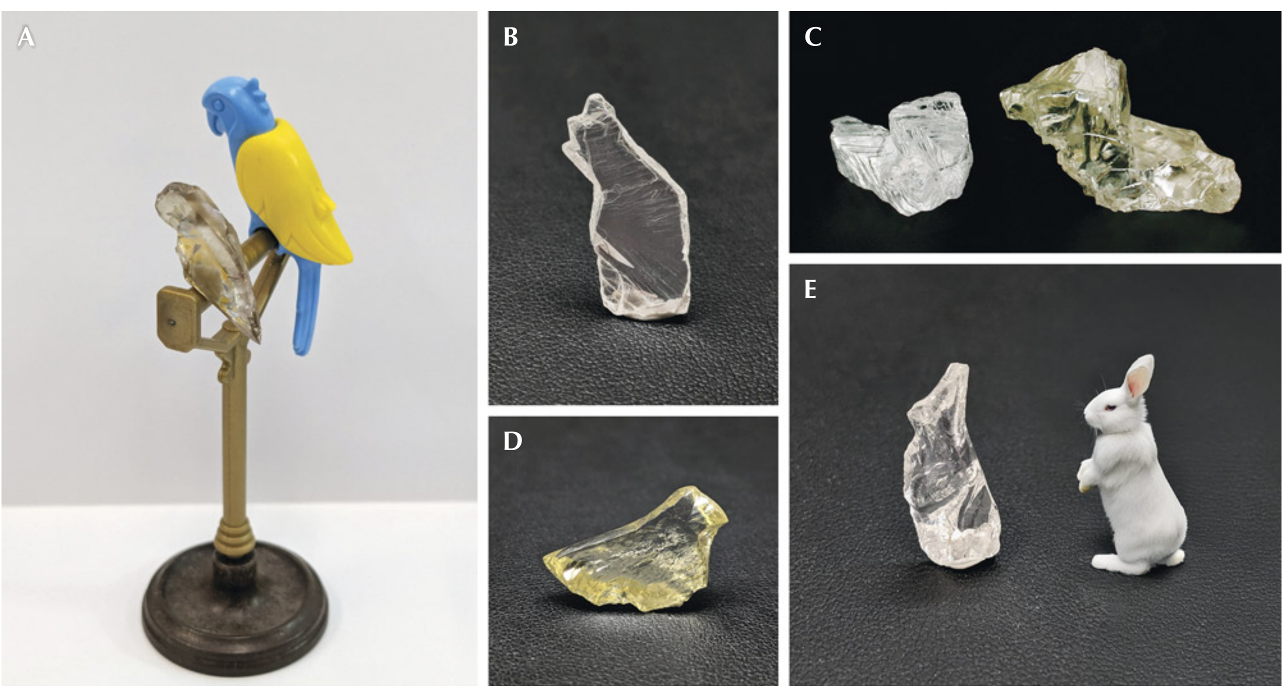
perpendicular to a macle edge. In this case, the breakage surfaces are parallel to {110} planes. Although they are not perfectly planar breaks, it is possible that the diamond is effectively cleaving because diamond does possess a rarely seen cleavage in this orientation (Brookes et al., 1990; Smith et al., 2017). Unlike diamond's typical {111} cleavage planes, there are three possible {110} planes that transect the twin plane and will align perfectly between both portions of a macle twin. Alternatively, these broken surfaces could develop by the combined action of multiple {111} cleavage planes, creating finely stair-stepped breakage surfaces that average out to a {110} plane. Some of these broken surfaces develop a characteristic chevron pattern.

Diamonds Resembling Animals and Objects

The complex sculpted forms of natural diamonds are fertile ground for lively imaginations. Depending on the lighting and viewing angle, some may resemble animals or familiar objects. Perceiving familiar shapes in inanimate forms such as clouds or rough diamonds is called pareidolia.

In some cases, these forms have arisen predominantly by growth (additive sculpting), while in other specimens, breakage or resorption (subtractive sculpting) has been more important. For example, in figure 6C, the small colorless "dog" on the left, resembling a West Highland white terrier, is an irregular octahedral crystal with stepped surfaces,

Figure 6. Rough diamonds resembling animals: parrot, 5.99 ct (A); sitting cat, 5.68 ct (B); small dogs, 2.15 and 3.66 ct, respectively (C); yellow bird, 5.69 ct (D); rabbit, 2.79 ct (E; white rabbit for comparison created using Adobe Photoshop Generative AI). Photos by Evan M. Smith.



which grew in this shape. The yellow "dog" on the right, however, resembling a dachshund, likely looked much different before being sculpted into this shape by breakage and resorption. The two "raindrops" in figure 7B are another example of contrasting formation, with the right dominated by growth and the left dominated by breakage. Coincidentally, the resulting "raindrops" are of equal weight.

One of the most unusual morphologies in the collection is the "mortar" (pictured with non-diamond pestle) shown in figure 7A. This bowl-like specimen consists of a colorless, gemmy cuboid that is broken in half, revealing an octahedral-shaped internal cavity. The cuboid faces are convex and rounded between the protruding corners. The hollow central portion looks as though an octahedron has been plucked out, leaving a depression in the shape of the apex of a square-based pyramid. One possible explanation suggests that an inclusion formed a discontinuous layer partially separating the inner core from the outer diamond rim (Harris and Stachel, 2024). The inclusion could have weakened the diamond, leading to breakage, after which the core and inclusion would have been released or etched away.

Superdeep Diamonds

All mined diamonds originate at great depths and are transported to Earth's surface by kimberlites or related mantle-sourced volcanic eruptions. Most diamonds crystallize in the base of old, thick parts of continental plates, at approximately 150–200 km deep. Some rare diamonds (estimated 1–2% of mined diamonds) originate from even greater depths, ranging from 300 to 800 km (Stachel et al., 2005; Shirey et al., 2024). Known as sublithospheric or superdeep diamonds, these curious crystals can carry mineral inclusions that provide invaluable insights into Earth's interior. Superdeep diamonds possess highly irregular shapes (figure 8) resulting from stressful growth conditions and multiple episodes of breakage and resorption during the torturous journey to Earth's surface.

The depth of crystallization is mostly based on inclusion mineralogy. Rocks and minerals undergo changes with increasing depth inside Earth as pressure and temperature increase. Some high-pressure minerals, such as

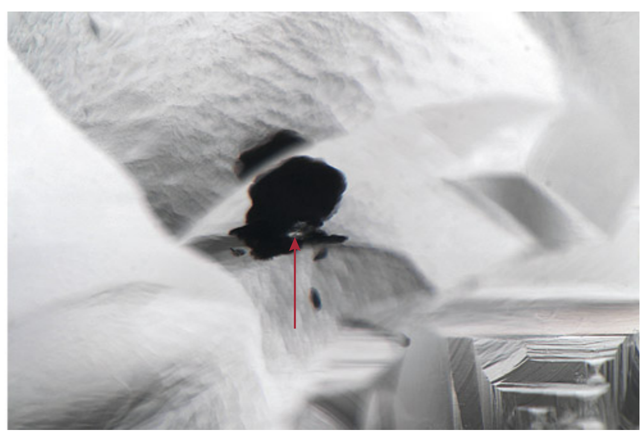
Figure 7. Rough diamonds resembling objects: mortar, 1.95 ct, with a pestle carved from a toothpick (A); raindrops, 3.23 ct each (B); campfire flame, 2.70 ct, backlit using orange light and placed with raw baguettes from figure 3 as firewood (C); gummy bear, 9.18 ct (D; colored gummy bears for comparison created using Adobe Photoshop Generative AI); fibrous diamond cuboids resembling dice, 22.45, 22.47, and 23.64 ct, respectively, shown with a superimposed 10 mm die (E). Photos by Evan M. Smith.

Figure 8. Superdeep diamonds, ranging from 1.27 to 12.97 ct, with typical irregular sculpted shapes resulting from extensive breakage and resorption. The top left specimen is 21 mm in length. Photo by Evan M. Smith.

ringwoodite, can only form at great depths, and when found as inclusions in a diamond, they indicate that the diamond must have crystallized at a depth where that particular mineral was stable. Combinations of multiple minerals also constrain the depth of diamond formation. The diamond at the center of figure 8 contains an inclusion identified as the mineral breyite ($CaSiO_3$; figure 9), which is a calcium silicate that signifies an original depth of diamond growth deeper than 360 km (Anzolini et al., 2016).

Other diamonds in figure 8 have been deemed superdeep on the basis of iron-rich metallic inclusions consistent with those found in a variety of superdeep diamonds referred to as CLIPPIR (Cullinan-like, Large, Inclusion-Poor, Pure, Irregular, and Resorbed) (Smith et al., 2016; Smith et al., 2017). All specimens in figure 8 are tentatively classified as CLIPPIR diamonds. Here purity refers to the low nitrogen concentration of these diamonds, being either type IIa, with no nitrogen detectable by Fourier-

Figure 9. This 2.13 ct superdeep diamond (left; and shown at the center of figure 8) has an irregular shape and strongly resorbed surface marked by many square etch pits or tetragons, which arise from resorption of {100} cube-orientation surfaces. The inclusion (right; red arrow) is a colorless crystal of breyite surrounded by a black graphitic fracture. Photos by Evan M. Smith; fields of view 14.52 mm (left) and 1.58 mm (right).



transform infrared spectroscopy, or type IaB, with very low (<20 ppm) concentrations of nitrogen in the form of B-centers. The specimens in figure 8 are all type IIa except for the top right and top left diamonds. The CLIPPIR acronym also calls out the characteristic morphology, being irregular in shape and highly resorbed, which are common traits across all superdeep diamonds.

In addition to CLIPPIR diamonds, the superdeep geological category encompasses type IIb (boron-bearing, often blue) diamonds as well as those typically less gemmy diamonds associated with the Juína region of Brazil and the Kankan region of Guinea (Smith et al., 2018; Shirey et al., 2024). All three varieties of superdeep diamonds can be found across multiple deposits worldwide, indicating that the processes that create these diamonds are not singular but repeat through time and space (Smith et al., 2025).

Concluding Remarks

The beauty of natural rough diamonds is easily overlooked, with most people only encountering diamonds after faceting. But given the opportunity to take a closer look, it is hard not to admire the myriad of morphologies among rough diamonds. Natural processes of crystal growth, breakage, and resorption can sculpt almost anything, from the ideal octahedron to irregular shapes resembling animals and familiar objects. The shape of each rough diamond is a testament to unseen geological activity inside our dynamic planet.

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