# *November 1999 Rock of the Month: Tektite*

Tektites have been known in the eastern world for a millennium; in the western world, for a century; yet it may be ages until we know their place of origin for a certainty. Still, we know they have been one place most of us will never go-- outer space!

*PHYSICAL PROPERTIES*

Chemistry: High silica content with oxides of calcium, aluminum, iron, and magnesium
Class: Not a mineral. Natural Glass
Crystal System: None; Amorphous
Crystal Habits: Usually small; typical shapes include irregularly spherical, ovoidal (egg-shaped), lens- or button-like, pear like, dumbell-like, spindle-like; rarely, flanged
Color: Bottle green to deep green to black
Luster: Vitreous to dull
Transparency: Opaque to tranparent
Streak: White
Refractive Index: 1.48-1.52
Cleavage: None
Fracture: Brittle
Hardness: 5.5-6
Specific Gravity: 2.3-2.5
Luminescence: None
Distinctive Features and Tests: Characteristic shapes, pitting; color, lack of cleavage or crystal faces; localities

*NAME*

Pronounced tek′-tīt, the name come from the Greek *tektos*, meaning “molten.”

*COMPOSITION*

A mineral is defined as a naturally occurring inorganic element or compound having an orderly internal structure and characteristic chemical composition, crystal form, and physical properties. Tektites meet all these criteria but two: they do not have an orderly internal structure and, as a result, they do not have a characteristic crystal form. So according to the current definition, a tektite is not a mineral but a **natural glass**. (Some call it a mineraloid. Other naturally occurring substances that do not fit the definition of a mineral that we hope to feature in the future are opal, obsidian [also a natural glass], amber, and coral.)

What, then, is mean by “natural glass?” It is defined as a state of matter intermediate between the close-packed, highly ordered array of a crystal, and the poorly packed, highly disordered array of a gas. Obviously, our tektite specimen is much more like a crystal than a gas. Natural glass, like tektite and obsidian, forms when molten (melted) rock is cooled quickly and does not have sufficient time to organize into an orderly internal structure, as it would if it cooled more slowly. Such a substance lacking a crystal structure is called **amorphous**. Natural glass as well as manufactured glass are classified as supercooled liquids. We do not usually think of something that seems immobile like glass to be liquid, but technically it is: we have heard reports of centuries-old window glass ever so slowly flowing and accumulating at the bottom of the pane! The scientific distinction between glass and liquid is based on **viscosity**, the property of a substance to offer internal resistance to flow; liquid water offers little internal resistance and flows easily, motor oil less easily, molasses even less, and while glass has tremendous resistance to flowing, it can flow, as noted above. Substances that fit the definition if a mineral will not flow, unless heated to their respective melting points, at which point they would be classified as liquids.

Tektites are composed mainly of silica (silicon dioxide, $SiO_2$) and oxides, as shown in the chart below. (See the December 1997 write-up on quartz under *Composition* for more about silica.)

**Typical Composition of Tektites in %**

| Locality | $SiO_2$ (Silica) | $Al_2O_3$ (Aluminum Oxide) | $Fe_2O_3$ (Iron Oxide) | MgO (Magnesium Oxide) | CaO (Calcium Oxide) | Other |
|---|---|---|---|---|---|---|
| Australasian (Including our specimens) | 72 | 13 | 7 | 2 | 3 | 3 |
| American | 79 | 13 | 3 | 1 | 1 | 3 |
| Moldavites | 79 | 11 | 2 | 1 | 2 | 5 |
| Ivory Coast | 71 | 15 | 6 | 3 | 2 | 3 |

Tektites are different in significant ways from other types of natural glass found on Earth, such as obsidian, pumice, volcanic bombs, and fulgurites, a fact some point to as proof of their extraterrestrial origin. They contain almost no water (OH) content, averaging 0.01-0.0001%, while obsidian has 0.1 to over 1%. Also, tektites show considerable internal structure, though not in the orderly way a crystal does. These unique properties make tektites a much purer, higher quality glass than most manufactured glass we see around us, and as well as other forms of natural glass. Researchers can recognize tektites from various localities by their typical composition, as shown in the chart above.

So just how do tektites form? There is disagreement between scientists and other experts, and until someone is out standing in a field somewhere, and tektites begin to rain down on them (and they survive), we probably will not know for sure. Let's examine briefly the main theories of tektite origin, and the pros and cons of each. (When tektites were first discovered in the western world, it was believed they were remains from ancient glassmaking factories. This theory was abandoned long ago.)

In the 1960's it was recognized that the various shapes of tektites indicate that they must at some point been outside the earth's atmosphere. (See *About Our Specimens* for more on how the shapes are formed.) On this point, all theories agree. It is how they arrived there that is in contention.

Years ago, some proposed that tektites are the remnants of meteorites composed of silica. This theory has been discounted, because evidence of cosmic radiation, such as would be picked up by an object traveling a great distance through space, is not present in tektites. This lack of radiation tells scientists that tektites must originate within the Earth-Moon system.

**TERRESTRIAL METEOR IMPACT THEORY** The theory most widely accepted now that tektites were formed by the impact of huge meteorites on Earth's surface. Such an event would generate sufficient heat to melt surface rock, and sufficient force to throw the melted rock high into the sky and out of our atmosphere, where it would cool and harden as gravity pulled it back to Earth. However, some scientists believe no impact would be great enough to throw molten rock into outer space, unless part of the atmosphere were also blown away. Others ask, where are the enormous craters offering proof of this theory? Proponents answer they are either filled in by erosion, buried under ice, or at the ocean floor. As proof, the Reis Kessel (meaning "Giant Kettle") Crater in Germany, which is 17 miles in diameter, is put forth as the source of the Moldavites, the Ashanti Crater in Ghana as the source of the Ivory Cost tektites, a newly discovered crater in Chesapeake Bay as the site of impact for the Bediasites and Georgiaites, and the craters left by the giant meteorite that caused the Australasian fall is believed to be buried under ice in Antartica.

**TERRESTRIAL VOLCANO THEORY** Most scientists agree that a volcano powerful enough to propel molten rock into space is unlikely, but the fact that tektites are similar to Earth rocks in their chemical and isotopic composition leads to the conclusion that they are terrestrial in origin and were formed by powerful volcanic activity or by the theory mentioned above.

**LUNAR METEOR IMPACT THEORY** This theory is based on research done by Dr. Dean R. Chapman of NASA in the 1960's, and confirmed by other prominent scientists of the day. Dr. Chapman's tests, including comparing the effects of falling through the atmosphere on tektites and on satellite and missile heat shields, led him to believe that tektites hit our atmosphere at a greater speed than could be achieved by an object thrown from the crust of the earth and then falling back, and that such a velocity could only be reached by something originating on or near the Moon. (Unless of course, they had been thrown clear to the Moon, and then fallen back, which seemed unlikely. And if they had, upon falling to Earth, they would be more evenly distributed over the Earth.) Further calculations led him to believe that Australasian tektites were produced by the impact that created Tyco Crater on the Moon's surface. Many reject this theory, saying that tektites vary too greatly in composition to Moon rocks brought back by Apollo missions to have originated there.

**LUNAR VOLCANO THEORY** It is proposed that large masses of silica rich glass ejected by a mighty volcanic force on the Moon would have a better chance of surviving the descent into Earth's atmosphere than do meteorites from far distant regions of space. They would enter the atmosphere at a slower speed than meteorites do; and layered, glass-like rocks would hold up to the stress of friction better than stony meteorites, which often explode in our atmosphere.

Giving credence to this theory is the fact that researchers inspecting the sites of meteorite and asteroid impacts have not found tektites, but rather, impact melts which differ in composition to tektites. At these sites, remnants of the impacting meteorite have been found in the rock thrown up in the cataclysm, while no meteorite remnants are found in tektites. It is further suggested that no sudden, violent impact would allow the formation of the kind of pure, high quality glass found in tektites, and that such could only form in a volcanic environment. For example, a unique type of tektite that is larger and shaped differently than most others, is called the Muong-Nong type tektite, after the type locality in Laos. Muong-Nong tektites show layers of microtektites (defined later) welded together. It is suggested that this took place near the vent of a lunar volcano, and could not take place by the destructive force of a meteor or asteroid impact.

The major obstacle to this theory is the common scientific belief that the Moon has been volcanically dead for the past two billion years, in addition to the objection noted regarding the composition of Moon rocks collected so far. So as of the year 1999, none of these theories fully fit all the known facts concerning tektites-- so if you happen to be out in a field and tektites start to rain down on you, please call us!

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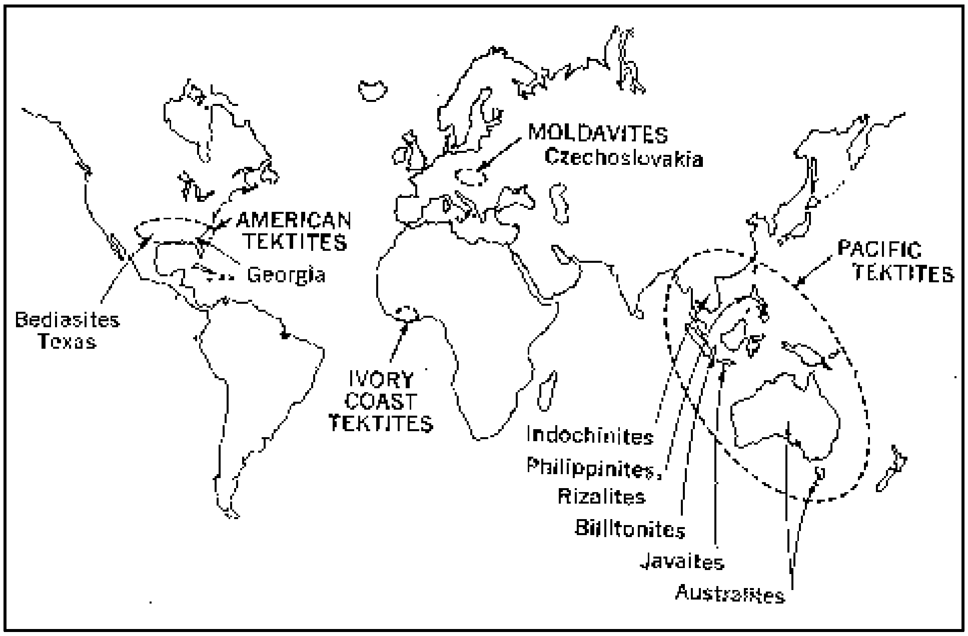
Another fascinating fact is that layers of microtektites the size of a pinhead down to about 40 microns have been found buried in ocean sediments in various places around the world. It is postulated that a tektite event may have been involved in the killing of the dinosaurs and in at least one reversal of Earth's magnetic field. Clearly, there remains much to be learned about these space travelers!

*COLLECTING LOCALITIES*

The map shows known tektite localities, which are known as **strewnfields**. Each was created as a molten mass of tektites followed a descending orbit, thereby falling only in each large but defined area. Tektites have been given individual names in reference to where they are found. Bediasites are found in Texas and named for the town of Bedias (evidently from a native American word) at the northern end of the Texas strewnfield. Georgiaites come from Georgia, and vary somewhat from their Texan relatives. Both are rare and valuable. Although both localities are currently considered to be part of the same strewnfield, no tektites have been reported in the in-between states. The American tektites are believed to be of the Eocene period, about 35,000,000 years old.



Worldwide Tektite Strewnfields. Image copyright by Lapidary Journal, used be permission.

Tektites from the Ivory Coast are also rare and valuable, hard to find in the thick forests in the area, where they were originally discovered in the hunt for gold earlier this century. The strewnfield extends for some distance into the Atlantic Ocean, where microtektites have been found in sediments at the ocean bottom. These are said to be of the Pliocene period, about 1,300,000 years old. Moldavite localities are described under *JEWELRY & DECORATIVE USES*, and are thought to be of the Miocene period, about 15,000,000 years old.

Our specimens are the babes of the tektite family, of the Pleistocene period, only 600,000-700,000 years old. (Some researchers believe they are just 15,000 years old.) They come from China, and are part of the largest strewnfield, the Australasian strewnfield, called Pacific Tektites in the map above. Australasian tektites have been given individual names, according to where they are found: australites from Australia (including Tasmania,) Javaites from Java, Billitonites from Billiton, Phillippinites from the Philippines, Rizalites from the Rizal Province, and Indochinites from the southeastern Asia nations of Vietnam, Thailand, Laos, Cambodia, and southern China. Though this strewnfield covers about 10% of the earth's surface, it is now considered much larger, stretching east across the Indian Ocean to the island of Madagascar and up to the Karakum Desert in Russia! We have seen very few tektites offered for sale from any of these localities except China, and when we do, they are commanding high prices. We will certainly obtain any moderately priced pieces we find to offer to club members.

*JEWELRY & DECORATIVE USES*

Dark tektites like ours are occasionally cut into cabochons and gemstones, and may resemble smoky quartz in thin slices or cleavage fragments. The most attractive tektites are the marvelous Moldavites, found along the Moldau River in Bohemia and Moravia. Moldavites can be a lovely translucent bottle-green color and exhibit graceful flow patterns, and are used in exotic jewelry and cut into valuable gemstones and cabochons. We hope to feature Moldavite in the future, and will delve more deeply into their remarkable occurrence at that time.

*HISTORY & LORE*

The oldest written reference to tektites is from a Chinese manuscript dated about a thousand years ago, where they are called lei-gong-mo, meaning "Ink-Black Stone from the Thunder God." Our early ancestors placed a premium on these strange stones. The Aborigines of Australia called them "Blackfellow's Buttons." In Thailand, they were (and still are) called Chanta Khant, meaning "Eclipse of the Moon." Archaeologists found a large tektite hidden away under an idol in temple ruins in Cambodia. They may also have been fashioned into tools and weapons.

Modern day crystal healers believe tektites can assist one in attaining knowledge and learning lessons throughout the travels of life, balance the masculine/feminine, strengthen one's energy field, stimulate thought transmissions, provide grounding energy, bring protection and security, and evoke positive help from non-earth sources. No technological uses for tektites were noted in our research.

*ABOUT OUR SPECIMENS*

Our tektites come from near Maoming City, a Chinese city of about 300,000 people, located roughly 200 miles northwest of Hong Kong in Guangdong Province, China. As noted before, some call them Indochinites. Though tons and tons of tektites fell in southeastern China, they are becoming more and more scarce because they are collected and used up by Chinese lapidary factories, which sprung up like mushrooms during the 1970's and 1980's. Due to the international appeal of these mystery rocks, and the dearth of other desirable cutting rock indigenous to China, these factories are using large quantities of tektites to make into beads, cabochons and stones.

One ingenious method to accelerate tektite collection was to offer a reward to schoolchildren for finding them. After school and on weekends, Chinese children are often called upon to follow cows and buffalo across fields and hills to prevent them from damaging rice fields. The children are encouraged to look for tektites in their travels, especially after a rainstorm rinses away the topsoil and partially exposes the



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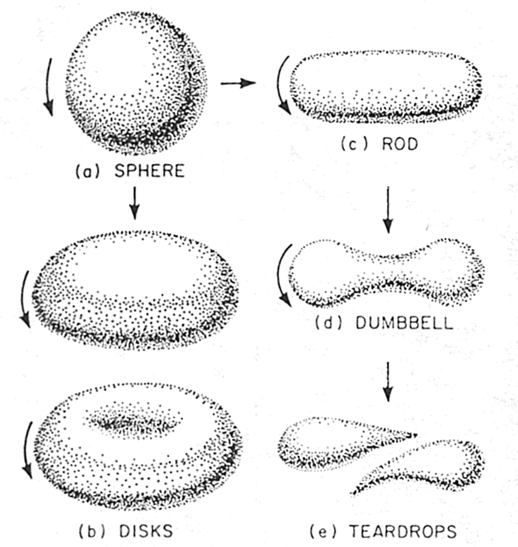
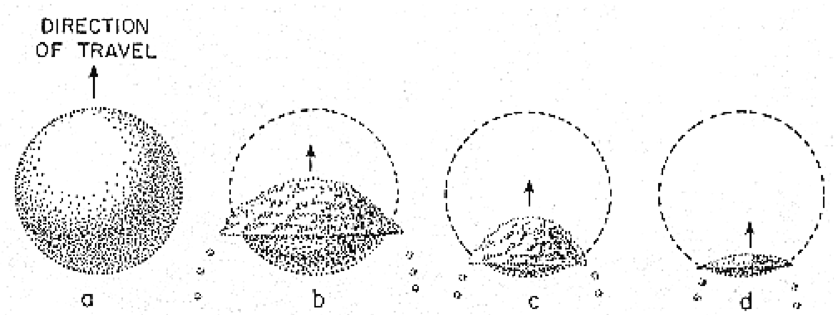
black, glassy treasures. The children receive a reward when turning tektites in at a local collection center, which in turn makes them available to mineral and fossil dealers.

The final fascinating feature of this month's tektite relates to the shapes they take and how they get that way. Here again we find disagreement among the experts. All agree that tektites started as molten natural glass, silica-rich rock, and spent time in outer space. As they solidified in the vacuum of space during their free fall toward our atmosphere, characteristic shapes resulted, which are shown to the right. The rate at which the tektite spun as it fell determined its final shape.




Do you see the shape of your tektite in any of these? There is another factor involved in the final shape, and that occurs when the tektite leaves the vacuum of space and falls through Earth's atmosphere. Here it is subject to friction fusion that causes surface melting, resulting in pitting and fine flow lines. **Ablation**, the removal of molten surface layers of meteorites [and tektites] by vaporization during flight through the atmosphere, occurs as the tektites plummet to earth. Sometimes when examining a tektite, one may find a side that is pit free, which would indicate that that particular side was facing up (away from the Earth) as it fell, so that it was not affected by friction. Close inspection with a hand lens may reveal flow patterns that testify to its movement through the atmosphere. Naturally, since the Australasian deposit is so much more recent than the others, they have not been nearly as damaged by the effects of weathering.

One of the most unusual and valuable tektite forms is the flanged tektite, whose mode of formation is illustrated to the right. Such flanged tektites are found only in the Australasian strewnfield.

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No doubt this information will enhance our appreciation for these well-travelled bits of natural glass. When will we be certain of their origin? Only time will tell!


References: Gem & Lapidary Materials, June Culp Zeitner, Geoscience Press; Rare & Beautiful Minerals, Fritz Hofmann, Exeter Books; The Mineral Kingdom, Paul DeSautels, Madison Square Press; Oddities of the Mineral World, William B. Sanborn, Van Nostrand Reinhold; The Complete Book of Rocks and Minerals, Chris Pellant, DK Publishing; World-Wide Investigation of Tektites Continued, Virgil E. Barnes, Lapidary Journal, April 1972; Rocks & Mineral From Outer Space Part II: Tektites, K. Nassau, Ph.D., LJ, May 1972; The Origin of Tektites, Daniel E. Russell, Rocks & Minerals, September 1975; Asian Tektites, Dr. John A O'Keefe, LJ April 1977; The "G" Tektite, Ken Buchanan, F.G.A., LJ October 1978; The Lunar Origin of Tektite Glass, Darryl S, Futrell, Rock & Gem, February 1999, March 1999




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