The Complicated History of Mozambique Cuprian "Paraiba-like" Tourmalines

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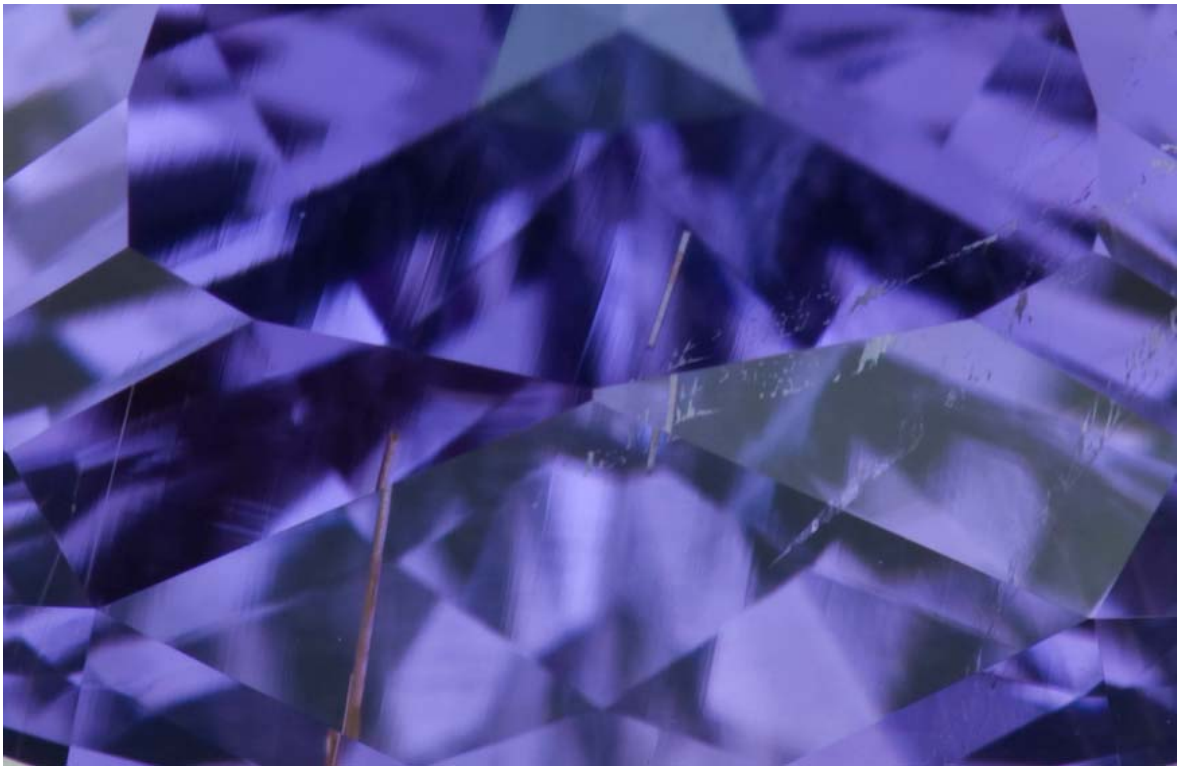

Photo is of a natural purple Mozambique Tourmaline

Recently, there have been suggestions (James 2009a, 2009b, 2009c; Wise 2009) that the copper-bearing tourmalines from Mozambique may owe their copper, and hence their color, to elemental (bulk or grain-boundary) diffusion—that is, to treatment. However, tourmalines are complicated minerals and grow in complex environments. If we understand these tourmalines' history, we can assess whether diffusion treatment is necessary to explain the features seen in these gemstones.

So let's look at the "three lives" of a tourmaline crystal. It its first life, a pegmatitic tourmaline grows from the bottom up and from the inside out. If its environment does not change, then the tourmaline's color would be uniform as it grows, or gradually more or less intense over time. However, a pegmatite is not a constant environment. Abrupt changes in the environment lead to abrupt changes in tourmaline growth, and in tourmaline trace-element- and color-zoning. These changes happen, for instance, when new minerals are precipitated or when the pegmatite fluid separates into liquid and gas. Some events are explosive, and crack the growing tourmaline crystals. The crystals continue to grow, healing some cracks to form “fingerprint” inclusions.

Often, tourmaline crystals grow faster along the long axis (*c*-axis) than perpendicular to it. At fast rates, tourmaline can grow as fibers (for instance, many tourmaline crystals have fibrous caps). As the tourmaline continues to grow, it fills in between the fibers. Incomplete growth leads to fibrous-looking cavities called *trichites* (meaning “hairs”).

The last pegmatitic fluids are often quite caustic, leading to eroded and etched crystals. This author has seen etch tubes that could be used, like drilled holes, to suspend a crystal section as a pendant.

In its second life, the pegmatitic tourmaline crystal is exposed to the atmosphere as its host rock erodes. Some pegmatitic minerals weather away; more durable ones, like tourmaline, can become pebbles in soil or river beds. River beds are filled with fine particulates that can be wedged into hollows in these crystals; and some particulates are radioactive. If wedged against a diamond, radioactive material causes green and brown spots; if lodged in a hollow tube of a manganiferous tourmaline, radioactive material may cause regions of more intense pink color, as seen in some Mozambique tourmalines (“Lab Alert,” 2009).

Consider a hollow tube in a tourmaline pebble in an alluvial environment. It gets the local “gunk” in it. If the gunk is radioactive, it will cause haloes of irradiated tourmaline around the hollow tube. If the tourmaline around the tube contains manganese, the irradiated areas can turn pink. Note that, in contrast to diffusion treatment, in this case the pink areas around the hollow tubes might be “blotchy” (such as those shown by James 2009c), rather than uniform in color.

The Mozambique tourmalines are found in lateritic soil, which is rich in iron oxides or hydroxides, clay, and tiny quartz crystals. This soil can also get into cavities in tourmaline pebbles; if heated, it would turn into a brick-like material.

The tourmaline crystal has grown in its complex pegmatite environment; it has been further etched, and its hollow tubes filled with other materials in its alluvial environment; now it is collected. What happens to it in its third life? Purple Mozambique cuprian tourmalines are polished; many blue ones are heat-treated as well. Heat-treatment changes the oxidation state of transition metals, and only fairly low temperatures are needed. (For instance, the heat-treatment of tanzanite can be accomplished on polished material, in a bed of kitty litter, within a toaster oven.) So the purple color of our tourmaline crystal has turned blue; its strongly pink radiation-damaged regions have deepened in color; its major and minor-element composition has not changed; and the lateritic gunk in its hollow tubes has baked into brick-like material. We do not need to invoke bulk or grain-boundary diffusion to explain these features.

References:

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