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Fission Track Dating of Tanzanite

C. W. NAESER

U. S. Geological Survey, Denver, Colorado 80225

JOHN M. SAUL

Rockland International Corporation, Box 44775, Nairobi, Kenya

Abstract

Seven crystals of tanzanite from the Ally and D'Souza Mines, Tanzania, gave an average fission track age of 585 ± 28 m.y. Tanzanite, a gem variety of zoisite, has annealing characteristics that are very similar to epidote; both require a temperature above 725°C for complete track annealing in an hour. Sub-gem-quality tanzanite, from a new occurrence 400 km to the south, in or near the Uluguru Mountains (Tanzania), has a younger age (355 m.y.).

Eight crystals of the gem mineral tanzanite (Hurlbut, 1969) from northern Tanzania have been dated by the fission track technique. The crystals all came from two mines: The Ally Mine and the D'Souza Mine in the main district (Lat. 3°30′S., Long. 37°00′E.). Sphene from a pyroxene-graphite gneiss which forms part of the country rock at the Ally Mine was also dated.

The tanzanite deposits occur within an area of Precambrian metamorphic and igneous rocks called the Kenya-Tanganyika Province of the Mozambique Belt by Cahen and Snelling (1966). K-Ar and Rb-Sr mineral ages in the Mozambique Belt range from 450–650 m.y., but represent only the last event in this complex rock system. U-Pb dating of uranium minerals in pegmatites from this belt suggests three periods of pegmatite formation: 835 m.y., 600 m.y., and 480 m.y. (Cahen and Snelling, 1966).

The origin of the tanzanite in this area seems to be related to the emplacement of pegmatites. Most of the tanzanite occurs either within orthoclase pegmatites or at the contact of pegmatite with the enclosing rock, which in most instances is a coarse-grained graphite-bearing dolomitic marble or a complex sulfide-bearing graphite schist. The complex rocks in this area contain a great number of gem quality minerals, including tourmaline (green and yellow), diopside (green), kyanite (blue), and grossular garnet (green, brown, and colorless). Slightly cloudy but otherwise gem-quality green apatite is found east of the mines, and transparent green actinolite has been reported in surface float.

The tanzanite was dated by using a variation of the dating method described by Naeser (1967). This method was chosen rather than the external detector method because the fission tracks in tanzanite are exceedingly difficult to develop completely by etching. Fission tracks in 20–50 fragments of each crystal were counted to determine the average track density. Fossil tracks were counted in a non-irradiated split, and the tracks counted in the irradiated split were both fossil and induced. The two grain mounts for each sample were etched at the same time in a 50 M NaOH solution at 140°C. The etch time varied from sample to sample; the shortest was 30 minutes and the longest was 2 hours. Sphene from the country rock at the Ally Mine was etched in the same solution for about 15 minutes. The induced tracks in the sphene were counted in a muscovite detector placed over the etched sphene during the irradiation. All ages were calculated using a decay constant of 6.85×10^{-17} yr^{-1} for ^{238}U fission. Uranium concentrations were determined by comparing the track density induced by the sample in an external muscovite detector to that induced by a piece of glass with 0.36 ppm uranium. This measurement involved a separate irradiation. One crystal, analyzed for uranium with the delayed neutron method, yielded a value of 15.1 ppm

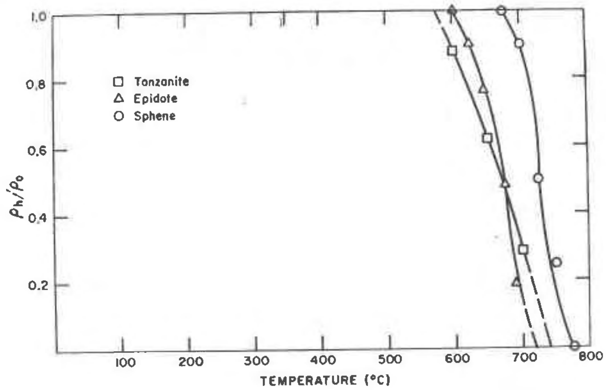

FIG. 1. Annealing after one-hour heating: ρ_o = track density before heating; ρ_h = track density after heating.

(P. Aruscavage, written communication, 1972). A value of 15.0 ppm for this crystal was obtained by fission track analysis.

The eight tanzanite crystals from the Ally and D'Souza Mines have a mean age of 585 ± 28 m.y. The assigned error is two standard deviations; which was calculated through counting 2611 induced and 4946 fossil tracks. The uranium content of these tanzanites ranged from 0.15 to 15.0 ppm. Sphene from the host rock at the Ally Mine has a fission track age of 525 ± 66 m.y. (2σ), and a uranium concentration of about 190 ppm. The 525 m.y. age should be considered a minimum age, because of the very high fossil track density (4.4×10^7 tracks/cm^2). Grains which have such a high track density are extremely difficult to count accurately. The single crystal from the Uluguru Mountains has an apparant age of 355 ± 22 m.y. (2σ) and 27.8 ppm of uranium.

A series of one hour annealing experiments were performed to determine the stability of fission tracks in tanzanite (Fig. 1). The annealing characteristics of tanzanite are very similar to those of epidote (Naeser, Engels, and Dodge, 1970). Both epidote and tanzanite require a temperature in excess of 725°C for an hour for complete track removal.

The tanzanite mineralization may be related to the period of pegmatite emplacement that took place about 600 m.y. ago (Cahen and Snelling, 1966). Alternatively, the tanzanite may have formed earlier, and the 585 m.y. age may represent a cooling age. In either interpretation, the age of this district is similar to that of most other deposits of colored gemstones which have been studied and described from parts of the former Gondwanaland super-continent (Saul, 1970), but not to that of some emerald, many amethyst, and all opal deposits.

Note Added in Proof

A new tanzanite deposit has been found on Mgmama Ridge, southeastern Kenya.

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