New insights about chemical etching for revelation of spontaneous fission tracks in garnets

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The study of fission tracks in terrestrial minerals and meteorites has demonstrated its usefulness for cosmic-ray prehistory, age, and thermal history of minerals studies [1]. The techniques based in chemical etching of natural tracks has been described by Fleisher, Price & Walker [2]. In 1965 Fleisher, Price & Walker proposed etching conditions for so many minerals. For garnets, the authors proposed a KOH etching for two hours at 150°C, but without measuring these etching conditions and their relationship with the fission tracks in the garnets. Haack & Gramse [3] have demonstrated that garnets, especially andradites and spessartines, can be appropriate minerals for fission tracks dating. Posteriorly, [4] etched in boiling (-150 °C) 50 mol / 1 NaOH solution for 20 - 30 min to reveal spontaneous fission tracks in the garnet.

However, for the garnets (Ca, Mg, Fe^{2+},Mn)$_3$(Al,Fe^{3+}.Mn,Cr,Ti^{4+})$_2$(SiO_4)$_3$, common rock-forming mineral in basic and ultrabasic igneous rocks and metamorphic rocks, any satisfactory or new etchant has been reported after Fleisher, Price & Walker [2], Haack & Gramse [3] and Wang, Chen & Tein [4]. Over the past years the research in fission tracks focused on minerals like Apatite and Zircon and their methods and techniques. In certain degree it was influenced by the fact of these minerals present low closing temperatures, in agreement with the maturity temperatures of the hydrocarbons. This research describes a satisfactory revelation of spontaneous fission tracks in garnets. The experimental method used consists in submitting the garnets to a chemical attack using an etching technique. The methodology has been based in [5], however these authors have used their methodology to revel natural fission tracks in olivines. For this reason, in this research we considered some modifications in their experimental method.

The attack has been consisted in a base-acid sequential immersion, where Potassium Hydroxide (KOH) (1mol/L^{-1}) and Hydrofluoric Acid (HF) were used. The garnets were submitted to KOH at 100°C for 4 minutes. After this, we insert the garnets in the HF for 30 seconds at 23°C. After chemical etching, the fission tracks in our garnets were characterized with scanning electron microscopy (SEM). The fission tracks were analyzed using a scanning electron microscopy. The SEM images were measured using a Zeiss, EVO-MA10. The samples were irradiated with an electron beam of 5kV, and the images was captured at 400x magnification.

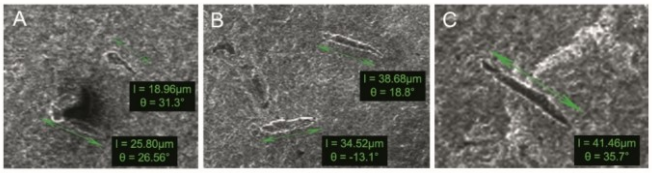

Figure 1. (a,b,c) Charged-particle spontaneous tracks in our garnets.

The fission tracks revealed on this experimental method have between 18.96µm and 50.06µm of length. Based on these results, it indicates that the experimental method is efficient to revel spontaneous tracks in garnets. Whtas suggests that this experimental method can be applied in other minerals and meteorites. On the other hand, new studies with variations of concentration, temperature and time of exposure in the experimental method are necessary to determine the behavior of the fission tracks in the new conditions for the garnets.

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