Evaluating the potential of an He cryogenic system for ESR dating of quartz grains

Verónica Guilarte,¹ Davinia Moreno,¹ Mathieu Duval¹,²

¹Centro Nacional de Investigación sobre la Evolución Humana (CENIEH), Burgos, Spain (corresponding author veronica.guilarte@cenieh.es)
²Research School of Earth Sciences. The Australian National University, Canberra, Australia.

Electron Spin Resonance (ESR) dating of quartz is based on the detection of various radiation-induced paramagnetic centers associated with defects present in the crystalline structure of quartz [1,2]. Among them, Aluminium [AlO₄]⁰ and Titanium centers [TiO₄/M⁺]⁰ (M⁺= Li⁺, H⁺ or Na⁺) have become so far the most widely used. However, unlike other materials like fossil tooth enamel, ESR signals of both the Al and Ti centers are not visible at room temperature and measurements should be performed at very low temperature instead.

A previous study of our group showed the strong influence of temperature on the ESR signal of the Al center: basically, the signal resolution and intensity are significantly increasing when the temperature decreases [3]. In geochronology, ESR measurements of quartz are usually carried out using liquid nitrogen systems, i.e. at temperatures between 77 and ~115 K, and measurements < 77 K have almost never been really carried out.

With the recent acquisition of an Elexsys E500 ESR spectrometer coupled with a 4112 HV Bruker Helium system, we got the opportunity to evaluate whether measurements close to He temperature may actually provide a significant improvement in ESR dating of quartz grains. To do so, we studied the behavior of Al and Ti centers in terms of sensibility and resolution of the signal at temperatures between 10 to 150 K and quantified the influence of temperature on the ESR signal of both centers. In particular, the impact on the ESR signal Ti-center will be specifically studied, since its great potential in ESR dating (i.e. fast bleaching kinetics and no residual ESR intensity, contrary to the Al center) is usually mainly limited by the difficulty to achieve reliable and reproducible measurements given the low signal-to-noise ratio usually encountered in quartz samples.