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Investigations on different measurement protocols of E` paramagnetic defect centres in quartz for provenance studies

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The sediment-routing concept [1] aims to integrate tectonic fluxes and climatically driven erosion, an approach that is at the core of modern studies into Earth-surface processes. The concept relies on the potential to track individual mineral grains from source to sink. Provenance studies are instrumental in this respect; until recently, almost all of these have focussed on accessory minerals. By contrast, the durability and abundance of quartz ensures that parent rocks containing quartz are represented by detrital quartz in their daughter sediment. Even the purest quartz crystal contains a vast number of point defects, which may be either intrinsic or due to impurities. Some of these defects remain unchanged under ionising radiation bombardment by natural environmental radioactivity, while others are transformed, generally in the form of charge trapping. Based on the dynamics of some of these radiation-sensitive defects under irradiation, quartz is frequently used for dating by luminescence or electron spin resonance (ESR). Another, less explored, application of these defects is the fingerprinting of sediment sources. For provenance applications to be successful, sedimentary quartz signals used should match the corresponding signals of quartz from the host rocks: they should remain unchanged during transport and/or weathering processes.

Here we conduct an exploratory study on fine (4-11 μm) quartz from loess from Central Asia (Kazakhstan and Tajikistan), a region dominated by westerly air transport. These study sites were chosen since recent studies based on geochemical fingerprinting, grain-size modelling and meteorological reanalysis suggest the contribution from different source areas [2,3]. We investigate the signature of E′ (≡Si·, an unpaired electron at an oxygen vacancy site) and peroxy intrinsic defect centers (≡Si-O-O·and ≡Si–O· non-bridging oxygen) using ESR, by measuring both quartz grains extracted from both untreated samples, and from samples irradiated to 2000 Gy and subsequently heated to 10 min at 350 °C (as suggested by Toyoda and others [4]). By investigating the dose response of these signals, with and without the application of thermal treatments, we conclude that natural E` signals hold great promise for provenance studies, thus considerably simplifying the currently used measurement protocols. We observe a significant difference between the E′ and peroxy signals between the Kazakh and Tajik samples, which is in tune with the hypothesis that the two loess sites derive from different dust sources.

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