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Investigations on paramagnetic centres in quartz for provenance studies

Alida Timar-Gabor^{1,2}, Aditi Dave³, and Kathryn Fitzsimmons³

¹Babes-Bolyai University, Institute of Interdisciplinary Research on Bio-Nano-Science, Cluj Napoca, Romania (alida.timar@ubbcluj.ro)

²Faculty of Environmental Sciences and Engineering, Babes Bolyai University, Cluj-Napoca, Romania

³Research Group for Terrestrial Palaeoclimates, Max Planck Institute for Chemistry, Mainz, Germany

The sediment rooting concept [1] relies on the potential to track individual mineral grains from their source to their ultimate sinks. Quartz is the second most abundant mineral in the Earth's crust and occurs in a broad variety of rocks and sediments. It is resistant to weathering and does not form solid solutions, thus being considered a pure mineral. However, even the purest quartz crystal contains a vast number of point defects, which may be either intrinsic (e.g., O-vacancies and related defects or Si vacancies) or due to impurities, most often as combination of monovalent (H^+ , Li^+ , and Na^+) and trivalent (Al^{3+} , Fe^{3+} , and B^{3+}) cations. Some of these defects remain unchanged under ionising radiation bombardment by the omnipresent natural radioactivity, while others are being transformed, generally by charge trapping. Based on the dynamics of some of these radiation sensitive defects under irradiation, quartz can be used for dating by luminescence or by electron spin resonance.

Another less explored application of these defects is fingerprinting the sources of the sediments. For provenance applications to be successful, the signals used when looking at quartz from the sediment should match the corresponding signals of quartz from host rocks, thus they should remain unchanged during transport and/or weathering.

Here we are conducting an exploratory study on quartz from loess from Central Asia (Kazakhstan and Tajikistan). This specific study site was chosen as very recent studies based on geochemical fingerprinting, grain size modelling and present-day meteorological data suggest contribution from different source areas in this Westerlies dominated region [2,3]. Consequently, this area is an ideal test site to look for spatial and temporal variability in source change. We are investigating the signature of E' (an unpaired electron at an oxygen vacancy site) and peroxy intrinsic defect centers (nonbonding oxygen) as well as the Al-hole ($[AlO_4]^0$, a hole trapped by substitutional trivalent aluminum at a silicon site) paramagnetic signals by electron spin resonance in loess samples, as well as in rock samples. We are also investigating the behaviour of these defects during laboratory experiments that aim at reproducing natural conditions during transport. While work is still in progress, we have observed a significant difference between the E' and peroxy signals for Kazakh and Tajik samples, which is in tune with the current hypothesis regarding the dust sources in the area presented above.

References