Subject offered for a contract starting October 2019

SUBJECT TITTLE: Tracking millennial-scale climate and environmental change across Eurasian Loess

Advisor: **LAGROIX, France, CR CNRS (HDR), lagroix@ipgp.fr**
Second Advisor: **GUYODO, Yohan, CR CNRS (HDR), yohan.guyodo@ipgp.fr**

Host lab/ Research Group : **IPGP- Paleomagnetism Research Group – UMR7154**

Financing: Doctoral contract with or without teaching assignment

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Tracking millennial-scale climate and environmental change across Eurasian Loess

Loess deposits are found on the Earth surface on every continent. Loess is the name given to glacial-age, windborne silt-sized deposits that are very homogeneous in composition (quartz, iron-bearing silicates like mica, amphibole, clays, etc.) as well as in particle size (between 10 and 100 µm) (Pye, 1995). In Europe, loess covers one fifth of its surface (Haase et al., 2007) and in China, the Loess Plateau blankets, over as much as 300 m, about 500 000 km^2 of its landscape. Important deposits are also found in other regions of Asia, Siberia, North America (continental US and Alaska), and in New Zealand, Australia and South America (e.g., Muhs et al., 2014). Since the pioneering work of Heller and Liu (1982, 1986) on Chinese loess, loess deposits are known to be a unique material for the study of paleoclimate and paleomagnetism on the continents recording global glacial (cold) and interglacial (warm) cycles and geomagnetic reversals (see Maher, 2016 and Liu et al., 2015 for a recent reviews of Chinese loess paleoclimate and magnetostratigraphic records). The Chinese Loess Plateau inclusively of the underlying aeolian red clays cover continuously the last ~22 Myr. Elsewhere, loess deposits cover much shorter time intervals (typically 1 or 2 glacial/interglacial cycles) but locally reversals such as the Matuyama – Brunhes (M/B) transition (772 ka; Simon et al., 2016) have been recovered (e.g., Forster et al., 1996 (Czech Republic) ; Jordanova et al., 2008 (Bulgaria) ; Nawrocki et al., 2016 (Ukraine) ; Westgate et al., 1990 (Alaska) ; Schellenberger et al., 2003 (Argentina)).

Fluctuating magnetic susceptibility of glacial loess and interglacial soil deposits in China, and a few places elsewhere, have been correlated very well with marine isotope stages and ice core records, illustrating a loess-global climate connection. Therefore, sub-Milankovitch scale (10^3 to 10^2 y) changes in magnetic susceptibility are likely related to regional (10^2 to 10^3 km) scale changes in paleoclimate and can provide important benchmarks for testing proposed regional-scale numerical models of climate change over the continents (e.g., Wyrwoll et al., 2016; Banerjee et al. (1993); Evans and Heller (2003); Maher and Thompson (1995); Verosub and Roberts (1995); Zhou et al. (1990)). Beyond magnetic susceptibility, variations in other rock magnetic parameters, targeting a given magnetic mineral component, its concentration and/or its grain size, are interpreted as being environmentally or climate controlled (e.g. review paper by Liu et al. (2012)). In European loess, millennial scale abrupt climate events have been described in grain size (Antoine et al. 2009, 2013, 2016, 2019), carbon isotope data (eg. Hatté et al., 2013), biological indices and now also in magnetic properties (Taylor et al., 2014, Taylor and Lagroix, 2015, Antoine et al., 2019) and proposed to be coeval with Dansgaard-Oeschger in Greenland ice cores and Heinrich events in marine sediments (Rousseau et al., 2002, 2007, 2013, 2017). Dust emission modelling seems to confirm the hypothesis that North Atlantic millennial scale abrupt climate events are imprinted in Western European last glacial loess (MIS 4-2) (Sima et al., 2009, 2013).

Recently published work (Antoine, Lagroix et al, 2019) and other mineral magnetic data (Lagroix et al. in prep) show millenial-scale variations through the penultimate glacial loess (MIS 6) from the Harletz loess and paleosol sequence in NE Bulgaria. What is (are) the origin(s) of these variations? Potential origins are, for example, changes in source material, variations in degree of alteration due to changes in sedimentation rate, climate or local environment. Are the observed variations in magnetic parameters of Eastern European penultimate loess linked to North Atlantic abrupt millennial climate events as demonstrated in last glacial loess of Western Europe? Can mineral magnetism track millennial-scale climate and environmental change in loess across Eurasian loess?

The present doctoral project will aim to bring answers to the above questions and more broadly contribute to deepening our understanding of (1) which environmental and climate variables cause change in the magnetism of paleosol and loess, and (2) how does magnetism evolve with time, quantitatively, when soils are buried under newly deposited loess and become paleosols ?

The objectives will be to:

(1) Acquire and interpret high resolution and comprehensive mineral magnetic data of a new loess-paleosol sequence in central Bulgaria that will be sampled in the spring of 2020 along side the established multi-disciplinary and multi-institutional working group with whom previous sections in France, Germany, Czech Republic and Bulgaria have bee sampled and studied.

(2) Acquire and interpret high resolution and comprehensive mineral magnetic data of a sequence sampled near Baoji (China) in April of 2017 sampled a continuous and high sampling resolution (2cm) and covering the last two glacial cycles.

(3) Compare and cross-check magnetic data with other multi-disciplinary data.

(4) Integrate interpretations with current knowledge of local, regional and global climate change since MIS 7 interglacial.

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