ÉCOLE DOCTORALE
SCIENCES DE LA TERRE ET DE L'ENVIRONNEMENT
ET PHYSIQUE DE L'UNIVERS, PARIS

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Subject title: Remanence acquisition and remagnetization mechanisms in continental aeolian sediments

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Financing: Doctoral contract with or without teaching assignment

Presentation of the subject:

Since the pioneering work of Heller and Liu (1982), it is known that loess deposits are effective recorders of geomagnetic field. Initial studies recovered the Matuyama/Brunhes (M/B) geomagnetic reversal boundary in Chinese loess within paleosol S8 in good agreement with the occurrence of the M/B boundary within interglacial stage 19 in marine sediments. However, subsequent studies at other locations within the Chinese Loess Plateau recovered the M/B within the overlying loess interval L8 (Liu et al., 1988; Rolph et al., 1989; Rutter et al., 1990; Spassov et al., 2001; Sun et al., 1993; Zhu et al., 1994). Delayed remanent magnetization acquisition due to post-depositional or chemical remanence acquisition would push the M/B boundary stratigraphically downward into L9 and not upwards to L8 (Spassov et al., 2003). Wang et al. (2006) and Liu et al. (2008) proposed that the paradox stemmed from an erroneous positioning of paleoclimate boundaries. Astronomical tuning of loess sequences is achieved through magnetic susceptibility time series, a parameter influenced by pedogenic alteration. Liu et al. (2008) demonstrated that if considering modal grain size variations in quartz grains, which are unaffected by pedogenic alteration, to pinpoint the transition between glacial and interglacial periods, the S8 to L8 paleoclimate boundary is pushed stratigraphically upwards and the recovered M/B boundary thus lies in the upper parts of S8 in agreement with marine sediments.
The above highlights the lack of knowledge we have concerning:

1) Remanent magnetization acquisition mechanism of loess deposits;
2) Remagnetization processes induced by mineral alteration in response to climate and environmental change.

Two experimental studies have attempted addressing the important question of remanence acquisition and remagnetization mechanisms (Wang and Lovlie, 2010; Zhao and Roberts, 2010), which brought limited answers and leaving a still vast and dominantly unexplored research area. Starting from the postulate that loess during its deposition acquires a natural remanent magnetization in the presence of the geomagnetic field, with what fidelity is the geomagnetic field recorded (both in direction and intensity)? After deposition a loess deposit will undergo burial, eventually pedogenesis (i.e. soil-formation) and potentially hydromorphic processes. It has been shown that all three of these processes lead to neo-formation, alteration and / or dissolution of Fe-bearing minerals and specifically the geomagnetic field recorders (Maher and Taylor, 1988; Taylor et al., 2014; Till et al., 2015; Till et al., 2014; Zhou et al., 1990). Can we quantify the impact of these processes on the paleomagnetic signal acquired at deposition?
The project aims to study the remanence acquisition and remagnetization processes in loess and paleosol deposits. This will be reached by:

1) Analysing paleomagnetic records from previously sampled loess deposits;
2) Analysing magnetic data from controlled laboratory experiments to characterize remagnetization processes;
3) Numerically modelling the evolution of magnetic signals from loess-paleosol sequences as a function of accumulation rates and post-depositional processes.

We seek candidates with some prior practical knowledge in paleomagnetism and/or rock-magnetism. Prior knowledge in computer programming (Matlab, Python) will be a plus.

Cited references:

Heller, F., and Liu, T. S., 1982, Magnetostratigraphical dating of loess deposits in China: Nature, v. 300, no. 5891, p. 431-433.
Liu, Q. S., Roberts, A. P., Rohling, E. J., Zhu, R. X., and Sun, Y. B., 2008, Post-depositional remanent magnetization lock-in and the location of the Matuyama-Brunhes geomagnetic reversal boundary in marine and Chinese loess sequences: Earth and Planetary Science Letters, v. 275, no. 1-2, p. 102-110.
Liu, X. M., Liu, T. S., Xu, T. C., Liu, C., and Chen, M. Y., 1988, The Chinese Loess In Xifeng.1. The Primary Study on Magnetostratigraphy of a Loess Profile in Xifeng Area, Gansu Province: Geophysical Journal-Oxford, v. 92, no. 2, p. 345-348.
Maher, B. A., and Taylor, R. M., 1988, Formation of ultrafine-grained magnetite in soils: Nature, v. 336, p. 368–371.
Rolph, T. C., Shaw, J., Derbyshire, E., and Jingtai, W., 1989, A detailed geomagnetic record from Chinese loess: Physics of the Earth and Planetary Interiors, v. 56, p. 151-164.
Rutter, N., Ding, Z. L., Evans, M. E., and Liu, T. S., 1990, Magnetostratigraphy of hte Baoji Loess-Paleosol section in the North-Central China Loess Plateau: Quaternary International, v. 7/8, p. 97-102.
Spassov, S., Heller, F., Evans, M. E., Yue, L. P., and Ding, Z. L., 2001, The Matuyama/Brunhes geomagnetic polarity transition at Lingtai and Baoji, Chinese Loess Plateau: Physics and Chemistry of the Earth Part a-Solid Earth and Geodesy, v. 26, no. 11-12, p. 899-904.
Spassov, S., Heller, F., Evans, M. E., Yue, L. P., and von Dobeneck, T., 2003, A lock-in model for the complex Matuyama-Brunhes boundary record of the loess/palaeosol sequence at Lingtai (Central Chinese Loess Plateau): Geophysical Journal International, v. 155, no. 2, p. 350-366.
Sun, D. H., Shaw, J., An, Z. S., and Rolph, T., 1993, Matuyama/Brunhes (M/B) Transition Recorded in Chinese Loess: Journal of Geomagnetism and Geoelectricity, v. 45, no. 4, p. 319-330.
Taylor, S. N., Lagroix, F., Rousseau, D.-D., and Antoine, P., 2014, Mineral magnetic characterization of the Upper Pleniglacial Nussloch loess sequence (Germany): an insight into local environmental processes: Geophysical Journal International, v. 199, no. 3, p. 1463-1480.
Till, J. L., Guyodo, Y., Lagroix, F., Morin, G., and Ona-Nguema, G., 2015, Goethite as a potential source of magnetic nanoparticles in sediments: Geology, v. 43, no. 1, p. 75-78.
Till, J. L., Guyodo, Y., Lagroix, F., Ona-Nguema, G., and Brest, J., 2014, Magnetic comparison of abiogenic and biogenic alteration products of lepidocrocite: Earth and Planetary Science Letters, v. 395, p. 149-158.
Wang, R. H., and Lovlie, R., 2010, Subaerial and subaqueous deposition of loess: Experimental assessment of detrital remanent magnetization in Chinese loess: Earth and Planetary Science Letters, v. 298, no. 3-4, p. 394-404.
Wang, X. S., Yang, Z. Y., Lovlie, R., Sun, Z. M., and Pei, J. L., 2006, A magnetostratigraphic reassessment of correlation between Chinese loess and marine oxygen isotope records over the last 1.1 Ma: Physics of the Earth and Planetary Interiors, v. 159, no. 1-2, p. 109-117.
Zhao, X., and Roberts, A. P., 2010, How does Chinese loess become magnetized?: Earth and Planetary Science Letters, v. 292, no. 1-2, p. 112-122.
Zhou, L.-P., Oldfield, F., Wintle, A. G., Robinson, S. G., and Wang, J. T., 1990, Partly pedogenic origin of magnetic variations in Chinese loess: Nature, v. 346, p. 737–739.
Zhu, R.-X., Laj, C., and Mazaud, A., 1994, The Matuyama-Brunhes and Upper Jaramillo transitions recorded in a loess section at Weinan, north-central China: Earth and Planetary Science Letters, v. 125, p. 143–158.