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Guest Editorial

Rates of soil forming processes and the role of aeolian influx

1. Introduction

This special issue comprises selected papers of workshops organized by the INQUA projects AEOMED and RAISIN in 2012 and 2013. Both projects started in 2012 under the umbrella of the new INQUA Focus Group PASTSOILS, established within the INQUA Commission on **Terrestrial Processes, Deposits and History** (TERPRO) at the same time. Here, we introduce this new INQUA Focus Group and the two projects in order to inform the scientific community about these initiatives, and to provide some background to this special issue.

2. Focus group PASTSOILS: palaeosol and soil analysis for assessing climate, time and duration of land surface stability of Quaternary terrestrial systems

Leaders: Daniela Sauer (Germany), Sergey Sedov (Mexico) and Rivka Amit (Israel)

2.1. Background

The Focus Group PASTSOILS was proposed in order to coordinate efforts of INQUA members working on deciphering palaeosols as records of past environmental conditions, and possibly contributing their results to interdisciplinary work on Quaternary palaeo-environmental archives such as sediment successions comprising embedded palaeosols.

Although other palaeo-environmental archives provide higher temporal resolution, terrestrial sediment-palaeosol sequences add important information, because i) they have a large spatial distribution and thus enable the detection of regional spatial patterns in palaeo-environmental conditions, and ii) in addition to palaeo-climatic conditions, they also record geomorphological and environmental responses to palaeo-climatic shifts. In periods of vegetation cover and stable geomorphic conditions soils start forming. Hence, successions of slope deposits may contain intercalated buried soils recording phases of relative land surface stability. Each sediment layer burying a soil indicates an event or episode of slope instability due to climatic forcing or tectonics. As another example, cycles of sedimentation and soil formation in loess and loess-like deposits indicate increased or decreased deposition of dust, mostly in response to shifts in regional or global climates. As soils interact with the atmosphere, hydrosphere, lithosphere and biosphere, they record palaeo-environmental information. Sediment-palaeosol successions thus represent instructive palaeo-environmental archives if interpreted appropriately. They may provide information on rates of sedimentation, interruptions of sedimentation, duration of such periods of geomorphological stability and soil formation, tectonic quiescence, climatic variations, and vegetation responses to climatic shifts. In some cases, specific compounds of palaeosols (such as soil organic matter or pedogenic carbonates) can be dated and analysed for their isotopic composition ($\delta^{13}C$, $\delta^{18}O$). The combination of datings and isotopic analyses carried out on the same compounds may provide particularly valuable information about environmental conditions during certain periods.

2.2. Main objectives and goals

The Focus Group PASTSOILS aims at stimulating international interaction between scientists dealing with various aspects of sediment-palaeosol successions. Many scientists in different parts of the world are facing similar problems in diverse environments when using soils and palaeosols as archives of landscape history. Therefore, PASTSOILS intends to bring together researchers working on any kinds of soils (recent soils, polygenetic soils, palaeosols) in the frame of Quaternary research, in order to promote reconstruction of Quaternary landscape history of various regions and to share, improve and develop new methods and new knowledge on dynamics, rates and duration of soil formation. One of the major aims of the focus group is to improve the knowledge on the relationships between identified pedogenic properties in soils or palaeosols on the one hand and the climatic conditions and time-span of tectonically and geomorphologically stable periods on the other hand. For this purpose, existing results on rates of soil formation in different climates will be brought to a synthesis, in order to establish a present state of knowledge. The influence of the factors time and climate on soil formation is hence the key issue of this focus group, because the main question to be answered based on palaeosol properties will always be: “Under which environmental conditions did this soil form, and how much time did it take to form this soil?”

In some regions, soil formation over time is complicated by considerable influence of aeolian input. Especially in Mediterranean regions dust contribution to soils plays a major role. It ranges from minor amounts of aeolian material mixed into the upper parts of soils to thick deposits of loess and loess-like sediments. The importance of aeolian input in Mediterranean areas has been repeatedly addressed in the literature. However, a systematic documentation of the type, thickness and extension of aeolian deposits

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and associated soils around the Mediterranean is still missing. A second objective of the focus group is hence to document the present state of knowledge on the type, thickness and extension of aeolian deposits and associated soils around the Mediterranean and make it available to the scientific community.

The main overall objectives of the PASTSOILS Focus Group are thus i) to establish a solid base for interpreting palaeosols in terms of duration of soil development, indicating tectonically and geomorphologically stable periods and ii) to evaluate the importance and spatial pattern of dust production, deposition and incorporation into soils in the Mediterranean region.

3. Project AEOMED: loess deposits and aeolian additions to current surface soils and palaeosols in Mediterranean climates

Leaders: Rivka Amit (Israel) and Stefano Carnicelli (Italy)

3.1. Background

Aeolian addition to soils represents an important pedogenic process, especially in Mediterranean climates. The main task of this project is, hence, to quantify long-term proximal and distal aeolian contributions to soils in hyper-arid, arid, semi-arid and sub-humid areas around the Mediterranean Sea. The obtained knowledge will contribute to the understanding of soil genesis on different parent materials under Mediterranean climatic conditions, spatial and temporal variations and erosion rates. Analysis of soils and palaeosols on sandy and loess-like materials around the Mediterranean will moreover improve the understanding of glacial-interglacial environments in this region and the interplay of human and climatically driven soil erosion processes.

Loess represents an important archive of Quaternary climatic changes. It can be classified into primary (wind-deposited), and secondary (reworked) loess, which is the result of re-deposition of primary loess. Primary loess is more suitable for studying dust sources, direct aeolian influx to soils, aeolian processes and wind regimes. However, secondary loess is more widespread, and therefore many loess studies focused on reworked or partly reworked loess successions. The production mechanisms of loess in non-glacial regimes, specifically of the coarse silt fraction, have been a matter of debate. Recently, aeolian abrasion of sand grains from vast sand dune fields located up-wind from warm desert loess successions has been proposed as a major process generating the coarse silt comprised in the majority of the loess deposits (Crouvi et al., 2008, 2010; Amit et al., 2011).

Besides extensive loess deposits in the Negev desert (eastern Mediterranean), loess is also widespread in Europe. Although most of the loess there is considered to be of glacial origin, recent studies demonstrated that there are also large loess deposits blown out from other local sources in Mediterranean Europe (Costantini et al., 2009). However, the loess deposits recorded around the Mediterranean are relatively thin and do not provide a long-term record of Quaternary environments comparable to those in central Europe, Asia and the Negev. Nevertheless, the importance of dust input for soil formation, especially in the Mediterranean, is evident, and its effects, including re-carbonatation, fertilization, and enhanced carbon sequestration capacity are crucial. Identifying and characterizing recent and ancient dust in soils may help to identify sources, modes of transport and phases of increased dust deposition. These goals can be achieved by systematically analysing primary loess and dust components in soils in similar geomorphic settings around the Mediterranean. Such broad temporal and spatial analysis will improve the understanding of both dust production/transport/deposition and soil formation over the Quaternary period, and it will contribute to a better understanding of the connections between the African and Arabian deserts and the Mediterranean.

3.2. Main objectives and goals

The main objectives and goals of the project AEOMED are:

- assessing the spatial pattern of primary and secondary loess deposits across the Mediterranean;
- analysing primary loess successions in similar geomorphic units of various Mediterranean environments, in order to evaluate the contribution of proximal and distal dust sources to the formation of Mediterranean soils;
- estimating the potential of dust emission and deposition in various Mediterranean regions, based on the understanding of the mechanisms of dust generation, transport and deposition;
- evaluating rates of loess/dust deposition in the context of palaeo-climate reconstructions;
- detecting sources of recent and palaeo-dust/loess around the Mediterranean.

These goals will be achieved through the following steps:

- selecting key sites: Key sites for this project in the Mediterranean basin will be selected based on the knowledge of soil scientists, sedimentologists and geologists working in this region and on published material. In addition, remote sensing techniques will be applied to map primary loess deposits on mountain tops based on the experience and methodology developed in the Negev desert (Crouvi et al., 2009).
- characterising primary loess: Generalized profiles of particle size distribution, geochemistry and mineralogy of primary loess successions in different regions across the Mediterranean will be created, using major and trace elements, and isotopic ratios of the various grain size fractions from selected sites around the Mediterranean.
- distinguishing between fine and coarse loess: Separating and comparing the aeolian grain size fractions at the selected key sites will enable distinguishing between distal and proximal dust fractions and interpreting them accordingly;
- detecting changes in loess composition in relation to climatic shifts: Changes (chemical, isotopic, and mineralogical) in the fine and coarse fractions with time will be analysed and related to known climatic shifts in the region;
- determining loess accumulation rates over time: Dating loess successions by OSL, ^{14}C, U series, and cosmogenic isotopes, in combination with density measurements, will allow for determining mass accumulation rates;
- evaluating dust influx to Mediterranean soils: Analysing soils on mountain tops, formed from parent material containing no quartz, such as alkaline volcanic rock or very pure limestone, will enable quantifying aeolian influx, based on the proportion of quartz grains, and isolating the recent dust and palaeo-dust fraction and evaluate its role in the development of Mediterranean soils;
- analysing primary loess successions: Several primary loess deposits of non-glacial origin are already known around the Mediterranean, e.g. on Crete (Pye, 1992); Mallorca (Rose et al., 1999), in Southern Spain (Günster and Skowronek, 2001) and Italy (Costantini et al., 2009). These sites may be re-visited. Additional sites will be selected on hilltops or interfluves, in order to avoid fluvial or colluvial processes. At all selected sites, the loess and soil units comprised in the successions will be described according to standard guidelines, and sampled for