Geomorphology 301 (2018) 39–52

Contents lists available at ScienceDirect

Geomorphology

journal homepage: www.elsevier.com/locate/geomorph

Discovery of a landscape-wide drape of late-glacial aeolian silt in the western Northern Calcareous Alps (Austria): First results and implications

Charlotte Gild [a], Clemens Geitner [a], Diethard Sanders [b,*]

[a] Institute of Geography, University of Innsbruck, A-6020 Innsbruck, Austria
[b] Institute of Geology, University of Innsbruck, A-6020 Innsbruck, Austria

ARTICLE INFO

Article history:
Received 21 March 2017
Received in revised form 24 October 2017
Accepted 25 October 2017
Available online 27 October 2017

Keywords:
Alps
Loess
Quaternary
Late-glacial

ABSTRACT

Aeolian deposits record palaeoenvironmental conditions and may coin soil properties. Whereas periglacial loess is extensively investigated for ~200 years, the study of the intramontane wind-blown deposits of the Alps has just stuttered along. Herein, we describe a drape of polymictic siliciclastic silt interpreted as an aeolian deposit that veneers extensive areas in the western Northern Calcareous Alps (NCA), from kames terraces near valley floors up to last-glacial nunataks.

The NCA — part of the Eastern Alps mountain range — consist mainly of Triassic carbonate rocks; these are overlain by deposits of the Last Glacial Maximum (LGM) and its deglacial-paraglacial aftermath (e.g., glacial tills, fluvio-lacustrine successions, alluvial fans, scree slopes) — and a regional drape of polymictic silt newly described herein. The drape is typically a few decimeters in thickness and slightly modified by soil formation; it consists mainly of well-sorted silt of quartz, feldspars, phyllosilicates (muscovite, chlorite, biotite), amphiboles and, rarely, calcite or dolomite. The drape is unrelated to the substrate: it overlies carbonate bedrock and — in lateral continuity — abandoned deposystems such as colluvial slopes of redeposited till, kames, alluvial fans, scree slopes, and rock avalanche deposits. The drape was spotted from near the present valley floors up to LGM nunataks, over a vertical range of some 2000 m; it is also present in catchments of the NCA that were not overridden by far-travelled ice streams and that lack metamorphic rock fragments. Two OSL quartz ages of the drape from two distinct locations (18.77 ± 1.55 ka; 17.81 ± 1.68 ka) fall into the early Alpine late-glacial interval shortly after the collapse of pleniglacial ice streams; this fits with geological and geomorphological evidence, respectively, that the drape should be of early late-glacial age, and that it accumulated during a specific interval of time.

In the NCA, localized minor deposition of aeolian dust is documented — by other authors — from plateaus deglaciated only during the late-glacial to Holocene; no evidence, however, exists for another phase of similarly widespread aeolian deposition such as that which gave rise to the described regional drape of silt. Intense aeolian transport and deposition was probably a direct consequence of the liberation of huge amounts of unsorted sediment during deglacial ice collapse, perhaps combined with climatic aridification. This provides a hitherto unappreciated element of the deglacial to paraglacial phase: intramontane dust storms. Because of its large extent and the availability to OSL dating, the aeolian drape provides an excellent geochronological marker level identified in terrestrial post-glacial successions of the Eastern Alps. Because of its fine-grained siliciclastic composition, the drape gives rise to widespread development of atypical Cambisols (on carbonate bedrocks) with comparatively high water storage capacity and nutrient supply.

1. Introduction

In the Quaternary, intervals of loess are widespread on continents and larger islands subject to glacial-interglacial cycles (e.g., Brunnacker, 1974; Zhongli et al., 1992; Dearing et al., 1996; Frechen, 1999; Antoine et al., 2001; Forman and Pierson, 2002; Little et al., 2002; Chlachula, 2003; Rutter et al., 2003; Zárate, 2003; Kehl et al., 2005; Heil et al., 2010; Hughes et al., 2010; Ma et al., 2013; Nottebaum et al., 2014; Klasen et al., 2016), and provide palaeoenvironmental information over a wide range of scales in space and time (e.g., Zhongli et al., 1992; Dearing et al., 1996; Little et al., 2002; Muhs et al., 2003; Iriondo and Kröhling, 2007; Vriend et al., 2011; Wolfe, 2013; Lehmkuhl et al., 2014;

* Corresponding author.
E-mail address: Diethard.G.Sanders@uibk.ac.at (D. Sanders).

https://doi.org/10.1016/j.geomorph.2017.10.025

Nottebaum et al., 2014; Cremaschi et al., 2015; Stauch, 2015; Boretto et al., 2017).

Loess records an important component of the (palaeo-)environment: dust-laden storms of sufficient sediment load and/or frequency to leave a geologically preservable interval of wind-transported sediment (e.g., Koster, 1988; Frechen et al., 2003; Iriondo and Kröhling, 2007; Smalley et al., 2011; Sprafke and Obreht, 2015). Because aeolian deposits are available to numerical age dating with the luminescence methods they can provide, both, environmental and geochronological information (e.g., Ding et al., 1997; Arimoto, 2001; Vriend et al., 2011; Lehmkuhl et al., 2000, 2014; Roberts, 2008; Stauch, 2015). Except for base-level changes imparted by tectonism or mass-wasting, in mountain ranges subject to glacial-interglacial cycles, practically all of the sedimentation and erosion is directly or indirectly linked to climate. Within a mountain range, over glacial-interglacial cycles, two major phases of sediment accumulation and geomorphic change are identified: (a) proglacial sedimentation, such as in valleys blocked by advancing ice streams, and (b) deglacial to paraglacial sedimentation during to shortly after melting of glacial icestreams (e.g., Church and Ryder, 1972; Van Husen, 1999; Meigs et al., 2006; Ostermann et al., 2006; Reitner, 2007; Sanders and Ostermann, 2011; Reitner et al., 2016). Subsequent to the deglacial-paraglacial sedimentation pulse, the pace of geomorphic change diminishes, and the regime is typically characterized by slower redeposition and erosional incision (e.g., Hinderer, 2001; Ballantyne, 2002; Orwin and Smart, 2004; Sanders, 2012).

In the Eastern Alps of Europe (Fig. 1), rapid collapse of last-glacial ice masses from ~21 ka to ~19 ka exposed trunk valleys and lower-positioned tributaries to deglacial-paraglacial sedimentation (Fig. 2) (see Auer et al., 2014, for summary). Because of very high rates of sediment dispersal, no soils or other levels suited for numerical age dating accumulated. The patterns of early post-glacial intramontane sedimentation, and its relation to late-Glacial to Holocene land surface changes, are thus hardly resolved to date. In addition, the subdivision of the Alpine late-glacial into an orderly succession of glacial advances and retreats — since Penck and Brückner (1909) — became controversial (see Reitner et al., 2016; Moran et al., 2016). In brief, except for exposure-dated moraines, the late-glacial terrestrial record of the Alps is poorly resolved with respect to chronology.

Over the past two years, in the western Northern Calcareous Alps (NCA), we have systematically field targeted a polymineralic siliciclastic drape typically a few decimeters in thickness (Figs. 1, 2 and 3). The drape veneers truncated bedrocks and — locally in exposed lateral continuity — abandoned late-glacial deposystems such as kames, redeposited till, scree slopes, alluvial fans, and rock avalanches (see

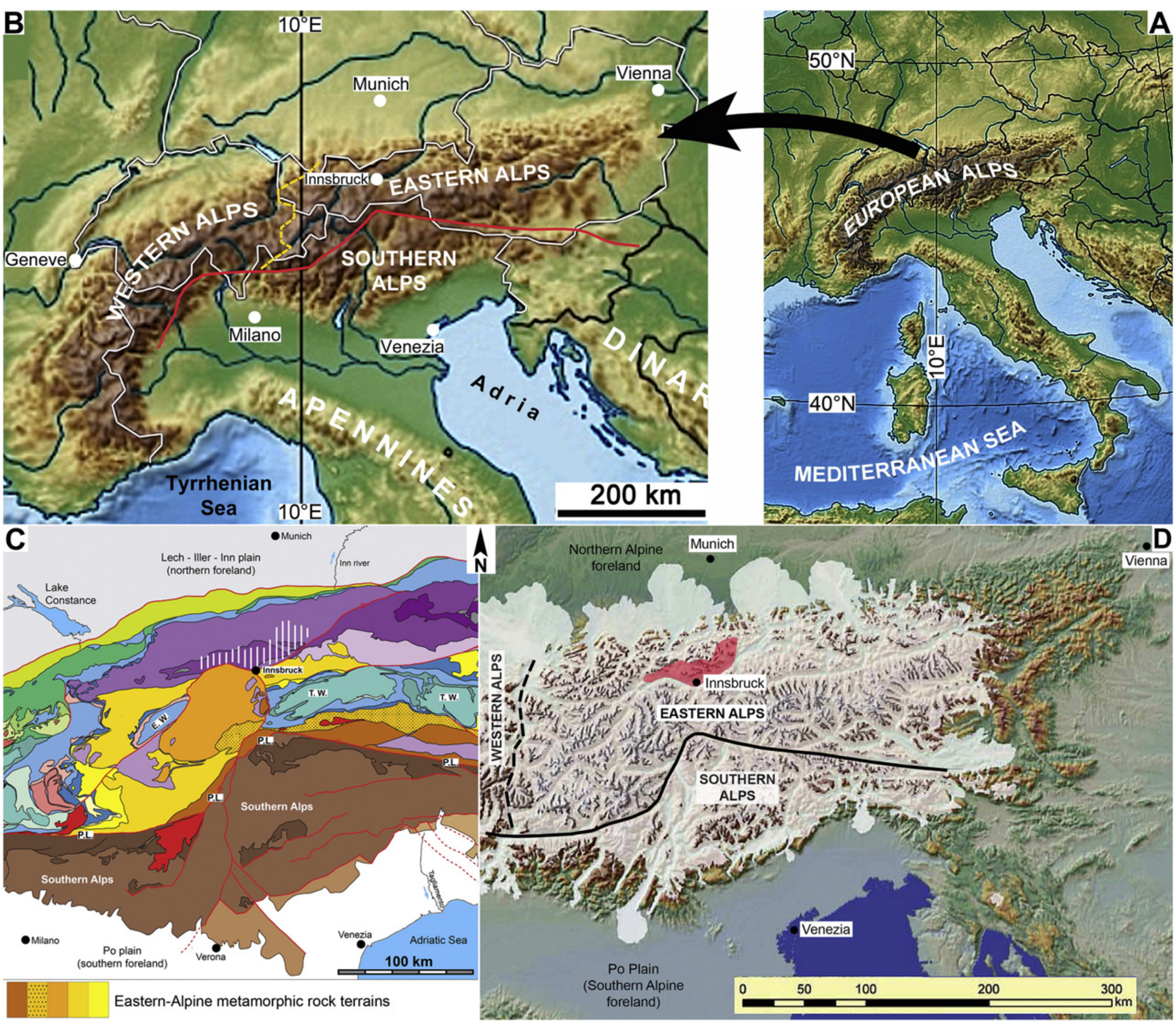

Fig. 1. (A) Position of European Alps in Europe. (B) Gross geological subdivision into Eastern, Western, and Southern Alps, respectively. (C) Part of geological map of the central sector of the Alps (modified from Schmid et al., 2004) showing the wider environs of Innsbruck city, and the position of the Northern Calcareous Alps (NCA). White dashed area in the NCA indicates the total area of inspected locations (see also subfigure E). (D) Map of Southern and Eastern Alps during the Last Glacial Maximum (modified from Ehlers, 2011, his Fig. 2.8). The red shade shows the total area of inspected locations.