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# Archaeopedology and chronostratigraphy of colluvial deposits as a proxy for regional land use history (Baar, southwest Germany)

Jessica Henkner [a,b,*], Jan J. Ahlrichs [a,c], Sean Downey [d], Markus Fuchs [e], Bruce R. James [f], Thomas Knopf [a,c], Thomas Scholten [a,b], Sandra Teuber [a,b], Peter Kühn [a,b]

[a] SFB1070 ResourceCultures, Gartenstr. 29, 72074 Tübingen, Germany
[b] Department of Geosciences, Soil Science and Geomorphology, Eberhard Karls University Tübingen, Rümelinstr. 19-23, 72070 Tübingen, Germany
[c] Institute for Pre and Protohistory and Medieval Archaeology, Eberhard Karls University Tübingen, Burgsteige 11, Schloss Hohentübingen, 72070 Tübingen, Germany
[d] Department of Anthropology, University of Maryland, 1106 Woods Hall, College Park, MD 20742, USA
[e] Department of Geography, Justus-Liebig-University Gießen, Senckenberstr. 1, 35390 Gießen, Germany
[f] Department of Environmental Science and Technology, University of Maryland, 0220 Symons Hall, College Park, MD 20742, USA

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ABSTRACT

Soils are the basis of our food production, supplying plants with nutrients and water. Farming leaves traces in the soil because cultivation can cause soil erosion. One result is the formation of colluvial deposits, which can be used as geoarchives of past human impacts on their terrestrial environment. The present study combines pedological and archaeological knowledge with chronostratigraphic analyses to infer deposition phases of colluvial material, thereby allowing the reconstruction of past land use and settlement activities in the Baar region, SW Germany. Local colluvial signals are interpreted as a regional proxy for increased soil erosion and colluviation. On the Baar, seven main deposition phases of colluvial material can be detected by 28 luminescence dates and 41 radiocarbon ages distributed through 26 soil profiles. Our results indicate increased colluviation in the younger Neolithic (~3800 BCE), the early to middle Bronze Age (~1550 BCE), the Iron Age (~500 BCE), the Roman Empire (~100 CE) and from the high Middle Ages onwards (>1200 CE, 1300 CE, 1600 CE). These dates and record of colluviation complement archaeological knowledge of the fundamental impact of human activities on the landscape due to sedentism and agriculture (early anthropogenic hypothesis). Our study shows that most periods of intensified colluvial deposition often, but not always, date to times with colder, more humid climatic periods. The spatial and temporal correlation of main depositional phases with archaeological finds points to land use as the determining factor of colluvial deposition, at least since Roman times.



## 1. Introduction

Today many landscapes and geographic regions are considered unfavorable for settlement or permanent use due to climate, soils, topography, and native plant communities, while others are classified as favorable. In central Europe, the concept of favorable and unfavorable regions refers to the environmental conditions and the time a region has been settled (Gebhardt, 2007). A favorable area (German: *Gunstraum* or *Altsiedelland*) is assumed to have been settled earlier than an unfavorable area. Reasons for an early settlement could include a more accessible landscape, fertile soils, warmer climate and sufficient rainfall for agriculture. Unfavorable areas are usually characterized as being less productive for agriculture, and therefore were supposedly settled later. However, the application of this definition to a research question needs to be explained in specific geographic and archaeological contexts. An interdisciplinary prehistoric archaeology and soil science project at the University of Tübingen is examining land use and settlement history in unfavorable areas in southwestern Germany. The focus is on soils that are a key resource for food production and human habitation. The technological capacity of human societies to use and modify soils has changed dramatically through time, as have the reasons for carrying out these activities. Soils itself preserve the signature of past human activities, as well as, paleoenvironmental conditions (James et al., 2014; Nicolay et al., 2014; Pietsch and Kühn, 2014).

Soils have been a research focus since the times of Thaer (in Kraft et al., 1880) and Liebig (1840), who studied agricultural land use. The first scientist to describe soils and their properties were Dokuchaev in Russia (Glinka, 1927) and Hilgard (1914) in North America. They suggested that soils result from interactions among parent material, climate, topography, biota and time. In 1941, Jenny (1994) explained soil formation in his quantitative pedology, which is based on these five functionally related soil forming factors. The theories and concepts of

* Corresponding author at: SFB1070 ResourceCultures, Gartenstr. 29, 72074 Tübingen, Germany.
*E-mail address:* Jessica.henkner@uni-tuebingen.de (J. Henkner).

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soil formation include the shape of the soil surface as an essential variable, at least since Milne (1935) published the concept of a *catena*. A *catena* or toposequence describes soils along a landscape sequence, where soil properties change gradually depending on geologic, geomorphic, atmospheric, or biologic processes (Wysocki and Zanner, 2006). However, none of these concepts explicitly include the effect of human activities on soil formation and erosion processes. This is changing; the term *Anthropocene* highlights a new geological epoch characterized by a significant transformation of the natural environment by humans (Crutzen and Stoermer, 2000; Lewis and Maslin, 2015; Ruddiman, 2013). Richter et al. (2015) describe how humans have altered soils chemically, physically, and biologically, transforming them into a human-natural system. This process started with the so called Neolithic Revolution - the transition from a hunting and gathering society to sedentism and the use of agricultural production. These changes in human settlement patterns, techniques for subsistence, and social organization subsequently triggered the Neolithic Revolution or Neolithic Demographic Transition, which saw higher carrying capacities and increased demographic growth rates (Bocquet-Appel, 2011; Downey et al., 2014). During this period, permanent land uses like farming, which involves digging, plowing, and harvesting, ultimately led to deforestation (Fyfe et al., 2015) and bare soils along slopes are prone to soil erosion. The eroded soil is deposited in depressions and along slopes, and called colluvial deposit. These deposits are important archives of the physical and cultural heritage of the region (Dreibrodt et al., 2010b; Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg (LUBW), 2008; Miehlich, 2009).

The German term *Kolluvium* is used when describing slope deposits formed by human induced or intensified soil erosion due to their land use (Ad-hoc-AG Boden, 2005; Kleber, 2006; Leopold and Völkel, 2007a). The characteristic corresponding land use is agriculture (Blume et al., 2010; Bork, 2006), but it could also be deforestation, mining, village establishment or infrastructure building. Hunter and gatherer populations also used the land and depended on the soil, but non-sedentary societies had smaller impacts on soil erosion and colluvial deposition than did agricultural societies (Miller, 2006). Thus, farming marks the beginning of a more intense and permanent anthropogenic land use that led to the formation of colluvial deposits. In this paper, the terms colluvium and colluvial deposit are used to describe soil landscape features formed by anthropogenic processes, including induced or intensified soil erosion by water and down slope deposition of eroded material. The term colluvial soil horizon describes a soil horizon out of colluvial material. These colluvial deposits are important resources to understand land use and settlement history (Emadodin et al., 2011; Leopold and Völkel, 2007a; Kühn et al. 2017). Further relocation of colluvial material, as well as absent, sustainable, or soil conserving land use lead to missing colluvial deposits. Soil formation, per the concept of Jenny (1994), takes place in periods of physical geomorphodynamic stability. If this stability is disturbed soil relocation occurs and pedogenesis slows dramatically. Environmental influences, especially precipitation variation and thunderstorm events associated with climate change, should be considered when interpreting and quantifying colluvial deposits as anthropogenic geoarchives (Dreibrodt et al., 2010a).

A colluvial deposit is always directly related to adjacent upward slope areas and thus it can be considered a local, high-resolution spatial phenomenon. The situation on nearby slopes can be different. If colluvial deposits are archives representing the impact of humans on their environment (Verstraeten et al., 2009), they can be used as a local proxy for the intensity and duration of human settlement, land uses, and migration during the Holocene (Dotterweich and Dreibrodt, 2011; Helbig et al., 2002; Leopold and Völkel, 2007b; Schroedter et al., 2013). Thus, we hypothesize that a geomorphological and spatially controlled sample of colluvial deposits can be taken as a regional proxy for land use history. Consequently, the research presented in this paper focusses on the following objectives:

(i) Analyzing the local chronostratigraphy and archaeopedology of colluvial deposits in different areas of the Baar region
(ii) Identifying main periods of colluvial deposit formation across the Baar region
(iii) Inferring possible causes of the formation of colluvial deposits as related to human land use history and climate

### 1.1. Regional setting of the Baar

The study area in southwest Germany comprises the granitic basement of the Black Forest to the west and the limestone escarpment of the Swabian Jura to the east (Fig. 1). In between is the Baar, a depression of older escarpments that includes the Danube River and its headwater streams, the Brigach and Breg. The entire study area is an unfavorable region, but compared to the Black Forest and Swabian Jura the Baar can be considered a favorable region for agriculture because it has fertile soils, often influenced by loess deposits (Kösel and Rilling, 2002; Lazar, 2005). The area was known as the breadbasket of the Baden region (Reich, 1859; Schröder, 2001). The Baar has an average elevation of about 700–800 m, and it has a lower relief intensity than the Black Forest and Swabian Jura. Mean annual temperature is 7–8 °C and mean annual precipitation is approximately 850 mm (Siegmund, 2006). Swabian Jura and Black Forest have lower average temperatures and higher annual precipitation; they are considered unfavorable for agricultural land use. In the low mountain range of Black Forest, soils tend to be more acidic, and the relief is higher, having peaks of up to 1000 m height. On the 750–900 m high plateau of the Swabian Jura, the supply of fresh water is limited because of low water storage capacity in the bedrock, and depends mostly on precipitation. Thus, this paper focuses on the Baar region, representing a rather favorable area for agricultural land use.

During the winter, stable atmospheric inversions occur in the Baar that can create heavy fog and many freezing days (122 $\pm$ 10 days from 1994 to 1996); along with short periods of frost-free days (approximately 140 days) (Siegmund, 2006). The Baar region is therefore more unfavorable than regions to the south and north, such as the Upper Rhine lowlands or the Hegau region.

Four sites on the Baar were chosen for archaeopedological and chronostratigraphic analyses because they provided the oldest archaeological findings in the Baar region, as known from literature. Since the locations were chosen in accordance with archaeological evidence (Table 1), we hypothesize that the phases of colluvial deposition can be linked to the local and regional settlement history. We, thus, use the colluvial deposits as a proxy for land use history. The four sites are: (1) The Magdalenenberg (Mag) site in the northwestern Baar close to Villingen, with its famous burial mound built of wood and earthen material dating to 616 BCE (Knopf, 2012). The location of the corresponding ancient settlement(s) is unknown. Archaeological findings indicate land use here since the Neolithic (Schmid, 1991, 1992). The bedrock is middle Triassic limestone, partially covered by loess containing Holocene slope deposits (Regierungspräsidium Freiburg, Landesamt für Geologie, Rohstoffe und Bergbau, 2013). (2) The Grueningen (Gru) site is located above the Brigach River near Donaueschingen. The dominant bedrock in the area is limestone covered by Pleistocene-to-Holocene deposits, containing admixtures of loess. (3) The Fuerstenberg (Fue) site is in the southern Baar and close to the transition to the Swabian Jura. It comprises slope deposits from late Jurassic limestone to early Jurassic clay-rich sediments covered by relocated loess. (4) At the site close to the town Spaichingen (Spa) the upper and middle slope is built up by limestone (middle Jurassic); the lower part consists of early Jurassic claystone and is covered by Holocene sediments.