Catena 137 (2016) 422–431

Contents lists available at ScienceDirect

Catena

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

Genesis of soils with an abrupt textural contrast in the United States

James G. Bockheim *

Department of Soil Science, 1525 Observatory Drive, University of Wisconsin, Madison, WI 53706-1299 USA

ARTICLE INFO

Article history:
Received 6 July 2015
Received in revised form 6 October 2015
Accepted 12 October 2015
Available online 26 October 2015

Keywords:
Soil classification
Soil formation
Texture-contrast soils
Duplex soils
Soil Taxonomy

ABSTRACT

Identified from the USDA Natural Resources Conservation Service databases, soils with an abrupt textural change (ATC)occur in four orders (Alfisols > Mollisols, Ultisols > Aridisols), 14 suborders and 31 great groups and represent nearly 1000 series in the USA. More than three-quarters (79%) of the soils have an argillic horizon and 21% have a natric horizon. An albic horizon is present in 40% of the soils. More than half (58%) of the soils with an ATC occur in Pale- great groups, suggesting older materials. Soil series with an ATC occur primarily in fine (56%) and clayey (14%) particle-size classes; smectitic (49%) and mixed (40%) mineral classes; mesic (39%) and thermic (33%) soil-temperature classes; and ustic (31%), xeric (27%), and aridic (21%) soil-moisture classes. On average, the texture of the eluvial and illuvial horizons varies by two classes on the soil-textural triangle. Of the several theories accounting for the origin of soils with an ATC, clay illuviation from the eluvial to the illuvial horizon must be considered a major process. More than halfof the soils are derived from alluvium and other stratified materials; residual soils may also contain sedimentary layering, which is important in the development of an ATC. Elevenpercent of the soils have a lithologic discontinuity at the eluvial-illuvial junction, which may influence the development of an ATC. The ATC in soils with an aquic soil-moisture regime (13%), such as the Argialbolls, may reflect plugging of the argillic horizon with fine clays which causes lateral subsurface flow that removes clay from the albic horizon.Climate may be important in the development of ATC in the USA, in that many of the soils are subject to extended dry periods, followed by intense thunderstorms. A third (34%) of the soils with an ATC occur in Texas. There are about 271,000 km^2 of soils with an ATC in the USA, which accounts for 3.2% of the total land area.

1. Introduction

An “abrupt textural change” is a diagnostic soil characteristic showing a “considerable increase in clay content within a very short vertical distance in the zone of contact... between an epipedon or eluvial horizon and an underlying argillic, natric, or kandic horizon” (Soil Survey Staff, 2014, p. 17). In the WRB (IUSS Working Group, WRB, 2014), this is referred to as an “abrupt textural difference.” The requirements of the two systems are similar except that the vertical distance over which the textural change occurs is 5 cm in the WRB and 7.5 cm in *Soil Taxonomy* (ST) (Table 1). Both definitions emphasize that the abrupt textural change is between an eluvial (A, E, AE, etc.) horizon and an illuvial (Bt or Btn) horizon.

In ST many soils with an abrupt textural change are readily discernible at the greatgroup and subgroup levels from the taxonomic name (Table 2). Soils with an abrupt textural contrast include Albaqualfs and Albaquults, Argialbolls except those in Arqiaquic and Argiaquic Xeric subgroups, and many Paleustalfs, Palexeralfs, Paleustolls, Palecryolls, Palexerolls, and Paleudults. However, soils with an abrupt textural change may be present in other taxa.

Soils withan abrupt textural change are also referred to as “texture-contrast” soils or “duplex” soils in Australia, where they account for 20% of the land area(Chittleborough, 1992). Abrupt textural differences are commonly observed in the Planosol and Stagnosol reference soil groups in the WRB, which classify as Albaqualfs, Argialbolls, and Albaquults in ST (Soil Survey Staff, 2014).Management problems of texture-contrast soils relate to perched water tables, restricted rooting depths, and lateral flow across the restricting layer on hillslopes(Cox et al., 2002; Hardie et al., 2013). Because of the unpredictability of their occurrence on the landscape, texture-contrast soils may require special techniques for mapping (Simeoni et al., 2009).

Chittleborough (1992) observed that chemical, mineralogical, and physical properties of texture-contrast soils were not diagnostic and that these soils exhibitedconsiderablediversity in their properties and mode of development. Several mechanisms have been proposed for the origin of texture-contrast soils, including original sedimentary layering; depositional upbuilding; episodic erosion and deposition; soil production byweathering; vertical or lateral translocation; bioturbation; and various combinations of these (Chittleborough, 1992; Phillips and Lorz, 2008).

* University of Wisconsin-Madison, Department of Soil Science, 1525 Observatory Drive, Madison, WI 53706-1299, USA.
E-mail address: bockheim@wisc.edu.

http://dx.doi.org/10.1016/j.catena.2015.10.011
0341-8162/

Table 1
Required characteristics of soils with an abrupt textural change in *Soil Taxonomy* (Soil Survey Staff, 2014).

1. > 8% clay in the underlying layer; and
2. within <7.5 cm, one of the following:
a. at least a doubling of the clay content if the overlying layer has <20% clay; or
b. > 20% (absolute) increase in clay content if the overyling layer has >20% clay.

Texture-contrast soils have been reported in Australia (Bishop et al., 1980; Chittleborough, 1992; Tennant et al., 1992), Spain (Alonso et al., 1994; García Marcos and Santos Frances, 1997), Mexico (Graham and Franco-Vizcaíno, 1992), Brazil (Oliviera et al., 2003; Parahyba et al., 2009); Ethiopia (Dumon et al., 2014), and Croatia (Rubinić et al., 2015). Although texture-contrast soils are known to occur in the USA (Harradine, 1963; Nettleton et al., 1975; Stahnke et al., 1983; Blank et al., 1996), there does not appear to have been a comprehensive study of the distribution and origin of these soils.

The objectives of this study are to utilize the Natural Resources Conservation Service (NRCS) databases to study the distribution and classification of soils with abrupt textural change in the USA and to apply a taxonomic-geographic approach to study the genesis of these soils. This approach uses the NRCS databases to determine the properties, classification, soil-forming factors, and distribution of soils with a particular diagnostic horizon or material to test multiple working hypotheses regarding their origin(Bockheim, 2014).

2. Methods

Soil series in abruptic subgroups were identified using the USDA NRCS soil classification (SC) database (Natural Resources Conservation Service, 2015a). In addition, a key-word search was done in the *Keys to Soil Taxonomy* (Soil Survey Staff, 2014) to locate taxa with an "abrupt texture change." Official Soil Series Descriptions (OSDs) were examined for taxonomy, soil morphological properties, and soil-forming factors (mean annual temperature and precipitation, vegetation, slope class, drainage, and parent material (Natural Resources Conservation Service, 2015b). Laboratory data were obtained from the Natural Resources Conservation Service (2015c) database.

Table 2
Identification of some soils with an abrupt texture change in *Soil Taxonomy* (Soil Survey Staff, 2014).

Taxonomic level
Great group
Albaqualfs
Albaquults
Argialbolls (except Argiaquic & Argiaquic Xeric subgroups)
Paleargids (optional)
Paleustalfs (optional)
Paleustolls (optional)
Palexeralfs (optional)
Palexerolls (optional)
Subgroup
Abruptic – Durixeralfs, Argidurids, Argiaquolls, Argicryolls, Palecryolls, Argiudolls, Natrudolls
Abruptic Argiduridic – Durixerolls (optional)
Abruptic Haplic – Durixeralfs
Abruptic Xeric – Argidurids
Albaquic – Hapludalfs
Albaquultic – Hapludalfs
Haplic Palexerollic – Durixerolls (optional)
Paleargidic – Durixerolls (optional)
Palexerollic – Durixerolls (optional)

Table 3
Diagnostic horizons in soils with an abrupt textural change.

Diagnostic horizon	Number of soil series	% of total
Epipedon		
Ochric	693	72
Mollic	271	28
	964	100
Subsurface horizon		
Albic	383	40
Argillic	757	79
Calcic	15	2
Duripan	115	12
Kandic	2	0
Natric	199	21
Petrocalcic	30	3

Abrupt textural changes were not always noted in OSDs. However, these could be determined through a comparison of the texture classes of the eluvial and illuvial horizons. Where they were available, ranges in clay contents for each genetic horizon were also used. There was little doubt that an abrupt textural change was present in a soil series when the eluvial and illuvial horizons varied by two or more classes on the soil textural triangle. These interpretations were checked by examining laboratory data of the 100 most extensive soils with an ATC. Only 8% of the pedons selected failed to meet the requirements of an ATC. In recognition of the requirement that the vertical distance must be 7.5 cm or less, only eluvial horizons with a lower boundary that was abrupt (<2 cm) or clear (2 - <5 cm) were accepted as having an abrupt textural change. The area of each soil series was determined using the NRCS soil extent mapping tool.

A spreadsheet was prepared giving the series name, the lead state, other states using the series, the Major Land Resource Areas in which the series occurs, the taxa (family, order, suborder, great group, subgroup), family classes (particle size, mineral, cation-exchange capacity activity, soil temperature, and soil moisture), diagnostic horizons, the textural class of the eluvial and illuvial horizons, the number of textural classes separating the eluvial and illuvial horizons featuring the abrupt textural change, the abruptness of the lower boundary of the eluvial horizon, and the nature and thickness of the eluvial horizon.

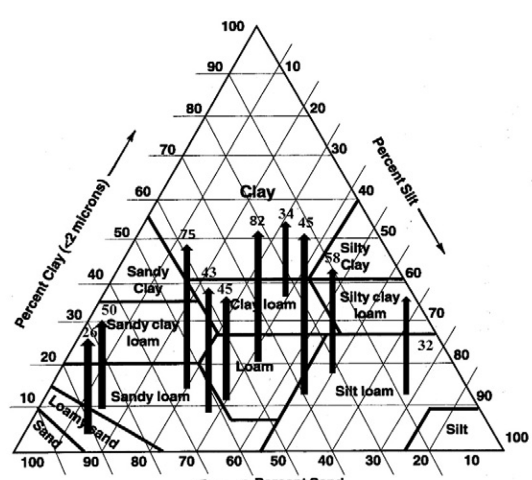

Fig. 1. Number of soil series with an abrupt textural contrast as approximated on the soil textural triangle.