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Classification and distribution of soils with albic horizons in the USA: A preliminary analysis

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ABSTRACT

The albic horizon, a diagnostic subsurface horizon that is comprised of primary sand and silt particles that are light-colored because they lack clay or iron oxide coatings, is unique in that it is an eluvial horizon that is defined on the basis of a loss rather than a gain of weathering products. Over 3000 official soil descriptions were examined in the US Natural Resources Conservation Service databases to identify which taxa contain albic horizons. Albic horizons are present (i.e., more than 8 soil series) in seven orders, 28 suborders, 73 great groups, and about 1600 soil series in soil taxonomy. Orders with albic horizons can be ranked on an area basis: Alfisols > Spodosols > Ultisols > Mollisols > Inceptisols, Entisols > Aridisols. The mean thickness of the albic horizon is 19 cm, with the greatest thickness in Alorthods (90 cm) and the least in Xerolls (3.1), Humods (4.0), and Ustolls (5.6 cm). Albic horizons may occupy one or two of several positions in the soil profile, including (i) the mineral soil surface, (ii) below an A horizon, (iii) as a buried horizon, (iv) between a variety of diagnostic subsurface horizons in bisequal soils, and (v) in some soils with alternating E and Bt lamellae. Albic horizons separate or are underlain mainly by an argillic or a spodic horizon. Half (50%) of the soils with albic horizons are excessively to well drained. Many albic horizons have been lost due to cultivation, especially in Aqualfs, Udalfs, and Udults.

1. Introduction

The albic horizon is defined in soil taxonomy (ST; Soil Survey Staff, 1999, 2014) as an eluvial, diagnostic subsurface horizon that is 1 cm or more thick and that has 85% or more albic materials. The albic horizon is underlain by an argillic, cambic, kandic, natric, or spodic horizon, or a fragipan. Albic materials are light-colored soil materials derived from primary silt and sand particles that are essentially devoid of coatings of clay and/or iron oxides.

The albic diagnostic horizon may or may not be comparable to the E (formerly A2 horizon) genetic horizon. In ST the E horizon is defined as a “mineral horizon in which the main feature is the eluvial loss of silicate clay, iron, aluminum, or some combination of these, leaving a concentration of sand and silt particles” (p. 335). Therefore, the albic horizon is more specific with a set of required colors (Table 1). Horizons designated as “E/B” may be albic if the E portion is ≥85%. The albic horizon may separate lamellae (e.g., E and Bt horizons) “that together meet the requirements for an argillic horizon” (Soil Survey Staff, 2014, p. 11). Relatively unaltered, light-colored sand, volcanic ash, or other related materials are not considered to be albic, despite that they may have the same color and apparent morphology of the albic horizon.

The albic horizon or albic materials are recognized in other soil taxonomic systems. The World Reference Base for Soil Resources (IUSS Working Group WRB, 2014) no longer recognizes an albic horizon but defines albic materials as “predominantly light-colored fine earth, from which organic matter and/or free iron oxides have been removed” (p. 70). Albic is used as a principal qualifier in 10 soil groups in the WRB.

The Australian soil classification system uses “gray” at the suborder level for seven orders and “bleached leptic” as a suborder in the Tenosols (CSIRO, 2015). The Brazilian system (EMBRAPA, 2013) recognizes an albic (albico) horizon but does not use it any of the three levels in the system. However, the Brazilian system does use gray (*acinzentados*) at the second categorical level in *Argissolos*. The Russian system does not recognize an albic horizon but uses gray and eluvial at different taxonomic levels (Lebedeva and Gerasimova, 2012).

The following selection of studies illustrates the kinds of analytical techniques that have been employed to supplement field observations in distinguishing between the albic horizon and underlying argillic or spodic horizons. In a French Albeluvisol (Albaqualf), albic and argillic horizons were readily differentiated according to their color by image analysis (Montagne et al., 2007). Albic and spodic horizons in Spanish Haplocryods and Haplorthods were distinguished according to their ability to sorb phosphates and sulfates, with greater sorption of these anions due to greater amounts of organic matter in the spodic than in the albic horizon (Camps Arbestain et al., 2002). In eastern North American Spodosols, albic horizons contained primarily smectites with a constant-charge, and spodic horizons contained aluminum-interlayered vermiculites with a variable charge (Laverdière et al., 1977). The albic horizon in tephra-derived Spodosols from Alaska and

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Table 1
Color requirements of the albic horizon in soil taxonomy.

Chroma					
≤2			≤3		
Moist		Dry	Moist		Dry
Value					
3	or	≥6	≥6	or	≥7
>4		≥5			

non-tephra-derived Spodosols from New England lacked allophane and imogolite and had lower amounts of Al–Fe complexes than spodic horizons (Shoji and Yamada, 1991). In Glossaqualfs of the Texas coastal plain, micromorphology was useful in identifying albic neoskeletal material formed along ped surfaces and root channels from the loss of clay and Fe from the surfaces of macropores (Vepraskas and Wilding, 1983). A portable X-ray fluorescence device was useful in differentiating albic horizons from light-colored tephra layers in Alaska and Idaho, based on Fe/Zr ratios (Weindorf et al., 2012).

Many studies have evaluated the role of the soil-forming factors on the development of albic horizons. For example, the thickness of albic horizon and the maximum concentrations of oxalate-extractable iron and aluminum oxyhydroxies (Fe_o and Al_o) in the underlying spodic horizon increased with elevation in the mountains of southern Mexico (Arteaga et al., 2008). Albic horizons were thicker and cutans in the underlying argillic horizon were thinner in coarse-textured than in fine-textured Paleudults and Hapludults of Indonesia (Ohta and Effendi, 1992). Albic horizons became lighter in color with age on raised marine terraces in southern Norway (Sauer et al., 2009). Albic horizons were thickest at the dissected edge, or transition zone between moderately well- and poorly drained Ultisols, where there was a relatively high but fluctuating water table (Daniels and Gamble, 1967; Daniels et al., 1967).

The genesis of the albic horizon may not been studied per se, but there is a reasonably good understanding of the processes leading to its development from the study of the underlying pedogenic horizons (Daniels et al., 1967, 1975; Vepraskas and Wilding, 1983; Farmer and Lumsdon, 2009; Quénard et al., 2011; Harris and Rischar, 2012; Bockheim, 2015).

The objectives of this study are to use the soil classification and official soil series descriptions databases of the US Department of Agriculture, Natural Resources Conservation Service (NRCS) to distinguish among the soil taxa, identify the properties, evaluate the influence of the soil-forming factors, and interpret the genesis of albic soil materials. Although over 3000 official soil descriptions (OSDs; out of a total of over 22,000) were examined, my list of soil series containing an albic horizon must be considered provisional until a mechanism is developed for electronically searching individual OSDs in the database. Moreover, as will be seen, many OSDs of soil series no longer contain albic horizons because of cultivation and addition of inorganic and organic materials.

2. Methods

The NRCS (2015a) soil classification database was queried for a list of the soil series by taxa in the Alb-suborders, great groups, and subgroups, e.g., Albolls (suborder), Albaqualfs and Albaquults (great groups), and Albaquultic (subgroup), as well other soil taxa which in the author's experience may contain an albic horizon. In addition, a key-word search was done in the Keys to soil taxonomy (Soil Survey Staff, 2014) to locate taxa with an "albic horizon." 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). The area of each soil series was determined using the 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, and the thickness, moist and dry color values and chroma of the eluvial horizons.

3. Results

3.1. Soil properties

Approximately 95% of the uppermost albic horizons were identified in soil descriptions as E or Eg horizons. Other genetic designations of albic horizons in uppermost horizons were A, Ap, AE, A/E, E/A, and E/B. Lower albic horizons were identified as E′, E/B (glossic) and Ex (fragic) in bisequal soils; Eb (buried); or E and Bt (cyclic as in lamellic soils). The thickness of the upper albic horizon in soils of the USA ranged from the minimum required of 1 cm to a maximum of 170 cm, with a mean of 19 cm. The thickest albic horizons were recorded in Alorthods (mean = 90 cm); the thinnest albic horizons were in Xerolls (3.1 cm), Humods (4.0), and Ustolls (5.6 cm) (Table 2).

Albic horizons occupy one or two of several positions in the soil profile: (i) at the mineral soil surface; (ii) below an A horizon, including thick mollic epipedons in Albolls; (iii) as a buried horizon, especially in soils derived from multiple tephra layers; (iv) between a cambic or spodic horizon and an argillic and/or fragipan horizon in bisequal soils; and (v) between lamellae (Fig. 1). Images of each of these positions of albic horizons are given in Fig. 2. The Rubicon sand (Fig. 2A), a sandy, mixed, frigid Entic Haplorthods, has an albic horizon extending from the surface to about 25 cm. The Shoepac silt loam (Fig. 2B), a coarse-loamy, mixed, superactive, frigid Alfic Oxyaquic Haplorthods, is a bisequal soil and has albic horizons at 5 to 15 cm and 58 to 84 cm. The Tetonka silt loam (Fig. 2C), a fine, smectitic, mesic Argiaquic Argialbolls, has a mollic horizon (0–35 cm), an albic horizon (35–46 cm), and an argillic horizon (46–100 cm). The Alcona fine sandy loam (Fig. 2D), a coarse-loamy, mixed, active, frigid Alfic Haplorthods, has an albic horizon from 2.5 to 7.5 cm and albic horizons separating lamellae (E/B) between 70 and 80 cm. Fig. 2E shows an albic horizon buried by about 30 cm of eolian sand. Fig. 2F is an Alorthod from Brazil with a hyperalbic horizon from the surface to 150 cm that is underlain by a Bh horizon. This soil is comparable to Alorthods from Florida.

Morphological properties of the albic horizon were determined from an 18% random sample of about 1600 pedons. Nearly half (41%) of albic horizons have a moist color value/chroma of 4/2 or 5/2, especially Spodosols, Alfisols, and Inceptisols (Table 3). In Ultisols the moist color of the albic horizon was mainly 6/2 or 6/3. More than half (53%) of the dry colors were 6/2 or 7/2, particularly in Alfisols, Spodosols, and Inceptisols. In Ultisols, dry colors were reported in only 5% of the pedons with albic horizons. The structure of albic horizons was most commonly (80%) absent (massive or single grain) or weak. Structural forms could be ranked by number of occurrences: subangular blocky (44%), massive or single grain (22%), granular (20%), and platy (14%) (Table 3).

In 63% of the soil series, an albic horizon was underlain by an argillic horizon, in many cases along with other diagnostic subsurface horizons (Table 4). A spodic horizon occurred below the albic horizon in 34% of the soil series, in some cases along with other diagnostic subsurface horizons. Other diagnostic subsurface horizons associated with an albic horizon included the glossic (15%), natric (5.1%), fragipan (4.8%), and cambic (3.3%) horizons. Entisols containing an albic horizon lacked another diagnostic subsurface horizon. One third (34%) of the soils with an albic horizon had two or more other diagnostic subsurface horizons; some pedons had as many as four (not shown in Table 4).