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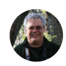

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The multidisciplinary origin of soil geography: A review

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ABSTRACT

Soil geography should be clearly recognized as a sub-discipline of physical geography and soil science, but at various times over the last century it was accepted as a complementary and descriptive sub-discipline of botany, agronomy and geology. In other words, there was not a clear consensus about its definition and origins. The main goal of this paper is to conduct a historical review (s. XX-XXI) of soil geography to clarify its origin, early methods, first authors and the importance of its interdisciplinary perspective within the scientific community. We found that soil geography was considerably advanced by the work of K.D. Glinka (1867–1927), one of Dokuchaev's students, who could be considered as the father of soil geography. Following the scientific line of Glinka, C.F. Marbut (1863–1935) could be considered one of the first world-reknown soil geographers. During the 1900s, this discipline continued to develop with research conducted by scientists including Kellogg, Simonson, Kubiëna, Huguet del Villar, Fitzpatrick, Duchaufour, Stremme, Zinck and entities such as USDA, FAO-UNESCO and CSIRO.

1. Introduction

Even before the scientific study of soils, early people utilized soil knowledge. Humans have made use of soils as raw materials for cultural purposes for a long time; one prime example is the use of hematite from soil in the prehistoric pigments employed in Paleolithic wall paintings in the Roucadour Cave (France) (Ospitali et al., 2006). Neolithic human groups considered the fertility of soils and their ability to provide food resources when choosing sites for settlements; this could be considered an early example of practicing what would become soil geography (Miller and Schaetzl, 2014). Another example is the use of soil spatial patterns to select cropping sites by 3000–2000 BCE (Krupenikov, 1992). Soil knowledge and its relationship with human practices developed in parallel with agriculture (Desruelles et al., 2016). At the beginning, these strong relationships were relevant in three specific areas: the Fertile Crescent (Western Asia, the Nile Valley and Nile Delta), Mexico, and Hindustan and East China (Porta et al., 2014). In fact, the Chinese had soil classification systems to assist in agricultural management as far back as 4000 BCE (Gong et al., 2003).

In the Western World, one of the most interesting links is related to Plato, philosopher in Classical Greece and the founder of the Academy in Athens. Plato remarked on the importance of soil loss and its distribution after observing some landslides near the expanding urban limits of the city of Athens (Fitzpatrick, 1980).

During the next few centuries, two groups started to design better strategies to qualitatively evaluate soil properties and fertility: religious congregations and the Muslim civilization (Rodrigo-Comino and Senciales González, 2013). The monks insisted upon the development of tillage and ploughing practices that removed soil horizons using animal labor during different seasons, and claimed that soil conservation techniques were important due to religious reasons (Hope and Jones, 2014). In the Arabian civilization, the Muslim worked on high quality irrigation systems driven by gravity to maintain moist, well-drained soils (Harrower, 2010). In fact, many soil scientists agree that one of the milestones in the rise of agronomy took place with the developed of the Arab gardens, and the work of Columella (4 BCE – c. 70 CE) is considered the beginning of soil science (Olson, 1943). In the southwestern part of the modern-day USA, Native American tribes chose

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their agricultural fields based on soils and landscapes to maximize water retention and runoff collection (Brevik et al., in press).

Despite all these precursors, soil geography only became a scientific discipline following the ground-breaking research carried out by the Russian school of landscape studies during the 19th and 20th centuries (Antipov and Semenov, 2006; Shaw and Oldfield, 2007). Soil geography is now recognized as a scientific discipline and soil geographers as practicing a specific branch of science (Rodrigo-Comino and Senciales González, 2013). As a scientific discipline, soil geography should be clearly recognized as a sub-discipline of both physical and human geography and soil science, but at various times over the last century it has been accepted as a complementary and descriptive sub-discipline of geology, agronomy and even botany. In other words, there was not a clear consensus about its definition and origins.

Several scientists and international organizations have performed research related to the establishment of pedological taxonomies that include a soil geographical point of view such as USDA (United States Department of Agriculture), FAO (Food and Agriculture Foundation) and CSIRO (Commonwealth Scientific and Industrial Research Organization). In addition, there is a geographic component to some of the most influential soil models used by modern scientists, such as those of Jenny and Runge (Brevik et al., 2016a). In many instances it is difficult to distinguish a clear line that separates soil science from soil geography.

The main goal of this paper is to carry out a historical review of soil geography to clarify its origin, early methods, first authors and the importance of its interdisciplinary perspective within the scientific community. The main reasons to make this historical review are: i) there is a lack of information about a correct definition of the soil geography discipline; ii) to the best of our knowledge, there are no studies focused on demonstrating the importance of soil geography as an integrated discipline within the soil sciences, geography and land management; iii) to help soil geographers with a consistent state of the art review to facilitate their future works; iv) and to clarify the origin and evolution of the discipline and avoid misunderstandings and lack of information; and, v) encourage other colleagues to contribute with research about the origin and evolution of soil science at national, regional, and even local approaches.

To achieve these goals, a short review of where soil geography acquired its methods will be given. Then early soil geographers will be discussed. A definition of soil geography and procedures within the context of geography, soil science, and territory will be presented. And a chronology of the main events, investigations and early researchers who have contributed to the soil geographical point of view will be provided.

2. The birth of soil geography and the first soil geographers

2.1. Agroecology and soil science as the scientific basis of soil geography

Some scientific disciplines such as chemistry and physics can be defined and their origins described without mentioning other fields such as geology, astronomy or botany. However, to enunciate a definition of soil geography and to find its roots, it is mandatory to highlight its clear dependency on agroecology and geology (McCracken and Helms, 1994; Tricart, 1962).

During the 1800s, the basis of soil science was established after specific investigations related to biochemical soil properties such as organic matter, color, mineralogy and biodiversity by scientists including J.G. Wallerius, Rieule, T. de Saussure, J. von Liebig and J.B. Boussingault. Based on these investigations the German agronomist Philipp Carl Sprengel published the first book strictly about soil science ("Die Bodenkunde") in 1837, which could make him the father of European soil science (Huguet del Villar, 1929). Another relevant event also occurred in Germany. The agroecologist Emil Ramman (1851–1926; he became Prof. of Soil Science in 1895 and 1900 moved as such to Munich), following on work done by Albrecht Thaer, von Richtofen, Albert Orth and Friedrich Fallou (Tandarich et al., 2002), started to describe soil weathering processes (Ramman, 1893), classified soils into two general groups (residual and alluvial), and developed the first scientific diagrams of soil profiles (Hartemink, 2009). In the USA, Eugene Woldemar Hilgard (Fig. 1a), considered a co-father of modern soil science by some researchers (Brevik et al., 2016b; Jenny, 1961), began his innovative studies into soil as an independent body and the influence of climatic parameters on pedogenesis (Hilgard, 1860, 1882, 1907).

The last important event in laying the early groundwork for soil geography occurred between 1877 and 1878, when the geologist and geographer Vasily Vasili'evich Dokuchaev (Fig. 1b) conducted his investigations of the soils of Ukraine for the Russian Government as a solution was sought for decreased agricultural production due to extremely dry periods (Bazykina, 2006; Fitzpatrick, 1980; Sánchez-Puig, 1995). Dokuchaev has been credited with developing the first scientific classification of soils, which included the Chernozem (Fig. 1c), methods for

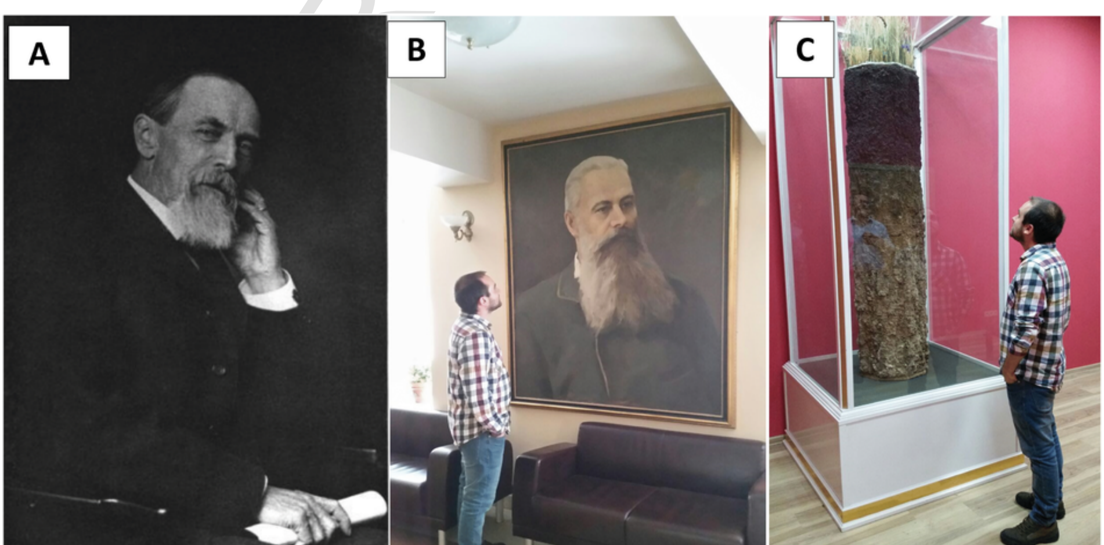

Fig. 1. E.W. Hilgard (A); V.V. Dokuchaev (B); Chernozem's monolith in V.V. Dokuchaev Soil Science Institute Moscow, Russia (C).

soil mapping, and establishing the foundation for the study of both soil genesis and soil geography (Buol et al., 2011). It is ironic that Dokuchaev himself refused to be associated with the field of geography and did not feel that soil science was linked to geography (Shaw and Oldfield, 2007).

Dokuchaev's findings were contradictory to those of his predecessor, Professor Mikhaíl Vasilievich Lomonósov, who wrote in his book *About the Layers of the Earth and other Works on Geology* in 1757 that soil should be considered a static entity and a simple part of the geological substratum (Lomonosov et al., 2012). Dokuchaev collaborated with other research groups from different disciplines such as geobotany, hydrogeology and geomorphology (Moon, 2005). During these collaborations with scientists such as V. Vernadskii and M.S. Giliarov (Dobrovol'skii, 2011), Dokuchaev and his students developed important ideas that shaped the future basis of soil geography: i) the soil as an interface between the atmosphere, lithosphere and biosphere; and ii) the application of different bio- and geoindicators to classify soil such as color, animals or insects, geomorphological features in the landscape and agricultural impacts (Oldfield and Shaw, 2013; Striganova, 2013). These ideas related to the natural and harmonious agreement between humans and the environment, indispensable to understand the development of the territory or land (Kiryushin, 2006). However, these ideas did not become widespread due to the difficulty of translating the Russian language and the controversial debates in Central Europe between geography and geology. The traditional European geologists assessed only some specific soil properties or viewed soil as a simple part of the geological substratum without inherent differences between them (Fitzpatrick, 1980; Tricart, 1962).

Despite the problems and challenges, Dokuchaev's students and other followers were eventually able to promote his ideas to scientists around the world (Dobrovol'skii, 2011; Kiryushin, 2006; Prokhorov, 1982; Semyonov, 1998). Those who promoted Dokuchaev's ideas included P. Semiónov (in Germany with the geographers Alexander von Humboldt and Karl Ritter), N.M. Sibirtsev (the first full professor of soil science), A.N. Sabatin (founder of the Academy of Soil Science in Moscow) and K.D. Glinka (influenced C.F. Marbut, who successfully introduced Russian ideas to the USA, and worked with the German soil scientist Hermann Stremme, a student of Albert Orth). In the USA G.N. Coffey was one of the first to introduce Russian ideas on soil science, but unlike Marbut was not successful in his attempts (Brevik, 1999).

2.2. K.D. Glinka and the birth of soil geography as a scientific discipline

Soil geography was considerably advanced by the work of Konstantin Dmitrievich Glinka (1867–1927), one of Dokuchaev's students. Despite his apparent disconnect with geography at the beginning of his career because of his taxonomic point of view (Shaw and Oldfield, 2007, 2015), Glinka generated novel ideas about pedogenesis and soil cartography following the ideas of the Geobotanical School of Kazan that was developed by S.N. Korzhinskii and A.Y. Gordyagin (Dobrovol'skii, 2006; Muggler et al., 2012). One major contribution, which is highly used nowadays, was the recognition of soil horizons as a key component to classify soils using the A, B and C nomenclature (Tandarich et al., 2002; Wilde, 1949; Yaalon and Berkowicz, 1997). This system was improved and published in English from the original German (Glinka and Marbut, 1927). From 1906 to 1910, Glinka coordinated different expeditions to perform qualitative soil assessments in Kazakhstan. From this data base, Glinka detected some important factors that conditioned pedogenesis: i) local climate characteristics highlighting the effects of variation in humidity, ii) vegetation, and iii) parent material. These factors were used to create the first complete soil classification, characterized by six groups and 23 sub-types (Glinka, 1914; Glinka and Marbut, 1927). From a soil geography perspective, the most relevant of this research was that Glinka emphasized the environment-human relationship over the territory where pedogenesis was occurring (Rodrigo-Comino and Senciales González, 2013). Glinka was also the founder of the Dokuchaev Soil Committee and the Soil Institute (Shaw and Oldfield, 2007).

Following the scientific line of Glinka, C.F. Marbut (1863–1935) could be considered one of the first world-renown soil geographers (Fig. 2a and b). He was a brilliant student of the father of American geomorphology, W.M. Davis (Sack, 2002). Through Marbut, Davis' con-

Fig. 2. K.D. Glinka and C.F. Marbut (A), K.D. Glinka and soil science community pictures (V.V. Dokuchaev Soil Science Institute Moscow, Russia).

cepts of landscape evolution were applied to pedogenesis (Brevik et al., 2016b; Lankford et al., 1985b). Marbut's published and non-published works clearly highlighted two concrete interests (Lankford et al., 1985a): i) to close the separation between soil geography, geomorphology, geobotany and biogeography; and, ii) to synthetize the knowledge of soils within the global environmental sciences. Decades later, these two concepts were also applied in the German school of geobotany and Russian landscape studies or ecogeography, although their studies were highly focused on abiotic elements (Isachenko, 2003; Melnyk, 2008; Tricart and Kilian, 1982).

Therefore, we can observe that from a multidisciplinary point of view soil geography had found its scientific roots. The main goals of the next generation of soil geographers would be to: i) classify soils, ii) delineate them over known areas of territory and; iii) achieve sustainable land management.

2.3. Soil geography during the 20th and 21st centuries

In the early 1900s, C.F. Marbut led the first complete study of the soils at a country-wide scale, which was based on the national scale soil survey established in the USA by Milton Whitney in 1899 (Brevik et al., 2016b). Marbut took over from Whitney when he retired and designed a hierarchical classification with multiple categories and a complete list of elements to identify the described soil profiles (Strahler and Strahler, 2002) (Fig. 3). Marbut's work formed the basis for the first USDA Soil Survey Manual (Kellogg, 1937) published since 1914 (Simonson, 1986). In 1951, C.E. Kellogg led the creation of the 1951 and 1975 editions of the Soil Survey Manual, which was applied worldwide by soil survey organizations. Moreover, R.W. Simonson and G.D. Smith (Fig. 4b) worked on the expansion of soil survey interpretations for agricultural and non-cultivated areas as well as renewing soil geomorphology, soil science and soil geography research (Helms, 2002, 2005) and the USDA provided major support for studies in soil geomorphology beginning in 1953 (Brevik et al., 2016a). Another important American contribution from this time was that of Hans Jenny (Fig. 4), who cast the five soil-forming factors into a state factor equation. One of the main goals of Jenny's model was to explain the geographic distribution of soils (Holliday, 2006).

In Germany, W.L. Kubiëna (Kubiëna, 1952, 1953) was one of the most important soil scientists and promoted the importance of the evolutionary process of soils interpreted through their pedo-morphological characteristics (Fig. 5a). This research line was considered useful for the elaboration of soil mapping at the regional scale (Tricart, 1962). During the 21st century, soil geography (in German Bodengeographie) is commonly established in many faculties of geosciences, usually as a subdiscipline of physical geography (Eitel and Faust, 2013; Gebhardt et al., 2012). The German soil geography school was also highlighted by the creation of the first international soil map of Europe (Stemmer, 1938, 1937), published on 12 sheets that totaled 4.8 m^2 and had input from 36 colleagues (Stemmer, 1997) led by the geologist and minimalist Herrmann Stemmer (1879–1961).

In Spain, E. Huguet del Villar (Fig. 5b) was the president of the International Association of Mediterranean Soil Sciences and introduced the term "*edafología*" in Spanish (*edapho –instead of pedo-* = soil from the old Greek). Huguet del Villar led and published several research projects related to the soils of Europe and the Iberian Peninsula (Albareda Herrera, 1940) and even influenced the Chinese soil classification system developed by Drs. Hou and Wong (Huguet del Villar, 1929). In his studies, del Villar stressed the importance of the term "geopedology" and associated it with several soil geographic research areas such as the Hindustan Peninsula or France, although the term evolved to "edafogeografía" (edaphogeography). In practice, only two general manuals contain the word "edafogeografía" in their titles (Ferreras and Fidalgo, 1991; Rodrigo-Comino, 2017).

After the Second World War, CSIRO implemented the use of aerial photography in its first soil classification in Australia (Jacquier et al., 2002; Northcote and Northcote, 1979). This tool became very important in soil mapping (Fitzpatrick, 1980; Miller and Schaetzl, 2014) following its development for soil survey purposes in the USA in the 1920s and 1930s (Brevik et al., 2017). Together with USDA Soil Taxonomy, the World Reference Base (WRB) developed by FAO-UNESCO in collaboration with the IUSS (International Union of Soil Sciences) have focused on classifying soils to promote agricultural and other forms of development (IUSS Working Group WRB, 2006). Most specifically, WRB establishes all its classifications within the scope of soil geography (IUSS Working Group WRB, 2006, 2014).

In France, P. Duchaufour (1912–2000; Centre biologique e pedologique de CNRS and president of the "Centre national de la recherche scientifique") was the most important individual related to soil science and soil geography between 1960 and 1990 (Fig. 5c). His research was related to genetic soil classification and land use planning (Duchaufour, 1956, 1970, 1997, 1998). In Scotland, Prof. Ewart A. FitzPatrick (Fig.5d) also worked with genetic classifications trying to find the most accurate explanation for soil distribution over the landscape and using a coordinate system with specific typologies (Fitzpatrick, 1980).

In The Netherlands, other remarkable soil geographers who were highly influenced by geomorphology (van Zuidam and van Zuidam-Cancelado, 1979; Verstappen et al., 1991) were in the ITC research group (Geo-Information Science and Earth Observation of the University of Twente). Specifically, A. Zinck worked on soil geographic databases, soil geomorphology and geopedology (Zinck, 2012; Zinck and Valenzuela, 1990a) without forgetting about other factors such as vegetation and climate (Ibáñez et al., 2013). Another remarkable place where soil geography plays an important role is in the ISRIC (International Soil Reference and Information Centre) in Wageningen. In this research center, the academics focus on serving the international community "as custodian of global soil information", providing information about the understanding of soils in major global issues.

3. The main procedures of actual and applied soil geography

Soil geography shares sources and methods with agronomy, soil sciences, ecology, geology and physical geography (geomorphology and biogeography). However, it is possible to establish some fundamental principles and procedures that distinguish it from other disciplines as shown in Fig. 6. These distinguishing principles are not closed, they are shared with other closely related fields, and soil geography is not only about cartography (Philipponneau, 1999), but rather follows the geographic method (Claval, 2001; Ortega Valcárcel, 2000; Schaefer, 1953).

In utilizing the geographic method, it is first necessary to delineate the study area (pedogeomorphic units) taking into account the different scales where all the possible human and environmental factors may intervene (Conacher and Dalrymple, 1977; Young and Goldsmith, 1977). Second, the identification and classification of soil types is mandatory by following criteria relevant to the research questions such as aptitudes, soil properties or potentialities (Riquier et al., 1970). Photointerpretation, field work, soil analyses, GIS data bases, and unmanned aerial vehicles (UAV) are some of the most important tools applied in the process of soil unit identification (Behrens et al., 2010; Brevik et al., 2016c; Bui et al., 2017; Grunewald, 2009; Le Bissonnais et al., 2002; Taylor et al., 2009). Third, a general assessment of the main environmental (geomorphological features such as falls, rills, gullies, flooded areas, etc.; types of lithology, biogeographical description such as types of vegetation and animals, distribution of main species, etc.;, climate conditions such as temperature or rainfall distribution; frost risks, etc.) and human characteristics (land uses such as types of

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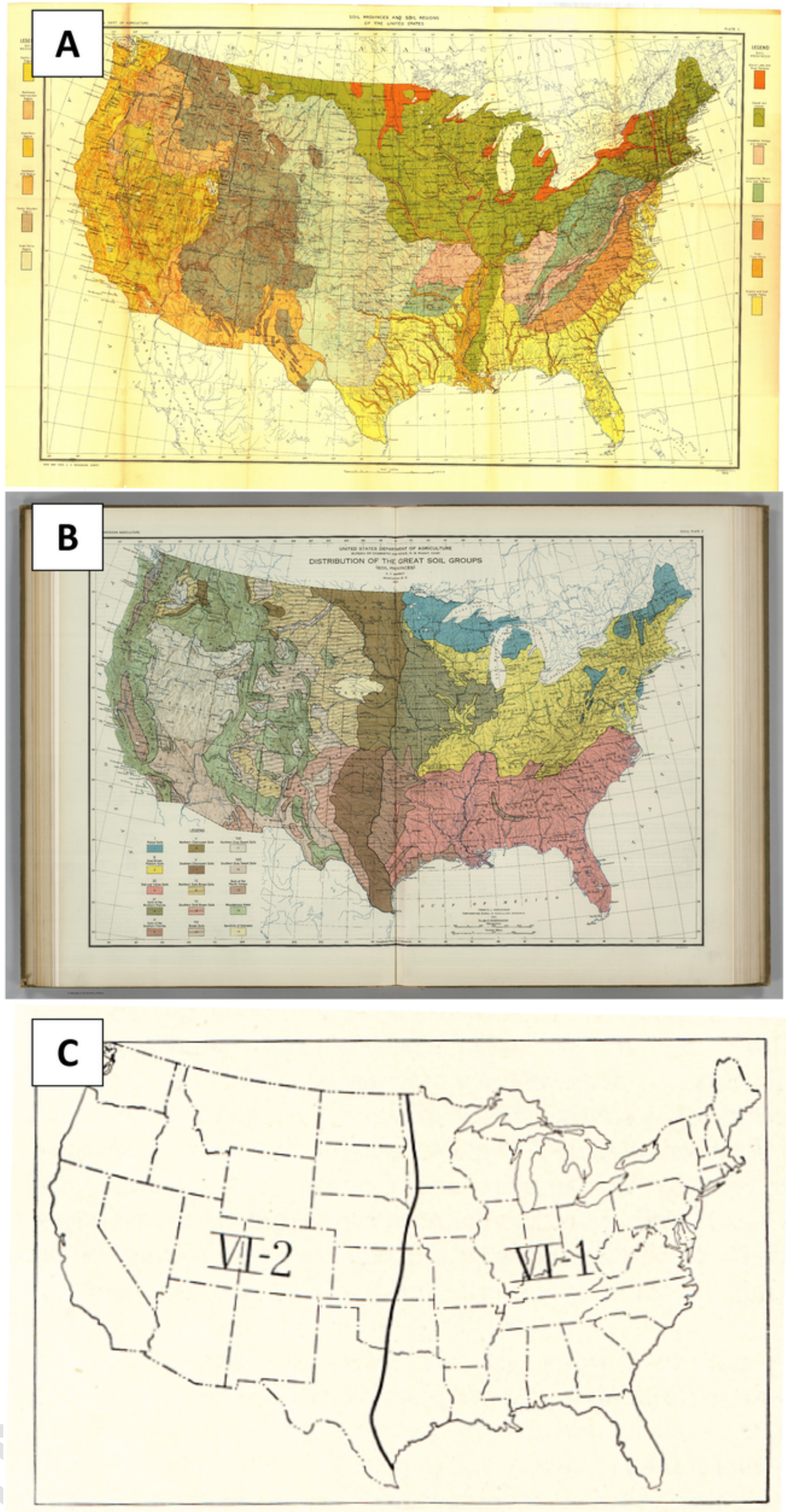

Fig. 3. Maps showing Marbut's evolving ideas regarding soil classification and distribution. Panel a – Map from Marbut et al. (1913), with soil subdivisions based on geology and physiography. Panel b – Map from Marbut (1935), which is based on soil properties and incorporates Russian ideas. Panel c – Another map from Marbut (1935), which shows the USA divided between soils that contain free calcium carbonate in their profile (Pedocals, VI-2) and soils that do not have free calcium carbonate in their profile (Pedalfers, VI-1).

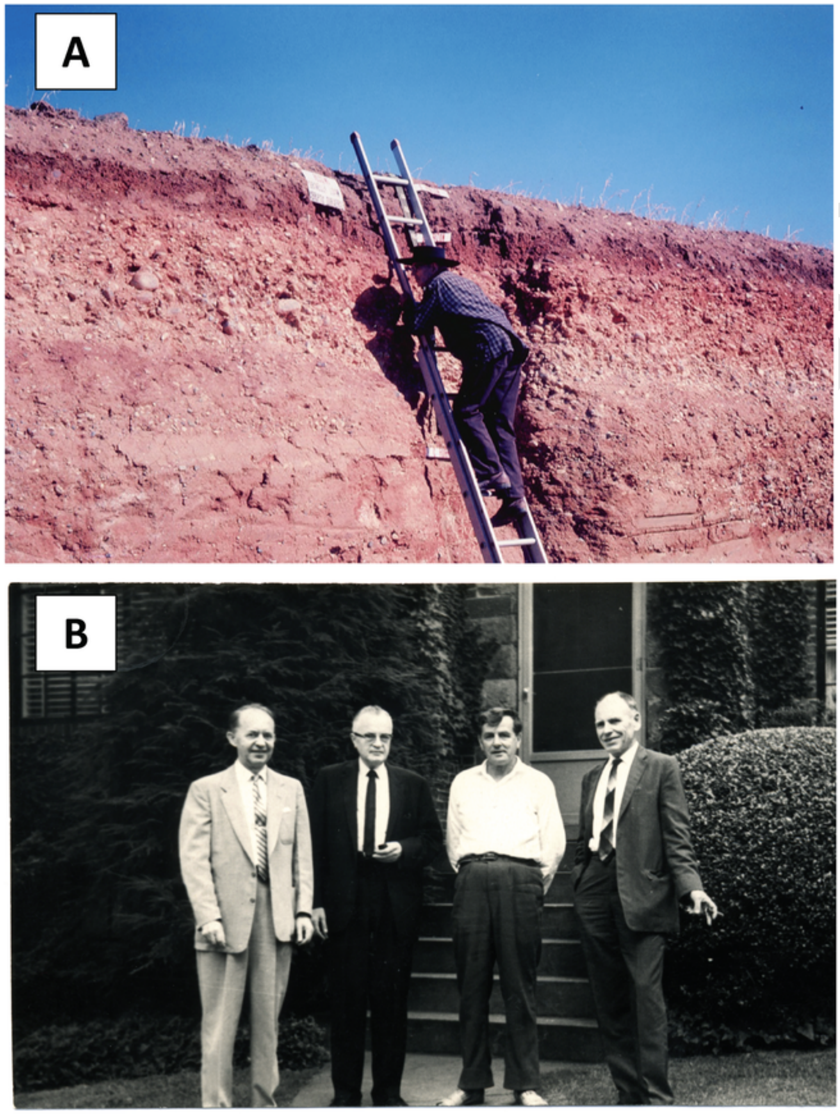

Fig. 4. Panel a – Hans Jenny inspecting a soil profile. Panel b – from left to right, Roy W. Simonson, Charles E. Kellogg, I.P. Gerasimov, and Guy D. Smith. Fig. 5. W. Kubiëna (A), Huguet del Villar (B), E.A. FitzPatrick (C) and P. Duchaufour (D).

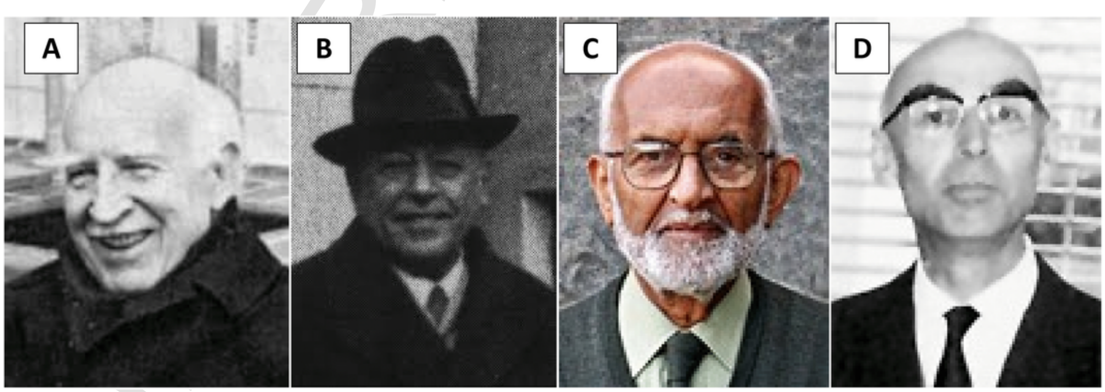

Fig. 5. From left to right: W.L. Kubiëna, E. Huguet del Villar, P. Duchaufour, Ewart A. FitzPatrick.

crops, evolution of land managements, etc.; demography such as amount of inhabitants, population density, etc.) must be performed in order to know the conditions under which pedogenesis was developed (Rodrigo-Comino and Senciales González, 2013). Subsequently, soil mapping is the main tool that should be used to allow the representa**-**tion and observation of geographic phenomena within soil geography (Miller and Schaetzl, 2014). It may be mandatory to rethink/review the elaborated soil cartography in order to carry out a meaningful interpretation at diverse scales without forgetting any major factor that has influenced pedogenesis and current land management.

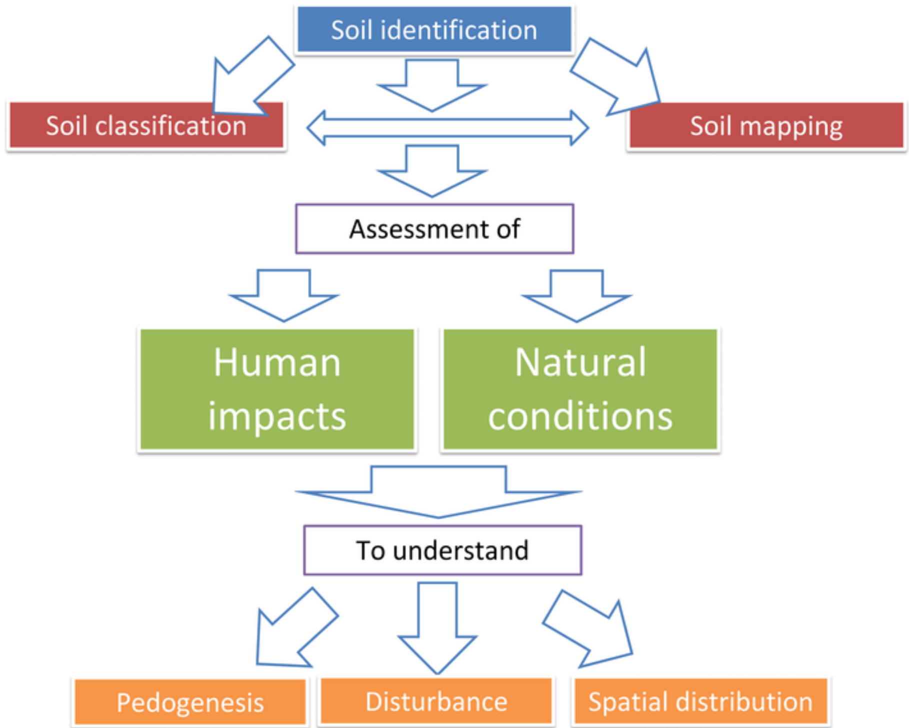

Fig. 6. The fundamental principles and procedures that distinguish soil geography as an independent field of study.

Miller and Schaetzl (2014) and Brevik et al. (2016c) emphasized that the introduction of GPS and GIS revolutionized soil geography. These tools provide more efficient and rapid ways to obtain base maps for soil mapping such as land-surface derivatives (Florinsky et al., 2002). However, they also remarked that other new tools used by soil geographers include advanced spatial statistical techniques, improved models, increasingly powerful computers, and remote and proximal sensing technologies, which are able to add new insights with additional information related to the environmental properties and their interactions with the electromagnetic spectrum (Eltner et al., 2013; Mulder et al., 2011).

4. Investigations in soil geography: Application to land management

Soil geography has produced an abundance of applied works related to geomorphologic methods and several surface processes such as weathering, desertification, sediment and water losses or morphological changes on hillslopes (Trudgill, 1983). The first main tool that joins both applied disciplines is geomorphological mapping or soil landform relationships. Gaucher (1968, 1981) elaborated the morphopedological mapping method where each part of the terrain represented a geomorphological unit that was associated with a specific soil type or groups of soils. The recognition of soil-landform relationships goes back to the 1930s with Milne's development of the *catena* concept (Gessler et al., 2000), and this type of mapping has been used in the USA since at least the 1930s, beginning with soil erosion mapping and proceeding on to soil survey; most of the legacy soil maps available in the USA today were created using soil-landform relationships (Brevik et al., 2016b). Conversely, mapped soils have also been used to provide geomorphological information (Brevik and Miller, 2015). Soil-landform relationships have been useful for tropical soil inventories within the framework of land evaluation studies beginning in the 1970s, and several authors have studied and improved the method as a part of soil survey (Bétard and Bourgeon, 2009; Gessler et al., 2000). Conacher and Dalrymple (1977) proposed the pedogeomorphic model, which assesses pedogenetic processes based on the morphological features of the surface. These types of units were called land surface *catena*. Several authors have worked on improving the methodological procedure related to the delineation of diagnostic units by overlapping lithofacies, topography, morphology, slope inclination, landscape units or vegetation cover in geographic information systems (GIS) and with remote sensing techniques (Mulder et al., 2011; Rodrigo-Comino et al., 2016; Rukhovich et al., 2011; Zinck, 2012; Zinck and Valenzuela, 1990b).

Soil geography has demonstrated a high affinity with biogeography. The main coincident methods and goals are highly related to nutrients, microorganisms, and vegetation and animal distributions. In this way, the inventories and surveys of biogeographers have frequently been used as tools in soil geography (Ibáñez et al., 2013; Tugel et al., 2006). Such applied research may be situated at the intersection between geography, biology, ecology and geobotany (Ferreras and Fidalgo, 1991; Pears, 1985; Taylor, 1984).

Dent and Young (1981) observed that land management experts would also need works that focused on the spatial distribution of soils. Modern digital soil mapping techniques include this in their output (Minasny and McBratney, 2016). In this way, soil geographers should be able to manage situations related to assessments of environmental impacts, military use, and land use planning, among others. Major advances in soil geography are highlighted in Table 1.

5. Future horizons

Land degradation issues increasingly need the support of a geographical approach related to the soil system (Butzer, 2005), as spatial variability is a major key to understanding system resilience and planning the appropriate application of restoration and rehabilitation strategies (Cerdà et al., 2017; Rodrigo-Comino et al., 2017a; Chen et al., 2007; Jie et al., 2002;). The need for mapping should be extended to other disciplines in ways that will help demonstrate the importance of soil geography as an applied discipline, such as Abrahams (2006)

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Table 1
Chronology of the highlights related to soil geography development.

Chronology	Socities and authors	Contributions
Antecedents: From 3.500 a. Chr. n. to s. XVII	Fertile Crescent (Western Asia, the Nile Valley and Nile Delta), Mexico and, Hindustan and East China	First activities related to soils and agricultural practices
	Religious congregation and Arabian civilization	Tillage and ploughing with animals, irrigation by gravity and soil conservation
s. XVIII-XIX	J.G. Wallerius, Rieule, T. de Saussure, J. von Liebig and J.B. Boussingault	Biochemical soil properties such as organic matter, color, mineralogy and biodiversity
1837	Philipp Carl Sprengel	First book strictly about soil science ("Die Bodenkunde")
1893	Emil Ramman	Classified soils into two general groups (residual and alluvial). Developed the first scientific diagrams of soil profiles.
1860–1907	Eugene Woldemar Hilgard	Soil as an independent body and the influence of climatic parameters on pedogenesis
1877–1878	Vasily Vasili'evich Dokuchaev	Developing the first scientific classification of soils such as Chernozem soil profile (Fig. 1c), methods for soil mapping, and establishing the foundation for the study of both soil genesis and soil geography
1906–1910	K.D. Glinka	Detected important factors that conditioned pedogenesis.
1926–1927	K.D. Glinka and C.F. Marbut	Create the first complete soil classification, characterized by six groups and 23 sub-types.
1929	E. Huguet del Villar	President of the International Association of Mediterranean Soil Sciences and introduced the term "*edafología*" in Spanish
1937–1938	Herrmann Stremme	First international soil map of Europe
1950 (After the Second World War)	CISRO	It implemented the use of aerial photography in its first soil classification in Australia
1956–1998	P. Duchaufour	Genetic soil classification and land use planning
1951–1975	C.E. Kellogg, R.W. Simonson and G.D. Smith	USDA Soil Survey Manuals
1952 and 1953	W.L. Kubiëna	Evolutionary process of soils interpreted through their pedo-morphological characteristics
1961	Hans Jenny	Five soil-forming factors into a state factor equation to explain the geographic distribution of soils
1979–2012	Van Zuidam, van Zuidam-Cancelado, Verstappen and A. Zinck	Soil geographic databases, soil geomorphology and geopedology
1980	Ewart A. FitzPatrick	Genetic classifications trying to find the most accurate explanation of soil distribution over the landscape and using a coordinate system with specific typologies

and Tabor et al. (2011) have shown related to human disease distribution and medical cartography. Another example is the interaction between biota and soils, where the role of soil geography is relevant (Ibáñez et al., 2016; Yin et al., 2010). As with any scientific field, soil geography is in a constant state of change and update, and the coming decades will see many technological advances. Human societies and their needs will change, and the environmental perception of the world will be altered just as it was over the last few decades (Bridges, 1981) and centuries (Williams, 1994). Soil geographers must be ready and willing to adjust with these changing needs, expectations, and capabilities. As one example of this, work on urban soils, which emphasize the soil-human relationship, has become increasingly important at the end of the 20th and beginning of the 21st centuries (Pickett et al., 2008; Howard and Olszewska, 2011; Howard and Shuster, 2015). Other examples include applied research devoted to solve problems such as accelerated soil erosion (Rodrigo-Comino et al., 2017b), pollution (Trujillo-González et al., 2017; Villacís et al., 2016), or soil degradation (Pereira et al., 2015; Pereira et al., 2017; Vaezi et al., 2017). Applied soil geography brings new ideas such as ecosystem services (Galati et al., 2016; Parras-Alcántara et al., 2016), interaction with other disciplines such as agronomy (Sharma et al., 2017), hydrology (Narany et al., 2017; Termeh et al., 2017), geomorphology (Yousefi et al., 2017b) or risk assessment (Yousefi et al., 2016b), and this modern soil geography seeks applied nature-base solutions (Keesstra et al., 2018) grounded in the holistic view of the soil system developed by soil geographers. This view is also present in policies developed in the 21st century such as the United Nations Sustainable Development Goals, in which soil is a key actor (Keesstra et al., 2016).

6. Conclusions

After carrying out a historical review of soil geography, we can consider it as a scientific discipline that is clearly recognized as a sub-discipline of geography and soil science. Despite not having a clear consensus about its definition and origins, a number of studies over the last century or more have confirmed its development and relevance. The main conclusions obtained from this historical review were: i) K.D. Glinka can be considered the father of soil geography; ii) C.F. Marbut was one of the first soil geographers known world-wide; iii) identification, soil classification, assessment of the human and natural factors that impact pedogenesis and soil distribution, and soil mapping are the main foci of soil geography; iv) soil geographers are able to carry out an important role in society by working on several issues related to the human and natural environments where soils play a determinant factor. Thus, we can define soil geography as the discipline that studies the causes of the distribution of soils and their relationship with humans.

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