Original Research Article

Determination of horizon, its boundary and depth in the soil profiles of North Western Himalayas

Abstract

The scientific study of the soil started almost 70-80 years ago with two school of thoughts, one worked in the lab and others in field. The main aim of the researchers studying in the field was to determine the profiles of soil along with its horizons so as to extent the knowledge on physical, chemical and biological properties. The distinctness of soil with depth means that soil has unique profile. All the soils in the world has some specific depth functions. The change of soil color or soil texture in a soil profile can be considered a good indicator of the soil formation and process and has been used as a proxy for degree of development or soil age . Uniform, gradational and rapidly changing soil textures are examples of soil profile forms used for soil classification. In the current study we studied twelve profiles having four different land uses and observed several horizons having various boundaries. The upper horizons were having diffused and wavy boundaries than the lower horizons. There was seen a clear relationship between the horizons and the various land uses. The study is very important as the soils in Himalayas are not very well developed and are prone to erosion. The study will help researchers and policy makers.

Key words Horizon, texture, structure, consistency

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Introduction

Pedology is one of most fascinating and ancient branch of soil science and includes petrology and pedogenesis (Ma et al., 2019, Bonfatti et al., 2018, Padarian et al., 2018, Zeraatpisheh et al., 2017, Zhang et al., 2017, Rahmati et al., 2017, Angelini et al., 2017) The other branches of soil science are said to be evolved from this particular branch. Dokuchiev the father of soil science is known to be first pedologist as he wrote his book entitled “Fundamental principles of pedology”. The scientific study of the soil started almost 70-80 years ago with two school of thoughts, one worked in the lab and were known as agro-chemists (Neina, D. 2019). The main aim of their study was to enhance soil conditions in existing agriculture fields. The second group of researchers were few and they worked in the field and were known as agro-geologists or pedologists. (Hartemink 2009, Brevik 2009, Hartemink et al., 2008, Feller et al., 2008, Hartemink et al., 2001) Their aim was to expand the knowledge of soil while characterizing, classifying and mapping it. The soil science became an established science when agro-geologists and agro-chemists held a joint meeting which later got established into a professional society the International Society of Soil Science in 1924. These pedologist worked in the field and reported that the pedogenesis or pedological process are said to be responsible for the horizon development (Owliaie et al., 2018, Abbaslou et al., 2013, Moazallahi, and Farpoor 2011 , Dominati et al., 2010, Khresat, Qudah 2006, Moazallahi, and Farpoor 2009). The major factors responsible for the formation of soil horizons include parent material, climate, organism, relief and time (Mishra and Roy 2019, Mahala 2018, Zhang et al., 2016)These horizons play an important impact on soil classification. The classification of any soil depends upon the number and type of horizons present. Hans Jenny (1941) reported that all the soils in this world have vertical distribution and is called horizons. These horizons reveal the potential problems as well as history and environment of the region. Generally, three genetic horizons occur which include master horizons, transitional horizons and subordinate distinctions within master horizon (Zhang et al., 2019a, Zhang et al., 2019b, Lowe 2019, Wu et al., 2018). Each horizon is described with the characters including horizon depth, horizon symbol, soil color under dry wet and moist conditions, mottling, texture, consistency, cutans, concretions, nodules and cementation. Many researchers have worked on the soil horizons. Jenny stated that horizon designation is a difficult process and needs a lot of expertise and suggested use of soil indicatrix for refinement and clarification of soil profiles and horizons.(Minasny et al., 2016). However, there are so many difficulties for horizon recognition and has been considered more of an art based on previous experience rather than a science having defined set of principles.

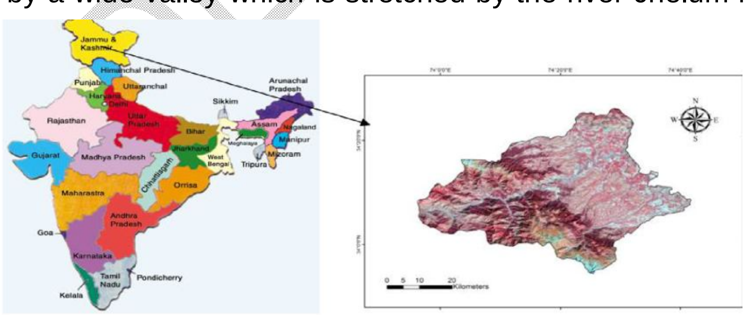
The classification of soils depends upon the classification of soil horizons within that profile. The approach appeared to be very simple as it was thought that soil profiles are formed by the straight forward interaction of active and passive soil forming factors including climate, biota, parent material, relief over a certain period of time, leading to development of soil with specific horizon sequence (Silva et al., 2018, Bockheim 2018, Ribeiro et al., 2017, Macedo et al., 2017, Stockmann et al., 2016, Sidorova 2016, Roudier et al., 2016, Mohammed et al., 2016, Minasny et al., 2016, Khitrov et al., 2016) This led to the concept of homology in soil science as it could form basis of classification. As in the animal and plant kingdom the classification is based on homologous relationship because of certain prominent characters, but it is intricate and outrageous to develop such relations in soil science. If the two soils have similar profiles still, they can differ due to the horizon depth and boundary (Hartemink et al., 2020, Goebes et al., 2019) In a profile the soil measurements are usually done on the basis of horizons, or defined depth intervals. Soil samples are usually bulked on the basis of horizons, ensuing in "stepped" data which may dissemble the persistence of soil properties. Soil scientists also measure soil properties at fixed depth intervals. The current study was to identify and delineate soil horizons, and its depth and boundary along the profile in various land uses.

Table 1 Previous study on soil horizons

Topic Name	**Country**	**Author**
Variation of the soil horizons in the soil profile	USA	Hartemink et al., 2020
Digital mapping of a soil profile	USA	Zhang et al., 2016
Application of mid-infrared spectroscopy for rapid characterization of key soil properties for engineering land use	Kenya	Warura et al., 2019
Improving In-Situ Estimation of Soil Profile Properties Using a Multi-Sensor Probe	USA	Pie et al., 2019
Characterization of soil profiles in a landscape affected by long-term tillage	USA	Papiernik et al., 2007
Soil spatial patterns analysis via X-ray fluorescence spectrometry and multivariate statistical methods	Romania	Pîrnău et al., 2020
A vertical profile imaging method for quantifying rock fragments in gravelly soil	China	Jiang et al., 2020

Material and Methods

Study area The study area is located in the temperate Himalaya of the North–Western part of India between the latitude 34º12' to 34º20' North latitude and 74º20' to 74º34' East longitude with an elevation of 1584 meters and an area of 3353 km2. The region has the high, mid and low altitudes consisting of mountains, hills and valleys. The region has an annual rainfall of 1270 mm and an average temperature of 24° C. The highland is separated by a wide valley which is stretched by the river Jhelum in the eastern and western direction. In the



north western part is the Jhelum and in the southern part is Pakistan. The topography of the area steep slopy to moderately slopy with some plain area as well.

Fig 1 gis map of the study area

Soil profile description and sampling

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The 12 profiles were excavated from the study site with four different land uses including agriculture, horticulture, forest and fallow lands. Theses profiles were exposed for two to three days so that the horizons are easily differentiated. Samples were collected from each horizon to a depth depending on the development of the soil and the lithic contact below the soil. The horizons were depicted following the standard descriptive nomenclature (Schoeneberger et al., 2012), with the following modifications: (i) an A horizon for forest sites is a mineral horizon that is moulded at the surface and is depicted by an accretion of organic matter intimately mixed with the mineral fraction and not dominated by characteristics of E or B horizons; (ii) an A horizon on cultivated sites (designated as Ap) is a mineral horizon that formed at the surface and has properties resulting from cultivation; (iii) a plowed mineral horizon, even though previously an E or B horizon, is designated as an Ap; (iv) an E horizon is a mineral horizon in which the dominant pedogenic process is loss of silicate clay; and (v) an argillic B horizon is characterized by an illuvial concentration of clay. For the purposes of this study, an A horizon at the native sites and an Ap horizon at the cultivated sites were designated as surface horizons. A subsurface horizon was an E and/or a transitional AB, EB, or BE horizon dominated by the characteristics of A, E, or B horizons, where the first letter designates the horizon most characteristic of the subsurface horizon. An argillic B horizon

Results and discussion

In the twelve soil profiles with four land uses certain soil horizons were reported. Four land uses were excavated from each altitude including the high, mid and low altitude. The horizons were distributed according to the clay content, soil consistency, texture, structure and the color of the soils.

In Profile P_1, five horizons were present and the depth ranged from 0-179 cm. The surface horizon (Ap) was having a depth of 0-21 cm with diffused wavy boundary and brown color (10YR 5/3). The sub-surface horizons (AB, Bt_1, Bt_2, Bt_3) ranged from 22-179 cm and were having clear smooth to diffused wavy boundary and the soil color varied from pale brown (10YR 4/2) to dark brown (10YR 2/2). In dry conditions the consistency of these soils ranges from hard to very hard, firm and friable in moist conditions and moderately sticky to sticky when wet. The plasticity was slightly plastic to plastic in all horizons and no effervescence was recorded in these horizons. **In Profile P_2**, there were three horizons and total soil depth was 83 cm with surface horizons (Ap) having a depth of 18 cm. The subsurface horizons. The color of surface and sub-surface horizons ranged from brown (10YR 5/3) to slightly greyish brown (10 YR 5/2). The boundary of these soils ranged from gradual wavy to diffused wavy and texture varied from sandy loam to loam. Dry consistency of these horizons varied from slightly hard to hard, moist consistency from friable to firm and wet consistency from slightly sticky to non-sticky and non-plastic. An effervescence was recorded in sub-surface horizons. There was no evidence of clay cutans, mottles or cracks in different horizons of the profile. While as many fine to few fine roots were observed throughout the profile.**The Profile P_3**, had a total depth of 188 cm in five horizons and the depth of surface horizon ranged from 0-17 cm and soil color recorded was brown (10 YR 5/4). The sub-surface horizons were having a color value of pale brown (10YR 4/3) to dark brown (10 YR 3/2). Soil texture of surface horizons was sandy loam and that of sub-surface horizons was loam to clay loam. The upper horizons were having clear smooth boundary while the lower horizons recorded diffused wavy boundary. The soil structure of surface horizons was having coarse weak and crumb structure and the lower horizons were having medium moderate angular blocky to fine moderate sub-angular blocky structure. In dry conditions the consistency of these soils ranged from loose to slight hard, friable when moist and slightly sticky when wet. The plasticity was slightly plastic to plastic with no effervescence in all the horizons. Roots were present in all horizons while as fine roots were confined up to a depth of 85 cm only.**In profile P_4** surface horizons extended up to 30 cm with total soil depth of 114 cm. The soil color of surface horizons was brown (10YR 5/4) and the sub-surface horizons were having dark brown color (10YR 3/4). The horizon boundary was clear smooth in surface horizons and diffused wavy in sub-surface horizons. The texture of surface horizons was sandy loam with coarse moderately granular structure and the sub-surface horizons were having loamy to clay loam texture with medium moderate sub angular blocky to fine strong angular blocky structure. The consistency varied from hard to very hard when dry, friable to very firm when moist and slightly sticky to sticky under wet conditions. The horizons were slightly plastic to plastic in nature with no effervescence. Few fine roots to very few fine roots were observed in the surface horizons only.

The profile P_5, had a total depth of 191 cm in five horizons and the depth of surface horizon ranged from 0-24 cm and soil color recorded was brown (10 YR 4/4). The sub-surface horizons were having a color value of dark

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brown (10YR 3/2). Soil texture of surface horizons was loam and that of sub-surface horizons was silt clay loam to clay. The upper horizons were having diffused wavy boundary while the lower horizons recorded clear smooth boundary. The soil structure of surface horizon was having medium moderate sub-angular blocky structure and the lower horizons were having fine strong angular blocky to fine strong sub-angular blocky structure. The consistency varied from hard to extremely hard when dry, friable to very firm when moist and slightly sticky to sticky when wet. The plasticity was slightly plastic to moderately plastic with no effervescence in all the horizons. Roots were present in all horizons while as fine roots were confined up to a depth of 85 cm only. **Profile P_6**, five horizons were observed with a total depth of 162 cm with surface horizons having a depth of 19 cm. The color of surface and sub-surface horizons ranged from brown (10YR 4/3) to very dark brown (10 YR 2/3). The boundary of these soils ranged from clear smooth to diffused wavy and texture ranged from loam to clay loam. The soil structure of surface horizon was coarse moderate granular to fine strong sub angular blocky in B horizon whereas BC horizon was having fine strong sub-angular blocky structure. Dry consistency of these horizons ranged from hard to extremely hard, moist consistency from friable to very firm and wet consistency from slightly sticky and slightly plastic to sticky and plastic in surface to sub-surface horizons, respectively. No effervescence was recorded in all horizons. There was no evidence of clay cutans, mottles or cracks in different layers of the profile. While as many coarse roots were present in surface horizons and fine to few fine roots were observed throughout the profile. **Profile P_7** four horizons were present and the depth ranged from 0-152 cm. The surface horizon was having a depth of 27 cm with diffused wavy boundary and a light yellowish brown color (10YR 5/4). The sub-surface horizons ranged from 28-152 were having diffused smooth to diffused wavy boundary and the soil color of pale brown (10YR 4/3) to brown (10YR 4/4). The textural class of these soils ranged from sandy loam to loam and structure varied from coarse weak sub-angular blocky in surface horizons to fine strong angular blocky in sub-surface horizons. The consistency was slightly hard to very hard when dry, friable to firm when moist and slightly sticky to sticky when wet. The soils were slightly plastic to plastic and no effervescence was recorded in all these horizons. **The profile P_8** surface horizons extended up to 25 cm with total soil depth in a range of 149 cm. The soil color of surface horizons was greyish brown (10YR 3/3) and the sub-surface horizons were having very dark brown color (10YR 2/2). The horizon boundary was clear smooth in surface horizons and gradual smooth in sub-surface horizons. The texture of surface horizons was silt loam with coarse moderately granular structure and the sub-surface horizons were having loam to clay loam texture with medium moderate sub-angular blocky to fine strong sub-angular blocky structure. The consistency varied from slightly hard to hard when dry, loose to friable when moist and slightly sticky to moderately sticky under wet conditions. The horizons were slightly plastic to plastic in nature with no effervescence. Few fine roots to very few fine roots were observed in the surface horizons only.

In profile P_9, there was total depth of 188 cm in six horizons and the depth of surface horizon ranged upto 13 cm and soil color recorded was light brown (10 YR 5/4). The sub-surface horizons were having a color value of yellowish brown (10YR 3/4) to very dark brown (10 YR 2/3). Soil texture of surface horizons was silt loam and that of sub-surface horizons was silt loam to silt clay loam with BC1 horizon having sandy texture. The upper horizons were having diffused wavy boundary while the lower horizons recorded clear smooth boundary. The soil structure of surface horizons was having medium moderate sub-angular blocky and the lower horizons were having medium moderate sub angular blocky to fine strong angular blocky structure with BC1 horizon having coarse weak and granular structure. The consistency varied from hard to very hard when dry, friable to firm when moist and slightly sticky when wet. The soils were slightly plastic with no effervescence in all the horizons. Roots were present in upper horizons while as fine roots were confined up to a depth of 96 cm only.**In profile P_{10}**, there were five horizons and total soil depth was 173 cm with surface horizons having a depth of 19 cm. The color of surface and sub-surface horizons ranged from light yellowish brown (10YR 5/2) to very dark brown (10 YR 2/2). The boundary of these soils ranged from clear smooth to diffused wavy and texture ranged from silt loam to silt clay loam. The soil structure of surface horizon was coarse moderate crumb to medium moderate angular blocky in sub-surface horizons. Dry consistency of these horizons was slightly hard to hard, moist consistency from loose, friable to very firm and wet consistency from slightly sticky and slightly plastic to moderately sticky and moderately plastic in surface to sub-surface horizons respectively. None of the horizons recorded effervescence. There was no evidence of clay cutans, mottles or cracks in different layers of the profile. While as many coarse roots were present in surface horizons and fine to few fine roots were observed throughout the profile. **In profile P_{11}**, there were six horizons and total soil depth was 207 cm with surface horizons having a depth of 28 cm and the lowest horizons showed the presence of water. The

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color of surface and sub-surface horizons ranged from yellowish brown (10YR 4/2) to very dark brown (10 YR 2/2). The boundary of these soils ranged from clear smooth to graduated smooth and texture varied from clay loam to clay in the surface and sub-surface horizons. The soil structure of surface horizon was medium moderate sub-angular blocky to fine strong angular blocky and fine strong sub-angular blocky structure. Dry consistency was slightly hard to very hard, moist consistency from friable to very firm and wet consistency from slightly sticky-slightly plastic to moderately sticky and plastic from surface to sub-surface horizons, respectively. No effervescence was recorded in all horizons. There was no evidence of clay cutans, mottles or cracks in different layers of the profile. While as many fine to few fine roots were observed throughout the profile. **The profile P_{12}** surface horizons extended up to 28 cm with a total soil depth of 88 cm. The soil color of surface horizons was light yellowish brown (10YR 5/4) and the sub-surface horizons were having brown color (10 YR 5/3). The horizon boundary was smooth clear in surface horizons and wavy gradual in sub-surface horizons. The texture of surface horizons and the sub-surface horizons was loam with medium moderate granular structure. The consistency in dry conditions was slightly hard to hard, in moist conditions it was friable to firm and slightly sticky to sticky under wet conditions. The horizons were slightly plastic to moderately plastic in nature with no effervescence. There was no evidence of clay cutans, mottles or cracks in different layers of the profile.

Discussion

In the study area twelve soil profiles were exposed, four from each altitude with various land uses. The soils of study area were moderately deep to deep except profile P_2, P_4 and P_{12} which showed a shallow depth. The soils of P_8 and P_7 mid altitude were comparatively shallower than the rest of profiles. The variation of profile depths may be attributed to the variation in topography and slope gradient (Wubie and Assen 2020, Husien et al., 2015, Bangroo et al., 2021, Sitangang *et al.,* 2006; Prathibha *et al.,* 2018). The other reasons are removal of finer soil particles, erosion of upper horizons, paucity of soil plasma, the degree and intensity of factors of soil formation etc. (Sitangang *et al.* 2006, Dengiz *et al.* 2012, Bashir et al., 2021, Naidu and Sireesha 2013 Karuma *et al.* 2014 and Harshitha *et al.* 2018). The color of soils in high altitude varied from dark brown to brown and in mid altitude it varies from dark brown to pale yellow. Similarly the soil color of low altitude ranges from dark brown to yellowish brown. In the various land uses the soils of forest area were darker than the other land uses. The soil color is apparent character of chemical and mineralogical properties. The textural property of the soils as determined by moisture regime and topographic position also play dynamic part in soil color. (Choudhury *et al.* 2013, Bashir et al., 2019, Bashir et al., 2016 Naidu and Sireesha 2013, Moritsuka *et al.* 2014, Purswani 2018. The data also revealed that surface soils were darker in color which may be due to large quantity of organic matter and clay humus complexes. The presence of grey color in these profiles may be due to clotting of calcium and iron with humus component. The yellowish brown, dark yellow brown, dark brown, and very dark brown color in the upper and lower horizons of profiles reveals a good drainage condition of these soils (Panagos *et al.* 2018, Debele *et al.* 2018 and Chen *et al.* 2018.

The structure of the soils of high altitude was coarse granular to angular blocky while as in the mid altitude it varied from medium granular to medium moderate sub angular blocky. The low altitude were having soil structure of medium moderate angular blocky to fine strong sub angular blocky. The soils of agriculture land use were having fine strong sub angular structure while as the forest soils were having weak granular to medium moderate sub-angular blocky structure. The hardness and development of sub-angular blocky and angular blocky structure may be associated with increase in clay fraction, compaction, tillage and climate (Tellen and Yerima 2018). The consistency in the profiles ranged from slightly hard to hard, friable to very firm and slightly sticky to sticky under dry, moist and wet conditions, respectively. The surface horizons showed slight hardness, friable and slight sticky nature which may be attributed to the high organic carbon, continuous manipulation and less amount of clay. (Ukut *et al.,* 2014; Yitbarek *et al.,* 2016 and Fekadu *et al.,* 2018). The increase in hardness, firmness and stickiness increased with the depth which may be associated with the increase in compaction and clay content in sub-surface horizons (Pulakeshi *et al.* 2014).

Conclusion

In the study of profiles we have observed both shallow and deep profile depths. In the higher altitudes the profile depth was less than the low and mid altitudes representing the effect of topography and slope on the soil formation. The horizon boundary were broken, clear, diffused, gradual, smooth and wavy. Mostly in all the profiles the boundary were clear and smooth representing a mature profile. The soils had fine weak granular to

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medium moderate crumb structure in surface horizons with increase in grade, class and type (sub-angular blocky to angular blocky) in the sub-surface horizons. The consistency changed from slight hard, friable, slightly sticky and slightly plastic in surface horizons to hard, firm, sticky and plastic in sub-surface horizons. The soils were slightly plastic to plastic representing a good clay content. A specific objective of soil depth and its boundaries can lead to a classical understanding of soil processes and soil horizon variation.

Table 2 Description of the various profiles

Profile (Land-uses)	**Horizon**	**Depth (cm)**	**Boundary**	**Structure**	**Consistency**	**Plasticity**
P_1 (Agriculture)	Ap	0-21	dw	m2cr	sh fr ss	Sp
	AB	21-44	cs	m2 sbk	sh fr s	mp
	Bt1	44-87	cs	m2 sbk	h vfi s	P
	Bt2	87-134	dw	m2 abk	vh fi s	P
	Bt3	134-179		m2abk	h fi ms	Mp
P_2 (Horticulture)	Ap	0-18	dw	m2gr	sh fr ss	Sp
	AC	18-56	gw	m2abk	h fi ms	P
	C	56-83		c1gr	h fr ss	Sp
P_3 (Forest)	Ap	0-17	cs	c1cr	sh fr ss	Sp
	AB	17-51	cs	c2gr	sh fi s	Mp
	Bt1	51-98	ds	m2sbk	vh fi ms	P
	Bt2	98-152	dw	f3abk	eh fi ms	P
	BC	152-188		m2sbk	h vfi s	P
P_4 (Fallow)	A	0-30	cs	c2gr	s hl ss	Mp
	Bt1	30-52	ds	m2gr	sh fr ms	Sp
	Bt2	52-88	gs	m2sbk	h fr ms	Mp
	Bt3	88-102	dw	f3abk	eh fi s	P
	C	102-114		f2abk	sh fr ss	P
P_5 (Agriculture)	Ap	0-24	dw	m2sbk	h fi ss	Sp
	AB	24-71	cs	m2sbk	sh fr ss	Mp
	Bt1	71-118	cs	f3sbk	eh vfi s	P
	Bt2	118-151	ds	f2abk	vh vfi vs	P
	Bt3	151-191		m3sbk	eh vfi s	P
P_6 (Horticulture)	Ap	0-19	cs	c2gr	sh fi ss	Sp
	Bt1	19-56	cs	m2sbk	h fr s	Mp
	Bt2	56-103	ds	m3abk	h fi ms	P
	Bt3	103-145	dw	f2abk	eh vfi s	P
	BC	145-162		f3sbk	eh vfi s	P
P_7 (Forest)	A1	0-27	dw	c1sbk	sh l ss	Sp
	A2	27-41	ds	f2sbk	h fi ss	Sp
	B	41-89	dw	f3abk	h fi s	P
	C	89-152		m1gr	h fi s	P
P_8 (Fallow)	A	0-25	cs	c2gr	sh l ss	So
	Bt1	25- 67	cs	m2gr	h l ss	Sp
	Bt2	67-83	gs	f3sbk	h fi ms	Mp
	BC	83-149		m2sbk	sh l ms	Sp
P_9 (Agriculture)	Ap	0-13	dw	m2sbk	h fi ss	Sp
	AB	13-31	cs	m3sbk	sh fi ss	Mp
	Bt1	31-75	cs	f3abk	h fi s	Mp
	Bt2	75-117	cs	m2abk	vh vfr s	P

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	BC1	117-126	gw	c1gr	l fr ss	So
	BC2	126-188		f2sbk	h vfi s	P

P_{10} (Horticulture)	Ap	0-19	cs	c2cr	sh l ss	So
	Bw1	19- 54	dw	c2sbk	sh fi ss	Sp
	Bw2	54-96	gw	m2abk	h fr ss	Mp
	Bw3	96-134	ds	m2abk	h fi ss	P
	BC	134-173		m2gr	sh fi ms	Sp
P_{11} (Forest)	A	0-28	cs	m2sbk	sh fr ss	Mp
	Bt1	28-59	cs	f2sbk	sh fi s	P
	Bt2	59-87	cs	f3sbk	h fi vs	P
	Bt3	87-132	gs	f3sbk	h fi vs	P
	Bg	132-181	gs	m2abk	sh vfi s	P
	BCg	181-207		m2sbk	sh vfi s	P
P_{12} (Fallow)	A	0-28	Cs	m2gr	sh l ss	So
	AC	28-56	Gw	c2gr	h fi ss	Mp
	C	56-88		c1gr	sh fr ss	Sp

Symbols used in Table-2

Boundary			**Structure**			**Consistency**		
b	:	broken	1	:	Weak	h	:	hard
c	:	Clear	2	:	moderate	sh	:	slightly hard
d	:	diffused	3	:	Strong	vh	:	very hard
g	:	gradual	f	:	Fine	l	:	loose
s	:	smooth	m	:	Medium	vfr	:	very friable
w	:	wavy	c	:	Coarse	fr	:	friable
			cr	:	Crumb	fi	:	firm
			gr	:	Granular	vfi	:	very firm
			sbk	:	sub-angular blocky	ss	:	slightly sticky
			abk	:	angular blocky	s	:	sticky
						ms	:	moderately sticky

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		vs	:	very sticky
		so	:	non-plastic
		sp	:	slightly plastic
		mp	:	moderately plastic
		p	:	plastic

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