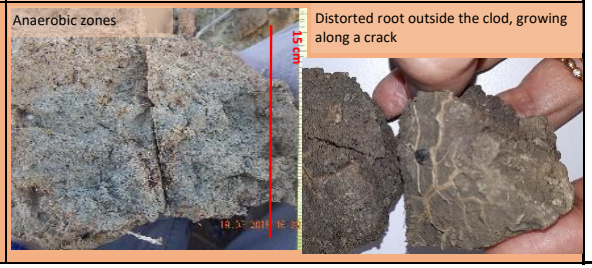
Spade-SubVESS Version 01.02.2023	**Soil structure aspect** (faces revealed after "opening")	**Opening (breaking) the clod**	**Resistance** [observe only in optimal moisture conditions]	**After opening (breaking)**		**Color and roots** [if visible]	**Interpretation**
				shape	**porosity**		
Ssq1 (Very good)		To open a clod, use both hands and try to make a break as straight as possible. If you succeed it is a bad sign (very straight = massive structure = bad; breaks according to inner structure = good). Observe and evaluate the revealed faces with the alongside descriptions.	Easily fragmented with fingers	"Opening" reveals rough faces with rounded and **subangular** aggregates. Includes loose sand	Porous. Many small visible pores throughout	Roots growing throughout the soil volume. No mottling	**Friable**. High porosity and rootability, good drainage and aeration
Ssq2 (Good)			Can be fragmented with hands	"Opening" reveals **rough faces**	Mainly porous. Some macropores, cracks and less porous zones are possible	Roots mainly growing throughout the soil volume. No mottling or only many diffuse faint mottles	Mostly rootable. Good drainage and aeration.
Ssq3 (Intermediate)			Difficult to break up	"Opening" reveals angular roughness with rather flat faces	Visible porosity mostly outside aggregates as cracks, **isolated macropores** and earthworm holes, acting as bypass pores	Roots mainly in worm channels and cracks. Possible mottling	Some compaction as either natural or man made. Roots may pass through, but non rootable zones are present. Rooting, drainage and aeration depend on the density of vertical pores and cracks
Ssq4 (Poor)			Very difficult to break up. Breaks mainly along cracks	"Opening" reveals flat faces or angular edges. Possibly prismatic, laminated or single grained	Very few pores and **cracks**	Roots grow around the clod or in cracks and may be distorted. Possible presence of grey blue anaerobic zones and well defined rust-coloured mottles around pores or blocked channels	Compacted with large scale structures. Not easily rootable. Poor drainage and aeration
Ssq5 (Very poor)			Impossible to break up or only possible along cracks	"Opening" reveals flat faces with very angular edges.	No pores. Some cracks	No roots or very distorted and only outside the clod along cracks. **Often anaerobic with grey-blue color**	Very compact. Roots cannot penetrate the clod. Very poor or no drainage and aeration. Often anaerobic

Spade-SubVESS Visual Evaluation of Subsoil Structure with a Spade (v.01.02.2023)

Fig. 1: Subsoil extraction with a 40-cm-long drainage spade

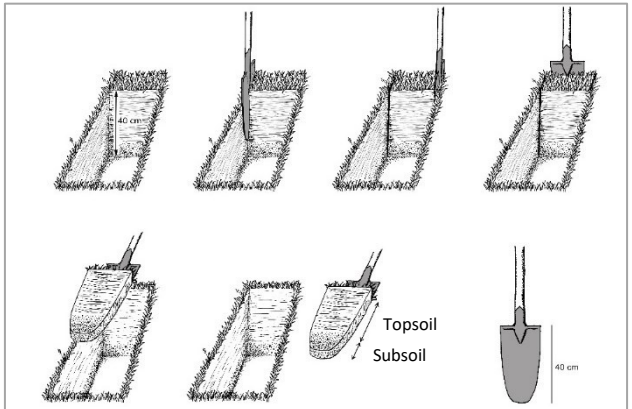


Illustration: Gabriela-Loza.com

Spade method for subsoil

This version of SubVESS is designed to evaluate the structural quality of a block of subsoil extracted with a spade down to a depth of about 40 cm. The block can be extracted with a long drainage spade (Fig. 1) or with a standard garden spade (Fig. 2). The Spade-SubVESS factsheet and criteria can also be used during a soil profile description, provided that clods can be removed from the profile for closer examination. A detailed description of how to proceed for a soil profile can be found on the original SubVESS flowchart (Ball et al., 2015).

Explanatory video of the topsoil VESS method on the 'Agroscopevideo' Youtube channel

Particularities of subsoil evaluation

Knowledge of the geomorphological situation is useful for subsoil quality assessment, because some natural features may be similar to signs of subsoil compaction. Examples:

- Mottling, blue colored zones may be explained by a high water table (e.g. in gleyic soils) and are not necessarily a result of compaction.
- A massive soil structure (but not compact) or presence of cracks may be a result of a very uniform texture and is not necessarily a sign of compaction.

Fig. 2: Subsoil extraction with a 20-cm-long garden spade

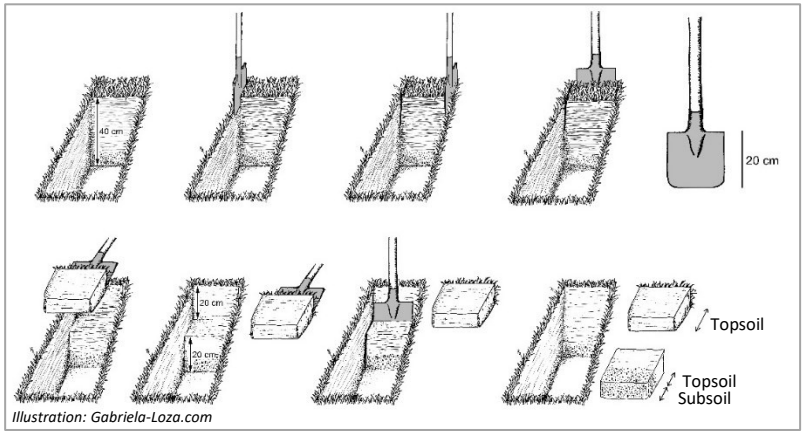


Illustration: Gabriela-Loza.com

Adaptation to anthropogenic soils. These soils are more heterogeneous than natural soils. The different structural qualities are not only distributed vertically but also horizontally within a layer. In this case, the proportion of each structural quality observed within a layer must be recorded and averaged for the layer. The weighted average of the layer is then used to calculate the weighted average of the block. This approach also allows us to keep track of the observed heterogeneity.

Field methodology

Equipment: Spade, measuring tape, camera, paper, pencil, plastic sheet.
When: The soil should be moist. Avoid very wet (deformable) and very dry soil (hard). Ideally, a time when roots are well established should be chosen.
Method:

1. Using a typical garden spade or long drainage spade, extract a block of about 35-45cm depth by digging a 'pre-hole' (Fig. 1 & Fig. 2), to facilitate subsoil block extraction.
2. Identify the **depth at which the subsoil starts: in ploughed soils, this is usually below the tilled topsoil (incl. a possible plough-pan layer).** (The topsoil structure can be evaluated with the $VESS_{2020}$ chart.)
3. Separate the subsoil block from the topsoil and gently manipulate with both hands to reveal cohesive layers or clumps.
4. Determine whether there are different layers of structural quality within the subsoil:
   - Observe changes in soil structure (compactness, aggregate size and shape, root behaviour) and identify the number of layers with different structures.
   - Measure the thickness of each layer.
5. Observe and score each layer individually with the help of the illustrated Spade-SubVESS chart.
   1. Observe the shape of the clods and aggregates, in particular their edges (rounded? angular?).
   2. Break the clods open to reveal their internal structure. Are they porous? Observe whether roots are growing within the clod, or only around it.

The block's score is calculated as a thickness-weighed mean of the different layers.
Example of subsoil block score calculation: A 15-cm-thick subsoil block containing a 5-cm-thick plough pan with a score of Ssq5 and a 10-cm-thick layer underneath with a score of Ssq3 is given a score of SSq3.7.

Score of subsoil block= [(5x5)+(10x3)]/15 = 3.7

Adaptation of the original SubVESS chart (Ball et al., 2015) (Soils | SRUC) using the extraction technique of the "double spade" method (Emmet-Booth et al., 2019). Adaptation made in the frame of the STRUDEL project (www.strudel.agroscope.ch)
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