Technique for preparation thin sections of structural soil aggregates of certain size fractions

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Morphological properties of soil aggregates are developed in the process of pedogenesis and reflect the complex of structure formation processes. The ped’s size, shape, and internal structure are peculiar to each corresponding soil type and genetic horizon. The technique proposed allows preparing thin sections on every sizes of structural units and, in contrast to known methods, it provides not only a ped immobilization in the mass of fixing material, but also pore space saturation with natural resin. It is also possible to prepare the sections with marking of large aggregates orientation in space; it requires application of gypsum marks on the aggregate surface in the process of their sampling from the soil profile. The technique modified consists of following stages:

1. Selection of aggregates with required fractions;
2. Preparation of sections with separate aggregates larger than 5 mm;
3. Preparation of sections with aggregates smaller than 5 mm.

In preparation of aggregates larger than 5 mm, a technique similar to that of preparing large soil block samples is used because it makes possible to process each soil aggregate separately. Another approach is required for processing of structural units up to 5 mm in size because it is impossible to prepare a section of individual issue with this size. The problem is solved when the units are saturated and processed not separately, but as a whole block sample which include a mass with peds of separate fraction. For this purpose, it is required to prepare cups comprised of walls from thick paper and a gypsum bottom.

For preparation the caps use a gypsum in the form of fine white powder rapidly solidified in addition of water in a certain proportion and forms a firm bottom of the paper cup. Cut out a square of 4×4 cm in size and a strip from thick paper and glue them together to gain a tube of 5 cm in height and 1.5–2 cm in diameter (i.e. 10×5 cm). Apply on the paper squares a prepared gypsum mass sufficient to retention of the paper tube until gypsum hardening. Fill a fraction of aggregates into the prepared cup in one-third of its height and cover it with prepared fixing substance with solvent. Saturation is carried out in accordance with the standard technique of section preparing using natural resins (Gagarina, 2004). After complete saturation, paper cups with a mass of aggregates in them turn into monoliths that should be processed in the same way as large soil samples. As a result of all operations, significant number of structural soil aggregates with same sizes may be found within the section plane.

Keywords: soil structure; soil micromorphology; method of studying soil properties

Introduction

Being a structural component of ecosystems, soil behaved like a complex hierarchical subsystem having diverse and interconnected links between different organization levels. As was noted by Kornblum (1975), such focus on the structural and functional organization of the soil creates the preconditions for development of genetic soil science and greatly expands the possibility for prediction the soil cover response to external influences. Voronin (1986) identified the following structural levels in the organization of soil as an independent natural body: molecular-ionic; elementary soil particles; aggregative; horizontal; soil individual; soil cover. Rozanov (2004) estimated the possibility of application the structural level theory and highlighted the need to develop an appropriate methodological approach and specific methods for studying each structural level of soil organization.

Development of soil aggregate morphology comes in the course of pedogenesis, and it reflects the complex of structure formation processes. The ped’s size, shape, and internal structure are peculiar to each corresponding soil type and genetic horizon. Therefore, determining the micromorphological organization of soil aggregates in specific size fractions is important in multipurpose soil studies.

Micromorphological studies with the using of thin sections of structural aggregates and techniques for their preparation were described in the papers of Polsky (1949, 1955), Polyakov (1965), Parfyonova, Yarilova (1977), Dobrovolsky (1983),

In this work we present a technique for preparation thin sections of soil aggregates of certain size fractions using natural resins (cedar, fir). The technique proposed can be also adapted at working with synthetic resins as fixing substances of soil material structure.

Results and discussion

Well-known methodical works were mostly devoted to techniques for the preparation of thin sections of sufficiently large soil soil block samples (Jongerius, Heinzberger, 1975; Parfyonova, Yarilova, 1977; Dobrovolsky, 1983; Bullock, Fedoroff, Jongerius, Stoops, 1985; Murphy, 1986; FitzPatrick, 1993; Stoops, 2003; Gagarina, 2004). But regarding the studying of aggregate micromorphology, such approach has a significant drawback due to the soil spatial heterogeneity in distribution of structural separates and accidentality of the section plane passage across soil material. As a result, it is quite difficult to determine whether the aggregates situated within the section plane correspond to own actual dimensions, and therefore whether the analysis of their internal structure is reliable by separate fractions, especially for aggregates of small size fractions.

Taking in consideration the above, we searched for techniques that would provide access to objective information about the microstructure at the aggregate level, since there is a need for differentiated study of soil aggregates various in sizes, various in their organization and in their effect on the soil-forming process both for different genetic soil types and for each individual soil unit.

The technique modified consists of the following stages:
1) selection of aggregates in required fractions;
2) preparation of sections with separate aggregates larger than 5 mm;
3) preparation of sections with aggregations smaller than 5 mm.

Separation of aggregates by fractions is carried out by dry sifting technique (Vadyunina, Korchagina, 1986). Further, the techniques of saturation with fixing substances are selected depending on the size of aggregates.

In preparation of aggregates larger than 5 mm, a technique similar to that of preparing large soil block samples is used because this make possible to process each soil aggregate separately. Fixed aggregates up to 10 mm in size it is advisable to glue for several pieces per one slide. Saturation with a fixing substance is convenient to carry out in metal weighing vessels.

Another approach is required for processing of structural units up to 5 mm in size because it is impossible to prepare a section of individual issue with this size. The problem is solved when the units are saturated and processed not separately, but as a whole block sample which include a mass with peds of separate fraction. For this purpose, it is required to prepare cups from thick paper with gypsum bottom.

Preparation stages of sections of structural aggregate less than 5 mm:
1. Selection of soil aggregates for the preparation of sections is carried out by genetic or formal soil horizons depending on the purpose of micromorphological studies. Aggregates are carefully selected from 3–5 points of the soil horizon (Fig. 1, a) to formation a representative average sample. The aggregate samples are transported and stored in cardboard boxes to prevention against damage the natural shape and surface relief of the units.
2. Drying of aggregate samples to air-dry state in laboratory conditions.

Fig. 1. Sampling of structural aggregates by soil genetic horizons from 3–5 sample points (a), selection of size fractions of aggregates with sifting technique (b, c)
3. The required size fractions of the aggregates are separated by sieving the sample through a set of sieves (Fig. 1, b, c).

4. For preparation the caps use a gypsum in the form of fine white powder that solidified rapidly in addition of water in a certain proportion and forms a firm bottom of the paper cup.

5. Cut out a square of 4x4 cm in size and a strip from thick paper and glue them together to gain a tube of 5 cm in height and 1.5–2 cm in diameter (i.e. 10×5 cm). Apply on the paper squares a prepared gypsum mass sufficient to retention of the paper tube until gypsum hardening.

6. Fill a fraction of aggregates into the prepared cup in one-third of its height and cover it with prepared fixing substance with solvent (Fig. 2, a). Saturation is carried out in accordance with the standard technique of section preparing using natural resins (Gagarina, 2004).

7. It is important to provide a gradual evaporation of the solvent with no bubbling onto fixing substance surface because the bubbling can lead to destruction of aggregates. Such undesirable phenomena may be avoided by selecting the optimal resin/solvent ratio and maintaining the saturation temperature up to 110 °C. After evaporation of the solvent, it is required to drain the resin carefully and a prepare a new mixture. The aggregates should not remain on the bottom but onto the walls of paper cup.

8. It should be noted that aggregate samples reach saturation in small volumes of fixing substance, so the solvent evaporates much faster than during preparation the larger sections. The degree of readiness is determined by the fixing mixture behavior (the resin cooled should be crushed when squeezing with fingers). Soil separates larger than 1 mm should be saturated up to 5 times, units smaller than 1 mm require only three saturation procedures.

9. After complete saturation, paper cups with a mass of aggregates in them turn into monoliths ready to process in the same way as large soil samples. Remove part of gypsum bottom and cut off the upper part of paper cup not filled with aggregates before abrading process.

As a result of all operations, significant number of structural soil aggregates with same sizes can be found in the plane of the section (Fig. 2, b, c).

**Fig. 2.** Paper cup with gypsum bottom used for saturation of structural soil aggregates with fixing substance (a), the lower dark part corresponds to the level of the cup filling after saturation. Thin sections (b) and microphotograph of the aggregates of the fractions 1–0.25 mm and 2–1 mm (c).
Conclusion

The technique proposed allows preparing thin sections on every sizes of structural soil aggregates and, in contrast to known techniques with a use of glass tubes (e.g., Vadyunina, Korchagina, 1986), it provides not only immobilization of separates in the mass of fixing material, but also pore space saturation with resin.

It is also possible to prepare the sections with marking of large aggregates orientation in space; it requires application of gypsum marks on the aggregate surface in the process of their sampling from the soil profile.

References


