Shape and structure of cracks in the dry-steppe zone of Northern Kazakhstan

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Abstract. This paper describes a new approach to the interpretation of the concepts of “tongue”, “pocket” and “clink”. These soil features at the same depth characterize the soil differently. The author defines a more detailed connection with the concepts of “tongue” and “crack”. The connection between “tongue” and “pocket” is also shown. This description of the soil details makes it possible to understand the shape and structure of cracks. On this basis, a new approach to describe the soil profile of chestnut soils is made. In other words, the output of these soil features data to the front wall of the section should be taken into account. The author shows that the shape of cracks is laid down from the soil surface. The width of the crack from the soil surface can continue deep into the soil. In this case, the thickness of this crack should also be highlighted. To explain the shape of the crack, its boundaries are outlined, which may be located on the front wall of the soil section. These boundaries are always parallel to the “clinks”. When the crack is opened from the surface, the center of the crack is explained in relation to its thickness.

1. Introduction
Morphological structure of soils in the steppe zone of Kazakhstan differs from the soils in the steppe zone of the European territory and steppe soils of the foothills of South and South-East of Kazakhstan due to climate [1–4]. But there is still no systematization of morphological features that reflect the structure of soils in the dry-steppe zone of Kazakhstan. These particular features of the soil profile and related concepts of soil and ecological processes in the environment have been poorly studied.

The available data on the study of cracks in the soils of the steppe zone of Kazakhstan by different researchers using generally accepted methods leave some ambiguities in the soil structure. The lack of a detailed description of all soil features diminishes their role in determining the soil functioning. To describe genetic horizons and their perception, attention should be paid to the shape and structure of soil cracks. This fact is fundamental, because it is necessary to characterize the elements of soil cracks comparing to what was accepted in the profile method.

The necessity to study the structure of cracks in the soils of the steppe zone is caused by both their different interpretation and more accurate identification of their functional features in the soil profile. When describing the soils of this region, in addition to the concepts of “tongue” and “pocket”, the concepts of “crack” and “pouch” [1–3, 5–7] are used, which reveal the object as complex to highlight the boundaries of soil horizons. Therefore, due to the existing features of the dry-steppe zone soils, it is difficult to bring them to standard descriptions when outlining their main morphological features. This concerns the depth of the soil and its separate horizons; coloring, structure, folding and other parameters.
that make up the structure of the soil profile. Because of the complicated color scale, different density and moisture and other indicators within the soil horizon, these descriptions are difficult to perceive.

Studies of soil cracks require careful analysis due to its special functions in the soil. It is also important to study soil cracks to identify approaches to systematize the cracks themselves and evaluate their functions.

In [5] the work “Humus in cryogenic cracks of permafrost meadow-black soils of Western Transbaikalia” it is written about the comparative analysis of the humus composition from the soil mass of cryogenic cracks (pockets) and the humus-accumulative horizon of permafrost meadow-black soils. The authors [6] give comparisons: the humic acids ratio H:C in the pockets is 0.74, and from the horizon this ratio H:C is 0.92.

In the work [8], the most purposeful approach was made to the size of cracks, the formation of a mosaic structure of pedons separated from each other by cracks on virgin chestnut carbonate–saline heavy loamy soil. In work [9], the author writes that the strongly humused particles of the upper horizons get into the cracks formed in this way, giving intensive humus–colored “tongues” during washing.

K.P. Gorshenin in [10] shows the relation of climate with cracks and the formation of horizon “B”. R.Dzhanpeisov [11], characterizing the structure of carbonate low humus black soil, gives the dimensions of the crack with a width of 0.5–1.0, and sometimes 2.0–3.0 cm, and that they reach the horizon B2. Here is what N.V. Orlovsky [2] writes: “For a long time we have known Kazakhstan’s cracks, which are called pocket black soils according to our systematic list in Middle Siberia. Their genesis is associated with frosty cracking of the soil, often to a great depth (50–80 cm), with subsequent filling these cracks with material from the upper humus horizon in spring, when soil is thawing”.

While studying the functioning of the soils of the steppe zone of Kazakhstan, the number of works [1–4, 8–9] was considered, after which the concepts of cracking with the tongue shape and pockets, as well as the concepts of “crack” and “pouch” as a whole, were connected. The features of the structure of chestnut soil of the steppe zone of Kazakhstan were reflected in the [12] work: the location of the cracks in the soil section was given: “On the front wall of the cut, which length is 120 cm long, there are 6 long and 3 short fractures. The distance between the long fractures 27, 6, 10, 13, 20 cm on the front wall of the cut below the treated soil layer was measured”.

The purpose of the work is to explain the concepts of “tongue”, “pocket”, “pouch” from the point of view of the concept of “crack” as a part of the soil, the mutual location of parts of which affects the description of the soil section.

Objectives include the following:
- showing the shape of the crack from the soil surface and at depth;
- explaining the width and thickness of the crack;
- showing the structure of the soil cracks in photos.

2. Research methods
Expeditionary methods of soil study and route field studies of the ecological direction were used. The observation method is the collection of information on the development, distribution and disclosure of surface cracks in soils. Comparison of available data on cross-sections from chestnut and dark chestnut soils of Northern Kazakhstan, as well as literature data of other authors was made. Visual description of soils by the profile method from the surface to the full depth of its thickness by genetic horizons, cracks, intercrack spaces and zones of contact with them, as well as comparison of the obtained features of the soil profile were carried out.

Expeditionary surveys in the territories of chestnut soils can determine the cracking of the soil throughout the subzone. The reasons why the distance between cracks in the front wall of the section is different were determined, where it was studied how short and long cracks in the soil profile are propagated perpendicular to the front wall of the section.

The problem of determining the regular relationship of functions between the soil mass divided by cracks and the cracks themselves requires a more detailed study. The complexity of revealing the functioning of the soil mass and soil cracks is connected with the volume form of cracks in different
sites and depths of the soil that also affects the complexity of describing the structure of the soil connected with it. Based on the interrelation between the concepts “tongue”, “pocket” and “clink”, the form and structure of genetic cracks are formed. The humus “tongue”, which goes deep into the “pocket” and humus pocket”, is the reason to be called as a closed crack. Actually, in the summer and early–autumn period, a crack is formed in the center of the “tongue”, which in arid and acutely arid years penetrates deep into the soil and lands. It gradually opens on the surface of the soil in the form of a “crack”. Such a crack is most actively functioning, both in the horizontal and vertical direction. To assess these effects, it is necessary to know the form of the crack: open or closed. In the dry-steppe zone, the morphological and micromorphological structure of the soil profile should also have a close connection with the processes created by the presence of cracks.

3. Result and discussion

In the chestnut subzone on alkaline soils, at the moment of studying the structure of soil details, 2 different crack directions were determined. The detection of some cracks in the soil section showed that they were perpendicular, while others came out at an angle to the front wall of the section. The cracks formed a certain configuration, braiding the sections with the soil mass. On the soil surface, at the intersection of cracks, their width increased to 2–3 cm or more. Intersecting surface cracks form a shape, which can be conventionally called a “knot”. These “knots” always have the biggest width of cracks. Where the cracks did not intersect, they were already there. In the upper part, the cracks reached a width of 1 cm, and at a depth of 65 cm, they reduced to 2 mm. Here, the concept of width should be taken as the thickness of the crack, which is visible from the soil surface and from the end on the vertical wall of the cut. On the divided part of thickness, the crack is denoted by the width. The distance of the crack part from the “knot” to the “knot” on the soil surface is determined as the length of the crack. In the soil, this flat part is represented by the width. In different years and in different summer periods on chestnut carbonate soils under wheat crops, the width of the top part of the crack ranged from 0.8 cm minimum to 3.5 cm maximum. The open cracks penetrated deeper than 70 cm.

For example, on Figure 1 it is possible to see how the shape and structure of cracks in the section “Dievka” look like, which were formed on heavy loamy dark chestnut soil. The survey of fields with crops as of 05.08.2016 showed that this year by this date cracks began to appear. In 2015, due to a drier summer, cracks in the cultivated areas appeared a month earlier. In the field with wheat, which is next to the fallow, there are cracks on the soil surface (figure 1). Wheat is in the phase of milky ripeness. This wheat field has a considerable number of open cracks, which stretch in different directions. Cracks often stretch along the sowing row or across the rows, intersecting with each other. The long part of the cracks is approximately 2 cm wide, and in some places, they reach a width of 5 cm (figure 1). The width of the crack on the soil surface depends on the aridity and moisture of the soil. Therefore, it is important to specify the time of measurements to determine the width of the crack opening.

Earlier, on June 18, 2016, a soil section was laid at the field No.67 of the Dievskoye agricultural firm. The section was located 20 km south of the village “Dievskoe”. Geographic coordinates of the section: latitude N 51° 48' 81"; longitude E 63° 40' 109". The section was dug in a fallow filed. In any section, a clear pattern of pockets even at a depth of 50–65 cm was observed. On the front wall in the lower part of the section, pockets with a thickness of 2 mm then went by a continuous width horizontally deep into the soil.

These pockets were clearly distinguished by a dark color from the rest of the soil mass. Defining the structure of such cracks should be associated with the structure of pockets, which are an extension of the “tongues”.

In this case, the “pocket” was the organomineral part of the soil located in the lower part of the soil between the soil masses. For example, one soil fragment, where cracks of different thicknesses were visible, was taken. Figure 2 shows a vertical projection of the subsurface area of dark-chestnut soil. On this plane of the soil, the interlacing of dark stripes on a light brown background is visible. Dark stripes have different length and thickness. This is clearly seen on the entire width of 65 cm of the soil plane. Such a mosaic, parallel to the plane, can be traced with depth (figure 2).
Here the term “crack” is not acceptable, as it is a solid mass of soil. That is why humus “pockets” are mentioned, which differ in color from “clinks”. If there are clearly visible cracks on the surface of virgin soils, the space between them is called the inter-crack space. At depth, the pockets differ in thickness (figure 2).

A piece of soil with a pocket placed in it was dug out to get a better idea of the shape and structure of this pocket. In the course of further study, this perpendicularly located pocket turned out to be a dense humus part, which was sharply different from the main soil mass. The humus pocket was a few millimeters thick. The thickness of the humus pocket decreased with depth. The shape of a small part of the pocket going through the crack can be seen in the photo (figures 3 and 4), where a wide part of the pocket is shown by removing the soil parallel to the humus part. I.e., this is the shape of a thin layer of humus pocket at such a depth. That is why in the photo of the soil with a ring of black-brown color, the yellow spot in the center was gently removed and the ring has become a solid piece of black-brown color. This elongation was explained in the same way in the next section of vil. Karamendy. The following example of the shape and structure of cracks is well reflected in the medium loamy dark chestnut alkaline soil.

On 21.06.2016, a section on the territory of “Naurzum State Nature Reserve” was laid. Coordinates: Latitude N 51° 39’ 119”, longitude E 64° 12' 245", Naurzumsky area, Karamendy village. The cut was laid to the east of vil. Karamendy, at a distance of 300 m from the meteorological station and from the poles at a distance of 200–220 m, westwards of the high-voltage line.

A very important definition was made for “Dievka”, on “Karamenday” section. To better understand the shape and content of the cracked pockets, a sample taken from 100–120 cm layer is demonstrated.
Such depth is needed to emphasize the vertical location of the studied soil detail. In this layer of soil–ground, there is a flat 2 mm thick dark gray pocket with a reddish shade of color with a significant number of small root hairs. This 2 mm thick humused pocket is a continuation of the wide part of the pocket. The photo shows this pocket, which is partially open on one side and partially closed by the contact area. White root hairs are clearly visible in the flow-like pocket. The photo itself (figure 5) shows the part of flow-like pocket 2 mm thick as the first step of the demonstration.

On each side of the pocket there is a white strong carbonate layer with a thickness of 7 mm. The carbonate layer is dense, flat, up to 2–2.5 cm thick, running in the soil only parallel to the humus pocket. Therefore, after the first step of demonstration of the structure of the pocket flat part, the second step demonstrating how to increase the plane in the photo is shown. For this purpose, another part of the carbonate crust which is not very tightly attached to the humus pocket was removed (figure 6).
Gradual cleaning of the pocket from the contact carbonate crust shows both its flat state and physical composition (figure 6). Part of the flow-like pocket after removing the contact zone shows not only the presence of root hairs of plants, but also the organic mass. This organic mass differs both from the humus of the upper horizons and from plant remains. The mineralization of plant residues at such a big depth, as well as the impact of all climatic conditions and the soil functioning, leads to such transformations of organic matter.

Genetic cracks in the lower parts of the soil and land are flow-like pockets. On the photo, on the front and side walls different pocket shapes, which continue along the bottom of the cut at a depth of 102 cm, are visible. In the right part of the photo, the passage of a wider pocket, which is a flow-like pocket (figure 7), can be seen. That is, this is the place where the flow-like pocket part is located parallel to the front wall and is slightly free from the contact zone. The photo shows the thickness of the pocketing, which becomes thinner with depth. However, the thick part of the crack section, which is located on the right side of the photo, is not the thickness of the crack, but its wide part. That is, a wide part of the crack opened when cleaning the front wall of the cut. At a depth of 90–110 cm, there are thin pocketed cracks. The crack thickness is 1 mm. Such a thin crack is symmetrically divided into two parts. On each symmetrically divided part, the fine crystal gypsum is abundantly stands out (figure 7).
symmetrically divided part, fine crystal gypsum is abundantly distinguished. To characterize the cracks in these soils, it is important to know that the cracks intersect at different angles, that is, they are connected to each other throughout the subzone. Thus, the thickness of cracks, pockets and their location on the studied part of the soil should be carefully described. This makes it possible to correctly evaluate their location, shape and structure in the soil.

4. Conclusion
The studied soils of the dry-steppe zone allow making corrections when assessing some soil indicators. The above photos make it possible to see the size of the cracks and their location both from the soil surface and at depth. This is evidence of a more active horizontal and vertical functioning of cracks as compared to the inter-crack space.

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