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Highlights on the phenomena of Sbeia ground collapse, preliminary diagnosis from field observations

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ABSTRACT

Ground cracks and collapse occurred recently in Awlad Abu Aisha area, municipality of Sbeia, is a serious event as it is unexpectedly caused abnormally extensive damage to the ground. In general, ground cracking is regarded as a natural phenomenon that are usually derived by seasonal temperature fluctuations acted on recent sediments dominated by mud; muddy soil. Such soil owns property preferable for shrinkage cracks to occur. The affected site is a low-populated agricultural region with no heavy building nor industrial activities. While the habitually known ground cracks are small and not dangerous, these ones, called Sbeia cracks, appear to have been unusually rapidly enlarged. They become a source of wariness to the local inhabitants who considered these cracks as a mysterious phenomenon. Apart from the public opinions about the secret behind these cracks, there is no any published research devoted to their origin. This is prompted us to visit/revisit the site of ground damage intending to investigate all aspects and appearances related to the Sbeia cracks. Consequently, the visible field features related to this phenomenon are then analysed in relation to the ambient geological and climatic circumstances. Observations are then discussed in the light of elsewhere documented researches. Although our study lies exclusively on visual observations, it comes up with reasonable explanation concerning the causes behind this ground damage. The study concluded that this feature is emerged as a result of the interaction of the properties of the soil with the local geo-climatic conditions.

Keywords: soil cracks, ground collapse, Awlad Abu Aisha, Sbeia, Libya.

تسليط الضوء على ظاهرة الانهيارات الأرضية بمنطقة السبيعة، والتشخيص الأولي لها من خلال المعلومات الميدانية

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ملخـــــــص البحـــــــث

يُعدّ ظهور تشققات وانهيارات أرضية مؤخرًا في منطقة أولاد أبو عائشة، التابعة لبلدية السبيعة، حدثًا خطيرًا نظرًا لتسببه بشكل غير متوقع في أضرار جسيمة وغير طبيعية للتربة. عمومًا، تُعتبر تشققات الأرض ظاهرة طبيعية ناتجة عادةً عن تقلبات درجات الحرارة الموسمية التي تؤثر على الرواسب الحديثة الغنية بالطين؛ أي التربة الطينية. تتميز هذه التربة بخصائص تُسهّل ظهور تشققات الانكماش. وتعتبر المنطقة المتضررة منطقة زراعية قليلة السكان، لا تضم مباني ضخمة

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ولا تشهد أنشطة صناعية. وفي حين أن التشققات الأرضية المعروفة عادةً ما تكون صغيرة وغير خطيرة، إلا أن هذه التشققات، التي تُسمى تشققات السبيعة، تبدو وكأنها قد اتسعت بسرعة غير عادية. فأصبحت هذه التشققات مصدر قلق للسكان المحليين الذين يعتبرونها ظاهرة غامضة. وبغض النظر عن الآراء العامة حول سرّ هذه التشققات، لا توجد أي دراسات منشورة تُعنى بمعرفة أصلها. هذا ما دفعنا لزيارة/إعادة زيارة الموقع المتضرر بهدف دراسة جميع جوانب ومظاهر تشققات السبيعة. ومن ثم تحليل الخصائص الحقلية المنظورة المرتبطة بهذه الظاهرة في ضوء الظروف الجيولوجية والمناخية المحيطة. بعد ذلك نوقشت المشاهدات في ضوء الأبحاث الموثقة المتاحة. وعلى الرغم من أن دراستنا تعتمد حصراً على الملاحظات والمشاهدات النظرية، إلا أنها قدمت تفسيراً منطقياً لأسباب هذا التضرر الأرضي. وخلصت الدراسة إلى أن هذه الظاهرة هي ناتجة عن تفاعل خصائص التربة المحلية مع الظروف الجيولوجية والمناخية السائدة.

الكلمات المفتاحية: تشققات التربة، انهيار الأرض، أولاد أبو عائشة، السبيعة، ليبيا.

1. Introduction

The Sbeia ground cracking and subsidence is come to dramatically appear in March 2024. It takes place in a farm located (N32° 22’ 40”; E13° 00’ 36”) in Awlad Abu Aish area, southern side of Jefarah plain NW Libya (Fig. 1). The dangerous damage is restricted to an area of ~0.5 square Km, exhibited as large cracks and land collapse that affected a dense mud-dominated soil. Worth mentioning that this location is known as one of wormiest region in Libya, with summer Av is 37°c, temperature of 45°c are not exception. According to the farm’s owner, their land is historically called ‘*Ard Ashgag*’ of which the English translation is the land of cracks. The phenomenon coincided temporally with other environmental events in Zliten city western Libya, which increased public concern. The latter comes in the form of polluted groundwater that has flooded the surface and caused unwanted damage to the city's infrastructure. Although there is likely no link between the two problems, the appearance of one shortly after the other caused panic enter the inhabitants. Despite this, there is still no any published reports on these serious cracks, our attempt would be the first.

In fact, although the usually known mud cracks are centimetre-sized, a literature review shows that large ground cracks similar to those in Sabia are also common worldwide. In broad since, ground cracks are referred to by various terms (desiccation cracks, mud cracks, drought cracks [1,2,3] and dehydration cracks (Morris et al, 1992; Weinberger, 1999) [4,5]. Remarkable, among the mentioned researches and many others, two aspects are in agreement; (i) the cracks are mainly restricted to fine grained clay-rich soils, and (ii) the dehydration (inter- and intra-particle water losses) is the deriving process for the formation of cracks, of which elevated temperatures is the essential factor [6,7]. This means that for the soil cracks to occur, they require temperature high enough to cause evaporation and a clay-rich (sediments) soil. Actually, the very well-known form of ground cracks occur on such fine sediments are called mud cracks. These cracks are typically known by their polygonal horizontal pattern and V-shaped vertical view. Their width usual ranges from less than one to several centimetres, and are preferably occurring during the summer seasons [8,9]

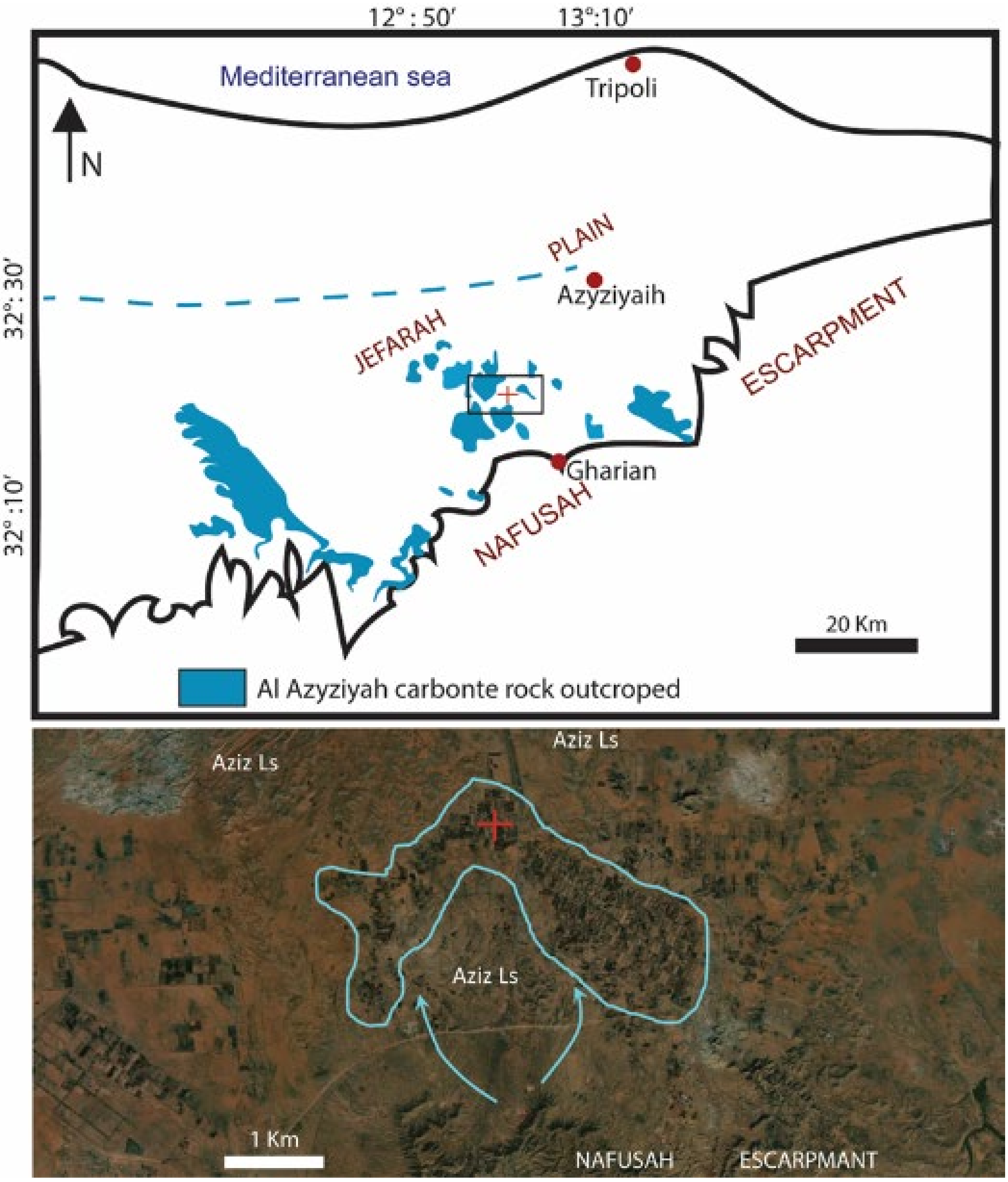

Figure 1. Location of the study area, shows: A) Plane map presents the position of the damaged ground (the rectangle) in Jefara plain. Remarkably, the site is located in an area where Al Azyziah carbonate rocks are exposed; B) Satellite view confirm shows the location relative to Nafusah escarpment

During hot seasons the water evaporated from clayey soil causes reduction of soil's bulk volume, and this leads to soil shrinkage and cracking [10,11]. Anyway, there are cases where cracked soil may swell and get back its original shape, this happens when wet seasons follows dry ones (rehydration; e.g., [10]). Unlike the small single season mud cracks, the Sbeia cracks exhibit cracks much larger in sizes besides the small ones. This admits that other factors must control the enlargement of the initially small cracks. It means that, as soon as the soil fractures are initiated, there must be other factors (besides temperature fluctuation) determine the cracks size and morphology [12,13,14,15]. According to Sridharan and Allam 1982 [10]; Tang et al., 2010 [7] the most important internal factors are, the soil heterogeneity which is mainly controlled by its clay content, the soil thickness and the grown crops. The external factors are always the climatic conditions (duration of the wetting-drying cycles), groundwater table, tectonic activities [16] in addition to the bed rock characteristics beneath the soil.

Given the interplay of multiple factors governing soil cracking and collapsing, their combined effects can lead to further complexity in soil behavior as well as unpredictable damage. Our study of Sbeia cracks therefore aims to analyze the reasons behind their enlargement and to investigate why they selected this location to occur. Indeed, this study is based solely on the in-situ description of the cracks and the affected soil and correlate this with similar published cases. Accordingly, the study concluded that for such cracks to appear they require the combination of two substantial elements. One linked to the type of soil and the other to the ambient geoclimatic conditions.

2. Method of study

This study is based uniquely on field investigation of the collapsed ground at Awlad Abu Shaybah area. The site has been visited twice. One in February, the other in June 2025, this allows to describe the morphology of cracks and measure their size and notice if there are seasonal changes. Photos and videos distributed by others were also useful. Moreover, in order to find out the influence of the ambient conditions a reconnaissance of the region around the site has been carried out. This was in order to recognize the types of the soil's parent rocks (around and beneath the soil) and their geological characteristics. Since the carbonate rocks of the Al Aziziyah Formation are the only exposed hard rocks around the affected area, special focus is therefore paid to the apparent properties of these rocks. Particularly fracturs nature (open or filled) and intensity. A lot of field photographs were taken to document these aspects, of which most representative ones are used here to provide illustrative evidence for the purposes of this research. Off course, all videos and photos defused by public or governmental sectors have been evaluated, the latest one was a video dated 25. Oct. 2025.

3. Geological and environmental context

The area of the collapsed soil is part of the southern side of the Jefara plain, located, 65 km south of the Mediterranean coast and several Kms north of Nafusa Escarpment (Fig. 1). Climate here is evidently hot and dry in summer and cool and humid in winter, it is accentuated in the area of the study as it is further south from the coast. Correspondingly, the location is much less habituated and people are typical live in scattered farms. The farms are found in clusters, located in areas of relatively low topography (Fig.1B), surrounded by hill built up by Al Aziziyah limestone Formation.

The farms proprietors confirm that their land is flooded during seasons of high precipitation. Recent muddy veneer left by floods can still be observed in low areas. In the adjacent higher areas' erosion groves also witnessing for recent floods. These grooves are subdued and dies down towards lower places. In overall, this area is located in the part of Jefara plain where the elevation contours ranges between 150 and 200 masl. In large scale, this area is structurally within the Al Aziziyah fault line, which is few tens of Km North of Jabal Nafusa escarpment. Google earth map and ground check indicate that the farms with land collapse are lying in the low (pedogenized) troughs relative to the surrounding rocky hills of Al Aziziyah limestone (Fig. 2A). No continuation of the soil cracks seen in the adjacent rocks. Worth to mention here that a subtle subcircular rings can be noted in the soil surrounding a collapsed spot (Fig. 2B) and that none of this is seen in the adjacent rocks. Anyway, both the geological map (IRC) and visual inspection confirm that the rocks of the adjacent hills are belonging to Al Aziziyah Formation, and the age of which are of the upper Triassic [17,18]. Inspection of fresh-cut exposed in the neighbourhoods show that these rocks are made up of hard carbonate strata of which fracturing and faulting are essential characteristics (Fig. 2C and D), open, partially open and closed fractures are all common.

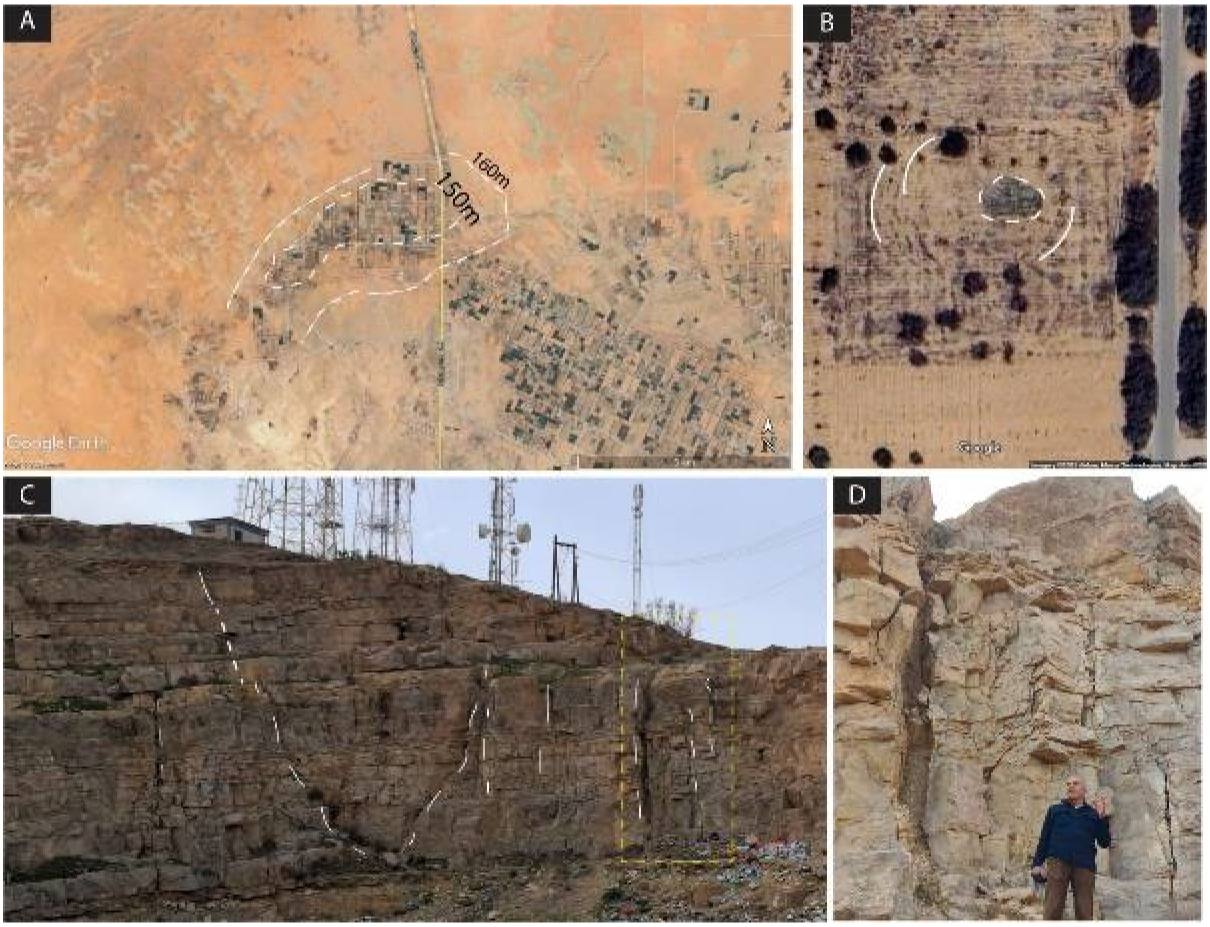

Figure 2. The geological circumstances: A) Google image shows the relatively low position of the cracked land compared to the surrounding rocks; dashed lines represent the contours; B) Google image shows presence of subtle subcircular rings around the subsided ground (dashed line); C) photograph of AL Aziziyah limestone exposed at Aziziyah city; illustrate that these rocks are highly fractured; D) close view from (C) shows that the majority of the fractures are open or partly open.

4. Description

4.1 The cracks

The cracks/collapse morphofeatures and the properties of the cracked soil are the two directly visible components that define this phenomenon. The cracks are of variable size, morphology and are of semicircular trends (Fig. 3). Their sizes are as large as several tens of decametres and as small as few centimeters (Fig. 3A) in length. In width they range from few millimetres to a few meters. Their depths are up to 2m in average, the depth proportionally increases with the length. Exceptionally, the depth measures more than 5m or more at the collapsed (trench-like) hole (Fig. 3C and 4A, B) . The overall appearance of the centimetre-sized cracks is polygonal

(Fig. 3A), radiating and random networks also seen. These small cracks are commonly occurred in-between, around, and connected to the large ones.

Figure 3. The cracks morphology and size: A) the commonest pattern taken by the small cracks (usually at a distance from large cracks (camera for scale); B) elongated cracks usually attached to larger crack; C) large; several tens of meters semicircular cracks (dashed line) centered around the deepest collapse. Subtle inclination of the ground can be noted from the crack toward the collapsed spot (dashed circle).

Contrastingly, the large cracks are generally subcircular at its long axis and V or U shaped in vertical view. It is obvious, in plain view, that these subcircular cracks are centered curvilinearly around the deep collapse (Fig. 3C and 4C). What should not be ignored here is the presence of a slight downward slope towards the deep (trench) collapse. Worth mentioning also that the larger cracks are exhibiting recent marks of water pathways at their bottom, these are presented as small ditches and channels (Fig.4A). A local widening of the cracks is also observed on their sides, indicating water erosion. In this regard, farmers have noted that rainwater seeps into the cracks and, unusually, infiltrates rapidly into the subsoil. Regarding the deep collapse (> 5m; Fig. 4A and B), this collapse appears as irregularly circular trench goes rapidly from 0 to >5 m and it measures about 15 m average diameter. The curved semi-circular cracks encircling this collapsed area is nearly 90m long, having a width of up to 2m (Fig. 3C).

Viewing the site on Google earth shows that the large semicircular cracks are in agreement with the semicircular rings seen from the sky (compare Fig. 2B). Anyway, the trench provides a representative and fresh soil profile. Notably, late defused videos (27/10/2025) shows that ground damage in the studied site seem to be slightly enlarged following a rainy event.

4.2 The Soil

Very clear and representative soil section is exposed by the trench (Fig. 4). Visible physical differences in this section suggests its subnivium into three superimposed intervals.: Two thick intervals of fine-grained cohesive soil separated (intermittently) by relatively too thin and too hard caliche bed. The three intervals of the soil section are described hereunder in descending order:

(i) The surface soil, is 1.5 to 2m thick extends from the ground surface to the top of the caliche (Fig. 4D and E), or to the top of lower soil when the caliche is absent (Fig. 5B). The grain size of this soil ranges from fine sand to clay, the clay fraction is estimated at 30%. Its color is light brown. This interval locks homogeneous and is weakly indurated (standing cross section), weak plasticity (could be crumbled by hand). Columnar structure is obvious characteristic of this soil with vertical joints delineating adjacent columns, the joints are millimetric in width (Fig. 4D). Recent roots exist in this layer; roots are denser and deeply penetrating close to (olive) trees. finally, the surface soil interval ends down at interval **(ii),** the caliche bed. This bed is 0.1 to 0.3m thickness, clearly distinguished by its contrastable hardness and white color (Figs. 4E, 5A). Strictly speaking, this hard caliche is discontinuous and is broken at the collapsed zone. What is especially interesting, is the presence of wide cavity below this hard caliche. The caliche in this case appears like a bridge anchored by the lower soil interval (Figs. 4E, 5A,).

Figure 4. Characters of the large cracks and collapses: A) subsided soil with >5m trench-like hole (white arrows); the blue arrow tracks the pathway towards the sunk ground; B) closer view of the sunk ground; C) subcircular crack (dashed line) centered around subsided ground, a repeated feature; D) cross-section from the upper part of the trench shows the surface soil interval. The columnar structure here witnesses for clayey soil type, the arrows points to the (open) joints that limits the soil columns; E) shows the middle soil interval represented by the white and hard caliche horizon. An empty cave is obvious below the caliche which acts as a bridge supported by the subsoil.

(iii) the lower interval is at least 3m thick (Fig. 5). Unlike the surface soil, this one is clay-dominated. It appears in the form of stratified and compacted layers of hardened mud containing small intercalations of very fine sand. (Fig. 5C). The sand is also as small irregular buckets within the mud. Gray and greenish gray is the dominating color of this interval, light brown for the sandy layers and buckets. Remarkably, this soil is fractured. Joints are 1-2 mm wide, irregularly oriented and are several cm in length. Exposed fracture faces are wedge- and bowl-shaped; a character that is certainly belongs to clayey soil [19]) for further explanation). Streaks of descending water are clearly visible on the faces of some fractures.

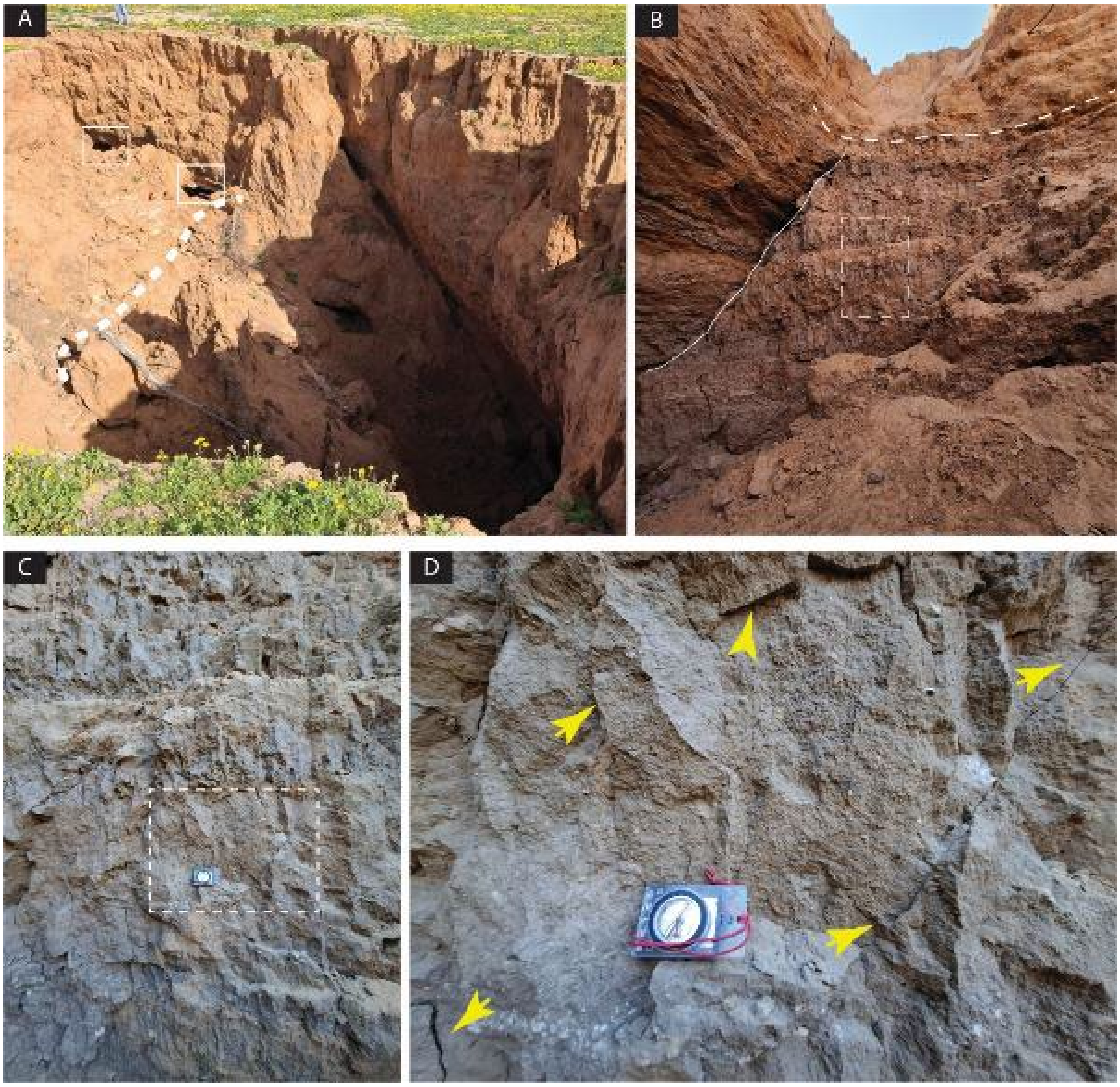

Figure 5. Visible characteristics of the exposed soil section: A) the trench made by the collapsed soil, it shows the position of the caliche (marked by the dashed line) and the erosion cavity below the caliche (the rectangles); B) representative view of the soil section, the dashed line separates the upper soil from the subsoil, the inclined line traces a large fracture in subsoil, the dashed rectangle is a view in the subsoil magnified in C) which shows the heterogeneity within the subsoil, represented by the presences of sandy patches/layers within the clay-dominated grey soil; D) close view from (the rectangle in C) shows that the subsoil is intensely fractures, the arrows points to open fractures and fracture faces

5. The results

The results of field investigation can be summarized into three categories: The types of the affected soil, the characteristics of the cracks and the ambient geological and climatic controls. The affected soils are three superposed layers; 1-The fine-grained surface soil with estimated clay content up to 30%, 2- The intermediate discontinuous, exclusively hard, caliche layer, 3- the lower, clay-dominated soil. Literature comparison (e.g., [8,19]) of the properties of these soil intervals locate them in "vertisols" group of soil. This soil possesses the properties of fine-grained clayey soil type and, particularly, wide range of cracking behavior [8]. Considerably, the upper soil is much less in the clay content than the lower soil intervals. The remarkably harder caliche (calcium carbonate) layer separates the two soils are relatively very thin, and locally missing making the upper and the lower soils in direct contact. Anyway, caliche is known to precipitate chemically (diagenetic) under semi-arid climate. As for the cracks, and regardless of their varying size, their shape is typically curved. and they are generally centered around the greatest ground collapse as in Figure 3C. Regarding ambient geological conditions, our (recent) soil is deposited directly above the very hard and fractured carbonate rocks of Al Aziziyah Formation which is dated upper Triassic age. These rocks are undoubtedly faulted and jointed.

6. The discussion

literature review of numerous cases of soil cracks and collapses confirms clearly that the occurrence of such phenomena is underpinned by two essential factors: (i) Internal factor, related to the soil properties and (ii) External, tied to the ambient environmental conditions (e.g., [6,20]). Accordingly, it can be stated the formation of soil cracks (and their development through time) is a result of interactions between inner and external conditions. Likewise, in the case of Sbeia ground collapse, the clayey fine-grained soil is the medium that has exposed to the ambient external conditions to be cracked. That is to say, the soil of Sbeia possess the prerequisite for cracks to occur in the presence of dry climatic conditions. Cracks in clayey soil explains and are explained by the arid climate in the region where they occur [19,21].

Thus, for the Sbeia fissures, the dry climate constitutes an external factor that are evidently prevailing in the region. Average annual temperatures in this area exceeds 30°c and in summer seasons 40°c is normal. Such temperature is recognised to causes clay to be dehydrated, reduced in volume (shrink) and ultimately cracks [8,5]. At early stages of this process cracks initiated (small) at the surface, or in a point below the surface [22]., they then spread upward and became visible at the surface [23]. This process occurs repeatedly in a seasonal basis; cracks then progressively grow and take their actual size and pattern, bearing in mind that irregular evaporation rates result in irregularity of shrinkage and cracking of the soil [24,25]. The more durable the dryness, the more penetration of the cracks into the interior of the soil. In addition to the dryness, the cracks variability in size and shape is certainly influenced by the soil properties (e.g., [26,10]), particularly soil heterogeneity. Heterogeneity in Sbeia soil is evident, and is given by the visible differences between the three horizons of the studied profile. Inhomogeneity is also proposed by variations among each single soil interval.

The role of heterogeneity in the behaviour of dryness cracks in clay-dominated soil is well illustrated in [2]. and references therein). Accordingly, in the case of Sbeia it can be confirmed that the interaction between soil heterogeneity and the prolonged episodes of dryness, together deemed responsible for the growth pattern of the initial cracks. In this regard, [16] stated that soil cracks, characterized by larger diameter and longer length are more regular in shape as well as orientation than small cracks (more information in [27,28]. This explains why the larger cracks in Sbeia are better aligned than the smaller ones (compare Figures 3A and B). Being visible or not at their initial stage, the small cracks are subtly propagating down into the subsoil. As a consequence, subsoil erosion is unavoidable over the courses of rainfall seasons. Admitting the low original permeability of the clayey (compacted) soil renders the cracks to be the favoured passage of water down into the ground [29,30]. This ends with the disintegration of the soil below the surface. Anyway, this is the only reasonable explanation for the presence of the subsoil caves below the caliche horizon (Figs. 4E, 5A). Other proof of subsoil disintegration/erosion is given by the presence of tracks of downward water flow.

Progressively, repeated periods of erosion caused the subsoil caves to discreetly enlarge to a point where the undersoil becomes unable to support the weight of the surface soil. Collapse occurs at this moment and looks like if it is a sudden mysterious event. To rend this explanation reasonable, one needs to answering the inquiry of where have gone the eroded soil? in fact, the absence of surface erosion, suggests that the whole eroded soil material is sent into the subsurface! Ultimately, it is the fractured carbonate rocks of the Al Aziziyah Formation (for instance figure 2C and D) that are found immediately below the Sbeia soil. Being fractured and very thick, these rocks, likely able to accommodate all the removed soils. The open fractures in Al Aziziyah rocks are acted as a downward passage of the eroded material to the earth interior. The abundance of fractures in Al Aziziyah Formation is not only essential cause of the ground collapse but would also be responsible for future ground damage in the area and similar areas providing existence of the same geo-climatic conditions. Coming to the interpretation of 'curvilinear' shape of the large cracks, figure 3C, hypothetically, this curvilinear could be attributed to the possibility that the smaller cracks are progressively coalesced under the influence of the large collapse. This hypothesis is suggested by the down-inclination of the subsided land from the cracks toward the deepest collapse, similar cases are provided by [2]. To end, invisible karstic properties of the carbonate bedrocks should be considered for detailed investigation.

7. Conclusions

This study of the Sbeia ground cracks is based only on field observations, it came up with following:

1- the ground damage in the area existed in the form of both cracks of different size and morphology as well as metric size subsidence and collapse. Few years ago, large cracks and land subsidence were not yet appeared. Meanwhile, millimetric cracks have been witnessed generations ago. The collapsed land is called "the land of the cracks" long time ago.

The elements necessary for the appearance of this phenomenon are evident in this part of the Jefara plain. External factors are mainly related to the semi-arid climate, while internal factors are related to the shrinkage properties of clay soil as well as the nature of the parent rocks underlying this soil.

2- taking (1) into consideration, it could be presumed that cracks were existed longtime ago, both in the surface soil where they are visible and also in the subsoil where they were not visible.

3- admitting the very low permeability of the clayey soil, then, these cracks should have acted as the unique passage for rain water into the subsoil. Overtime, erosion of the subsoil created hollows especially below the hard caliche bed.

4- Finally, the moment came when, in some places, the subsoil no longer supports the load and consequently collapsed.

5- the fractured carbonate rocks of Al Aziziyah formation subjacent to the soil is/was worked as the storage of the soil material sent/to be send by the water.

6- Durable dehydration of the whole mass of the clayey soil (as is located in-between the hard rocks) causes volumetric shrinkage of the entire thickness of this soil relative to the stable hard carbonate rocks around this soil (differential compaction mechanism; [31]).
7- The problem would not disappear in presence of the same conditions. Fortunately, these soil properties are not widespread in the region, thus, this soil damage remains localized and can be anticipated through further studies of the surrounding soils.
8- Based on the findings of this study, further investigations are recommended, including geophysical surveys and soil laboratory testing, to better understand subsurface conditions. In addition, continuous monitoring of the affected area is important to assess the development of cracks over time. Such efforts would help improve the interpretation of the phenomenon and support future practical solutions.

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