Reviewer: Rui-Lin Cheng, The University of Hong Kong

Overview

The manuscript submitted by Zinelabedin et al. (manuscript No.: egusphere-2024-592) presents a comprehensive investigation of the interesting and unique salt wedges hidden in the subsurface in the northern Atacama Desert, using a variety of analytical methods to examine both surface salt crust and subsurface salt wedges. The results indicate that haloturbation is the primary process that has formed the salt wedges and inferred polygonal patterned ground. This study also links surface/subsurface processes to the changes in the climate and interactions with the atmosphere within the temporal constraints of surface exposure dating. Overall, this is a well-written manuscript and represents a useful contribution to the community.

However, I have major comments regarding clarifying the formation processes and the extrapolation of this work to Mars, as well as a few minor suggestions for improving clarity in certain areas. Please find details in the attachment. I would recommend it for publication with the condition that moderate revisions are made to address the comments I have provided.

Major comments:

1. Further clarification is needed regarding the formation of salt wedges and polygons in this study.
    a. The three main proposed formation processes of salt wedges and polygons are haloturbation, thermal contraction, and desiccation, which have been mentioned throughout the text (i.e., lines 51-55, 111-114, and 346-348).
        i. The introduction part lacks a brief overview of the latter two processes.
        ii. The exclusion of the latter two processes from this study requires more justification. This has been briefly mentioned in lines 344-348. However, a detailed discussion about the differences between the features observed in this study and those dominated by thermal contraction or desiccation in Atacama would be helpful.
    b. To enhance clarity, it is better to provide specific descriptions of salt minerals.
        i. It is recommended to use specific sulphate terms such as “anhydrite” and “gypsums” instead of “calcium sulfate” whenever possible to facilitate reader comprehension of the discussed salts. For example, in lines 376-380, which type of salts caused the volume increase? In lines 398-400, which salts caused the crack opening, and which salts/materials caused the filling?
        ii. It is worth considering the estimation of volume changes caused by sulfates in the study, similar to the calculation presented in lines 60-65 and 410-415. This analysis could provide additional insights into the impact of sulfates on the formation processes.

2. The extrapolation of this work to Mars
   The Atacama Desert is a good terrestrial analog for Mars. And it is reasonable to extend the findings of this study to Mars and share them with a broader scientific community. However, the content presented in lines 103-106 and 552-562 requires additional information to support the comparison/analogy.
   a. Line 104: “concluded” -> “suggest”
   b. Line 557: Osterloo et al. (2008) did not interpret polygonal morphologies related to a periglacial origin.
   c. Lines 559-560: While this study focuses on Ca-sulphates, the references listed here include a diverse range of salt minerals.
      i. In this study, phase transitions among different sulfate phases can cause volume change. Does this mechanism apply to other salts (e.g., chlorides, chlorates, and perchlorates)?
      ii. Among the references cited, only Dang et al. (2020) reported polygonal morphologies on Mars, with the interpretation involving desiccation. How can formation processes proposed in this study contribute to a better understanding of Martian polygons?
   d. Recommended references:
      - Rapin et al., 2023, Nature, https://doi.org/10.1038/s41586-023-06220-3
        This work reported Ca/Mg- sulfate-enriched polygonal ridges at Gale Crater, Mars.
      - Cheng et al., 2021, Geomorph., https://doi.org/10.1016/j.geomorph.2021.107695
        This study reported polygonal features controlled by Ca/Na-sulfates at the Qaidam Basin and discussed the implications for Martian polygons.
      - The enrichment of hydrous sulfates (gypsum and aluminite) without halite in the surface crust at the studied site (Section 5.2 and line 510) is quite interesting to me. The presence and distribution of hydrous sulfates on the surface of Mars have intrigued the community (Gendrin et al., 2005, Science: https://doi.org/10.1126/science.1109087 and references therein). Extrapolating this study to Mars from this perspective may provide valuable insights. Nevertheless, this might deviate from the original focus. Thus, I leave it here for open discussion.
      - (following the point above) Zhu et al., 2024, Geomorph., https://doi.org/10.1016/j.geomorph.2023.108934
        This study reported halite enrichment on the surface of polygons in the arid environment in the Qaidam Basin. It is also intriguing to explore the factors that may cause such differences in mineral enrichment.

Minor comments:

Lines 43 & 103: The missing reference of Amundon (2018) in the bibliography list. Please also check other references.

Lines 57-59: Need some rewording.

Line 66: At the beginning of a paragraph, “such processes” refers to?

Lines 66-96: It seems like this part can be briefer in the introduction. Some can be moved to the section about the regional setting; other can be moved to the discussion regarding the moisture source/input.

Line 103: Additional references should be included.

Fig. 1A: Add the legend for the red squares or mention them in the captions. The sketch in Fig. 1E is excellent.

Lines 148-151: Fig. 2 seems more like results rather than serving as the illustration of the collected samples. Fig. 3 can be moved to Section 3 to illustrate the sampling locations. Add in-text Fig. citations to enable easy navigation to photos of the samples.

Line 234: Are these soil cracks related to desiccation? Please also clarify the terms: “soil” vs “salts” vs “samples”, and “soil cracks” vs “salt wedges”, throughout the text.

Line 268, 273-276, and Fig. 4: It is recommended to directly use “wedge center” and “periphery” (and label them in Fig. 4B) instead of “LP” and “RP.”

Line 306 & 336: It would be more concise to mention “aluminite” specifically instead of using the phrase “evaporite content (except for Ca-sulfate).

Line 316: The dimension of the crack size should be specified.

Fig. 5: Add a scale bar for the sample.

Line 381: “Formed by subsurface pressure” is confusing.

Fig. 6: The red arrows only illustrate the swelling stress. How about the shrinking one?

Fig. 7: Add the scale bar for all images. What materials, particularly the type of salts, are present in each site?