REPLIES TO QUERIES FROM REFERES AND INDICATIONS OF HOW SUGGESTIONS ARE IMPLEMENTED IN THE REVISED VERSION

REFEREE #1

We appreciate the valuable and helpful comments, which have contributed to improve the quality of our manuscript. Please find below our answers to your comments and an explanation of the changes in the revised version of the manuscript (text in blue).

R#1: The primary objective of this research was to characterize surficial sediments for mineralogic and particle-size properties from a few sites in the Mojave Desert and to compare these results with those from some Moroccan dryland settings and dust-emitting settings on Iceland. The careful analytical work on the Mojave samples is highly commendable. The manuscript is well organized. In my view, however, many clarifications, corrections, and revisions are required before the manuscript is suitable for publication.

Reply: We thank reviewer 1 for recognizing the value of our work. Below we describe the clarifications, corrections, and revisions we made following the reviewer´s suggestions.

MAJOR COMMENTS:

R#1: It is not clear why EMIT mineral identification maps are presented, except to convey that it “enriches our understanding of the region’s mineralogic diversity”. A few limited interpretations and a couple of maps (Fig. 3) are provided under Methodology (not under Results), but no comparisons of EMIT results with those of this manuscript or discussion follow. Unless there is detailed mineralogic comparison among EMIT interpretations and those of this study, it appears that mention of EMIT in this manuscript is unnecessary. Sure, EMIT employs highly valuable tools aloft and data reduction methods on the ground, but the “transfer” of mineral identification from surface sediments to actual dust seems to remain an interesting challenge and a topic for further discussion beyond this manuscript.

Reply: Thanks this comment. Our intention with Fig.3 was to provide a glimpse of the mineralogical diversity in the Mojave Desert offered by the new EMIT sensor onboard the International Space station. As highlighted by the reviewer, it is beyond the scope of this study to perform a quantitative comparison between the in situ XRD mineralogy and PSD analyses shown in the paper and comparable quantitative EMIT products. Quantitative surface mineralogy (mineral mass abundances of the 10 EMIT-targeted minerals) and soil texture products are currently being developed by the EMIT team for use in Earth System Models, and their publication and evaluation will be the scope of forthcoming publications.

Fig. 3 are standard Tetracorder RGB color composite products for EMIT. Tetracorder is a software system that employs a set of algorithms within an expert system decision making framework to identify and map compounds, whether solid, liquid or gas (Clark, 2024; Clark et al., 2024). Fig. 3 shows a true color image, together with the standard product for Fe2+ and Fe3+ bearing mineral electronic absorptions (including hematite and goethite) in the visible to very-near infrared spectral range, and the standard product for the EMIT 8 minerals (excluding hematite and goethite): calcite, chlorite/serpentine, dolomite, gypsum, illite/muscovite, kaolinite-dioctahedral group, montmorillonite group, and vermiculite. The standard products highlight areas where the presence of each mineral or component is significant (in terms of band depth*fit, where the fit represents the least squares correlation coefficient from a feature fit of observed and reference library spectrum) relative to other areas in the image.

Despite not providing an in-depth analysis and evaluation of EMIT maps in this paper, we believe the standard products provide useful context. At the same time, we acknowledge the reviewer's concern and we have added more context related to EMIT in the introduction, while also broadly compared the semi-quantitative signals in the standard products with the results of our in-situ analyses in the results section.

Introduction:

Added in 113-121: *"Since 2022, the EMIT mission has been acquiring comprehensive measurements of surface mineralogical composition for use in Earth System models (Green et al., 2020). EMIT employs imaging spectroscopy across the visible to short wavelength infrared (VSWIR) spectral range from the International Space Station to map the occurrence and estimate the abundance of ten key dust source minerals. Additionally, EMIT has the potential to estimate surface soil texture. While identifying dominant surface minerals has traditionally been a strength of spectrometers, quantifying these minerals poses significant challenges. Factors such as mineral grain size and composition can affect spectral absorptions, certain dominant materials like quartz and feldspar exhibit minimal absorption features, and the presence of other materials can further complicate the analysis."*

Methodology:

Added in 231-253: *"The new EMIT sensor onboard the International Space Station offers a glimpse of the mineralogical diversity in the Mojave Desert (Green et al., 2020). Figure 3 displays standard Tetracorder RGB color composite semi-quantitative products for EMIT. Tetracorder is a software system that employs a set of algorithms within an expert system decision-making framework to identify and map compounds (Clark, 2024; Clark et al., 2024). Figure 3 shows a true color image, along with standard products for Fe2+ and Fe3+ bearing mineral electronic absorptions (including hematite and goethite) in the visible to very-near infrared spectral range. It also displays standard products for the EMIT-targeted minerals, excluding hematite and goethite: calcite, chlorite/serpentine, dolomite, gypsum, illite/muscovite, kaolinite-dioctahedral group, montmorillonite group, and vermiculite. These products highlight areas where the presence of each mineral or component is significant, measured in terms of band depth*fit, where the fit represents the least squares correlation coefficient from a feature fit of observed and reference library spectra. These analyses reveal the widespread presence of phyllosilicates such as kaolinite, smectite, montmorillonite, and illite across the area. The northeastern sector, particularly around Mesquite Lake, exhibits notable concentrations of carbonates and gypsum. Additionally, goethite and hematite are detected, with a more pronounced presence of goethite in the northern portion and hematite in the southern part of the region. The detection of mixtures of Fe2+ and Fe3+ within various minerals enriches our understanding of the region's mineralogical diversity.*

Quantitative surface mineralogy (mineral mass abundances of the 10 EMIT-targeted minerals) and soil texture products are currently being developed by the EMIT team for use in Earth System Models. Their publication and evaluation will be the focus of forthcoming publications. Thus, it is beyond the scope of this study to perform a detailed quantitative comparison between our analyses and comparable EMIT products. However, in the results section, we broadly compare these standard products with the results of our in-situ analyses."

Results:

Lines 486-499: "The EMIT standard products (Figure 3) indicate the presence of phyllosilicates such as kaolinite, smectite, montmorillonite, and illite, broadly consistent with our results. Specifically, around Mesquite Lake, where elevated levels of gypsum and carbonates were detected, the EMIT results *corroborate the significance of these minerals in the same vicinity. Similarly, in Coyote, Ivanpah, and Cronese Lakes, there is agreement regarding the prevalence of illite and muscovite as the major clay minerals, alongside kaolinite. However, discrepancies arise in Soda Lake, where EMIT identifies a dominant presence of montmorillonite, contrasting with our XRD results indicating a predominance of illite, muscovite, and kaolinite. While Tetracorder identified predominant montmorillonite, illite, muscovite and kaolinite could be on the order of 30% of the montmorillonite abundance and not show in the EMIT spectra without a more sophisticated non-linear radiative transfer model to find the relative abundances of these two minerals. This is due to the relative absorption strengths of the spectral features of these minerals relative to those in montmorillonite. While our XRD analyses highlight the presence of maghemite/magnetite, these minerals do not present clear absorbing features in the spectral range of the EMIT instrument and are not considered within the 10 EMIT standard minerals. In contrast to the XRD results, EMIT highlights the significant presence of goethite in the northern sources (Mesquite and Ivanpah Lakes). Conversely, in the southern sources (Soda, Cronese, and Coyote Lakes), EMIT highlights a major mixture of Fe2+ and Fe3+ species. The limited precision of XRD for low proportions of Fe oxides, underscores the need for complementary techniques and analyses to bolster our findings."*

References:

Clark, Roger N., 2024, PSI-edu/spectroscopy-tetracorder: Tetracorder 5.27 with expert systems to 5.27e + specpr, spectral libraries, and radiative transfer models (v5.27.0). Zenodo. https://doi.org/10.5281/zenodo.11204505

Clark, R. N., G. A. Swayze, K. E. Livo, P. Brodrick, E. Noe Dobrea, S. Vijayarangan, R. O. Green, D. Wettergreen, A. Candela, A. Hendrix, C. P. Garcia-Pando, N. Pearson, M. D. Lane, A. Gonzalez-Romero, X. Querol, and the EMIT and TREX teams, 2024, Imaging spectroscopy: Earth and planetary remote sensing with the PSI Tetracorder and expert systems: from Rovers to EMIT and Beyond Planetary Science Journal in review.

R#1: This work did not characterize dust. The presented results depend greatly on the compositions of sand-size particles, and not directly on actual dust, although some inference can be made from the plots in Fig. 5. The work characterized bulk samples from sites that apparently emitted dust. A meaningful assessment of mineral dust in the samples would have been to dry sieve the bulk samples to separate out the PM63 fraction, that is, the silt plus clay size particles and analyze those. A useful addition would be listing PM63 vol. % derived from PSD data. Because dust emission from sampled sites has not been demonstrated or adequately inferred on the basis of, say, prevalence of dust PM sizes in the samples, I strongly suggest that the title be revised to delete “dust-emitting sediments”; it’s not adequately demonstrated that the samples represented dust. Please see following comments on water treatments of samples.

Reply: Thanks for the comment. We agree with the reviewer that our study does not characterize dust. We stated that we analyse dust-emitting sediments, not emitted dust, that is, sediments that can produce dust under favourable conditions (high winds, dry soil). All samples were sieved to pass 2 mm. In our revised manuscript we have further emphasized that information on the PSD, mineralogy and aggregation state of the sediments is key to evaluate future spectroscopically derived surface mineral abundances and texture, while providing valuable information to dust modelers.

We acknowledge the importance of quantifying mineralogy in different size ranges. Such data is key to understand how mineral composition changes with size, and is also helpful to modelling endeavours. Therefore, in the revised version of the manuscript we added additional analyses by size range. We provide the mineral fractions in the ranges 250-500, 80-250, 63-80, 40-63, 20-40, and <20 µm, which were separated by dry sieving. We added in the Supplement the mineralogical composition in these size ranges for 20 selected samples (16 crusts and 4 ripples, totalling 120 sub-samples). In the main text we included a section summarizing the enrichment factors of each mineral group in each size range with respect to the bulk <2mm samples. We added text and a figure in the main text, and a table in the Supplement.

In lines 297-302 we added: *"In addition, we separated 20 selected samples from different sources, including 16 crusts and 4 aeolian ripples, into different size ranges to understand how mineral composition changes with size. We used a series of sieves with mesh sizes of 2 mm, 1 mm, 500 µm, 250 µm, 80 µm, 63 µm, 40 µm, and 20 µm. The sieving process involved hand shaking the full column for 1 minute, followed by ultrasound sonication for 1 minute at the 500 µm, 80 µm, 40 µm, and 20 µm size fractions. This method ensured the effective separation of the size fractions for subsequent mineralogical analysis."*

Furthermore, we added in the results section:

Added at lines 389-392: "Dry sieved size fractions of dust-emitting sediments show the highest percentage of mass in the 250-500 and 80-250 µm fractions, with minimal mass at 500-1000 µm and 1-2 mm and in the finer fractions (20-40 and <20 µm) (Figure 6, Table S2). In both cases, the size fractions from 80 to 500 µm accumulated a total of 75 to 90 % of the total mass fraction (Table S2)."

Lines 500-515: *"The mineralogical composition of the dry size-segregated fractions of the dust-emitting sediments is outlined in Table S4. The findings indicate that there is no significant size enrichment process in crusts; rather, there exists a relatively uniform distribution of quartz, feldspars, zeolites, and Fe oxides across all size fractions (Figure 6). A slight, albeit not significant, enrichment of carbonates and clays is observed, along with a slight depletion of Na-salts and gypsum in the finer fractions (<20 µm). Additionally, pargasite shows a slight enrichment in the 40-80 µm fraction. In contrast, for aeolian ripples, quartz exhibits significant enrichment in the coarser fraction (250-500 µm) and depletion in the finer ones (<80 µm). Regarding carbonates, clays, and Fe oxides, there is an enrichment towards the finer fractions (<20 µm), while the content of feldspars remains relatively homogeneous. Pargasite content increases in the 40-80 µm fraction, and Na-salts and gypsum are either not detected or present in trace amounts (Figure 6). The notable disparity in the enrichment factor between crusts and aeolian ripples is partly attributed to the reduced amount of sand and the differing cohesion states: crusts exhibit high cohesion, resulting in a homogenized mineralogy across size fractions (as aggregates form a homogeneous concretion of minerals), while aeolian ripples display lower or negligible aggregation, leading to a slightly more heterogeneous mineralogy across size fractions compared to crusts."*

Table S2 and S4 were added to the Supplementary document to provide the mass and mineralogy fractions by size in detail.

R#1: Because the sample treatment for PSD is extremely important, that method should be described in this manuscript and not simply referred to as Gonzalez-Romero et al. 2023. Relevant methods described by Sperazza should be included.

It appears that samples were treated in liquid: "*To analyse mineral-size fractionation (< 10 and 10–63 µm), a fully dispersed size fractionation conducted using Milli-Q-grade water and by shaking the samples was applied prior to separation for 12–24 h.*" from Gonzalez-Romero et al. 2023. Wouldn't that treatment have fully dissolved at least some of the salt minerals (e.g., thenardite, burkeite, others) in any or all samples? To any extent, then, the treated-sample PSDs cannot be those of their natural occurrences (see also Buck et al.).

Reply: Thanks for the comment. In González-Romero et al. (2023), we also used wet sieving to obtain the fractions < 2 µm and < 63 µm to compare with current mineralogical atlases provided by Claquin et al. (1999) and Journet et al. (2014). In the present manuscript we analysed the mineralogy of the sediment < 2 mm obtained by dry sieving, not the wet one. Therefore, the mineralogical characterization of our bulk samples (and the subsamples for each size range in the revised version of the manuscript) are not affected by a potential dissolution of salt minerals.

Once we obtained the < 2mm dry fractions, we implemented both wet and dry PSD analysis to the samples to evaluate aggregation. In this case the wet PSD can dissolves salts, but not the dry one.

As requested, we added more detailed information in the methodology as follows:

Line 288-296: *"Particle size distributions (PSD) of bulk samples (<2 mm) were analysed as described in González-Romero et al. (2023) for the evaluation of the aggregation state. First, we conducted a minimally dispersed PSD (MDPSD) analysis, which minimizes the breaking of the aggregates that are encountered in natural conditions. Second, we conducted a fully dispersed PSD (FDPSD) analysis, which breaks the aggregates. Wet dispersion was done according to Sperazza et al., (2004), using water and sodium hexametaphosphate dispersion for 24 h. Both PSDs (MDPSD and FDPSD) were obtained by a laser diffractometer with the Malvern Mastersizer 2000 Hydro G and Scirocco for the fully and minimally dispersed conditions, respectively. We note that under wet dispersion, at least some salt minerals may dissolve."*

R#1: There is a disconnect between the spatial assessment of dust-producing settings in the Mojave (Fig. 2) and the locations of actual dust sources that were a target of this study. The broad AOD footprint map is a superb rendition of general dust activity, but it does not inform about footprints of actual dust-emission point sources. Much dust emitted from the Mojave is from alluvial settings—dry river beds, the toes of alluvial fans, and disturbed areas (many references, especially the Reheis articles). For one observation, the blue contours apparently attributed to "Soda" do not closely coincide with the areal extent of Soda Lake playa. The blue area corresponds primarily to the floodplain of the Mojave River as it exits Afton Canyon. Dust from this floodplain has been studied in detail for timing and frequency of dust emission, as well as aeolian sediment (including dust) mineral composition and PSD (Urban et al., 2018). All of the major emission from the Soda area is generated from floodplain deposits. Yes, some white dust is emitted from the Soda playa surface but only rarely under certain conditions of surface wetting/drying, and such emission is short-lived in small amounts as the ephemeral salt fluff is quickly dispersed.

Reply: Thanks for these very relevant comments. We have included all these limitations of our studies and the sources identified by the literature that your referred to. We have also re-written the description of the sampling to together with the FoO maps. The sampling points are also now included in Figures 1 and 2. We included the following text.

Lines 147-148: "lakes and alluvium deposits near playa lakes (Reheis & Kihl, 1995; Reheis et al. 2009, Urban et al., 2018)."

Lines 196-221: *"The regional distribution of the annual Frequency of Occurrence (FoO) of dust events, with dust optical depth exceeding 0.1, derived from MODIS Deep Blue C6.1 Level 2 data following the methodology of Ginoux et al. (2012), is illustrated in Figure 2. The FoO provides an overall estimate of dust emission frequency above a certain threshold at a resolution of 0.1º by 0.1º over the region. Sediment samples were collected from various locations within the Mojave Desert region, including areas with relatively high FoO (see locations in Figures 1 and 2). Among these locations is Soda Lake and its surroundings, near Baker, CA, which is linked to Silver Lake to the north and is surrounded by* *igneous, volcanic, and carbonate rocks, as well as dune fields to the south (Figure 1). The area is influenced by aeolian, alluvial, and fluvial processes and experiences annual precipitation of 80-100 mm (Urban et al., 2018). This ephemeral lake contains salts resulting from the evaporation of groundwater sourced from an aquifer nestled in the Zzyzx Mountains (Honke et al., 2019). Dust emissions are a recurrent phenomenon, originating from fine sediments accumulated in the lake's central areas during sporadic floodings, from the white evaporite surfaces in the lake, and from the alluvial deposits to the south of the playa lake (Urban et al., 2018). According to the FoO, the areas with higher dust emissions are the southern part of the lake and the alluvial deposits to the southwest, extending up to Afton Canyon.*

Samples were also collected from the Cronese lakes, Mesquite Lake, Ivanpah Lake and Coyote Lake (Figure 1), which lie in areas with significant FoO signals (Figure 2) and have been documented as dust sources in Reheis & Kihl (1995) and Reheis et al. (2009). The Cronese lakes are adjacent to the Soda Lake area to the west, sharing a similar geologic context (Figures 1 and 2). Mesquite Lake, located on the border between California and Nevada, is encircled by carbonate and igneous rocks, mirroring the geological setting of the nearby Ivanpah Lake. Notably, Mesquite Lake playa is the only playa affected by a gypsum mine pit, as documented by Reynolds et al. (2009). Further contributing to the diversity of the region's geological makeup is Coyote Lake, flanked by Miocene and Pleistocene sediments. These playa lakes, characterized as endorheic ephemeral lakes, receive groundwater inputs in some cases, enriching the lakes with salts that subsequently precipitate on the surfaces of their central regions (Whitney et al., 2015; Urban et al., 2018)."

Lines 224-230: "It is important to note that the FoO may tend to highlight areas such as playas and their surroundings, where in some cases the most dust per unit area could be produced (Floyd and Gill, 2011; Baddock et al., 2016). However, some alluvial regions with lower emission rates not surpassing the FoO threshold may produce more dust overall due to their greater areal extent (Reheis and Kihl, 1995; Baddock et al., 2016). Additionally, many other types of dust-producing surfaces active in the Mojave Desert, such as gravel roads, agricultural lands, and recreational off-road tracks, are rarely observed by satellite retrievals (Urban et al., 2018)."

R#1: With respect to disturbed areas, some major ones are military bases--foremost Fort Irwin (centered ~34.04, -115.86). Dust-source sediment there can accumulate to many cm depths before winds sweep it up and carry it beyond base boundaries. It appears that much of the Fort Irwin footprint coincides with high FoO of AOD (Fig. 2). (The small playa at Ft. Irwin is a dry playa and emits insignificant amounts of dust and only then when heavily traveled).

Reply: Thanks for these very relevant comments. We include all these aspects of the AOD and the FoO at Fort Irwin area affected by anthropogenic activities. We included the following text.

Lines 222-224: *"Other areas with relatively high FoO not sampled in our study include the Ashford Junction alluvial deposits and the Fort Irwin area, where the northern valley, including Nelson Lake, may be more prone to dust emission due to significant anthropogenic disturbance."*

R#1: The rationale for choosing to sample only "ripples" and crusts is not clear. These features are ephemeral and superficial. And these features could appear under somewhat different conditions in different places. For example, there are many different types/compositions of crusts with great variability in wind-erosion vulnerabilities (e.g., see Buck et al., 2011, an excellent, highly significant study). In addition, the formation of ripples depends on wind strengths, PSD, and other sediment properties related to sorting phenomena and so many not be identical from place to place.

Reply: Thank you for your feedback. We recognize the potential variability among crusts and ripples within the studied locations due to varying conditions. However, we believe our samples broadly represent the composition and particle size distributions (PSDs) of this type of sediments in these areas, allowing for meaningful comparisons with sediments from other locations. Our rationale for selecting ripples and crusts is two-fold:

Dust Emission Mechanisms: Dust emission is primarily driven by two mechanisms: saltation bombardment and aggregate disintegration. In saltation bombardment, dust is ejected from soil aggregates (typically crusts and paved sediments rich in clay and silt particles) when impacted by saltating sand particles. In aggregate disintegration, dust is released from saltating soil aggregates (Shao et al., 1993; Alfaro et al., 1997; Shao, 2001). By characterizing the PSD (both dry and wet sieved) and mineralogy of ripples (concentrating sand particles) and crusts (concentrating clay and silt particles), we provide comprehensive and valuable information for developing and refining dust emission models.

Surface Mineral Abundance and Remote Sensing: In arid and semi-arid regions, quartz and feldspar typically dominate sediment mass. However, current spaceborne hyperspectral instruments (such as EMIT) cannot directly identify feldspar and quartz because their absorption features lie outside the instrument's spectral range. This poses a significant challenge in quantifying surface mineral abundances from remote spectroscopy. At all FRAGMENT sampling locations (Morocco, Iceland, US-Mojave, and Jordan), we measured reflectance spectra using an ASD Fieldspec 3. By characterizing and contrasting ripples (with high quartz and feldspar content and larger particle sizes) and crusts, we aim to enhance understanding and improve modeling assumptions for estimating surface mineral abundances and soil texture from remote spectroscopy. Our paper focuses on sediment characterization in the Mojave Desert. Additional papers are in preparation, leveraging the synergy between these measurements and reflectance spectra from multiple campaigns.

In the revised manuscript we acknowledge the potential variability in the sediments within locations, while also providing a clearer rationale on the sampling of ripples and crusts.

Added in 84-94: *“Dust primarily originates from arid inland basins, which include various sedimentary environments such as aeolian deposits, endorheic depressions, and fluvial- and alluvial-dominated systems (Bullard et al., 2011). Wind typically mobilizes loose sand from adjacent ripples or dunes, which then erodes more consolidated surfaces, typically paved sediments and crusts, to release dust (Stout and Lee, 2003; Shao et al., 2011). Atmospheric dust emission models have improved by identifying preferential dust sources using criteria like topography and hydrology (Ginoux et al., 2001). However, these models still struggle with capturing small-scale variability partly due to the lack of relevant soil measurements in arid regions, despite advancements in understanding the geomorphological and sedimentological factors influencing dust emissions (Bullard et al., 2011). For instance, the particle size distribution (PSD) and cohesion of the sediments affect saltation bombardment and aggregate disintegration processes involved in dust emission (Shao et al., 1993).”*

Added in 113-121: *“Since 2022, the EMIT mission has been acquiring comprehensive measurements of surface mineralogical composition for use in Earth System models (Green et al., 2020). EMIT employs imaging spectroscopy across the visible to short wavelength infrared (VSWIR) spectral range from the International Space Station to map the occurrence and estimate the abundance of ten key dust source minerals. Additionally, EMIT has the potential to estimate surface soil texture. While identifying dominant surface minerals has traditionally been a strength of spectrometers, quantifying these minerals poses significant challenges. Factors such as mineral grain size and composition can affect spectral absorptions, certain dominant materials like quartz and feldspar exhibit minimal absorption features, and the presence of other materials can further complicate the analysis.”*

Added in 264-285: *"Our rationale for selecting crusts and ripples is two-fold. On the one side, dust emission is primarily driven by two mechanisms: saltation bombardment and aggregate disintegration. In saltation bombardment, dust is ejected from soil aggregates (typically crusts and paved sediments rich in clay and silt particles) when impacted by saltating sand particles. In aggregate disintegration, dust is released from saltating soil aggregates (Shao et al., 1993; Alfaro et al., 1997; Shao, 2001). By characterizing the PSD (both dry and wet sieved) and mineralogy of ripples (concentrating sand particles) and crusts (concentrating clay and silt particles), we provide comprehensive and valuable information for developing and refining dust emission models. On the other side, in arid regions, quartz and feldspar typically dominate sediment mass. However, current spaceborne hyperspectral instruments (such as EMIT) cannot directly identify feldspar and quartz because their absorption features lie outside the instrument's spectral range. This poses a significant challenge in quantifying surface mineral abundances from remote spectroscopy. At all FRAGMENT sampling locations (Morocco, Iceland, US-Mojave, and Jordan), we measured reflectance spectra using an ASD Fieldspec 3. By characterizing and contrasting ripples (with high quartz and feldspar content and larger particle sizes) and crusts, we aim to provide information to enhance understanding and improve modeling assumptions for estimating surface mineral abundances and soil texture from remote spectroscopy in subsequent studies.*

We acknowledge that the limited number of samples collected may not fully represent the potential variability among crusts and ripples within the studied locations due to varying conditions (Buck et al., 2011). However, our samples should broadly represent the composition and particle size distributions (PSDs) of this type of sediments in these areas, allowing for meaningful comparisons with sediments from other locations."

R#1: I don't understand the rationale about comparing properties of rippled sediment among the Mojave, Morocco, and Iceland.

Reply: In the previous response we have provided a rationale.

We added in 95-112: *"Understanding the mineral composition of dust is also crucial for assessing its climate impact. Dust contains various minerals such as quartz, clay minerals, feldspars, carbonates, salts, and iron oxides. The climate effects of dust are influenced by these minerals' relative abundances, sizes, shapes, and mixing states. For example, iron oxides control solar radiation absorption by dust (Formenti et al., 2014; Engelbrecht et al., 2016; Di Biagio et al., 2019; Zubko et al., 2019), nano Fe oxides and easily exchangeable Fe increase the fertilising effect of dust in ocean and terrestrial ecosystems (Hettiarachchi et al., 2019; Baldo et al., 2020, Hettiarachchi et al., 2020), K-feldspar and quartz impact ice nucleation in clouds (Atkinson et al., 2013; Harrison et al., 2019; Chatziparaschos et al., 2023), and calcite influences acid reactions on dust surfaces (Paulot et al., 2016). The mineralogical composition of dust can vary significantly across different regions due to geological and climatic factors (Claquin et al., 1999; Journet et al., 2014). However, most models assume a globally uniform dust composition due to limited global data on parent soil sources. Only a few models account for dust mineralogical composition variations (e.g., Scanza et al., 2015; Perlwitz et al., 2015; Li et al., 2021; Gonçalves Ageitos et al., 2023; Obiso et al., 2024) by using global soil type atlases and extrapolating from a limited number of analyses (Claquin et al., 1999; Journet et al., 2014). These atlases rely on assumptions about soil texture and color, often base their data on soil samples taken from depths deeper than those relevant to wind erosion, and the method used to characterize particle size and associated mineralogy fully breaks down natural soil aggregates."*

Added in 113-121: "*Since 2022, the EMIT mission has been acquiring comprehensive measurements of surface mineralogical composition for use in Earth System models (Green et al., 2020). EMIT employs imaging spectroscopy across the visible to short wavelength infrared (VSWIR) spectral range from the*

International Space Station to map the occurrence and estimate the abundance of ten key dust source minerals. Additionally, EMIT has the potential to estimate surface soil texture. While identifying dominant surface minerals has traditionally been a strength of spectrometers, quantifying these minerals poses significant challenges. Factors such as mineral grain size and composition can affect spectral absorptions, certain dominant materials like quartz and feldspar exhibit minimal absorption features, and the presence of other materials can further complicate the analysis."

R#1: At this time, some points can be drawn and will be emphasized later:

- There are many dust sources of variable composition in the Mojave.
- Many major sources are not playa surfaces.
- The overall picture of Mojave dust is that, with any given windstorm, dust from many different sources activate, and so dusts of variable compositions are mixed (see Reheis et al. 2009; Reynolds et al., 2006).

Reply: Thanks for these comments. In the following comments, the specific bullets are emphasized in specific comments and suggestions.

R#1: For these reasons as examples, the statements in the manuscript about characterizing the dust-source sediments across the Mojave is way too far a stretch and thus regrettably misleading. No, the authors have characterized just a few samples from limited areas that may not very well represent Mojave dust compositions during major dust storms. In addition, a large fraction of most samples is sand.

Reply: Thanks for your comment. We agree that our manuscript does not characterize dust-source sediments in all locations of the Mojave. In this sense we re-wrote the statements referring to selected Mojave Desert sources. We also modified the title to avoid any confusion by replacing "across" by "from"

"CHARACTERIZATION OF THE PARTICLE SIZE DISTRIBUTION, MINERALOGY AND FE MODE OF OCCURRENCE OF DUST-EMITTING SEDIMENTS FROM THE MOJAVE DESERT, CALIFORNIA, USA"

R#1: Along these lines, the attribution of "hot spots" to the sampled areas is not well justified. Authors have not tightly demonstrated that the sampled sites are sites of major, recurrent emission.

Reply: Thanks for your comment. It is true that the areas are not tightly demonstrated to have major recurrent dust emission with in situ dust levels measurements during a long period. Nevertheless, the selected areas are supported by high FoO and also by prior studies that points the areas as potential dust emitting basins (Reynolds et al., 2007; Urban et al., 2018). We agree that the term hotspot is not well fitted and we changed to potential dust emitting basins in the Mojave.

R#1: The manuscript claims to have identified variability in PSD and mineralogy as influenced by sediment transport dynamics and groundwater fluctuations (e.g., see abstract). The work did not involve measurement or investigation of sediment transport dynamics and groundwater fluctuations but only cursorily inferred these conditions from some literature.

Reply: Thanks for your comment. As you state, we did not perform any measurement or investigation of sediment transport dynamics and groundwater fluctuations. What we tried to do is to link our measurements and analyses to previous studies in the literature focusing on those aspects (Goudie, 2018, Reynolds et al., 2009, Urban et al., 2018 and the new literature presented thanks to the reviewer). We have revised the abstract and the manuscript so it is clear that we use other studies to interpret and analyse the results of our measurements.

Lines 399-400: “as seen also by other authors (Reynolds et al., 2007; Nield et al., 2016a; Nield et al., 2016b; Urban et al., 2018).”

Lines 402-403: “(Nield et al., 2016a and Nield et al., 2016b)”

Lines 449-450: “its cycle interaction with the surface causes the massive mobilisation of Na-salts that consolidate the crusts (Figure 4) (Nield et al., 2016b)”

Lines 605-606: “as suggested by literature (Nield et al. (2016a and b), Urban et al. (2018) and Goudie (2018)”

R#1: With respect to understanding emissions and properties of dust from playa surfaces, at least a few years of observation and measurements are required to capture playa-surface/groundwater interactions to understand interlinked dynamics and variability in crust structure, roughness, mineral composition, PSD, and emissivity. Importantly, the most voluminous dust emissions from playa surfaces – wet playas only -- occur when very strong winds (typically > 20 m/s) rip off thin crusts to expose many cm-thickness of soft, fine-grained sediment beneath the crust that then is emitted as dust. The fine-grained sediment is typically a mixture of lithogenic and salt mineral particles.

Reply: We agree with the reviewer. Our observation was that the formed crusts in the centre of wet playas are difficult to rip off. By the playa edges, under high winds conditions, due to the porosity created by the remobilisation of salts in the surface, the thin efflorescences can be removed and dust emission is possible. For that, we agree on the reviewer comment and added to the conceptual model section the following:

Lines: *“In wet playas, strong dust emission may have when very strong winds rip off thin crusts exposing fine-grained sediment that mixes lithogenic and salt mineral particles (Rich Reynolds, personal communication). “*

R#1: The original description of wet and dry playas in the Mojave (and vulnerability to dust emission from them) was not cited (Reynolds et al., 2007) despite adopting interpretations presented in that article (and as summarized by Goudie).

Reply: Thanks for catching this. We addressed the reference list, including the works of Reynolds, Nield and Buck in the subject.

R#1: With respect to Mesquite lake playa: Mesquite Lake playa is treated as one that has been “significantly” disturbed by human activity, in this case, mining. Out of roughly 1630 hectares of playa surface, only about 65 hectares are currently in the gypsum-mine area. So, a very small fraction (~4%) of the playa surface is “exploited” (line346). Mining gypsum there does not involve “pumping groundwater to separate different salts for economic purposes” (lines 344-345). The mining for gypsum and no other minerals occurs in a dry quarry. There is no evaporation at Mesquite to produce brines. Please see https://www.sbcounty.gov/Uploads/lus/Desert/MesquiteLake/MesquiteLakeIS.pdf

Reply: Thanks a lot for catching this important error. It was a deduction from the in-situ visit, which obviously was wrong. Now we corrected the whole paragraph.

Lines 456-464: *“Mesquite Lake features extensive gypsum deposits at the surface, which are a major component of both dunes and crusts. A small gypsum mine operates in Mesquite Lake. The gypsum content in crusts is notably higher at the center (80%) compared to the margins (3-11%). In contrast, the contents of Na-salts and carbonates are greater at the margins (30% and 12-18%, respectively) than at the center (7.5-14% and <0.1-6.9%, respectively). Aeolian ripples at the center of Mesquite Lake exhibit a very high gypsum content, whereas at the margins, these ripples contain higher amounts of quartz, feldspars, and clays. Despite the presence of the disturbed mine area, most large dust events at Mesquite Lake have been observed to originate from natural (undisturbed) playa surfaces near the margins (Reynolds R., personal communication).”*

R#1: Most large dust events witnessed by this reviewer while at Mesquite have been generated from natural (undisturbed) playa surfaces close to its margins.

Reply: Thanks, we have highlighted this in the paper (see previous response).

R#1: Fe occurrences. I understand that the Fe-extraction methods in this study are commonly used by some labs. But mineral identification from chemical extractions involves assumptions and uncertainties. The best ways to identify actual Fe-bearing minerals is a combination of Mössbauer spectroscopy at liq. He temperatures and rock magnetics techniques. It’s fully understandable that one or both such approaches cannot commonly be done. Nevertheless, results on the Fe mineral habitats in Mojave dusts are available in the literature (Reheis et al., 2009; Reynolds et al., 2006). For example, magnetite is ubiquitous in Mojave dusts emitted during regional wind/dust storms because such winds tap many magnetite-bearing dust-source sediments. As written, this manuscript appears to claim that its analyses describe all Fe occurrences “across the Mojave”. Such inference is misleading. For example, this statement is a stretch: *“Aeolian ripples have very similar contents and modes of Fe occurrence* ***across the Mojave Desert****”* (p. 10). The samples described in this manuscript deal with just a miniscule part of the Mojave and only a very limited number of the hundreds to thousands of different dust-point-sources there.

Reply: Many thanks. We have made clear that our results refer to the areas samples in our study. We also acknowledge the limits of XRD and the Rietveld methods and the difficulties to differentiate between maghemite and magnetite due to their similar crystal structure and elemental composition as referred by other studies such as Vandenberghe et al. (2000). Also given that other previous studies using Mössbauer spectroscopy at liq. He temperatures and rock magnetics techniques have shown that magnetite is ubiquitous in Mojave dusts, and the potential limitations of XRD we now refer to maghemite/magnetite and clarified the reasons for it:

Lines 430-435: “*These diverse bedrocks mineralogy results in a wide variety of minerals in the dust-emitting sediments. The form of iron oxide detected in the samples, identified via XRD, is maghemite. However, distinguishing between maghemite and magnetite using XRD is challenging (Vandenberghe et al., 2000), and magnetite has been found to be ubiquitous in Mojave dust (Reheis et al., 2009; Reynolds et al., 2006). Therefore, we refer to maghemite/magnetite to account for the potential presence of both in the samples.”*

Across the text we have changed *maghemite* to *maghemite/magnetite for clarification*.

Vandenberghe, R. E., Barrero, C. A., Da Costa, G. M., Van San, E., and De Grave, E.: Mössbauer characterization of iron oxides and (oxy) hydroxides: the present state of the art. Hyperfine Interactions, 126, 247-259, 2000.

R#1: Based on chemical extractions, the authors conclude that their Mojave samples, and by inference, Mojave dust-source sediment contain maghemite and the only occurrence of crystalline Fe oxides (lines 368-369). This inference is highly misleading. Magnetite is present in many Mojave dust-source sediments and is ubiquitous in dust generated by widespread windstorms.

Reply: Many thanks. See our previous response.

R#1: The use of "Mode of occurrence of Fe" is cumbersome. One could write more clearly: "Occurrences of Fe", or "Mineral habitats for Fe".

Reply: Thanks for your suggestion. We used the mode of occurrence of Fe due to its general use in prior chemical studies of Fe metal ore minerals were the differentiation between the presence of Fe in different species and/or mineral habitats is crucial. In addition, this terminology has been also used in prior studies of the same project such as Gonzalez-Romero et al. (2023 and 2024). Overall, this consistency makes our analysis comparable and valuable for dust modelers and climate scientists.

González-Romero, A., González-Florez, C., Panta, A., Yus-Díez, J., Reche, C., Córdoba, P., Moreno, N., Alastuey, A., Kandler, K., Klose, M., Baldo, C., Clark, R.N., Shi, Z.B., Querol, X., Pérez García-Pando, C.: Variability in grain size, mineralogy, and mode of occurence of Fe in surface sediments of preferential dust-source inland drainage basins: The case of the Lower Drâa Valley, S Morocco. Atmos. Chem. Phys., 23, 15815–15834, https://doi.org/10.5194/acp-23-15815-2023, 2023.

González-Romero, A., González-Florez, C., Panta, A., Yus-Díez, J., Córdoba, P., Alastuey, A., Moreno, N., Kandler, K., Klose, M., Clark, R.N., Ehlmann, B.L., Greenberger, R., Keebler, A.M., Brodick, P., Green, R., Querol, X., Pérez García-Pando, C.: Probing Iceland's Dust-Emitting Sediments: Particle Size Distribution, Mineralogy, Cohesion, Fe Mode of Occurrence, and Reflectance Spectra Signatures. Atmospheric Chemistry and Physics. EGUSPHERE [Preprint], 2024.

R#1: I don't understand the significance of comparing Mojave (and Moroccan) settings to those in Iceland. The differences, especially in bedrock mineralogy and thus dust-source sediments, are obvious, and thus dust properties will obviously differ greatly. And as implied (line 434-435), all, or nearly all, Icelandic dusts from alluvial (mostly glacial outwash) settings.

Reply: Thank you for your valuable feedback. We understand your concern about the significance of comparing the Mojave and Moroccan settings to those in Iceland, given the apparent differences in bedrock mineralogy. From the point of view of a soil scientist, it is clear that different bedrock geology and other conditions can lead to variations in sediment mineralogy, particle size distribution (PSD), and aggregation state of surface sediments. However, our paper is largely addressed to atmospheric scientists interfacing with surface properties, and more specifically to dust modelers. As we explain above, information on the differences in dust source sediments in terms of PSD, mineralogy, Fe mode of occurrence, and aggregation state across different dust sources is key for dust modelling and climate impact studies. Here are the key reasons for including these comparisons:

Diversity of Dust Sources: Models generally assume that the composition of dust from all sources is homogeneous. By comparing regions with distinct bedrock mineralogy, such as the volcanic landscapes of Iceland and the arid deserts of the Mojave and Morocco, we aim to provide a perspective of the broad spectrum of sediment characteristics that should be accounted for in global models in the future. Future integration of this diversity should help enhancing the robustness and applicability of dust emission models across various environmental settings.

Remote Sensing Calibration: The inclusion of regions with different mineralogical compositions allows for a more comprehensive calibration of remote sensing instruments. For instance, the spectral signatures of dust from quartz-rich deserts and basaltic terrains differ significantly, and incorporating these variations can improve the accuracy of remote sensing data interpretation.

Global Dust Cycle: Dust from different regions contributes to the global dust cycle, influencing climate, biogeochemical cycles, and human health. By studying and comparing diverse environments, we aim to better help understanding the global implications of dust emissions and their impact on various Earth system components.

Additionally, we provide a consistent comparison among the source regions by applying the same sampling and analysis methods across all our campaigns. This consistency makes our comparisons particularly relevant and valuable for dust modelers and climate scientists.

We have elaborated on these points in the revised manuscript to clarify the significance of our comparative approach and to address the concerns raised.

Lines 84-112: *"Dust primarily originates from arid inland basins, which include various sedimentary environments such as aeolian deposits, endorheic depressions, and fluvial- and alluvial-dominated systems (Bullard et al., 2011). Wind typically mobilizes loose sand from adjacent ripples or dunes, which then erodes more consolidated surfaces, typically paved sediments and crusts, to release dust (Stout and Lee, 2003; Shao et al., 2011). Atmospheric dust emission models have improved by identifying preferential dust sources using criteria like topography and hydrology (Ginoux et al., 2001). However, these models still struggle with capturing small-scale variability partly due to the lack of relevant soil measurements in arid regions, despite advancements in understanding the geomorphological and sedimentological factors influencing dust emissions (Bullard et al., 2011). For instance, the particle size distribution (PSD) and cohesion of the sediments affect saltation bombardment and aggregate disintegration processes involved in dust emission (Shao et al., 1993).*

Understanding the mineral composition of dust is also crucial for assessing its climate impact. Dust contains various minerals such as quartz, clay minerals, feldspars, carbonates, salts, and iron oxides. The climate effects of dust are influenced by these minerals' relative abundances, sizes, shapes, and mixing states. For example, iron oxides control solar radiation absorption by dust (Formenti et al., 2014; Engelbrecht et al., 2016; Di Biagio et al., 2019; Zubko et al., 2019), nano Fe oxides and easily exchangeable Fe increase the fertilising effect of dust in ocean and terrestrial ecosystems (Hettiarachchi et al., 2019; Baldo et al., 2020, Hettiarachchi et al., 2020), K-feldspar and quartz impact ice nucleation in clouds (Atkinson et al., 2013; Harrison et al., 2019; Chatziparaschos et al., 2023), and calcite influences acid reactions on dust surfaces (Paulot et al., 2016). The mineralogical composition of dust can vary significantly across different regions due to geological and climatic factors (Claquin et al., 1999; Journet et al., 2014). However, most models assume a globally uniform dust composition due to limited global data on parent soil sources. Only a few models account for dust mineralogical composition variations (e.g., Scanza et al., 2015; Perlwitz et al., 2015; Li et al., 2021; Gonçalves Ageitos et al., 2023; Obiso et al., 2024) by using global soil type atlases and extrapolating from a limited number of analyses (Claquin et al., 1999; Journet et al., 2014). These atlases rely on assumptions about soil texture and color, often base their data on soil samples taken from depths deeper than those relevant to wind erosion, and the method used to characterize particle size and associated mineralogy fully breaks down natural soil aggregates."

Lines 113-138: *"Since 2022, the EMIT mission has been acquiring comprehensive measurements of surface mineralogical composition for use in Earth System models (Green et al., 2020). EMIT employs imaging spectroscopy across the visible to short wavelength infrared (VSWIR) spectral range from the*

International Space Station to map the occurrence and estimate the abundance of ten key dust source minerals. Additionally, EMIT has the potential to estimate surface soil texture. While identifying dominant surface minerals has traditionally been a strength of spectrometers, quantifying these minerals poses significant challenges. Factors such as mineral grain size and composition can affect spectral absorptions, certain dominant materials like quartz and feldspar exhibit minimal absorption features, and the presence of other materials can further complicate the analysis.

Overall, there is a notable lack of comprehensive measurements characterizing relevant properties of surface sediments in dust source regions. This gap hampers our ability to evaluate and constrain mineral abundance derived from reflectance spectroscopy and to improve dust emission modeling. Addressing this issue, the FRontiers in dust minerAloGical coMposition and its Effects upoN climaTe (FRAGMENT) project has, over recent years, conducted a series of coordinated and interdisciplinary field campaigns across remote dust source regions. The project's objectives include enhancing the understanding and quantification of dust-source properties, examining their relationship with emitted dust characteristics, refining spaceborne spectroscopy retrievals of surface minerals (Green et al., 2020, Clark et al., 2024), and improving the representation of dust mineralogy in Earth system models (Perlwitz et al., 2015; Li et al., 2021; Gonçalves et al., 2023; Obiso et al., 2023). The FRAGMENT field campaigns involved regional sediment sampling in several regions and detailed wind erosion and dust emission measurements at selected sites. Studies stemming from these activities include those by González-Romero et al. (2023), González-Flórez et al. (2023), and Panta et al. (2023), and González-Romero et al. (2024). These campaigns have been executed in various geographic locations, such as the Moroccan Sahara (2019), Iceland (2021), the Mojave Desert in the United States (2022), and Jordan (2022). Through these efforts, the FRAGMENT project contributes to filling critical knowledge gaps in dust-source characterization."

R#1: The Conclusions section is mostly a discussion of comparisons among Mojave, Moroccan, and Icelandic results. I suggest a separate Discussion section for the comparisons.

Reply: Thanks for the feedback. We have renamed the section as Discussion and Conclusions. The section provides a conceptual model, while discusses key aspects of the results, including some comparisons with other regions.

ADDITIONAL COMMENTS/SUGGESTIONS BY LINES (L)

R#1: 102. Franklin Lake playa

Reply: Thanks, changed.

R#1: 106. Northerly

Reply: Thanks a lot, changed.

R#1: 107. …natural factors, whereas…

Reply: Changed, thanks.

R#1: 108-109. …training, and livestock grazing

Reply: Added, thanks a lot.

R#1: 123. Topic sentence needed.

Reply: Thanks, we added "In the Mojave Desert, three different Aridisols are present in the Rand mountains alluvial fan, corresponding to Xerillic soils or Aridisols according to Eghbal & Southard (1993), typical from arid and semi-arid regions, with low organic matter content and low structures."

R#1: 146. Lakes existed for thousands of years after the LGM.

Reply: Thanks, added.

R#1: 156. What is the Zzyzx "complex"?

Reply: Thanks a lot, it referred to the California State University Desert Studies Centre, but it has been removed in the revised version.

R#1: 170. What is meant by "other notable areas"?

Reply: Thanks, we changed in the text for a better description of the FoO. We changed the text in lines 196-230 to: *"The regional distribution of the annual Frequency of Occurrence (FoO) of dust events, with dust optical depth exceeding 0.1, derived from MODIS Deep Blue C6.1 Level 2 data following the methodology of Ginoux et al. (2012), is illustrated in Figure 2. The FoO provides an overall estimate of dust emission frequency above a certain threshold at a resolution of 0.1º by 0.1º over the region. Sediment samples were collected from various locations within the Mojave Desert region, including areas with relatively high FoO (see locations in Figures 1 and 2). Among these locations is Soda Lake and its surroundings, near Baker, CA, which is linked to Silver Lake to the north and is surrounded by igneous, volcanic, and carbonate rocks, as well as dune fields to the south (Figure 1). The area is influenced by aeolian, alluvial, and fluvial processes and experiences annual precipitation of 80-100 mm (Urban et al., 2018). This ephemeral lake contains salts resulting from the evaporation of groundwater sourced from an aquifer nestled in the Zzyzx Mountains (Honke et al., 2019). Dust emissions are a recurrent phenomenon, originating from fine sediments accumulated in the lake's central areas during sporadic floodings, from the white evaporite surfaces in the lake, and from the alluvial deposits to the south of the playa lake (Urban et al., 2018). According to the FoO, the areas with higher dust emissions are the southern part of the lake and the alluvial deposits to the southwest, extending up to Afton Canyon.*

Samples were also collected from the Cronese lakes, Mesquite Lake, Ivanpah Lake and Coyote Lake (Figure 1), which lie in areas with significant FoO signals (Figure 2) and have been documented as dust sources in Reheis & Kihl (1995) and Reheis et al. (2009). The Cronese lakes are adjacent to the Soda Lake area to the west, sharing a similar geologic context (Figures 1 and 2). Mesquite Lake, located on the border between California and Nevada, is encircled by carbonate and igneous rocks, mirroring the geological setting of the nearby Ivanpah Lake. Notably, Mesquite Lake playa is the only playa affected by a gypsum mine pit, as documented by Reynolds et al. (2009). Further contributing to the diversity of the region's geological makeup is Coyote Lake, flanked by Miocene and Pleistocene sediments. These playa lakes, characterized as endorheic ephemeral lakes, receive groundwater inputs in some cases, enriching the lakes with salts that subsequently precipitate on the surfaces of their central regions (Whitney et al., 2015; Urban et al., 2018).

Other areas with relatively high FoO not sampled in our study include the Ashford Junction alluvial deposits and the Fort Irwin area, where the northern valley, including Nelson Lake, may be more prone to dust emission due to significant anthropogenic disturbance. It is important to note that the FoO may tend to highlight areas such as playas and their surroundings, where in some cases the most dust per unit area could be produced (Floyd and Gill, 2011; Baddock et al., 2016). However, some alluvial regions may produce more dust overall, despite lower emission rates, due to their greater areal extent (Reheis *and Kihl, 1995; Baddock et al., 2016). Additionally, many other types of dust-producing surfaces active in the Mojave Desert, such as gravel roads, agricultural lands, and recreational off-road tracks, are rarely observed by satellite retrievals (Urban et al., 2018)."*

R#1: 167-169. Suggested re-write (please do not begin a sentence/paragraph with Figure x shows, etc.

As derived from MODIS Deep Blue C6.1 Level 2 data, the regional distribution of the annual Frequency of Occurrence (FoO) of dust events with dust optical depth exceeding 0.1 is illustrated in Figure 2.

Reply: Thanks for the comment, changed as you suggest.

R#1: 209. Suggest minor re-write: …amount of dry ground sample was mixed and dry ground again…

Reply: Thanks for the suggestion, changed.

R#1: 232. …crystalline…, not crystallized.

Reply: Thanks for the suggestion, changed.

R#1: 255. Unclear was is meant by "very reduced dust emissions".

Reply: Many thanks, changed to: "reduce the dust emission potential of the surface"

R#1: 255. ...this, not these

Reply: Many thanks, changed.

R#1: 256-276. Use past tense.

Reply: Thanks, changed.

R#1: 259. … "whereas", not "while" in this usage.

Reply: Thanks for the comment, changed.

R#1: 261-262. Averaged FDPSDs and MDPSDs of aeolian ripples from the Mojave Desert were similar, typically featuring a major size mode between 100-300 µm.

Reply: Many thanks for the suggestion, changed.

R#1: 283. "relatively small" is subjective. What are the actual differences?

Reply: Thanks, changed to: "almost 2 times coarser."

R#1: 299-300. How (or by whom) was this interpretation made?

Reply: Our interpretation is based on the observation that particle diameter decreases from the mountains towards the center of the playa lake. Given that sediment transport is predominantly from the mountains to the lowlands, we infer that this decrease in particle diameter results from the size segregation of the coarser particles along the transport pathway. This trend is consistent with findings from other regions, such as Morocco and Iceland, as reported by González-Romero et al. (2023, 2024), and with previous studies in riverine environments, such as Ferdowski et al. (2017). To enhance clarity, we have revised the text to read:

"The slight particle size segregation, with finer particles accumulating towards the center of the lake, can be attributed to the transport of sediments from the surrounding mountains to the lake's center by runoff waters during rain episodes. Initially, the coarser particles are deposited, followed by the finer particles that remain suspended in the water for a longer duration."

Ferdowsi, B., Ortiz, C. P., Houssais, M., & Jerolmack, D. J.: River-bed armouring as a granular segregation phenomenon. Nature communications, 8(1), 1363, 2017.

González-Romero, A., González-Florez, C., Panta, A., Yus-Díez, J., Reche, C., Córdoba, P., Moreno, N., Alastuey, A., Kandler, K., Klose, M., Baldo, C., Clark, R.N., Shi, Z.B., Querol, X., Pérez García-Pando, C.: Variability in grain size, mineralogy, and mode of occurence of Fe in surface sediments of preferential dust-source inland drainage basins: The case of the Lower Drâa Valley, S Morocco. Atmos. Chem. Phys., 23, 15815–15834, https://doi.org/10.5194/acp-23-15815-2023, 2023.

González-Romero, A., González-Florez, C., Panta, A., Yus-Díez, J., Córdoba, P., Alastuey, A., Moreno, N., Kandler, K., Klose, M., Clark, R.N., Ehlmann, B.L., Greenberger, R., Keebler, A.M., Brodick, P., Green, R., Querol, X., Pérez García-Pando, C.: Probing Iceland's Dust-Emitting Sediments: Particle Size Distribution, Mineralogy, Cohesion, Fe Mode of Occurrence, and Reflectance Spectra Signatures. Atmospheric Chemistry and Physics. EGUSPHERE [Preprint], 2024.

R#1: 302-304. It has not been shown in this manuscript that mineralogy of crusts and ripples have identified dust source markers.

Also, “size fractionation processes” have not been described in any detail.

Reply: many thanks for your suggestion, we changed the intro of the section 3.2 for a better description of the content.

R#1: 305-314. This study did not analyze actual emitted dust. Mineral abundances were determined on heavily treated bulk samples that did not appear to represent dust. In addition, crust types, mineral compositions, and strengths can and do vary greatly and sometimes very quickly depending on the factors of wetting/drying of surfaces and more. Because emissivity and dust properties can be variable under certain recurrent conditions, a snapshot in time with one collection may not represent all important aspects of dust emissivity and properties.

Reply: Thank you for your feedback. As explained above, we have added new results to the manuscript that provide detailed mineralogical composition across a variety of size ranges, along with enrichment factors by size relative to the bulk dust (see Supplement and new Figure 6). While we acknowledge that sample characteristics can vary within locations, we firmly believe our data represents broadly important aspects of dust emissivity and properties. Furthermore, the samples analyzed in this paper will also be combined with the in-situ reflectance spectra measurements, whose analysis will provide valuable input for remote spectroscopy evaluation and dust modelling efforts. This integration enhances the relevance and applicability of our findings for atmospheric scientists and modelers working on dust emission and climate impact studies.

R#1: 322. Soda Lake is not a hotspot. Please see comments above.

Reply: Thank you for the feedback. We agree that the center of the Soda Lake, with its Na-salt crusts, has limited potential for dust emission. However, our consideration of the Soda Lake extends beyond its center to include the surrounding areas and alluvial fans. These areas are more prone to dust emission under specific conditions, such as soil humidity, crust depth, and wind conditions. Based on your suggestion and previous comments, we have revised the terminology from "hotspot" to the more appropriate "potential dust-emitting basin."

R#1: 376. Delete “presence”.

Reply: Thanks, changed for:

“Zeolites contents may be…”

R#1: 395. What is meant by “top sediment”, here and elsewhere?

Reply: Thank you for your comment. We used the term "top sediment" to describe the surface sediments in Iceland, where the lack of cohesive minerals, such as secondary minerals, clays, and Na-salts, results in non-crusted surfaces. Using the term "crust" might cause confusion for readers. Therefore, we referred to these low-cohesion surface sediments as "top sediment," which we found more descriptive than "crusts." For clarification, we will updated lines 540 and 602 to read: "top sediment (loose surface sediments in Iceland according to González-Romero et al. (2024))."

R#1: 438-440. Please see comments about Mesquite Lake playa in the foregoing. This setting is not a good example of a disturbed playa. Only a small fraction has been disturbed. And I don’t find evidence in this manuscript that the mined portion is a significant dust producer.

Reply: As answered in previous comments, we addressed the Mesquite lake dust production and its relationship to undisturbed areas in the margins of the lake instead to the mine in the centre.

R#1: 443. The water table does not supply salts. Direct evaporation or vapor discharge from the water table might.

Reply: Many thanks for the comment. We rephased as: “At Soda Lake, a hard crust measuring up to 0.5 meters in thickness (Figure 3), forms through the extensive precipitation of Na-salts, particularly near the Zzyzx area, where a relatively constant mobilisation of salts is due to the water table evaporation or vapour discharge from deeper parts of the sediment towards surface (Nield et al., 2015, 2016a and b).”

I recommend incorporating the compositional property findings presented in the following articles with citations to provide a much fuller picture of Mojave dust mineralogy, PSD, other properties, and emissivity. The studies by Nield et al. are also highly relevant to playa-surface dynamics and dust emission.

Reply: Many thanks for the suggested references. They help to enhance the background of the manuscript, providing additional context and support for the key aspects discussed. Incorporating these references strengthens the foundation of our study and ensures a more comprehensive understanding of the subject matter.

Buck, B.J., King, J. and Etyemezian, V., 2011. Effects of salt mineralogy on dust emissions, Salton Sea, California. *Soil Science Society of America Journal*, *75*(5), pp.1971-1985.

Reheis, M.C., Budahn, J.R., Lamothe, P.J. and Reynolds, R.L., 2009. Compositions of modern dust and surface sediments in the Desert Southwest, United States. *Journal of Geophysical Research: Earth Surface*, *114*(F1).

Reheis, M.C., Goodmacher, J.C., Harden, J.W., McFadden, L.D., Rockwell, T.K., Shroba, R.R., Sowers, J.M. and Taylor, E.M., 1995. Quaternary soils and dust deposition in southern Nevada and California. *Geological Society of America Bulletin*, *107*(9), pp.1003-1022.

Reheis, M.C. and Kihl, R., 1995. Dust deposition in southern Nevada and California, 1984–1989: Relations to climate, source area, and source lithology. *Journal of Geophysical Research: Atmospheres*, *100*(D5), pp.8893-8918.

Reheis, M.C., Budahn, J.R. and Lamothe, P.J., 2002. Geochemical evidence for diversity of dust sources in the southwestern United States. *Geochimica et Cosmochimica Acta*, *66*(9), pp.1569-1587.

Reheis, M.C., 1997. Dust deposition downwind of Owens (dry) Lake, 1991–1994: Preliminary findings. *Journal of Geophysical Research: Atmospheres*, *102*(D22), pp.25999-26008.

Reynolds, R.L., Yount, J.C., Reheis, M., Goldstein, H., Chavez Jr, P., Fulton, R., Whitney, J., Fuller, C. and Forester, R.M., 2007. Dust emission from wet and dry playas in the Mojave Desert, USA. *Earth Surface Processes and Landforms: The Journal of the British Geomorphological Research Group*, *32*(12), pp.1811-1827.

Reynolds, R.L., Reheis, M., Yount, J. and Lamothe, P., 2006. Composition of aeolian dust in natural traps on isolated surfaces of the central Mojave Desert—Insights to mixing, sources, and nutrient inputs. *Journal of Arid Environments*, *66*(1), pp.42-61.

Urban, F.E., Goldstein, H.L., Fulton, R. and Reynolds, R.L., 2018. Unseen dust emission and global dust abundance: Documenting dust emission from the Mojave Desert (USA) by daily remote camera imagery and wind-erosion measurements. *Journal of Geophysical Research: Atmospheres*, *123*(16), pp.8735-8753.

“In its geomorphology and surficial sediment, the Soda Lake basin is similar to many other dry-lake and ***associated alluvial settings*** *known to emit dust in the Mojave Desert …. Moreover, many other types of dust sources are active in the Mojave Desert, including broad, open alluvial fans and drainages, agricultural lands, military bases (heavy-vehicle training centers), dirt and gravel roads, and recreational areas for off-road vehicles. Dust emissions from these settings are only rarely observed in satellite retrievals.”*

Reply: Added in line 191 to 193: “Moreover, many other types of dust surfaces that are active in the Mojave Desert as gravel roads, agricultural lands, recreational off road tracks, among others, and these are rarely observed by satellite retrievals (urban et al., 2018).”

Nield, J.M., Bryant, R.G., Wiggs, G.F., King, J., Thomas, D.S., Eckardt, F.D., and Washington, R., 2015. The dynamism of salt crust patterns on playas. *Geology*, *43*(1), pp.31-34.

Nield, J.M., Neuman, C.M., O'Brien, P., Bryant, R.G., and Wiggs, G.F., 2016. Evaporative sodium salt crust development and its wind tunnel derived transport dynamics under variable climatic conditions. *Aeolian Research*, *23*, pp.51-62.

Nield, J.M., Wiggs, G.F., King, J., Bryant, R.G., Eckardt, F.D., Thomas, D.S. and Washington, R., 2016. Climate–surface–pore-water interactions on a salt crusted playa: implications for crust pattern and surface roughness development measured using terrestrial laser scanning. *Earth Surface Processes and Landforms*, *41*(6), pp.738-753.

Some recent articles associating atmospheric processing of Fe (Ti) oxides to ocean fertilization.

Hettiarachchi, E. et al., 2019. Bioavailable iron production in airborne mineral dust: Controls by chemical composition and solar flux. *Atmospheric environment*, *205*, pp.90-102.

Hettiarachchi, E. et al., 2020. Atmospheric processing of iron-bearing mineral dust aerosol and its effect on growth of a marine diatom, Cyclotella meneghiniana. *Environmental Science & Technology*, *55*(2), pp.871-881.

Reply: Many thanks for these two references. Both has been added to line 87.

REFEREE #2

Many thanks for your valuable and helpful comments, which have contributed to improve the quality of our manuscript. Please find below our answers to your comments and an explanation of the changes in the revised version of the manuscript (text in blue).

R#2: This well-written manuscript presents observations of the Mojave desert, especially including particle size distributions and mineralogy and iron mode of occurrence characterization. The authors identify segregation patterns in PSD and mineralogy difference within the Mojave basins, relevant to understand dust emission dynamics and properties of emitted dust in such regions.

Reply: Thank you for your comments and suggestions. Your feedback has helped improving the quality and clarity of our manuscript.

GENERAL COMMENTS

R#2: Although the presented observations are highly informative and relevant, some changes to the discussion could, in my opinion, help increase the applicability and the impact of the presented findings. Firstly, the differences in properties at sampling locations and the dynamics (mostly related to ground water) are discussed, but it is hard to get an overview of their occurrence due to the different map types and lack of information on topography. The relationship to dust emissions does not become clear. The manuscript could benefit from a final spatial overview indicating the location of different dust source types (not just sampling points) and a comparison to the AOD shown in figure 2. Do the dust properties explain the spatial variability of AOD or is meteorology important as well? A map of the dust source types and a discussion on dust emissions/airborne dust can help implement such findings in dust emission models.

We appreciate your feedback and suggestions for enhancing the discussion section to increase the applicability and impact of our findings:

1) Spatial Overview and Topography: We understand the importance of providing a comprehensive understanding of the sampling locations in relation to topography. As you requested, now Figures 1 and 2 both include topographical information to provide context for the location of the dust sources sampled. We have ensured that this information is appropriately highlighted in the text. As you may notice, the highest Frequencies of Occurrence (FoO) of AOD > 0.1 generally correspond to topographic lows where potentially emissive sediments accumulate.

2) Relationship to Dust Emissions and AOD: attempting to directly relate the properties of the sediments to the frequency of occurrence (FoO) of high dust optical depth or to the dust optical depth directly is not appropriate for several reasons. On the one side, the local dust optical depth depends to a large extent on the magnitude of local dust emissions (which in turn strongly depends on wind conditions and other factors) along with some contributions from dust transport from upwind. Our study does not measure dust emissions or meteorology, but the properties of dust sources in the Mojave. Therefore, we refrain from drawing direct conclusions regarding the relationship between sediment properties and AOD in our discussion. We would like to emphasize that despite not being able to link our results to the observed AOD, the data and analyses provided in our paper are key inputs for constraining dust emission models and future evaluation of remote spectroscopy retrievals. Also note that the description of the sampling areas together with the FoO maps has been largely improved in the revised version of the manuscript.

3) Focus on Dust Emissions and Airborne Dust: We focus our discussion on providing insights into the potential implications of our sediment property observations for dust emissions. In contrast to other FRAGMENT campaigns, this one did not involve intensive measurements of the airborne PSD and meteorology in one location. However, in the revised version of the manuscript we added additional analyses by size range. We provide the mineral fractions in the ranges 250-500, 80-250, 63-80, 40-63, 20-40, and <20 µm, which were separated by dry sieving. We added in the Supplement the mineralogical composition in these size ranges for 20 selected samples (16 crusts and 4 ripples, totalling 120 sub-samples). In the main text we included a section summarizing the enrichment factors of each mineral group in each size range with respect to the bulk <2mm samples. We added text and a figure in the main text, and a table in the Supplement.

R#2: Furthermore, the authors choose to compare the observations mostly to observations in the Moroccan Sahara and Iceland. These were part of the same project, but in this manuscript the motivation for this comparison is lacking and hardly informative. I could think of many other regions where dust properties are different. Maybe it is interesting to focus on similar regions and help the reader understand if the conclusions help describe dust properties and emissions elsewhere, or if findings are unique to the Mojave Desert? And are there previous observations in the Mojave Desert that support and complement your current findings?

Reply: Thank you for your valuable feedback. We understand your concern about the significance of comparing the different settings. From the point of view of a soil scientist, it is clear that different bedrock geology and other conditions can lead to variations in sediment mineralogy, particle size distribution (PSD), and aggregation state of surface sediments. However, our paper is largely addressed to atmospheric scientists interfacing with surface properties, and more specifically to dust modelers. Information on the differences in dust source sediments in terms of PSD, mineralogy, Fe mode of occurrence, and aggregation state across different dust sources is key for dust modelling and climate impact studies. Here are the key reasons for including these comparisons:

Diversity of Dust Sources: Models generally assume that the composition of dust from all sources is homogeneous. By comparing regions, such as the volcanic landscapes of Iceland and the arid deserts of the Mojave and Morocco, we aim to provide a perspective of the broad spectrum of sediment characteristics that should be accounted for in global models in the future. Future integration of this diversity should help enhancing the robustness and applicability of dust emission models across various environmental settings.

Remote Sensing Calibration: The inclusion of regions with different mineralogical compositions allows for a more comprehensive calibration of remote sensing instruments. For instance, the spectral signatures of dust from quartz-rich deserts and basaltic terrains differ significantly, and incorporating these variations can improve the accuracy of remote sensing data interpretation.

Global Dust Cycle: Dust from different regions contributes to the global dust cycle, influencing climate, biogeochemical cycles, and human health. By studying and comparing diverse environments, we aim to better help understanding the global implications of dust emissions and their impact on various Earth system components.

Additionally, we provide a consistent comparison among the source regions by applying the same sampling and analysis methods across all our campaigns. This consistency makes our comparisons particularly relevant and valuable for dust modelers and climate scientists.

We have elaborated on these points in the revised manuscript to clarify the significance of our comparative approach and to address the concerns raised.

As stated in previous comments, we include the following text:

Added in 95-112: "*Understanding the mineral composition of dust is also crucial for assessing its climate impact. Dust contains various minerals such as quartz, clay minerals, feldspars, carbonates, salts, and iron oxides. The climate effects of dust are influenced by these minerals' relative abundances, sizes, shapes, and mixing states. For example, iron oxides control solar radiation absorption by dust (Formenti et al., 2014; Engelbrecht et al., 2016; Di Biagio et al., 2019; Zubko et al., 2019), nano Fe oxides and easily exchangeable Fe increase the fertilising effect of dust in ocean and terrestrial ecosystems (Hettiarachchi et al., 2019; Baldo et al., 2020, Hettiarachchi et al., 2020), K-feldspar and quartz impact ice nucleation in clouds (Atkinson et al., 2013; Harrison et al., 2019; Chatziparaschos et al., 2023), and calcite influences acid reactions on dust surfaces (Paulot et al., 2016). The mineralogical composition of dust can vary significantly across different regions due to geological and climatic factors (Claquin et al., 1999; Journet et al., 2014). However, most models assume a globally uniform dust composition due to limited global data on parent soil sources. Only a few models account for dust mineralogical composition variations (e.g., Scanza et al., 2015; Perlwitz et al., 2015; Li et al., 2021; Gonçalves Ageitos et al., 2023; Obiso et al., 2024) by using global soil type atlases and extrapolating from a limited number of analyses (Claquin et al., 1999; Journet et al., 2014). These atlases rely on assumptions about soil texture and color, often base their data on soil samples taken from depths deeper than those relevant to wind erosion, and the method used to characterize particle size and associated mineralogy fully breaks down natural soil aggregates.*"

Added in 113-121: "*Since 2022, the EMIT mission has been acquiring comprehensive measurements of surface mineralogical composition for use in Earth System models (Green et al., 2020). EMIT employs imaging spectroscopy across the visible to short wavelength infrared (VSWIR) spectral range from the*

International Space Station to map the occurrence and estimate the abundance of ten key dust source minerals. Additionally, EMIT has the potential to estimate surface soil texture. While identifying dominant surface minerals has traditionally been a strength of spectrometers, quantifying these minerals poses significant challenges. Factors such as mineral grain size and composition can affect spectral absorptions, certain dominant materials like quartz and feldspar exhibit minimal absorption features, and the presence of other materials can further complicate the analysis."

Added in 122-138: *"Overall, there is a notable lack of comprehensive measurements characterizing relevant properties of surface sediments in dust source regions. This gap hampers our ability to evaluate and constrain mineral abundance derived from reflectance spectroscopy and to improve dust emission modeling. Addressing this issue, the FRontiers in dust minerAloGical coMposition and its Effects upoN climaTe (FRAGMENT) project has, over recent years, conducted a series of coordinated and interdisciplinary field campaigns across remote dust source regions. The project's objectives include enhancing the understanding and quantification of dust-source properties, examining their relationship with emitted dust characteristics, refining spaceborne spectroscopy retrievals of surface minerals (Green et al., 2020, Clark et al., 2024), and improving the representation of dust mineralogy in Earth system models (Perlwitz et al., 2015; Li et al., 2021; Gonçalves et al., 2023; Obiso et al., 2023). The FRAGMENT field campaigns involved regional sediment sampling in several regions and detailed wind erosion and dust emission measurements at selected sites. Studies stemming from these activities include those by González-Romero et al. (2023), González-Flórez et al. (2023), and Panta et al. (2023), and González-Romero et al. (2024). These campaigns have been executed in various geographic locations, such as the Moroccan Sahara (2019), Iceland (2021), the Mojave Desert in the United States (2022), and Jordan (2022). Through these efforts, the FRAGMENT project contributes to filling critical knowledge gaps in dust-source characterization."*

Also note that our manuscript includes and refers to the majority of previous studies in the region.

SPECIFIC COMMENTS

R#2: Section 2.2: Could you please add some discussion on how representative these different sample types are for the region? E.g. how much of the area is covered with crusts or ripples?

Reply: Thanks for your comment. To comprehensively characterize the all the dust-emitting sources in the Mojave Desert, a large-scale research project would be necessary. As stated in the text, our samples do not represent all potential dust-emitting regions in the Mojave. However, our study demonstrates that Frequency of Occurrence (FoO) maps effectively reflect dust emissions from the sampled basins. We have included new references, such as those by Reynolds et al., to support the significance of dust emissions from these basins. Additionally, we have revised the title to better reflect the study's scope and findings.

"CHARACTERIZATION OF THE PARTICLE SIZE DISTRIBUTION, MINERALOGY AND FE MODE OF OCCURRENCE OF DUST-EMITTING SEDIMENTS FROM THE MOJAVE DESERT, CALIFORNIA, USA" (eliminating ACROSS the Mojave change)

R#2: Section 3.1: How do observed PSD of samples relate to PSD of emitted dust?

Reply: Many thanks for your suggestion, we do not have measurements from the PSD of emitted dust in the region. Therefore, we did not include a comparison with fresh emitted dust in the region. However, as highlighted above, in the revised version of the manuscript we provide the mineral fractions in the ranges 250-500, 80-250, 63-80, 40-63, 20-40, and <20 µm, which were separated by dry sieving. We added in the Supplement the mineralogical composition in these size ranges for 20 selected samples (16 crusts and 4 ripples, totalling 120 sub-samples). In the main text we included a section summarizing the enrichment factors of each mineral group in each size range with respect to the bulk <2mm samples. We added text and a figure in the main text, and a table in the Supplement.

R#2: Section 3.2: Do you expect similar mineralogy of emitted dust or is it likely that mineralogy will be shifted because some aggregates are more susceptible to emission.

Reply: Thank you for your suggestion. As recommended by Reviewer 1, we have added a section on Particle Size Distribution (PSD) and mineralogy of the dry sieved size fractions. Our analysis shows that the PSD primarily consists of aggregates, as supported by the comparison between the FDPSD and the MDPSD. Additionally, the mineralogy appears to be more size-fractionated in the ripples than in the crusts. This suggests that aggregate formation homogenizes the mineralogy of the size fractions, resulting in emitted dust from crusts (comprising both single particles and aggregates) being homogenized as well. However, some slight enrichments and depletions are observed in the mineralogy of the finer fractions (20-40 µm and <20 µm).

R#2: Line 277-287: It is not clear from the manuscript why this comparison to observations in Morocco and Iceland is relevant here. A comparison of observations to previous field campaigns in the Mojave desert would be useful.

Reply: Many thanks for your suggestion. As in the previous comments, we understand your concern about the importance of comparing to other regions. As mentioned in previous comments, information on the differences in dust source sediments in terms of PSD, mineralogy, Fe mode of occurrence, and aggregation state across different dust sources is key for dust modelling and climate impact studies.

We added in 113-121: *"Since 2022, the EMIT mission has been acquiring comprehensive measurements of surface mineralogical composition for use in Earth System models (Green et al., 2020). EMIT employs imaging spectroscopy across the visible to short wavelength infrared (VSWIR) spectral range from the International Space Station to map the occurrence and estimate the abundance of ten key dust source minerals. Additionally, EMIT has the potential to estimate surface soil texture. While identifying dominant surface minerals has traditionally been a strength of spectrometers, quantifying these minerals poses significant challenges. Factors such as mineral grain size and composition can affect spectral absorptions, certain dominant materials like quartz and feldspar exhibit minimal absorption features, and the presence of other materials can further complicate the analysis."*

Added in 122-138: *"Overall, there is a notable lack of comprehensive measurements characterizing relevant properties of surface sediments in dust source regions. This gap hampers our ability to evaluate and constrain mineral abundance derived from reflectance spectroscopy and to improve dust emission modelling. Addressing this issue, the FRontiers in dust minerAloGical coMposition and its Effects upoN climaTe (FRAGMENT) project has, over recent years, conducted a series of coordinated and interdisciplinary field campaigns across remote dust source regions. The project's objectives include enhancing the understanding and quantification of dust-source properties, examining their relationship with emitted dust characteristics, refining spaceborne spectroscopy retrievals of surface minerals (Green et al., 2020, Clark et al., 2024), and improving the representation of dust mineralogy in Earth system models (Perlwitz et al., 2015; Li et al., 2021; Gonçalves et al., 2023; Obiso et al., 2023). The FRAGMENT field campaigns involved regional sediment sampling in several regions and detailed wind erosion and dust emission measurements at selected sites. Studies stemming from these activities include those by González-Romero et al. (2023), González-Flórez et al. (2023), and Panta et al. (2023), and González-Romero et al. (2024). These campaigns have been executed in various geographic* *locations, such as the Moroccan Sahara (2019), Iceland (2021), the Mojave Desert in the United States (2022), and Jordan (2022). Through these efforts, the FRAGMENT project contributes to filling critical knowledge gaps in dust-source characterization."*

R#2: Line 429/435; I would suggest using 'interactions' between groundwater and crust formation, rather than relationship. Also, I think the discussion on differences between Mojave Desert and glacier forefields should include the repeated deposition of new sediments by flooding in contrast to the salt enrichment and effects on porosity by the shifting groundwater, if I understand the presented concepts correctly.

Reply: Many thanks for the comment. We changed the words influence and interaction for relation and relationship to make more clear the topic and make easier to read.

R#2: Figure 1: Please add height contours to emphasize the playa lake extents and help understand the concepts in figures 7/10.

Reply: Changed, thanks a lot for the comment.

R#2: Figure 2; Showing the gridded map rather than iso-contours should give a better representation of the observations. Only add the arrows for places also indicated in Figure 1 (i.e. no need for Los Angeles).

Reply: Changed, thanks for the suggestion.

R#2: Figure 5: I find the colours confusing and would suggest using blue for all crust observations vs red for all ripple observations.

Reply: Changed, many thanks.

R#2: Figure 7: Legend is incomplete.

Reply: Changed, many thanks for the comment.

R#2: Figure 10: shouldn't there be a larger difference in the amount of emitted dust in these examples?

Reply: Changed, many thanks for the comment, it helps to understand the examples.