Article title:

Liquefaction and related ground failures from July 2019 Ridgecrest Earthquake Sequence

Author names:

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Description of the Supplemental Material:

Table S1 lists the locations of liquefaction and other ground failure features observed during post-earthquake event reconnaissance by CGS, USGS, and US Navy teams. These features are grouped based on geographic location within the base property; Paxton Ranch, southern end of China Lake Playa, and Salt Wells Valley. Figures S1-S17 show ground and/or aerial photos of observations listed in Table S1. Figures S18 and S19 show track logs of reconnaissance missions along with DPMs and USGS liquefaction hazard maps. Figure S20 shows lateral displacement features along Argus Transect AT1. Figure S21 shows a damaged railroad track area in Argus. Figure S22 shows an overview of the Searles Lake area and identifies DPM-based priority zones selected prior to field deployment.

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Table S1: Locations of liquefaction features observed during post-earthquake event reconnaissance by CGS, USGS, and US Navy teams.

List of Supplemental Figure Captions:

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Figure S2: Sand boil in the Paxton Ranch area on 7/10/2019. Lat. 35.807216°, Lon. -117.642838°. Photo 8320 credit B. Olson, CGS.

Figure S3: Lateral spread features in the Paxton Ranch area on 7/6/2019. Curved, discontinuous zone of disturbed lateral spread cracks with vertical displacement. Observations made from about 150m above the ground surface during helicopter overflight. Lat. 35.807064°, Lon. -117.635664°. Photo 1241 credit M. DeFrisco, CGS.

Figure S4: Lateral spread features in the Paxton Ranch area on 7/6/2019. Curved, discontinuous zone of disturbed lateral spread cracks with vertical displacement. Some cracks highlighted by seepage. Observations made from about 150 m above the ground surface during helicopter overflight. Lat. 35.806699°, Lon. -117.636770°. Photo 1268 credit M. DeFrisco, CGS.

Figure S5: Lateral spread features in the Paxton Ranch area on 7/6/2019. Curved, discontinuous zone of disturbed lateral spread cracks in foreground. Observations made from helicopter overflight. Lat. 35.810333°, Lon. -117.638333°. Photo 1294 credit M. DeFrisco, CGS.

Figure S6: Large spring adjacent to edge of playa. Seepage generated from strong shaking in the Paxton Ranch area on 7/6/2019. Observations made from helicopter overflight 2019. Lat. 35.801238°, Lon. -117.617693°. Photo 2029 credit M. DeFrisco, CGS.

Figure S7: Lateral spread in the Central area - Southeast end of China Lake on 7/6/2019. Discontinuous distributed lateral spread cracks. Ponded water collected in ephemeral drainages across playa. Observations made from helicopter overflight. Lat. 35.730889°, Lon. -117.581806°. Photo 2228 credit M. DeFrisco, CGS.

Figure S8: Liquefaction sand boils within Central area - southeast end of China Lake on 7/6/2019. Smaller sand boil to the left approximately 2 m diameter opening, larger on the right approximately 4 m opening. Lat. 35.733005°, Lon. -117.581745°. Photo 2266 credit J. Hernandez, CGS.

Figure S9: Ruptured water line Central area - southeast end of China Lake on 7/6/2019. Rupture generated from surface rupture across pipeline. Lat. 35.725442°, Lon. -117.574290°. Photo 1539 credit J. Hernandez, CGS.

Figure S10: Lateral spread cracks in the Central area - southeast end of China Lake on 7/6/2019. Cracks near area of detention basin near distal edge of alluvial fan. Lat. 35.724154°, Lon. -117.567795°. Photo 1910 credit M. DeFrisco, CGS.

Figure S11. (a) Sand boils on the south-eastern edge of the China Lake playa, observed after the **M** 7.1 event; (b) fossilized gastropod shells found in the ejecta (bottom portion of Figure S11a, towards the edges of the ejecta). Lat. 35.71504167°, Lon. -117.595000°. Photo 0139 credit US Navy.

Figure S12: Sand boils within the Salt Wells Valley on 7/12/2019. Area has small sand boils and lateral spread features, located along the **M** 6.5 surface rupture. Extent of sand ejecta approximately 50 cm diameter. Lat. 35.661949°, Lon. -117.520229°. Photo 6795 credit T. Dawson, CGS.

Figure S13: Liquefaction springs along **M** 6.5 surface rupture within Salt Wells Valley on 7/12/2019. Lat. 35.666544°, Lon. -117.515341°. Photo 6801 credit T. Dawson, CGS.

Figure S14: Lateral spread extending into Salt Wells creek, with three circular pits near the center of the frame, generated from **M** 6.5 event. Photo taken 7/5/2019 during overflight observations after **M** 6.5 event. Lat. 35.661797°, Lon. -117.519150°. Photo 0156 credit K. Hudnut, USGS.

Figure S15: Parallel set of lateral spread cracks and small sand boils within the Salt Wells Valley. Features generated from the **M** 7.1 event. Lat. 35.656551°, -117.491037°. Photo 0448 credit J. Patton, CGS.

Figure S16: Parallel set of lateral spread cracks and small sand boils within the Salt Wells Valley. Features generated from the **M** 7.1 event. Lat. 35.656551°, -117.491037°. Photo 0454 credit J. Patton, CGS.

Figure S17: Lateral spread along banks of Salt Wells Valley. Active creek bank free-face failure due to seismic shaking from **M** 7.1 event. Lat. 35.651326°, -117.485338°. Photo 0408 credit J. Patton, CGS.

Figure S18: Track logs of the USGS-CGS-US Navy helicopter flights, GEER team, and NASA-supported team, along with the DPM produced following the **M** 7.1 mainshock.

Figure S19: Track logs of the USGS-CGS-US Navy helicopter flights, GEER team, and NASA-supported team, along with the USGS liquefaction hazard map produced following the **M** 7.1 mainshock.

Figure S20: Example Photograph of lateral displacement features along Argus Transect AT1. Lat. 35.744538°, Lon -117.396016°.

Figure S21 (a, b): Photographs of damaged railroad track area in Argus. Lat. 35.7495°, Lon -117.3903°.

Figure S22: Priority zones identified within Searles Lake.

Table S1. Locations of liquefaction and other ground failure features observed during post-earthquake event reconnaissance by CGS, USGS, and US Navy teams.

North Dry Lakebed Area – Paxton Ranch – AREA A				
Figure	**Latitude (degrees)**	**Longitude (degrees)**	**Observation description**	**Observation type**
S1	35.809808°	-117.634767°	Lateral spread meandering cracks, post **M** 7.1, Photo 8331	Lateral spread
S2	35.807216°	-117.642838°	Sand boils - N15W fissure trend, with second fissure about 25 m to SW, post **M** 7.1, Photo 8320	Sand boil
S3	35.807064°	-117.635664°	Lateral spread features – helicopter reconnaissance, post **M** 7.1, Photo 1241	Lateral spread
S4	35.806699°	-117.636770°	Lateral spread features – helicopter reconnaissance, post **M** 7.1, Photo 1268	Lateral spread
NA	35.807125°	-117.638558°	Sand boil in area of lateral spread, post **M** 7.1, no photo	Lateral spread and sand boil
NA	35.799415°	-117.645474°	Spring-expulsion of water - lacking blow sediments, post **M** 7.1, no photo	Spring
NA	35.802661°	-117.630001°	Discontinuous zones of Lateral spread in Dry Lake, post **M** 7.1, no photo	Lateral spread
S5	35.810333°	-117.638333°	Lateral spread features – helicopter reconnaissance, post **M** 7.1, Photo 1294	Lateral spread
NA	35.794489°	-117.615534°	Lateral spread zone, post **M** 7.1, no photo	Lateral spread
S6	35.801238º	-117.617693º	Large spring along edge of playa, post **M** 7.1, Photo 2029	Spring
NA	35.77653°	-117.6276°	Pre-existing ephemeral feature that experienced renewed activity from **M** 7.1 based on review of Google Earth series of historical imagery	Spring

North Dry Lakebed Area – Paxton Ranch – AREA A cont.				
Figure	**Latitude (degrees)**	**Longitude (degrees)**	**Observation description**	**Observation type**
NA	35.7736°	-117.6387°	Pre-existing ephemeral feature that experienced renewed activity from **M** 7.1 based on review of Google Earth series of historical imagery	Spring
NA	35.7851°	-117.6451°	Pre-existing ephemeral feature that experienced renewed activity from **M** 7.1 based on review of Google Earth series of historical imagery	Spring
NA	35.78603°	-117.6467°	Pre-existing ephemeral feature that experienced renewed activity from **M** 7.1 based on review of Google Earth series of historical imagery	Spring
Central Area – Southeast end of China Lake – AREA B				
S7	35.730889°	-117.581806°	Lateral spread zone, post **M** 7.1, Photo 2228	Lateral spread
S8	35.733005°	-117.581745°	Two large sand boils, one approximately 4 m diameter, the other approximately 2 m diameter opening, post **M** 7.1. Sand ejecta dimensions approximately 40 m by 28 m on larger, and 18 m by 16 m on the smaller sand boil, based on measurements from Google Earth imagery dated 7/13/2019, Photo 2266	Sand boil
S9	35.725442°	-117.574290°	Ruptured water pipeline, post **M** 7.1, Photo 1539	Damaged pipeline
NA	35.80666°	-117.6356°	Lateral spread – helicopter reconnaissance, post **M** 7.1, no photo	Lateral spread
NA	35.80785°	-117.6353°	Lateral spread – helicopter reconnaissance, post **M** 7.1, no photo	Lateral spread

Central Area – Southeast end of China Lake – AREA B cont.				
Figure	**Latitude (degrees)**	**Longitude (degrees)**	**Observation description**	**Observation type**
NA	35.8083°	-117.6338°	Lateral spread – helicopter reconnaissance, post **M** 7.1, no photo	Lateral spread
NA	35.80646°	-117.6366°	Lateral spread – helicopter reconnaissance, post **M** 7.1, no photo	Lateral spread
NA	35.80895°	-117.6377°	Lateral spread – helicopter reconnaissance, post **M** 7.1, no photo	Lateral spread
NA	35.81117°	-117.6391°	Lateral spread – helicopter reconnaissance, post **M** 7.1, no photo	Lateral spread
NA	35.80983°	-117.6349°	Lateral spread – helicopter reconnaissance, post **M** 7.1, no photo	Lateral spread
NA	35.80233°	-117.6187°	Springs along edge of playa, helicopter reconnaissance, post **M** 7.1, no photo	Spring
NA	35.80174°	-117.6187°	Springs along edge of playa, helicopter reconnaissance, post **M** 7.1, no photo	Spring
NA	35.80055°	-117.6185°	Springs along edge of playa, helicopter reconnaissance, post **M** 7.1, no photo	Spring
NA	35.736973°	-117.604216°	Ring fractures around outer edge of sewage treatment pump building excavation, appears related to backfill settlement. Pumping water evidence sprayed up around outside of foundation. Structure did not appear to be affected by potential differential settlement, post **M** 7.1, no photo, J. Hernandez personal observation	Settlement
S10	35.724154°	-117.567795°	Lateral spread rupture – detention basin area, post **M** 7.1, Photo 1910	Lateral spread

Central Area – Southeast end of China Lake – AREA B cont.				
Figure	**Latitude (degrees)**	**Longitude (degrees)**	**Observation description**	**Observation type**
NA	35.714692°	-117.593583°	Springs – post **M** 7.1 based on review of Google Earth imagery dated 7/13/2019. Spring located along bedrock/alluvium contact	Spring
NA	35.71423°	-117.5996°	Springs – post **M** 7.1 based on review of Google Earth imagery dated 7/13/2019. Spring located along bedrock/alluvium contact	Spring
NA	35.71296°	-117.5986°	Springs – post **M** 7.1 based on review of Google Earth imagery dated 7/13/2019. Spring located along bedrock/alluvium contact	Spring
NA	35.71473°	-117.5956°	Springs – post **M** 7.1 based on review of Google Earth imagery dated 7/13/2019. Spring located along bedrock/alluvium contact	Spring
NA	35.71431°	-117.5922°	Springs – post **M** 7.1 based on review of Google Earth imagery dated 7/13/2019. Spring located along bedrock/alluvium contact	Spring
NA	35.71474°	-117.5901°	Spring post **M** 7.1, based on review of Google Earth imagery dated 7/13/2019	Spring
NA	35.72637°	-117.6687°	Spring post **M** 7.1, based on review of Google Earth imagery dated 7/13/2019	Spring
NA	35.72483°	-117.6745°	Spring post **M** 7.1, based on review of Google Earth imagery dated 7/13/2019	Spring
NA	35.72939°	-117.625°	Sand boil post **M** 7.1. Opening is about 2.5m diameter, based on review of Google Earth imagery dated 7/13/2019	Sand boil
NA	35.72717°	-117.5992°	Sand boil post **M** 7.1, based on review of Google Earth imagery dated 7/13/2019	Sand boil

Central Area – Southeast end of China Lake – AREA B cont.				
Figure	**Latitude (degrees)**	**Longitude (degrees)**	**Observation description**	**Observation type**
NA	35.72665°	-117.5991°	Sand boil from **M** 7.1 event, based on review of Google Earth imagery dated 7/13/2019	Sand boil
NA	35.72575°	-117.5984°	Spring post **M** 7.1 based on review of Google Earth imagery dated 7/13/2019	Sand boil
NA	35.72495°	-117.5981°	Sand boil about 5 m in opening diameter post **M** 7.1 based on review of Google Earth imagery dated 7/13/2019	Sand boil
NA	35.72347°	-117.5975°	Spring post **M** 7.1 based on review of Google Earth imagery dated 7/13/2019	Spring
NA	35.71468°	-117.603°	Spring post **M** 7.1 based on review of Google Earth imagery dated 7/13/2019	Spring
NA	35.7052°	-117.637°	Pre-existing ephemeral spring that experienced renewed activity as a result of the **M** 7.1 event, based on review of historical Google Earth imagery	Spring
NA	35.70586°	-117.6329°	Cluster of springs that experienced renewed activity post **M** 7.1 based on review of historical Google Earth imagery	Spring
NA	35.70705°	-117.6386°	Pre-existing ephemeral spring that experienced renewed activity as a result of the **M** 7.1 event, based on review of historical Google Earth imagery	Spring
NA	35.70811°	-117.6398°	Spring from **M** 7.1 event based on review of Google Earth imagery dated 7/13/2019	Spring
NA	35.6853°	-117.6183°	Cluster of springs that experienced renewed activity post **M** 7.1 based on review of historical Google Earth imagery	Spring

Central Area – Southeast end of China Lake – AREA B cont.				
Figure	**Latitude (degrees)**	**Longitude (degrees)**	**Observation description**	**Observation type**
NA	35.68082°	-117.621°	Pre-existing ephemeral spring that experienced renewed activity as a result of the **M** 7.1 event, based on review of historical Google Earth imagery	Spring
NA	35.698369°	-117.626946°	Lateral spread feature reported by US Navy personnel - not observed directly, post **M** 7.1, no photo	Lateral spread
NA	35.690585°	-117.620000°	Lateral spread feature reported by US Navy personnel - not observed directly, post **M** 7.1, no photo	Lateral spread
NA	35.680830°	-117.640556°	Lateral spread feature reported by US Navy personnel - not observed directly, post **M** 7.1, no photo	Lateral spread
S11	35.71504167°	-117.595000°	Sand boils and fossilized gastropod shells found in the ejecta, from **M** 7.1 event, reported by US Navy personnel, Photo 0139	Sand boil
Southern Area – Salt Wells Valley – AREA C				
S12	35.661949°	-117.520229°	Sand boils observed near **M** 6.5 surface rupture, post **M** 7.1, Photo 6795	Sand boil
S13	35.666544°	-117.515341°	Liquefaction-related springs along **M** 6.5 surface rupture, post **M** 7.1, Photo 6801	Spring
S14	35.661797°	-117.519150°	Lateral spread cracks and three circular pits from **M** 6.5 event – Salt Wells creek, Photo 0156	Lateral spread
S15	35.656551°	-117.491037°	Parallel set of lateral spread cracks and small sand boils – Salt Wells valley, post **M** 7.1, Photo 0448	Lateral spread and sand boil

Southern Area – Salt Wells Valley – AREA C cont.				
Figure	**Latitude (degrees)**	**Longitude (degrees)**	**Observation description**	**Observation type**
S16	35.656551°	-117.491037°	Parallel set of lateral spread cracks and small sand boils – Salt Wells valley, post **M** 7.1, Photo 0454	Lateral spread and sand boil
S17	35.651326°	-117.485338°	Lateral spread along Salt Wells Creek bank, post **M** 7.1, Photo 0408	Lateral spread
NA	35.661022°	-117.505322°	Sand boils in Salt Creek Wash, from **M** 7.1 event based on review of Google Earth imagery dated 7/13/2019	Sand boil
NA	35.661113°	-117.505179°	Sand boils in Salt Creek Wash, from **M** 7.1 event based on review of Google Earth imagery dated 7/13/2019	Sand boil
NA	35.660623°	-117.509429°	Spring in Salt Creek Wash from **M** 7.1 event, based on review of Google Earth imagery dated 7/13/2019	Spring
NA	35.665809°	-117.513112°	Pre-existing ephemeral feature that started flowing as a result of the **M** 7.1 event, based on review of Google Earth imagery dated 7/13/2019	Spring
NA	35.665039°	-117.514227°	Pre-existing ephemeral feature that started flowing as a result of the **M** 7.1 event, based on review of Google Earth imagery dated 7/13/2019	Spring
NA	35.664160°	-117.514094°	Pre-existing ephemeral feature that started flowing as a result of the **M** 7.1 event, based on review of Google Earth imagery dated 7/13/2019	Spring

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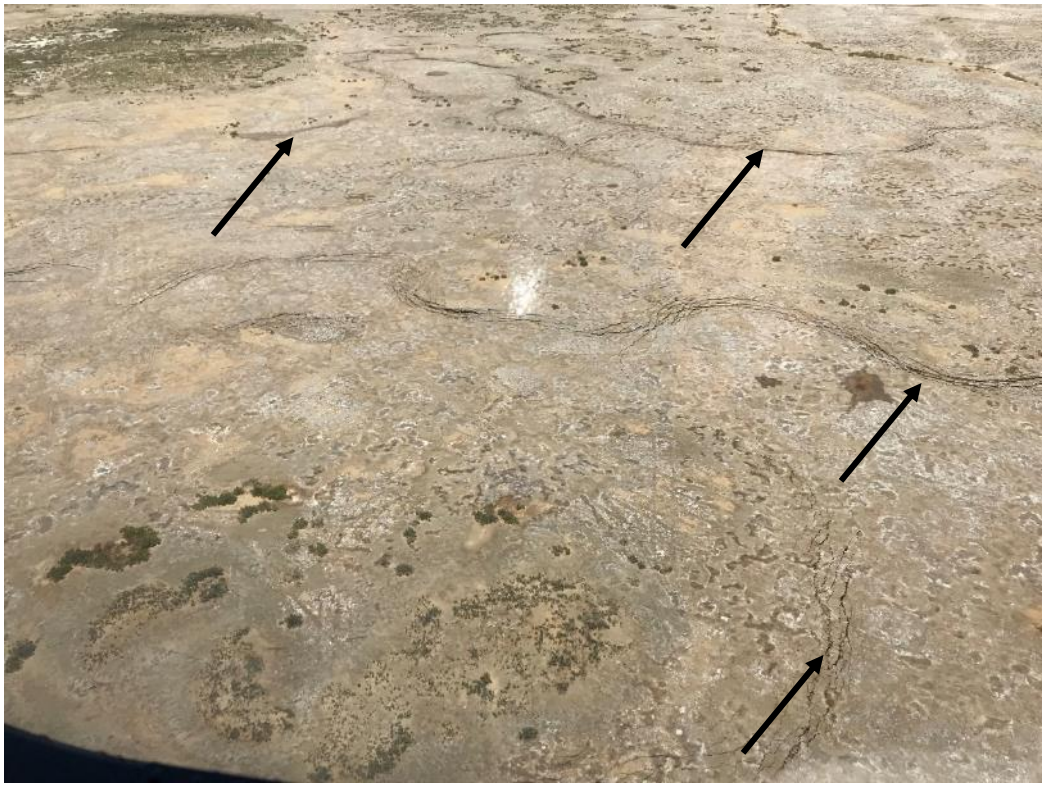

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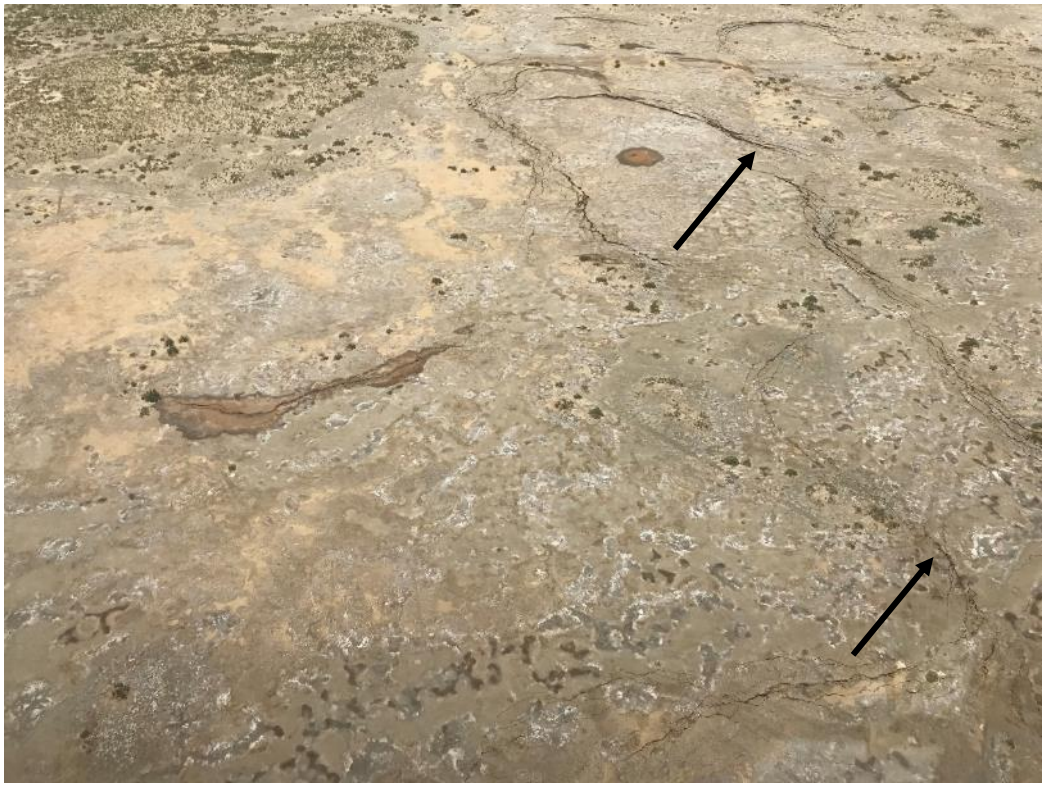

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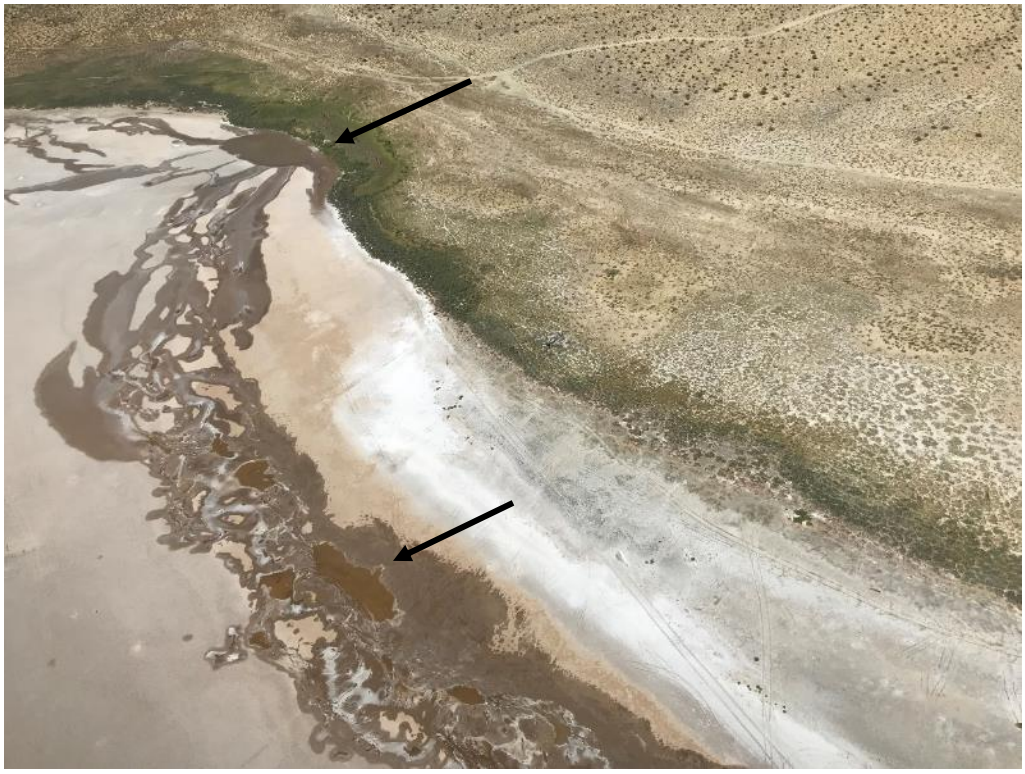

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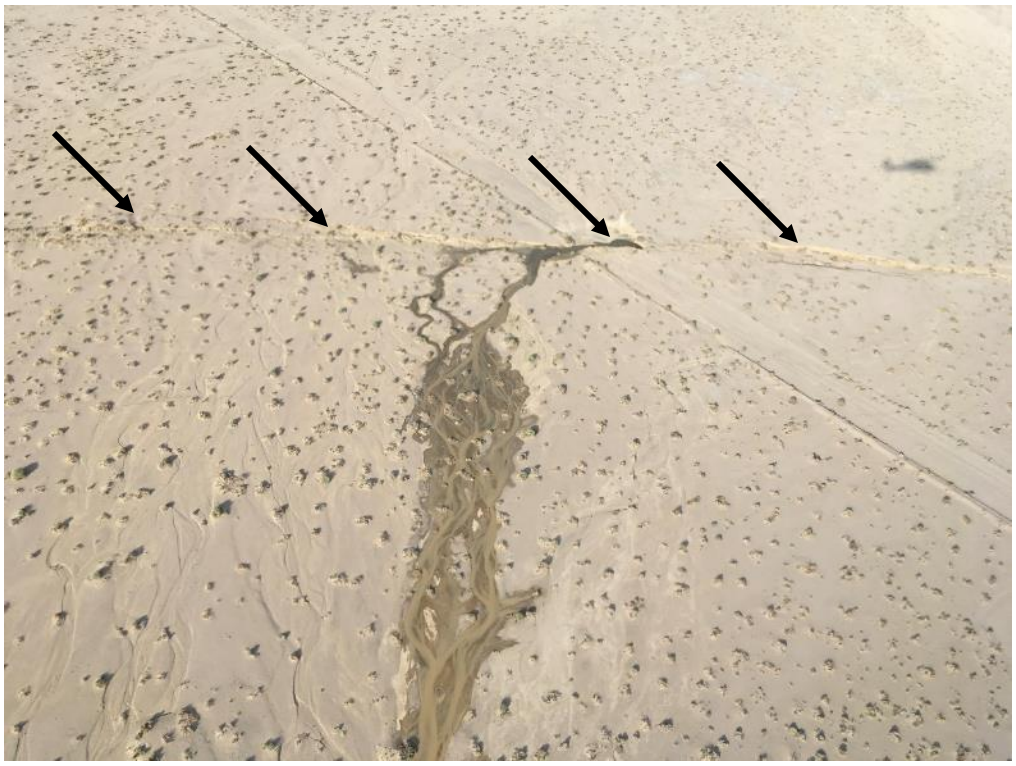

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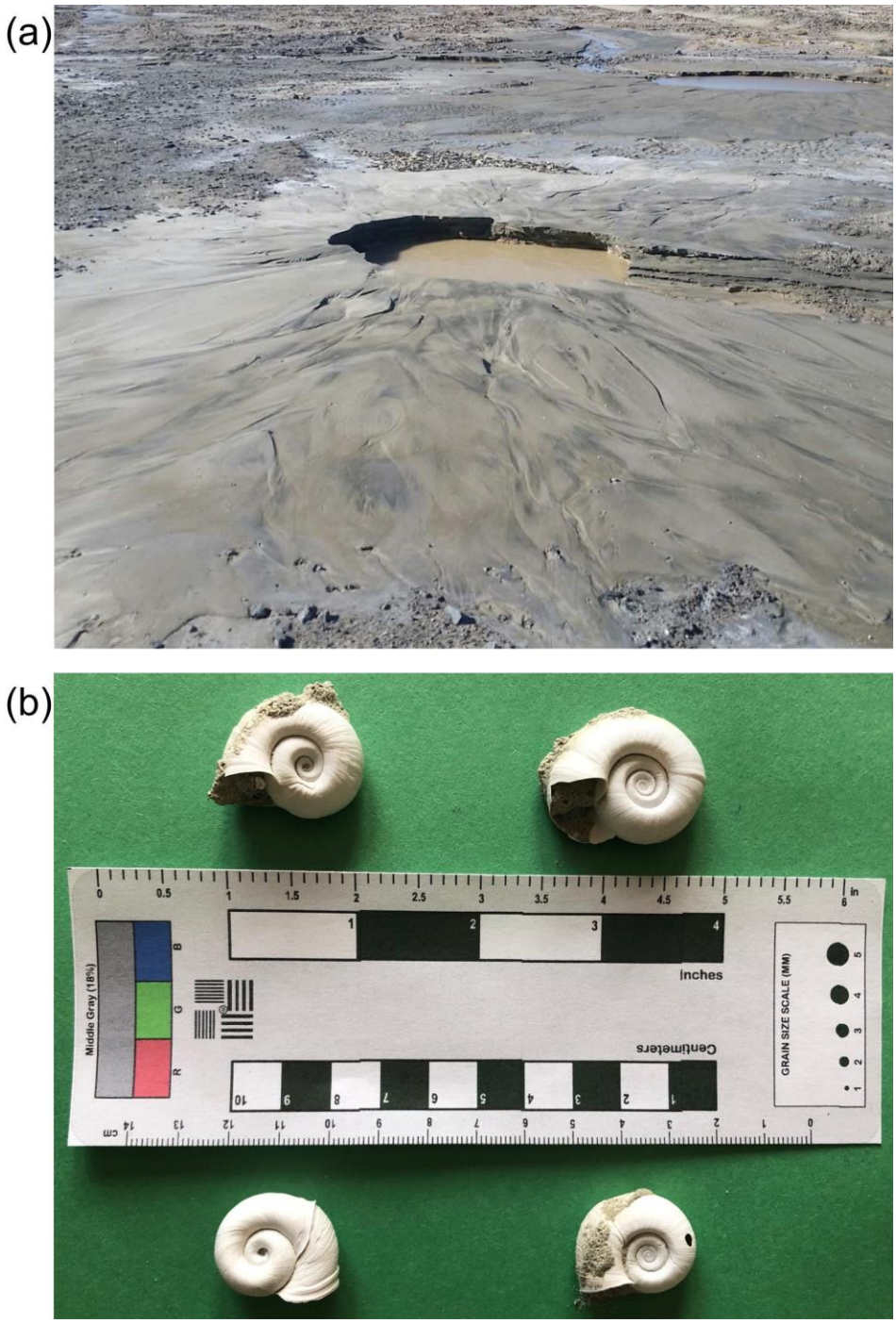

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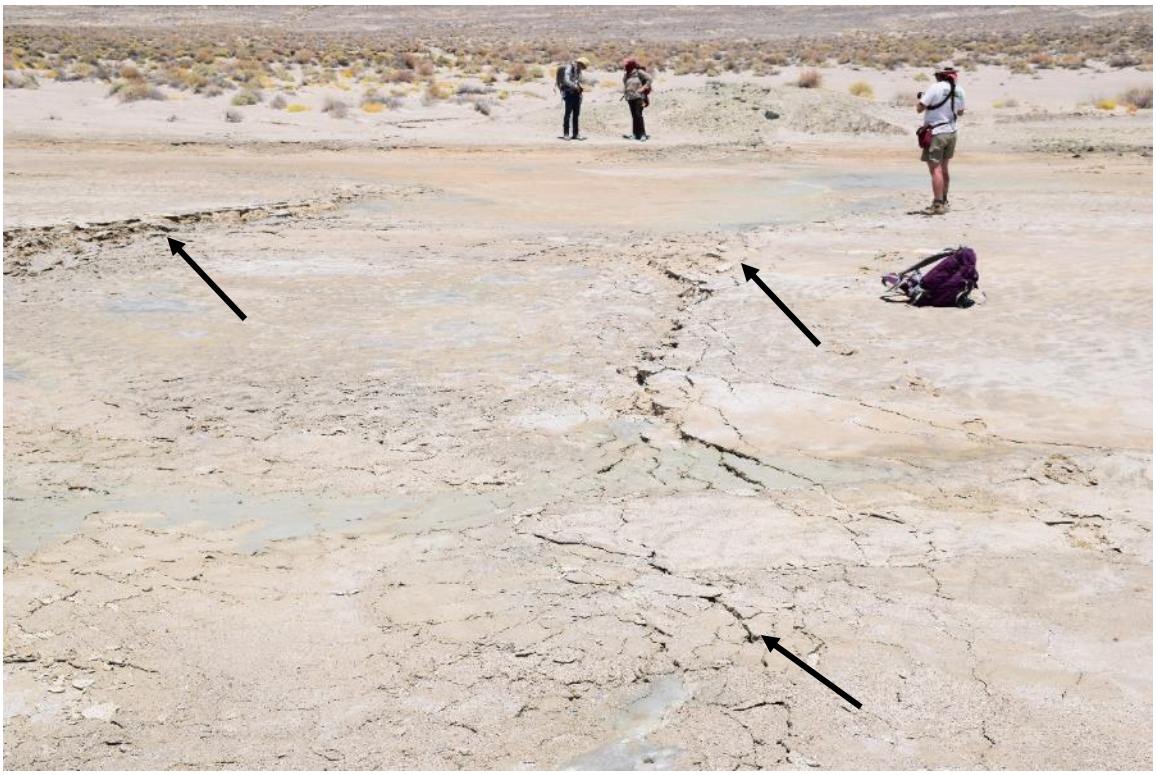

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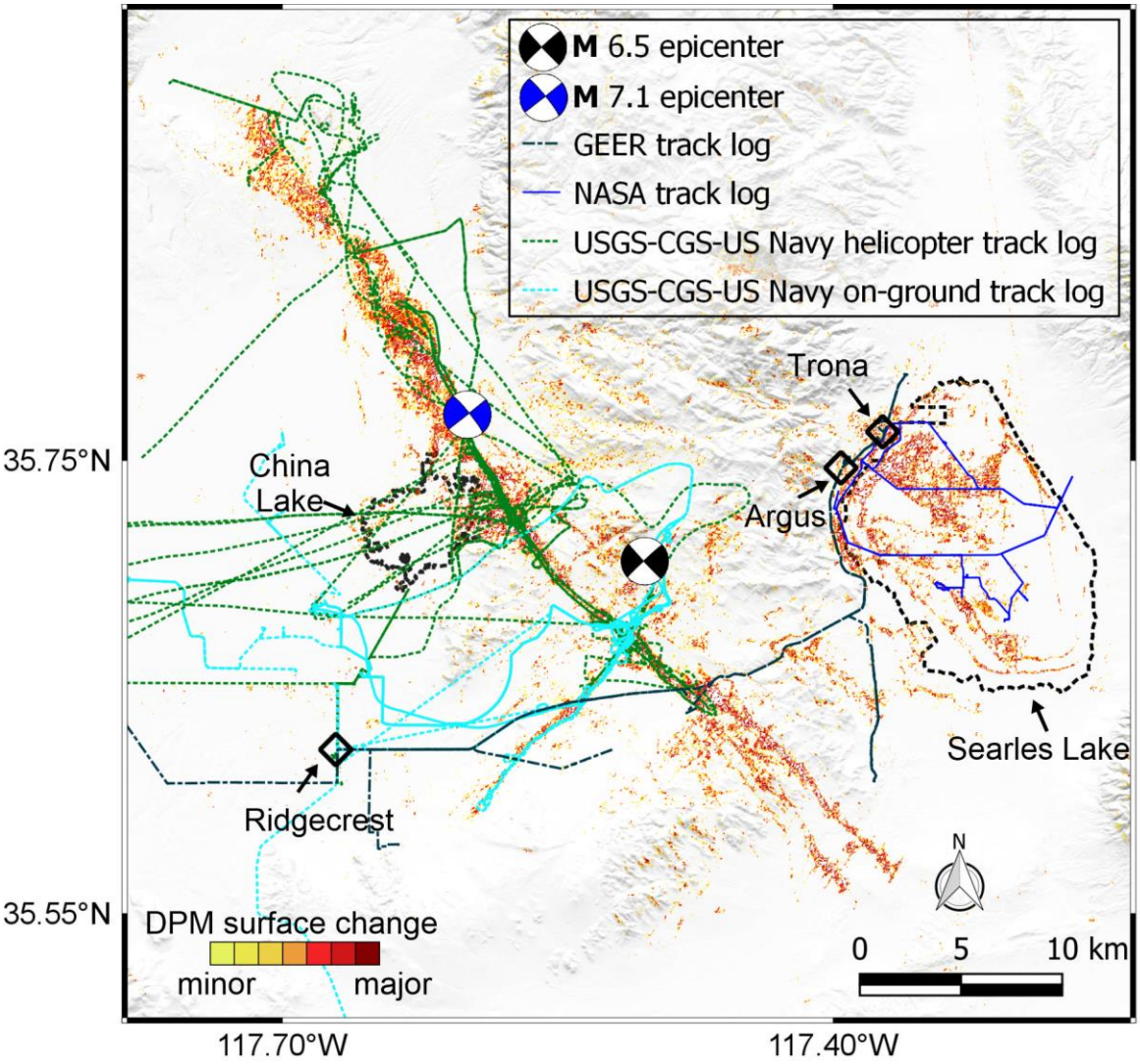

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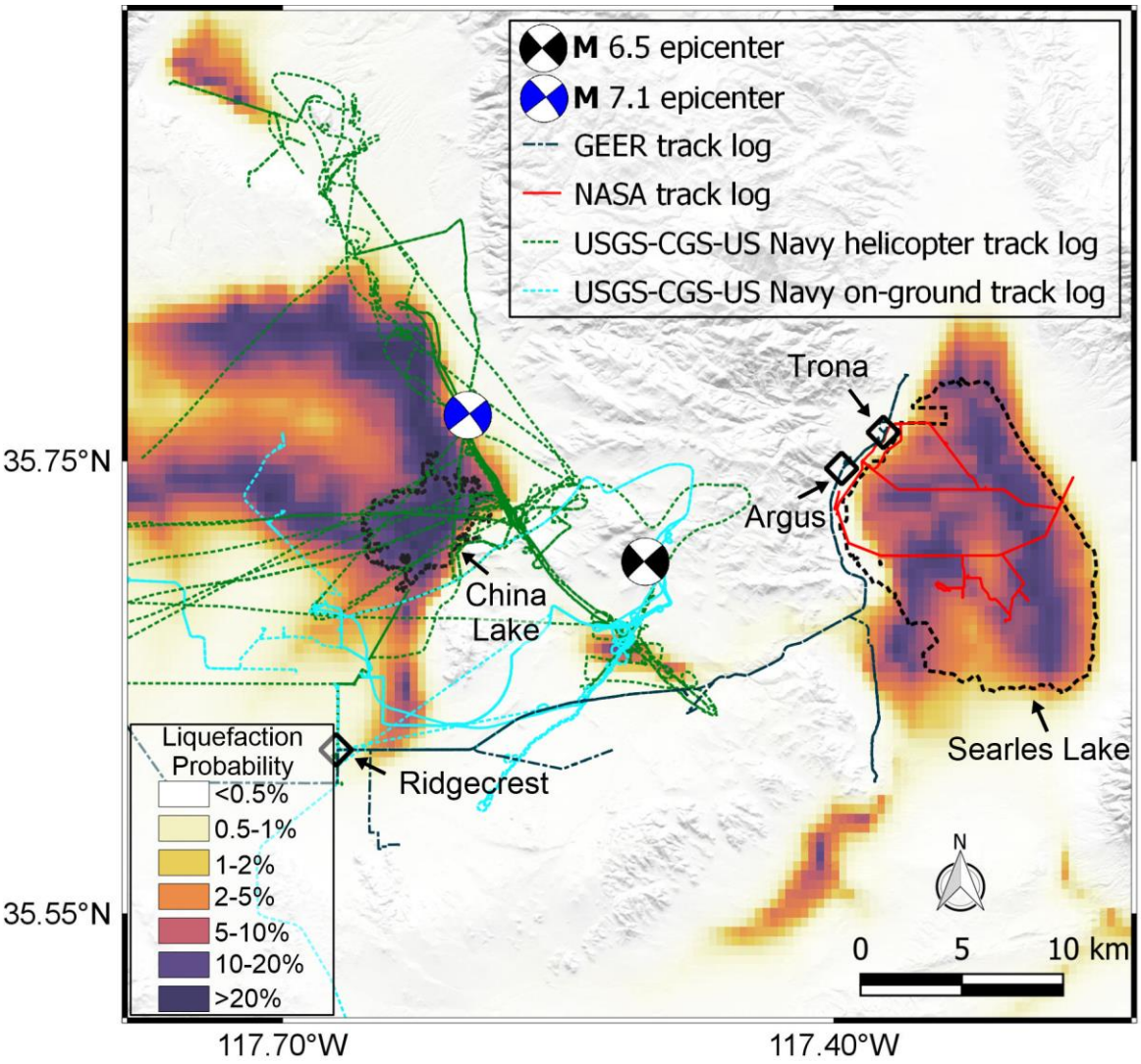

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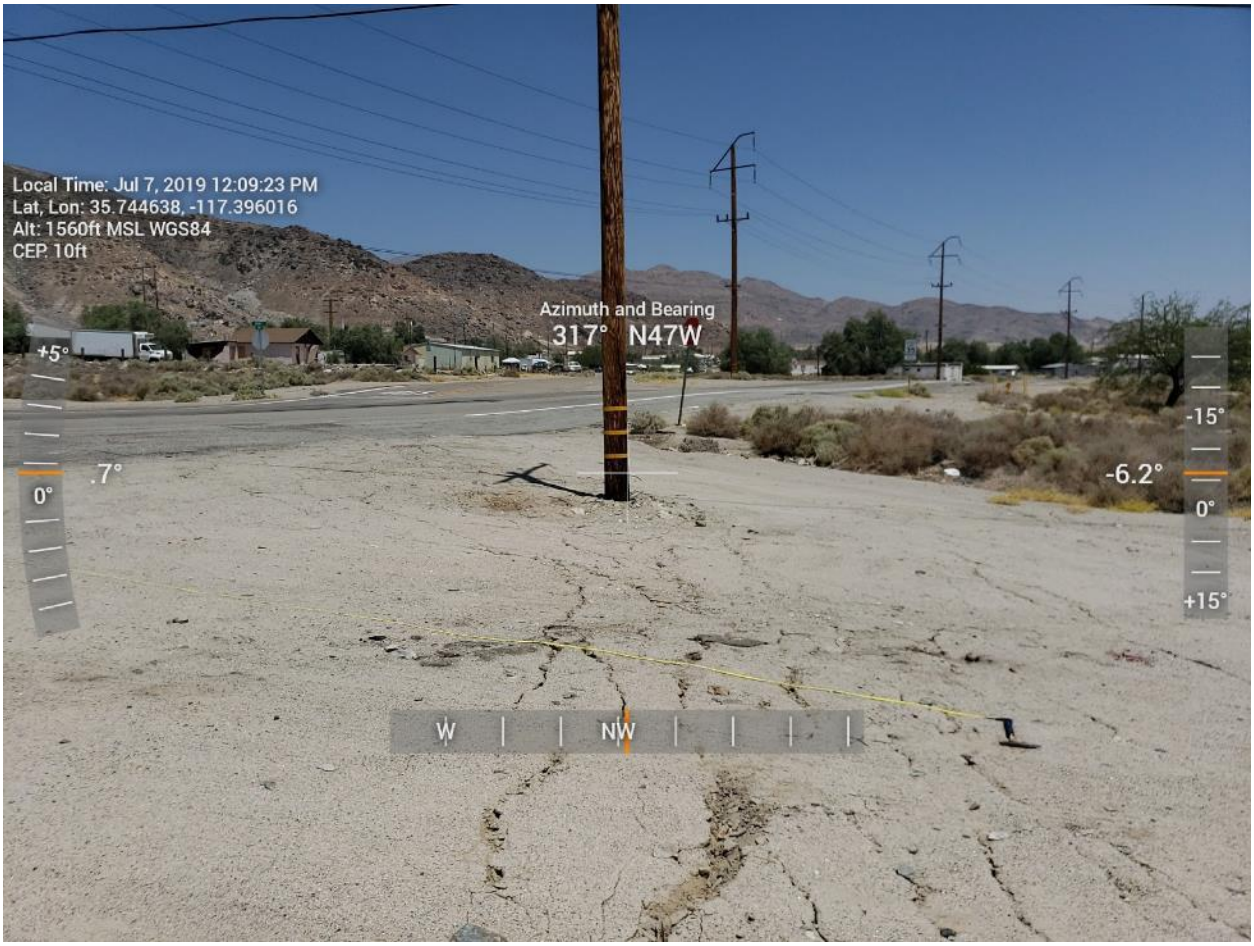

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(a)

(b)

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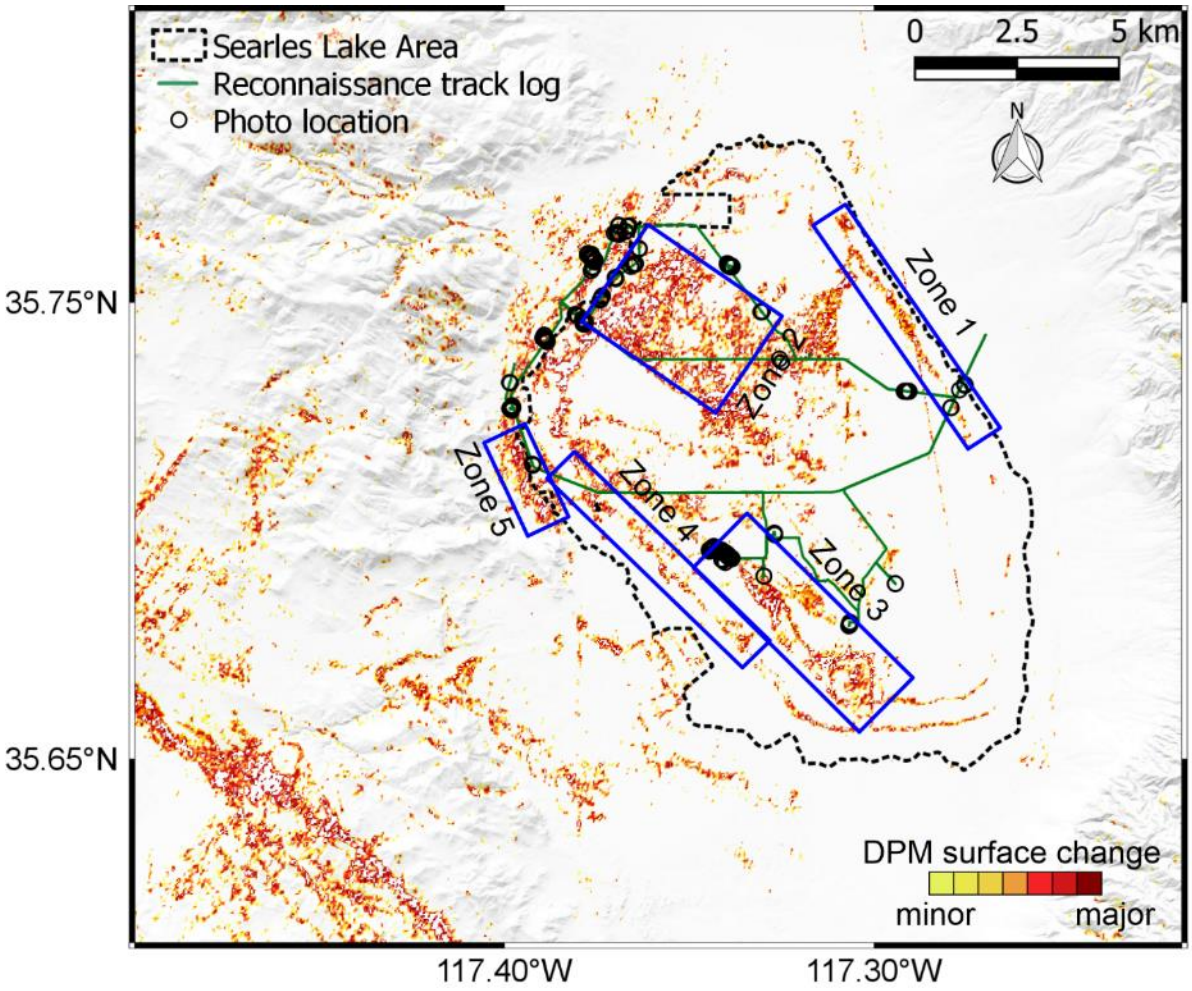

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