GEOLOGIC OBSERVATIONS ASSOCIATED WITH THE JULY 2019 Mw 6.4 AND Mw 7.1 RIDGECREST EARTHQUAKE SEQUENCE

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Extended Abstract

The Ridgecrest Earthquake Sequence began on July 4, 2019 with a M_w 6.4 earthquake at 10:33 am PDT at a depth of 8.7 km. The epicenter was located about 18 km east-northeast of the City of Ridgecrest within the Naval Weapons Station China Lake (NWSCL) property. This event was preceded by several small foreshocks a few days prior to the event. Surface rupture from this event was expressed as a zone of surface faulting over 17 km long, consisting of several strands with en-echelon stepovers, striking northeast-southwest with left-lateral displacement of the ground surface. Rupture appears to have propagated from the epicenter toward the southwest.

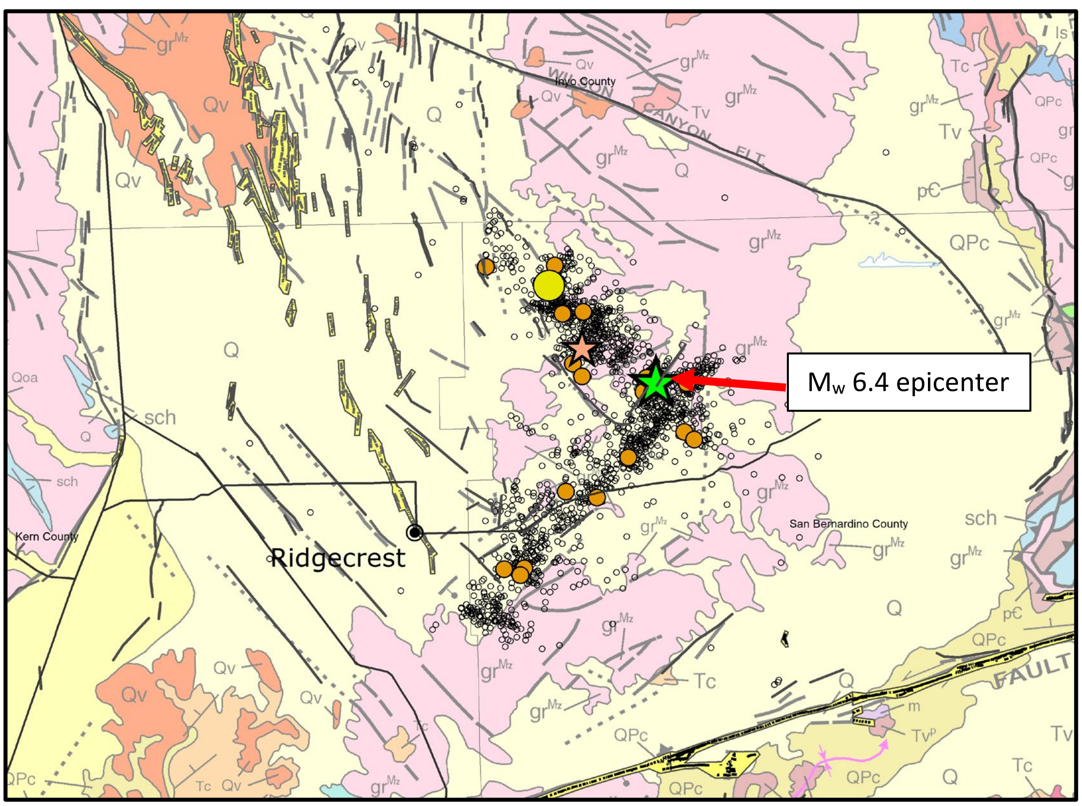

Figure 1 – Seismicity pattern from Ridgecrest July 4, 2019 Mw 6.4 earthquake (SCEDC, 2013). Epicenter location (green star) and aftershocks, including M4.9 (orange star) prior to Mw7.1 event. Geologic map shows the area is underlain by granitic bedrock (pink polygons) surrounded by younger alluvial valley deposits in yellow. Bright yellow polygons surrounding faults are Alquist-Priolo fault zone boundaries for Holocene faults.

Aftershock patterns following the M_w 6.4 event followed the northeast-southwest trend, however a perpendicular northwest-southeast L-shaped pattern developed near the epicenter at the north end of the fault zone (Figure 1).

This northwest-southeast aftershock pattern appeared to be weakly coincident with a discontinuous zone of northwest striking, previously mapped Holocene-active faults. The pattern of faulting and seismicity hinted at the possibility of cross-fault triggering, similar to what was observed in other earthquake sequences such as the 1987 Elmore Ranch - Superstition Hills earthquake sequence (Hudnut and others, 1989).

About 34 hours after the M_w 6.4 event and numerous aftershocks, some of which were M5+, the M_w 7.1 mainshock event occurred at 8:19pm PDT. The epicenter of this mainshock was located approximately 10 km northwest of the Mw 6.4 epicenter, at a depth of 10 km (Figure 2). Surface rupture from this event occurred along a northwest-southeast striking fault zone, roughly coincident with the northwest -southeast seismicity observed north of the M 6.4 rupture prior to the mainshock. Displacement was right-lateral and extended bilaterally away from the epicenter over a distance of ~50 km.

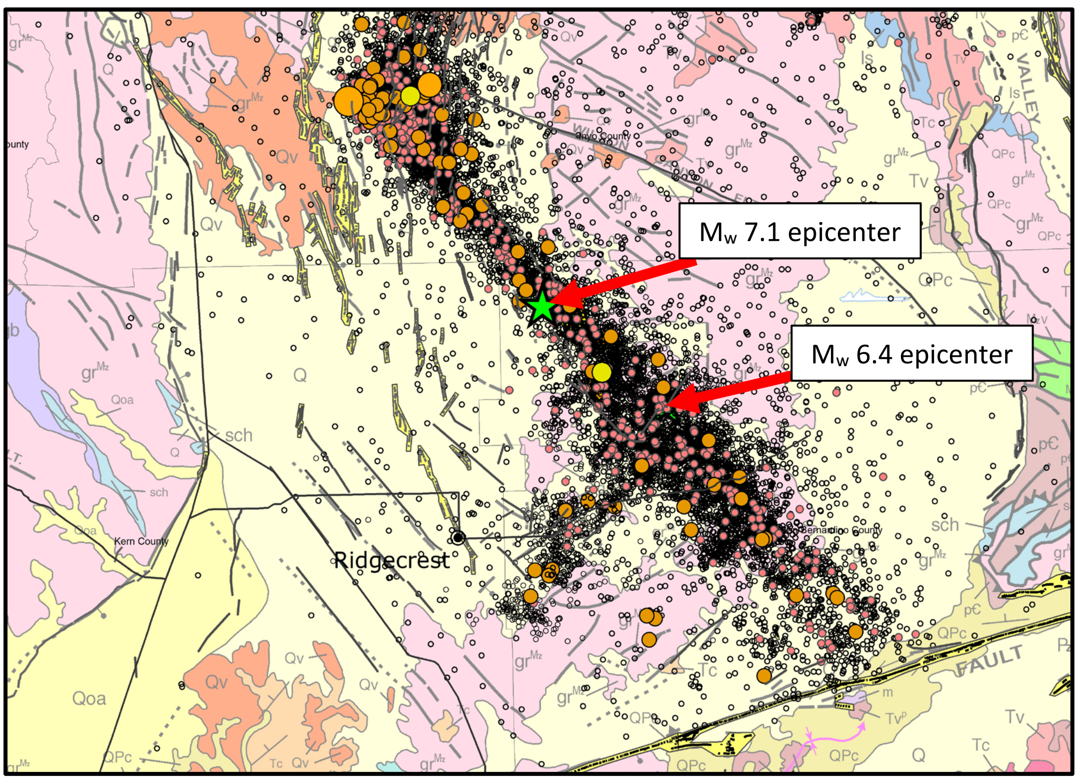

Figure 2 – Seismicity pattern from post-Mw 6.4 and 1-week post-Mw 7.1 earthquake events (SCEDC, 2013). Surface rupture from both large earthquake events occurred on faults that were either not previously mapped, or on faults with discontinuous mapped traces.

The Ridgecrest Earthquake Sequence is located within the Eastern California Shear Zone, which is dominated primarily by active, steeply-dipping, right-lateral, strike-slip and oblique-slip faults that are overall part of the system of the San Andreas Fault and North American plate boundary. The Ridgecrest area and the greater Indian Wells Valley have experienced numerous historic earthquake swarms.

Previous events that produced surface rupture include: Indian Wells Valley M 5.2 earthquake event on October 1, 1982, (Roquemore, and Zellmer, 1983), and the Ridgecrest M_L 5.8 earthquake on September 20, 1995 (Hauksson and others, 1995). Surface rupture from these two events occurred on the Little Lake and Airport Lake Faults, where they exhibited minor right-lateral and vertical displacements. Observations from the 1982 event included 4mm of separation, distributed along en-echelon fault segments over a distance of ~10km. The 1995 event generated about 1cm of right oblique slip on a fault segment about 3km long. These fault traces were subsequently zoned by the State as part of the Alquist-Priolo Earthquake Fault Zoning program.

Field observations of surface rupture were made starting on July 4, 2019 immediately after the M 6.4 event by the Ridgecrest Rupture Mapping Group (Kendrick and others, 2019). Methods of collecting data included; helicopter overflights, field mapping, UAV (drone) imagery, ground-based lidar, and review of digital satellite imagery, much of which was available within a few days after the first earthquake event. Social media postings were also helpful in documenting surface rupture, in some cases prior to road repairs were made on public right of ways. Much of the surface rupture documentation was done on iPad tablets using ArcCollector application, and later compiling data into ArcGIS platform.

Documented surface rupture from the Mw 6.4 event extended a distance of ~ 17 km, with up to 1.5 m of left-lateral displacement, and about 15 cm of vertical displacement. At the southwest termination of the M 6.4 rupture, distributed faulting is present on multiple strands. Left-lateral displacements on these distributed faults are typically less than 5 cm, and increase to tens of cms as the fault zone integrates into a single strand about 1 km northeast of Randsburg Wash Road.

Surface rupture from the Mw7.1 event extended a distance of ~50 km with up to 5 m of right-lateral displacement, and about 1.5m of vertical displacement. Maximum displacements were noted within China Lake playa, near the epicenter. The principle surface rupture is variably expressed as a single fault with knife-edge vertical scarps and narrow fault zone, to multiple strand, left-stepping en-echelon ruptures with conjugate faults that splayed away from the main strand, continuing over a significant distance.

Analysis of the surface ruptures and fault geometry is ongoing. There are multiple sources of high precision data that are currently being analyzed, and field mapping that is continuing to be performed in areas where complexities occur and digital analysis methods need to be field verified. Lidar was flown in early August by the National Center for Airborne Laser Mapping (NCALM) and was funded by the National Science Foundation, the U.S. Geological Survey, with support from the Southern California Earthquake Center. The lidar data is expected to be released in late 2019, after processing by NCALM and a review by the U.S. Navy.

In conclusion, the Ridgecrest Earthquake Sequence is one of the most complex modern set of earthquakes to date, and it produced extensive surface rupture in a fairly remote area of southern California. Having the benefit of advanced technology and rapid assessment by a team of geologists, we anticipate learning much from these earthquake events.

References

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