2026 SCEC Parkfield 2.0 Workshop
Statewide California Earthquake Center

June 10 – 11, 2026
Moffett Field, California

Workshop Breakout Group Summaries

1. Modernizing the Observatory: Existing Networks, and New Instrumentation
2. Operational Readiness
3. Earthquake Precursors, Nucleation and Rupture
4. Defining Parkfield 2.0
5. Parkfield Earthquakes and Interaction with 1857-Type Events
6. Earthquake Cycles

Group 1: Modernizing the Observatory

Modernizing the Observatory: Existing Networks, and New Instrumentation

Defining scope of work should be guided by expectations and testable hypotheses. In other words, these recommendations should be revisited after the goals of PKF2.0 are defined. And, obviously, feedback from existing network operators is essential to maintain realistic goals.

Leverage and Repurpose Existing Infrastructure

Operating in a 'do more with less' type atmosphere. To maximize limited resources, we should assess the viability of adopting existing but underutilized assets, and find ways to be inter-disciplinary. Examples might include:
Investigating the functional status of NOTA boreholes and GNSS, and considering adopting them.
Working with telecom fiber network owners to use their networks.

Integrate High-Resolution Fiber Optic Sensing

Fiber optic sensing is emerging as a critical, relatively low-maintenance tool to fill observational gaps. Specifically, zig-zagging fiber lines along the fault could allow for continuous monitoring of propagating creep. They can also broaden the aperture to get at deeper processes, complement traditional networks, and facilitate imaging and methods like dV/V.
Could add on-demand, remote controlled active sources for repeat measurements.
Managing this high-frequency, high-resolution data presents a challenge, but also a major opportunity for cross-disciplinary engagement.

Upgrade Seismic and Geodetic Instruments

There is a need to modernize legacy systems to capture increasingly smaller signals with greater fidelity. Key upgrades include outfitting the High-Resolution Seismic Network (HRSN) with modern seismometers and geophones to better detect small sources and tectonic tremor.
It would be beneficial for continuous GNSS stations to provide high-rate solutions in real-time,

to assess rupture evolution and static deformation, as well as constraints on rapid post-seismic signals.
Collocate borehole accelerometers with strainmeters if possible.
Utilizing advanced InSAR and optical imagery is a given, but satellite systems are out of our control.
Can we augment it to include lidar and cameras in the near field?
Can we make re-surveying alignment arrays continuous?
Complement shallow observations of creep with deeper ones (e.g., inclinometer arrays): push down as far as possible.

Modernize Telemetry to Handle Denser Arrays

As networks become denser and produce higher volumes of real-time data, telemetry infrastructure must be significantly upgraded to prevent bottlenecks. Evaluating and expanding current transmission capabilities, such as the USGS microwave system, is necessary to support these enhanced observational networks, especially given current personnel shortages relative to existing operational needs.
Is there a chance to utilize fiber connections for both sensing and data transfer?

Focus on Collaborative, Complementary Network Design

Return on investment increases significantly when instruments provide complementary measurements rather than operating in isolation. Future network expansions could focus on co-locating different types of sensors (e.g., merging magneto-telluric, seismic, hydrologic, strain) and maintaining active communication with broader initiatives and facilities like EarthScope/NGF.

Network design could be done in a way that both fills in observational gaps in traditional networks and allows for testing of newer technologies. For example, can fiber optics be used to sense fault creep or (quasi)static strain? Numerous high-quality results demonstrate the reliability of DAS in the seismic band, but there are major outstanding questions about performance in the sub-seismic band. A fiber path that crosses a creeping portion of the fault would be a great opportunity to test this, and the broader fiber array might represent added benefit to seismic networks regardless of the outcome of those tests.

Group 2: Operational Readiness

Motivated by having a predetermined plan for efficiency Should decide:

1. What triggers a deployment, and
2. What comprises the deployment

Would be useful to have a document that goes through scenarios (if this happens, then we do this…) along with people assigned to roles. There is an added complication because Parkfield sits between USGS northern/southern California coordination areas. Would be useful to decide who would be leading the response coordinator now.

Access:

- For instrumentation, two endmembers (likely would be somewhere in between): all public land, and all private land
- One limitation is knowing who owns land at sites of interest - so just knowing who owns land beforehand would make deployments more efficient in the moment, or having a list of local contacts as well as any internal staff who already have a relationship with that contact
- One landowner for the town (lodge, restaurant) - good contact to have an ongoing relationship with
- Discussion of having primary internal liaisons for each landowner so communication with them is clear

Seismic instrumentation:

- Clements: has a proposed plan for nodal geophone deployment on county/public roads, with permission obtained beforehand.
- Want to prioritize aftershock kits in the near-field, broadband and nodes farther away to avoid clipping issues
- Suggests doing a practice deployment to build capacity and to determine what skills and staff are necessary.
- Do we have an inventory of aftershock kits and nodes available? Would want to include ASL aftershock kits. Determine the contact and process for obtaining these
- Cultivate a “deep bench” so that when an event happens, available people will be ready.
- Keep in mind nodal geophones do not have a large dynamic range, so good for recording small aftershocks but not a large M7 aftershock scenario.
- CGS: post-earthquake plan would be to collect data from un-telemetered stations rather than deploying any new stations
- Reoccupy PA2P and PA3P that recorded 1966 and 2004 earthquakes (a third Gold Hill site is still operational)

Geologic response

- mapping rupture (nature, offsets)

- mapping afterslip (alinement arrays, or drone-based lidar)
- Secondary target would be creepmeter (not as time sensitive)
- Surface rupture may attract students, consultants, etc., and in that case more coordination (e.g., a clearinghouse) would be useful.
- Philibosian: possibility of doing a post-earthquake trench. Would be best to go through the permitting process in advance if there was a site in mind. Would want to make sure the trench could be dug before a winter season passes post-earthquake.

Other targets:
- Campaign GPS/reoccupation would be another large effort (Phillips?)
- Satellite imagery (task?): current contract is expiring, usually managed by Golden
- SAR: wait for images to come in (handled by Guns, Yin)
- Video/camera stations?

Coordination
- USGS to provide information and tools for coordinating response and ingesting data via ArcGIS online (need an account, usually through CGS because USGS has too many restrictions)
- USGS trailer is still parked in Parkfield - who has the keys to this?
- Do we have an inventory of aftershock kits and nodes available? Would want to include ASL aftershock kits
- This group is heavily USGS; likely need another organization (SCEC) to help handle coordination with other partners (academia, etc.). Would want the response and coordination to be public so anyone interested could be involved
- Planning document should include places to stay (Paso Robles, King City) and a meeting place for physical clearinghouse if wanted
- County OES coordination
- Do we need MOUs in place to facilitate rapid sharing of information?

Community Engagement/Media Response:
- Would be useful to develop a brochure that encompasses multiple agencies (USGS, SCEC, CalTech, Berkeley, etc.) so that landowners/public are not confused by multiple groups doing the same task
- Could develop (some) Parkfield media talking points in advance, because they would likely involve lots of information/context about past earthquakes
- Yearly townhalls/outreach in Parkfield? 2 hour ask-a-scientist at the cafe or local schools
- 1-page flyer or fact sheet to distribute? Include forward looking information (if an earthquake happens, expect scientists to be in the area, these are the types of things we will be doing). There is already a 2004 Parkfield Experiment factsheet that was published before the 2004 earthquake; would need to be updated

Scientific questions to target:
- For aftershocks - do we think a M6.0 would be a foreshock for a larger rupture to the south? If so, would we want to deploy instruments to the south?

- Another ground motion prediction experiment?
- Would we want to monitor microseismicity and strain at the south end of the segment as a way to understand precursors to a larger M7? (hard to get a permanent deployment there due to landowner, so temporary deployment would be necessary)
- Could develop these more at a planning meeting

Action items:

- Have a meeting to develop a plan for response: who would host the response, who would be responding, and what the response would look like (this could be a side meeting at SCEC?)
- Decide on a platform and method to coordinate deployment of instruments in real time so there is no duplication of effort. USGS ArcGIS online works well for those with access, but access can be difficult for external partners or internal staff without government phones.
- Pursue pre-emptive nodal geophone deployment
- Update Parkfield fact sheet
- Choose a coordinator in advance (do we need an internal Parkfield science coordinator now?)
- Organize town halls in Parkfield (short presentations or ask-a-scientist booths)
- Follow up with CGS about possibility of clearinghouse activation post earthquake
- Decide what gain settings are ideal for nodal deployment (depends on purpose - amplitudes vs timing/sps) and determine a minimum distance as a function of magnitude where they are less likely to clip

Group 3: Earthquake precursors, nucleation & rupture

Nucleation:

SAFOD Repeaters:
There's a strong desire to maximize what has been learned from the samples from the SWDZ, NBF and CDZ by connecting it with more direct observations of the repeaters. The rocks are different between strands, based on the casing deformation there's no creep on the northern boundary fault but it still has repeaters. There's a desire to drill through two repeaters to contrast one on each SWDZ and NBF in terms of composition. Even sampling HI by itself would be really informative and easier.
Science Questions:
-What are the geology/mineralogy differences between repeaters?
-When you have multiple strands, does a repeater recurrence interval reflect the main creeping strand or its own strand?
-We need a detailed understanding of the HI patch before drilling into it. We need to know which part to target; monitor strain beforehand but closer than the current hole. Strainmeters need to be very close to see rate-state nucleation phases. There's a need to update those calculations and make sure the strainmeter is in the right position.
-What precursory indications of slip are there before before a repeater event that are similar to lab experiments? E.g. can we observe/rule out things like tremor, small AE equivalents to lab experiments?
-Do SF, LA, HI events have systematic foreshocks? Not obviously so. Does this need more examination?

-Well log tools don't give absolute creep rates. Well casing deforms for lots of reasons. CDZ is creeping more energetically. Can we get absolute creep rates on the different strands?

Target nucleation of small events with borehole observations:
Drilling projects in future need to have long-term perspective - focusing on M2s at SAFOD makes sense

Catching a single M2 at Hawaii at very close range would be worthwhile

Would it be possible to drill not perpendicular to, but along the patch?

Other/General Nucleation:
There are two known (past) hypocenter locations (Middle Mtn/Gold Mtn.), but we should not assume that these are the only likely M6 nucleation zones. Past evidence suggests that

precursors, if they happen, are more likely at Middle Mountain than Gold Mountain.

Could consider active source close-in imaging (LBNL experiment and Nature paper and more recent work). Results not definitive? Other forms of array imaging to monitor fault-zone changes.

Is it still worth to look for nucleation phases early in rupture (fraction of a second) that are diagnostic of event magnitude?

Fluids: Is there an observable at depth that can be monitored for temporal variations in the vicinity of SAFOD. Poroelastic effects in the fault-zone/damage zone.

Fault roughness: What scale do we need to worry about? Does roughness make asperities (as opposed to VW/VS)? Why is HI asperity always there? Is roughness a control on nucleation?

Fault zone deformation (width etc.) of creeping vs. seismic ruptures to forecast surface fault deformation hazard.

Precursors:

- Focus more on nucleation and rupture. Longer-term precursors are complex, variable and “unreliable”.
- Look at the Italian example from Marone et al., ML identification of foreshocks (Laurenti et al., 2024 NCOMMS)
- Goal can be to learn something new+important science wise, not necessarily set up a formalism for public warning notices.
- If there are one or more M4 events (large SSE), have a plan on what to do (enhance observations, check system status, defer maintenance).
- Measure pore pressure, strain in situ in the fault zone from SAFOD.
- Temporal monitoring of fluid pressure.
- Is there more information in seismic data from tremor zone that could reflect sources difference from slip on strike-slip fault patches organized in LFE families?

Rupture Arrest in M6s:

Rupture arrest at both ends and particularly in SE. is a major opportunity that is special about Parkfield, e.g. we know where to place instruments to have a good change of capturing rupture termination in detail. How should the inputs/parameters for digital cousins be set up? Currently many models use relatively ad hoc spatial distributions of friction parameters etc., but we might be able to decide between competing mechanisms. Observationally we would need to pair detailed constraints on rupture deceleration with high-res creep/strain post-seismic monitoring to help differentiate low-stress regions from velocity-strengthening regions from geometrical discontinuities. Set up UPSAR style arrays that can differentiate stopping phases from the rest of the wavefield and constraint the slip-rate distribution along the faults near where the rupture ends. Do the Northern and Southern rupture terminations happen in the same way? Can this help export insights to other faults? A state-of-the-art strong motion network focused on two ends of PKF segment would be valuable. What is the physics of barrier arresting rupture? Role of fault geometry and variable geology along the fault. Two ends are likely to have some of the highest ground motions due to directivity, so get that from the same data. Note these observations require strong motion instruments, DAS will not be useful for studying the M6 because standard telecom fibers are not coupled to the rock and not reliable in strong ground motion based on studies elsewhere.

LFEs/Lower Crust:

-isotopic evidence for deep fluid sources is very clear

-Are there pulses in the fault-zone that you could see with packers?

Group 4: Defining Parkfield 2.0

Summary:

- Broader motivation: transfer of what we learn about M6 eqs to other more urban areas
- Advancing observational techniques, method development, modeling
    - Unique opportunity to have testable hypotheses and bring together disparate datasets
    - Determine what additional observations would differentiate between different hypothesized processes
    - Opportunities for application of machine learning with multiple labeled, high-resolution datasets
    - SAFOD related activities provide unique data on subsurface that will continue to inform other activities
    - This is a special location with a range of fault slip types - tremor, creep, earthquakes

All Notes:

Applicability of learning about a M6.0 (where it hopefully won't have big effects) for a M6.0 in an urban area. Include engineers in what information should be collected (peak ground motions, variability, impacts on infrastructure, postseismic) or other efforts.

Opportunity to update techniques for imaging ruptures, imaging fault zones before the next earthquake to know what resolution we might be able to get to. We likely need models to guide what types of observations we need to focus on and where to focus new observations. Close collaboration (rather than handoffs/exchange) between modelers and observational scientists. Example: Physics-informed joint inversions of disparate datasets. Machine learning. Connecting geology and geophysical models

How do we better connect surface observations with deeper processes on the fault

Use past earthquakes to map out fault geometry, make hypotheses on how that geometry can impact source processes. Are aftershocks of the next earthquake going to happen in the same place as the last earthquake.

Parkfield also has repeating (every few years) smaller quakes that could be more carefully studied for understanding behavior of fault processes.

SE edge - What is coverage like, could revisit tremorscope, KIT array, strong motion data may not have been fully utilized. Tremor and SSE at SE edge. What happens with models where the SE end is not creeping as has been does so far in earthquake cycle modeling.

Why does tremor disappear right underneath Parkfield?

Earthquake-LFE transition - only a couple of km separates them in some locations, variations with depth and along strike. Does that depth separation change after a large earthquake.

Role of broader faults in the timing of earthquakes, slip deficit, etc.

Machine learning for tremor detection, machine learning for modeling kernels (ala Nadia's talk), machine learning to combine datasets

Is there non-linearity in ground motions that has been observed, what are the variabilities?

Need to define what could be done on the very short term. Lots of data already exists - have we mined the data fully? Current/new approaches applied to old data?

Heatflow during rupture at depth (SAFOD)

Recommendation to include students - relatively few at this workshop

Velocity model merging - multiple scale models exist but could be combined as step towards digital twin

Group 5: 1857 Type Events and Parkfield

Summary: 1857 was 170 years ago and had a lot of precursory activity near Parkfield including at least 5 foreshocks including the two Parkfield type events that are often referred to. The penultimate event on Cholame and Carrizo sections of the SAF was around 1712 (about 140 years prior to 1857). Slip in the most recent events south of Parkfield has been about 5 meters in the last two events. Since 1857 there may be a 6-meter slip deficit on these sections. Prior to 1712 the rate of recurrence on the Carrizo section was more likely higher than the last two events. The 2004 Parkfield earthquake might have been expected to trigger the next large earthquake, but it did not. The next Parkfield earthquake is more likely to trigger an 1857-type event. Not adequately imaging this type of fault interaction would be a huge mistake. It is a once in two generations type of opportunity that the community should not miss. Additionally, if we have a Parkfield 2.0 experiment and don't make this part of the focus and subsequently an 1857 event does happen, it would feel embarrassing.

Parkfield earthquakes trigger post-seismic afterslip and microseismicity on many parts of the fault but not to the SE. Why? Have we imaged and monitored this transition adequately to understand this absence of phenomena? The observation of tremor at these latitudes of the fault is very intriguing. Currently Parkfield instrumentation is centered on the heart of the Parkfield section which made sense for Parkfield 1.0. Understanding why events propagate or don't propagate is a huge question. We would advocate for improving instrumentation from Cholame through Southern Parkfield. We want to be able to image true microseismicity down to M0 events. We would encourage investigators to image the transition from locked to creeping behavior in detail using geodetics. While SAFOD suggest that it is the materials right at the fault zone that matter for creep, why is it that at the macroscale the creep to locked transition is so tied to the large mappable geologic transition from Franciscan to more normal sedimentary rocks on the NE side of the fault zone? While it might not be reasonable to drill to seismogenic depths south of Parkfield, we would like to encourage geologists to seek out bedrock fault lenses at Parkfield and elsewhere to the SE and on the southwest side of the fault. especially those bringing materials up from seismogenic depths to compare with observations of materials from SAFOD. We want a detailed model of the fault zone from the surface to seismogenic depths through this transition zone. We will need seismic imaging of the fault zone and leveraging existing mapping as well as improvements on those.

In summary we suggest: new Instrumentation densification to the SE, extending south of highway 46, creating a dense network through the presumed nucleation zone of 1857. We want to be able to capture nucleation if an event occurs, is it dynamic stress triggering, is it asperities that matter, is it triggered by post seismic creep, is it something else. We must know! More Geology/Seismology. More INSAR work. More Rupture modeling to test ideas.

Group 6: Earthquake Cycles

Key concepts:

Fault zone rheology and damage localization remain key open questions, particularly the transition from frictional sliding to ductile shear at depth, how tremor and low-frequency earthquakes relate to this transition, and what fault zone width and strain localization reveal about deformation mechanisms.

Fault zone structure, damage, and healing play major roles in fault zone activity and predominant deformation signatures, with ongoing questions about damage zone width at depth, off-fault deformation, fault localization through time, hydrothermal and mineralogical healing processes, and the resulting effects on fault strength and stability.

Understanding creep, afterslip, and transient deformation, including the controls on steady versus episodic creep, the relationship between surface and deep fault slip, the role of stress heterogeneity and aftershocks, and the physical mechanisms driving long-lived postseismic transients.

Rapid advances in geodetic and seismic monitoring are creating new opportunities to study fault processes, with improved InSAR, GNSS, DAS, UAVSAR, LiDAR, and seismic catalogs enabling better constraints on afterslip, slow slip, tremor, creep, foreshock activity, and fault-zone evolution.

Integrating laboratory experiments, mechanical models, and field observations in future work, particularly for constraining rheological parameters, fault-zone viscosities, damage evolution, strain localization, and the links between observed seismicity patterns and the material properties of fault zones.