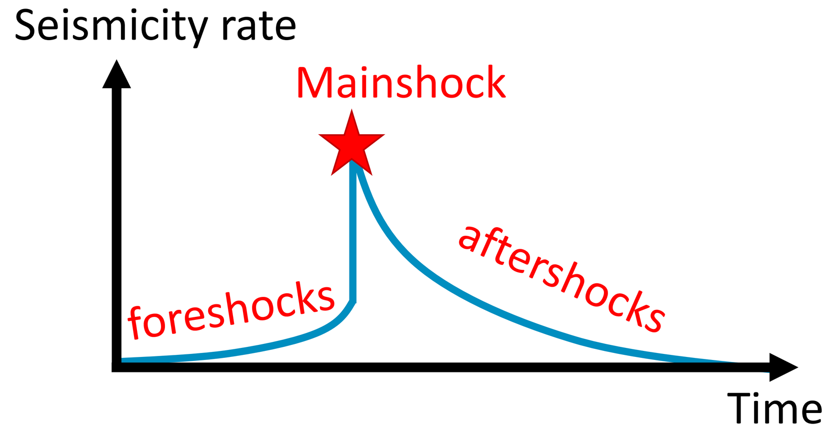
The 2020 Westmorland, California earthquake swarm as **aftershocks of a slow slip event sustained by fluid flow**

Krittanon "Pond" Sirorattanakul[1,*], Zachary E. Ross[1], Mostafa Khoshmanesh[1], Elizabeth S. Cochran[2], Mateo Acosta[1], Jean-Philippe Avouac[1]

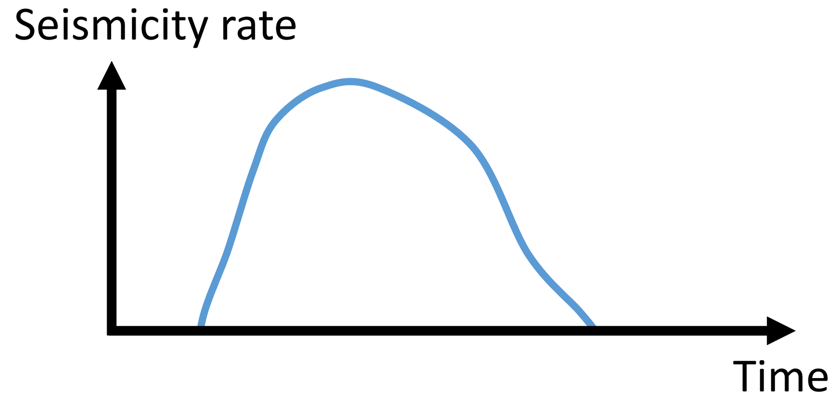
[1]Caltech [2]USGS Pasadena *Email: ksirorat@caltech.edu

- ✓ 5-min sampled GPS supplemented with InSAR resolves a shallow slow slip event, which preceded the swarm by 2 – 15 hours.
- ✓ Seismicity was driven in the early stage by slow slip event leading to non-linear expansion and later by fluid with propagating back front.
- ✓ A stress-driven model explains the overall evolution of seismicity and provides constraints on friction and fluid pressure



Mainshock-Aftershocks

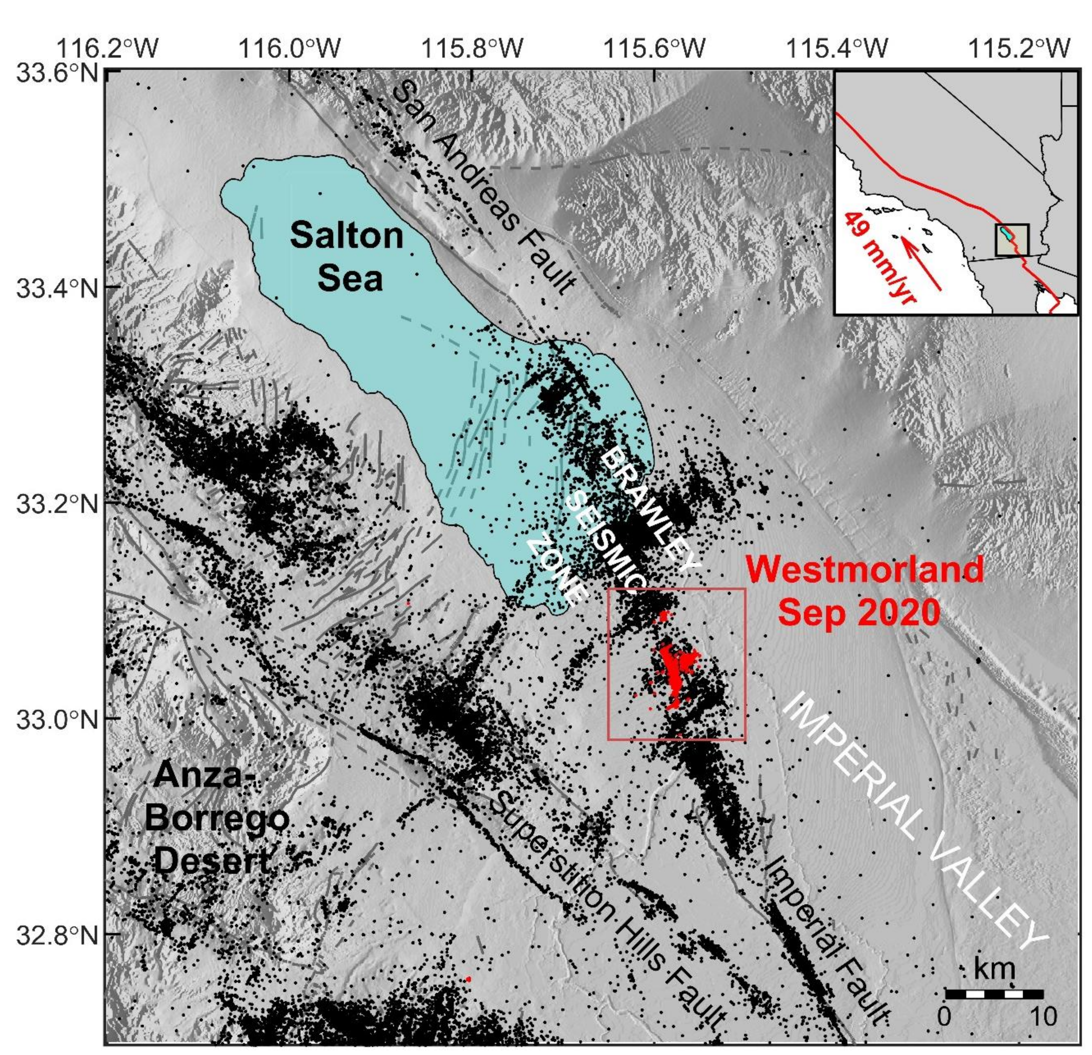
- clearly identifiable mainshock
- aftershocks follows Omori's power law decay
- driven by stress changes induced by the mainshock



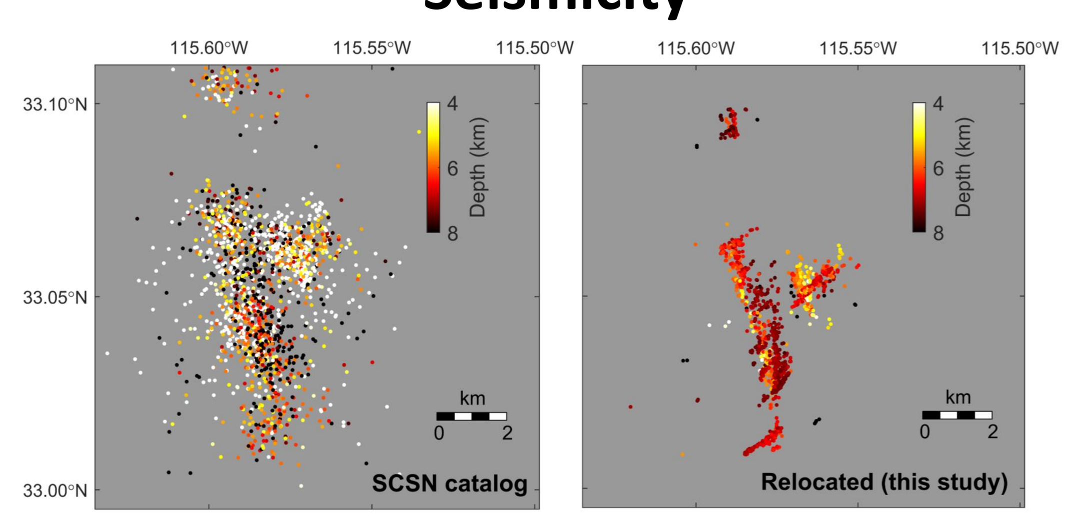
Swarm

- burst of small earthquakes
- behaviors are enigmatic, no well-defined pattern
- driven by aseismic processes (e.g. slow slip, fluids)

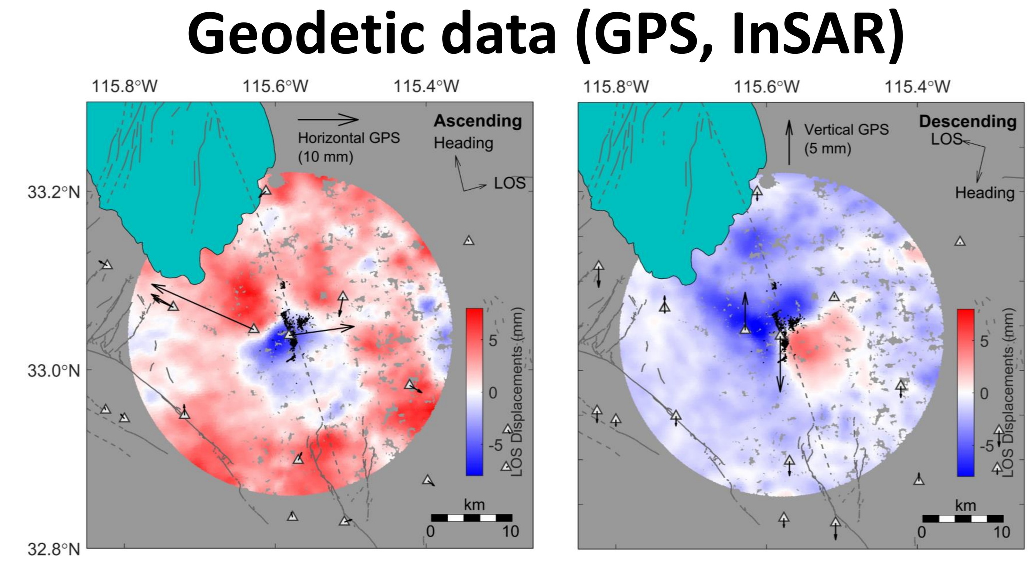
The 2020 Westmorland, California swarm



Seismicity



Geodetic data (GPS, InSAR)

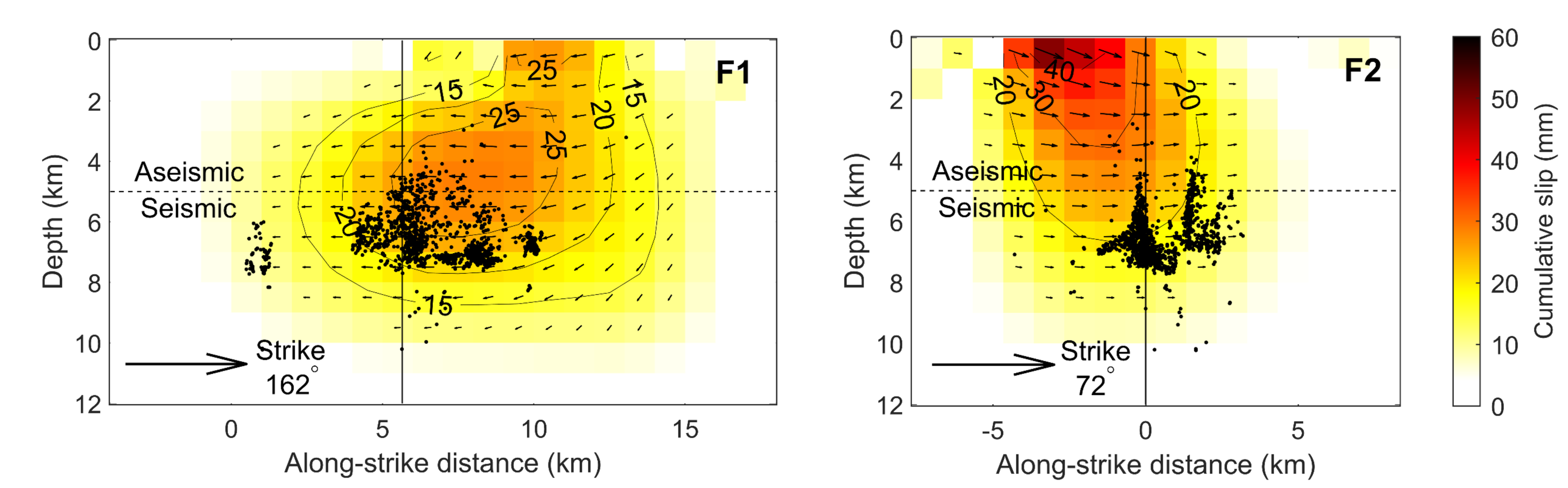


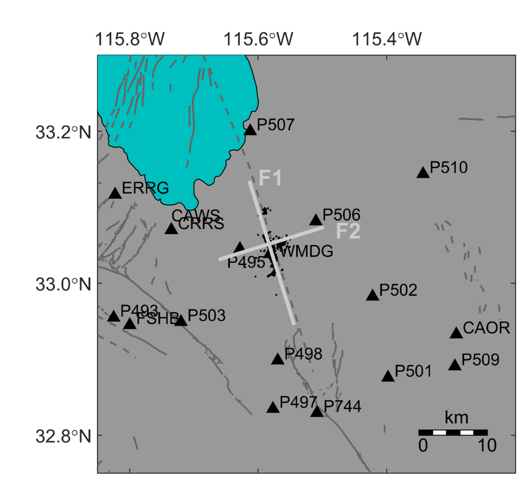
- Swarms are common in the Brawley Seismic Zone, which hosted a mixture of left-lateral strike-slip step-over faults that connect shorter segments of the main right-lateral strike-slip fault.
- The sequence began around 22:00 UTC on Sep 30, 2020 and lasted for approximately 140 hours.
- There were > 2000 events with M_w 4.9 being the largest.
- Peak seismicity rate is > 10,000 times the background rate.

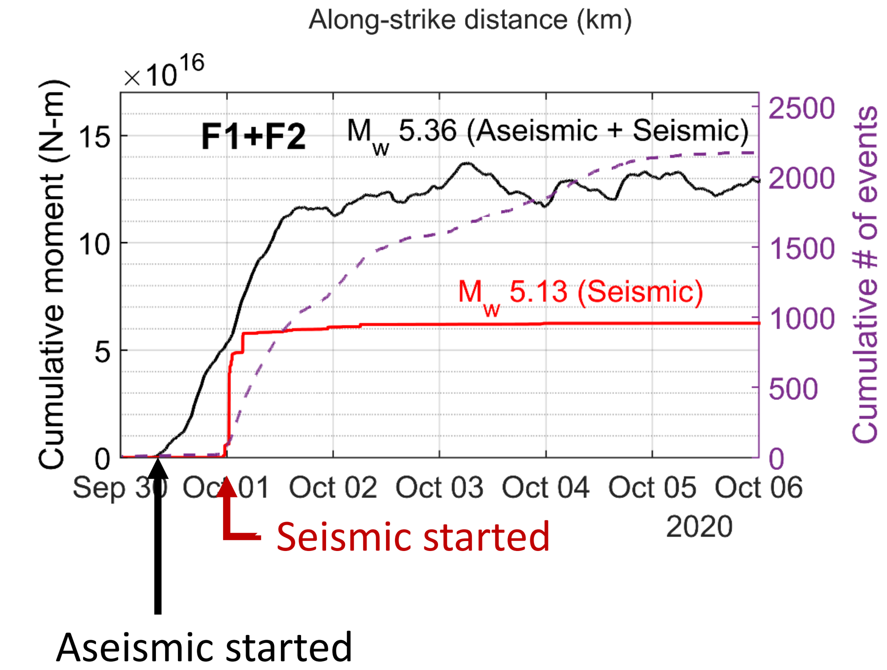
Triggering mechanisms

(1) Shallow slow slip preceded the swarm

- Depth < 5 km: There is fault slip but no seismicity → *aseismic*
- Depth > 5 km: Geodetic moment ~ seismic moment → *seismic*

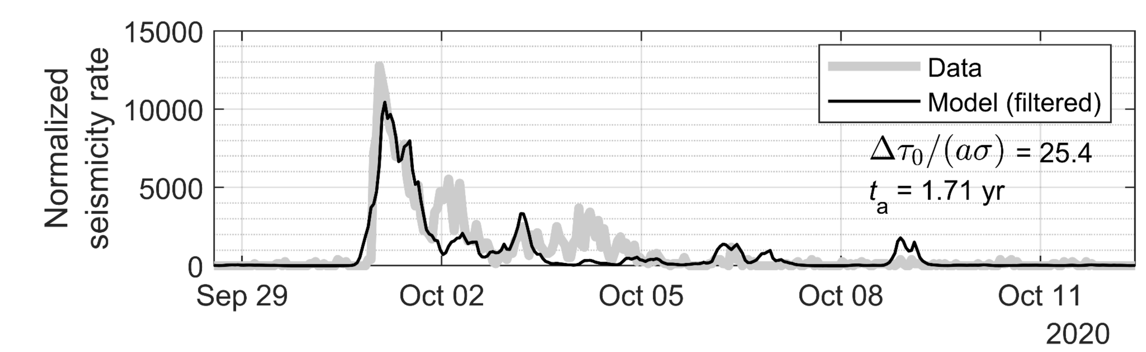






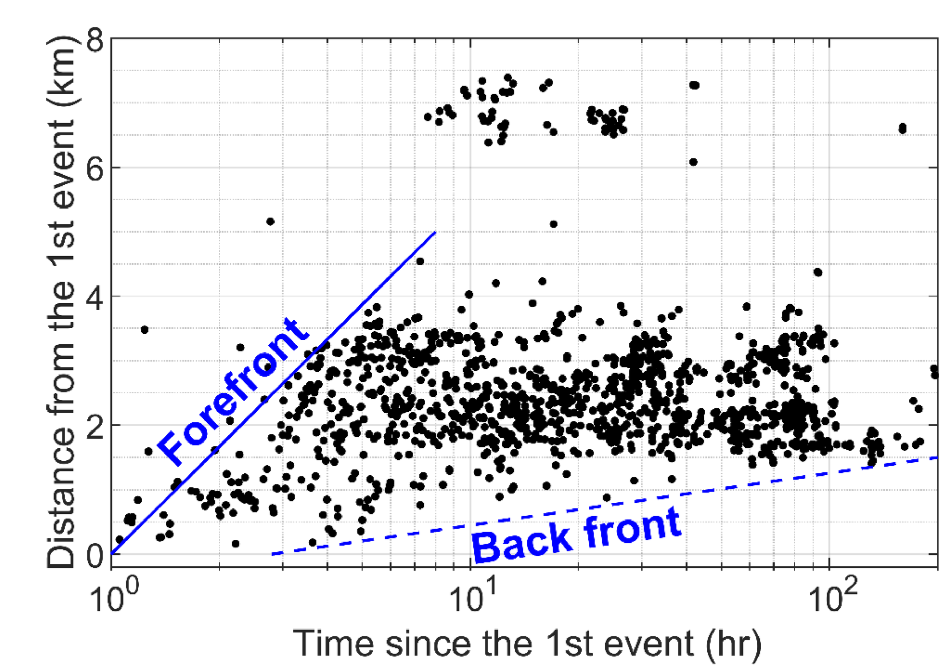
(2) Stressing front from slow slip event triggered seismicity with log(t) propagation

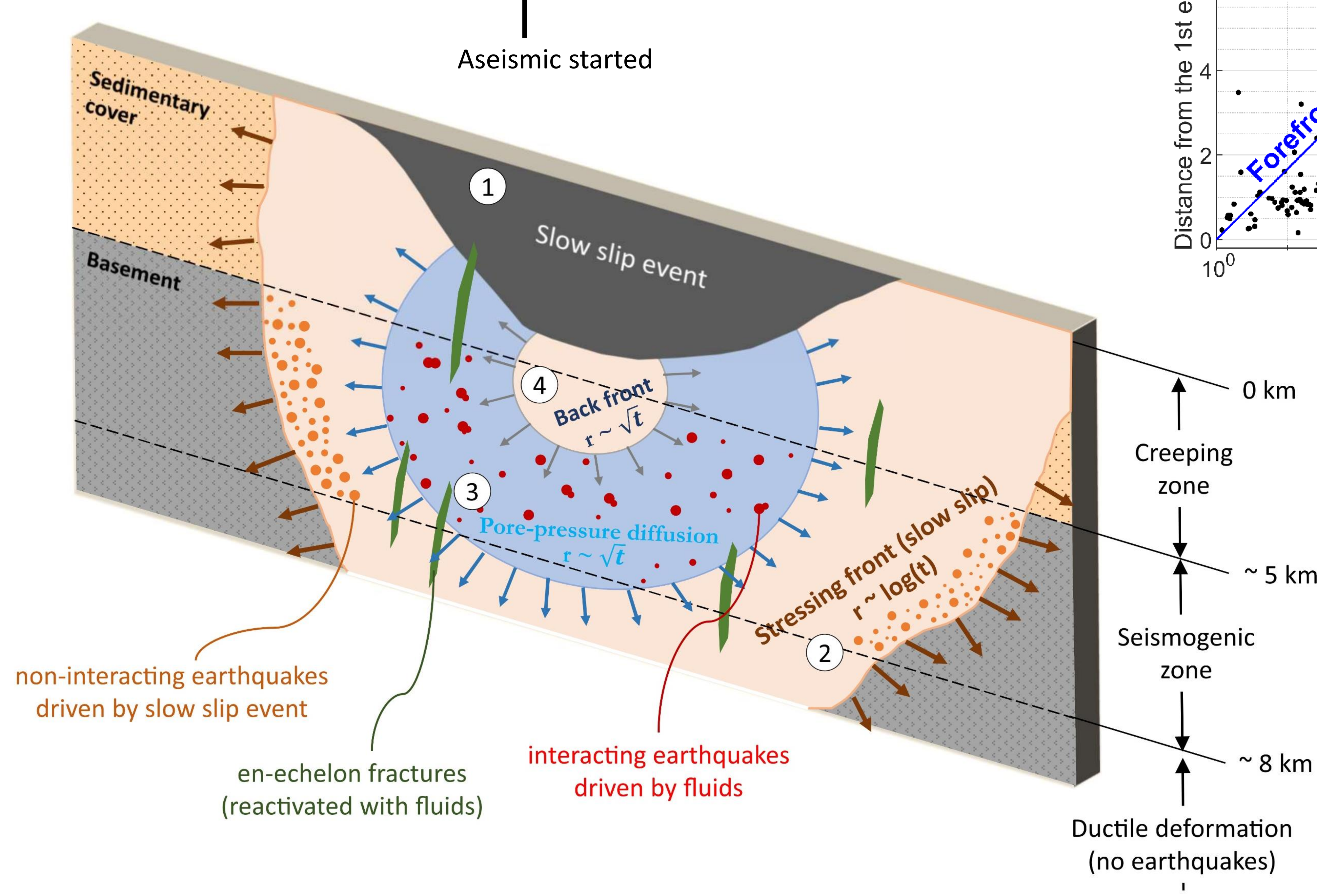
- A stress-driven model (Dieterich, 1994) explains the observed seismicity and the time delay



(3) Pore-pressure diffusion + (4) Back front

- A stress-driven model cannot explain the latter part of the swarm, requiring secondary mechanisms.
- Pore-pressure diffusion is a plausible candidate due to existence of propagating back front.





Slow slip driven
45 – 65%

Inter-earthquake interactions
10 – 35%

Fluids
10 – 30%