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Abstract

- In China, Changning shale gas field faces severe induced earthquake hazards since 2015, including 2 $M > 5$, 22 $M > 4$, 80 $M > 3$ events since 2015.
- Factors controlling moderate to strong HF-induced earthquake behaviors remain unclear.
- Integrate high-resolution V_s model, source attributes of $M > 3$ earthquakes, dynamic ruptures of $M > 5$ events, seismic reflection profiles and InSAR data.
- We find high velocity zones control induced earthquake behaviors.

Geological settings of the Changning shale gas field

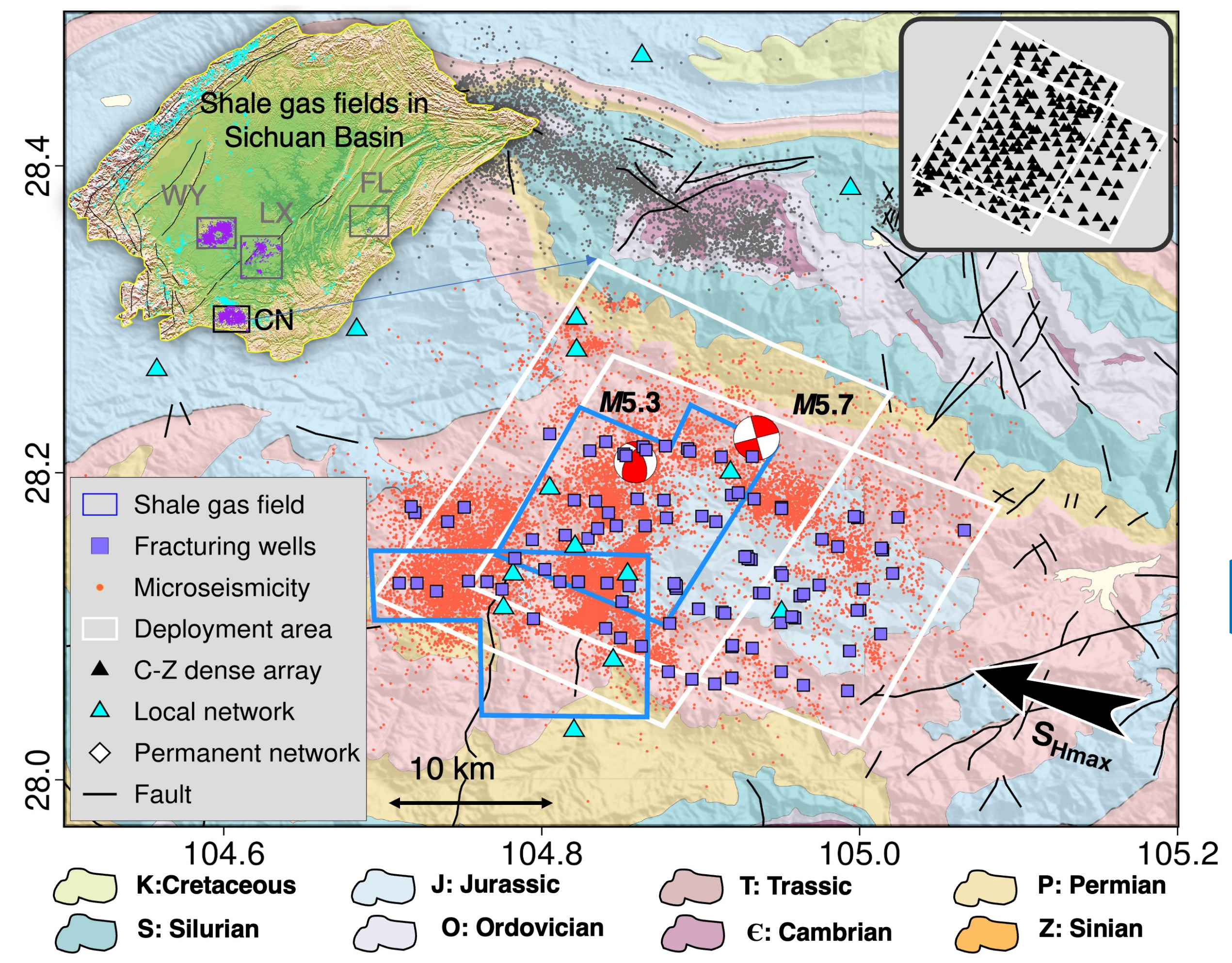


Fig. 1 Seismicity distribution and geological settings.

- ~400 wells since 2014
- Target shales at 2 km depth
- Structure: Jianwu Syncline
- 2015-2019: ~26,000 events from M_0 to $M_{5.7}$
- 2018 Xingwen $M_{5.7}$ & 2019 Gongxian $M_{5.3}$

Two-phased dense arrays

- 70 d: 2019.2.28-2019.5.8
- 336 5-Hz nodal stations
- ~1.5 km spacing
- ~13,000 earthquakes from $M_{-1.7}$ to $M_{3.3}$

Seismic potentials in the Changning shale gas field

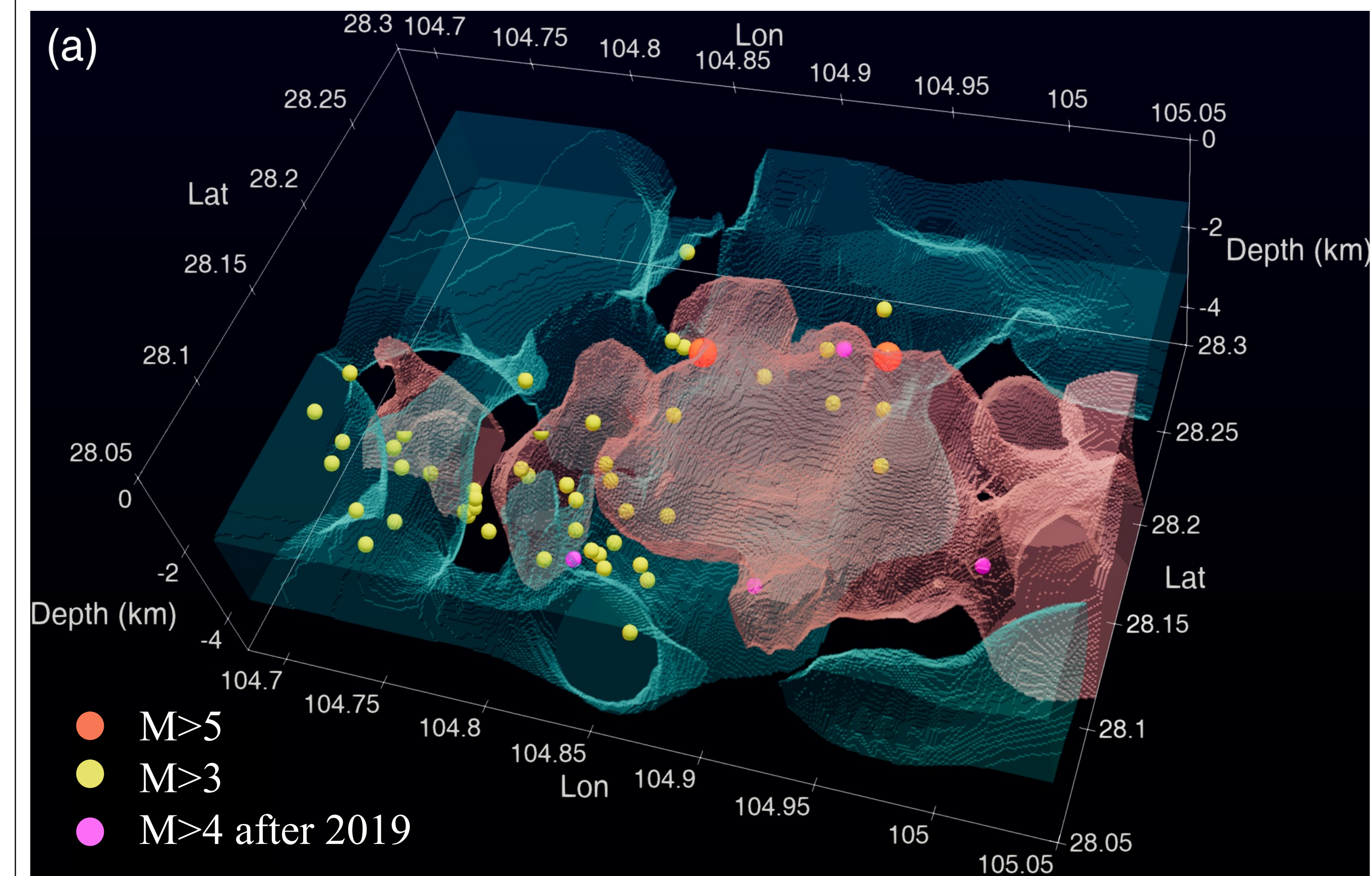


Fig. 5 Regional seismic potential assessment. Regions between high (blue) and low (red) V_s areas are of high seismic potentials.

Conclusions

- Moderate HF induced earthquakes tend to initiate at areas of large V_s gradients.
- High velocity asperities control ruptures & magnitudes of $M > 5$ events.
- Velocity model can estimate the geological susceptibility to potential runaway earthquakes and their maximum magnitudes.

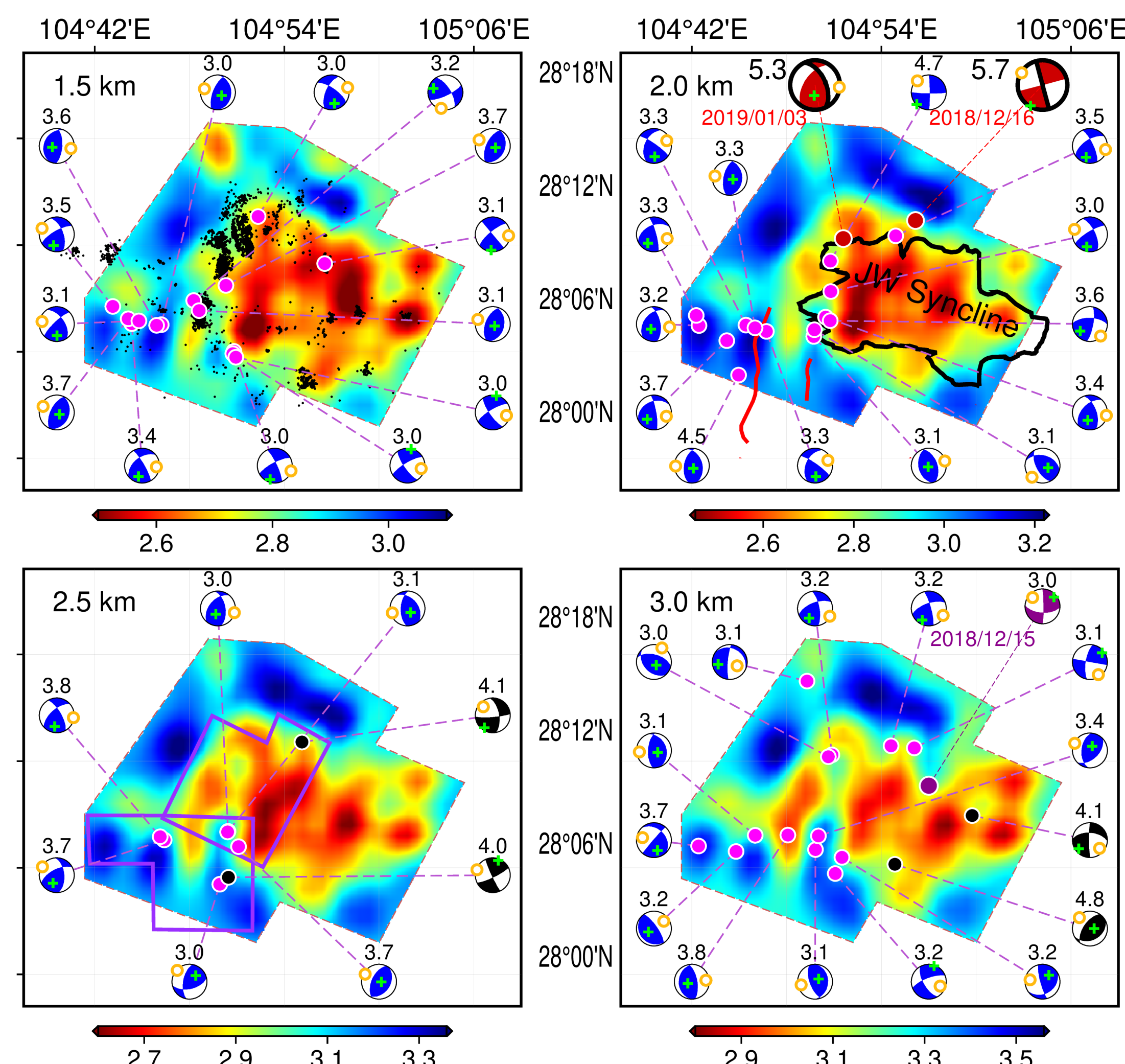


Fig. 2 Shear wave velocity and source mechanisms.

Ambient noise tomography

- One-step inversion method
- ~8,600 Rayleigh wave phase velocity dispersion curves
- Horizontal resolution ~2km
- Syncline core of low V_s

Moment tensor inversion

- Earthquakes located at areas of large V_s gradients
- Strike-slip/thrust events
- Red beachballs highlight Xingwen $M_{5.7}$ and Gongxian $M_{5.3}$ events

- Finite fault inversion: Combine InSAR data and Seismograms
- Runaway earthquakes
- Ruptures & magnitudes correlated well with the sizes of high velocity bodies

Rupturing Processes



Dynamic ruptures of Xingwen $M_{5.7}$ & Gongxian $M_{5.3}$ main events

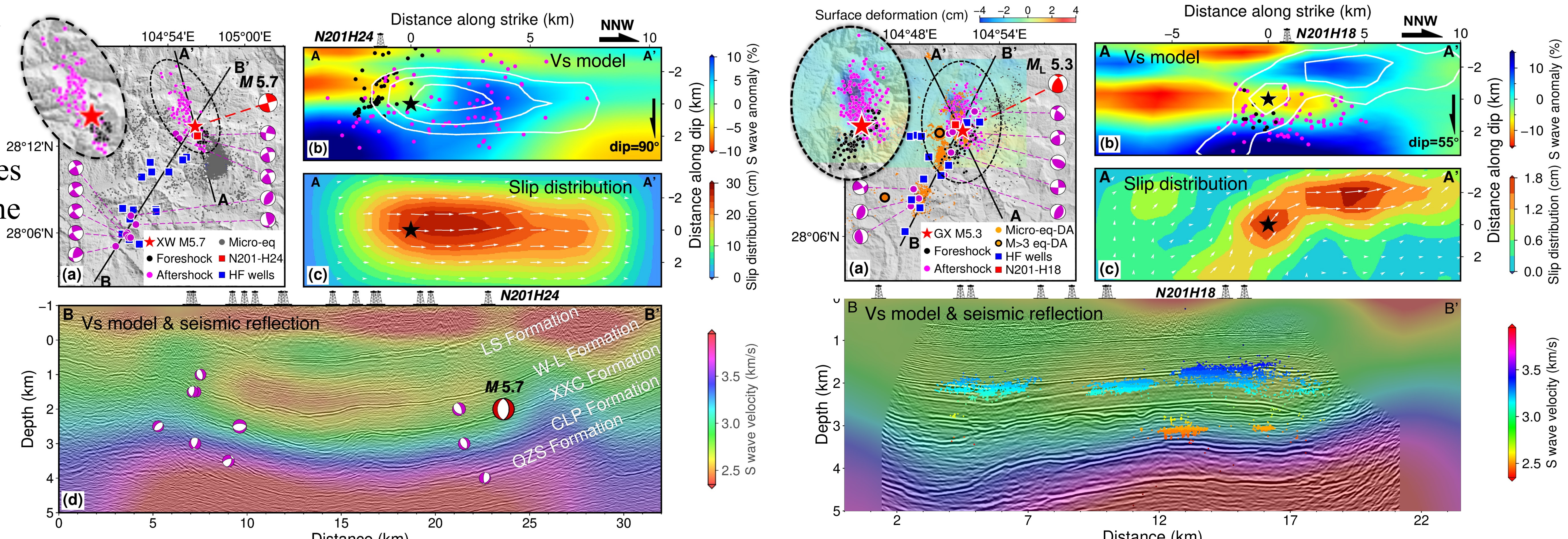


Fig. 3 Fault slip distribution of Xingwen $M_{5.7}$ earthquake.

Fig. 4 Fault slip distribution of Gongxian $M_{5.3}$ earthquake.