Investigating the Subsurface Geometry of the Mogod Fault System in Mongolia Through Earthquake Hypocenter Relocation

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INTRODUCTION AND MAIN RESULTS

The January 5 1967 Mogod earthquake (Ms 7.5, Mw 7.1) in Mongolia caused significant surface faulting and has long been a focus of seismological studies. This research's key area of investigation is the junction at 48.2°N, 103.05°E, where north-south (N-S) and north-northwest–south-southeast (NNW–SSE) fault systems intersect. Despite the lack of surface evidence linking these faults, subsurface structural interactions have been inferred by relocating seismic events using the SeisComP module SCRTDD. This approach has revealed that there is a connection between two faults at depth of around 3-10 km, a possible fault plane dipping to west for an angle of roughly 75-80 degrees, providing insights into fault behavior and seismic hazard potential.

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P1.2-552

Introduction

Recent collaborative research (2022–2024) between The Institute of Astronomy and Geophysics, Mongolia, and The Korea Institute of Geoscience and Mineral Resources (KIGAM) has advanced the understanding of The January 5 1967 Mogod earthquake (Ms 7.5, Mw 7.1) fault system in Mongolia.

10 temporary seismic stations in coverage of the Mogod fault were installed and detected total 8551 events with 164330 local phases manually picked during this period.

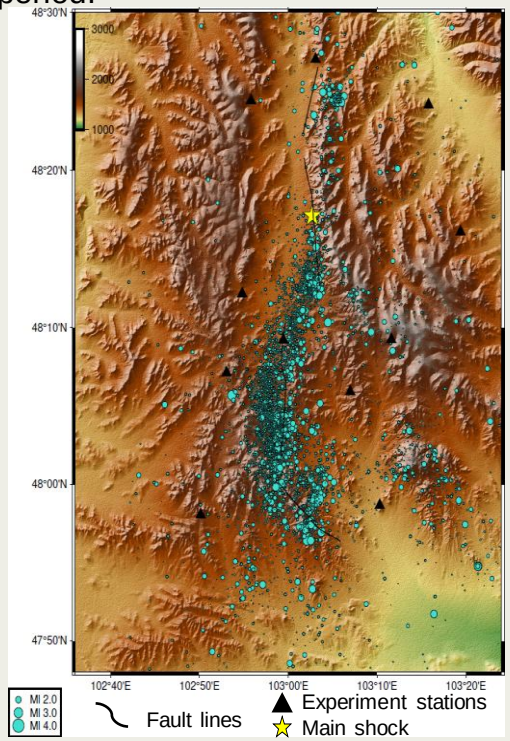

Fig 1. Seismicity of the region

Methods and data

Double difference method relocates earthquakes by minimizing travel-time residuals between observed and predicted arrivals for closely spaced event pairs. It is based on the assumption that nearby events share similar ray paths to a common station. It reduces systematic errors from poorly known velocity models and utilizes both absolute travel times from traditional picks differential travel times from waveform cross-correlation.

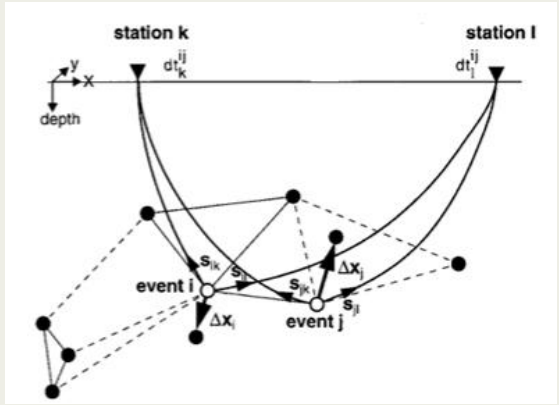

Fig 2. Double-difference method illustration

$$dr_k^{ij} = (t_k^i - t_k^j)^{obs} - (t_k^i - t_k^j)^{cal} \; ; \; \frac{\partial t_k^i}{\partial m}\Delta m^i - \frac{\partial t_k^j}{\partial m}\Delta m^j = dr_k^{ij}$$
$$where\ \Delta m(\Delta x, \Delta y, \Delta z, \Delta \tau)$$

Definition of double-difference by Waldhauser and Ellsworth (2000)

$$\boldsymbol{WGm = Wd}$$

The linear version of the equation, where $\boldsymbol{W}$ is diagonal matrix to weight each equation, $\boldsymbol{G}$ is a matrix containing partial derivatives with a size of $M \times 4N$ (M, number of double-difference observations, N, number of events), $\boldsymbol{d}$ is data vectors of double-differences

Results

The comparison between the initial catalog and relocated results by Seiscomp SCRTDD are shown in Fig 3 and Fig 4.

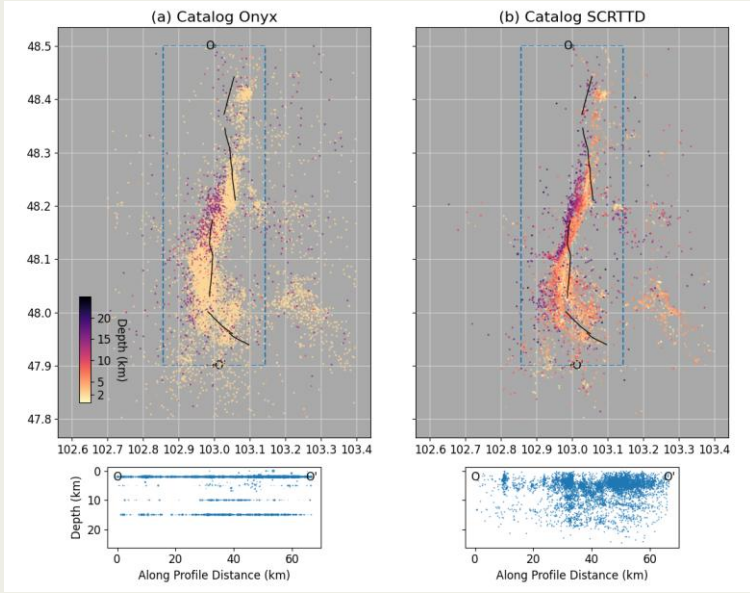

Fig 3. (a) Initial catalog event distribution and depth profile along OO'
(b) Relocated catalog event distribution and depth profile along OO'

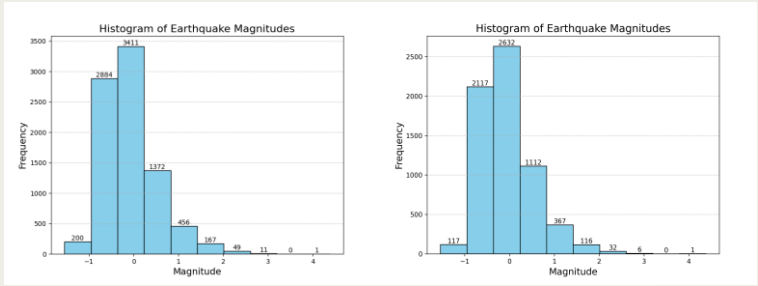

Fig 4. (a) Initial catalog event magnitude distribution
(b) Relocated catalog event magnitude distribution

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Results and conclusions

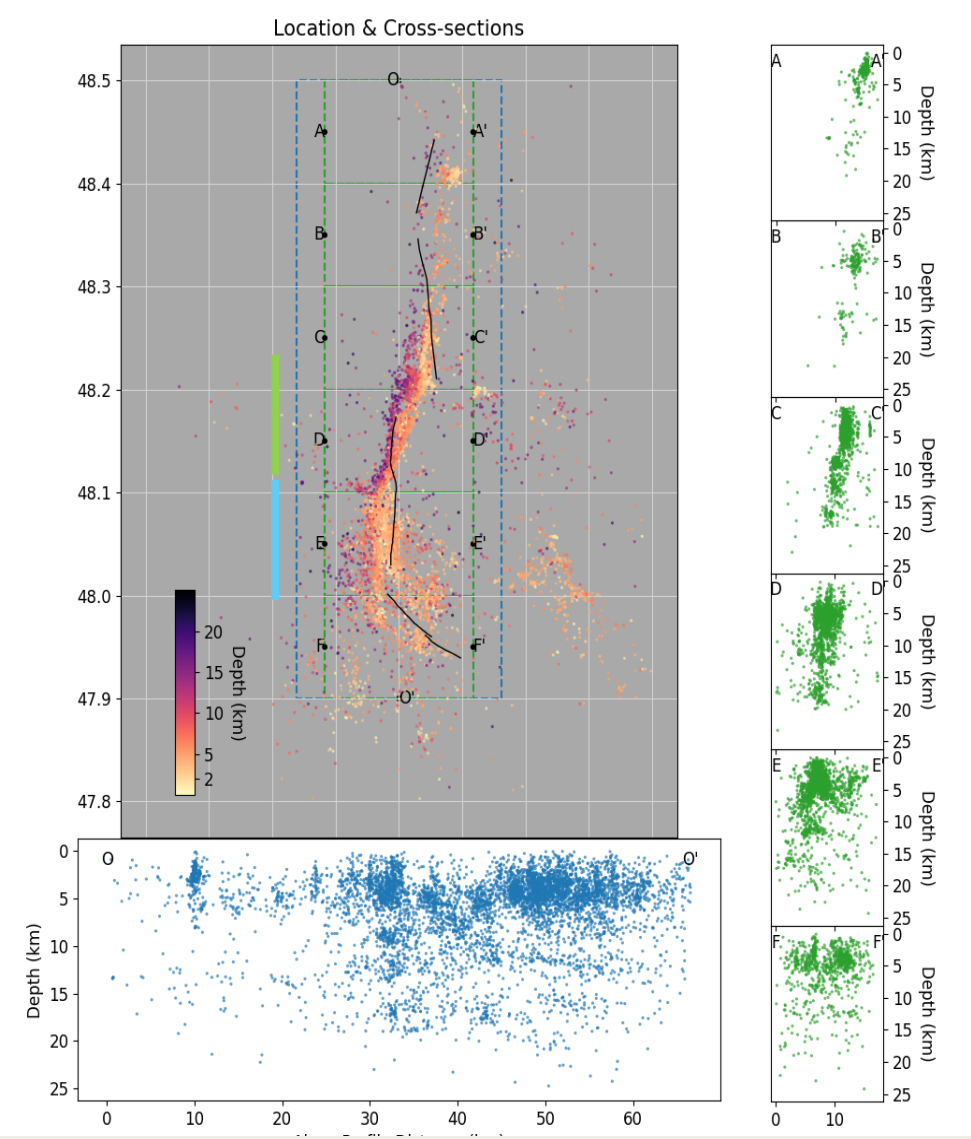

Fig 5. Relocated event catalog vertical and horizontal cross-sections
Blue – Vertival cross-section along OO'; Green – Horizontal cross-section AA' – FF'

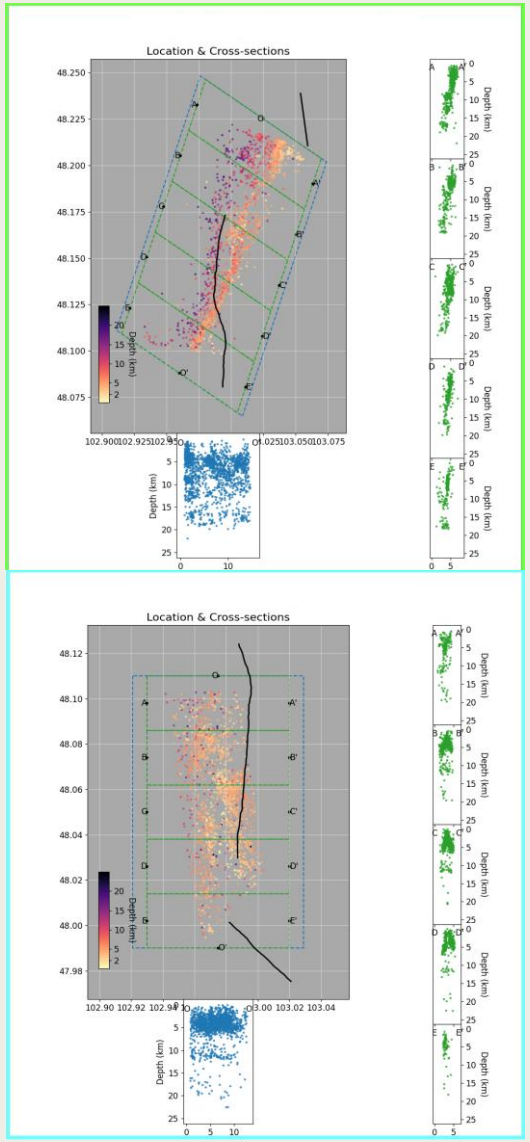

Fig 6. The zoomed cross-section part of the junction of two vertical faults
Blue – Vertival cross-section along OO'; Green – Horizontal cross-section AA' – FF'

- **KIGAM** and **IAG** deployed joint seismic experiment from **2022-2024** on an important seismically active region, which is 1967's magnitude **Mw7.1 Mogod earthquake** rupture zone to understand how **two vertical faults** in this area is connected.
- From the relocation of events, it is quite clear that **there is a connection** between them at depth of around **3-10 km**, a possible fault plane dipping to west for an angle of roughly **75-80 degrees**.
- Cross-correlated Seiscomp **SCRTDD module** works quite good to relocate events.

In future:

- Due to the absence of a formula for the magnitude of very local earthquakes with distance range of 1-60 km, there is a problem on estimating local magnitude.
- Ml for very near distance or duration magnitude Md needs to be calculated. After this, a seismic regime study of Mogod region using the experiment data could be possible.
- Estimating local velocity model to check the stability of relocations and recalculate historical data, specially aftershock between 1964-1970.
- Constrain stress field and focal mechanism with high quality seismic waveforms including other permanent stations.

Fig 7. The zoomed cross-section part of the bottom part of lower vertical fault
Blue – Vertival cross-section along OO'; Green – Horizontal cross-section AA' – FF'