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ADVANCES IN ASTRONOMY AND GEOPHYSICS

Application of Depth Scanning Algorithm in the Mogod Region

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INTRODUCTION

Focal depth is a key parameter in earthquake monitoring, providing critical insights into seismic source processes and hazard assessment. Accurate depth estimation improves our understanding of local tectonics, fault behavior, and earthquake risk. In this study, we apply the Depth Scanning Algorithm (**DSA**) to determine absolute focal depths of earthquakes in the Mogod fault zone, a seismically active region in Mongolia. This work is part of an international collaboration with the Korea Institute of Geoscience and Mineral Resources **(KIGAM)**, under which **10 temporary seismic stations** were deployed to enhance network coverage. These additional stations enable more precise event localization and offer an opportunity to test automated depth determination tools, ultimately contributing to improved seismic monitoring and a clearer understanding of regional seismicity.

Figure 1. "Mogod" fault and the fence at the station MG01

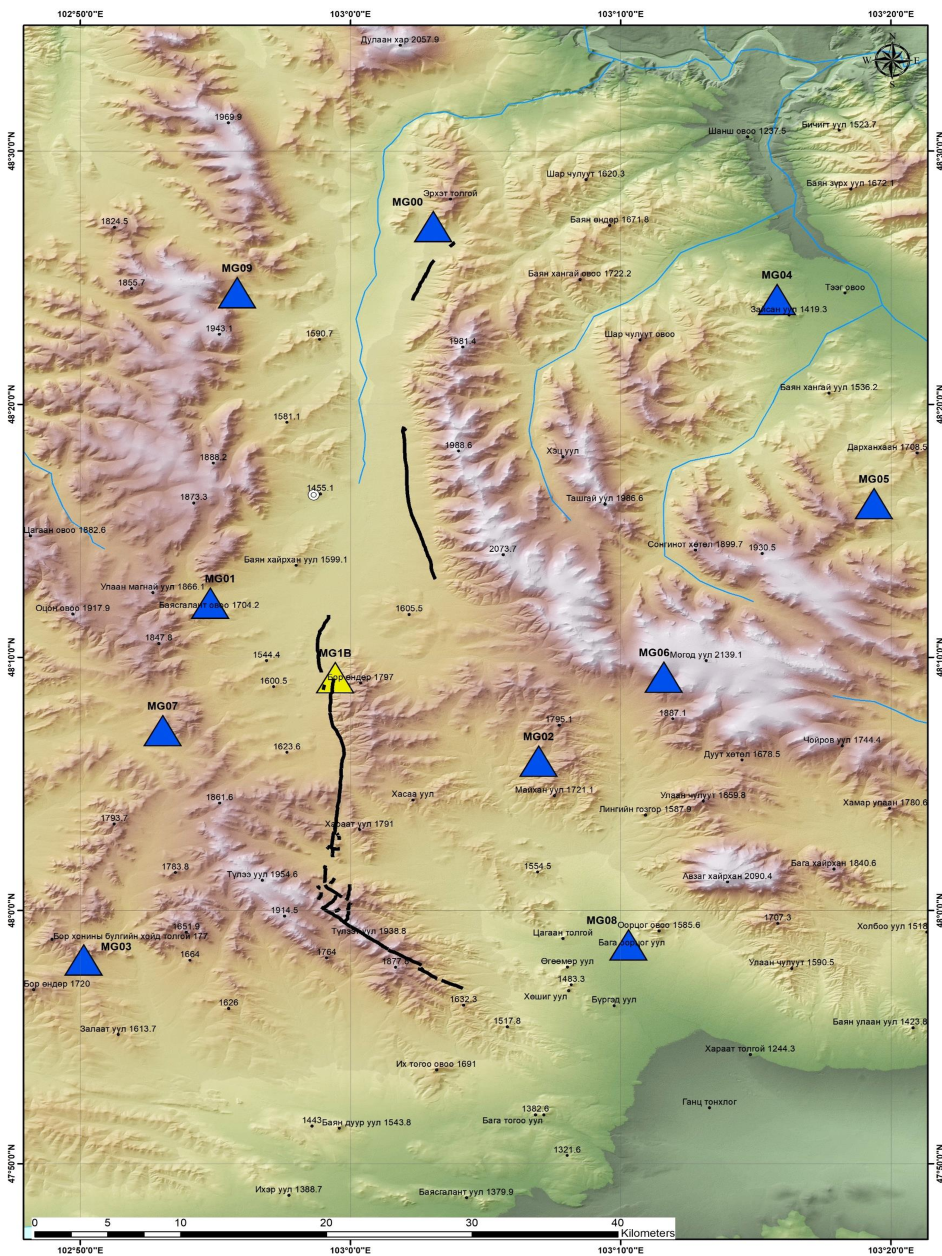

Figure 2. Distribution of the KIGAM experiments along the "Mogod" fault. (The map developed by A.Amarmend, researscher from IAG, EEW laboratory)

DATA

For the event selection and data retrieval, we analyzed a total of **6,356 seismic events** recorded by stations in the KG network, spanning the timeline from **December 19, 2022, to August 26, 2024.**

From this comprehensive dataset, the **DSA successfully calculated** focal depths for **3,388** events by identifying applicable depth phases and their corresponding reference phases.

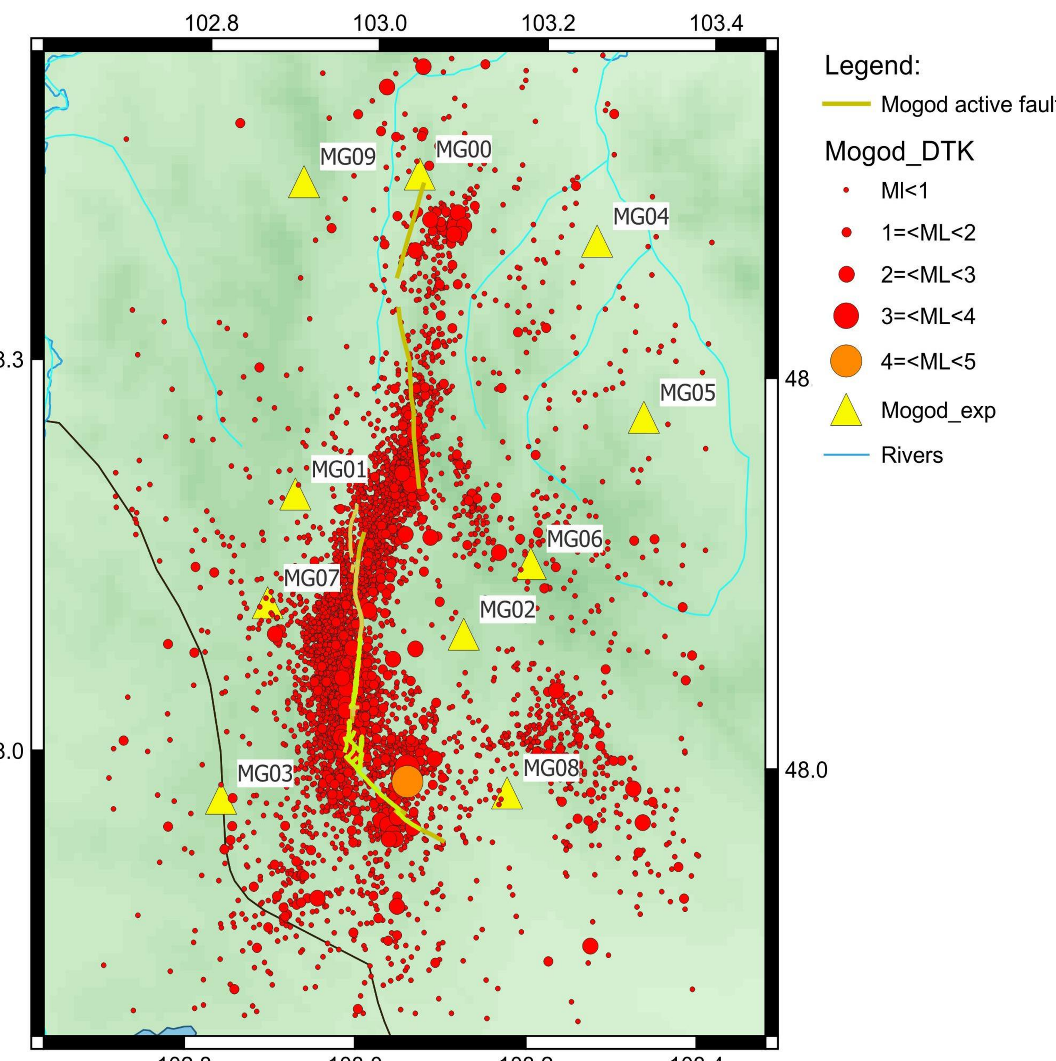

Figure 3. Epicenter distribution of all earthquakes utilized for Depth Scanning Algorithm (DSA) calculations from December 19, 2022, to August 26, 2024.

METHOD: **Depth Scanning Algorithm (DSA)**

The Depth Scanning Algorithm *(Yuan, 2020)* is designed to determine earthquake focal depths by identifying depth phases in seismic waveforms recorded at local and regional distances. Depth phases, such as **pPg**, **sPg**, and **sPmS**, are secondary arrivals produced when seismic waves reflect off the Earth's surface before reaching the station. These phases exhibit predictable time delays relative to the primary **P** and **S** waves, making them valuable indicators of source depth.

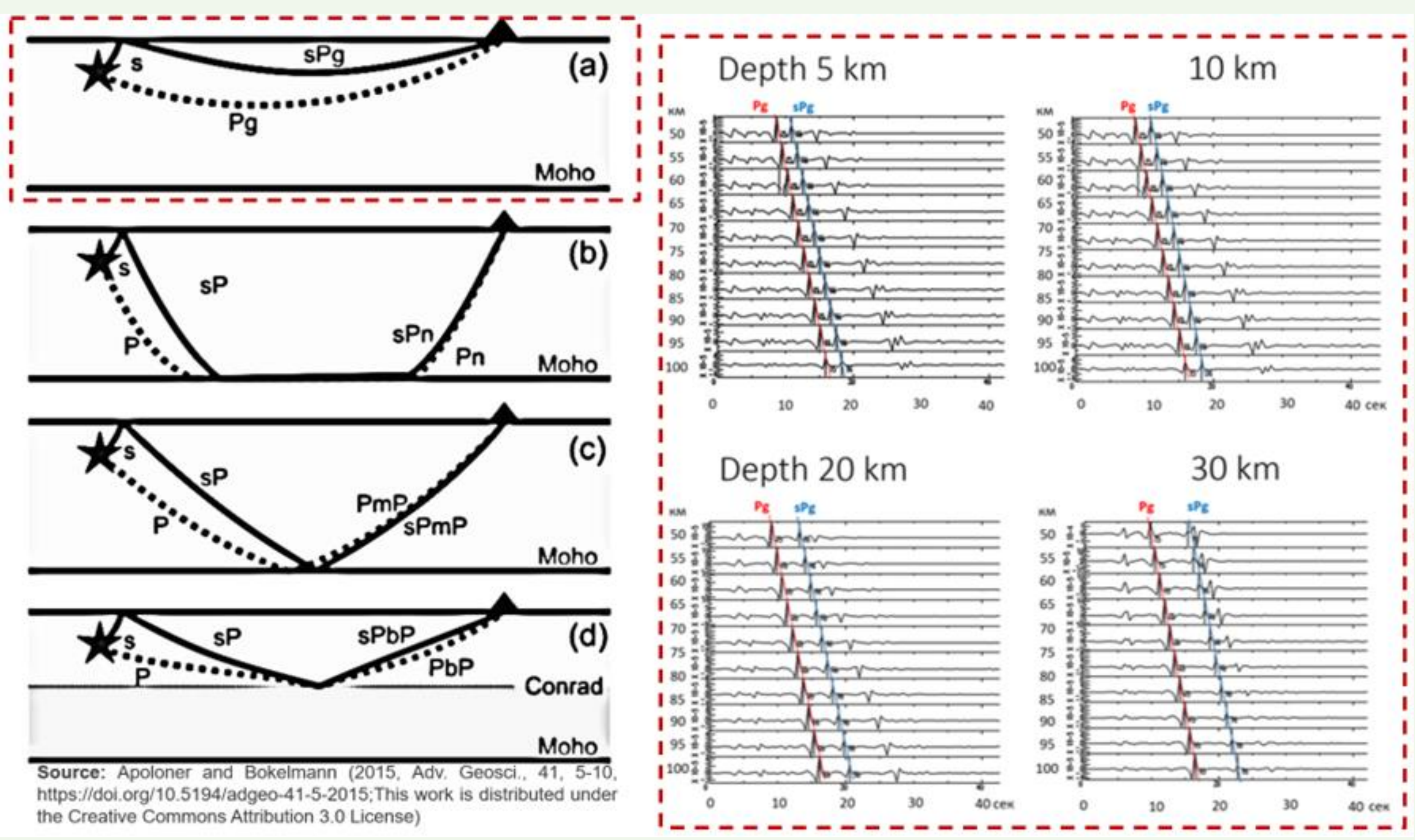

Figure 4. Ray paths of regional depth phases, illustrating the propagation of seismic waves from a fixed focal depth. As an example, synthetic seismograms for the Pg and sPg phases are shown, generated using the ERZSOL program for epicentral distances ranging from 50 km to 100 km. These seismograms demonstrate the arrival patterns of Pg and sPg waves at varying distances, highlighting the impact of focal depth on phase identification.

Velocity Model

Synthetic seismograms were calculated using a **1D four-layer velocity model** (sediment, upper crust, lower crust, mantle) based on the global AK135 model *(Kennett et al., 1995).* This model provides theoretical arrival times for different depth phases at varying source depths.

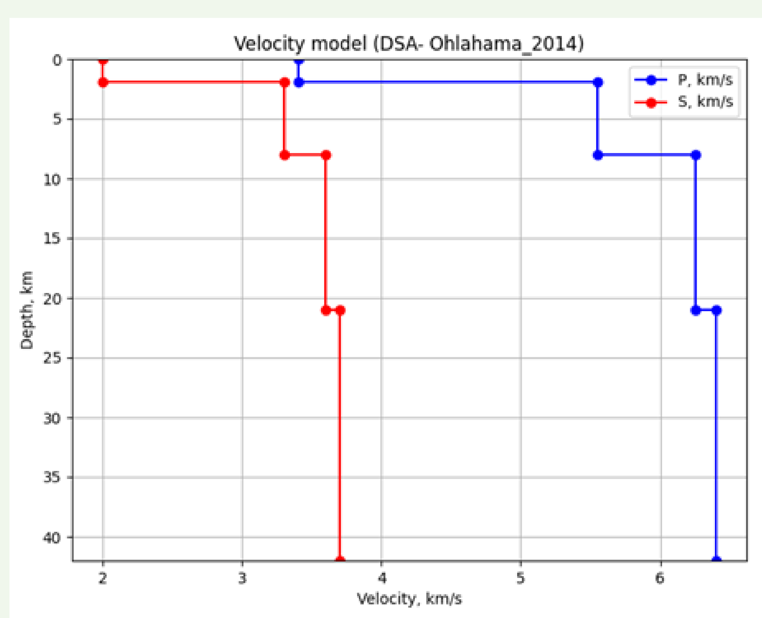

Figure 5. Velocity model used for synthetic calculations, showing the velocities of P-waves (blue line) and S-waves (red line).

Procedure

To estimate the focal depth of earthquakes, we applied the **Depth Scanning Algorithm (DSA)**, which systematically compares observed arrival times of depth phases with synthetic travel times from a 1D Earth model. The following steps summarize the full procedure, from data selection to depth determination.

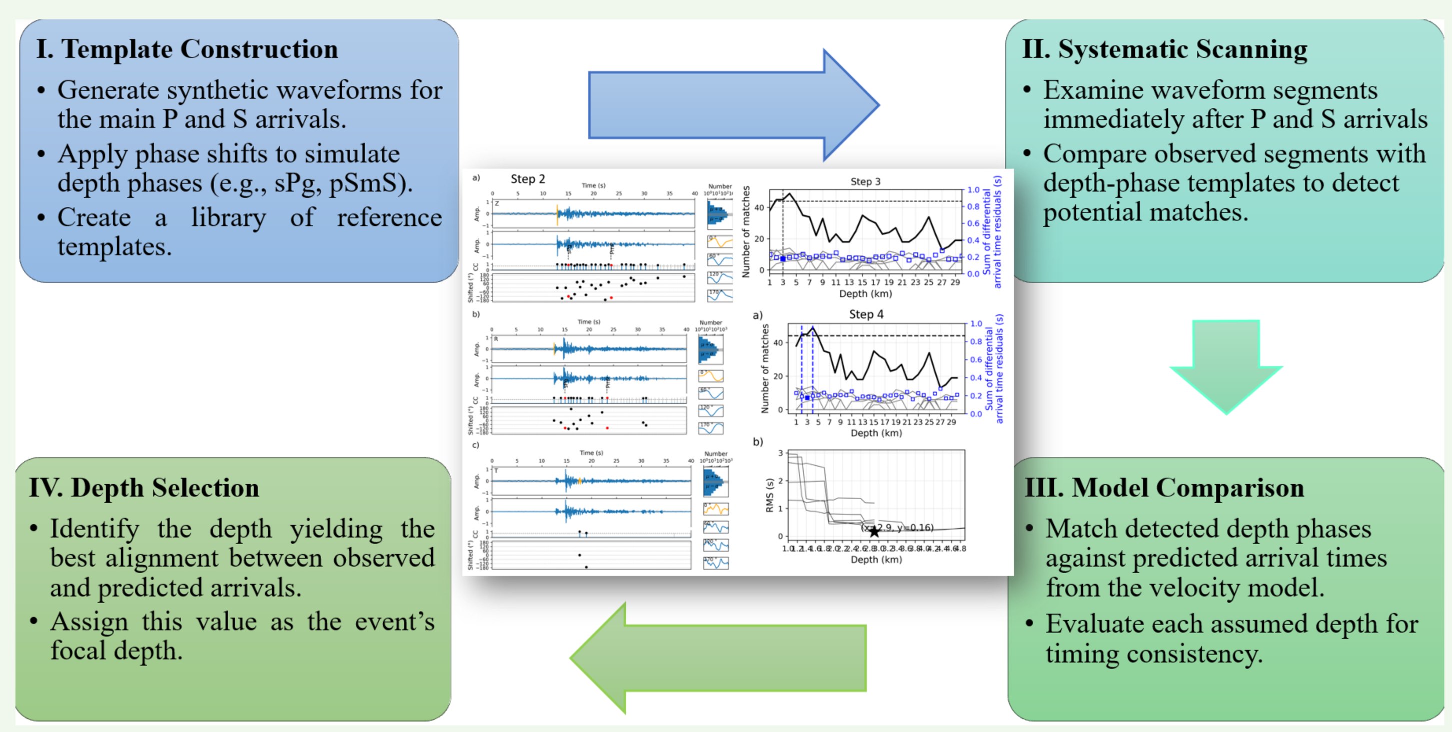

Figure 6. Flowchart of the Depth Scanning Algorithm (DSA) procedure used to estimate earthquake focal depths by comparing observed and synthetic arrival time differences of depth phases.

RESULT

Most earthquakes occurred at shallow depths, especially between **2–10 km**, making up over **70%** of all events. A few deeper earthquakes (over **20 km**) were also observed, possibly linked to changes in tectonic structure. To better understand these patterns, **five cross-sections** were made along and across the Mogod fault. These revealed varying fault geometries—some segments show **vertical clustering**, while others suggest **inclined fault planes**, hinting at different fault behaviors and stress directions.

Sub-Cross Section Analysis

To better understand fault behavior, we created **four sub-cross sections** aligned along fault branches of the Mogod fault zone, plus one **latitude-aligned cross section**.

- These profiles reveal variations in seismicity patterns.
- This depth-structure relationship is critical for identifying active fault zones

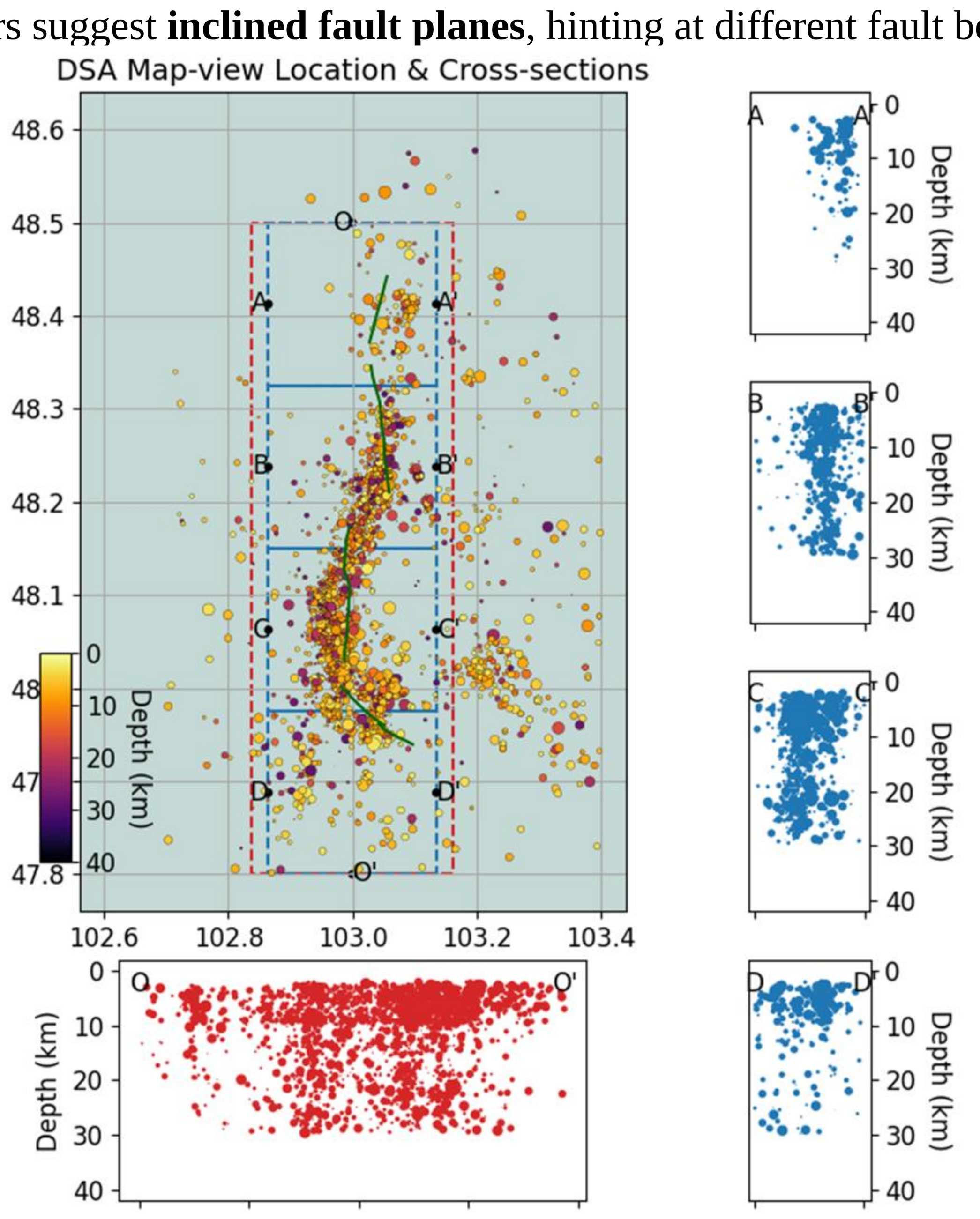

Figure 7. DSA map-view location plot illustrating the depth distribution of seismic events, with a color bar representing the depth ranges.

Focal Depth Distribution

- Focal depths ranged from **2.0 km to 29.7 km**.
- Over **70% of events** occurred at depths **shallower than 10 km**, indicating a dominance of shallow seismicity.
- A smaller subset of events showed **deeper focus (>20 km)**, which may reflect variations in tectonic structure or stress regime.

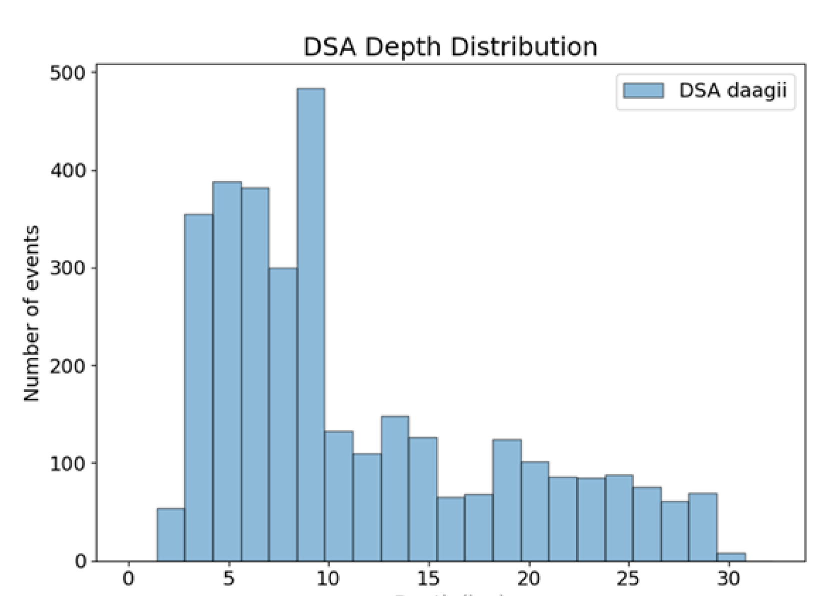

Figure 8. A histogram of the depth distribution by the number of events. It's providing a visual summary of the focal depth characteristics in the dataset

DISCUSSION

The application of the Depth Scanning Algorithm (DSA) in the Mogod region provided valuable insight into the **vertical distribution of seismicity** and the **geometry of active faulting**. The results show that:

- **Shallow seismic events (2–10 km)** dominate the region, suggesting that brittle deformation occurs primarily in the upper crust.
- The presence of **deeper events (up to ~30 km)** in certain areas indicates more complex tectonic behavior, possibly involving **crustal segmentation** or **deep-seated fault zones**.
- Sub-cross-section analysis revealed **distinct fault structures** within the Mogod fault system, with variations in depth clustering, fault dip, and seismicity concentration.
- These differences may reflect **heterogeneous stress fields** and variations in fault maturity or slip behavior.

The DSA proved to be an effective tool for **automated focal depth estimation**, especially when enhanced by a dense local network. It contributes significantly to our ability to **resolve fine-scale structures** within active fault zones, which is essential for understanding seismic hazard.

FUTURE WORK

To build on the findings of this study, future work will focus on:

🔍 **Refining focal depth estimates** by integrating regional velocity models and comparing with alternative localization methods (e.g., PhaseNet, double-difference location).

🌐 **Expanding DSA applications** to other active regions in Mongolia using the same processing workflow and station setup.

🧠 **Improving automated depth-phase detection** using machine learning tools trained on synthetic and observed waveforms.