THE INTERNATIONAL CONFERENCE ON THE 120TH ANNIVERSARY OF THE BULNAY EARTHQUAKE: ADVANCES IN ASTRONOMY AND GEOPHYSICS

MACROSEISMIC SURVEY RESULTS OF THE KOSH-AGASH EARTHQUAKE, RUSSIA

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Abstract

On February 15, 2025, at 01:48:18 UTC (08:48 local time), an earthquake with a magnitude of 6.4 occurred in southern Siberia, Russia, approximately 20 km southeast of Kosh-Agach village (49.87°N, 88.84°E). The tremor was felt across the western regions of Mongolia, including Bayan-Ulgii, Uvs, and Khovd provinces. To evaluate the intensity of the seismic shaking, a total of 758 macroseismic field observations were collected and analyzed based on the MSK-64 intensity scale through a specialized questionnaire. This study is of significant importance for seismic hazard assessment, as it establishes the relationship between regional soil characteristics, seismic wave propagation, and intensity perception. The findings provide essential baseline data for disaster risk reduction strategies and regional planning and policy development.

Introduction

On February 15, 2025, at 01:48:18 UTC (08:48 local time), an earthquake with a magnitude of 6.4 occurred in southern Siberia, Russia, approximately 20 km southeast of the village of Kosh-Agach (49.87°N, 88.84°E) (Figure 1). The seismic shaking was felt across the territories of Bayan-Ulgii, Khovd, and Uvs provinces. Preliminary observations indicate that the perceived intensity and structural impacts varied significantly, depending on local geological conditions. Given these variations, it became necessary to assess the extent and intensity of the earthquake using macroseismic methods. This study focuses particularly on the relationship between ground shaking and geological conditions within Bayan- Ulgii province, aiming to evaluate intensity levels and understand how site-specific factors influence seismic response.

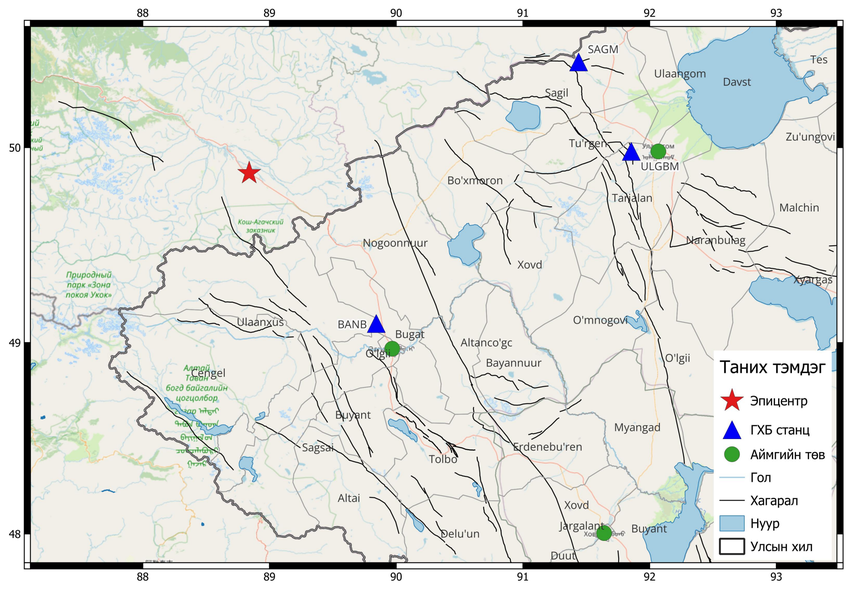

Figure 1. Epicentral map of the M6.4 earthquake that occurred near the village of Kosh-Agach

Geologically, the soil of Ulgii soum is predominantly composed of unconsolidated Quaternary sediments of Cenozoic age, formed by fluvial, lacustrine, and alluvial processes. These sediments mainly consist of sand, silt, and gravel, which are uncemented and unindurated—referred to as loose deposits. The bedrock density is approximately 2.58 g/cm³. According to regional geological investigations, the thickness of the loose sediments has been determined to range between 80 and 100 meters. The subsurface composition of Ulgii soum is primarily characterized by these loose deposits, with variable thickness across different areas. For instance, sediment thickness tends to be greater in river valleys and flat plains, while it is relatively thinner in elevated terrains and at the foothills of mountains [11].

Methodology

A specialized questionnaire was developed for this study based on the MSK-64 intensity scale. Oral interviews were conducted with local residents to gather information on their experiences during the earthquake. This qualitative data was then subjected to statistical analysis to calculate the average intensity values. The questionnaire was designed to assess the perceived effects of the earthquake on people, following the macroseismic intensity scale, and the intensity values were computed using the following formula [8].

$$I = \frac{\sum_{i=1}^{12} i s_i \theta\,(s_i - 0.75\,max(s))}{\sum_{i=1}^{12} s_i \theta\,(s_i - 0.75\,max(s))}$$

$$\theta = \begin{cases} 0, n < 0, \\ 1, n \geq 0, \end{cases} \textit{(unit step function) [3]}$$

Here:
I - denotes the intensity value calculated from the questionnaire (the target intensity value).
i - ranges from 1 to 12, representing the intensity scale steps.
s_i - refers to the frequency of the *i*-th intensity rating.
max(s) - represents the maximum intensity rating among the selected values.

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Data collection

To develop the database for this study, macroseismic data were collected from 280 residents across 13 soums and 1 village in Bayan- Ulgii province. Of these, 270 individuals reported strong ground shaking, while in one soum, the earthquake was not felt. In Uvs province, survey responses from a total of 258 individuals revealed that 92 people across five soums perceived the earthquake, whereas 166 reported no sensation of shaking. In Khovd province, residents from five soums—220 individuals in total—reported feeling the earthquake (Figure 2). Given these observations, the study aims to explain how the observed seismic impact in Bayan- Ulgii province correlates with the region's geological and geomorphological conditions.

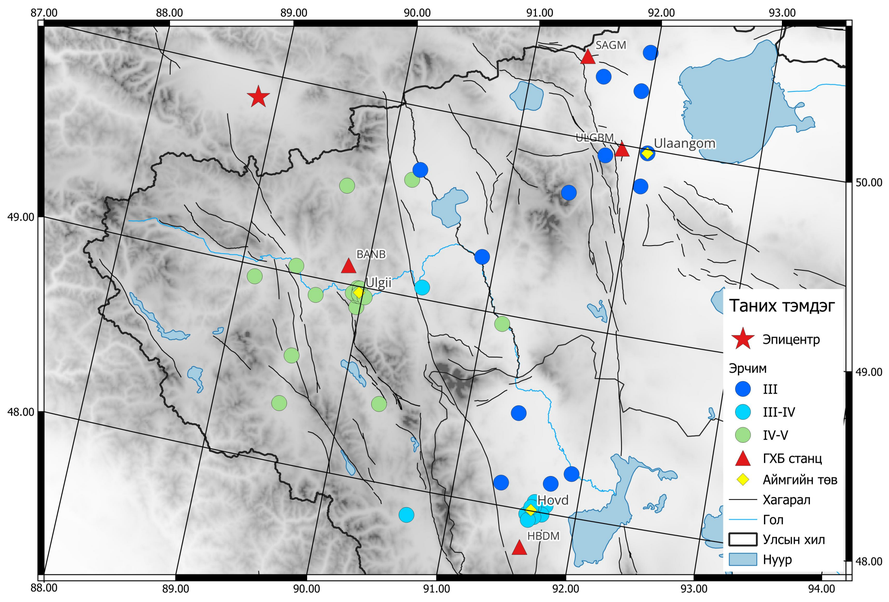

Figure 2. Macroseismic survey based on data from 582 respondents, evaluated using the MSK-64 intensity scale.

Conclusion

The strong earthquake was felt with an intensity of IV at the epicentral area near Kosh-Agach village (Figure 3), IV–V in Bayan- Ulgii province, III in Uvs province, and III–IV in Khovd province. Collaboration with seismic stations in Khovd and Uvs provinces supported these assessments. These results indicate that the intensity of ground shaking varied across regions, depending on the direction of seismic wave propagation and the physical properties of the local soil. The observed decrease in intensity with increasing distance from the epicenter further illustrates this trend. Based on these findings, an isoseismal map for the Kosh-Agach earthquake was developed (Figure 4).

Figure 3. Cracking observed in the wall-mounted stove of a resident's home in Kosh-Agach village

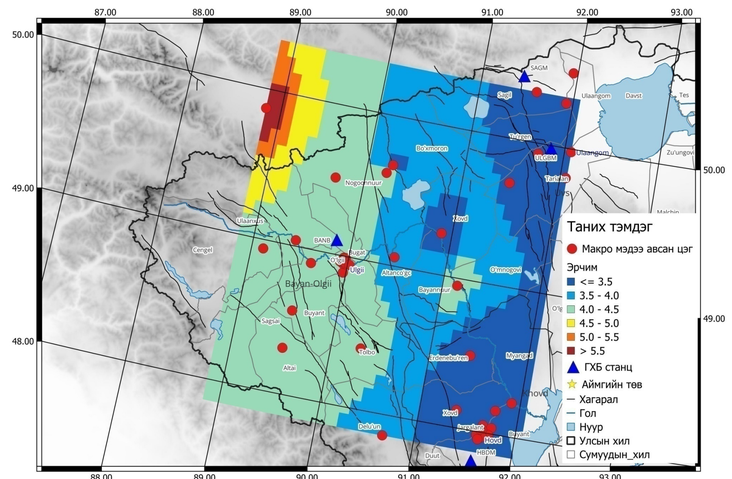

Figure 4. Isoseismal map of the Kosh-Agach earthquake.

On the macroseismic intensity distribution map of the earthquake, variations in intensity values were observed in Bayan-Nuur soum (Bayan- Ulgii), Bukhmurun soum (Uvs), and Khovd soum (Uvs). In the case of Bayan-Nuur soum, the area is dominated by soft alluvial sediments in river valleys and flat plains. The presence of thick sedimentary layers of fluvial origin contributes to seismic wave amplification, which in turn leads to higher observed intensity levels [11]. Bökhmörön soum is located on the western flank of the Altai Mountains and lies within a zone of volcanic basaltic and metamorphic rocks [12]. These types of rocks tend to attenuate seismic waves due to their higher rigidity and density, which reduces wave amplification. As a result, the intensity levels observed in this region were relatively low. Khovd soum in Uvs province is geologically characterized by hard granitic and crystalline rocks and is situated at a higher elevation above sea level. These factors contribute to the dissipation of seismic wave energy along the propagation path, resulting in lower intensity levels [13].

The territory of Bayan- Ulgii province is largely covered by unconsolidated sediments, making the observation of wave amplification in this area well-justified [11]. Therefore, the intensity values derived from the macroseismic survey are consistent with theoretical models of seismic wave amplification, reinforcing the reliability of the study's findings.
Furthermore, during the earthquake, the peak ground acceleration (PGA) recorded by an accelerometer station located in Bayan- Ulgii province was 0.02006 g. This corresponds to an intensity level of approximately IV–V, which is in agreement with the intensity estimates obtained from the macroseismic survey.