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

SEISMIC REGIME STUDY OF DUNDGOVI PROVINCE

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Abstract

Dundgovi Province is geographically located in the central part of Mongolia, situated in a transitional zone between steppe and semi-desert regions. It encompasses the southern part of the Khentii region, including major and minor branches of the Khentii Mountains. Geologically, the area includes active fault zones about 45 km wide and 200 km long, oriented from southwest to northeast along the southeastern edge of the Mongol-Amur Hercynian system. Although seismic activity is moderate, there is a significant potential earthquake risk. The primary active seismic area is the Deren fault zone, located at the border between Deren and Delgertsogt districts, where increased seismic activity has been observed in recent years.
From 1964 to 2024, the National Information Center recorded 173 earthquakes with magnitudes greater than 3.5, 53 earthquakes exceeding magnitude 4.0, and five earthquakes above magnitude 5.0. After data completeness adjustment, a total of 7,597 earthquakes with magnitudesof 2.0 and above were documented. Frequency-magnitude analysis yielded a b-value of 0.872 ± 0.009 (Magnitude completeness = 2.0), indicating a moderate energy release and a relatively low probability of major earthquakes.
Specifically, the Deren fault zone experienced three major earthquakes exceeding magnitude 5.0 (magnitudes 5.7 in 1998, 5.2 in 2010, and 5.1 in 2019) and thirteen earthquakes exceeding magnitude 3.5 from 1964 to 2024. In total, over 2,400 earthquakes were recorded in this zone, with a calculated b-value of 0.687 ± 0.03 (Magnitude completeness = 1.6), suggesting moderate stress release and an increase in weaker earthquakes in recent years.
Keywords: Magnitude, activity, frequency, seismic regime

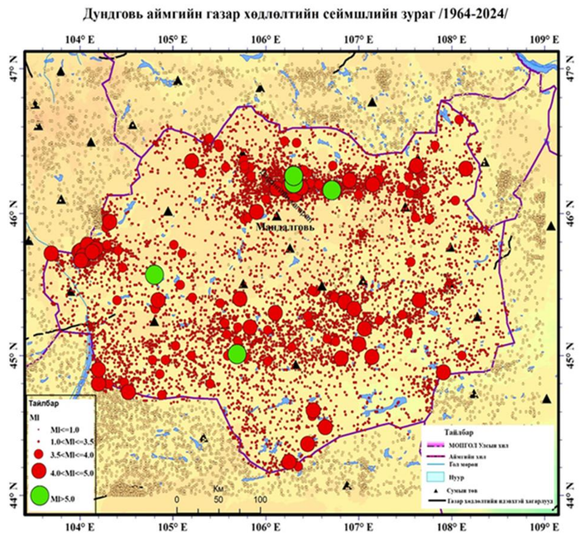


Figure 1: Earthquake Map of Dundgovi Province (1964–2024)

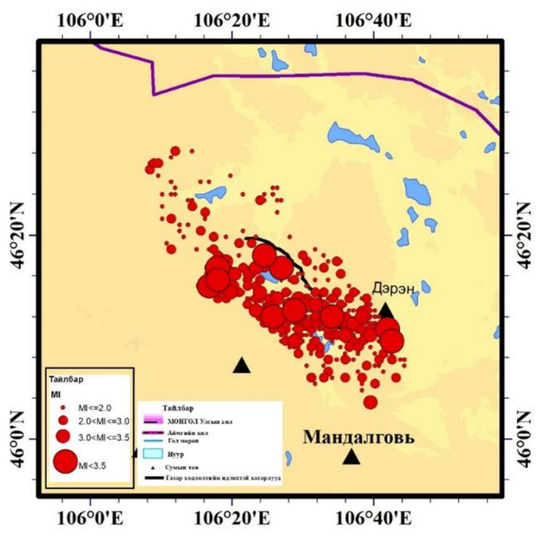


Figure 2: Earthquake Map Along the Deren Fault

Figure 3: General Topographic Overview of Dundgovi Province

Figures 4: The Deren Fault

Figures 5: The Deren Fault

Figures 6: The Deren Fault

Introduction

Dundgovi Province is centrally situated in Mongolia within a transitional region between steppe and desert environments. The province's highest elevation is Delgerkhangai Mountain at 1,926 meters above sea level. Other notable geological features include the Ikh Gazriin Chuluu and Baga Gazriin Chuluu mountain ranges. Upper Paleozoic deposits dominate the northern parts, while Cretaceous and Cenozoic deposits are prevalent in the southern areas.
Geologically, the area falls within the southern part of the Khentii mountain region, intersected by an active fault zone approximately 45 km wide and 200 km long, oriented southwest to northeast along the southeastern edge of the Mongol-Amur Hercynian system. Although characterized by moderate seismic activity, this region has a considerable potential earthquake risk. The primary active seismic zone is the Deren fault line located between Deren and Delgertsogt districts, extending from southwest to northeast (Odonbaatar, 2017).
The Deren fault is relatively small and has not been extensively studied, characterized by low hills and terrains transitioning from steppe to semi-desert regions. The fault is prominently visible on the surface, averaging about 6 meters high and inclined eastward, stretching approximately 57 km oriented northwest to southeast (azimuth 315-330 degrees). Analysis of fault length and displacement indicates it resulted from multiple seismic events rather than a single earthquake event. The fault is intersected by the Ulaanbaatar-Mandalgobi highway.

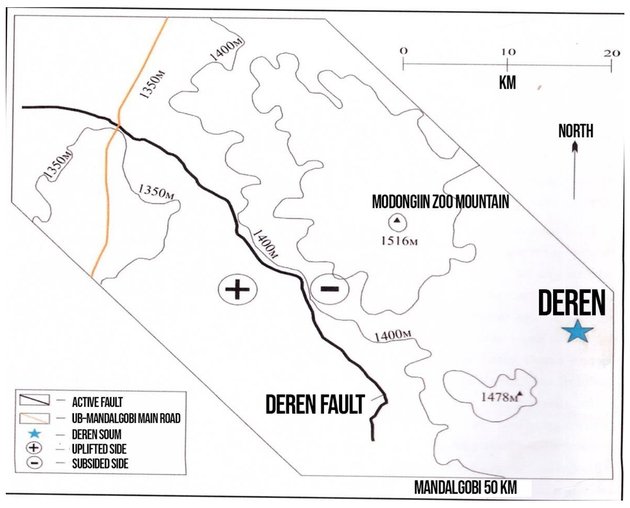


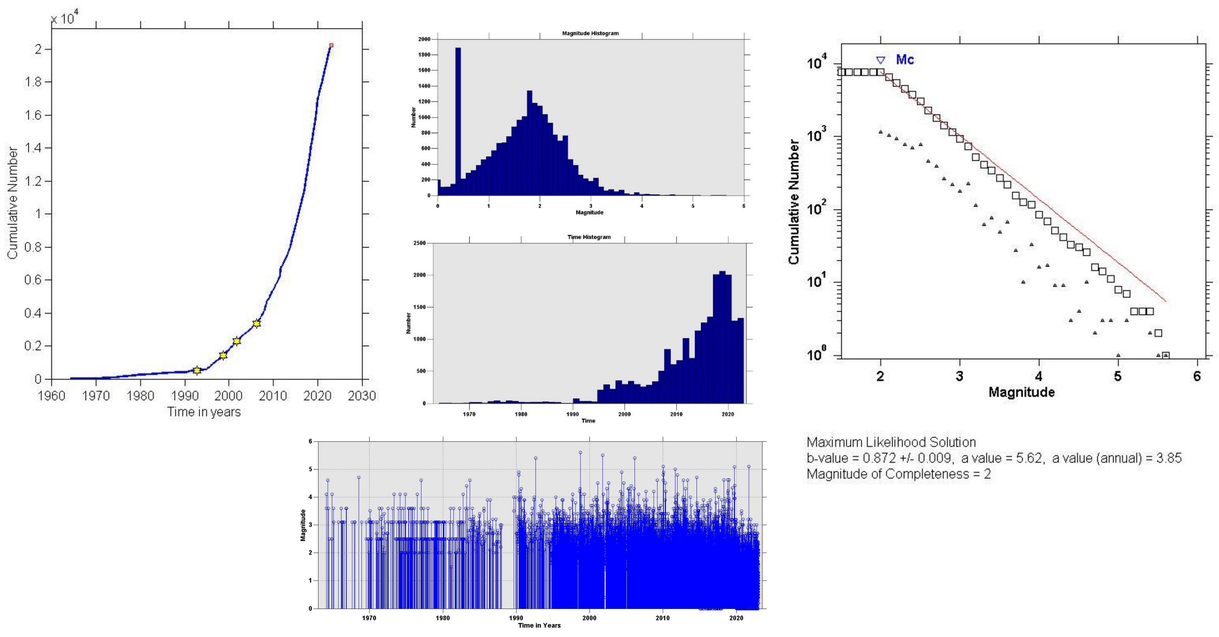
Figure 7: Simplified Topographic Map of the Deren Fault Area

Theoretical Background and Research Methodology

Gutenberg-Richter Law
Annually, numerous small earthquakes and relatively fewer large earthquakes occur globally. Gutenberg and Richter (1954) established a logarithmic relationship between the annual frequency of earthquakes (N) and their magnitude (Ms):
log N = a - bM
Here, 'a' typically ranges between 8 and 9 depending on the region, and 'b' usually approaches unity for regional seismicity analyses (Angelo De Santis, 2009).
The Gutenberg-Richter frequency-magnitude relationship utilizes seismic data to determine seismic activity levels and recurrence intervals. Accurately identifying seismic phases and precisely locating earthquake epicenters is essential, especially when differentiating seismic events from vibrations caused by mining blasts or other movements.

Seismic Regime Study of Dundgovi Province

A seismic regime study was conducted in Dundgovi Province to evaluate earthquake impacts, potential risks, and recurrence in populated settlements. Data from the National Information Center recorded a total of 9,343 earthquakes from 1964 to 2024, including 766 events with magnitudes below 1.0 and 8,577 events exceeding magnitude 1.0. Among these, 173 earthquakes had magnitudes greater than 3.5, 53 exceeded magnitude 4.0, and five surpassed magnitude 5.0.
Data completeness analysis from 1964-2024 indicated that 7,597 earthquakes with magnitudes of 2.0 or higher were fully documented. Frequency-magnitude analysis produced a b-value of 0.872 ± 0.009 (Magnitude completeness = 2.0), suggesting moderate energy release and a relatively low probability of major earthquakes occurring. The seismic activity index (a-value) calculated for this province was 5.62, indicating a high seismic activity level predominanlty associated with minor earthquakes. The region's seismicity remains predominantly moderate, with infrequent occurrences of significant seismic events.
Detailed analysis of the recorded earthquakes shows that despite the high overall activity index, the likelihood of high-magnitude seismic events remains comparatively low. The earthquake frequency has been consistently high, especially for minor earthquakes, signifying a continuous release of seismic energy and reduced accumulation of stress, thereby mitigating the probability of major earthquakes in the near term.



Seismic Regime Study Along the Deren Fault

Seismic activity along the Deren fault was analyzed using comprehensive earthquake data collected between 1964 and 2024. The Deren fault stretches approximately 215 km and is situated around 20 km west of Deren town. Over this period, the fault zone experienced approximately 3,200 earthquakes, including 834 events exceeding magnitude 1.0, about 70 events above magnitude 3.0, and three major earthquakes surpassing magnitude 5.0—the strongest of which was magnitude 5.7, recorded on September 24, 1998.
Frequency-magnitude analysis for the Deren fault zone yielded a b-value of 0.687 ± 0.03 (Magnitude completeness = 1.6), indicating moderate seismic energy accumulation with an estimated 40% likelihood of significant earthquake occurrences. The seismic activity index for this area was determined to be 3.7, reflecting moderate seismic activity primarily characterized by frequent occurrences of weaker earthquakes.
The detailed study also highlighted a gradual increase in minor seismic activities in recent years, which could be indicative of ongoing stress release in the region. Analysis of seismic data along this fault line underscores the importance of continuous monitoring, as minor earthquakes frequently serve as precursors to larger seismic events, emphasizing the potential seismic risks inherent to this geologically active zone.