Comprehensive Seismic Study of North Sulawesi Indonesia *b-Value, z-Value*, and Earthquake Recurrence Time

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CTBTO
PREPARATORY COMMISSION

INTRODUCTION AND MAIN RESULTS

Research in North Sulawesi, Indonesia, explored seismic activity by analyzing *b-values, z-values*, and earthquake recurrence times. Findings: *b-value* 0.7-1.3 (lower indicates major quakes/high stress); *z-value* -0.3 to -0.7 (reflects increased small quakes/local stress release). Large earthquakes (M>7.0) are projected every 50 years, while extremely large ones (M>8.0) recur every 150 years.

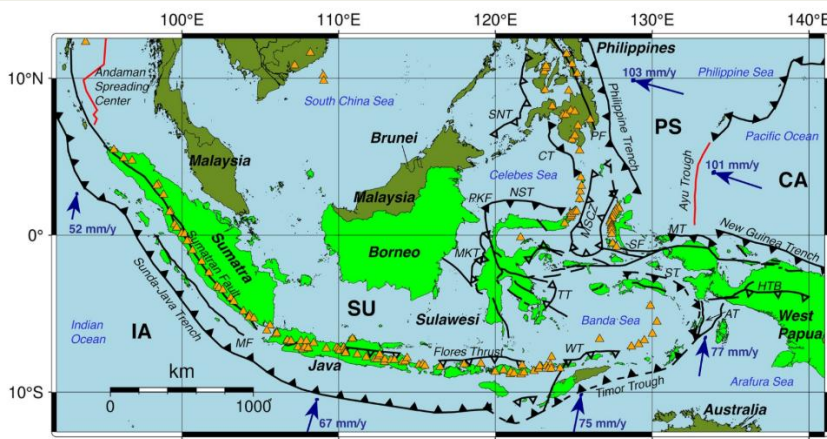# Comprehensive Seismic Study of North Sulawesi Indonesia : *b-Value, z-Value,* and Earthquake Recurrence Time

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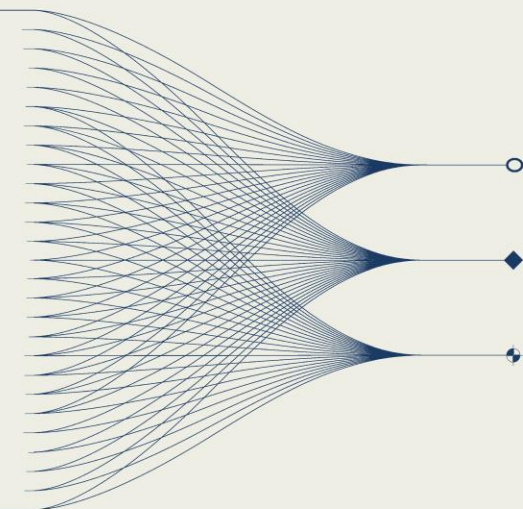
Introduction

Figure 1. Tectonic Setting in Indonesia

Figure 2. Seismicity Map in North Sulawesi

Figure 3. Histogram Date in Research Area

Figure 4. Seismicity 3D Map in North Sulawesi
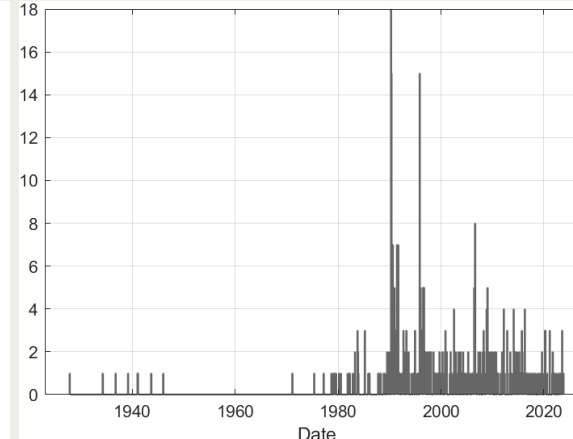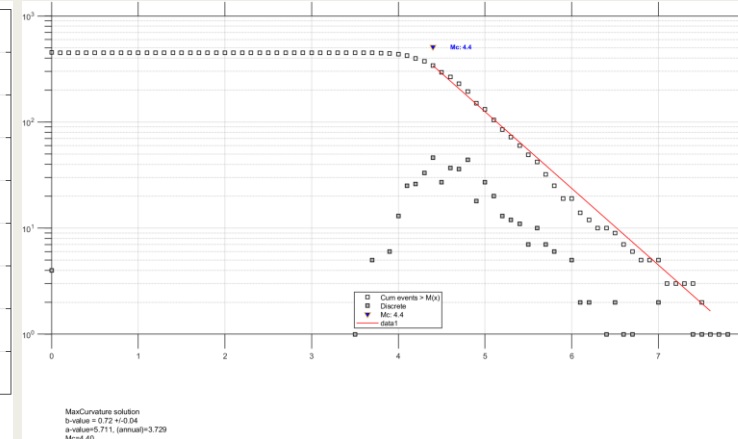
Data & Method

Figure 5. Frequency Magnitude distribution

USGS Earthquake Catalogue
Number of Events: 1678
Magnitude Range: 3 - 7.9
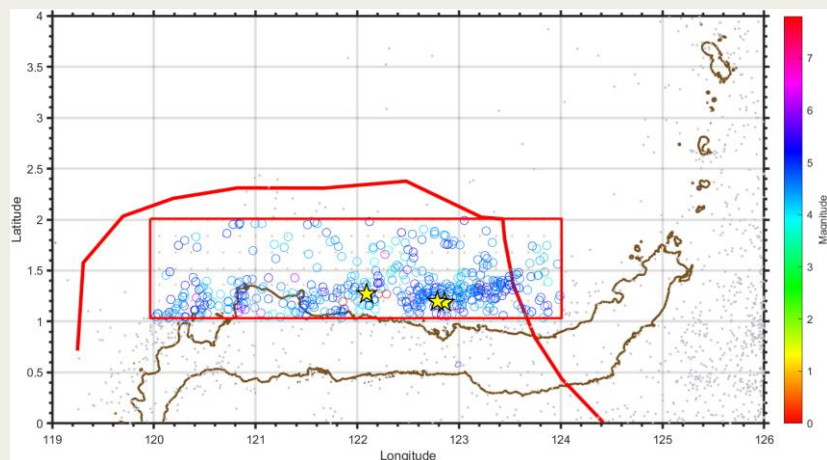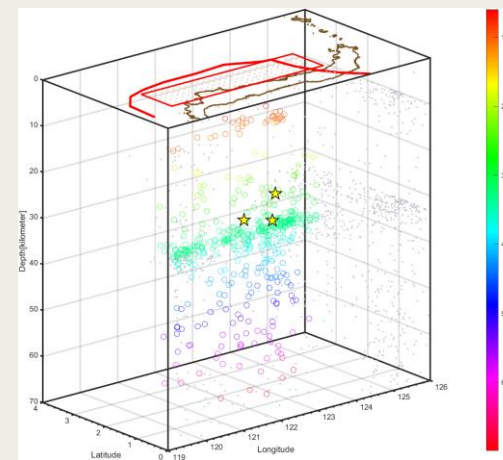Start Date: 1925-06-03
End Date: 2023-12-26
Depth: 10 - 70 km

Reasenberg 1985

$$LogD(km) = 0.4M - 1.943 + k$$

$$\tau = -\ln(1 - p_1) \big/ 10^{2(\Delta M - 1)/3}$$

Gutenberg Richter - Law

$$\lg N = a - bM$$

b-Value
Maximum Likelihood Estimation

$$b = \frac{\log_{10}(e)}{[\bar{M} - (M_c - \Delta M_{bin}/2)]}$$

$$P[N = n] = \frac{(\lambda t)^n e^{-\lambda t}}{n!}$$

$$P[N \geq 1] = P[N = 1] + P[N = 2] + P[N = 3] + \ldots + P[N = \infty]$$

$$P[N \geq 1] = 1 - P[N = 0]$$

$$P[N \geq 1] = 1 - e^{-\lambda t}$$

$$Probability(P(M)) = 1 - e^{-\lambda_m t}$$

$$Return\ Period = \frac{1}{\lambda_m}$$

$$Z(t) = \frac{R_{mean} - R_w}{\sqrt{\frac{\sigma_{mean}^2}{n_{mean}} + \frac{\sigma_w^2}{n_w}}}$$

Figure 6. Formula used in the research

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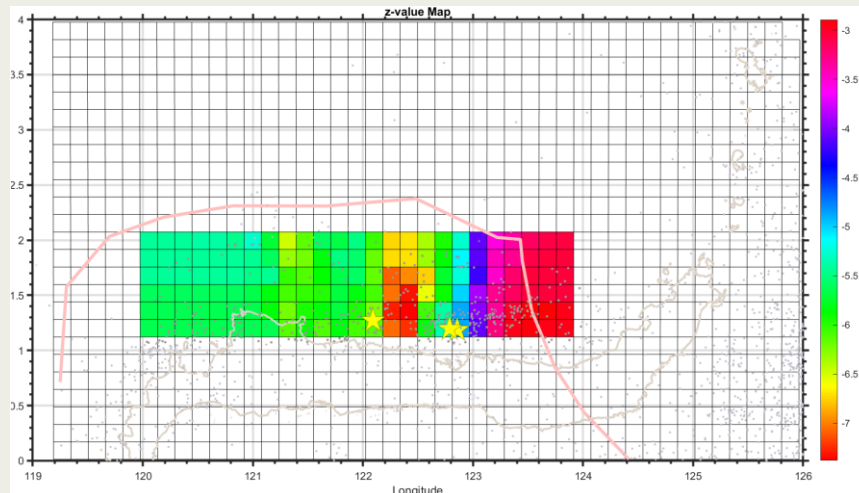
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Results
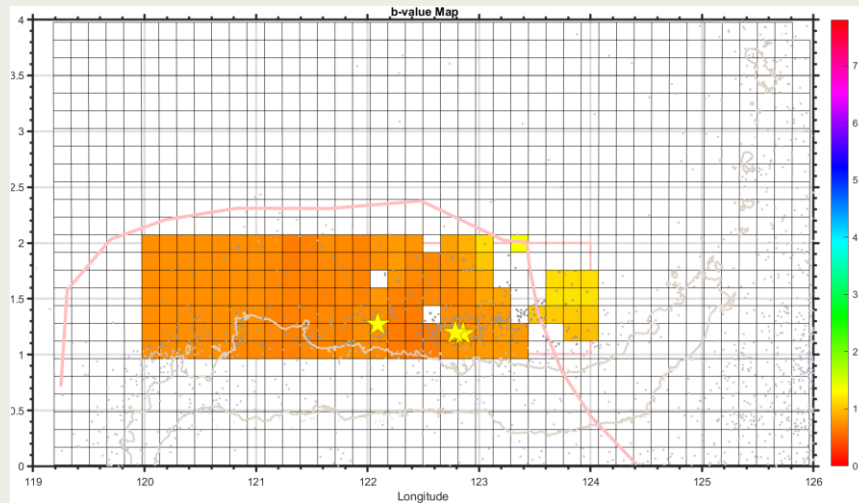
Figure 7. *b-value* map distribution in North Sulawesi

Figure 9. Recurrence Time in North Sulawesi

Figure 11. *b-value* vs Depth

Figure 8. *z-value* map distribution in North Sulawesi
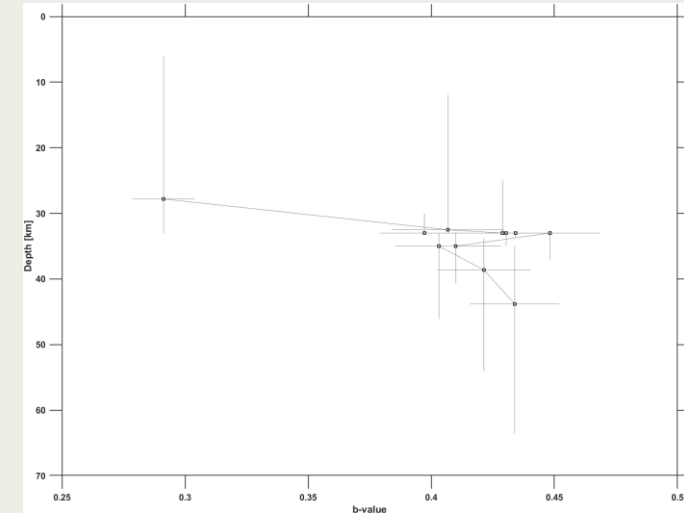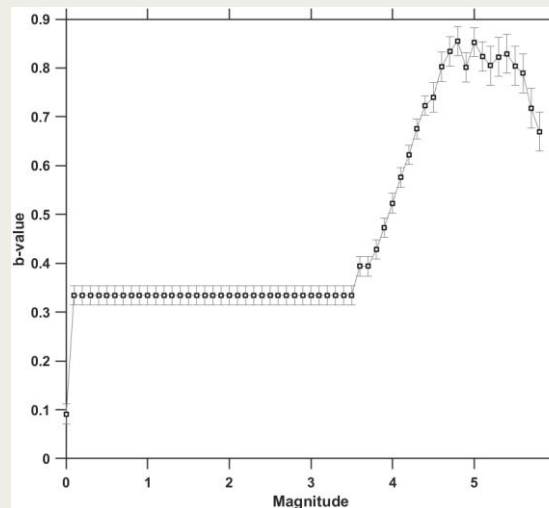

Figure 10. *b-value* vs Magnitude

Conclusion

This research found that the *b-value* ranged from 0.7 to 1.3, with lower values indicating the dominance of major earthquakes in subduction zones or areas of high stress accumulation. The study also found that the *z-value* ranged from -0.3 to -0.7, reflecting increased small earthquake activity, such as aftershock clusters or background seismicity, due to local stress release. The region has the potential for large earthquakes (M > 7.0), which are projected to occur every 50 years, while extremely large earthquakes (M > 8.0) have a recurrence time of around 150 years. Based on these findings, high-risk zones can be identified by integrating these parameters, providing essential insights for seismic risk mitigation in disaster-prone areas.

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