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# A new physical model for earthquake time interval distribution

Guoliang Liu *

*School of Environmental Sciences and Resources, Shanxi University, Taiyuan 030006, Shanxi, PR China*

## HIGHLIGHTS

- This paper reports a new physical model for earthquake time interval distribution.
- For the earthquakes with magnitude $\geq M$, there existed $\lg N(> t) = c - dt$.
- The value $d$ decreased with $M$.

## ARTICLE INFO

## ABSTRACT

This paper reports a new physical model for time interval distribution of earthquakes, which was obtained by borrowing the idea from the research in the time interval distribution of sand-dust storms. Of the model, it was hypothesized that the earthquakes were induced by the magma movement inside the earth, and if the speed of magma $\geq$ threshold value $U_t$, the earthquakes with magnitude $\geq M$ occurred. With this model, it was obtained that for the earthquakes with magnitude $\geq M$ there existed $\lg N(> t) = c - dt$, where $N$ was the number of time intervals longer than $t$; the value $d$ decreased with $M$. This result was also verified by analyzing the earthquake data from the China Earthquake Networks Center (CENC).

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## 1. Introduction

Statistical properties of time interval distribution of earthquakes have been frequently studied [1–16]. However, there is no uniform time interval distribution function and the most appropriate distribution function still remains under debate and open.

In our previous paper [17], a physical model was introduced in studying the duration of sand-dust storms. In the model, $X$ represents the random signals of a normal Gaussian distribution with zero mean and variance of one; $Xr$ is the threshold value. Events occur only when $X \geq Xr$. It was also proven that this model could be used in studying the time interval distribution [18]. From this model, while the threshold value $Xr$ did not vary with time, the time interval distribution of log-linear type

$$\lg N(> t) = c - dt \tag{1}$$

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* Fax: +86 351 7010600.
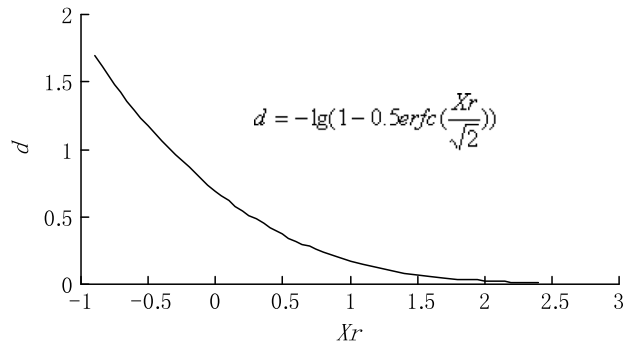  *E-mail address:* glliu@sxu.edu.cn.

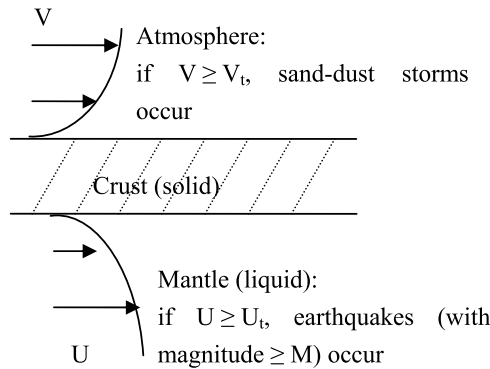**Fig. 1.** Relationship between $d$ and $Xr$ given in Eq. (2).



**Fig. 2.** Instruction chart for the similarity of earthquake and sand-dust storm.

could be deduced in theory, where $N$ was the number of time intervals longer than $t$. The value of $d$ decreased with $Xr$ and

$$d = -\lg\left(1 - 0.5erfc\left(\frac{Xr}{\sqrt{2}}\right)\right), \tag{2}$$

where $erfc(x)$ was the complementary error function. The relationship described in Eq. (2) is shown in Fig. 1.

Borrowing the idea from above researches [17,18], the time interval distribution of earthquakes was studied in this paper. This work may provide a new idea to study the time interval distribution of earthquakes.

## 2. Model

From the knowledge about the structure of the interior of the earth, the earth is composed of multiple layers, which can be defined by earth crust, earth mantle, and the core. The earth crust is solid, while the earth mantle is liquid. The earthquakes occur as a result of fracture and a frictional slip of fault, which is induced by the liquid (magma) movement of the earth mantle.

Fig. 2 is the instruction chart describing the similarity of the earthquake and the sand-dust storm. The sand-dust storms are caused by movement of the atmosphere. It is supposed that while the wind speed $V \geq$ threshold value $V_t$, the sand-dust storms occur [17]. Analogously, if the magma speed $U \geq$ threshold value $U_t$, the earthquakes with magnitude $\geq M$ occur. The $U$ represents the speed of magma near the crust. The $U_t$ is the threshold value for earthquake with magnitude $M$. While the dynamo action within the Earth' Liquid is the generation source of the geomagnetic field [19], it can be supposed that the $U$ is related with the geomagnetic field.

According to Eq. (1) it can be obtained that while the threshold value $U_t$ does not vary with time, in a region for earthquakes with magnitude $\geq M$, there should exist $\lg N(>t) = c - dt$, where $N$ is the number of earthquake time intervals longer than $t$, and $d$ decreases with $M$, which is similar to Eq. (2) (i.e., $d$ decreases with $Xr$).

## 3. Testimony

The earthquake data were analyzed to verify this result. The earthquake catalogs were downloaded from the China Earthquake Networks Center (CENC).