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# Source parameters and $f_{max}$ in Kameng region of Arunachal Lesser Himalaya

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ABSTRACT

A data set of 79 local events ($0.7 \leqslant M_w \leqslant 3.7$) occurred during February 2003 to May 2003, collected by a temporary network deployed in Kameng region of Arunachal Lesser Himalaya have been analyzed to study the source parameters and $f_{max}$. In this study Brune model that yield a fall-off of two beyond corner frequency along with high frequency diminution factor for frequencies greater than $f_{max}$ represented by a Butterworth high-cut filter (Boore, 1983) has been considered. The software EQK_SRC_PARA (Kumar et al., 2012) has been used to estimate the spectral parameters namely: low frequency displacement spectral levels ($\Omega_0$), corner frequency ($f_c$) above which spectrum decays with a rate of two, the high-cut frequency ($f_{max}$) above which the spectrum again decays and the rate of decay ($N$) above $f_{max}$. These spectral parameters are used to estimate source parameters, viz., seismic moments, source dimensions and stress drops and to develop scaling laws for the region. Seismic moments vary from $1.42 \times 10^{17}$ -dyne-cm to $4.23 \times 10^{21}$ dyne-cm; the source radii vary from 88.7 m to 931.5 m. For 28 events, stress drops are less than 1 bar and 51 events have stress drops between 1 bar and 40 bars. A scaling relation, $M_0$ (dyne-cm) = $2 \times 10^{22} f_c^{-3.34}$ has been derived for earthquakes having seismic moments greater than $1.5 \times 10^{19}$ dyne-cm. The estimated values of $f_{max}$ values by and large conform to the worldwide observations. Dependence of $f_{max}$ on source sizes, focal depths, epicentral distances and recording sites has been studied on the basis of comparative dependency of $f_c$ and $f_{max}$. The $f_{max}$ and $f_c$ show almost similar dependency to seismic moments which shows $f_{max}$ is also due to source process and is independent of epicentral distances and focal depths. At different recording sites, the observed values of $f_{max}$ show consistent increase with seismic moment. This reflects that the source is the main controlling factor rather than recording site conditions for the observed variation of $f_{max}$ in the Kameng region.



## 1. Introduction

The scaling of seismic spectrum with earthquake size has been used to study the characteristics of earthquake source. Information about scaling laws and two parameters, namely stress drop and $f_{max}$ have been used by earthquake engineering community as these parameters form important ingredients for the simulation of strong ground motion using stochastic source model.

Aki (1967) made first effort in this direction and examined the dependence of the amplitude spectrum of seismic waves on source size on the basis of two dislocation models of an earthquake source. One of the model (Haskell, 1964, 1966) is called the $\omega^3$ model, and the other called the $\omega^2$ model – constructed by fitting an exponentially decaying function to the autocorrelation function of the dislocation velocity. The $\omega^2$ model gave a satisfactory agreement with observations on the assumption of similarity, but the $\omega^3$ model did not. Aki (1967) considered a constant stress drop in these models. However, he pointed out that if the stress drop differs, the scaling law will not apply. If the stress drop varies systematically with respect to environmental factors such as focal depth, orientation of the fault plane, crust-mantle structure, we need to develop different scaling laws for different regions.

Brune (1970, 1971) modeled an earthquake source as a tangential stress pulse applied instantaneously to the interior of a dislocation surface. This model employed three independent parameters (seismic moment, source dimension and fractional stress drop) to determine the shape of the far-field displacement spectrum of body waves. He constrained the relationship of the corner frequency to the fault radius by assuming that the effective stress was equal to the average static stress drop.

In the earthquake source models the acceleration source spectrum increases with increasing frequency and become constant beyond corner frequency. Hanks (1982) observed that there is another frequency called the maximum cut-off frequency $f_{max}$ above which acceleration spectral amplitudes diminish abruptly. There is a controversy about the origin of this cut-off frequency $f_{max}$. Hanks (1982) and Anderson and Hough (1984) among others,

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argued that $f_{max}$ is due to recording site effect while Papageorgiou and Aki (1983a,b) and Yokoi and Irikura (1991) attributed it to a source effect. Tsai and Chen (2000) fitted a regression model in terms of distance, earthquake magnitude, and site and showed that the high-cut process is controlled by both the site and source effects. They also inferred that distance is the least significant parameter controlling the high-cut process.

In the present study source parameters, namely, seismic moments, source dimensions, stress drops and spectral parameter $f_{max}$ have been estimated. The relationship of $f_{max}$ with seismic source size, focal depths, epicentral distances and recording sites have been studied. A data set of 79 local events ($0.7 \leqslant M_w \leqslant 3.7$) occurred during February 2003 to May 2003 in Kameng region of Arunachal Lesser Himalaya collected by employing six station local network has been used for this purpose. A software EQK_SRC_PARA (Kumar et al., 2012) has been used in this study, which is based on Brune model and make use of Butterworth filter to estimate $f_{max}$.

## 2. Seismotectonics of the study region

Within the framework of new global tectonics the Himalaya has been formed due to continent–continent convergence of the India and Eurasia tectonic plates. This convergence process has been operating from last about 40 million years and has shaped the present-day structure and tectonics of the Himalaya. Fig. 1 shows the major global and regional scale tectonic features (modified after Khattri et al., 1984; Walling and Mohanty, 2009).

From south to north, the Himalaya has been sub-divided into three major tectonic provinces viz., the Sub-Himalaya, the Lesser Himalaya and the Higher Himalaya. Further to the north of Higher Himalaya is the Tsangpo Suture Zone (TSZ) that represents the probable collision boundary where the India plate first collided with the Eurasia plate about 40 million years ago. From west to east, the Himalaya has been divided into three sectors viz., the Western Himalaya, the Central Himalaya and the Eastern Himalaya (e.g., Ganser, 1964; Le Fort, 1975).

The northeastern region of India exhibits very distinct tectonic setup. The region has been broadly subdivided into four geotectonic units, viz., the Arunachal Himalaya, the Lohit Himalaya, the Patkoi Naga-Lusai-Arkanyoma (Indo-Burman) hill ranges and Shilong Plateau–Assam Basin. The Arunachal Himalaya is situated between the Bhutan Himalaya in the west and the Lohit Himalaya in the east. The Arunachal Himalaya shows a general east-west trend in its western part and takes gradually an east-northeast west-southwest to north-east south-west trend in its eastern part. This trend terminates against northeast-southwest trending lineament called Siang fracture zone (e.g., Nandy, 1976).

Within the above broad tectonic framework, the study area is located in the west Kameng District, and falls in the western part of Arunachal Lesser Himalaya. The region lies between the Main Boundary Thrust (MBT) and the Main Central Thrust (MCT) and exhibits complex tectonic environment as evidenced by the presence of several local tectonic features. Fig. 2 shows the position of these two major boundary thrusts in the region along with other local tectonic features mapped in the study area (GSI, 2000). The southern margin of the Arunachal Lesser Himalaya is bounded by Siwalik foothills. Most of the local tectonic features are generally trending east–west in the south, and towards north, their trend changes gradually from east-northeast to northeast. A northwest-southeast trending Bomdila lineament passes through the study area and runs discordant to the local and regional tectonic thrusts. The Main Foothill Thrust (MFT) is the southernmost tectonic feature and is buried under the alluvium (Nandy, 1976).

The northeast region of India is characterized by high level of natural seismicity which is primarily attributed to two factors namely, the under-thrusting of India tectonic plate below the Eurasia tectonic plate to the north and subduction of India plate below the Burmese plate to the east. This complex tectonic process leads to high strain accumulation in the region that is periodically released in the form of moderate, large and great earthquakes. This is amply demonstrated by the occurrence of two great earthquakes, namely, the Shillong earthquake of 1897 ($M_S$ 8.7) and the Great Assam earthquake of 1950 ($M_S$ 8.6). The epicenters of these two great earthquakes lie about 200 km and 450 km respectively from the study area. Other prominent damaging earthquakes reported to have occurred in the region are the Cachar earthquake of 1869 ($\sim M_w$ 7.4) that caused damage to buildings, land fissures and liquefaction; the Srimangal earthquake of 1918 ($M_S$ 7.6), the Dhubri of 1930 ($M_S$ 7.1), and the Manipur Earthquakes ($M_w$ 7.2) of 1988 (Kayal, 2008).

## 3. Data set

A six-station local network deployed in the region around Kameng is shown in Fig. 2. The purpose of this network was to

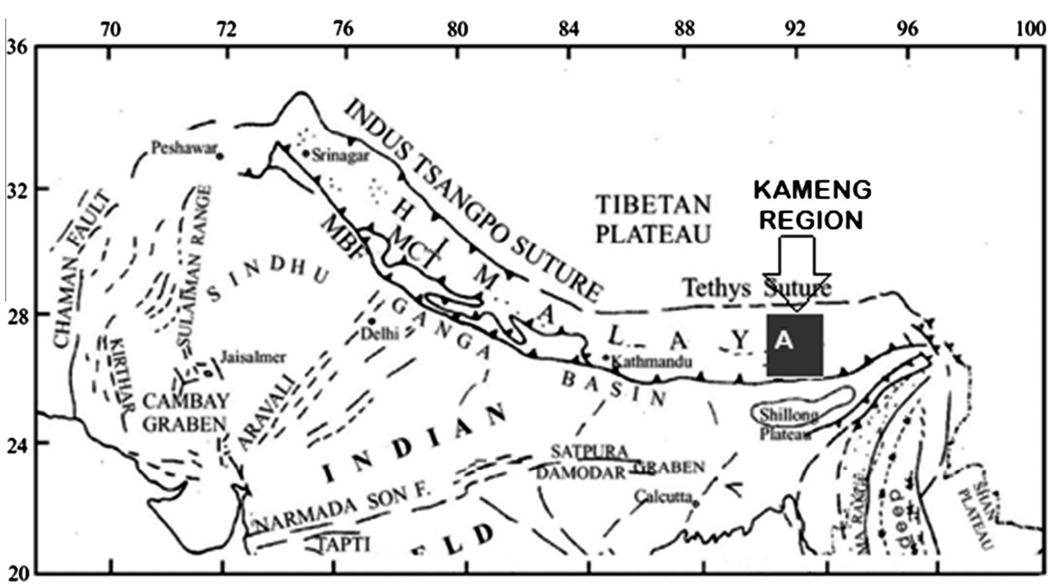


**Fig. 1.** The major tectonic feature of the Himalaya and the studied region of Kameng shown by black rectangle (modified after Khattri et al., 1984; Walling and Mohanty, 2009).