Scaling of LURR Critical Region

Xiang-Chu Yin(1,2), Ke-Yin Peng(1,2), Huai-Zhong Yu(2), Yu-Cang Wang(2,3), Can Yin(2,3) and Yong-Xian Zhang(1, 2)

(1) Center for Analysis and Prediction, China Seismological Bureau, Beijing, 100036, China. (E-mail: xcyin@public.bta.net.cn, phone: +86-10 8801 5574; fax; +86-10 6252 1284). (2). State Key Laboratory of Nonlinear Mechanics, Chinese Academy of Sciences, Beijing, 100080, China (E-mail: yuhz@lnm.imech.ac.cn, phone: +86-10 62548133; fax; +86-10 6252 1284). (3) QUAKES, Department of Earth Sciences, The University of Queensland, Brisbane, Australia (e-mail: wangyc@quakes.uq.edu.au; canyon@quakes.uq.edu.au , phone:; +61 7 3365 2176, , fax: +61-7 3365 7347).

Abstract

LURR is a parameter that can measure the susceptivity of the crust of a specified region to the external factor so that it may be related to the CPH. The scaling of LURR critical region is : log *R0.34M* which is in accord with the scaling of AMR/AER critical region. This result suggests that both LURR and AMR have a common underlying mechanism—CPH or CPH-like.

The Load-Unload Response Ratio (LURR) method is an intermediate-term earthquake prediction approach (Yin and Yin, 1991[14]; Yin, 1993[15]; Yin et al., 1994[16]; Yin et al., 1995[17]; Yin et al., 2000[18]; Yin et al., 2002[19]) that has shown considerable promise. The idea that motivated the LURR earthquake prediction approach is that when a system is stable, its response to loading is nearly the same as its response to unloading, whereas when the system is approaching an unstable state, the response to loading and unloading becomes quite different.

LURR Y is defined as

$$Y = \frac{X^+}{X^-} \tag{1}$$

where X^+ and X^- are response rates during loading and unloading respectively and the response rate is defined as

$$X = \lim_{\Delta P \to 0} \frac{\Delta R}{\Delta P} \tag{2}$$

if P undergoes a small change ΔP resulting in a small change ΔR of R. When a system is in a stable or linear state, $X^+ \approx X^-$ so $Y \approx 1$ while a system is damaged, $X^+ > X^-$ and Y>1. High LURR values (Y/Y_c >1, Y_c is the threshold value of LURR, YIN et al., 2000[15]) indicate that a region is prepared for a large or great earthquake. Hence, LURR can be used as a criterion to judge the proximity to instability of a system and then as a precursor of a strong earthquake. In this way some earthquakes have been predicted (Yin and Yin, 1991[14]; Yin, 1993[15]; Yin et al., 1994[16]; Yin et al., 1995[17]; Yin et al., 2000[18]).

On the other hand, according to the CPH (Critical Point Hypothesis), earthquake rupture can be considered as a critical point (Vere-Jones, 1977[9]; Sornette and Sornette, 1990[7]; Sornette and Sammis 1995[8]; Bowman et al, 1998[1]; Rundle et al, 1999[6]; Jaume and Sykes, 1999[3]). Any critical phenomenon must be characterized by susceptibility to external factors. The susceptibility of crust certainly leads to triggering earthquakes significantly by tidal stress (Grasso and Sornette, 1998[2]) and consequently anomalous high value LURR prior to large earthquakes (Wei, et al, 2000[11]; Xia et al., 2002[12]; Xia et al., 2002[13]).

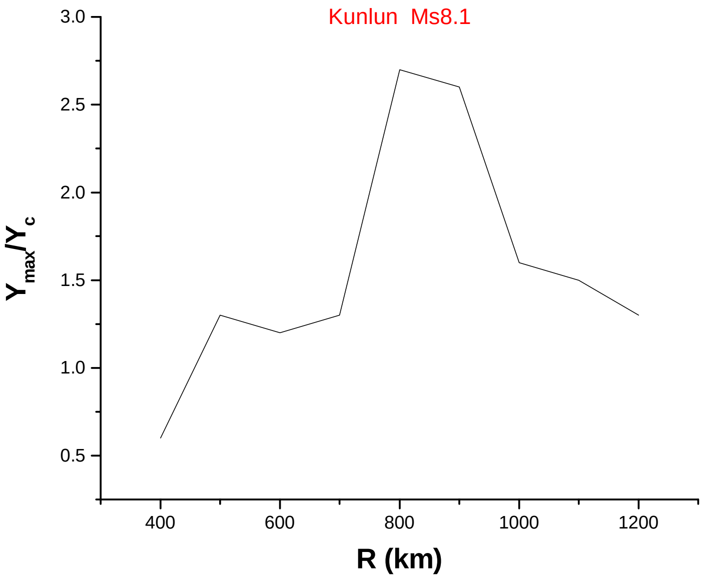

Figure 1: The Y max/Yc against the radius R of the region for Kunlun earthquake

When we calculate the values of Y for a region and specified time window, the Y values are a function of the size of the region (say, radius R of a circle region centered at the epicenter). The size which maximums the peak value of Y_{max} / Y_c is called critical region size. In Figure 1 the curve is plotted for Y_{max} / Y_c against the radius R of the region for earthquake Kunlun (M 8.1, Nov. 14, 2001). The critical region size for earthquake Kunlun from Figure 1 is R=800 km**.**

Fourteen earthquakes that occurred in the China have been studied with magnitudes ranging from 5.1 to 8.1. It is found that the critical region size scales with the magnitude of earthquake (Figure 2). Fitting the data in Figure 2, the function between critical region size and the magnitude is:

$$\log R\ (\text{km}) = 0.087 + 0.34M \tag{3}$$

Jaume and Sykes (1999) [3] have found that the critical region size for accelerating energy release (AER/AMR) is

$$\log R \propto 0.36M \tag{4}$$

and Bowman et al (1998)[1] found

$$\log R \propto 0.44M. \tag{5}$$

Obviously they coincide with each other quite well.

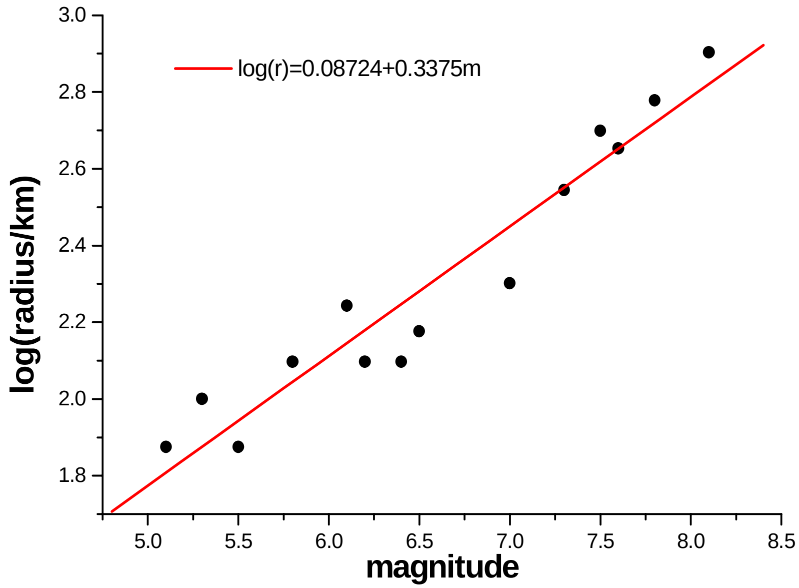

Figure 2: Critical region radius r as a function of the magnitude of earthquakes occurred in China which are (a) Tangshan earthquake (Hebei), M=5.1, 1991; (b) Boketu earthquake (Inner Mongolia), M=5.3, 1980; (c) Fengzhen earthquake (Inner Mongolia), M=5.5, 1981; (d) Longyao earthquake (Shanxi), M=5.8, 1981; (e) Datong earthquake (Shanxi), M=6.1,1989; (f) Zhangbei earthquake (Hebei), M=6.2, 1998; (g) Baotou earthquake (Inner Mongolia), M=6.4 ,1996; (h) Wuding earthquake (Yunnan), M=6.5, 1995; (i) Gonghe earthquake (Qinghai), M=7.0,1990; (j) Songpan earthquake, M=7.3, 1976; (k) Mani earthquake (Tibet) , M=7.5, 1997; (l) Luhuo (Sichuan), M=7.6, 1973; (m) Tangshan earthquake, (Hebei), M=7.8, 1976; (n) Kunlun earthquake M=8.1, 2001.

In our previous work (Yin et al, 2002[19]) we have discovered that a strong correlation is evident between the AMR/AER and LURR critical region sizes that suggest these two observations maybe have a common physical mechanism. Recent simulations demonstrate Accelerating Moment/Energy Release (Mora et al, 2002[5]) and an evolution in stress correlations prior to large events (Mora and Place, 2000[4]; Weatherley, et al, 2002[10]) consistent with that predicted by the CPH (Critical Point Hypothesis). This suggests a mechanism that is CPH or CPH-like. If so, LURR may offer an approach to detect the critical sensitivity (Wei et al, 2000[11]; Mora et al, 2002[5]) of the crust as it approaches a critical point in the lead-up to a large event. Furthermore, based on the results presented in Figure 2, the critical region size — magnitude scaling relation for LURR provides a means to estimate the magnitude of an oncoming earthquake.

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