第10卷 第1期 西北地震学报 Vol.10,No.1
1988年3月 NORTHWESTERN SEISMOLOGICAL JOURNAL March,1988

SIGNIFICANCE OF A GROUND AND BLOCK ROTATION IN EARTHQUAKE PREDICTION

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In 1957, we studied a lot of historical records of the Jan. 23, 1556 Guanzhong earthquake (M≥8). We found two interesting records in the epicenter area: About eight hours before the great earthquake, people felt a kind of ground rotational movement and dizzied. We pointed out that is a kind of foreshock phenomenon[1]. In 1971, the auther and Qin Baoyan studied this phenomenon and considered that it is a slow motion which is useful for earthquake prediction[2]. In this paper, we intend to discuss the cause of the ground rotation before great earthquake. Besides, we also intend to discuss a significance of block rotation in earthquake prediction.

Cause of ground rotation before great earthquake

If a foreshock is a small dislocation with single direction, the displacement of seismic wave on ground is predominant and the ground rotation is too weak to be felt by people. If there are two or more foreshocks take place on big fault plane of the future great earthquake, the synthetical ground motion has obvious rotation, when these foreshocks satisfy the following conditions:

1. If the foreshocks are located at almost the same place, they must have different dislocation directions and occurrence times, as shown in Fig.1 a. In this figure, the arrow indicate the foreshocks.

2. If the foreshocks have the same dislocation they must have far

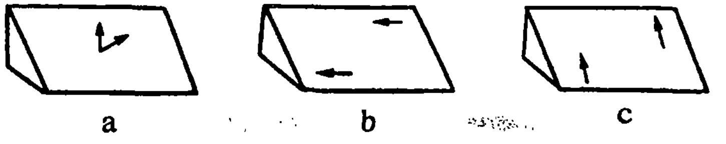

Fig. 1 Foreshocks are located on the big fault plane of the future great earthquake

distance from one to one, which are shown in Fig. 1 b and c.

3. The synthesis of seismic waves having different vibration azimuths, periods and phases should fit to the following formula

$$(t_1-t_2)+(T_1-T_2)<T \qquad (1)$$

where t_1 and t_2 are the occurrence times of the foreshocks, T_1 and T_2 are the travel times of p waves radiated from different foreshocks, T is the lasting time of seismic waves which are radiated from the preceding fore shock. In general, the angle between two horizontal components is arbitrary. If two horizontal components of seismic waves are perpendicular each other and have different phases:

$$V_y=A_1\cos(\omega t-\phi_1) \qquad (2)$$

$$V_x=A_2\cos(\omega t-\phi_2) \qquad (3)$$

the synthetical locus is determined by the following formula:

$$\frac{V_x^2}{A_1^2}+\frac{V_y^2}{A_2^2}-2\frac{V_x}{A_1}\frac{V_y}{A_2}\cos(\phi_1-\phi_2)=\sin^2(\phi_1-\phi_2) \qquad (4)$$

where A_1 and A_2 are the amplitudes of the two seismic waves, V_x and V_y are the two displacement components of synthetical motion. A general locus of ground motion is descrebed by the Lissajous figure.

It should be pointed out that if the rotation motion of ground is slow, it means there are slow slips in a large part of the whole fault plane, which is easy to urge a great earthquake to occur.

Rotation of crustal block and earthquake occurrence

In the meizoseismal area of the Dec. 16, 1920, great Haiyuan earthquake (M=8.5), the distribution of displacements of the fault caused by the great earthquake has the following characteristics: strike slips cover the whole length of the fault, normal and thrust displacements are located in the two end segments, respectively, which is shown in Fig. 2. We consider that this kind of distribution of dip displacements may be explained by the Bridgman effect[3]. This effect indicate that the rotation of blocks is helpful for fault slipping. In other words, if we found a long

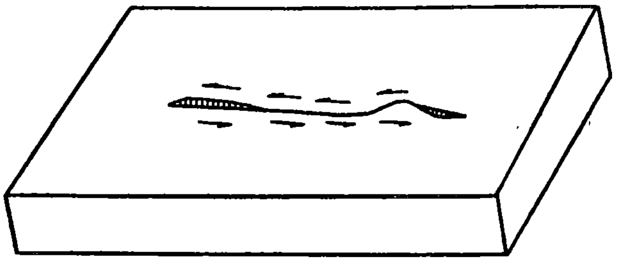

Fig. 2 Distribution of dip displacements along a long strike fault

strike seismogenic fault has some traces of normal and thrust faults in its different segments, this region should be regard as a potential great earthquake area.

The cause of block rotation is possiblly attributed to vertical tectonic movement, as shown in Fig. 3.

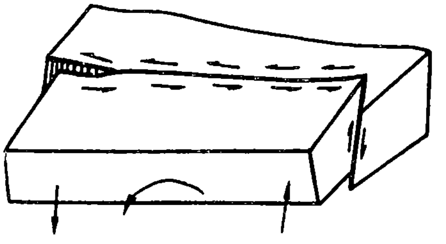

Fig. 3 Superposition of strike slip and dip slips

Discussion

Seismic waves forming superposition include the horizontal components of P,S,Q and L waves radiated from different foreshocks. In epicenter the synthetical rotation motion is mainly caused by SH. In the far field, the rotation is weak due to that the seismic rays from different sources are near to parallel. Almost synchronization of occurrence of two or more foreshocks on a future great earthguake fault plane means the great earthguake will soon occur.

According to our veiwpoint, We suggest that it is necessary to design a instrument to record the slow ground rotation. We consider, in that places where both the horizontal and the vertical tectonic movements are very strong, to recod this kind of rotation is useful for great earthquake prediction. For detecting the Bridgman effect in field, it should be careful to study geodetic and neotectonic data.

Reference

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第10卷 第1期　　西北地震学报　　Vol.10,No.1
1988年3月　NORTHWESTERN SEISMOLOGICAL JOURNAL March,1988

地旋与地震预报

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摘　　要

1957年我们研究了1556年陕西关中8级大震前约8小时在震中区两县出现的“地旋”和“地旋运”现象，认为这是一种前震现象。1971年作者和秦保燕再次研究了上述地旋和地旋运的现象，认为它与一般前震的波动不同，可能是一种较缓慢的地面旋转运动，并指出这种现象可能是大震前震源断层面上较大部份弱化并产生预运动所致。本文进一步指出产生地旋和地旋运的原因是由于未来大震震源断层面上不同子源发出的波到达震中区地面后具有不同的振动方向但又相遇在一起互相迭加的结果。要造成这种迭加结果大致有以下三种情况：一个是大震前震源断面上同一部位有异向的缓慢错动（相夹角不大于90度）；另一个是两个或两个以上的缓慢错动虽是同一方向但它们相距较远（都位于未来大震的震源断层面上）；第三个是只有一个错动但错动面积很大，该面积上不同边界处的错动部份相距较远。以上三种情况发生的波在地表的合成皆会形成明显的旋转运动，其中第三种情况包含第二种情况，它是我们1971年提出的产生地旋和地旋运现象需要较大断层面积上发生预运动的原因。当然也不排除震源地方有单旋和双旋运动在地表产生地旋和地旋运的可能。以上讨论的是临震前的地旋前兆，我们建议设计专门的仪器记录这种缓慢的地面旋转运动。

在中长期地震预报方面尚有地块旋转运动的可能。对此我们在1987年曾讨论过。即某些大震是走滑兼块体的旋转。这种现象可由大震在地表造成的错动后果分析出来。即全段是走滑但两个端部地段分别兼有正断层式和逆断层式倾滑成份。1920年海原8.5级大震就是这样的。从力学道理上来说，这是在大区域水平挤压情况下沿断层不同地方其地壳下方有不同的垂直力作用的结果。这种不同的垂直力作用可造成断层盘体的旋转。根据布里季曼（Bridgman）效应，旋转是有利于粘滑错动的，因之它在走滑上的迭加可能对大震的发生具有重要意义。作者建议在野外应寻找与旋转有关的形变指标和新构造运动指标，以利于判定潜在的大震危险区。此可称为剪旋模式。