

## **XI'AN GROUND FISSURE AND THE DISCIPLINE OF GROUND FISSURE AS A NEW BRANCH OF EARTH SCIENCES**

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### **Abstract**

The classification of various ground fissure disasters, and the preliminary studies on the causes of various ground fissures were made on the basis of comprehensive research of ground fissures in Xi'an city. The macro-distribution of ground fissure disasters in China was mapped briefly, but more detailed in Fen-Wei Basin, where the fissure disasters are severe. The tasks on ground fissure research were put forward. In theory, the special laws should be studied, about how the ground fissures are unstable, propagate and stop in homogeneous, soft shallow soil-layers of the earth. In practice, the practical techniques should be provided to protect environment, resources and city plan from damage caused by the fissure disasters. Furthermore, some basic information may be given to benefit the earthquake prediction research and geothermal energy development. The tasks should be undertaken by a new branch of earth sciences—Groundfissurology, which will be born in the beginning years of IDNDR(International-Decade for Natural Disaster Reduction).

### **Introduction**

Xi'an ground fissure (XGF) has become a special environmental and geological disaster. With its tremendous power of damage and heavy economic losses to the district of Xi'an city, it is drawing public concerns of the whole society. Look back in the history, there were documental records of ground fissures occurred as early as four thousand years ago. Now the XGF are the outcome of evolution from the archaic ground fissures.

In the world, the disasters of ground fissures are not unfamiliar, and rather distribute extensively in some area. Ground fissures, are complicated in genesis, differ in nature and form (Xie Guanglin, 1989).

XGF disaster is the typical one of various ground fissure disasters in China. A general remark about ground fissure disasters is given here so as to enable the readers to understand the problem systematically.

### 1. Ground fissures, a special kind of environmental and geological disaster frequently encountered

Ground fissure is the surfacial fracture of the earth's crust which can be seen on the ground. The media as a whole of crustal surface layer is broken in its continuity and integrity due to the actions of the earth's endogenic and tectonic processes, or even human activities. And most likely, the genesis of Ground fissure is a consequence of the combined action of them.

Ground fissures and faults differ in many aspects, the former is on the ground with small dimensions, while the latter is under ground with large dimensions, and the former has multigenesis, while the latter is due uniquely to the tectonic movement. But ground fissures may have connections to the tectonic faults. It may be the outcrop of active fault, or induced by the movements of the secondary faulting. Its disastrous effect may occur without earthquake events, and mostly revealed gradually as the case of creeping of active fault.

Although the behaviors of ground fissures include all the phenomena by the discontinuity of the media of the earth's surface layer we discuss only the ground fissures which may cause severe disastrous effects. As for the ground fissures which are less disastrous and have small range of influence, for example the ground cracks resulted from the improper or ill administering of ground foundation in construction, are not included here.

### 2. The classification of ground fissures

#### A. Tectonic ground fractures

Ground fissures due to the actions of tectonic movements are known as tectonic ground fissures. According to the various kind of tectonic movements, the tectonic ground fractures are distinguished as following three kinds mainly.

#### Earthquake ground fissures

Appeared in the events of tectonic earthquakes as the earthquake intensity were about 7 or higher. The scale and damage effects increase while the earthquake intensity increases.

#### Volcanic ground fissures

Prior to the eruption of volcano, the ascending media of the earth's crustal shallow layers with high pressure may lead to the formation

of volcanic ground fissures which look like radial from the crater. According to the different eruption patterns, the ground fissures may be formed differently.

#### Creeping fault ground fissures

Induced by the creep-slippage of the active faulting movement, the influential range of this kind of ground fissures is determined by the scale and the creeping rate of the active faults. Sometimes they may occur along the outcrop of active faults, and sometimes they may be the small secondary faults of the chief active faults themselves. The disastrous effect under the influence of other harmful factors may be very serious.

#### B. Landslide ground fissures

Resulted from the instability or slip, of the land slope. The types of land slope and the types of instable movements of landslide may be various. However, the ground fissures and their developments are usually recognized as the forerunner, or warning sign of the landsliding movement.

#### C. Subsidence ground fissures

Formed in the process of land subsidence. The types of land subsidence ground fissures include faulting-subsidence ground fissures (relevant to underground cavity), and ground subsidence ground fissures (relevant to the over tapping of underground fluid such as oil, gas and water). The former usually appears as ground fissures developing with high speed, and is followed by faulting-collapse, the latter produces ring shaped ground fissures around the center area of ground subsidence.

#### D. Specific soil ground fissures

Resulted by the special physical nature of the ground surface soil. There are two types of soil frequently encountered, namely the soil with the nature of dilatation and the soil with the nature of shrinkage when they meet moisture. The specific characteristic of this kind of ground fissures is that the range is confined in the soil layers and usually relevant to the ground surface water.

#### E. Meteorological ground fissures

It is intimately related to the meteorological factors. This kind of ground fissures may divided into many types, such as rain-waterlogging ground fissures, drought ground fissures, and frozen ground fissures, etc.

#### F. Multigenesis ground fissures

Resulted by the combined actions of two or more genes listed above.

### 3. A bird's view of ground fissure disaster in the world

Ground fissure disasters are all around the world. According to the preliminary statistics, in America, New Zealand, Italy, Soviet Union, Turkey, Mongolia, Japan, Mexico, Switzerland, Peru, Germany and Canada, various kinds of ground fissure disasters have ever appeared, causing the collapses of constructions, the breakages of highway or railway, and the evaporation from the crack in the drought farms. Worthy of note, much more ground fissure disasters are related to the human activities, therefore, the International Decade for Natural Disaster Reduction (IDNDR) should also pay attention to the reduction of ground fissure disasters.

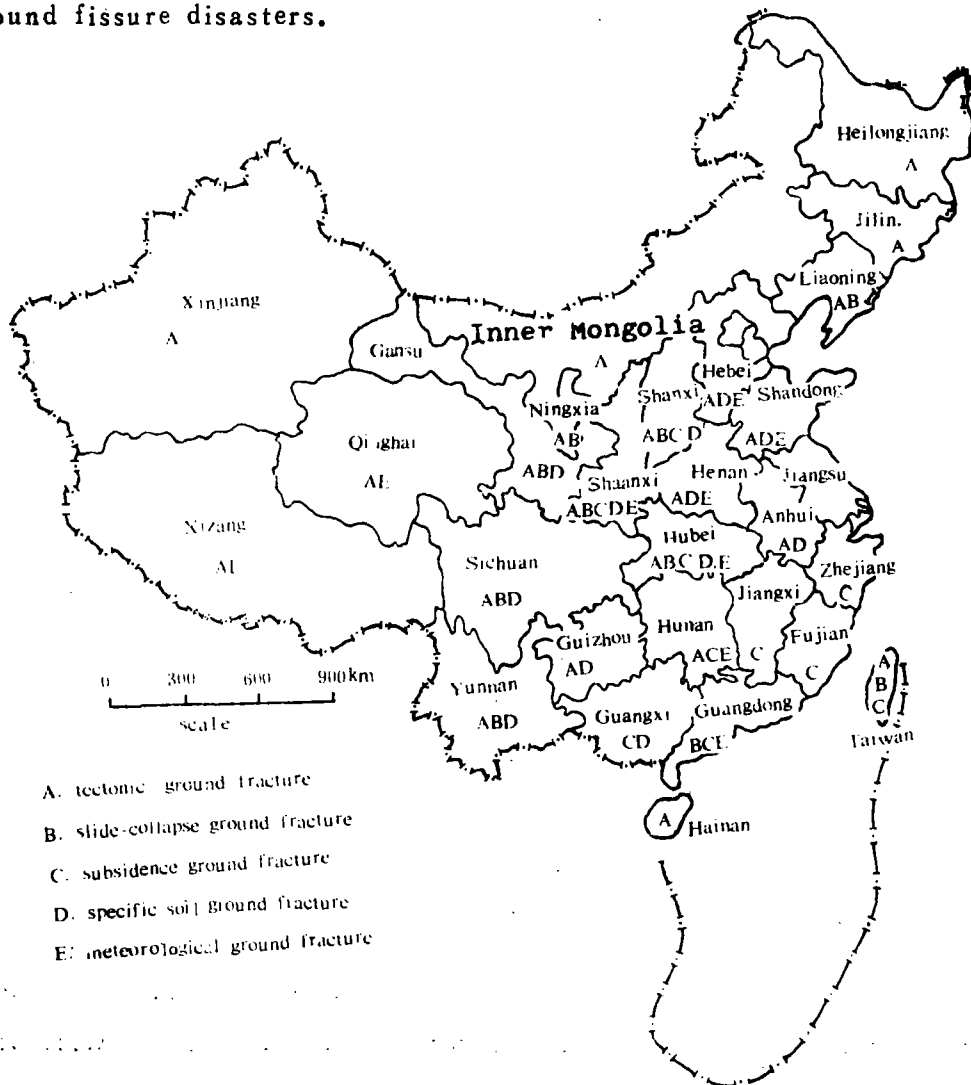


Fig. 1 Distribution of ground fissure disasters in China

#### 4. A general summary of ground fissure disasters in China

Ground fissure disasters distributed all over our country. In recent years, several thousand spots were hit by them, covering a area of 600,000 km. The kinds of ground fissures locating in each province of China are shown in Fig. 1.

#### 5. A general survey of ground fissure disasters in the Fen-Wei basins

Fen-wei Basins ground fissures zone, distributed along the

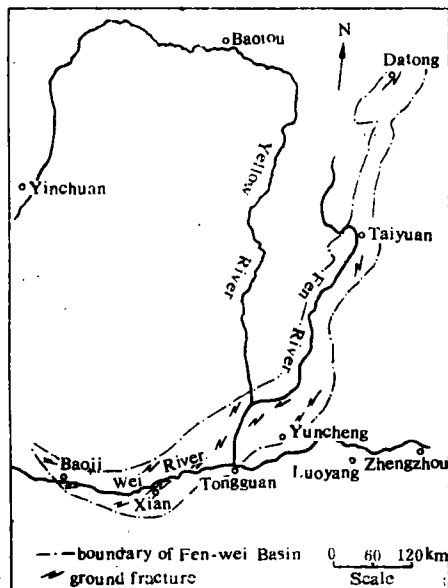


Fig. 2 Distribution of ground fissure disasters in Fen-Wei Basin

Fenhe river and Weihe river graben, where normal active faults are abundant, is the most disastrous and typical ground fissures in China. In recent several years, ground fissures appeared in more than 50 counties along the Fen-Wei Graben where the severe damages have been brought. Just in Xi'an city the total economic loss is more than 20 million yuan, further more, XGF has resulted ground water pollution. Fig. 2 shows the distribution of ground fissure disasters in Fen-Wei

Basin. A brief is given here according to the kinds of ground fissures.

##### A. Tectonic ground fissures

The Fen-Wei River valley is an inland tectonic graben where the stretching structures of normal faults are developed with vertical differential movement and inclining movement. Tectonic ground fissures are imparted all of the features of this normal faulting movement. Most of the ground fissures distributed along in the same direction of neighbouring active fault. Tectonic structures have a controlling influence upon the ground fissures.

##### B. Slide-collapse ground fissures

Loess and slide distributed extensively about some thousand spots in the Fen-Wei Basin, In addition, rock or soil collapse and slide are frequent around the brink of the Basins. So apart from the extensive distribution, their forms are complicated as a characteristic in this region. In consideration of the heavy losses of both economy and human lives every year incurred by landslide disasters, monitoring and

warning of the danger of slide-collapse ground fissures based on the researches of this discipline are of significance.

#### C. Subsidence ground fissures

Both faulting subsidence ground fissures and surfacial layer subsidence ground fissures exist in the Fen-Wei Basin. The former mostly appears in the area of cavities left by coal mining; the latter mostly appears in the district where groundwater has been over tapping. In the forthcoming years accompanying the extraction of oil and gas in the north Shaanxi province, ground fissures of this kind are anticipated. Consideration about countermeasures are necessary.

#### D. Multigenesis ground fissures

The causes of XGF are typically multigenesis as the cases of ground fissures in Fen-Wei Basins, as well as in the world at large. In addition to the basic features of tectonic ground fissures, there are displacements of ground subsidence superposed on it, and waterlogging subsidence ground fissures also appeared on some fragments in the ground fissure zone. In the multigenesis of ground fissures, a single cause may be essential which determines the nature and form of the ground fissures, and other causes are secondarily important. However, in some circumstances the less important causes may be the decisive factors, or triggers of disasters. Moreover, human activities usually play a considerable role in the process of ground fissure disasters.

It seems that the occurrence of disasters is influenced partially by the unrestricted demand from the nature. Hence the solution of disaster reduction problem not only depends on the researches of natural sciences and applied technique, but also relies upon the study of social sciences and administering methods.

### 6. The significance of the researches of XGF disasters and the countermeasures against them

A. The economic development in Xi'an region has seriously influenced by ground fissure disasters. The development of ground fissures shows an unfavorable tendency, the damage is expected to increase. It is obvious that the researches in this kind of geological disaster and the engineering countermeasures against it are of great application value. Practice proved that the preliminary disaster reduction measures suggested by our Institutes and other scientific and production departments cooperatively have gained considerable economic benefit. It may be anticipated that the further researches into this problem and the widely spreading of engineering countermeasures will enormously

reduce the loss from ground fissure disasters.

B. XGF belongs to the Fen-Wei Basin ground fissure system. Since they are typically multigenesis, intensive researches into the problem of ground fissure disasters will throw light on the general study of the various kinds of ground fissure disasters in the Fen-Wei Basin. And can be used for reference in many other places where the ground fissure disasters are being studied.

C. Because of the fact that activities of ground fissures bring to us the information about the variation of the physical and chemical properties of the earth's crust from deeper layers, therefore it will facilitate some researches, e.g. earthquake prediction, the exploitation of geothermal energy resources, and protection of ground water from pollution.

D. The research on ground fissures will promote the development of Fracture Mechanics. It's well known that Fracture Mechanics is a discipline on the law of emerging, propagating and stopping of fissures. The fractures in some homogeneous media e.g. metal, rock etc. have been studied. However, the ground fissures occurring in the shallow layer of the earth, where the media are inhomogeneous, i.e. both soil and water as well as gas exist in the same place concerned by us, have not been studied. To solve the fracture problems complicated like that, we should set up some new models of the media and widen the field of classical Fracture Mechanics. Besides the theoretical research, we should develop some new practical technique to protect civil engineering from the damage of ground fissures

### Summary

Ground fissure disaster occurs widely in the world. Accompanied by changing our environment unplannedly, it occurs more and more frequently. Now, it is high time to treat the disaster seriously. The comprehensive research on XGF will make a foundation for a new branch of Earth Sciences, "Ground-Fissures-logy", which will be a borderline subject linking Fracture Mechanics, Seismogeology, Geophysics, Engineering Geology, Catastrophology, Systematic Engineering etc. The principles of the multidiscipline will be developed to solve various problems of ground fissures. It will get achievements both in theory and in practice, and not only to discover the law of the disaster, but also to give the technological countermeasures to mitigate the damage. It will be born in the beginning years of IDNDR (Int-

ernational Decade for Natural Disaster Reduction).

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### References

- [1] Xie Guanglin, Ground Fissures, Seismological Press, Beijing, 1988.
- [2] Li Yongshan et al., Ground Fissures in Xi'an City, Seismological Press, Beijing, 1986.
- [3] Geng Dayu et al., A Preliminary discussion on evolution of Xi'an Ground Fissures (1985—1989) and its mechanism, Northwestern Seismological Bureau, Vol.12, No. 2, 1990.

## 西安地裂与地裂学——地球科学的一门新分支

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### 摘 要

在对西安地裂进行了全面综合研究的基础上,本文对各种不同的地裂灾害进行了归纳分类,并对其各自的成因进行了初步分析。给出了各类地裂在中国的宏观分布及地裂灾害最严重的地区——汾渭盆地的地裂分布。提出了在地裂的研究中,理论上要认识在多因迭加下浅部地层的非均匀、软弱、多相介质中断裂的失稳、扩展及终止的规律;应用上要解决各类建筑的防裂减灾技术问题,并能服务于环境、资源保护和城市规划,同时,还可以为地震预报、开发地热等工作提供某些基础资料。地裂学就是旨在完成上述任务的一门新兴的边缘学科,它将作为地球科学的一门分支学科在“国际减灾十年”中应运而生。