

三軸圧縮実験下断層形成・成長過程に伴う微小破壊についての実験研究

Microcracking During Quasi-static Fault Growth in a Brittle Rock Under Triaxial Compression

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<http://www.aist.go.jp/GSJ/~lei/lei00.htm>

三軸圧縮破壊実験における断層形成成長過程に伴う微小破壊音（AE）を計測し、その時空間分布および発震機構について調べた。断層が初期化された場所（断層核）にわずかの初期破壊しかなかった。断層核が形成した後、高い微小破壊活動を示す先端破壊ゾーン（process zone）を持って成長した。微小破壊間の相互作用を定量化するため自己励起モデルとb値を計算し、先端破壊ゾーンおよび微小破壊密度の高い断層面内に微小破壊が強い相互作用を示すことがわかった。発震機構によれば先端破壊ゾーンにはほとんど張力型クラックしかなかったが、断層面内にはせん断クラックが多かった。

Laboratory experiments of rock deformation are considered as a tool for understanding the rule of the occurrence of natural earthquakes. Many experimental studies on the frictional behavior of well-prepared fault plane have contributed many important rules. Although, indeed most earthquakes are usually assumed to occur on previously existing faults, the fracturing process of intact rock is still important since if a fault or some parts of the fault is healed, the healed parts must be fractured firstly before dynamic slip. Further, earthquake faults are a fault zone of width in the order of 10m to 100m, and fault rupture is not a distinct slip cross a simple fault plane but rather a shear zone. In the quasi-static nucleation of faulting, both friction and fracturing (including microfracturing) are important.

However, studies have been made difficult by the tendency for fault growth in an uncontrolled manner after fault initiation. Since there are very high microcracking activity in a very short time (generally in seconds) during the nucleation and growth of fault, most experimental system can not detect enough AE data, especially waveform data, to make clear what and how happen in such a short time. We developed a fast AE waveform recording system, which has 32 channels and is able to record as many as eight thousands AE events with a very small mask time of 200 μ sec.

In this study, one sample of fine-grained amphibole, which was cut into cylinder of 100 mm in length and 50 mm in diameter, was used in a triaxial compression test. The confining pressure was set at 60 MPa and was held constant throughout the experiment. The sample was loaded at a constant rate of 0.05MPa/s, and then kept constant when obvious AE activity was observed.

Since an AE event is generally corresponding to a microcracking, AE hypocenter distribution reflects directly the distribution of microcracking. Fault initiation and growth were monitored very well, by AE hypocenters. In a total view, microcracking distributed in the main fault plane, which was a curved 3 dimensional plane. The fault firstly initiated at one site near the top end of the sample where had only slight preceding damages, and then propagated spontaneously in its own plane with a process zone (in other words, the front area of the fault) of intense microcracking. The speed of fault growth was in cm/sec order, which are in the same order with that obtained from some friction experiments at a slip rate in the order of $1E-6$. After the fault front passed through, the nucleation zone had generally high microcracking activity. The time interval between the initiation of fault to dynamic rupture of the final fracturing is about 15 seconds.

Mechanism solutions showed that tensile microcracking was dominant at the early stage of fault growth and in the front of the fault (process zone). When density of microcracks in the nucleation zone increased or when the fault growth was accelerated, shear mode or other modes of shear component became the dominant modes of microcracking.

The interaction between microcracks can be quantitatively or qualitatively described using b-value, self-exciting model and focal mechanism solution. Enhancement of interaction of microcracks can be characterized by following facts. 1) Lower b-value, which indicates that the probability of the occurrence of larger microcracks is increased.

2) Strength of the impulse function of self-exciting model is enhanced, showing that the probability of exciting events is increased. 3) More AE events have shear mode or other modes of shear component, indicating that the link-up between microcracks is strengthened.