MICROSCOPIC STUDY AND NUMERICAL SIMULATION OF THE FAILURE PROCESS OF GRANITE

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Abstract of PhD thesis Failure of granite is a complicated process and is affected by a number of internal and external factors. Among thenii mineralogy is one of the most important factors and it directly governs the failure mechanism as well as failure process of this poly-crystalline material. In the study reported in this thesis, an effort has been made to reveal the failure behavior of major minerals in granite and their significant roles in the failure process. The microscopic study involves two essential parts, namely the experimental observation and the numerical simulation.

To examine the microcracks induced by the externally applied load, a double replica technique has been developed. The technique is essential to the success of the large number of experimental observations and statistical analyses performed in this research study.

Through the replica technique, failure behavior of major minerals in granite when loaded can be observed systematically under the optical microscope and the scanning electron microscope (SEM). Together with an image analysis system, the development of cracks in different minerals can be characterized quantitatively. The roles of these minerals during the failure process of granite are comprehensively studied and a mechanism for the failure process is proposed accordingly.

To verify the mechanism proposed and to explain the phenomena observed, the successive process of crack evolution is first traced in the experimental investigation. The micro fracture mechanisms of different minerals are then inspected carefully under the SEM with the aid of the energy dispersive X-ray (EDX) analysis system. Finally, the process is simulated and reproduced numerically by using the rock failure process analysis (RFPA) code.

The three major minerals forming the granite are quartz, feldspar and biotite. It is found from the vast observation data that, under uniaxial compression, failure of granite begins with the opening of quartz grain boundaries parallel to the direction of loading. Cracking of quartz grains starts at around 50% of the failure compressive stress (σ_c). whereas stress-induced cracks appear at about 75% of crc in feldspar. Failure of biotite, however, is highly dependent on the local stress condition.

According to experimental observations and numerical simulations, it is believed that the non-linear behavior of stress-strain curve prior to the peak-stress is mainly related to the cracking of the quartz grains. On the other hand, large number of microcracks around biotite grains are caused by stress concentrations locally.

It is revealed from this study that quartz is the crucial mineral in granite failure. Not only that cracks will first develop in quartz, it also greatly influences the behavior of the entire failure process of granite. The violent fracturing of feldspar normally takes place in the post-peak region. The major contribution of biotite to the failure of granite is to speed up the process by inducing microcracks at lower stress levels.

Key words microscopic study, failure, granite, replica technique, numerical simulation

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