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STUDY OF THE FORMATION OF MICROCRACKS AND THE POSSIBILITY OF DESTRUCTION OF MINERALS AFTER ULTRASONIC TREATMENT

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Abstract: In the realms of scientific and practical studies, minerals exhibit a wide range of applications and various reactions. Understanding their characteristics and developmental processes, as well as identifying harmful elements within them and how to assess them using ultrasonic techniques, constitute crucial issues in the scientific field. Ultrasonic methods play a significant role in implementing various procedures on minerals. These methods influence the molecular structure of mineral materials and can alter their specific properties. In this context, the study of microcrack formation on minerals and the potential for their destruction is of paramount importance. Investigating the formation of microcracks on minerals through ultrasonic methods provides invaluable insights into theoretical and practical concepts of mineral development. These features contribute extensively to the demonstration of technical experiments and laboratory conditions in the exploration of mineral characteristics.

Key words: Ultrasonic techniques, technical experiments, technical experiments, crucial issues, microcracks.

Introduction. Microcracks have a profound impact on the structure and development processes of mineral materials. Their formation encompasses changes in the mineral structure, alterations in mineral crystalline arrangement, thermal and mechanical property variations, and many other fundamental changes. These changes significantly affect the physical and chemical properties of mineral materials. Ultrasonic vibration frequency is an important parameter in ultrasonic-assisted rock-breaking, indicating the speed of ultrasonic vibration. The high-frequency cyclic load causes the rock to fatigue, and the cracks inside the rock gradually increase and expand, which reduces the strength of the rock. It is inferred that the strength of a rock can be reduced by vibration. Ultrasound imaging has been used for over 20 years and has an excellent safety record. It is based on non-ionizing radiation, so it does not have the same risks as X-rays or other types of imaging systems that use ionizing radiation [1]. Ultrasounds are used in medicine for diagnostic tests and as treatments for some diseases and injuries. Sound waves produce some mechanical vibrations, known as localized cavitation. These vibrations produce psychochemical changes in the body that cause thermal energy. In the cardiovascular area, this thermal energy generated by ultrasound is used to perform thrombolysis, coronary interventions, drug administration and gene transfer, and to facilitate the recovery of therapeutic injuries. The biological effects due to ultrasound exposure may be due to energy absorption or heating of tissues. Ultrasounds are used for the thermal ablation of tissues in surgery or for therapeutic treatments [2]. These tissues can also be treated with ultrasound by activating the gas in the body with inertial cavitation, causing interactions between bubbles, contrast agents or the pulmonary alveoli. Ultrasound is used in the treatment of cancer tumors and gene transfer via the permeability of cells. For lithotripsy (the removal of kidney stones), waves of 100 kHz to 200 kHz spaced at 1 s intervals are used. The level at which intestinal bleeding occurs is usually higher than the range used for diagnosis. Miller observed that the biological effect of hemolysis

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under ultrasound usually decreases by increasing the frequency [3]. It was observed that diagnostic ultrasound testing resulted in increased temperature and cavitation. This increase in temperature and cavitation produced mechanical effects that led to the hydrodynamic breakage of hydrogen bonds, an oscillation of these ions, and chemical effects when free radicals were released. The occupational exposures to ultrasound that are transmitted by contact and manifest themselves in the body as functional alterations of the nervous system, headaches, vertigo, fatigue, reflex modifications, vasomotor and peripheral turbulations, can cause heating damage to the skin and even to the bones; or cellular damage, with destruction of the own cells by a cavitation phenomenon [4].

At the same time, the deep surrounding rock mass will be damaged to varying degrees after excavation due to the more complex stress field in the deep mine roadway (Figure 1). Therefore,

comprehending the rock mechanics under the coupling action of accumulated damage and impact load is critical for deep mining engineering.

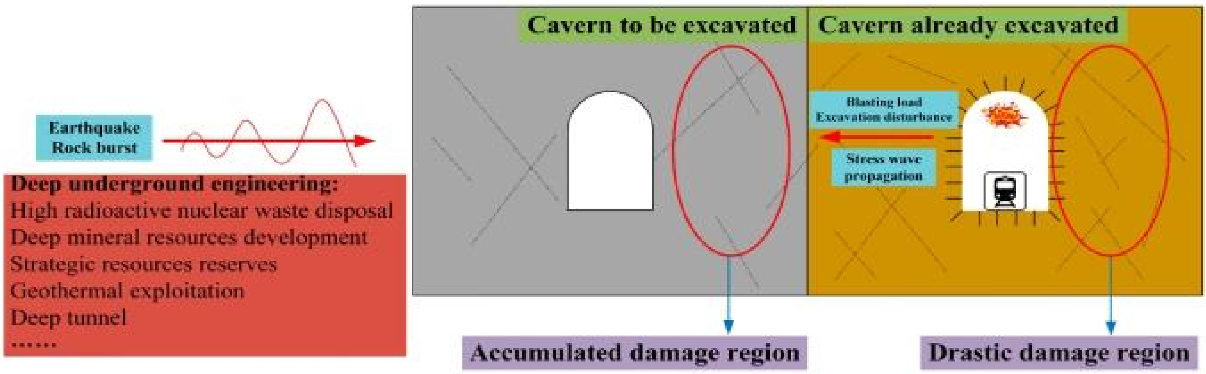

Figure 1. Overview of rock dynamics and accumulated damage problems in deep underground engineering.

Micro-cracks begin to develop within the rock when damage is produced in the specimen. After that, as the damage within the rock progressively intensifies, the cracks gradually expand to penetrate the rock, eventually leading to rock destruction. The rock will deform when it is subjected to external loads. At the same time, energy, namely strain energy, will gradually accumulate inside the sample. The rock sample will be destroyed once the accumulated strain energy exceeds the limit value. Exposure to ultrasound in the air can produce biological effects that manifest themselves in the abnormal development of cells, hematological effects, genetic effects and effects on the nervous system, with symptoms similar to those manifested by exposure through contact. Likewise, the possible displacement of hearing due to the sound components that may accompany ultrasound cannot be ruled out [5].

The effects of a high strain rate and accumulated damage on the sandstone's mechanical behavior and damage evolution were investigated. The results reveal that accumulated damage has a considerable impact on specimen stress–strain curves and lowers dynamic compressive strength and deformation modulus substantially. The sandstone failure mode looks to be shear failure from a macroscopic perspective, while it appears to be intergranular fracture between the mineral particles from a microscopic perspective. The macroscopic and microscopic failure mechanisms of the sandstone specimens likewise conformed to the energy absorption law. The accumulated damage factor and the accumulated damage correction coefficient were presented in order to construct a statistical damage constitutive model of rocks based on the Weibull

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distribution [6]. As described in the previous section, the stress–strain curves of sandstone specimens with accumulated damages at different strain rates reveal a certain similarity in the overall shape. The linear elastic phase, the plastic deformation phase, and the strain softening phase are well reflected in these stress–strain curves, indicating that their mechanical behaviors are similar. However, the initial phases show differences as the accumulated damage increases. Specifically, when the specimen has accumulated damage, the first phase in the stress–strain curve is no longer a linear elastic phase but a crack closure phase. In this phase, the stress–strain curves are nonlinear and tend to be concave. Furthermore, when the specimens experience the same accumulated damage, the dynamic compressive strength gradually rises with the increasing strain rate, suggesting that strain rate and the accumulated damage have an essential role in the sandstone behavior at the same time. The most likely explanation for the decrease in sandstone strength with the increasing damage factor is that the existence of accumulated damage leads to more micro-cracks. As loading proceeds, the transverse cracks in the sandstone specimens gradually close, while the vertical cracks continue to expand faster. These micro-cracks may also interpenetrate and eventually form macroscopic cracks, thus leading to a sharp reduction in the bearing capacity of sandstone. Therefore, the damage pattern of rock specimens is more likely to consist of two modes: tensile fracture and shear fracture. This situation is more evident under a high strain rate than in the quasi-static tests. This research aims to highlight the effects of accumulated damage on deep rocks [7]. In this study, coal measures sandstone is set as the main object of study for impact tests. It is well known that different types of rocks have distinct physical and mechanical properties, which makes it likely that the effects of accumulated damage on them will be highly varied. It is unknown whether the experimental results and the proposed statistical damage constitutive model in this study are applicable to other types of rocks. The next attempt is to apply accumulated damage to other types of rocks and alter the type of accumulated damage using different stress paths. Future research will offer fresh perspectives on estimating the accumulated damage impacts of deep in situ rock environments.

Conclusion. Ultimately, studying the formation of microcracks on minerals and analyzing their potential destruction sheds light on the significance of ultrasonic methods in the mineral field, paving the way for new advancements in mineral technology.

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