COMPUTER CONTROLLED VOLUMETRIC STRAIN MEASUREMENTS IN METADOLERITE

MESURE VOLUMÉTRIQUE DES DÉFORMATIONS DANS UNE MÉTADOLÉRITE PAR ORDINATEUR

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Abstract

A new volumetric strainmeter system has been developed for the measurement of true volumetric strains occurring in selected fresh and decomposed rock samples tested under computer controlled triaxial loading conditions. The system is capable of resolving volume adjustments of the confining medium to within ± 2.8 mm³ and maintain confining pressure deviations to ± 6.9 kPa. The results of the investigation have shown the inadequacy of the commonly used strain gauge method to represent the volumetric strains occurring in the whole of the test specimen and they have provided further experimental evidence for the continuity concept in the fracture mechanism of rocks. Even in the most decomposed samples tested, crack initiation and propagation starts at lower stress levels than previously recognised, in contrast to the generally accepted concept of critical stress levels which characterise and define the process of brittle fracture propagation in rocks.

Résumé

Un nouvel appareil destiné à contrôler les déformations volumétriques a été mis au point pour mesurer les véritables différences de volume se produisant sur un échantillon de roche comprimé dans les trois axes sous contrôle d'un ordinateur. L'appareil est capable de mesurer des différences de volume en milieu confiné de l'ordre de ± 2,8 mm³, et de garder une pression du milieu entre ± 6,9 kPa. Les résultats de ces investigations ont montré le manque de précision de la méthode usuelle pour représenter les volumes des déformations se développant dans l'échantillon et elles ont permis de confirmer par des expériences le principe des mécanismes de rupture des roches.

Même dans les essais d'échantillons plus altérés, l'origine des fissures et leur développement commencent sous des contraintes inférieures à celles prévues, contredisant ce qui est généralement admis.

Introduction

The common way of measuring volumetric strains depends on the measurement of the principal linear strains, both axial and radial, by the use of electric resistance strain gauges bonded to cylindrical specimens, Brace et al (1966), Bieniawski (1967), (1968), Scholz (1970), Edmond and Patterson (1972), Scholz and Kranz (1974), Zoback and Byerlee (1975). This method suffers the limitation that highly localised deformation can affect the measurement of linear strains at any stress level and especially at high strains (Brace et al, 1966), and if linear strains occur remote from where the strain gauges are located and are not properly recorded, this results in a conservative estimate of volumetric strains.

If major displacements occur along structural or compositional defects and the strain gauge measurements do not adequately reflect these events, misleading conclusions will be inevitable when these measurements are extrapolated to the whole rock sample and ultimately to a field situation. This paper introduces the use of a volumetric strainmeter system developed for the accurate measurements of volume changes in rock samples under computer controlled triaxial loading conditions, free from localized effects and representative of the whole sample.

The volumetric strainmeter system

The principle behind the development of the volumetric strainmeter is based on the fact that, under constant lateral pressure triaxial testing conditions, continuous volume adjustments of the confining fluid are necessary to compensate for radial expansion of the specimen being tested. The amounts of these volume adjustments

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provide the means for a direct measurement of volumetric strains occurring in the whole sample. Using this principle Crouch (1970) and Wawersik (1975) were able to resolve volume changes of the confining pressure medium to within approximately 6.6 mm (4 x 10⁻³ in) and control deviations of confining pressures to about ± 20.7 kPa (3 psi).

The technique presented in this paper differs from previous ones in that a much higher accuracy of measurements was achieved by the more sophisticated instrumentation used, overall design and the computer controlled mode of operation of the entire system. Confining pressure deviations were sensed and maintained at ± 6.9 kPa and volume adjustments of the confining medium were resolved to within ± 2.84 mm³.

Figure 1 and Figure 2 show a detailed representation of the volumetric strainmeter unit and a diagram of the entire volumetric strainmeter system respectively. As can be seen from Figure 1, a Bellofram separates chamber A, or the triaxial test cell side, from chamber B on the servovalve or reference side. Both sides of the volumetric strainmeter are connected to a pressure transducer of 7 MPa capacity, which is in turn connected to the computer via an amplifier and the confining pressure is supplied to the system in a computer controlled mode, via a hydraulic servovalve (Fig. 2). Under computer controlled triaxial testing conditions, once the operating confining pressure is applied, needle valves 2 and 5 (Fig. 2) are closed, thus establishing a test cell side “A” and a pressure reference “B” in the volumetric strainmeter.

Any variations of confining pressure on the test cell side “A” are recorded by the pressure transducer, led to the computer via the amplifier and the analogue to digital converter, compared with the required value of confining pressure of the reference side and, if necessary, compensating adjustments are operated in a computer controlled mode by the servovalve via the digital to analogue converter. The servovalve is opened or closed as the case may require thus allowing the aluminium piston in the volumetric strainmeter and consequently the high pressure L.V.D.T. core attached to it, to travel in the cylinder. These linear movements of the L.V.D.T. core are continuously recorded and fed to the computer memory and, since the experimental value of the effective cross sectional area of the cylinder is known, the volume adjustments can be computed. For practical reasons, an oil-water interface cell was placed between the volumetric strainmeter and the triaxial cell so that water could be used as the confining medium in the test cell instead of the hydraulic oil used for the rest of the system.

Calibration tests of the new volumetric strainmeter system satisfied the following requirements:

1. Linearity of the inbuilt high pressure L.V.D.T.