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Effect of porosity on the cratering efficiency of underground peaceful nuclear explosions in a shale medium

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Abstract. The effect of porosity on the cratering efficiency as measured by the kinetic energy imparted by a peaceful nuclear explosion to a shale medium has been evaluated, using a spherical symmetric rock mechanics computer code. A model using the measured material properties of the rock medium has been developed to represent the effect of porosity on the shear strength and compressibility (coupled parameters) of the rock. The calculated spall velocities, peak pressures and kinetic energies show that the cratering efficiency of this shale is first enhanced with increase in porosity and then degraded. This is due to the fact that at low porosities, the strength effects are more significant and at high porosities, the effects due to compressibility are more dominant.

Keywords. Peaceful nuclear explosions; porosity; cratering efficiency; shale.

1. Introduction

The use of a subsurface peaceful nuclear explosion as an excavation tool for canals, reservoirs, dams, etc. requires the evaluation beforehand of the geological medium in which the detonation is to take place. This has to be done to fix the depth of burst and the explosive yield for producing the required crater dimensions. Two methods are normally employed to model nuclear explosive effects. The first method involves experiments with low-yield chemical explosives at shallow depths followed by scaling up of the data for nuclear explosive yields. The second method uses numerical simulation by rock mechanics computer codes, in which the material properties of the rock medium are used as input parameters. The chemical explosives method is expensive and extrapolation of the results to nuclear yields at larger depths also requires that exact similitude be first established between chemical and nuclear explosions using numerical codes (Burton *et al* 1975). In numerical codes, however, the rock properties can be parameterised and the effects of the variation in these parameters can be studied. Some of these parametric studies have been done by Terhune *et al* (1970) for different rock media, and by Goodrich *et al* (1976) for clays. The results of these studies have produced guidelines about the dependence of the cratering efficiency of the medium on the following equation of state parameters: compressibility, porosity, water content and