



## **Correlation between dynamic and static bulk moduli of porous sandstones: Insight from the roles of microcracks and pores**

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We studied the continuous evolution of static and dynamic bulk moduli of a porous sandstone (Bentheim sandstone) with isotropic stress under different hydromechanical conditions. The static bulk moduli were achieved from the analysis of the stress-volumetric strain curve while dynamic bulk moduli were derived from the changes in ultrasonic P- and S-wave velocities along different traces which were monitored simultaneously during the entire loading and unloading cycle. To elucidate the effects of microcracks and pores on these moduli, a novel approach, capable of quantitatively determining the evolution of microcrack porosity and pore porosity with pressure in double porous media, was proposed based on poroelastic theory, and such a technique was verified to be practical and reasonable. These moduli were increased drastically with isotropic stress until the crack closure pressure, followed by the stable growth reflecting both dynamic and static bulk moduli are magnificently sensitive to the crack porosity in comparison with pore porosity. We observed the rapid decrease in the magnitude of the dynamic-static modulus ratio prior to the crack closure pressure, and subsequently it tended to level off in the range spanning from 1.0 to 1.1 for dynamic-tangent bulk modulus ratio under dry and undrained conditions. It was estimated that the effect of microcrack porosity on dynamic and static bulk moduli of Bentheim sandstone is approximately an order of magnitude greater than pore porosity regardless in the dry or undrained case. We found there exist two evidently different slopes in the dynamic-static bulk moduli curves separated by the events of microcrack closure suggesting the different roles of microcracks and pores. Our results suggested that the distributed cracks in porous sandstone appeared to impose a stronger effect on static bulk moduli than dynamic ones resulting in the gradually narrowed gap between them.