Experimental study of overburden and stress influence on non-Darcy gas flow in Dakota sandstone

Zhengwen Zeng(1), Sukesh Ganda(2) and Reid Grigg(1)

(1) New Mexico Petroleum Recovery Research Center, Socorro, NM, 87801 USA
(2) Schlumberger, 225 Schlumberger Dr., Sugar Land, TX, 77478 USA

Abstract

A series of laboratory experiments were conducted on Dakota sandstone to investigate the influence of overburden and in-situ stress on non-Darcy gas flow behavior. The experiments were conducted at 100F, and pump pressure at 2,000psi with flow rate from 25 to 10,000cc/hour, overburden from 1,000 to 10,000psi, axial stress from 1,000 to 10,000psi, and radial stress from 1,000 to 10,000psi.

Permeability and non-Darcy coefficient have been determined using Forchheimer method. Equations correlating permeability and non-Darcy coefficient to overburden and in-situ stress have been established. In addition, sectional linearity phenomenon has been observed: the Forchheimer plot can be divided into three linear parts, corresponding to a Reynolds number of about 0.03 to 20, 20 to 65 and 65 to 125. Permeability and non-Darcy coefficient determined from each section are different: the higher the Reynolds number, the lower the permeability and the non-Darcy coefficient.

The influence of in-situ stress on non-Darcy behavior is not available in the literature. Similar studies include stress influence on liquid flow permeability in porous media (e.g. Bai et al., 2002, Jones and Smart, 2002), and stress influence on gas flow through natural fractures (Warpinski et al, 1991).

Dakota sandstone is widely distributed in Colorado, New Mexico and Texas. The experimental conditions are close to the reservoir conditions in this region, so equations developed in this paper can be directly applied. In addition, under high pressures the results of this paper are similar to those of other sandstone obtained by Tiss and Evans (1989), indicating wider applications.

Technical contributions include: (1) Showed magnitude effects of in-situ stress on the non-Darcy gas flow behavior; (2) developed equations to quantify the influence of overburden and in-situ stress on the permeability and non-Darcy coefficient; (3) revealed sectional linear non-Darcy flow behavior under different Reynolds number, further analyses is on going.