**Dispersion Measurement as a Method of Quantifying Geologic Characterization
and Defining Reservoir Heterogeneity**

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An Experimental Study of Gas-Gas Dispersion in Consolidated Porous Media to Characterize Reservoir Rocks

1. Background of the Study

Dispersion of fluids flowing through porous media is an important phenomenon in miscible displacement. Much of the research involving dispersion and dispersivity as a property of reservoir rock has focused on miscible liquid-liquid displacement processes. This study addresses the measurement of dispersion in a gas-gas displacement system. It will enlarge the understanding of the characteristics of dispersivity and flow systems of reservoir rocks.

2. Objectives of the Study

Dispersion in miscible displacement is a characteristic of porous media. It is influenced mainly by the heterogeneity of reservoir and fluid flowing conditions. S-shaped breakthrough curves are typically used to describe the dispersion phenomenon in porous media.

Much research work has been conducting on the study of dispersivity as a reservoir rock property for several years. A significant amount of experimental work has been conducted in this area. The effects of scale, velocity and rock properties on liquid-liquid dispersion have been studied. The objective in previous research was to characterize and define reservoir heterogeneities by measuring liquid-liquid dispersion in porous media. The measurement of dispersion with gases will significantly contribute to the overall understanding of flow systems in reservoir rocks.

The objectives of this study are:

- (1) To develop a method and set up an experimental apparatus to measure gas-gas dispersion in consolidated rocks.
- (2) To study the effect of displacement velocity and pressure on gas-gas dispersion and dispersivity.
- (3) To study the heterogeneity of reservoir rocks and investigate the relationship between dispersivity and rock properties to characterize the flow system using gas-gas dispersion measurements.

3. Scope of the Study

New experimental methods and apparatus for gas-gas dispersion were developed in this study. A schematic diagram of the equipment used for gas-gas dispersion is shown in Figure (1). The system included (1) two bottles of pure helium, one was used as the displaced gas, the another was used as the carrier gas in the gas chromatograph; (2) one bottle of nitrogen used as the displacing gas; (3) three precise pressure and flowrate regulators on the top of each gas cylinder; (4) a core holder; (5) a vacuum pump; (6) a pressure gauge; (7) a gas flow meter; (8) a bubble gas flow meter; (9) a gas chromatograph; and (10) some needle valves.

Twenty eight gas-gas miscible displacement measurements under different flowrates and pressures were conducted on three Berea sandstone cores of varying lengths and physical properties. A gas chromatograph was utilized and modified to measure the concentration of gas at the outlet of the cores. Nitrogen was used as the displacing gas, while helium was used as the displaced gas. Figure (2) shows the flow chart of the experimental procedures used in the measurements of gas-gas dispersion in this study.

The experimental results were illustrated using S-shaped effluent breakthrough curves. The effect of flowrate and pressure on gas-gas dispersion, dispersion coefficient, dispersivity, and dispersion factor were determined from these curves. Gas effective diffusion coefficients were obtained by graphical methods using the dispersion coefficients under low velocities. A new method to determine the total flowing pore volume by dispersion measurement was proposed in this study. The heterogeneity of reservoir rock can be studied by this method.

Figure 1. Experimental Apparatus for Gas-Gas Dispersion

Figure 2. Flow Chart of Experimental Procedures for Gas-Gas Dispersion

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