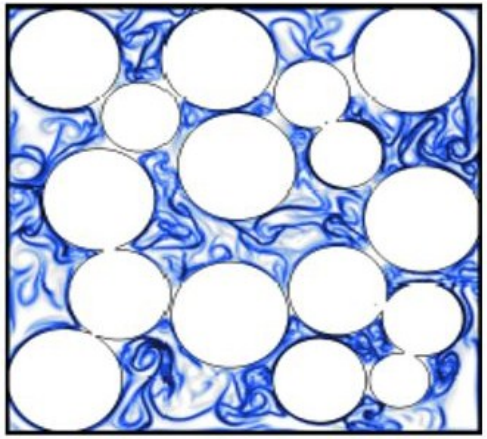

Porous Media

CHAPTER I

MECHANICS OF FLUID FLOW THROUGH A POROUS MEDIUM

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Contents

Natural porous materials

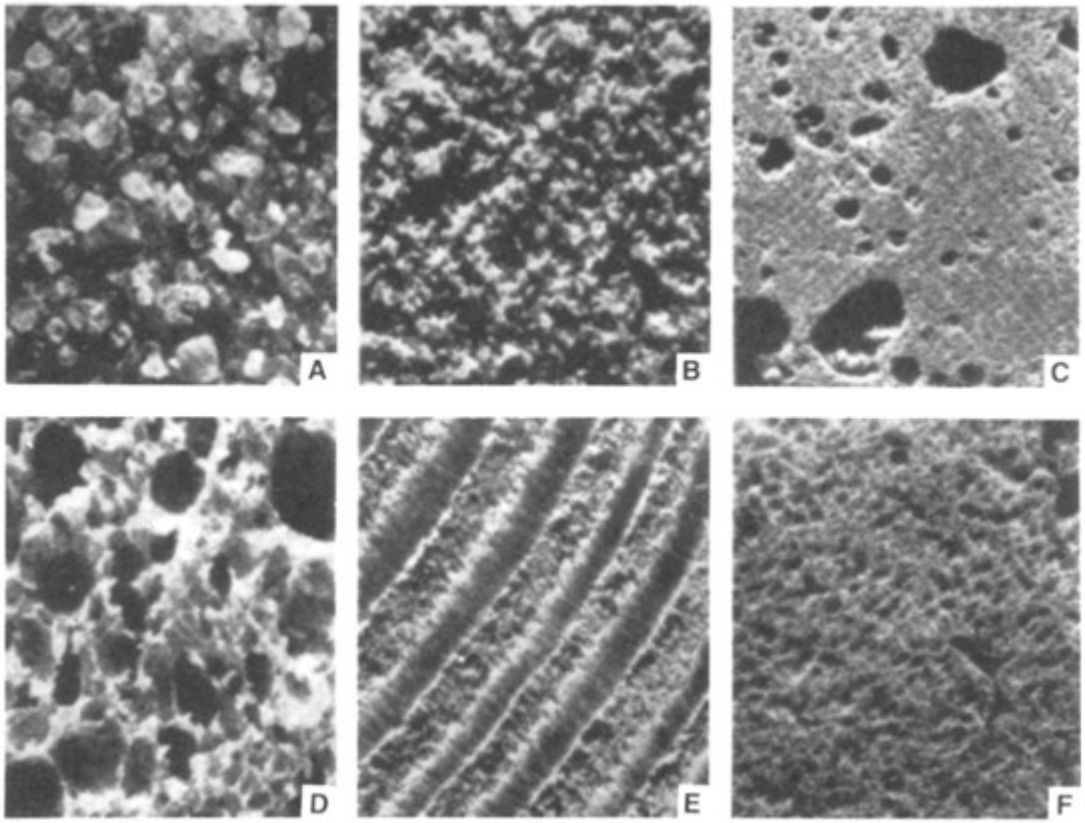
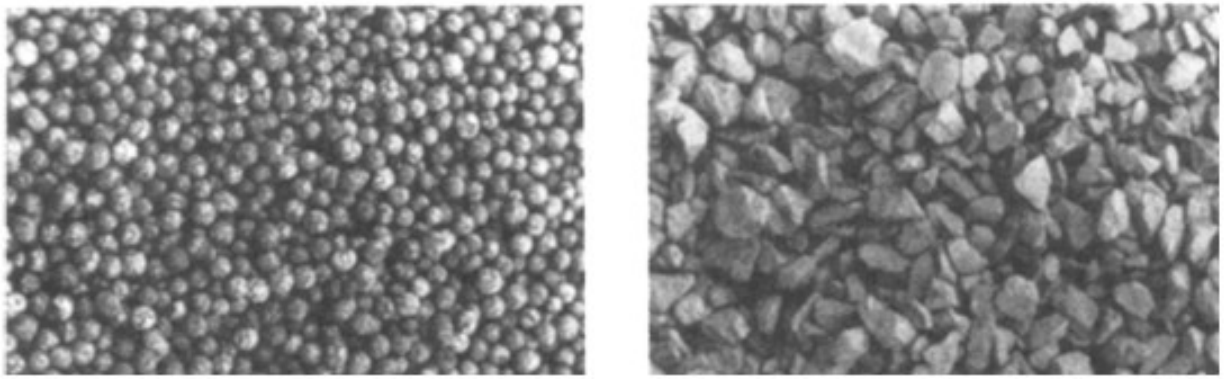


Figure 1.1. Top: Examples of natural porous materials: A) beach sand, B) sandstone, C) limestone, D) rye bread, E) wood, and F) human lung (Collins, 1961, with permission

Artificial porous materials



from Van Nostrand Reinhold). Bottom: Granular porous materials used in the construction industry, 0.5-cm-diameter Liapor® spheres (left), and 1-cm-size crushed limestone (right) (Bejan, 1984).

Spatial averaging: r.e.v.

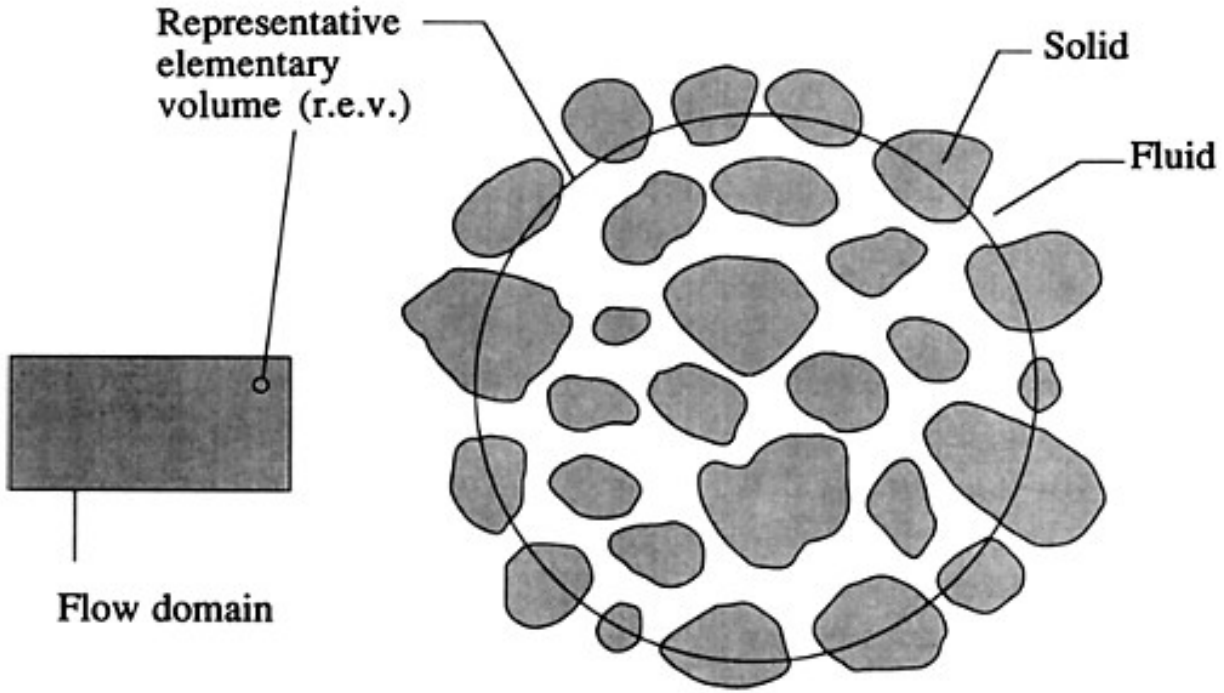


Figure 1.2. The representative elementary volume (r.e.v.): the figure illustrates the intermediate size relative to the sizes of the flow domain and the pores.

Table 1.1. Properties of common porous materials [based on data compiled by Scheidegger (1974) and Bejan and Lage (1991)]

Material	Porosity φ	Permeability K [cm^2]	Surface per unit volume [cm^{-1}]
Agar-agar		2×10^{-10}–4.4×10^{-9}	
Black slate powder	0.57–0.66	4.9×10^{-10}–1.2×10^{-9}	7×10^3–8.9×10^3
Brick	0.12–0.34	4.8×10^{-11}–2.2×10^{-9}	
Catalyst (Fischer-Tropsch, granules only)	0.45		5.6×10^5
Cigarette		1.1×10^{-5}	
Cigarette filters	0.17–0.49		
Coal	0.02–0.12		
Concrete (ordinary mixes)	~ 0.1		
Concrete (bituminous)		1×10^{-9}–2.3×10^{-7}	
Copper powder (hot-compacted)	0.09–0.34	3.3×10^{-6}–1.5×10^{-5}	
Cork board		2.4×10^{-7}–5.1×10^{-7}	
Fiberglass	0.88–0.93		560–770
Granular crushed rock	0.45		
Hair (on mammals)	0.95–0.99		
Hair left		8.3×10^{-6}–1.2×10^{-5}	
Leather	0.56–0.59	9.5×10^{-10}–1.2×10^{-9}	1.2×10^4–1.6×10^4
Limestone (dolomite)	0.04–0.10	2×10^{-11}–4.5×10^{-10}	
Sand	0.37–0.50	2×10^{-7}–1.8×10^{-6}	150–220
Sandstone ("oil sand")	0.08–0.38	5×10^{-12}–3×10^{-8}	
Silica grains	0.65		
Silica powder	0.37–0.49	1.3×10^{-10}–5.1×10^{-10}	6.8×10^3–8.9×10^3
Soil	0.43–0.54	2.9×10^{-9}–1.4×10^{-7}	
Spherical packings (well shaken)	0.36–0.43		
Wire crimps	0.68–0.76	3.8×10^{-5}–1×10^{-4}	29–40

Basics: special cases of fluid

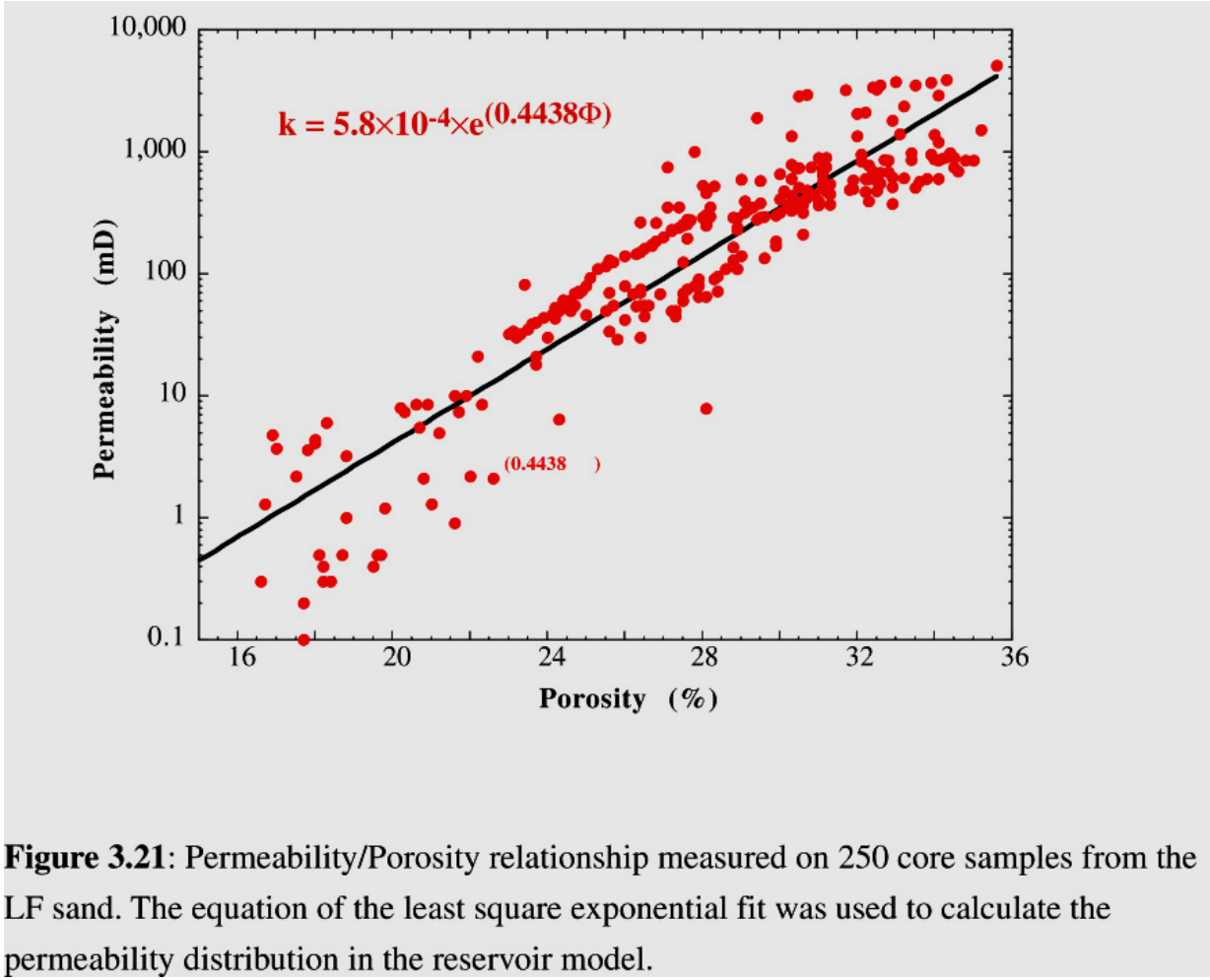
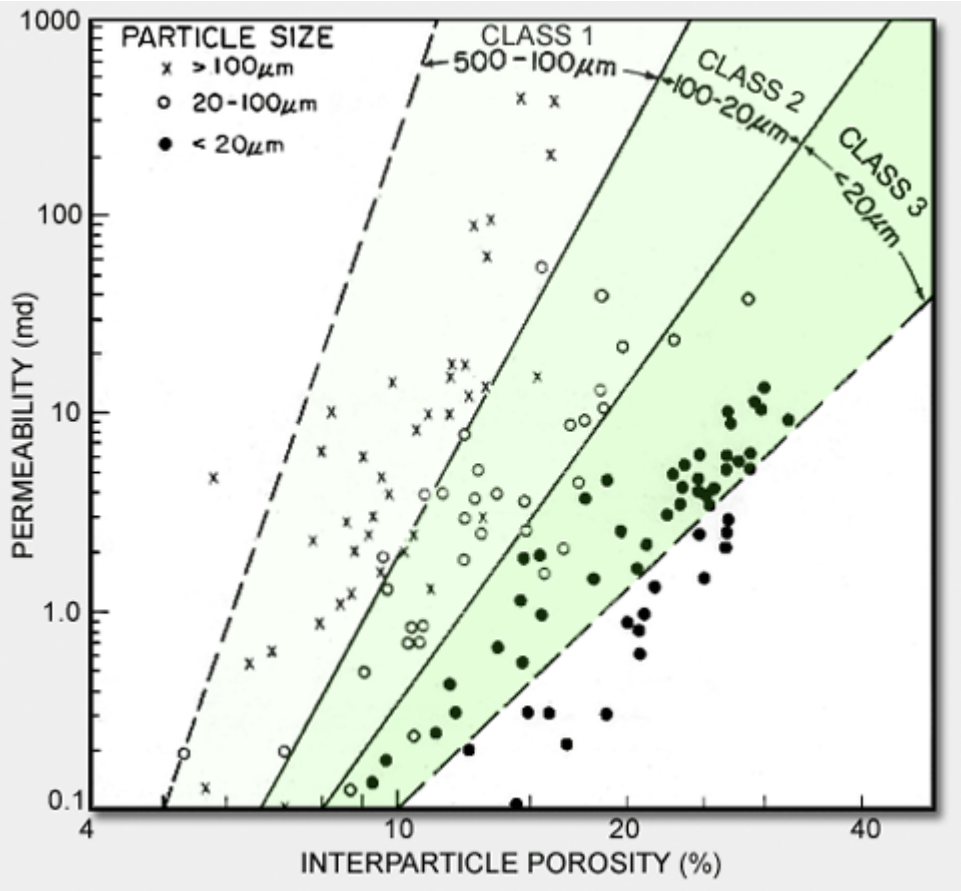


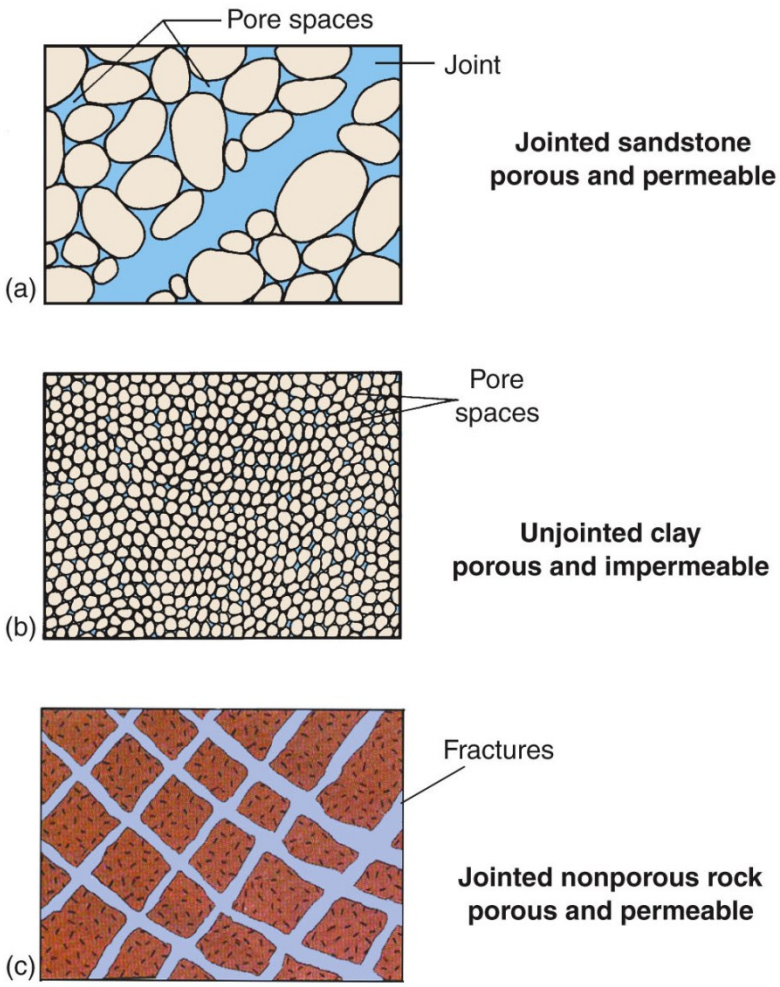
Figure 3.21: Permeability/Porosity relationship measured on 250 core samples from the LF sand. The equation of the least square exponential fit was used to calculate the permeability distribution in the reservoir model.

Basics: special cases of fluid



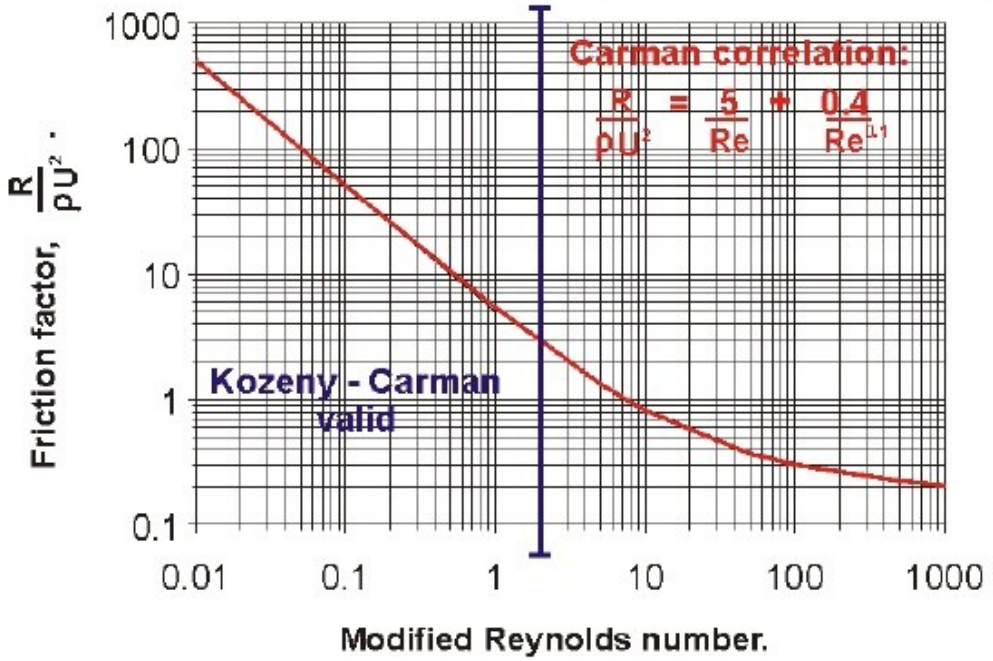
Porosity-air permeability relationship for various particle-size groups in nonvuggy carbonate rocks (Lucia, 1983)

Basics: special cases of fluid

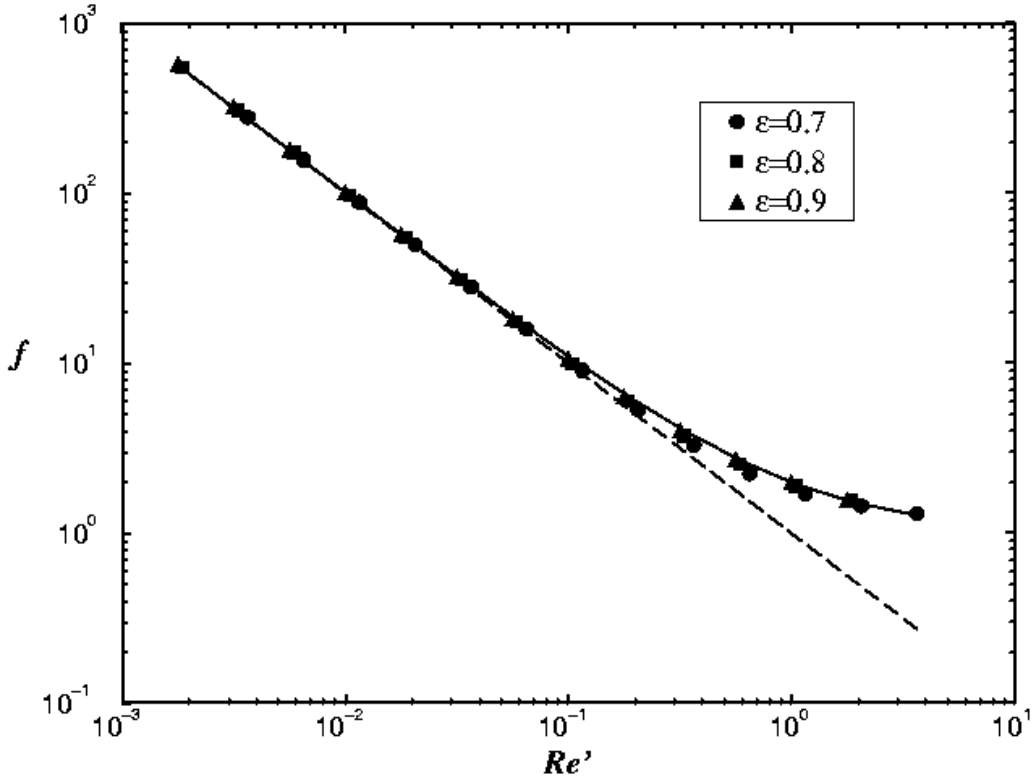


Basics: special cases of fluid

Friction factor plot – p. 24



Basics: special cases of fluid



Flow regime

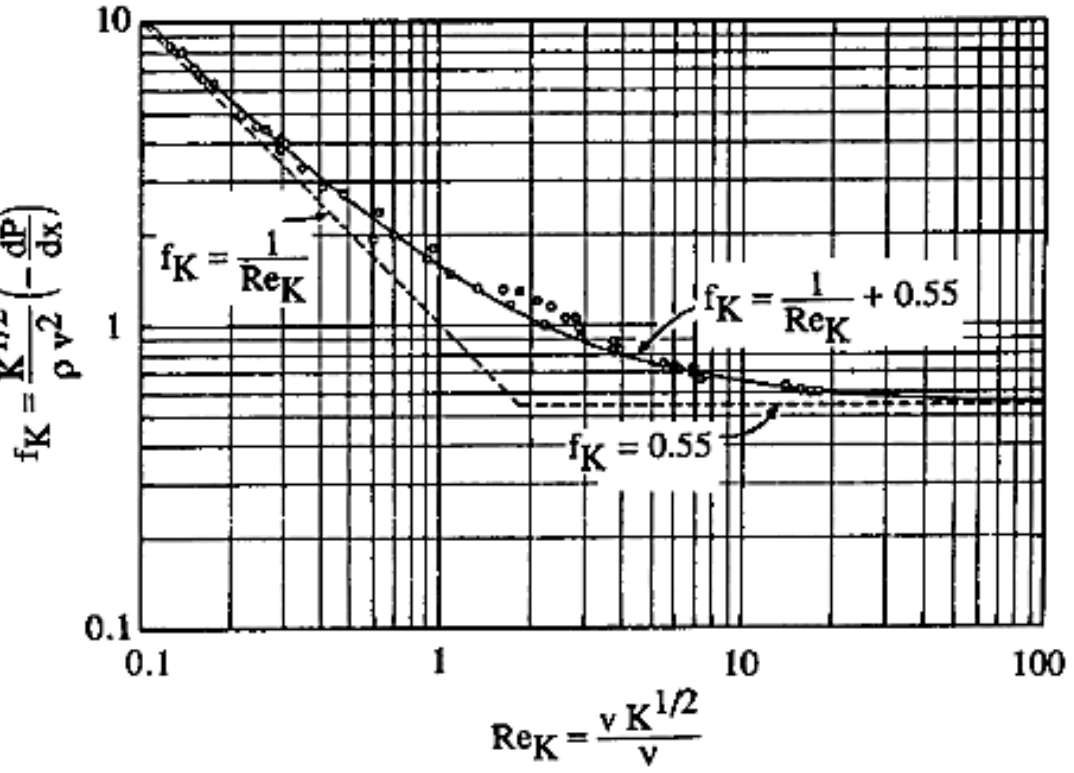


Figure 1.3. The transition from the Darcy regime to the Forchheimer regime in unidirectional flow through an isothermal saturated porous medium (Ward, 1964).