Contribution ID: **359** Type: **Oral Presentation**

The Impact of System Softness on Haines Jumps in Porous Media

Monday, 13 May 2024 12:10 (15 minutes)

Haines jump is an interfacial instability characterized by fluid redistribution and sudden pressure changes. It is a pore-scale phenomenon that occurs during displacement front movement and is widespread in multiphase flow processes in porous media. It is an essential physical process that affects fluid distribution, flow regimes, and displacement efficiency. Previous studies have shown that Haines jump is an instability phenomenon taking place in a soft system comprised of entrapped gas bubbles, deformable porous media, and interacting menisci. This study aims to further investigate the impact of system softness on Haines jumps in porous media.

We conduct fluid displacement experiments in polydimethylsiloxane (PDMS) microfluidic chips and analyze the pressure signature and flow phenomena during Haine jumps. A syringe pump (Chemyx Fusion 200) maintains a constant injection rate, and a microscope (ZEISS) records the displacement process. A microfluidic pressure sensor (Fluigent) placed at the inlet measures the pressure change. The system softness is controlled by adjusting the volume of an air bubble entrapped near the inlet. The PDMS microfluidic chip is fabricated using the standard soft lithography technique. De-ionized water and ethanol are used as wetting fluids, and air is the nonwetting fluid. The impact of system softness is investigated in three conditions: single pore throat, pores in series, and pore network.

Results show that system softness affects the position where Haines jumps occur at the pore throat and the distance of the interface jump. The interface jumps a longer distance when the entrapped air bubble volume increases. It also takes a longer time for the interface to reach the unstable point. An analytical model is proposed to explain the pressure change and interfacial jump at the pore throat and matches well with the experimental observation. In cases of pores in series, the pressure signature shows a “saw”shape where sudden pressure changes and interface jumps occur at pore throats. However, the interface can jump across more than one pore as the system softness increases. As the system softness affects the magnitude of Haines jumps, it also influences the snap-offs, entrapped fluid saturation, and displacement efficiency in pore networks.

In summary, the influence of system softness on Haines jumps and its impact on fluid displacement are analyzed in detail in both single pores and pore networks. Our experiments provide insights into the pore-scale physics of Haines jumps and the impact of Haines jumps on multiphase flow in porous media.

Keywords: Haines jump, porous media, microfluidics, instability, multiphase flow, interface

Acceptance of the Terms & Conditions

Click here to agree

Student Awards

Country

China

References

Conference Proceedings

I am not interested in having my paper published in the proceedings

Primary author: SUN, Zhonghao (Xi'an Jiaotong University)

Co-author: YANG, Dianrun (Xi'an Jiaotong University)

Presenter: SUN, Zhonghao (Xi'an Jiaotong University)

Session Classification: MS06-B

Track Classification: (MS06-B) Interfacial phenomena across scales