Geophysical Research Abstracts
Vol. 14, EGU2012-14447, 2012
EGU General Assembly 2012

Let us keep observing and play in sand boxes (Henry Darcy Medal Lecture)

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Henry Darcy was a civil engineer recognized for a number of technical achievements and scientific discoveries. The sand column experiments for which he is known revealed the linear relationship that exists between fluid motion and driving forces at low velocities. Freeze and Back (1983) stated, "The experiments carried out by Darcy with the help of his assistant, Ritter, in Dijon, France in 1855 and 1856 represent the beginning of groundwater hydrology as a quantitative science." Because of the prominence given to this experiment, two important facts behind Darcy's contributions to subsurface hydrology have not received much attention. First, Darcy was not only a good engineer, but he was also a highly respected scientist whose knowledge of both the fundamentals of fluid mechanics and the natural world of geology led to better conceptualizing and quantifying of groundwater processes at relevant scales to solve practical problems. The experiments for which he is known may have already been conceived, based on his theoretical understanding, and the results were anticipated (Brown 2002). Second, Darcy, through his contributions with Dupuit, showed that they understood hydrologeology at a regional scale and developed methods for quantification at the scale of geologic stratum (Ritz and Bobek, 2008). The primary thesis of this talk is that scientific contributions such as the one Darcy made require appreciation and a thorough understanding of fundamental theory coupled with observation and recording of phenomena both in nature and in the laboratory. Along with all of the significant theoretical, mathematical modeling, and computational advances we have made in the last several decades, laboratory experiments designed to observe phenomena and processes for better insight, accurate data generation, and hypothesis development are critically important to make scientific and engineering advances to address some of the emerging and societally important problems in hydrology and water resources engineering. Kleinhans et al. (2010) convincingly argued the same point, noting, "Many major issues of hydrology are open to experimental investigation." Current and emerging problems with water supply and their hydrologic implications are associated with sustainability of water as a resource for global food production, clean water for potable use, protection of human health, and impacts and implications of global warming and climate change on water resources. This talk will address the subsurface hydrologic science issues that are central to these problems and the role laboratory experimentation can play in helping to advance the basic knowledge. Improved understanding of fundamental flow, transport, reactive, and biological processes that occur at the pore-scale and their manifestation at different modeling and observational scales will continue to advance the subsurface science. Challenges also come from the need to integrate porous media systems with bio-geochemical and atmospheric systems, requiring observing and quantifying complex phenomena across interfaces (e.g., fluid/fluid in pores to land/atmospheric in the field). This talk will discuss how carefully designed and theory driven experiments at various test scales can play a central role in providing answers to critical scientific questions and how they will help to fill knowledge gaps. It will also be shown that careful observations will lead to the refinement of existing theories or the development of new ones. Focusing on the subsurface, the need to keep observing through controlled laboratory experimentation in various test scales from small cells to large sand boxes will be emphasized. How the insights obtained from such experiments will complement modeling and field investigations are highlighted through examples.

References

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