THE INTAERNATIONAL DEVELOPMENT OF THEORETICAL GROUNDWATER FLOW SYSTEM STUDIES

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Keywords: groundwater flow system, hydraulics, stagnation point, flowing well

In early 1960s, Toth (1962, 1963) proposed the theory of groundwater flow systems to characterize the hydraulics of basin-scale groundwater flow. The theory has resulted in a paradigm shift from “pipe flow in confined aquifers” from outcrops to outcrops to “regionally unconfined cross-formational flow systems" from recharge areas to discharge areas (Toth, 2016), which is critical for understanding a variety of geologic processes. This presentation aims to review the births the old and new paradigms, and recent development of groundwater flow systems.

The old paradigm of “pipe flow in confined aquifers” can be traced to observations of flowing wells in the Paris Basin, France, which was later confirmed in the London Basin, UK and in the Dakota sandstone aquifer beneatch the Great Plains, USA. In the turn of 19th and 20th centuries, field observations of water table (King, 1899) and experimental investigation of groundwater flow around drainage canals (Pennink, 1905) led to understanding of groundwater flow in unconfined aquifers. In the 1920s and 1930s, Forchheimer’s flow net of groundwater underneath a reservoir dam was popularized by Karl Terzaghi, which also trigerred rethinking flow pattern in unconfined aquifers. These developments contributed to Hubbert’s (1940) classic plot of flow net between two river valleys.

Inspired by Hubbert (1940), Toth (1962, 1963) obtained cross-sectional flow pattern using analytical solution of steady-state 2D groundwater flow. In recent two decades, there are many theoretical developments in this field, including but not limited to the following: transient groundwater flow systems in different time-scales, groundwater flow systems and stagnation points in the 3D domain, improved upper boundary conditions (from specified-head to specified-flux), variable density groundwater flow induced by salinity and temperature, coupling of basin-scale groundwater age and hydrochemistry distribution.