The Wisconsin Roots of Ground Water Hydrology

Mary P. Anderson

[NOTE: A longer version of this article was published in Ground Water *43(1), p. 142-145, copyright National Ground Water Association 2005.]*

Figure 1. Artesian fountain, Prairie du Chien, Wisconsin (Chamberlin 1885).

We can trace the roots of ground water hydrology in the U.S. to Wisconsin at the end of the nineteenth century when there was a remarkable confluence of talent at the University of Wisconsin (now the University of Wisconsin-Madison), including T.C. Chamberlin, F.H. King and C.S. Slichter. Although none of these men likely would have identified himself as a hydrologist, each did seminal work in ground water hydrology.

Thomas Crowder Chamberlin was born on a farm in Illinois, just south of Beloit, Wisconsin. He received degrees from Beloit College in 1866 and 1869 (Bailey 1981) and later taught at Whitewater Normal School (now the University of Wisconsin-Whitewater) and from 1873-1882 at Beloit College during which time he also worked at the Wisconsin Geological Survey (now the Wisconsin Geological and Natural History Survey), serving as Chief Geologist starting in 1876. He became known nationally for his work on the glacial geology of the state. In 1887, he became president of the University of Wisconsin, a position he occupied until 1892 when he left to head a new geology department at the University of Chicago. Buildings are named in his honor on the campus of Beloit College and at the UW-Madison. On the Madison campus there is also Chamberlin Rock, a large, gneissic, glacially-rounded boulder, perched on the side of Observatory Hill.

While in Wisconsin, Chamberlin wrote his famous essay on the method of multiple working hypotheses (Chamberlin 1890), which advocates that multiple lines of evidence be pursued simultaneously when investigating geological phenomena. His 1885 paper entitled "The Requisite and Qualifying Conditions of Artesian Wells" (Chamberlin 1885; reprinted in Freeze and Back 1983) was published as the U.S. Geological Survey's first report on ground water. The frontispiece to this paper is a beautiful print of an artesian fountain in Prairie du Chien, Wisconsin (Figure 1). One of Chamberlin's students at the Whitewater Normal School was Franklin H. King, who became a soil physicist (Ingraham 1972). King was a professor in the College of Agriculture at the UW from 1888 to 1901 (Ingraham 1972) and King Hall, which currently houses the Department of Soil Science, is named in his honor. King published two important papers on ground water while at UW (King 1892, 1899).

King (1892), as cited in Meinzer (1928), reported fluctuations in water level in an observation well at Whitewater, Wisconsin, in response to arrivals and departures of trains at a nearby station. Such fluctuations are now known to be caused by storage effects related to compression and expansion of the confined aquifer penetrated by the well. In his 1899 paper, King presented what may be the first ground water flow map, showing water table contours and flow lines as well as a cross section of flow to a stream (see Figures 1, 2 in Fetter 2004). The flow map depicts an area adjacent to Lake Mendota, Madison, Wisconsin. King identified the paradigm, later invoked by Toth (1963), among others, that the water table mimics the topography.

It appears that King began to collaborate with Charles Sumner Slichter, a professor of mathematics, around 1894 and may have been motivated to contact Slichter at the suggestion of Chamberlin who then was president of the university and knew both King and Slichter (Ingraham 1972). Slichter received a B.S. in mathematics from Northwestern University, Illinois, in 1885, becoming an instructor in mathematics in 1886 and then an assistant professor (1889) and professor (1892) at the University of Wisconsin. He rose up the ranks to department chairman (1902) and was Dean of the Graduate School from 1920 until he retired in 1934. Although he worked for the USGS during some summers, he spent his entire career at the University of Wisconsin, marrying a local girl, living in a house close to campus and raising four sons (Wang 1987, Ingraham 1972). He died in Madison in 1946 and is buried in Forest Lawn Cemetery. Slichter Hall is named in his honor and one of his quotes ("We are all mentioned in the wills of Homer and Shakespeare.") is emblazoned on the side of Memorial Library. His portrait hangs in the reception room of the University Club, an institution he helped found and where he was active for many years.

In his first and most famous ground water paper, Slichter (1899; reprinted in Freeze and Back 1983) demonstrated that potential theory, specifically the Laplace equation, could be used to solve ground water problems. In another important paper, Slichter (1905) presented what might have been, as he claimed in the introduction to the paper, the first direct field measurements of the rate of ground water flow in the U.S. Slichter also studied the spreading (dispersion) of solute in laboratory experiments using tanks filled with sand from Picnic Point and water from Lake Mendota. Slichter was also one of the first, if not the first, person to point out the potential of heat as a ground water tracer. In his 1905 paper, he concluded that relatively high ground water temperatures, measured in July in Long Island, New York, reflected induced infiltration from a pond. Other of Slichter's ground water papers were published by the USGS during the period 1902-1906 (Wang 1989). During this time and up to around 1912, Slichter was also involved in a number of engineering consulting projects including acting as an expert witness (Wang 1989, Ingraham 1972). Although his educational background and departmental affiliation at the university peg him as an applied mathematician, his career was not so different from the life of a modern-day professor of ground water hydrology.

In addition to the work on ground water hydrology produced by the nexus of Chamberlin, King and Slichter, fundamental work in geology, largely by Charles R. Van Hise (president of the university 1903-1918) and C.K. Leith, was on-going at UW in the early part of the 20th century (Dott 1999). Pioneering work was also being done in the engineering aspects of hydrology by Daniel W. Mead (professor of engineering 1904-1932) and in limnology by Edward A. Birge (promoted to professor of zoology in 1879, Dean of the College of Letters and Science 1891-1918, and president of the university 1901-1903 and 1918-1925). In the summers of 1925-1942, Birge, with biologist Chancey Juday and co-workers, collected data from several hundred lakes near Boulder Junction in northern Wisconsin.

While Slichter and Birge knew each other socially and interacted through their administrative posts at the university (Ingraham 1972), apparently they never collaborated scientifically. Birge and Juday (1934) recognized that there was the possibility for exchange of water between lakes and the ground water system. Nevertheless, the paradigm at the time was that lakes were essentially sealed off from ground water by fine-grained lakebed sediments so that seepage to and from ground water was small and insignificant, if it occurred at all (Hutchinson 1957). Not until Meyboom's (1966) work was it recognized that exchange with ground water is potentially important in many seepage lakes. What might have happened had the nexus of ground water hydrology at the University of Wisconsin enveloped Birge and Juday?

References

Bailey, S.W., editor. 1981. The History of Geology and Geophysics at the University of Wisconsin-Madison 1848-1980. Department of Geology and Geophysics, University of Wisconsin-Madison, Madison, WI, 174 p.

Birge, E.A. and C. Juday. 1934. Particulate and dissolved organic matter in inland lakes. Ecol. Monogr. 4, 440-474.

Chamberlin, T.C. 1885. Requisite and qualifying conditions of artesian wells. U.S. Geological Survey Annual Report 5, 131-175.

Chamberlin, T.C. 1890. The Method of Multiple Working Hypotheses. Science 15 (366), 92-96. http://www.accessexcellence.org/RC/AB/BC/chamberlin.html.

Dott, R.H. 1999. The Wisconsin School of Geology: Early Intellectual Exports. Wisconsin Academy Review 45(3) Summer 1999, 29-36.

Fetter, C.W. 2004. Hydrogeology: A short history, part 2. Ground Water 42(6), 949-953.

Freeze, R.A. and W. Back, eds. 1983. Physical Hydrogeology. Benchmark Papers in Geology V. 72, Hutchinson Ross Publ. Co.

Hutchinson, G.E. 1957. A Treatise on Limnology: Volume I: Geography, Physics, and Chemistry. John Wiley & Sons, New York, 1015 p.

Ingraham, M.H. 1972. Charles Sumner Slichter: The Golden Vector. The University of Wisconsin Press, Madison, WI, 316 p.

King, F.H. 1892. Observations and experiments on the fluctuations in the level and rate of movement of ground water on the Wisconsin Agricultural experiment station farm, and at Whitewater, Wisconsin. U.S. Weather Bureau Bulletin 5, 67-69.

King, F.H. 1899. Principles and conditions of the movements of ground water. U.S. Geological Survey 19th Annual Report, Part 2.

Meinzer, O.E. 1928. Compressibility and elasticity of artesian aquifers. Economic Geology 23, 263-291.

Meyboom, P. 1966. Unsteady groundwater flow near a willow ring in hummocky moraine, Journal of Hydrology 4, 38-62.

Slichter, C.S. 1899. Theoretical investigations of the motion of ground waters. 19th Annual Report, Part II, U.S. Geological Survey.

Slichter, C.S. 1905. Field measurements of the rate of movement of underground waters. Water-Supply and Irrigation Paper No. 140, U.S. Geological Survey, Washington, D.C.

Toth, J. 1963. A theoretical analysis of groundwater flow in small drainage basins. Journal of Geophysical Research 68, 4795-4812.

Wang, H.F. 1987. Charles Sumner Slichter—An Engineer in Mathematician's Clothing. In: The History of Hydrology, History of Geophysics 3. American Geophysical Union, 103-112.