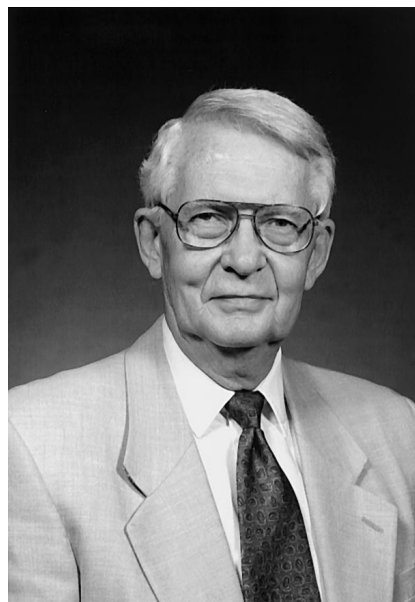

Robert N. Farvolden – Pioneering contributions in Mexican hydrogeology

Alejandra Cortes · Jaime Durazo

At the end of the 1970s at the height of the petroleum bonanza, Mexico seemed to be growing away from economic underdevelopment. At that time, as in many parts of the world, the country was also beginning to realize the limitations of its water resources and to be sensitive to the related risks of water degradation. The issue of water-resource management in Mexico had already received international attention because of the huge and growing demands of Mexico City. The situation in Mexico, however, became of particular interest to two world-renowned hydrologic scientists and professors from the University of Waterloo in Canada: Drs. Peter Fritz and Robert N. Farvolden. Through an almost prophetic foresight, they recognized that a water crisis in Mexico was looming and that a comprehensive evaluation of the country's water resources was of paramount importance. Their interest was primarily focused on the groundwater resources. Over a 15-year period, beginning in the early 1980s, Drs. Fritz and Farvolden made significant and lasting contributions to the understanding of the groundwater resources in Mexico. Their two stories are different; here, we focus on that of Professor Farvolden.



Robert N. Farvolden
(1928–1995)

Who was Robert N. Farvolden?

Robert N. Farvolden was one of the early pioneers in the development of modern hydrogeology as both a science and a profession. A Canadian, he studied at the University of Illinois and worked at the Desert Research Institute in Reno, focusing on regional hydrogeologic issues and the interaction between groundwater and surface water. In the mid-1960s he began his long and illustrious academic career, first at the University of Illinois and then at the University of Western Ontario, in London, Ontario. In the early

1970s, he moved to the University of Waterloo in Waterloo, Ontario, where he founded what would grow to be one of the largest and most progressive institutions for the study of groundwater science in the world. Over the subsequent two decades, Professor Farvolden taught literally hundreds of young earth scientists, from the undergraduate to the PhD level. At the same time, he maintained a high international profile, working on studies of regional hydrogeology in about 15 countries throughout the world. The vast majority of this work focused on the development and management of safe water supplies for populations in underdeveloped areas.

After his retirement in 1992, Dr. Farvolden accepted the position of Senior Scientist for the National Ground Water Association (NGWA), North America's largest hydrogeological association, headquartered in Columbus, Ohio. As one of his major initiatives, Farvolden promoted the international aspect of the NGWA; his concept was to provide hydrogeology professionals in the more remote parts of the

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world with access to modern developments in groundwater technology and training. At the time of his death in 1995, Dr. Farvolden was anything but retired. He was steering NGWA into new areas of development and was actively involved in several groundwater-management projects distributed throughout Latin America. Latin America had become a focus and passion for him over the previous decade. Above all, however, what captivated him most were the unique hydrogeologic issues in Mexico.

Farvolden in Mexico

In 1983, at the age of 55, Bob Farvolden arranged for a sabbatical leave at the National Autonomous University of Mexico (UNAM) in Mexico City, working in the Institutes of Physics and Geophysics. He studied Spanish intensively and would go on to teach in that language in subsequent years. Over a 10-month period, Farvolden set the stage for what would become more than a decade of collaborative science between researchers at UNAM and the University of Waterloo. Among the most significant contributions he made during this initial visit were the construction of a Graduate Program in Hydrogeology, based at the Institute of Geophysics, and the creation of a regular Groundwater Seminar Series, the first of which is in full operation today.

He became captivated by the magnitude of the water-supply problems in Mexico City, an industrialized megalopolis housing a population two-thirds that of Canada and situated in a hydrologically closed basin about 2240 m above sea level. Most of the water supply for this massive urban centre is drawn from deep aquifers beneath the city. The management of this water-supply system may be unprecedented in its complexity. Farvolden not only recognized the technical challenges associated with issues of groundwater-resource management, but also perceived the scientific opportunity.

In 1984 he and his Mexican colleagues began the preparation of a draft project proposal that would subsequently draw six years of Canadian government funding for hydrogeological study within the Basin of Mexico. The International Development Research Centre (IDRC) of Canada supported this project, entitled "The Aquifer System of the Basin of Mexico," from 1986 to 1992. The scope of the project ranged from the development of a regional conceptual model of the aquifer system, encompassing both geologic and hydrogeologic information, to three-dimensional computer simulation of groundwater flow within this complex system. Specific studies related to interbasinal groundwater flow, land subsidence, and groundwater-contamination issues were also pursued within the context of this project.

This period of intense collaboration between Canadian and Mexican scientists resulted in the training of

14 students from both countries at the undergraduate and graduate levels and in the preparation of numerous articles, books, and theses (see Further Reading). Much of the information derived through the course of this project was presented in national and international conferences. In Mexico City, short courses and workshops were initiated on various aspects of hydrogeology specific to the Mexican environment. This effort contributed to bringing together the hydrogeologic community in Mexico and encouraged dialogue. In fact, The Geological Society of America invited several of the Mexican scientists involved in these conferences to participate in the preparation of the hydrogeology section of their series of books on the geology of North America.

The process of technical workshops and conferences on groundwater issues continues to flourish throughout Mexico, as the awareness of the need for careful groundwater management grows throughout the country. Under Professor Farvolden's continuous guidance, this project produced a significant portion of the scientific literature on the hydrogeology of Mexico City and in some ways was an academic prelude to the North American Free Trade Agreement.

Beyond Mexico

In conjunction with the research activities in Mexico, Farvolden also initiated groundwater projects at university institutions within Brazil, Bolivia, Argentina, Nicaragua, and Costa Rica. These projects were initially co-sponsored by the IDRC in collaboration with the recipient country and were run as a network of research activities emanating from Bolivia. This network of collaborating scientists spawned the formation of a Latin American association of groundwater professionals known as ALHSUD, which in English translates as "the Latin American Association for Groundwater Hydrology for Development." This association is now an extremely active and rapidly developing group, many years after the Canadian funding ceased.

In addition, a Graduate Program in Hydrogeology that reaches throughout Central America and northern South America was developed at the University of Costa Rica in San Jose as a result of the research network established by Farvolden. This program was initiated through support of the IDRC in Canada and is now being significantly expanded through grant support from the Canadian International Development Agency (CIDA). The Graduate Program and CIDA grant are under the direction of two Canadian scientists at the University of Calgary. Professor Farvolden trained both of these students at the University of Waterloo on projects within Latin America.

A Farvolden Farewell

We finish this profile by referring to a specific date in December 1995, three months after Dr. Farvolden's death. At that time, the NGWA, UNAM, and the Mexican National Water Commission hosted the "Forum in Mexico on Ground Water Remediation" in Mexico City. Leading scientists in the field from across North America were invited to participate in the seminar, which once again promoted a new avenue of hydrogeologic activity in Mexico. The forum was conceived by Farvolden during the terminal stages of his illness and represented his last professional activity dedicated to Mexico. As a pragmatic farewell, he wrote in the invitation triptych:

We (Americans and Canadians) want to tell Mexicans in the groundwater industry of some of the successes and failures we have had, after spending 50 billion US dollars over the past 10 years or so on groundwater remediation...I think it is important that Mexicans become aware of our experience both good and bad,...and (to) take advantage of that experience.

Certainly, we Mexican hydrogeologists are taking advantage of that experience in many ways.

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Key words profiles · general hydrogeology · Mexico

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Robert N. Farvolden ¹ Pioneering contributions in Mexican hydrogeology. Cortes and Durazo 2000. Profiles, general hydrogeology, Mexico. William B. White (b. 1934) e Elizabeth L. White (b. 1936) e. William B. White and Elizabeth L. White (USA): their contributions to karst hydrogeology discussed in an interview. Goldscheider et al 2009. Profiles, interview, USA, karst, caves. A contribution to the empirics of economic growth*. N. gregory mankiw david romer david n. weil. This paper examines whether the Solow growth model is consistent with the international variation in the standard of living. It shows that an augmented Solow model that includes accumulation of human as well as physical capital provides an excellent description of the cross-country data. The paper also examines the implications of the Solow model for convergence in standards of living, that is, for whether poor countries tend to grow faster than rich countries. The evidence indicates that, holding James Robert Temple Hazell, known to many as Robin Hazell, passed away in March 2017, in Bodmin, Cornwall, aged 89, after a professional life spanning close to 70 years. Robin's main contributions addressed the exploration for and development of groundwater especially in hard rock areas. Much of this work was undertaken in the country of his first overseas posting, Nigeria, and was primarily spent in the field. He started his career in south and east Nigeria mapping groundwater resources and uncovering links between geology, baseflow and the likelihood of surface water being contaminated.