Kansas Professor Partners with Chinese Academy of Sciences to Map Subsurface Features in North China Plain

The potential of direct push electrical conductivity (EC) logging to provide detailed, reliable estimates of sediment textures in the unsaturated North China Plain sediments in northeastern China was examined in a collaborative project between American and Chinese scientists. Marcia Schulmeister, Assistant Professor of Earth Science at Emporia State University (ESU) in Emporia, KS, and Li Zheng and Yuqin Fu, Chinese Academy of Science (CAS), Center for Agriculture Modernization in Shijiazhuang, China, teamed up for a two-year investigation. As part of the project, Schulmeister introduced EC methods to CAS scientists, and trained staff and graduate students in the use of EC technology. The work was jointly supported by ESU’s Graduate College and the Chinese Academy of Science.

Northeastern China is one of the world’s fastest growing population centers. The North China Plain (NCP) aquifer underlies a 52,510 sq. mi. (136,000 sq. km.) region in northeastern China, and provides the primary agricultural and domestic water supply for the region. In the last 30 years, significant groundwater withdrawals have led to water level declines of 66 ft. (20 m) or more in rural areas, and as much as 164 ft. (50 m) near urban centers. Management of this critical aquifer requires an understanding of water movement in the growing unsaturated zone. Efforts to understand recharge and chemical loading to the NCP aquifer are complicated, however, by the presence of a complex network of fluvial and alluvial channels that exist in the aquifer’s dominant recharge area. These well-sorted, fine- to coarse-sand filled Holocene “paleochannels” dissect the fine-grained diluvial and loess-mantled pediments, making it difficult to model recharge to the aquifer system.

As part of the joint study between Emporia State University and the Chinese Academy of Science, EC logs were obtained in the upper 66 ft. (20 m) of the unsaturated zone in the NCP aquifer’s dominant recharge area using a Wenner array EC probe. According to Marcia Schulmeister, Assistant Professor of Earth Science at ESU and a member of the field team who conducted the study, low total dissolved solids in adjacent core samples demonstrated that the influence of fluid chemistry on soil EC is minimal in the areas studied. This suggests that strong correlations between EC and fine sediments, and between soil moisture and fine sediments, were observed; indicating high EC values could be used to identify fine-grained stratigraphic features. Well-sorted, fine- to coarse-sand layers were identified in grain-size analysis of seven continuous soil cores, verifying the presence of the paleochannels. The depths of these layers corresponded with baseline conductivity values in adjacent EC logs, in sharp contrast with overlying and underlying fine-grained layers.

According to Marcia, “The mobility and high-resolution capability of the direct push EC approach provided rapid access to more detailed information on the distribution of preferential flow paths in NCP sediments than was possible using conventional driller’s logs and map surveys.”

The collection of 50 EC logs in the 663 sq. mi. (1,200 sq. km.) study area allowed for refinement of paleochannel margins, depths, and thicknesses predicted in previous studies. Model cross-sections (shown below) created by using a series of EC logs revealed distributions and thicknesses of continuous sand bodies. The generation of high-resolution 3D framework models is possible when EC logs are combined. Ongoing modeling efforts will incorporate these results in predictions of fluid movement and improve efforts to advance the aquifer’s sustainability.

The Geoprobe® 54DT and most of the tooling used was owned by CAS. The study area is approximately 19 mi. (30 km) southeast of the city of Shijiazhang, home to approximately 8 million people. “There are numerous small farming villages around the study area,” Marcia said, “so we worked with local farmers to gain access to the probing sites. Most of the residents had never seen an American, so they were stunned when a tall, American woman, dressed in field clothes and boots, said ‘hello’ to them in Chinese!” She said the students did most of the negotiating with the locals for permission to core and log on private property.

The work was an extension of a project Li Zheng and Marcia had been working on that focused on the evaluation of the direct push EC approach for high-resolution hydrostratigraphic characterization. The heterogeneity of the thick, unsaturated zone provided an ideal setting in which to test EC logging. A great deal of work had already been done using conventional driller’s logs which allowed this team to compare their approach to conventional approaches.

Marcia said that the information exchange that took place as part of this investigation benefited both Chinese and American scientists. “The Chinese were an excellent partner and their work benefitted both Chinese and American scientists.” She said the application of the new EC approach will enhance predictions of fluid movement and improve efforts to understand aquifer recharge. In addition to an opportunity to pursue research goals in one of the world’s most complex unsaturated systems, “I gained practical teaching experience through working with international students and many non-English speaking colleagues,” Marcia added. “Despite an occasional lapse in communication, graduate students were thrilled by the opportunity to help solve a problem of national importance.”

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