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Perspective

Opportunities and challenges for geological work in China in the new era

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Editor's Note: In celebration of the Geological Society of China's centennial anniversary, a seminar titled "Groundwater and Healthy & Green Development" was held on November 24–25, 2022. It was hosted by the Geological Society of China and organised by its committees on Hydrogeology, Geothermy, Medical Geology, and Mine Water Prevention and Utilization. The seminar aimed to adapt to the new requirements of geological work in the new era and fully leverage the basic, leading, and binding roles of water resources. It sought to promote the conservation of water resources, the protection and ecological restoration of water environments, and the conversion of the cutting edge theoretical research in geothermal technology into achievements; and the advancement of interdisciplinary development of hydrogeology, geothermal geology, and medical geology. The seminar featured an important speech by Wang Min, Vice Minister of the former Ministry of Land and Resources of the PRC, which is included below.

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Respected academicians, experts, and colleagues, good morning!

This seminar was organized jointly by the Hydrogeology, Geothermy, Medical Geology, and Mine Water Prevention and Utilization Committees of the Geological Society of China, the Institute of Hydrogeology and Environmental Geology under the Chinese Academy of Geological Sciences, the China University of Geosciences (Wuhan), and the China University of Mining & Technology (Bei-jing). The seminar attracted participants from diverse academic fields, indicating the significance of the topic discussed. As members of the hydrological-engineering-environmental geological community, we work under the guidance of geology, particularly hydrogeology. As the whole nation continues to study and implement the spirit of the 20th CPC National Congress, we are here in commemoration the centennial anniversary of the Geological Society of China. The seminar's theme, " Groundwater and Healthy and Green Development" , provides a platform for us to exchange views and ideas, and to promote innovation and better serve the construction of ecological civilization through in-depth exploration. It is a highly significant event that will enable experts and researchers to collaborate.

Groundwater is a valuable resource, and a significant geologic agent that plays an active and sensitive role in the environment. In 1856, Darcy's Law was proposed, which provided a disciplinary foundation for quantitative hydrogeological studies. With the introduction of percolation theory, groundwater could be described comprehensively and quantitatively, similar to surface water resources, leading to a new stage of hydrogeology as a whole. Some researchers even referred to hydrogeology as " underground hydrology" during this time, which undoubtedly guided the exploitation of groundwater resources. However, percolation is not a true water flow, and the percolation velocity does not correspond to the actual groundwater velocity. As groundwater research progressed from the hydrogeology stage to the ecological environment stage, accurately describing particle motion and pollutant migration of groundwater became challenging. Unfortunately, this issue has not yet been resolved.

Groundwater plays a distinct environmental

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function compared to surface water. When groundwater is too deep, it can cause the soil surface to lose water support and become dry and cracked, leading to desertification, rocky desertification, and a sharp decline in biodiversity. Conversely, when groundwater is too shallow, it can result in large-scale secondary salinization. In the past, we have placed a greater emphasis on the resource function and water supply capacity of groundwater, particularly the potential of deep groundwater for large-volume, high-quality water supply. However, this approach led to excessive groundwater exploitation, resulting in numerous ecological and environmental problems.

There are two main issues with groundwater utilization. Firstly, due to pollution and the limited capacity for single-well water recovery, shallow groundwater that is easily recharged and circulated and is often left unused. This leads to the continuous rise in the phreatic surface and a thinner vadose zone, resulting in the development of swampy conditions, increased breeding of mosquitoes and flies, and a reduction in the regulation and storage capacity of groundwater. This phenomenon is particularly prevalent in South China. Secondly, excessive exploitation of deep confined groundwater leads to extensive land subsidence and ground cracking, which severely limits regional economic and social development. The recovery of water through well shut-in and control of groundwater exploitation in the North China Plain has provided valuable insights and alerts to us.

Previous research has provided some insights regarding the understanding of the formation, evolution, recharge mechanisms, and environmental effects of groundwater resources. The evaluation of the composition of groundwater resources, especially the groundwater recharge volume, and the questions of whether, where, how much, and how groundwater can be exploited have also been addressed. However, these insights have not been fully valued.

For instance, in the Hebei Plain, it has been founded that only 4% of the deep groundwater yield originates from lateral recharge, while 35.19% comes from upper leakage recharge and the remaining 60% originates mainly from compaction of cohesive soils. Isotopic dating of groundwater in the same region has shown that groundwater in the pediment zone has an age of less than 100–200 years, while flow systems with an age of 100–200 years are locally present in the central part and the shallow coastal plain. The deep groundwater, on the other hand, mostly has an age of approximately 10 000–20 000 years. These findings indicate the complex composition of groundwater. In particular, pore groundwater at a greater burial depth serves as mineral resources to a larger extent. However, careless exploitation of medium and deep confined groundwater can easily cause damage to the natural environment. Given the current emphasis on environmental protection, there is a pressing need to further explore and gain an understanding of the dual attributes of groundwater as water resources and mineral resources, as well as the accurate assessing the impact of groundwater on resources and the environment.

Groundwater can be considered as a large natural chemical laboratory. Throughout the process from recharge to runoff and finally discharge, groundwater inevitably interacts with surrounding rocks via various leaching, dissolution, and deposition processes under different conditions such as temperature, pressure, acidity, oxidizing and reducing reactions. As a result, various exchange of energy and matter, as well as physicochemical and biochemical processes take place, which have a long lasting impact on the quality of the ecological environment. Therefore, if the relationship between humans and the land is considered the most important foundation for promoting harmonious coexistence between humans and nature, then hydrogeology is the “golden key” to unlocking this mystery.

Although significant progress has been made in many areas after years of efforts, there are still a number of challenges that need to be addressed in order to promote the construction of a beautiful and healthy China. Despite the integrated protection and restoration of mountains, water bodies, forests, fields, lakes, grass and sand, the role of groundwater and its assessment, conservation, and regulation are still being determined based on concepts and principles. There is a lack of systematic and in-depth research on the impact of the subsurface environment on the human living environment, as well as the relationships between the geological environment and the production, living, and ecological space. Even in previous field research, geologists were referred to as “Mr. Feng Shui” by local residents, highlighting the importance of hydrogeology in identifying mountains and water distribution. Therefore, it is necessary to intensify hydrogeological research to promote the harmonious coexistence of man and nature.

Groundwater is an extremely valuable carrier of information, interacting with water-bearing media and other relevant environmental elements to form rich traces that can be used for source identification and indication of environmental changes.

As such, it is crucial for future hydrogeological research to focus on accurately describing these traces and gaining a comprehensive understanding of groundwater through interdisciplinary research and the comprehensive application of various techniques and methods.

Hydrogeology develops mainly through theoretical research, experimental research, and the application of techniques and methods. However, it is widely recognized that basic research has been weakened since the adjustment of hydrogeological disciplines. In particular, large-scale laboratory simulation experiments and observations, which were once vibrant, are hard to see now. Traditional theories, techniques, and methods are still widely applied, indicating a lack of innovation. The current situation is certainly unfavorable for the development of hydrogeology. I sincerely hope that we can work together to change this and promote innovation in hydrogeological research.

Finally, I would like to address the importance of "going one step further" in geological work. While geological work is highly fundamental in many aspects, it is crucial to break through the limitations of expertise, systems, and mechanisms in order to drive it to serve a wide range of fields. These limitations are not limited to the separation between prospecting and mining, as seen in soil geochemical surveys. Large-scale soil geochemical surveys have been performed across China, revealing both large areas of soil contamination and the distribution of many beneficial elements. However, taking the next step to conduct appropriate follow-up studies and provide in-depth services has rarely been done. In the natural environment, the same element may occur in different forms, be involved in different biochemical processes, and be taken up to different extents by plant roots under varying redox and acid-base conditions. For example, in paddy fields with excessive cadmium content, the cadmium content in rice can be significantly reduced by sprinkling a small amount of lime to appropriately increase the pH of paddy water. Excessive heavy metal content does not necessarily cause contamination of agricultural products, but the opposite may occur if the environment changes. This also applies to the enrichment of beneficial elements and the cultivation of high-quality agricultural products. These practices differ greatly from the previous geochemical surveys for ore prospecting. Therefore, it is necessary to adapt our working methods and research contents to meet the latest demands. Taking that extra step forward can lead to the emergence of a new scene.

The case of geothermal geology is similar to that of soil geochemical surveys. In order to accelerate the exploitation of shallow geothermal energy, comprehensive surveys, evaluation, and zoning were conducted. However, geologists have been far less extensively and deeply involved in subsequent geothermal exploitation than in the early stages. They were also active in the exploitation of middle and deep geothermal resources primarily in the early stages. This pattern also applies to the exploitation of critical minerals and the minerals required for strategic emerging industries, as well as urban geology, tourism geology, and military geology, where geologists excelled in the early stages but contributed inadequately to later achievements. To address this, geologists need to seize the valuable opportunities brought about by the transformation of geological work, accelerate the change in traditional ways of thinking and working, and broaden the horizons of research. Moreover, they should intensify research based on demand, enhance their awareness and ability to take the extra step forward, and comprehensively improve the supply capacity and level of geological services.

As the seven major organizers of this seminar all have great influence in the industry, and the experts and scholars present here are mostly active in frontline scientific research, I hope this meeting will further promote academic exchanges, drive innovation in theory, technology, and method, and broaden and deepen the application of geological work. Through these efforts, geologists can contribute their knowledge to China's green development.

I wish the conference great success. Thank you!