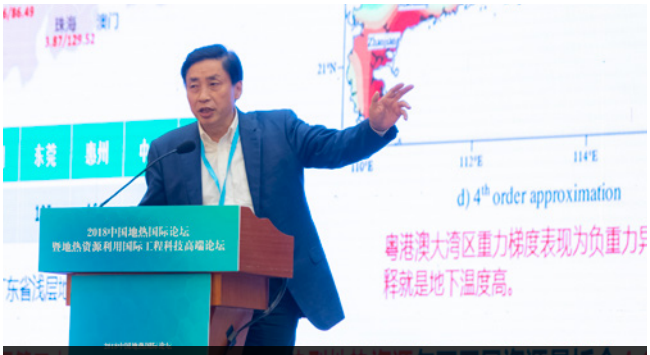
A deep search for clean energy solutions

A YOUNG INSTITUTE IN SHENZHEN is transforming insights on rocks into plans for developing green energy sources.



CAE member Heping Xie outlines the distribution of geothermal vents in the Greater Bay Area, a network with great clean energy potential.

Many underground minerals contain large volumes of carbon. The natural process of mineral carbonation, over centuries, has inspired scientists to find approaches to remove CO_2 from the air by storing it in carbonate minerals, helping reduce carbon emissions. At the Institute of Deep Earth Sciences and Green Energy (DESGE), at Shenzhen University, researchers are applying knowledge gained from deep-Earth science to innovations in clean energy technologies.

Led by Heping Xie, a scientist of rock mechanics, and member of the Chinese Academy of Engineering, the institute, established in 2018, seeks to bridge studies on minerals and rocks with investigations into geothermal energy, ocean energy, fuel cells, and other clean energy sources. As early as 2014, Xie proposed an approach to harvest electrical energy directly from CO_2 mineralization, leading to a fuel cell system that uses CO_2 and industrial alkaline wastes to produce a useful chemical compound, $NaHCO_3$ (commonly known as baking soda), while generating electricity. Their system has high power density, demonstrating a viable way to achieve CO_2 reduction and energy generation at the same time. Xie is also leading his team to develop efficient electrochemical technologies for CO_2 capture.

Working on low carbon technologies, Xie's DESGE team is improving the coal-to-power process to make it cleaner and more efficient. In a recent study, they improved coal pre-treatment to produce a highly pure char. This modified char and a nano silver-infiltrated anode led to a hybrid direct coal fuel cell that converts coal to electricity efficiently, with low emissions. Researchers are also mining hydrogen from the sea to develop clean energy sources.

Another source investigated by DESGE is geothermal energy. In a study that explores the geothermal resource potential in the Guangdong-Hong Kong-Macao Greater Bay Area, Xie's team found that local geological features and lithology are conducive to the formation of optimum geothermal conditions for energy generation. To enhance the permeability of the geothermal reservoirs, they proposed various fracturing techniques. Particular attention is given to ways of improving the efficiency of geothermal power generation at low or medium temperatures, including magnetic levitation and thermovoltaic technologies, involving the use of maglev wind turbines and thermoelectric generators.

Studies of coring and prospecting that retain deep *in situ* geological conditions and rock dynamics are another key strength of DESGE. Xie was the first to propose the idea of collecting cores and testing rock with maintaining *in situ* pressure, integrity, temperature, and moisture levels. His group has studied physical and mechanical behaviours of rocks at varying depths with retaining the *in situ* geostress to develop deep rock mechanical theories and corresponding technologies. The research supports improving deep-Earth resource acquisition capabilities. The team also studies rock dynamic behaviour and responses to disturbances during construction and operation of major engineering projects. They explored 3D rock dynamic theories, wave propagation, attenuation and superposition in rock masses, rock dynamic responses to various dynamic disturbances, and developed disaster mitigation and safety protection techniques.

With more than 200 million yuan in research grants, DESGE is looking to recruit global researchers at all levels to push the boundaries of green energy and deep-Earth sciences, driving growth of the field in Shenzhen and beyond. ■

Heping Xie and Diwen Zhu discuss the potential of carbon dioxide mineralization for electricity generation.

The world's first demonstration of kW-class CO_2 mineralization cell with power co-generation

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