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The teaching system development of geothermics in the context of energiewende and carbon neutrality

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ABSTRACT

The central government of China has clearly established a target of 'carbon neutrality' and new energy development policies. With the upsurge of geothermal resources research and the development of geothermal energy industry, it is necessary for energy universities to pay more attention to geothermal education and strengthen the practical training of geothermal geology professionals. With the advantages in the geothermal geology research and teaching, we developed the teaching system of geothermics from teaching materials, theory teaching, practical education, teachers' team and the combining of production, education and research, based on the pre-existing courses. Through systematic research and analysis, in view of the demand of production enterprises, the professional training requirements and the practice ability training, for the improvement of the running and the management of the practice teaching system and experimental teaching platform, practice bases for the exploration and development of geothermal resources are established and the practice teaching platform of geothermal lessons are promoted. A comprehensive geothermal teaching laboratory has been completed, which is a trinity of geothermal temperature and rock thermal physical property testing, geochemical analysis and numerical simulation platform. The achievements have provided strong support for the development of clean energy education of our university, and can also provide reference for the construction of new energy teaching system in other energy universities.

1. INTRODUCTION

Compared with oil, coal and other non-renewable energy sources with high emissions, geothermal energy is both clean and renewable energy. In the future energy consumption, geothermal energy is expected to play an important role (Pang et al., 2012; Wang et al., 2012; Lin et al., 2013). At present, the Chinese government has clearly put forward the goal of 'carbon neutrality', so it is necessary for energy colleges and universities to pay more attention to geothermal education and strengthen the training of professional talents in geothermal geology. As an energy university, it is necessary to grasp the opportunity of energy education transformation, formulate and improve the corresponding curriculum and personnel training plan, and walk in the forefront of the professional education of emerging energy (Xu et al., 2010; Zhu et al., 2016; Shen et al., 2020.

Relying on the advantages of scientific research and teaching in geothermal geology, it grasps the development opportunity of new energy education in time, and establishes a geothermal teaching system systematically from the aspects of theoretical teaching and textbook construction, practical teaching system construction, teacher team and industry-university-research integration construction based on the original geothermal teaching curriculum and teaching resources. It takes the lead in forming a perfect geothermal course teaching and personnel training system in China. The achievements have undoubtedly provided groundbreaking support for the school's development in the education of clean energy professionals in the new era.

2. APPROACHS

1.1 Theoretical curriculum and subject construction

Training engineering and technical talents with solid theoretical knowledge and strong practical ability needs to pay attention to the comprehensive design of professional construction (Wei et al., 2015). In the construction of geothermal discipline in the field of earth science, the first thing is to strengthen the course education of geothermal geology, and the second thing is to strengthen the cooperation with geothermal exploration and development units, to combine production, education and research.

Through literature research, information retrieval, exchange visits, etc., the demand of production units for geothermal talents and the education and training of geothermal talents by geothermal education institutions are investigated. Starting from the demand of geothermal talents, the current situation and problems of geothermal education, the direction of the construction of geothermal theory courses and disciplines in our school is proposed and gradually implemented. After a systematic survey on the publication of textbooks and monographs related to thermal science at home and abroad, the textbook 'Sedimentary Basin Geothermal Science' suitable for the current geothermal theory courses in China was compiled (Qiu et al., 2019).

1.2 Construction of practical teaching platform

Experimental and practical teaching is an important link in the teaching of energy and geology courses, including geothermal geology (Zha et al., 2013; Zhang et al., 2014). This topic aims at the needs of employers, professional training requirements, practical ability cultivation, etc., to optimize the current teaching content, absorb and utilize the advanced experience and site resources of laboratory construction and engineering practice of relevant domestic production units and research institutes, and orderly promote the construction of geothermal geology practical teaching platform in our school. A practice base of geothermal exploration,

development, comprehensive utilization and other links has been jointly established with off-campus units to form a reasonable and mature geothermal geology practice teaching system.

1.3 Construction of teacher teams and teaching cases

The teaching work in the new era also needs to innovate the personnel training mode, strengthen the construction of teachers' teams, and establish an integrated training system of 'production, study and research' (Zha et al., 2013). In the construction of faculty team, a school-level teaching team is established with academic leaders in teaching and research in the school as the leader. Theoretical teaching is dominated by school leaders and young teachers. On-site teaching, case teaching and frontier courses are mainly taught by geothermal Research Center of Institute of Geology and Geophysics, Chinese Academy of Sciences, Tianjin Geothermal Exploration and Development Design Institute, Beijing Institute of Geological Prospecting Technology and other experts engaged in geothermal front-line research and development. Through centralized lesson preparation, teaching training and other links, the teaching methods are constantly improved. By solving various problems encountered in the teaching process, the teaching level of teachers is improved, the team spirit is concentrated, the team is echelon construction is realized, and the leading teaching team in the field of 'industry-university-research' integration is built in China. At the same time, practical training and case teaching outside the campus experiment platform are carried out by relying on production cases and test and engineering sites of production units and research institutes.

3. CONSTRUCTION ACHIEVEMENTS

2.1 Achievements of theoretical curriculum and discipline construction

Through the implementation of the project, based on the original one graduate course, *Temperature and Pressure Field of Oil-gas Basin*, three new graduate courses related to geothermal, *Fundamentals of Geothermal Science*, *Development and Utilization of Geothermal Resources*, *Frontier of Geothermal Resources Development and Application*, and one undergraduate course, *Geothermal Resources Exploration*, have been set up. The average number of graduate students and undergraduates attending courses has exceeded 200 per year.

In addition to the addition of relevant courses, the curriculum system of the previous graduate course Temperature and Pressure Fields in Petroliferous Basins was optimized. Relying on the experimental platform of geothermal field and thermochronology, the curriculum knowledge system was constantly adjusted, allowing students to connect theory with practice and develop their scientific thinking from the perspective of improving their practical ability. Relying on the existing teaching and research resources, it has set up a new recruitment direction of 'Geothermal Resources Evaluation' in the discipline of Geological resources and geological engineering, enrolling more than 20 master and doctor students every year.

2.2 Achievements of practical teaching platform construction

A comprehensive geothermal teaching laboratory practice teaching platform integrating thermochronology, geotemperature and rock thermophysical properties testing, geochemical analysis and numerical simulation platform has been built (FIG. 1).



Figure 1: Practical teaching of rock thermal property measurements

a. Thermochronology experiment platform: including fission track automatic tester, helium extraction measuring instrument, LA-ICP-MS and other large instruments and equipment, which can carry out practical teaching of fission track, (U-Th)/He, U-Pb and other dating analysis.

b. Rock thermal physical properties experiment platform: including Hot Disk rock thermal physical properties test system, TCS rock thermal conductivity test system, portable thermal conductivity instrument, which can be used to measure and teach core, cuttings, fluid thermal conductivity, thermal diffuser, specific heat capacity and other thermal physical properties.

c. Geothermal fluid geochemistry experiment platform: including fluid ion chromatograph, fluid fluorescence tracer and other equipment, which can conduct the experimental teaching of fluid composition analysis, heat storage connectivity and fluid activity analysis.

d. Numerical simulation experiment platform for geothermal development: including COMSOL, OGS, FEFLOW and other numerical simulation software, which can carry out practical operation teaching of numerical simulation for exploitation and utilization of geothermal resources.

2.3 Achievements of practical training and case teaching construction

The establishment of a combination of production, learning and research teaching team of 3. The courses such as Temperature and Pressure Field of Sedimentary Basin and Exploitation and Utilization of Geothermal Resources have absorbed experts from Tianjin Geothermal Exploration and Design Institute, Beijing Institute of Geological Exploration and Technology and other geothermal exploration and development units to teach case studies on geothermal development and cascade utilization in Tianjin and utilization of geothermal resources in Beijing. In cooperation with relevant units, I have carried out on-site teaching of temperature measurement (geothermal logging), geothermal heating technology and other aspects (FIG. 2, FIG. 3).



Figure 2: Practical teaching of geothermal heating technology



Figure 3: Practical teaching of rock geothermal logging

4. CONCLUSIONS

The systematic teaching system and the education mode combining production, university and research have greatly enhanced our school's strength in geothermal education. The course teaching and talent training have achieved outstanding results. The main features are as follows:

a. Specialty features: As part of the specialty reform of energy colleges and universities, geothermal is a dynamic discipline. The achievements of this project in geothermal theory, practical teaching system, practice base, new energy enrollment and training, etc., belong to the leading work among domestic energy colleges and universities. It takes the lead in exploring and establishing a geothermal education system that combines theoretical courses, practical teaching platforms and training bases. Under the background of ‘carbon neutrality’, it further enhances our school's advantages in geothermal resources education and provides successful experience for our school and other universities to build courses and disciplines in the direction of new energy as well as the industry-university-research integration.

b. Integration of industrial chain and combination of production, university and research: This project covers the whole industrial chain of geothermal geology theoretical research, geothermal resource exploration, geothermal resource development and comprehensive utilization. Experts from first-line production units and scientists from leading domestic research institutions participate in the teaching work of our school. Relevant units provide practice sites for our school and build a leading ‘industry-university-research’ integrated teaching team in China. A new model of professional education for the whole industry chain has been formed.

c. In terms of regional cooperation, the cooperation units of the ‘production-university-research’ integrated education team of this project are all located in the Beijing-Tianjin-Hebei region. The ‘Xiongan New Area’ and Tianjin area of Hebei Province are typical areas with the most successful utilization of geothermal heating in China.

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