

PRACTICE OF EARLY TECHNOLOGY SIFTING AND TECHNOLOGY TRANSFER OPERATION BY TECHNOLOGY MANAGERS IN GEOLOGICAL INDUSTRY UNIVERSITIES



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ABSTRACT

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As a key force to carry out the technology transfer, more and more colleges and universities have set up specific departments for promoting technology transfer vigorously. Due to the strong professionalism and specialized application fields, universities with geological industry characteristics need to set up specialized internal technology transfer organizations to carry out the operation and management of patented technologies and the technology transfer. Promoting the technology transfer of the university based on early technology sifting requires the excavation and promotion by professional technology teams. China has successively introduced policies to encourage technology managers to participate in serving the technology transfer. Universities have set up offices for the technology transfer, built teams of technology managers and carried out the practice of serving the technology transfer. This study focuses on advantageous geological engineering directions, locating potential technology fields, summarizing technology application bases, taking stock of technology achievement accumulation, and basically completing early technology sifting through market value assessment and transformation prospect analysis. It supports and cultivates high-value achievements by setting up transformation fund, coordinates with pilot validation, introduces achievements to the market, and promotes them extensively, which eventually leads to the technology transfer.

Contribution/ Originality: This study built an internal technology manager team which is familiar with our advantageous geological engineering directions and research teams with potential technologies. This study offered a unique service to promote technology transfer by setting up internal fund, coordinating with pilot validation, introducing achievements to the market.

1. INTRODUCTION AND OBJECTIVE

As the main base for training scientific and technological talents and engaging in scientific and technological innovation in the country, universities are the key force in carrying out the technology transfer (Deng & Wang, 2020). As the main form of science and technology achievement transformation, patent transformation is an important basis for evaluating the quality of scientific research achievements and innovation ability of universities (Luo & Huang, 2020). Every year, the number of scientific and technological achievements transformed by Chinese

universities accounts for about 1/4 of all scientific and technological achievements transformed in China. However, the conversion rate of scientific and technological achievements of Chinese universities is only 20%, and the conversion rate of patents is only 5% (Lin & Mao, 2019). The conversion rate of scientific and technological achievements that can actually be put into production applications is even lower, and there is a significant gap with developed countries (Shen, Zhang, Zhu, & Sun, 2016).

There are many environmental factors affecting the transformation of results, mainly including two aspects, one of which is government factors, including policies, laws, etc. Xu, Zhang, and Cui (2015) the government has a guiding role in knowledge transfer, and the government plays a key role in major scientific and technological progress. Second aspect is intermediary factors, including consulting, intelligence, incubation, etc. Technology intermediaries are the links and bridges in the combination of universities and enterprises, and China's production promotion centers, technology markets, and university science and technology parks have all made significant contributions to knowledge transfer between universities and enterprises. Insufficient resources for patent management and operation transformation services are an important reason for the low efficiency of patent achievement transformation in universities (Luo & Huang, 2020). From foreign experience and current domestic actual situation, commercialization in the process of university technology transfer will affect universities in many aspects, meanwhile, the complexity of university technology achievement transformation lies in the fact that it is an activity combining the market-oriented logic of industry and the logic of university academic research, which includes both commercial behavior and the influence on academics and teaching. Therefore, foreign universities attach more importance to cultivating composite technology brokers who know both technology and management, as well as law and finance, and are good at communication and coordination, while there is a serious shortage of such talent resources in China. At present, most domestic universities not only lack a clear concept that they should carry out the transformation of scientific and technological achievements based on physical science and technology service institutions, but also absent of institutions that can provide specialized science and technology services in intellectual property rights, finance and law, and cooperation and consultation for university researchers (Yang, Shi, & Zuo, 2018). In contrast, universities in the UK and the US attach great importance to intermediary service resources for technology transfer, and the industry generally considers the skills and experience of foreign university technology transfer offices (TTOs) as one of the most influential factors in the commercialization of university intellectual property achievements. Major universities in the UK, US, Japan, and Korea have set up specialized IP management organizations, and some universities have set up specialized technology transfer offices within the institutional framework of universities, while deeply integrating with transfer service resources through diversified ways such as investment and shareholding in technology brokers and patent co-pending.

The transformation of scientific and technological achievements of colleges and universities can be regarded as a transaction. Its essence is that colleges and universities, as the producers of new knowledge or new products, transfer the potential productivity obtained in the process of research and development to the outside world, and realize certain practical benefits through circulation and application (Deng & Wang, 2020). The Coase Theorem holds that when the transaction cost is zero or very small, the final result of market equilibrium is efficient regardless of who is given the property right (Marciano, 2012). However, in the process of transformation of scientific and technological achievements in colleges and universities, there will be transaction costs such as information costs, negotiation costs, performance costs, and supervision costs. Complex cost components make it difficult to reduce transaction costs.

Inventors of scientific and technological achievements in US universities can obtain original patent rights according to US patent law, that is, the right to apply for a patent naturally arises under any circumstances. Even if there is an employment relationship with the university, the university also needs to obtain the patent application right of the original inventor through legal means such as agreement and contract (Dou, Gu, & Wang, 2017; Stevens, 2004). A series of policies in China only delegate the initiative of science and technology achievement

transformation to universities, and university researchers still cannot really participate in the transformation of science and technology achievements, and universities have only formally obtained the right of independent transformation of science and technology achievements.

In February 2020, the Ministry of Education, the State Intellectual Property Office and the Ministry of Science and Technology issued "Several Opinions on Improving the Quality of Patents in Colleges and Universities to Promote the Transformation and Application", which put forward clearer guidance for comprehensively improving the quality of patents in colleges and universities, strengthening the creation, application and management of high-value patents, and giving better play to the important role of colleges and universities in serving the economic and social development. At the same time, it is emphasized to take the transfer and transformation performance of scientific and technological achievements such as patent transformation as an important indicator for dynamic monitoring, effectiveness evaluation and discipline evaluation of first-class universities and disciplines, not only to assess the number of patents, but also to highlight the transformation and application. In February 2022, the Ministry of Education, the Ministry of Finance and the National Development and Reform Commission issued "Several Opinions on Deeply Promoting the Construction of World First-class Universities and First-class Disciplines", pointing out that the construction of universities and disciplines should create a new model of world class universities and first-class disciplines in solving China's problems and serving the high-quality development of economy and society. Two disciplines of Geology, Geological Resources and Geological Engineering of China University of Geosciences (Beijing) were shortlisted for the second round of national "double first-class" construction of first-class disciplines. The current important objective of the university is how to better transform and apply the patented scientific and technological achievements in the field of geological resources and geological engineering to help the university and the national economy and society develop together in a high-quality way.

The construction of professional institutions and talent teams is an important support for better intellectual property management and operation in universities (Lei, 2021). The Ministry of Education guides colleges and universities to support and guarantee achievement transformation and technology transfer institutions in terms of personnel, venues, funds, etc., and supports qualified colleges and universities to establish special institutions integrating technology transfer and intellectual property management and application as soon as possible. In 2016, the State Council issued "Several Provisions on the Implementation of the Law of the People's Republic of China on Promoting the Technology transfer", and the Ministry of Education and the Ministry of Science and Technology issued "Several Opinions on Strengthening the Technology transfer in Higher Education Institutions", which requires that higher education institutions should strengthen the construction of specialized scientific and technological achievement transformation teams, encourage the construction of specialized technology transfer institutions and establish a team of professional managers for the transformation of achievements. More and more universities have set up special departments for technology transfer, drawing on the beneficial experience of technology transfer institutions in colleges and universities at home and abroad (Qiu, Wang, & Yang, 2021) which vigorously promote the technology transfer in universities. However, it is a great objective and challenge for both the technology managers of technology transfer agencies outside the university and the technology managers of science and technology management departments within the university, who would be familiar with the scientific and technological achievements within the university and could also effectively dock with the market, when promoting the transformation of scientific and technological achievements, as long as a university has abundant early scientific and technological achievements.

The screening of early technologies is an initial stage and a key link in promoting the transfer and transformation of scientific and technological achievements. Because the technologies involved in the transformation of achievements often contain a lot of tacit knowledge, it is difficult to fully reflect them in written form (Xu et al., 2015). Only when the technological achievements with great transformation potential are screened

can the transfer and transformation of scientific and technological achievements with greater value be more likely to be realized.

The university where the author works is a comprehensive geological research based university, which focuses on basic geological theory research and has relatively few marketable application technologies. Therefore, it becomes a key objective and challenge to sift through the early technologies to promote the transfer of scientific and technological achievements of the university.

2. METHODS

2.1. Technology Transfer Agency Building

In order to comprehensively promote the technology transfer, China University of Geosciences (Beijing) has set up a special office for the technology transfer and built a professional technology manager team to carry out the whole process of technology transfer operation and management.

2.2. Early Technology Sifting

In order to transfer and transform the scientific and technological achievements with greater value, the technological achievements with great transformation potential should be screened at first. The first step is to focus on the advantageous geological engineering direction and locate the potential technology field. Then we need to summarize the basis of technology application and take stock of the accumulation of technical achievements. Finally, we collect scientific and technological achievements and assessing market value.

2.3. Technology Transfer Operation

After the early technology are sifted by technology managers, we conduct a series of operation services to transfer technologies. First step is to offer transformation fund support, which can cultivate high-value achievements. After that, we would coordinate pilot scale experiments and conduct research achievements promotion. Extensive docking and promotion would be conducted to facilitate the transfer and transformation of achievements.

3. RESULTS AND DISCUSSIONS

3.1. Technology Manager Team Building

According to the spirit of relevant documents of the State Council, Ministry of Education and other ministries and commissions, China University of Geosciences (Beijing) actively explores the pilot technology manager system and establishes a team of technology managers to participate in the whole process of technology transfer, such as patent navigation, pre-application assessment of patents, disclosure of scientific and technological achievements of positions, technology promotion, value assessment, and docking negotiation, to promote the technology transfer. From 2018 to present, some technology managers have been organized to attend the training for technology managers organized by the Science and Technology Development Center of the Ministry of Education, China Technology Market Association, Beijing Technology Market Association and Beijing Brokers Association. In 2022, China University of Geosciences (Beijing) cooperated with Beijing Technology Market Association and invited experts in the field to conduct technology manager training for teachers and students of the university.

At present, there are 23 people in China University of Geosciences (Beijing) who have obtained the certificate of technology manager, and their majors are related to the main science and technology fields such as geological resources, geological engineering, new mineral materials, information technology, energy and environmental protection, applied physics, etc. They also have work experience in scientific research, science and technology management, state-owned assets management, laboratory and equipment management, legal service, bidding and

procurement, which has formed a preliminary technology transfer service team covering all aspects of the technology transfer and fully serving the university's scientific research team in the transformation of achievements.

The multi-disciplinary coverage of the technology manager team is more conducive to the development of the transfer and transformation of our scientific and technological achievements, which can better carry out the transformation layout of scientific and technological achievements, achieve the packaging and transformation of scientific and technological achievements, and make our university's transferable achievements more competitive. The technology manager involves multiple management departments of the university, which is conducive to the linkage of multiple departments and the unblocking of the transfer and transformation process. A technology transfer service team covering all aspects of the transformation of scientific and technological achievements, familiar with achievements with transfer and transformation potential in various fields, has been formed, and comprehensively serves the scientific research team of the university to carry out achievements transformation. The growth of technology managers and the accumulation of practical experience of the team cover the whole chain of scientific and technological achievements transformation process from the early patent layout to the middle feasibility demonstration to the late marketization.

In 2020, the invention patent of the geophysical and information technology team - broadband intelligent long period magnetotelluric measurement system was transferred to Beijing Yousai Huanyu Technology Co., Ltd. at a transaction price of 200,000 yuan. The team has been engaged in marine electromagnetic method research for many years, which has several invention patents. Some technology managers of our university formed a special docking team. After investigating and understanding the status of the team's scientific and technological achievements and transformation, we finally selected Beijing Yousai Huanyu Technology Co., Ltd. for further cooperation after a lot of screening and docking from the previous partners of the team and the enterprises in the market that the technology serves. In 2022, the technology manager team made a field visit to the company to understand the current situation and needs of the company and promote the communication and docking between the scientific research team and the company. At the same time, the technology manager team contacted with the Shijingshan Park Management Committee, and went to the Shijingshan Administrative Service Center for communication and docking with Beijing Yousai Huanyu Technology Co., Ltd. to seek government support and promote tripartite cooperation. After many times of communication and docking, the university signed a transfer contract for scientific and technological achievements with the company, and transferred the patent right of "noise detection method of noise detection device of orthogonal basic mode fluxgate sensor" to Beijing Yousai Huanyu Technology Co., Ltd. at a transaction price of 1 million yuan. After the implementation and transformation of the scientific and technological achievements, the university has established a good cooperation with the company. At present, the technology manager team is continuing to promote further industry university research exchanges and cooperation among schools, enterprises, and governments, and strive for greater cooperation in the transformation of scientific and technological achievements.

3.2. Early Technology Sifting

3.2.1. Focus on the Advantageous Geological Engineering Direction and Locate the Potential Technology Field

China University of Geosciences (Beijing) has two first-rate disciplines: geology and geological resources and geological engineering, the former being "geological science" and the latter being "geological engineering". Based on the analysis of the market for the transformation of achievements, the search for disciplines with market application potential naturally focused on the university's strengths in geological engineering. Geological engineering is involved in many fields, such as materials, equipment and environmental protection. By analyzing the 57 patented technologies that have been transformed in the past 5 years, the technology manager analyzed the research team that mastered the patented technologies, the research fields they are good at, the projects that the results are based on, and the published papers, and located the technology fields with potential application, such as

new materials, engineering equipment, energy and chemical industry, etc. The results of data analysis in Figure 1, show that the new material achievements of the university account for 33.33% and are generally applied in the field of comprehensive utilization of mineral materials; the engineering equipment achievements account for 29.82% and are generally applied in the field of geological engineering; the energy chemical achievements account for 19.30% and are generally applied in the field of oil and gas exploration and development.

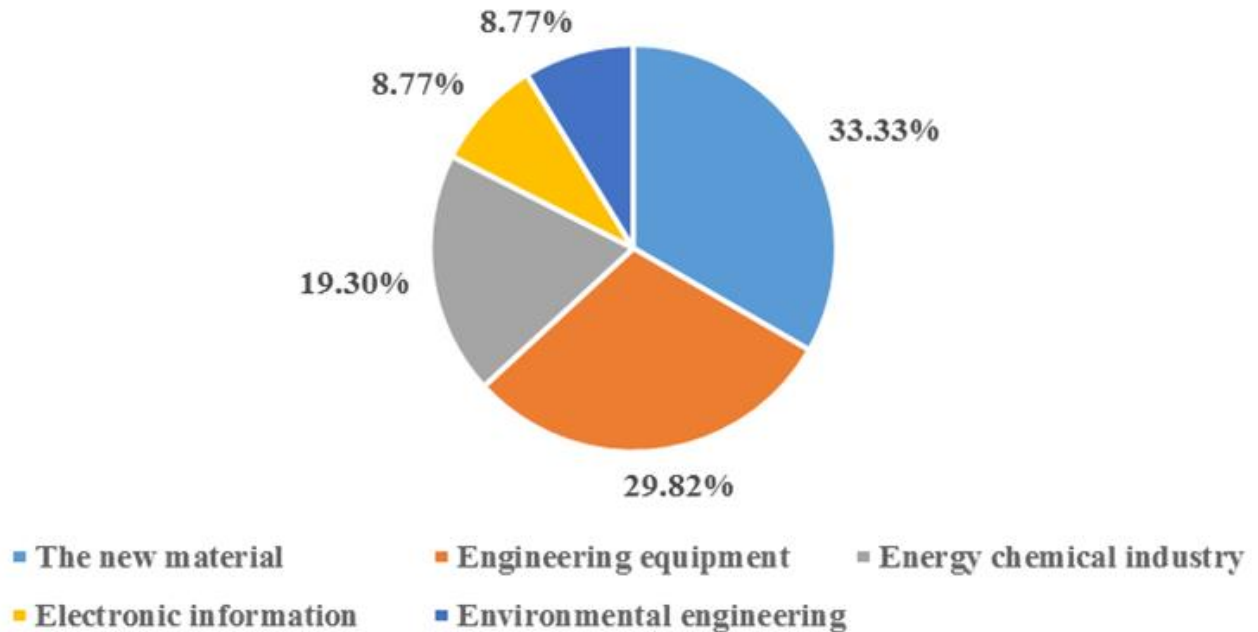


Figure 1. Transformation ratio of scientific and technological achievements in different technology fields of the China University of Geosciences (Beijing) in the past five years.

3.2.2. Summarize the Basis of Technology Application and Take Stock of the Accumulation of Technology Achievements

The application of early technology in the research team is generally defined based on the industry-university-research cooperation with enterprises for technology services (Yang et al., 2018) i.e., undertaking horizontal project research, which is mainly reflected in technology development and technology services. Therefore, the Transformation Office collated and summarized the horizontal projects of China University of Geosciences (Beijing) for many years, and conducted multi-dimensional analysis in terms of scientific research content, cooperation units, project funding, and result requirements, focusing on key research teams in key fields. The key teams have a more mature or leading technology application basis in the university or even in the industry. For teams with leading technology, we should promote the concept of transformation of scientific and technological achievements, to let scientific researchers understand what transformation of scientific and technological achievements is and how to carry out transformation of scientific and technological achievements, and then convert the mode of thinking so that scientific researchers are happy to carry out transformation of scientific and technological achievements. The accumulation of technology applications of some research teams can also be largely reflected to the accumulation of patented technology achievements of the team. Take the team of comprehensive utilization of mineral composite materials in the School of Materials of our university as an example, the team undertook 10 horizontal projects from 2017 to 2019, with a total contract funding of 7.31 million yuan. After 3 years of technology and cooperation accumulation, the team successfully realized 5 patent technology transfers in 2019-2021, with a total contract amount of 12.26 million yuan. Technology manager analyzes the development trend of the team's horizontal project accumulation and patent technology transfer. In Figure 2, the patent formed by the technology accumulated in the early stage has successfully realized the fruitful transformation in this industry field.

The realization of this achievement transformation not only solves the problem of market production, but also returns new value to the research team's research.

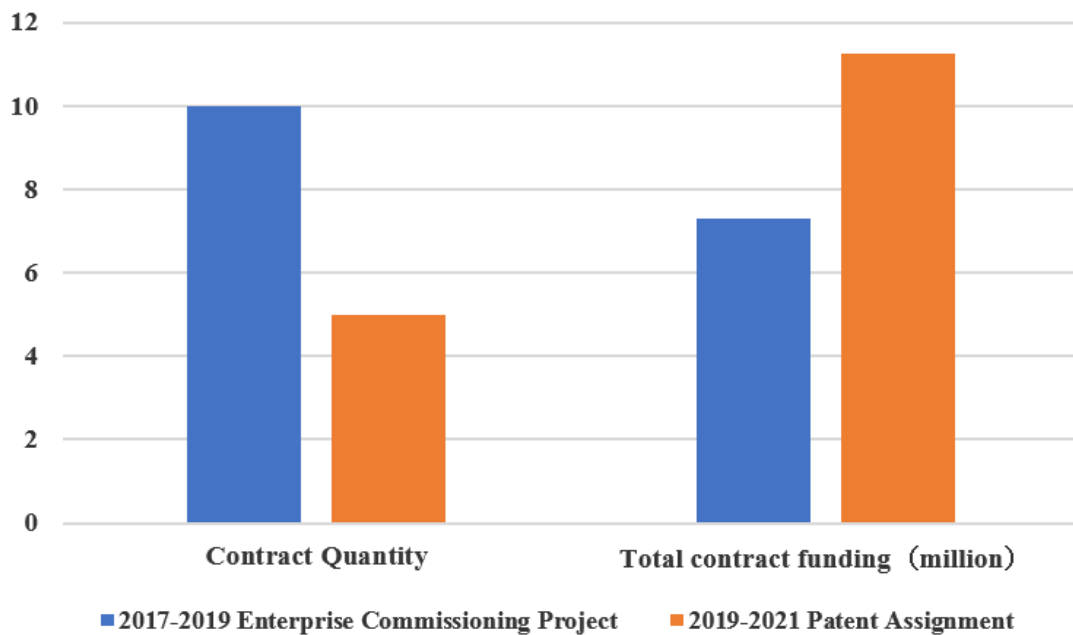


Figure 2. Trends in the accumulation of commissioned projects and patent technology transfer by team companies.

3.2.3. Collect Scientific and Technological Achievements and Assess Market Value

Through the basic preparation of the above two steps, The Science and Technology Achievement Transformation Office will start the collection of scientific and technological achievements on the university, taking a combination of declaration by scientific researchers and interviews by the personnel of the Office of Scientific and Technological Achievement Transformation to work in a targeted manner. After completing the collection of achievements, combined with the research situation, some early technologies with greater potential for transformation can be initially sifted out. The early technologies collected and researched are categorized according to the fields they belong to and the maturity of the technologies. Based on preliminary analysis, we evaluate the general process from existing technologies to final implementation and the required input for transformation through market value assessment and transformation prospect analysis, so as to basically complete the screening of early technologies.

Commercialization value assessment and analysis were conducted for 598 licensed invention patents and utility model patents valid at China University of Geosciences (Beijing) as of the end of 2019, and 90 key transformation potential patents were finally screened out, and these patents became the screened series of early technologies (Figure 3). These early patent technologies involved 40 industries, among which 13 patents were screened out from all 94 patents in the oil and gas extraction industry, ranking first in number, but with a screening pass rate of 13.4%; 7 patents in the water resources management industry ranked second in number, with a pass rate of 50%; the pass rates of patents in other industries spanned a wide range, between 6.5% and 57%. The industries with 100% pass rate include luminous materials, combustible ice mining, flexible luminous devices, new energy, flexible thin film energy storage materials, batteries and supercapacitors, nanotechnology, etc. All of them are more advanced and hot industries, which are worth investing more resources for in-depth research.

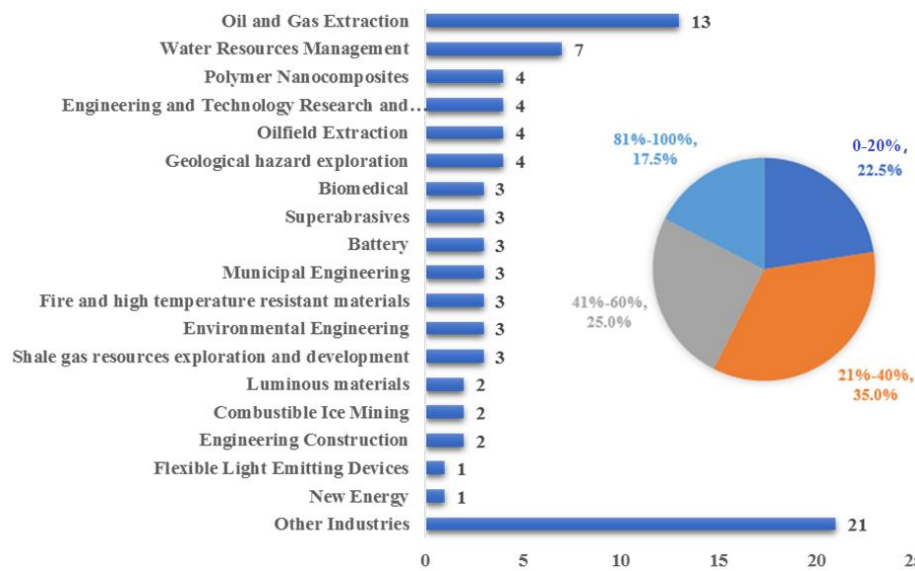


Figure 3. Distribution of industries involved in early patent technology and qualified rate of key screening.

In 2019, China University of Geosciences (Beijing) screened out several high-value patents of different levels by conducting a patent inventory assessment and exchanging and discussing with the research team. Further based on the characteristics of the patent cases, targeted patent promotion and transformation is carried out. China University of Geosciences (Beijing) has maintained long-term scientific and technological cooperation with Zibo City, Shandong Province, China, and organizes a team of experts and scientific and technological achievements from the university to participate in scientific and technological achievements exchange meetings there every year. In particular, the team from the School of Materials has close project cooperation with the local materials industry. After years of cooperation and cultivation, the invention patent of "an antibacterial plastic masterbatch filled with red mud and its composite material" of China University of Geosciences (Beijing) has reached an agreement with Shandong Didan New Material Technology Co. The Achievement Transformation Office actively participated in the negotiation and promotion. Through many communications and negotiations between the two sides, the patent technology was finally licensed for 3 years at a price of 2.18 million yuan in the region of Shandong Province, China.

3.3. Technology Transfer Operation

3.3.1. Transformation Fund Support, Cultivate High-Value Achievements

The purpose of establishing a guidance fund for the technology transfer is to further cultivate and incubate the mature achievements of the university to the market, and to produce scientific and technological achievements with greater transformation value with the participation of the university. The university supports researchers to apply for high-value patents, carry out proof-of-concept and prototype production through the research fund. Further transfer and transformation strategies are then developed based on the researcher's research and development requirements and achievement promotion prospects (Wu, 2022). In this process, the Office of Scientific and Technological Achievement Transformation is responsible for the operation and management of patent intellectual property rights, and the coordination support of results cultivation and experimentation. From 2019 to 2020, the fund has funded 44 projects involving types such as technology transfer, cultivation of high-value patents and exploration of work to promote transformation. At present, a total of 23 projects have achieved the technology transfer, with a total contract amount of 15.81 million yuan, which has greatly enhanced the effectiveness of the technology transfer of our university.

An invention patent, orthogonal fundamental mode fluxgate sensor noise detection device, funded and cultivated by China University of Geosciences (Beijing), announces an orthogonal fundamental mode fluxgate

sensor noise detection device and noise detection method, which belongs to the field of instrument development, and this invention patent solves the fluxgate. This invention patent solves the difficult problem of the fluxgate sensor testing process. The fluxgate sensor is a key sensor of submarine geomagnetic instrument, which is used for submarine geomagnetic field measurement and serves for submarine deep structure research. Tiandun Gaoxin (Beijing) Technology Co., Ltd. produces and sells submarine electromagnetic instruments, and there is a demand for sensor testing in the instrument production process. In 2021, after technology communication and business negotiation between the two parties, an agreement was reached on the transfer of sensor noise detection device patent, with a transaction price of 600,000 yuan.

3.3.2. Coordinate Pilot Scale Experiments and Conduct Research Achievements Promotion

After the technology achievements have obtained intellectual property protection and passed the proof of concept, Technology Managers will further discuss with the accomplished team about the technology pilot test and promotion plan. Through the cooperation support established with relevant government departments and enterprises in the industry, we will contact them to carry out relevant pilot scale experiment and preliminary cooperation intentions to realize the transformation of results within a certain range. At the same time, the Technology Managers will also promote the scientific and technological achievements by exhibiting in scientific and technological achievement exchange meetings, docking with enterprises' technology needs and other ways of industry-university-research cooperation. Take the green processing and utilization of red mud project of China University of Geosciences (Beijing) as an example, the project is highly professional and has good market prospect, but the pilot validation cost is high and direct transformation is difficult. The technology manager team cooperated with the third-party professional team to find industrial resources, led the technology team to carry out results promotion with red mud tailings enterprises in many cities in Shandong Province for many times, and carried out multi-faceted cooperation with provincial governments, universities and enterprises, which finally led a large aluminum company in Shandong Province, China, to reach a pilot validation cooperation with the university and other companies to jointly transform the relevant red mud green processing and comprehensive utilization technology.

3.3.3. Extensive Docking and Promotion, Facilitate the Transfer and Transformation of Achievements

After the scientific and technological achievements have basically completed all stages of experiments and through specialized market potential assessment, the Technology Managers will carry out all-round docking and promotion until the results are transferred and transformed. Through the communication with the team, we learn the transformation target of the team; and then discuss the transformation plan with relevant enterprises. Through multiple consultations among the three parties, we basically complete the transformation positioning, determine the market scope, cooperation mode and transaction price, and finally complete the technology transfer. Recently, the technology manager team combined the foundation of China University of Geosciences (Beijing) submarine electromagnetic detection technology team and the cooperative enterprises in Shijingshan District, Beijing, China, and communicated deeply with the management committee of Zhongguancun Shijingshan Industrial Park to discuss the cooperation mechanism of deepening the transformation and landing of the university's scientific and technological achievements in Shijingshan, which further promoted the transfer and transformation of the university's scientific and technological achievements in Beijing.

4. CONCLUSIONS

As a university with geological industry characteristics, China University of Geosciences (Beijing) has strong specialization and specialized application fields, and needs to set up a special internal technology transfer organization to carry out the operation and management of patented technology and the technology transfer. Based

on the sifting of early technologies to promote the technology transfer of the university, it needs the excavation and promotion of professional technology team.

First of all, the university sets up a full-time technology transformation department, which understands the characteristics and development status of the university's disciplines, can organize the sifting of the university's scientific and technological achievements, and plan to further cultivate and incubate these scientific and technological achievements. The industry generally considers the skills and experience of foreign university technology transfer institutions (Technology Transfer Office, TTO) as one of the most influential factors in the process of commercializing intellectual property achievements of universities. More and more universities have set up special departments for the transformation of scientific and technological achievements, and have greatly promoted the transformation of scientific and technological achievements of universities by drawing on the beneficial experience of domestic and foreign university technology transfer institutions.

Secondly, establish a team of technology managers who understand the profession, management, and market. The team is familiar with the university's research teams and the research areas and achievement characteristics of the research teams, knows how to effectively address the needs of the researchers, and interface with the industry and market to tap and promote the university's scientific and technological achievements. The complexity of the transformation of scientific and technological achievements in colleges and universities lies in the fact that it is an activity combining the market-oriented logic of industry and the logic of academic research in colleges and universities, which includes both commercial behavior and consideration of the impact on academics and teaching. Therefore, universities should cultivate composite university technology brokers who know both technology and management, as well as law and finance, and are good at communication and coordination.

As long as a special technology transformation department is set up, while a technology manager team is built, a series of comprehensive operation services are necessary to be supplied. Transformation fund should be supported, in order to cultivate high-value achievements. It needs to coordinate pilot scale experiments before conducting research achievements promotion. Extensive docking and promotion are further needed, which would be possible to facilitate the transfer and transformation of achievements.

Furthermore, cooperate with third-party service organizations in relevant fields outside the university, and give full play to the unique market-oriented and professional characteristics of service organizations (Wang & Zheng, 2020) in order to strengthen the exchange and cooperation with enterprises in the industry, and promote the technology transfer in the market. Universities should both explicitly use physical science and technology service organizations as the backbone to carry out the transformation of scientific and technological achievements, and cooperate with science and technology service organizations that can provide specialized services in intellectual property rights, finance and law, and cooperation and consultation for university research workers.

The Science and Technology Achievement Transformation Office has formed a team of technology managers to carry out operation services among scientific research teams and achievements throughout the whole process, constantly sums up experience, improves service methods, enhances service capacity, and strives to promote the technology transfer of universities in the geological industry with high quality.

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