Comparison of undergraduate geology courses in China and recommendations for change

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ABSTRACT: Differences in the curriculum design and training at different universities were found as a result of a comparative study carried out on six well-known Chinese universities at which geology undergraduate courses are taught. On the basis of the comparative analysis of the training plans, an undergraduate training model for geology courses is proposed. Further, the advantages and disadvantages of undergraduate training in geology at petroleum institutions are presented and discussed in this article.

INTRODUCTION

Geology is one of the five basic sciences, together with mathematics, physics, chemistry and biology. It is a natural science involving the study of the earth's material composition, structure, formation and evolution [1]. The impetus to study geology results from society's demand for mineral resources, such as petroleum, coal, metals and non-metals. With the growth of society, the impact of human activity on the earth has increased, leading to more restrictions on human activity. How to use the earth's resources rationally and effectively, while maintaining living standards, has become an issue of common concern around the world. Energy sources have changed, from conventional to unconventional, as the greenhouse gas effect and other environmental problems increasingly influence human life.

The study of geology gradually has moved to the ultramicro-scale and includes changes over time. The study involves research from many other fields. Geological universities need to cultivate high quality talent, addressing the fundamental question of what kind of person to train and how to train such a person [2].

The geology undergraduate training plans of six well-known Chinese universities were examined to determine the differences between their curricula. These differences allow several conclusions about the teaching of undergraduate geology. The advantages and disadvantages of geology undergraduate training in a petroleum institution were summarised by considering the geology undergraduate teaching at the China University of Petroleum (East China).

CHINESE UNIVERSITY GEOLOGY UNDERGRADUATE TRAINING

Comparing the geology undergraduate training of six well-known Chinese universities reveals that the curricula are very similar. The curricula are divided into five components, viz. general education courses (in some schools these are public-basic courses); professional foundation courses (in some schools these are discipline-based courses); professional core courses; professional elective courses and practical teaching. The total credits are between 169 and 208.5 (see Table 1). Some details follow:

- The general education and professional basic courses account for between 50.10% and 66.80% of the credits. The difference lies in whether mathematics, physics and chemistry are incorporated into the professional basic courses.
- The credits for professional core courses were between 7.00% and 15.90% of total credits, with Jilin University the lowest.
- The credits for professional elective courses were between 8.00% and 22.20% of the total, with the China University of Petroleum (East China) the highest.

- The credits for practical teaching were around 20%. Northwest University and China University of Petroleum (East China) was lower than 20% and Northwest University was the lowest at 12.50%. The reasons for the lower proportions were the lack of enrolments and the shorter practical teaching time.

Table 1: Comparison of geology courses at six well-known Chinese universities.

School / Course setting		China University of Geosciences (Wuhan)	Northwestern University	Jilin University	Chang'an University	China University of Petroleum (East China)	Yangtze University
Total class hour		2480+31.5 weeks	3128+16 weeks	2350+37weeks	2518+35 weeks	1986+26 weeks	2288+35weeks
Total Credit		208.5	169	170	190	180	176.5
General education courses	Class hour/ credit	808/50.5	1530/68	1272/67.5	1264/73	704/39.5	880/55.5
	Credit proportion	24.20%	40.20%	39.70%	38.40%	22%	31.50%
Professional basic courses	Class hour/ credit	864/54	972/45	672/42	524/26	970/56.5	712/44.5
	Credit proportion	25.90%	26.60%	24.80%	13.70%	31.40%	25.20%
Professional core courses	Class hour/ credit	528/33	410/21	192/12	370/20	308/19	376/23.5
	Credit proportion	15.90%	12.40%	7%	10.50%	10.60%	13.30%
Professional elective courses	Class hour/ credit	280/17.5	216/14	214/13.5	592/33	*/40	320/20
	Credit proportion	8.40%	8.30%	8%	17.40%	22.20%	11.30%
Practical teaching	Class hour/ credit	31.5 weeks/45.5	16 weeks/21	37 weeks/35	35 weeks/38	26 weeks/25	35 weeks/33
	Credit proportion	21.80%	12.50%	20.50%	20%	13.80%	18.70%

Note 1: The data come from the Internet or personal communications
Note 2: An asterisk * means that there are no data

Table 2 (see page 5) shows the course content, and Table 3 (see page 6) shows the teaching content of the geology courses at the six Chinese universities. Each university includes general geology (or introduction to earth sciences), crystal optics, crystallography and mineralogy, petrology, paleobiology, historical geology, structural geology, geochemistry, geophysics and metallogeny. However, there is a big difference in the class hours allocated.

For example, the class hours for magmatic rock and metamorphic rock at petroleum universities, such as the China University of Petroleum (East China) and Yangtze University are less than in the old geological institutions, such as China University of Geosciences (Wuhan) and Jilin University. Again, as for the metallogeny courses, petroleum universities have insufficient teaching resources and class hours.

GEOLOGY PROFESSION UNDERGRADUATE TRAINING MODE: DISCUSSION

The different universities that were studied all try to lay solid foundations for the study of geology, as well as emphasise good scientific literacy and innovative ability, and adapt to the requirements of the times. However, in view of the differences of training plan between these universities, several conclusions can be drawn:

- Importance of mathematics, physics and chemistry:

  In the process of cultivating professionals, it is necessary to strengthen the foundations, broaden the scope and put an emphasis on applications [3]. Because geology is complex and influenced by multiple mutually restrictive factors, a geological process cannot be the result of a single physical and chemical process. So, geology is an interdisciplinary natural science closely integrated with mathematics, physics and chemistry. Hence, the importance of basic and interdisciplinary courses.

  Some universities, among those researched, include mathematics, physics and chemistry in their general education courses but, then, the credit and class hours of the professional basic courses are reduced, e.g. see Table 1 for Chang'an and Jilin University. Other universities incorporate mathematics, physics and chemistry into their professional basics courses.

  Mathematics, physics and chemistry in geology are important. Therefore, strengthening the education of mathematics, physics and chemistry, and including them in the professional basics courses system does not dilute

the profession, but rather strengthens it. With this as a solid foundation, students can confidently pursue their study of geology and even interdisciplinary research in geology.

- Cultivating professional quality students:

  The geological profession has a strong practical component. Laboratory teaching internships and field study are important in training geoscience students [4]. Therefore, in geology training, the teaching of theory should be balanced against the duration and operation of practical teaching.

  In the six surveyed universities, the basic core courses of structural geology, historical geology, palaeontology and geology, and petrology take up a large number of class hours and of laboratory teaching internship class hours. But, the universities differ in significant ways, e.g. the class hours for palaeontology vary, from 36 to 64 hours; the class hours for three rocks are around 40 hours, but the class hours for magmatite and metamorphic rocks in some universities are 50 hours in total. The advice is to guarantee balanced class hours to cultivate geological students with solid professional foundations.

  The field geology internship is a very important part of teaching geology [5]. It is the practical teaching link to cultivating knowledge, ability and quality [6]. Every university attaches great importance to field geological practice. The internship units correspond to the General Geology course for freshmen; Petrology, Paleobiology, Structural Geology for sophomores; and professional knowledge application in the senior year. The duration of an internship is 10 to12 weeks.

  Some universities develop the basis of the practical teaching and provide the relevant management organisation, e.g. the Zhou Koudian field practice teaching internship basis by the China University of Geology and the Xingcheng field practice teaching internship basis from Jilin University. These training bases can not only meet the practical teaching needs of their own universities, but also provide a model for other universities. These measures and means help guarantee that practical teaching is carried out successfully and efficiently, as well as cultivating geological professionals of good quality and strong practical ability.

- Production practice and innovative ability:

  With the continued deepening of geoscience education reform, geology teaching should pay more attention to practical and innovative ability of future geologists [7]. The survey revealed that the graduation design of many universities starts from the summer of the junior year. Some universities even put the task of the internship on to the tutor. The tutor supervises the field and production practice of the student and together they attend to the scientific research project of the tutor. By doing so, the students' professional knowledge has been applied in practice, and their professional knowledge and skills have been enriched and supplemented. In addition, the teachers' teaching and scientific research can be combined organically. Hence, this develops students and solves scientific problems.

  In terms of innovative ability, many universities have students develop experimental plans in innovation. Such a plan requires a university student to undertake a series of tasks from a document survey, project application, design of experimental plan, analysis of experimental data and reporting, all under the guidance of a tutor. Hence, the innovative thinking and ability of the students are developed in the process of undertaking innovative research, as well as publishing creative and even high-level research papers.

- Cultivating students' views on life and values:

  Training should focus on a human's comprehensive development, including world view and life values. Some universities set one or two weeks aside for enrolment and graduation education (see Table 2). During this time professors and academicians can introduce the current situation and direction of universities, as well as the profession. They can summarise and pass on the principles and methods that should be followed in study and scientific research, as well as provide directions for the students' life planning. Although this takes up part of the teaching class hours, it plays an important role in establishing students' professional self-confidence and in cultivating their correct view of employment and life. In addition, co-operation between schools and enterprises should be strengthened to cultivate high quality talent. With the development of the Chinese economy, competition between enterprises has become increasingly severe and the demand for graduates of high quality and ability has increased. The university should strengthen the student's knowledge of national and enterprise conditions, and strengthen humanistic qualities so as to help the students understand the social, enterprise and employment environment [2].

CONCLUSIONS

The professional features of petroleum institutions are distinctive and targeted, such as that of the China University of Petroleum (East China), which is to create a …*domestic well-known, high level research university with a world leading*

petroleum discipline. The target of the geology profession is *…to cultivate advanced specialised talent with good science literacy, relatively high comprehensive quality and innovative spirit, with basic theory and knowledge of geology* [2]. The training for oil gas exploitation has been developed, with obvious advantages. But, with the change in society, the disadvantages of this training mode have gradually become apparent. The details are as follows:

The oilness *of the course: u*ndergraduate training suitable for the oil field has been developed over several years of teaching and co-operation between the school and enterprises, and reflects enterprise needs. The graduates can play an important role in the oil field and have acquired recognition from three oil companies, viz. China National Petroleum Corporation (CNPC), Sinopec and China National Offshore Oil Corporation (CNOOC).

Although employment has expanded continuously, the exploration for conventional oil and gas is depressed. So, previous advantages with the emphasis on oil can become disadvantages instead. This, then, requires the geology petroleum universities to rebalance their courses. An advantage and characteristic of petroleum universities lies in the teaching about sedimentary rocks and petroleum geology. In future, the class hours spent on the subject of three rocks and relative geology courses should be increased to maintain the advantages.

Employment is limited to the oilfield profession: currently the employment destination of the graduates of the petroleum universities is still confined to petroleum oil institutions, and they do not break through into other areas of the true geology industry. The main reason is that graduates have not sufficiently mastered the material and working methods required by the geological industry; e.g. they do not have the ability to do a regional geological survey. As a result, geology enterprises only recruit graduates from non-oilfield geology courses, while the geology graduates from oilfield universities can only choose to go into the oil field. Their opportunities are far less than the students from resource exploration engineering courses. In order to change this situation, the geology training at oilfield universities should cultivate high-quality geological graduates.

Strengthening the teaching of geology: the geology training goal of the China University of Petroleum (East China) is to cultivate advanced geology professional talent. The students should master the basic theory, knowledge and skills of geology. In addition, they should have an all-around development of their moral, intellectual, physical and aesthetic abilities. They should develop the ability to apply geological theory and techniques to analyse and solve actual problems in geology. Graduates should be able to engage in the application of their knowledge and abilities, theoretical study or management related to their profession. They should be able to gain employment in enterprises, such as geology, oil, mining, coal or scientific research institutions. However, this is far from the current situation, and much needs to be done to achieve this goal.

Efforts should be made to improve the course construction, the allocation of faculty and teaching resources, and the scientific research orientation. First, the correct balance for the professional courses should be achieved. The courses guided by oil and gas geology should be transformed to include other mineral products and energy. To not lose dominant courses, the new courses should be energetically developed. Second, there should be a diversification of scientific research, which should not be confined to the exploration and development of oil fields. There should be many projects, including geological surveys, the environment, quaternary and marine geology. This should help to reach the goal of cultivating students' comprehensive geological quality.

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Table 2: Content of geology courses at six well-known Chinese universities.

China University of Geology (Wuhan)		Northwestern University		Jilin University		Chang'an University		China University of Petroleum (East China)		Yangtze University	
General Geology B	48/3	Introduction to Earth Sciences	72/3.5	Introduction to Earth Sciences	64/4	Dynamic Geology Theory	60/3	Introduction to Earth Sciences	52/3	General Geology	48/3
Crystal Optics and Optical Mineralogy B	40/2.5	Crystal Optics and Petrology	180/7.5	Crystal Optics and Optical Mineralogy	48/3	Crystal Optics and Magmatic Petrology	82/4	Crystal Optics and Optical Mineralogy (Including test)	60/3	Crystal Optics and Optical Mineralogy	32/2
Crystallography and Mineralogy	80/5	Crystallography and Mineralogy	72/3	Crystallography and Mineralogy A	80/5	Crystallography and Mineralogy	90/5	Crystallography and Mineralogy(Including test)	60/3	Crystallography and Mineralogy	40/2.5
Magmatic Petrology	40/2.5			Petrology A I	44/3	Robot Geology	50/3	Magmatic Rocks and Metamorphic Rocks(Including test)	50/2.5	Magmatic Petrology	48/3
Sedimentary Petrology	32/2			Petrology A II	42/2.5	Sedimentary Petrology	46/2	Sedimentology (Including test)	88/5	Sedimentary Rocks and Sedimentary Facies	64/4
Metamorphic Petrology	40/2.5			Petrology A III	42/2.5	Metamorphic Petrology	46/2	Professional Foreign Language	32/2	Metamorphic Petrology	32/2
Paleobiology A	64/4	Paleobiology	54/2.4	Paleontrology and Stratigraphy A	96/6	Paleobiology	44/2	Paleobiology	36/2	Paleo-biology	40/2.5
Historical Geology A	64/4	Historical Geology	54/2.5	Celestial Evolution and Planetary Geology	32/2	Historical Geology	46/2	Historical Geology	40/2.5	Historical Geology	32/2
Structural Geology A	64/4	Structural Geology	54/2.5	Structural Geology A	64/4	Structural Geology	60/3	Structural Geology(Including test)	72/4	Structural Geology	64/4
Geochemistry	48/3	Geochemistry (Including Isotope Geochemistry)	72/4	Geochemistry	48/3	Regional Geotectology	50/3	Geochemistry	56/3.5	Seismic Exploration Principle	32/2
Solid Geophysics Introduction	40/2.5	Geophysics Prolegomena	72/3.5	Geophysics Theory	48/3	Sedimentary Facies and Environment	40/2	Geophysical Well Logging	64/4	Geophysical Well Logging	32/2
Metallogeny B	56/3.5	Metallogeny (Including Mineragraphy)	80/4	Metallogeny A (Including Mineragraphy)	112/7	Metallogeny Principle (Including Mineragraphy)	90/5	Metallogeny	52/3	Metallogeny	40/2.5
Mineral Exploration Theory and Method	80/5			Geoevolution I	32/2	Geological Prospecting Exploration	40/2	Oil and Gas Geology	72/4.5	Geological Prospecting Exploration	32/2
				The Geology of China	48/3	Territorial Resources Surveys Method	40/2	Geotectology	32/2	Subsurface Geology of Oil and Gas Fields	48/3
				Geomorphology and Quaternary Geology B	32/2	Deposit Statistical Prediction	60/3	Geological Statistical	48/3	Geology of Petroleum and Natural Gas	64/4
				Geotectology	32/2	Geological Resources Information System	50/3	Seismic Exploration Theory and Explanation	64/4		
								Sequence Stratigraphy	24/1.5		

Table 3: Teaching plans for geology courses at six Chinese universities.

Labour Education	1 week/1			Enrolment Education	1 week/0	Enrolment Education and Graduate Education	1 week/1	Military Training	3 weeks/1	National Defence Education	1 week/1
Military Training	2 weeks/2			Military Training	3 weeks/3	Military Training	2 weeks/2			Social Practice	4 weeks/2
Computer High-level Language Course Design	1.5 weeks/2	Regional Geology Work Method and Theory	2 weeks/2	Voluntary Labour	1 week/1	Voluntary Labour	1 week/1			General Geological Practice	4 weeks/4
Teaching Field-work of Survey A	1 week/1.5	Subject Scientific Research Internship	4 weeks/4	Graduate Education	1 week/0	Geological Cognition Internship	1 week/1			C Language Programming Course Design	2 weeks/2
Geological Cognition Internship	2 weeks/3	Geologic Cognition and Practice	3 weeks/3	Cognition Internship	2 weeks/2	Geological Practice Teaching	5 weeks/5	Geological Recognised Internship	3 weeks/3	Seismic Exploration Theory Course Design	1 week/1
Geological Teaching Practice A	6 weeks/9	Geological Skills and Mapping	4 weeks/4	Geological Teaching Practice	6 weeks/6	Production Practice	6 weeks/6	Geological Teaching Practice	3 weeks/3	Geophysical Well Logging Course Design	1 week/1
Graduate Internship B	8 weeks/12	Term Paper	*/1	Professional Practice	2 weeks/2	Graduate Design and Paper	13 weeks/13	Comprehensive Geological Practice	4 weeks/4	Comprehensive Geological Measurement Practice	5 weeks/5
Graduation Thesis A	10 weeks/15	Graduation Design	6 weeks/7	Production Practice	4 weeks/4	Structural Geology Course Design	1 week/1	Graduation Design	12 week/12	Geology of Petroleum and Natural Gas Course Design	1 week/1
				Graduation Practice and Graduation Paper	10 weeks/10	Palaeontology Geo-history Course Design	1 week/1	Geology of Petroleum and Natural Gas Course Design	1 week/1	Oil and Gas Field Underground Geological Practice	2 weeks/2
				Subject (Profession) Basic Main Course Comprehensive Research	3 weeks/3	Territorial Resources Survey Method Course Design	1 week/1			Mining Geology Internship	2 weeks/2
				Practical Skill and Ability Training	4 weeks/4	Exploration Geological Course Design	1 week/1			Graduation Design	14 weeks/12