

# Using contemporary education strategies to improve teaching and learning in petrology courses at Peking University

Chunjing Wei  
School of Earth Sciences  
Peking University  
Beijing 100871  
People's Republic of China

cjwei@pku.edu.cn

## Introduction

Since the 1970s, a series of authentic pedagogical theories have appeared to dominate a view of learning articulated in the educational literature. These include the constructivist theory (Piaget 1972; von Glaserfeld 1989), students' alternative frameworks (Driver and Easley 1978), or 'schema' construction (Anderson 1977), self-regulation in learning (Schunk and Zimmerman 1994), situated learning (Lave and Wenger 1991) and the practice of learning (Wilson 1996). A common characteristic of these authentic pedagogical theories is that learners play an active role in learning. For example, constructivism considers learning as the learner's own active initiative and personal knowledge construction, i.e. self-regulation of learning.

The student does not just passively take in knowledge, but actively constructs it on the basis of his/her prior knowledge and experience (Piaget 1972). Consequently, knowledge is the product of a learner's activities (von Glasersfeldt 1991), and is directly associated with the individual learner. Moreover, knowledge is shaped within a continually changing social context. In this perspective, the most important task for a teacher lies in the stimulation and coaching of a learner. The students develop an independent and active attitude of great importance for his or her functioning in a modern dynamic society (Taylor 1992).

If students are to become independent, lifelong and active learners, our program of teaching strategies needs to include methods and tasks which are interesting, motivating and require our students to be involved in both team and individual learning tasks. Intrigued by these authentic pedagogical theories, many western universities such as the University of New South Wales, the University of Sydney, Harvard University and University of Newcastle have employed a number of student-centred teaching strategies including case study, problem-based learning (PBL), small group inquiry/investigation, simulation, discussion-questioning, viewing-listening, community activity and a mixture of mini lectures and traditional lectures. These teaching strategies are seen as being more interesting, more realistic, representing a better training for post-university professional life, and are simply more valuable to students.

Participating in the program, 'Teaching Science in English, a professional development course for the Chinese university science teachers' sponsored collaboratively by the University of Sydney and the China Scholarship Council, I have had an opportunity to access these contemporary authentic pedagogical theories and teaching strategies in the lectures presented by Mike King and Mary Peat and I was deeply spellbound by them. Stimulated by these theories and educational strategies, I would like to consider how to improve the teaching and learning of petrology courses which I have taught over ten years at Peking University in the People's Republic of China.

## Current structure of the petrology courses and the approaches in teaching and learning

At Peking University, the petrology course includes four parts: optical mineralogy, igneous, sedimentary and metamorphic petrology. Optical mineralogy involves the study of the optical properties of the rock forming minerals using the polarized light microscope. Igneous, sedimentary and metamorphic petrology involves the identification and description of common mineral and rock textures, collectively referred to as petrology and the study of processes that formed these rocks which are collectively referred to as petrogenesis. About ten years ago, these four parts in petrology formed four independent courses with 80 hours of teaching for each. After several curriculum innovations, the four parts have been integrated into one course involving only 34 hours for each part (see Table 1).

	Optical petrology	Igneous petrology	Sedimentary petrology	Metamorphic petrology
Lectures	16 hours	16 hours	16 hours	16 hours
Laboratory practice	16 hours	16 hours	16 hours	16 hours
Examination	Laboratory practice taking 40% and lecturing taking 60%			

**Table 1.** Current structure of the petrology courses at Peking University

There are some problems with the current approaches employed in teaching petrology courses at Peking University. Four points proposed by Wu et al. (2002) are listed as follows:

1. in general, the current approach employed in teaching petrology (sedimentology) at PKU mostly involves lectures with few practical laboratory sessions;
2. lecturers dominate the teaching schedule, with the lecturer carefully delivering highly detailed material, while students carefully record the lectures in their note books before comprehensively committing their class notes to memory;
3. assessment is entirely by examinations in which students 'dump' the memorized material back onto paper; and
4. questions tend to be simple and usually require a brief factual response.

According to my observation, these four points are mostly true except that the laboratory practices have actually taken an important role both in the teaching and the examination processes. However, both the present lectures and laboratory practices are far from satisfactory. Most of our students are not very interested in the courses and, therefore, they learn them by a very surface level approach of recollection and reproduction.

For lectures, there are too many concepts and facts indoctrinated into the students. This problem has partly arisen from the Syllabus of Petrology provided by the Supervision Committee of Petrology based on the Ministry of Education, China, in the 1980s when there were over 300 hours for petrology courses. In the syllabus, detailed titles and subtitles for each chapter and paragraph of petrology courses were provided to the relative universities around the country. Affected by this syllabus and the existing textbooks which are also based on this syllabus, we considered subconsciously that the contents which had been taught for many years should be important to students. In the last decade, there has been some level of dispute amongst colleagues over whether we should teach students petrogenesis or just petrography in such a short teaching time. In fact, we have not paid too much attention to the students' interests because petrology is a compulsory course for the students completing a major in earth sciences. What we did was to pour all the contents in petrology that we considered was necessary for our students to know, by means of high-tech facilities such as multimedia and computer based learning.

For the laboratory practices, the students are required to complete too many boring descriptions of rock samples and thin sections. But they do not know what these descriptions are used for or indeed what their value is?

How should we make our lectures in petrology be informative and more interesting? How can we link the tedious petrographic descriptions with the petrogenetic process of a type of rock, or to a larger extent, with a process of geodynamics, or plate tectonics? These are the important questions we should consider.

## **Modifications in the petrology courses through contemporary education strategies**

The major practical development in contemporary educational strategies is the move towards student-centred approaches. On the basis of these teaching strategies, I would like to modify our teaching and learning approaches in petrology courses from the current di-variant approaches of lecture and laboratory practice into the tri-variant approaches of lecture, laboratory practice and PBL. However, an aspect that we cannot modify is the teaching hours, which are determined by a number of factors at all Chinese universities. This means that we should reorganize our lectures first of all.

### ***Modification of the lectures***

According to the author's experience, the conventional lecture would or should, still play an important role in the teaching and learning process. On one hand, an interesting and informative lecture will stimulate the students' interests and curiosity, and should be pivotal in helping students to choose their professions. On the other hand, most student-centred approaches require that students be equipped with some basic knowledge and facts of the related courses, which, can be easily obtained from their teachers' lectures. As has been mentioned above, the current lectures in our petrology courses contain too many basic concepts and facts which are influenced by a course syllabus and existing textbooks. As an example, the syllabus for metamorphic petrology (Wei and Zhang 2000) which is still being implementing at Peking University is shown as follows:

- *Chapter 1 Introduction;*
- *Chapter 2 Metamorphic reactions and their influential factors;*
- *Chapter 3 Characteristics of Metamorphic rocks;*
- *Chapter 4 Phase equilibria and compatibility diagram;*
- *Chapter 5 Metamorphic facies;*
- *Chapter 6 Contact metamorphism and metamorphic rocks;*
- *Chapter 7 Regional metamorphism and metamorphic rocks;*
- *Chapter 8 Other metamorphic processes and rocks;*
- *Chapter 9 Methodology of the study of metamorphic rocks; and*

• Chapter 10 Metamorphism and crustal evolution.

Each chapter involves a series of detailed concepts and content. For example, the contents of Chapter 1 alone include:

1. Concept of metamorphism
2. Ways of metamorphism
  - Recrystallization
  - Metamorphic reaction
  - Metamorphic differentiation
  - Metasomatism
  - Deformation
3. Types of metamorphism
  - Contact metamorphism
  - Regional metamorphism
  - Dynamic metamorphism
  - Heat fluid metamorphism
  - Migmatization
  - Ocean floor metamorphism
  - Impact metamorphism
  - Burial metamorphism
4. Significance of the study on metamorphic rocks

Generally, most of our students cannot understand the main ideas and, in particular, the relationships between the concepts in metamorphic rocks even after they have memorized the content from the lectures because the concepts in metamorphic petrology are mostly abstract and far from people's everyday life. In dealing with these problems, I think some strategies such as question-based learning (QBT), concept mapping and case study would be helpful. Consequently, I would like to discuss these issues by using the example of 'metamorphism'.

Metamorphism is one of the most important concepts in metamorphic petrology. It means the mineralogical and fabric adjustment of existing rocks (protoliths) to physical and chemical conditions that differ from those under which the protoliths originated.

In lectures, some questions which are close to daily life such as what would have happened in the process in making bricks and/or porcelains would be asked, concept maps for metamorphism would be provided by teachers or by students. An example of a concept map for metamorphism is shown in Figure 1.

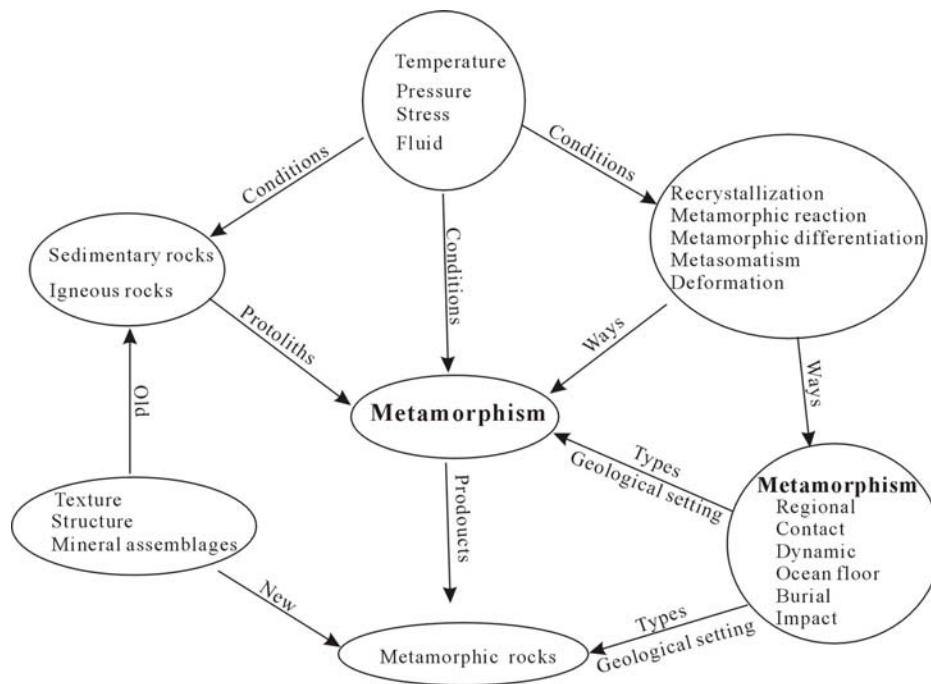


Fig. 1 Concept map of Metamorphism

**A case study of the metamorphism of claystone**

Case study is one important contemporary educational strategy. In this strategy, students could learn particular concepts, issues or topics in a relevant course through a complete and real story which has academic and professional significance as well as social implications. Strictly speaking, the typical cases which can be set in a real life context do not present many opportunities for metamorphic petrology although metamorphism by itself is a process that occurs in the natural world. However, the types of case studies would be various. On the basis of the wide range of concepts, contents and topics in our metamorphic petrology course, several case studies would

be helpful for students to understand metamorphic processes and to master their identification of the main types of metamorphic rocks. As an example, the metamorphism of claystone is discussed below.

Claystones are generally very sensitive to metamorphism. In people's real life, the processes can be represented by the manufacturing of bricks and porcelains. For a claystone that is composed of kaolinite  $[Al_2Si_2O_5(OH)_4]$ , illite  $[(K,H_3O)(Al)_2(Si,Al)_4O_{10}((OH)_2, H_2O)]$ , and quartz  $[SiO_2]$ , the metamorphism dominated by a temperature increase would result in three steps:

Step 1  
 kaolinite = pyrophyllite  $[Al_2Si_4O_{10}(OH)_2]$  + quartz +  $H_2O$   
 illite = muscovite  $[KAl_2(AlSi_3O_{10})(OH)_2]$  +  $H_2O$

Step 2  
 pyrophyllite = kyanite/andalusite  $(Al_2SiO_5)$  + quartz +  $H_2O$

Step 3  
 muscovite + quartz = andalusite/sillimanite + K-feldspar  $(KAlSi_3O_8)$  +  $H_2O$

These three steps of metamorphism are shown in Figure 2.

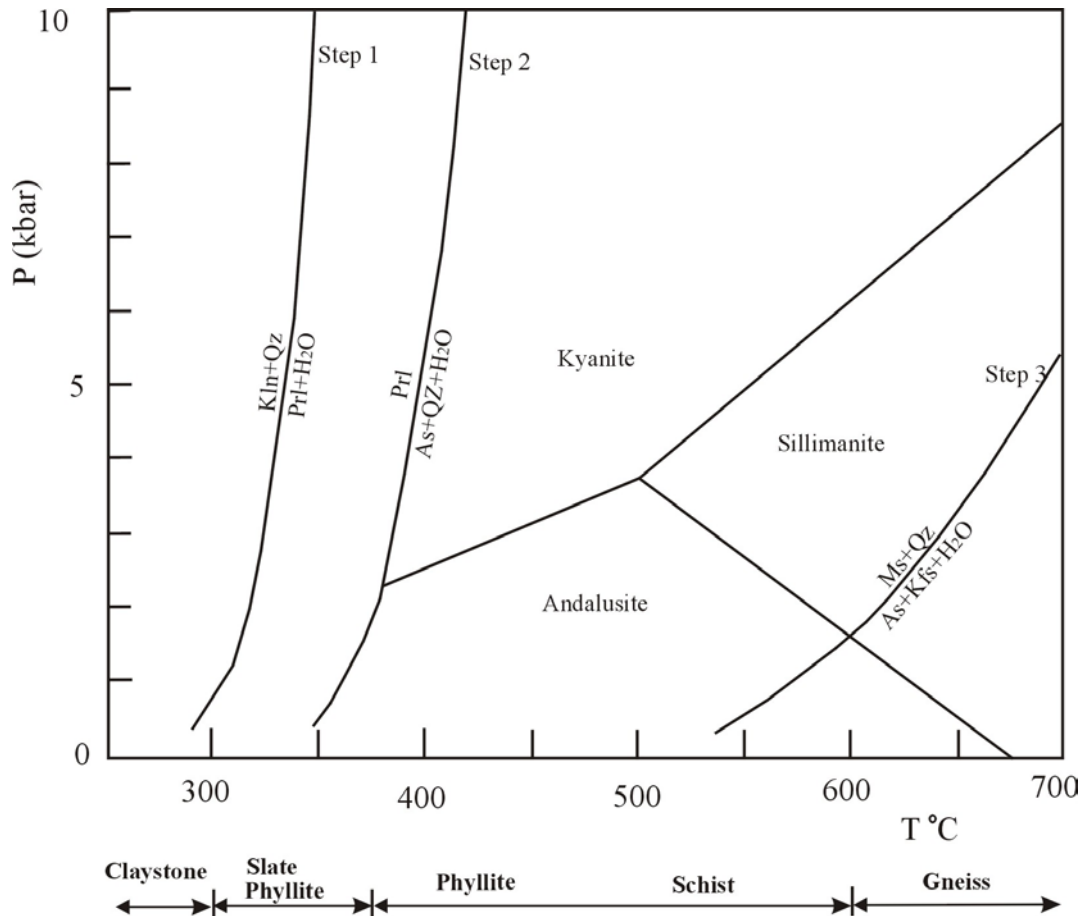


Fig. 2 P-T diagram showing the three steps of metamorphism of a claystone

This case is helpful in that it enables students to understand the metamorphic process, involving a claystone changing into a variety of metamorphic rocks through a series of metamorphic reactions. By means of images of different metamorphic rocks and/or through laboratory practice, students can master the petrographic characteristics of these rocks, which would lead to the laboratory practices being more teleological.

**Implementation of problem-based-learning strategies**

Student-centred, problem-based learning (PBL) is one of the most exciting and powerful educational options that has appeared in the last four decades. According to Woods (1994), forms of PBL that have been used include research, case studies, guided design, engineering design projects and, more recently, the McMaster Medical School model of PBL. In PBL students are expected to become active

learners while teachers are not the conventional knowledge transmitters but act as learning supporters. Students learn not only from solving the real world problem, but also from the learning process itself. This helps students to develop their own lifelong learning skills. PBL strategy generally requires that a real world or real life problem be solved as motivation for learning about the content and concepts of the subject.

Petrology covers such a wide range of knowledge that it is difficult to involve all of it into a real world problem. Moreover, the solution of a real world problem generally requires a great deal of interdisciplinary knowledge. Therefore, we will design several PBL activities for our students to choose according to their interests. For example, we will select some problems related to the oil and natural gas basins in China for the students that are interested in

sedimentary petrology and select problems related to the typical orogenic belts in China for the students that are interested in igneous and metamorphic petrology. Herein, I present an example of PBL which we will use in the future.

### **Example**

Scenario: The Chinese Continental Scientific Drilling Project

Employing modern deep drilling techniques, Chinese Continental Scientific Drilling (CCSD) Project aims to drill a 5000 metre deep hole in the eastern part of Dabie-Sulu ultra-high pressure metamorphic (UHPM) belt. The scientific objective is to reconstruct the forming and exhumation mechanisms of the UHPM belt by interpretation of the analyzed data from the drill core, liquid and gas samples taken from the hole, the in-situ logging data and information. Additional aims involve revealing the deep materials that constitute components of the convergent plate margin, its mineralization and fluid action, and to establish a deep laboratory for the long-term observation and as a base for the research of deep crust materials.

This project was listed in July 1997 as one of the National Key Science Engineering Projects in the period of the ninth Five-Year-Plan by the State Science and Technology Leading Group, and on May 7, 1998 as one of the International Continental Scientific Drilling Projects by the International Continental Drilling Program (ICDP). The project, which started in 2000, will last five years and consume over 100 million RMB.

The task that will be given to students is to present a scientific comment over 3000 words on the CCSD project involving a role play as though he or she were a member of the special committee to evaluate the proposal of the project, or just from a professional geologist point of view.

In this comment, it is a general expectation that students attempt to answer the following questions.

1. Is it necessary to develop the Chinese Continental Scientific Drilling (CCSD) program?
2. Why was the Dabie-Sulu UHPM belt selected as the focus of the project?
3. How should the scientific goals be evaluated through the CCSD project?

To make such a range of comments, a wide range of knowledge is required. This includes:

- a brief history of the International Continental Drilling Program (ICDP), and what important scientific issues can be, or have been, solved through this program;
- with respect to the CCSD project and its aim to drill into the continental orogenic belt, what are the key aspects of our understanding of the continental orogenic belt at the present time; and
- what is UHP metamorphism, and how has it changed the understanding of geodynamics?

Through such comment, students would improve their understanding of basic concepts and principles in petrology, in particular, improve the students' understanding of the petrogeneses of basalt and granite, metamorphic facies, facies series, PTt paths and ultrahigh-pressure

metamorphism, etc. and link these abstract concepts with the plate tectonics.

In writing such a comment, the students are required to collect information through lectures, textbooks, scientific journals and the Internet, and they are also required to observe and describe 15-20 thin sections and specimens of the eclogites and their surrounding gneisses and granites from the drilling area and drill cores. This assists students in learning the basic skills of petrology and to link the boring observations of thin sections under the microscope or on rock specimens with a great geodynamic process.

The other advantage for the PBL designed here is that it is comparatively flexible. The students will be required to finish their comments in three to five weeks and work on the problem in groups or individually. We will encourage our students to discuss or communicate their ideas in small groups or with their peers as well as with teachers. It is easy to balance the time used for conventional lectures and for PBL.

Frankly speaking, to make a comment for a PBL design is different from the PBL commonly used to solve a real world problem (Woods 1994). However, this is in agreement with the important objective of geoscientific research, to study the history of the Earth's evolution. It is helpful to stimulate the curiosity and interest of our students in geology, and to shape the students to function as informed citizens and successful professionals: that is, with the ability to engage in critical and analytical thinking, to problem solve, and to communicate effectively (Czujko 1994).

### **Concluding remarks**

Since the 1970s, the major theoretical development in pedagogy has been the move towards the constructivist perspective and this contemporary view of how people learn science. The major practical development has been the move towards student-centred approaches. However, not all students learn equally well through the same strategies. Some prefer to learn through inquiry, while others favour traditional expository approaches. The main opinions presented in this paper involve the modification of the petrology courses at Peking University to make them more interesting, informative, relevant and motivating by means of the use of more student-centred strategies on the basis of our traditional approaches. The modifications would be helpful for facilitating our students' learning, especially to improve the students' analytical and critical thinking ability and their lifelong learning skills.

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