GEOLOGY, THE PROFESSION

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Introduction

Geology deals with the Earth and its processes. The variety of ways in which geologists work has been evolving for millennia. It is now the most complex and diverse profession in society, so that geologists could be regarded as modern-day polymaths. The profession continues to evolve, with many areas of expertise, ranging from palaeontology to geophysics and from volcanology to environmental geology. Along with other modern professions, it has adopted the professional qualification system, which is based on the four pillars of academic training, professional experience, a code of ethics, and continuing professional development (**Figure 1**).

Ancient History

Geology as a profession can be traced back to the birth of civilization. At the moment that our hunter–gatherer ancestors picked up a stone as an implement, the profession of geology was born.

Soon, the discerning, evolving, human being realized that some rocks have better properties than others depending on the needs at hand. Some were harder and did not shatter when used as a hammer; others could be worked to produce a sharp edge and wielded as axes, arrows, or spears. As an interest in rocks developed because of their use as building materials, metal sources, agricultural ingredients, pharmaceuticals, jewellery, and wealth, the *Homo sapiens* with a geological eye became valued by society.

The specialized quarryman, ore smelter, or miner was representative of geologists for thousands of years. Their keen observation and skill was exemplified by their ability to hue megaliths and other objects for use in many aspects of Mesopotamian, Egyptian, Greek, Roman, Aztec, and Inca life. Their constructions produced such marvels as elegant obelisks, the impressive Parthenon, dramatic amphitheatres, and pyramids – to mention only a few. These men knew their geology, and they understood the nature of bedded rocks and how joints broke up the beds into usable blocks. So the profession was divided for a long while into miners, quarrymen, masons, brick makers, etc.

However, even in ancient times people thought about the causes of phenomena such as earthquakes and volcanoes. Philosophers such as Aristotle, Lucretius, Herodotus, and especially Avicenna made astute observations based on meagre information, and these data were preserved through the dark ages only by Arab intellectuals. Then, towards the end of the fifteenth century, Leonardo da Vinci observed that fossils had once been living organisms and that the land had once been covered by the sea. So it was with the development of the Enlightenment that ancient ideas were re-examined and new thoughts advanced by such Italians as Vallisneri and Moro. They followed Bishop Nicholas Steno, the founder of modern geology, who developed the ideas of stratigraphy in Florence in 1669. Then, in the late seventeenth century, Descartes in France followed by Leibnitz in Germany formulated the concept of the development of the planet from vapour through molten rock to the solid surface.

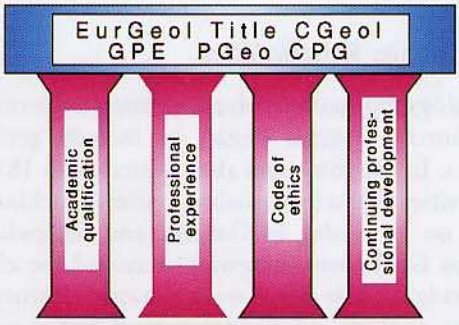

Figure 1 The four pillars of professional geological qualifications. EurGeol: European Geologist (Europe), CGeol: Chartered geologist (UK), GPE: Geologo Profesional Especialista (Spain), PGeo: Professional Geologist (Ireland) and Professional Geoscientist (Canada), CPG: Certified Professional Geologist (USA).

More Recent History

In the eighteenth century geology became the preserve of the gentleman polymath. These men of substance, quite a number of them questing clergymen or surgeons, found that they could read the rocks like a book and could see that certain layers always appeared above others and that they contained distinctive fossils. Gradually they put together the sequence of deposition of the rock layers.

In France, the Académie Royale des Sciences was the seat of the discussions that crystallized French learning about the Earth, such as Desmarest's 1771 memoir, in which he presented his theory of the

volcanic origin of basalts. The founding fathers of modern geology included men such as James Hutton (*see* **Famous Geologists:** Hutton), who published his '*Theory of the Earth...*' in 1795, and Charles Lyell (*see* **Famous Geologists:** Lyell), whose *Principles of Geology* was published in 1833. In England gentlemen organized themselves into the Geological Society of London in 1807; this was initially a discursive dining club, but it eventually became the home of geology (*see* **Geological Societies**).

Geological maps were being drawn at that time in many countries and included Tighe's Kilkenny map of 1802 in Ireland and Mantell's 1822 map of the South Downs in England. However, one man who was involved with the practicalities of the industrial revolution made enormous strides. A blacksmith's son working on the development of canals throughout the UK drew detailed maps of the changes in the rocks across the countryside. So William 'Strata' Smith (*see* **Famous Geologists:** Smith) drew the first geological map of most of Britain in 1815.

Thus during these times geological learning evolved from a restricted interest in mining or mineralogy to broader geology. For a long time, in many parts of Europe, geology was seen as a subservient branch of engineering, and amazingly in some countries a geologist still cannot sign his own professional report, but must ask an engineer to do it for him!

The Breadth of Geology

It can be seen that the practice of geology developed and enlarged over the millennia and embraced many disciplines. It has burgeoned into perhaps the broadest discipline to be found in society.

Geologists include palaeontologists and palynologists who specialize in zoological and botanical sciences; their understanding of the processes of evolution is central to their work. Sedimentologists image past processes and compare them to modern ones. Mineralogists and crystallographers deal with minerals and crystals. Metamorphic geologists look at the changes that take place in rocks under extreme heat and pressure. Hydrogeologists deal with the crucial area of the movement of groundwater and our ability to provide clean water to society; a subgroup specialize in the disposal of society's waste in a safe, clean manner. Geophysicists, through mathematics and physics, use diverse techniques, such as the micromeasurement of gravity, the response of the ground to electrical currents, the reflection of radar waves, and, of course, the measurement of seismic waves, whether produced naturally by earthquakes or by artificial sources. Marine geologists look at geology below the surface of the sea, imaging the seafloor and working with their geophysicist colleagues to see deep into the rock strata. Petroleum geologists understand the formation of oil and gas and how these vital commodities are caught in traps in the rocks; they help to deliver these resources to society. Volcanologists or igneous geologists deal with active volcanoes and igneous processes and with their now fossilized equivalents in the geological record. Geochronologists use their knowledge of the radioactive decay of some elements as a crucial tool in the absolute dating of rocks and sediments, for example by using the decay of uranium into lead to date ancient intrusive igneous rocks that are between 1 Ga and 400 Ma old, the decay of potassium-40 into argon do date rocks formed during the last 500 Ma, or the decay of carbon-14 into nitrogen to date more recent organic sediments that are a few tens of thousands of years old. Geochemists specialize in the mineral constituents of rock, following on from the smelting of ores for thousands of years, and this was an important aspect of the development of the science of chemistry. Structural geologists apply mathematical and geometrical knowledge to the way that rocks behave under varying conditions of pressure and temperature. Engineering geologists must know about the technical properties of rocks and sediments and be able to communicate this information to their engineering colleagues; they also deal with natural hazards such as danger from landslips, etc. Environmental geologists have become central to the management and development of society; their input into land-use planning improves the quality of life for the inhabitants and ameliorates the risks posed by geohazards. Planetary geologists learn from our planet and its moon and work with their astronomical colleagues in investigating distant bodies. Remote-sensing geologists use satellite imagery to examine the surface of our planet.

Our science overlaps into a plethora of other disciplines.

Academic Education

As geology gradually evolved, existing university natural history courses began to include geological options. In the five years after Waterloo in 1815, the universities began to formalize matters: Buckland was taken on as reader in Oxford, and Sedgwick (*see* **Famous Geologists:** Sedgwick) received the chair in Cambridge. These chairs were in natural history, mineralogy, geology, or a combination, but the course was becoming a geological one. The degree awarded was still a Bachelor of Arts, of course.

This trend continued, and colleges around the world began teaching geology. Degree courses

evolved until 3 years of education were required to receive a Batchelor of Science degree, or 4 years with Honours. Most universities now offer postgraduate Master of Science degrees, involving 1–2 years work, through thesis and/or examination, whilst Doctor of Philosophy (PhD) degrees may take between 3 and 5 years of research to complete. In Europe, this may take up to 10 years. In general it is considered that most geologists need to complete at least 5 years of education before becoming suitable for a long-term geological career.

The Learned Societies

In order to cater for all the interests of these geologists, various bodies came into existence. They fall into the categories of learned and technical societies, but a new function or even a new type of society has evolved with the recent birth of the professional societies (*see* **Geological Societies**).

We see that the major national societies such as the Geological Society of London, the Union Français des Geologues, and the Ilustre Colegio Oficial de Geólogos cater for many areas of geological life and interest, especially when they are able to set up special interest groups. The specific concerns of large groups of specialized geologists, especially when these are of a global nature, have lead to the establishment of large organizations such as the International Association of Engineering Geologists, the European Union of Geological Sciences, the Petroleum Exploration Society of Great Britain, the Micropalaeontological Society, the International Association of Hydrogeologists, and the Society of Exploration Geophysicists. All cater for a particular area of geological interest, and most produce a journal carrying technical peer-reviewed articles.

The Professional Bodies

The evolution of the professional geologist, working in academia, government, or industry, has lead to the need for organizations to look after them. Some learned societies, such as the Geological Society of London, have evolved easily to cater for this new function. In Ireland it was necessary to create a new independent body – the Institute of Geologists of Ireland – to look after Irish professional geologists, and in the USA the American Institute of Professional Geologists took on this role. The European Federation of Geologists (**Figures 2** and **3**) took on the continental role of representing the national associations, some of which were professional bodies and others learned societies. Similarly, in Canada the Canadian Council of Professional Geoscientists represents the professional interests of the provincial bodies (**Table 1**).

All of these bodies are striving towards the same goal of ensuring professional standards and representation. They are establishing mutual recognition and other agreements to benefit their members worldwide.

The Profession

The practice of geology occurs in three principle areas: academic, governmental, and industrial.

Clearly, the teaching of geology is crucial, and it is amazing that so little is taught in primary or secondary schools; geology is simply seen as a small aspect of geography! It is in tertiary education that geology comes into its own, and universities develop courses that give the neophyte geologist a grounding in so many disciplines. So, most geologists working in academia are based in university geology departments, though some may be found in the allied disciplines of geography, archaeology, etc. Some can also be found in Schools of Mines or Technical Institutes, where they instruct mining geologists, geosurveyers, and geological technicians.

In Government, the traditional area of practice has been in geological surveys. These have long been seen as the providers of modern geological maps, and this is indeed one of their main functions. It has been interesting to see the variation in the response of geological surveys around the world to modern changes in such areas as digital data management. Those surveys that have remained traditional have come under great pressure, and some have had to close. Others that understand the demands of the digital era have been quick to adjust to being data managers and providers, not just map makers, and so have become a necessary organization rather than an 'appendix'. Consequently, geologists working in these areas have also developed their geological skills, often into new areas such as heritage or marine. Other bodies have also created opportunities for geological employment, and in the last few years departments such as Environmental Protection Agencies have sprung up to look after the world we live in. Geology naturally also has a role to play in the supply of renewable energy, allowing countries to be less reliant on fossil fuels.

Industry is a huge area of employment for geologists. The supply of fossil fuels or mineral resources depends on the geological setting and on the location of the deposit to be exploited. So a geologist must be mobile and able to travel to any part of his or her country and even to any part of the world if necessary. Consequently, an ability with foreign languages can be highly advantageous at times. However, in the area

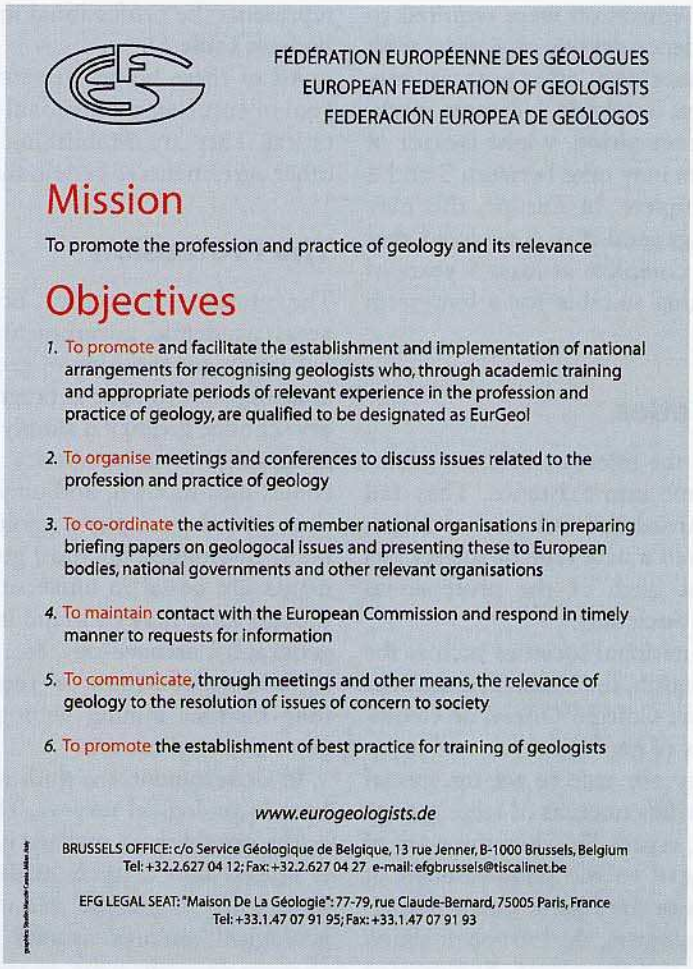

Figure 2 Mission and objectives of the European Federation of Geologists.

of industrial minerals, geologists deal with the supply of basic raw materials such as limestone, sand and gravel, and aggregates; many of these materials are supplied very close to their extraction source since transport is the major cost.

The birth of new areas of geology, taking over to some extent from the older ones, has lead to more home-based occupation, including hydrogeology, waste disposal, pollution remediation, environmental geology, geotechnical geology, renewable energy geology, and geophysics.

Professional Qualifications

Professional qualifications have been developed during the last half of the twentieth century. This profession has set up requirements that geologists must demonstrate not only that they have a good academic education, but also that they have achieved a high standard of professional expertise over a number of years and that they can demonstrate this in front of their peers by examination of both their work and their knowledge. Another part of this process has been the signing by geologists of agreements to obey codes of ethics demonstrating that they will work to high ethical standards. These codes are backed up by disciplinary committees. A further aspect that has become formalized is the agreement to demonstrate that continuing professional development is being carried out by the geologist.

Around the world this movement has proceeded and the standards that have been set up are very similar in most countries, so that across Europe there is a single standard to be achieved, and this is recognized to be equivalent to the standard achieved in other continents, with reciprocal rights and recognitions existing between different international groups, allowing geologists to travel and practice around the world.

Also of importance has been the acceptance by government and business bodies of this professional standard. For them, this quality-assurance mark is a

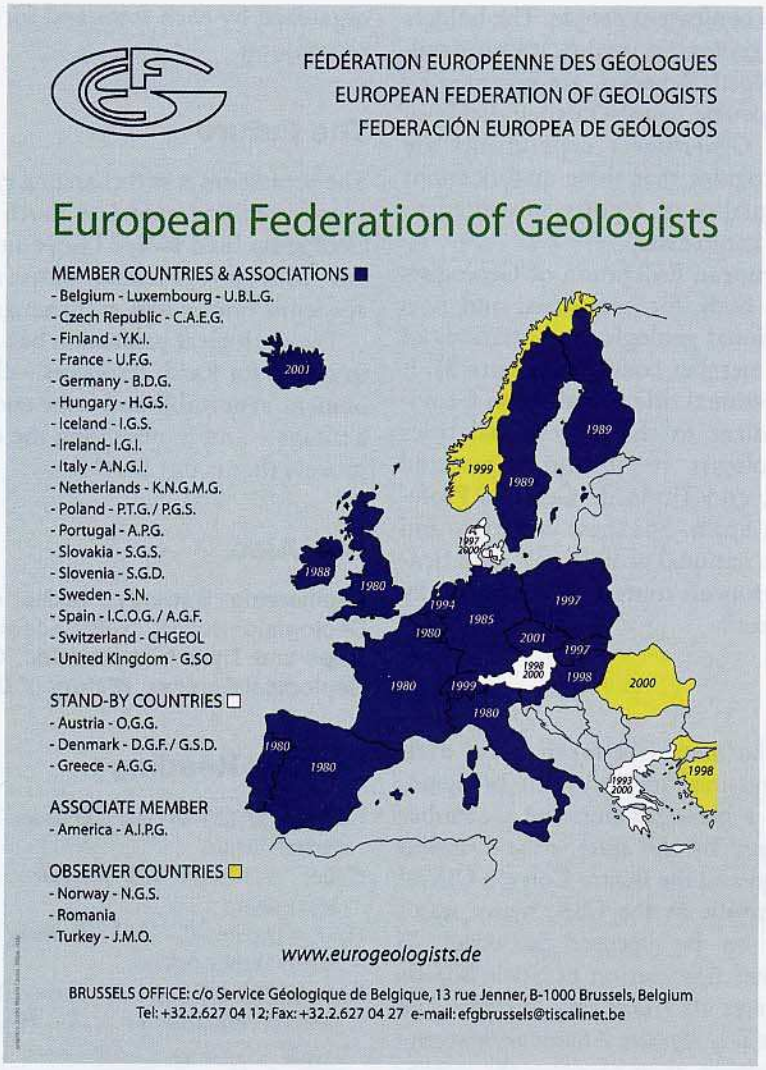

Figure 3 Members of the European Federation of Geologists. Single dates are years that countries became observers or members. Double dates are periods for which countries were members.

Table 1 Professional websites

European Federation of Geologists	www.eurogeologists.de
Geological Society of London (UK)	www.geolsoc.org.uk
Illustre Colegio Oficial de Geólogos (Spain)	www.icog.es
Institute of Geologists of Ireland	www.igi.ie
American Institute of Professional Geologists	www.aipg.org
Canadian Council of Professional Geoscientists	www.ccpg.ca
Berufsverband Deutscher Geologen, Geophysiker und Mineralogen EV (Germany)	www.geoberuf.de

way of ensuring high standards in the geological input to projects.

Part of the motivation for this movement has been the necessity to demonstrate high standards to local, national, and continental governments. Especially in this litigious age, the use of appropriately highly qualified people in all aspects of life is becoming a necessity.

Another powerful motivation has been the recent requirement by financial bodies such as the Canadian, Australian, British, and Irish stock exchanges that all sections of bankable reports on mineral

deposits are signed by competent people. The holders of these professional geological qualifications, available in Europe and North America, are accepted by these bodies as competent people in their fields of geological expertise. Government departments are also beginning to recognize that these qualifications help to ensure the quality of reports submitted to them by professional geologists.

In Europe, the European Federation of Geologists is the representative body for geologists, and it is composed of the national geological associations of each of the nineteen member countries (**Figure 3**). It administers the professional title of European Geologist, which is equivalent to the professional titles of Professional Geologist in Ireland, Chartered Geologist in the UK, and Titulo de Geologo Profesional Especialista in Spain. For these countries and for those that have no national professional qualification it provides a European route to a continentally recognized qualification.

Regulation

In some countries the State has taken upon itself to regulate the profession. In Italy and in Spain, in order to practice, a geologist must be a member of the body recognized by the state – the Consilio Nazionale dei Geologi and the Ilustre Colegio Oficial de Geologos, respectively. In the USA, many states require a geologist to be licensed in order to practice. The National Association of State Boards of Geology coordinates this licensing system. The role of the professional body, the American Institute of Professional Geologists, then becomes the organization of a high professional standard. In Canada the Provincial Geological Bodies have come together to form the Canadian Council for Professional Geoscientists, which coordinates the professional standards organized by each state and formalizes their mutual recognition.

The Future

The profession is still changing rapidly. Will the trend towards calling ourselves Earth Scientists instead of Geologists hold sway? I hope not! It appears to be a fad with no practical basis except to persuade academic bodies that real change is going on.

The geological profession has a clearly defined role in caring for Earth resources – clean water, the environment, renewable and finite energy, geohazards, and heritage – and in observing the continually changing process that is our Earth.

See Also

Engineering Geology: Codes of Practice. **Famous Geologists:** Hutton; Lyell; Sedgwick; Smith. **Geological Maps and Their Interpretation**. **Geological Societies**. **Geological Surveys**. **History of Geology Up To 1780**.

Further Reading

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GEOLOGY OF BEER

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Introduction

The fermentation of an extract of cereal grains is probably one of the oldest processes known to man, with techniques stretching back to Ancient Egypt. In the UK and parts of western, central, and eastern Europe a wide variety of fermented barley beverages are produced, known generally in English as beer or ale. Much of the variety is a direct result of the chemical composition of the water used to extract the sugars from the barley prior to fermentation. This variation derives from the geology of the water sources.

The pleasures of beer consumption are encapsulated in the following quotation, from an unknown source.

ELSEVIER DETAILS

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