Relevance of geology*

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There seems to be much misperception, even in responsible quarters, on the relevance of geology and its present-day importance as a branch of scientific enquiry. A vague impression seems to be lurking in their minds that the subject is something to do with rocks and minerals and natural disasters. Whenever a tragic earthquake shakes up the land or a tsunami strikes, the inference is immediately drawn that something is wrong with the geological education in the country that can allow such things to happen without giving any warning. Even the editor of such a sober and well-informed science journal as *Current Science* has gone to the extent of condemning the inadequacy of the sciences of modern geophysics and seismology in prediction of earthquakes, and branding earth sciences in India as remaining at a low ebb, tradition-ridden and dull, untouched by modernity. These critics seem to forget that our civilized existence today is made possible through the painstaking labour of a large number of men who, by adopting traditional and classical methods, have been able to provide the metals and energy required for civilized existence. Excitement and curiosity is not the sole monopoly of popular branches of science like physics and chemistry.

Geology is fundamentally an observational field science and geological map its main tool

Geology emerged in the early part of the nineteenth century as a revolutionary but practical concept of examining sedimentary rocks arranged over the earth in layers and containing fossil remains of ancient life. From such simple beginning has developed a whole science of calibrating geological history. The establishment of a relevant timescale is geology's greatest contribution to our basic knowledge, on which depends all that we now know of the biologic, tectonic and environmental changes the earth has undergone in the past. We cannot conceive of a world without geoscience as our water supply, energy and raw materials are all dependent on a cultivated understanding of the subject.

Field mapping is the principle tool which has enabled us to understand the earth as no other science could ever hope to do. A geological map is the highest form of scientific research, requiring all the modernity and advances in knowledge of other basic sciences to distil the most essential information and make it available to everyone. Unfortunately, geologists in this country, in their vain chase for modernity, have discarded this fundamental exercise and gone in search of newer branches of knowledge. One of the worst tragedies that has overtaken geology is the total abandonment of traditional methods.

The basic requirement of any country is knowledge of its territory and its character, and the geological map is the tool for obtaining this knowledge. It is the primary duty of the geologist to collect all the available data and store them on a map. The 'map' itself is an easily constructible database which stores the greatest amount of data possible, provides us easily assembled representation of this data, and thereby becomes a most effective vehicle of communication.

To quote BRGM – 'the geological map is a scientific research instrument of prime importance that reflects the continued development of geological concepts. It is the translation of the teams 'knowledge and ability to exchange, understand and transit in terms and images the reality and organization and evolution history of the rocks in a determined geologic area'.

Changed aspects of modern geology

Geology as practised a hundred or even fifty years ago was different from what it is today. It was then more descriptive and historical and in the same state of physics before Newton or chemistry before the periodic table. A vast amount of data had been collected, but with no acceptable theory to integrate it all. Then came plate tectonics – a theory conceived by a geologist who labelled it when he announced it as a case of 'geopoetry'. A picture of a dynamic earth has emerged with a continuous system of mobile belts marked by mountains, mid-oceanic ridges and subduction zones, all connected to each other and forming a pattern dividing the earth into several rigid plates. As a result of the application of this theory the scope of geology has enormously increased, with new techniques borrowed from physics and chemistry. New specialist fields of geophysics and geochemistry have emerged and are growing in strength.

The bulk of our country was mapped in the pre-plate tectonic era. Now new analytical techniques and a plethora of new concepts have emerged, which require that our geological maps be continuously updated.

The scope of geological science is vast. Based on certain simple guiding principles, geologists have literally been able to read 'Sermons in stones and books in the running brooks'. As a result, the science has turned out to be the mightiest of all detective stories, figuring out step by step the progress of past events and constructing a remarkably absorbing story of how earth has developed, through what vicissitudes it has passed, and the procession of life forms which inhabited the planet. It is this accumulated knowledge which helped Darwin form his all-absorbing theory of evolution, his constant book of reference being *Principles of Geology* by Lyell. Geology is no ordinary science – let people not mock at its simplicity. It is the primary vehicle of knowledge which has brought to light a host of useful minerals and rocks, to form the base on which the mighty pyramid of modern civilization is rearing itself high. The services which geology has rendered to human welfare have been immense and cannot be belittled.

As knowledge and experience grow, the traditional and historical perspectives of geological sciences have tended to change, requiring new tools for study by specialized branches like geophysics, geochemistry, oceanography, etc. and in acquiring an array of ships, aircrafts and costly instruments in air-conditioned rooms. Geology, in this development process, has been relegated to the position of a poor relative in the family. Field work, petrology, structural geology, stratigraphy and palaeontology are no longer fashionable, but are dubbed traditional and classic. Maps have become irrelevant, the location of a sample, its mineralogy and petrological characters are unnecessary details not to be bothered about. Any sample can be fed to a machine which churns out endless figures. These

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are further manipulated to yield yet more numbers, which are received with the greatest respect and adorn the pages of prestigious journals. Are we to consider this as real geology and discard field maps and all the geological history in them as mere junk!

Geologists in India, instead of becoming specialists in their own field, have fallen victims to the current fashion. They have discarded field work and students are no longer taught the fundamentals of field mapping. Our government too, contributes to this neglect by denying topographic maps to bonafide researchers by raising the bogey of defence of India. Australia, Canada and South Africa, who started geological surveys a long time after India, are producing excellent field maps in colour, which are the envy of the geological community. As against this, our own progress is miserably poor, nowhere reaching modern standards of cartographic excellence. Even Geological Survey departments have given up field work and mapping as their main line of activity, while there is, on the other hand, a rush for securing air-conditioned labs housing costly instruments. Foreign suppliers, knowing the weakness of developing countries, supply equipment which frequently go out of order, requiring a technician to come all the way from the supplying country to rectify even a minor malfunction. Most instruments, on which crores have been spent, go out of order within a year or two of their installation. Meanwhile, manufacturers are putting out newer versions and the ones bought at great cost are discarded and put in wraps. Moreover, these expensive instruments are also not freely accessible and are put in charge of one or two individuals who call themselves specialists.

This is the sorry state of most 'Earth Science' departments of the present day. Real geology, the study of rocks and minerals, the sculpturing of landforms, the multitude of ways in which the rocks weather, the building of strata in basins and the changing life forms they contain, the reconstruction of past history are no longer accepted as branches of geology worthy of study.

The availability of detailed topographic map is a primary requisite for geological work. The Survey of India has produced some excellent maps with a wealth of information which formerly were available across counter in any stationary shop. Post-independent India however, has put severe restrictions on the availability of these maps and all our efforts to effect a change in policy have miserably failed.

The new minister of science and technology, back from his visit to Antarctica, promised to induce dynamism in the lethargic ways of some of the government-managed scientific departments. Some time ago he announced that there would be a change in the policy of the government in the matter of availability of maps, but there has been no change so far in policy. A tsunami has struck and gone, but possibly changed coastline features which cannot be mapped by agencies outside the official departments. School children are being 'educated' without knowing how to read a map and know the physical features of the country more intimately. Are we to wait for another tsunami before the government will act, change its indefensible policy and make maps available to all?

Science departments, unfortunately, are not people-oriented. Information is denied, letters remain unanswered, topographic maps are supplied only to government-sponsored agencies and not to others. Can we blame geologists when they are denied the basic tool of their craft?

The backwardness of the country, in a large measure, is due to knowledge being confined to a few individuals at the top, whose research does not meet the specific needs of the people. Most of them are after international recognition and career advancement, and have given least thought to solving any of the country's problems and have become strangers in their own land. Mineral development has not gone beyond the stage of extracting and exporting minerals in the raw state. In times of crisis, as in the recent tsunami, the entire scientific community is stunned, not knowing what to do. Since the Government of India has thought it fit to restrict the supply of toposheets, the entire coastline of India, its configuration and its vulnerability to disasters remain unknown outside official circles. Fundamental principles of geology are not taught in schools, the large majority of the population remain ignorant of possible dangers and no attempt is made at popularization of science.

In the Indian Institute of Science (IISc), at Bangalore, considered as the citadel of modern science, geology does not figure, even remotely, as a subject for study. In that whole campus, not an inch of space is allotted for a museum where students can see wonderful products of nature and begin to think. It was given only to Raman to earmark several magnificent halls in his research institute to exhibit colourful minerals and rocks. There are few men with such vision now. The other day, I happened to glance through a copy of an early edition of the famous book *Geology of India* by Wadia, purchased by the library of IISc. As a matter of curiosity, I checked the slip pasted at the end and to my great surprise found that, since the purchase of the book in 1947, only one person had borrowed the book! How do we account for this total neglect of an important branch of knowledge.

Geology is the most essential component of mineral exploration

Whether it is metals or hydrocarbons or industrial minerals, knowledge of geology is indispensable for it provides an intellectual framework and the most essential baggage for use during the course of exploration. This subject too, is most neglected and not taught properly with illustrative examples and the amount allotted to mineral exploration is minimal. Practitioners of the art are not exposed to new ideas, nor are they provided with opportunities to visit classic areas and gain first hand knowledge of what is happening in the rest of the world. Government policies, resulting in enormous delays in the granting licenses, have killed this branch of geological science which could contribute to the accumulation of real wealth and prosperity of the country, but is languishing because of such lethargic policies. It has become almost impossible to get a new mining lease or prospecting licence and employment potential is being lost through the failure of government departments to act promptly and take workers as partners in the industry.

The philosophy of geology

James Hutton, the founder of geology, was a thinker, who, in his study of how rocks are formed, disintegrated, destroyed and washed to the sea to form new sets of rocks, came to the profound conclusion that in the process operating in nature he saw *no vestiges of a beginning nor prospect of an end.* All processes were cyclic and the earth survived from age to age despite the processes of construction and destruction going on without intermission. Geology inculcates a particular 'Weltanschauung' or perspective anchored in the knowledge that nothing is permanent but in a state of constant flux, ever changing, taking new shapes and forms and yet,

somehow retaining the thread of continuity. Such a perspective is extremely important to bring mankind together and in transcending the narrow divides of religion, race and colour causing so much conflict in the present-day world. There is no better way to encourage development of such a world view than at the impressionable school age by making geology as a subject taught to everyone, whether one becomes an engineer, doctor, scientist or a lawyer in his later life. Earth as our habitat and home acquires a new meaning and the fate of all life forms in the evolutionary history of planets and our place in the cosmic/universal scheme of things, an entirely fresh, invigorating and catholic outlook. The great debate about environmental protection and preservation will find a holistic echo, if geology is introduced at a tender age as a subject of study. Hence, there is a pressing and urgent need to introduce geology at the school stage without any further delay.

Natural hazards

Geologists cannot be blamed merely because they adopt traditional and classical methods untouched by modernity. Natural hazards will continue to occur despite all the modernity and millions of dollars spent on their prediction. What is more important is to take steps to mitigate the severity of such hazards through social planning and preparedness, through proper and adequate emergency response exercises. A geologist, with his better knowledge of ground conditions, is in a better position to be of assistance to the community. In spite of all the new knowledge acquired from geophysics and geochemistry, we still do not know how the earth works and what will happen at any particular place and time.

Educate young minds – Take geology to the schools

We must develop in young minds the faculty of thinking and imagining how sediments are deposited at the sea bottom layer after layer, become compacted, folded and lifted up to form loftiest mountain ranges. This lesson, which only geology can teach, should be learned as early as possible.

We may ignore the criticisms of physicists and chemists, which can only be considered as born out of misconception of the role of geology. Our role is not in making atom bombs, space shuttles, poisonous gas and chemicals. It is less spectacular and confined to looking after the basic needs of our fellowmen and women, providing them with clean drinking water, minerals and energy, assuring them adequate food and construction materials to protect themselves from the vagaries of climate and natural disasters. Our support should come from the appreciation of persons who value these services. Those who have knowledge of geology and understand its principles and its philosophy are more service-oriented, taking a balanced view of things and have a value in the basic education of mankind as a whole.

The inspiring message of geology – See what it teaches us

Let me quote as to what lessons we can learn from the *Book of Stones*:

'...In the eyes of geology, a thousand years hence is as tomorrow and the age of Socrates as yesterday. These are necessary facts to incorporate into our daily consciousness. Then we shall have patience. Then we shall have room for hope.

Take the main facts again. A million year ago the ray of consciousness broke in on man. He stood back, he saw, he became detached. That was a rudimentary ray. We are not wiser than Socrates. We are wiser than Neanderthal man. We are not more ethically inclined than Confucius. We are more ethically inclined than Neanderthal man... If this is true, it is a tremendous truth; for if the aesthetic sense alone is developing it means that love and peace and beauty and worship and reverence are growing. This is growing backslidings or not. Another million years will show us much differences again. We may call this faith, it is close to fact....

Our development is attached with sorrow, it is woven with tragedy, it is dedicated to perennial disasters – but it goes on; it does climb upwards. All the arts tell us this. Did the early men have our ears or eyes? No, they had to worship sticks and stones. We have thrown the idol away. We press on towards the next stage. We will reach it if we have faith in our power to do so.'

This philosophy should become part and parcel of our education system, so that young citizens grow in this climate of culture. But there is so little knowledge about geology in the minds of the public and there is no effort to teach it in schools, although the subject is so interesting. There is need to bring out a large number of illustrative pamphlets aimed at rousing the interest of young minds. In the universities and other education institutions, importance should be given more to teaching and stimulation of intellectual activity. The ability to teach is important. Field programmes – more and more of these should be arranged to kindle the wonder in the minds of the young, of natural objects and develop their thinking process.

Geology departments, neglected by the administration, denied funds to equip museums stocked with rare minerals, rocks and fossils, or good laboratories equipped with modern petrological microscopes, are in a sorry state. They need to be improved. Let geophysicists and geochemists bask in their new-found importance with modern buildings, air-conditioned rooms and the most sophisticated instruments, which only one or two specialists can handle. Geology departments should be open to everybody to enjoy the marvels of nature. Space and Atomic energy are glamorous departments no doubt, attracting money and attention but geology strategically is as important.

Geology, let me repeat, is not a laboratory science; the field is its laboratory, where thinking reaches dimensions in space and time too vast to comprehend directly. On the pretext of chasing modernity, we should not give up geology as we know it and try to style ourselves as geophysicists and geochemists. Those are specialized fields which only specialists can handle. It is admitted that mere surface geology does not carry us very far. Geologists should be ever on the vigil for newer advances in sister sciences and be quick in using them as tools for a better understanding of the science in general and its problems in particular.

Let me end this note with the inspiring vision of Preston Cloud, a great geologist and thinker of yesteryears, on the future of geology:

'I look forward to the next decade to a broad extension of our understanding of planetary dynamics, backward in time, outwards in space and forward into the future.'

'Progress toward these goals will depend partly on the degree to which the new geology under the traditional data sources and historical perspective of the earth sciences with the principal methods and instrumentation of chemistry, biology, fluid dynamics, nuclear physics and other relevant fields, into one great science of the earth, its cosmic antecedent and its perspective future as the abode of mankind.'

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