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HISTORICAL NOTES

Symbiotic relation between Geology and Botany— Pramatha Nath Bose and Girish Chandra Bose

Chittabrata Palit*

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Pramatha Nath Bose was a famous geologist. He introduced the subject when it was in adolescent state in both India and abroad. Jamsedji Tata was greatly influenced by him for the establishment of TISCO (Jamsedpur) and Indian Institute of Science (Bangalore). Both Pramatha Nath Bose and Girish Chandra Bose were close friends and it was due to former's influence that Girish wrote a Manual of geology (*Bhutattva*, Calcutta, 1881) for students in Bengali with skillful vernacularisation of the English terms and terminology. The book begins with emphasis on the symbiotic relation between botany and geology. He illustrated the text with Indian phenomena, fossil evidence of plants with indirect evidence of their presence, and the evidence of photosynthesis in the geological record. The evidence for photosynthesis in the rock record is varied, but primary evidence comes from around 3000 materials, in rock records and fossil evidence of cyanobacteria, photosynthesizing prokaryotic organisms. Chloroplasts in eukaryotic plants evolved from an endosymbiotic relationship between cyanobacteria and other prokaryotic organisms producing the lineage eventually leading to photosynthesis of eukaryotic organisms in marine and freshwater environments. Both botany and geology were integral in command with agricultural science. Girish Chandra Bose's Geology is the corner stone of his reputation as an agricultural scientist.

Geology is the scientific study of the origin, history, and structure of the Earth. Throughout the ages geology provides essential theories and data that shape how society conceptualizes the Earth. In 1846 D. H. Williams of British Geological Survey was appointed as the geologic advisor to the East India Company. In 1851 Thomas Oldham took charge of office which marks

*Director, Corpus Research Institute, Kolkata; email: corpusri@gmail.com

the establishment of the Geological Survey of India. Pramatha Nath Bose was the first Indian to join the Survey on a graded post and served it for 23 years.

Pramatha Nath Bose is not only a famous geologist of India but also of the world because geology was an adolescent subject in both India and abroad. Pramatha was a graduate of St. Xavier's College, Calcutta from where he passed his B.Sc. degree in 1874 and was awarded the Gilchrist Scholarship to join the London University. In 1878 he again earned a B.Sc. degree there. Together with it he passed a certificate examination of the Royal School of Mines in 1879. He came back to India in 1880 and joined the Geological Survey of India as a geologist. Unfortunately despite his enormous field experience and contribution to imperial wealth he was superseded by his junior British official T. J. Holland as Superintendent. This incident made him a nationalist. During his official carrier his field work led to a discovery of geological India. Starting from his initial work in Nimar, he also excavated the Dhulli, Rajhara iron deposits. These cause the corner stone of the future Bhilai plant. He went on to discover coal in Raniganj, Darjeeling and Assam, copper in Sikkim and many other minerals in Burma even Indian princely states like Indore and Kashmir and he explored oil from sand stone in Kashmir and manganese and iron ore in Durg. It took a lot of courage to plumb into these queries surrounded by wild forest and animals. His exploits in the Narmada Valley help us to understand the rock structure of the Deccan. In the process he contributed immensely to petrology, paleontology, mineralogy and specially fossils. He discovered the unique carbonatite rock and means to extract minerals from granitite stones. His knowledge of stratigraphy helps to understand protohistory and prehistory. He located the Gondwana layer in the Deccan which connects Indian history with Africa. His knowledge of fossils was astounding. He could determine the age of the stones by radio-carbon method. He is held by scientist like Meghnad Saha for discovering the mineral wealth of India. All his findings are recorded in the memoirs and bulletins of Geological Survey of India. Even after his retirement his geologist soul continued to work when he was appointed the superintendent of the mines of the Mayurbhanj state in Orissa. It was here that he located deep cast iron ore in Gorumohisani Area. He had noticed that all his findings were being utilized by the British Government for their own benefit. So, this latest discovery was passed on to the Tatas

and had a contract made between the Maharaja of Mayurbhanj and Jamsedji Tata. This led to the foundation of TISCO at Sakchi or modern Jamshedpur. Even Tatas first biographer Harris has acknowledged Bose's contribution to the rise of the Tatas. At his instance Jamsedji established the Indian Institute of Science in Bangalore and appointed foreign trained Indian scientist in TISCO. This was the beginning of the Industrial Revolution in India.

It is well known that both Pramatha Nath Bose and Girish Chandra Bose were close friends. It was due to his influence that Girish Chandra wrote the Manual of geology for students in a unique vernacular version. P.N. Bose in tern got him to write that immaculate chapter on Indian agriculture in the centenary commemoration volume of Asiatic Society edited by him. Without P.N. Bose in the backdrop the work of Girish Chandra, a kindred nationalist scientist cannot be appreciated.

Girish Chandra defines geology as the knowledge of the firma terra on which we stand its transition and transformation. He contends that geology is not very far removed from botany or physiology. They are integral to geological understanding and vice versa. The hard nature of earth's crust is no indicator of its true nature. Over thousands of years this hard crust has evolved. But geologists trace in it sand, clay, softer rock, marble, etc., which had transformed themselves into the solid crust of the earth. The Himalayas itself has heaved from the seabed due to tectonic displacement and is composed of softer rocks and not igneous granite. This transformation of the Himalayas is evident from the fish fossils on its surface. Many such fossils of animals and plants are captured in stratified rocks. These stratified rocks themselves are born of the sediments thrown by the rivers into the sea. In the Siwaliks, even the fossils of big animals like the elephants and other animals now extinct are visible. Igneous rocks like the granite have crystallized from molten lava. The igneous rocks are the original rocks under the surface and they produce all other kinds of rocks through metamorphosis except those which are come out of the seabed. From the nature of the composition we call some stones as sand stones and some as granular. Some stones have evolved from clay, others from lime. What we call coral is actually the petrification of coral insects. Then there is the marble stone composed of mineral particles. Besides these there are bituminous, dolomite, gypsum and alabaster stones. When the Calcutta Fort

William was constructed after digging deep into the earth all the above rocks were found stratified one above the other but finally grounded on sand of the coastal area. This shows that the eastern zone was a soft soil area out of river deposits unlike the igneous rocks of the Gondwana belt of the Deccan. In paleontology it is possible to trace the origin of the many north Indian mountains including the Himalayas through a study of the different kinds of fossils. Fossils can indicate the nature and age of the mountains and highlands. These established the intimate link between geology and botany and other kinds of animal life. Not all fossils are sea born. They could be also terrestrial and caught between jutting rocks. Thus geology can provide the history of the earth's vegetation more correctly than any other science. It provides clue to both organic and inorganic substances. Thus paleontology and morphology are two vital branches of geological science to understand the earth's crust. The various transformations due to earth quakes and tsunami are visible in the chequered surfaces fractures and faults. The removal of the top soil by overflow of rivers exposes the root stone. Again the dumping of powdered hard rock's brought by rivers creates alluvial soil. The geologists can excavate and discover layers of mineral deposits for industrial use. As a geologist P.N. Bose did field work almost all over India and discovered coal in Madhya Pradesh, iron ore in Bihar and Orissa, lime stone in Assam, gold in Kashmir, Karnataka and Chhotonagpur. Civilizations are marked by rock formations like Chalcolithic, Neolithic, Paleolithic stages. The dating of these civilizations is possible from radio carbon analysis.

Girish Chandra Bose was a pioneer agronomist of modern India. Basically a student of botany, he passed both BA and MA degree in that subject from Hooghly Mohsin College with distinction. Even before he completed his MA he was selected by the Government to become a lecturer in botany in Ravenshaw College, Cuttack. After some years he became a government scholar to go to England to study agriculture. He joined the Cirencester College for higher studies in agriculture in which he got a diploma of excellence. Botany was a parent subject of agriculture and as such he could also hone his knowledge of botany. In 1920 he published his '*A Manual of Indian Botany*' from Blackie and Son Limited, Bombay which had branches in London and Glasgow.

Maybe one of the first naturalists to adopt botany on a geological dating problem was the English ambassador in Naples: Lord William Hamilton

(1730-1803). Hamilton used the density and kind of vegetation cover to interfere the age of lava flows of Vesuvius. Before any other influences began to fashion life and its lavish diversity, geological events created the initial environments - both physical and chemical - for the evolutionary drama that followed. The history of botany examines the human effort to understand life on Earth by tracing the historical development of the discipline of botany—that part of natural science dealing with organisms traditionally treated as plants. Rudimentary botanical science began with empirically-based plant lore passed from generation to generation in the oral traditions of paleolithic hunter-gatherers. The first written records of plants were made in the Neolithic Revolution about 10,000 years ago as writing was developed in the settled agricultural communities where plants and animals were first domesticated. The first writings that show human curiosity about plants themselves, rather than the uses that could be made of them, appears in the teachings of Aristotle's student Theophrastus at the Lyceum in ancient Athens in about 350 BC; this is considered the starting point for modern botany. Paleobotany, also spelled as palaeobotany (from the Greek words paleon = old and "botany", study of plants), is the branch of paleontology or paleobiology dealing with the recovery and identification of plant remains from geological contexts, and their use for the biological reconstruction of past environments (paleogeography), and both the evolutionary history of plants, with a bearing upon the evolution of life in general. A synonym is paleophytology. Paleobotany includes the study of terrestrial plant fossils, as well as the study of prehistoric marine photoautotrophs, such as photosynthetic algae, seaweeds or kelp. A closely related field is palynology, which is the study of fossilized and extant spores and pollen. Paleobotany is important in the reconstruction of ancient ecological systems and climate, known as paleoecology and paleoclimatology respectively; and is fundamental to the study of green plant development and evolution. Paleobotany has also become important to the field of archaeology, primarily for the use of phytoliths in relative dating and in paleoethnobotany, Scientists start the search for fossil evidence of plants with indirect evidence for their presence, the evidence of photosynthesis in the geological record. The evidence for photosynthesis in the rock record is varied, but primary evidence comes from around 3000 Ma, in rock records and fossil evidence of cyanobacteria, photosynthesizing prokaryotic organisms. Cyanobacteria use water as a reducing agent,

producing atmospheric oxygen as a byproduct, and they thereby profoundly changed the early reducing atmosphere of the earth to one in which modern aerobic organisms eventually evolved. This oxygen liberated by cyanobacteria then oxidized dissolved iron in the oceans, the iron precipitated out of the sea water, and fell to the ocean floor to form sedimentary layers of oxidized iron called Banded Iron Formations (BIFs). These BIFs are part of the geological record of evidence for the evolutionary history of plants by identifying when photosynthesis originated. This also provides deep time constraints upon when enough oxygen could have been available in the atmosphere to produce the ultraviolet blocking stratospheric ozone layer. The oxygen concentration in the ancient atmosphere subsequently rose, acting as a poison for anaerobic organisms, and resulting in a highly oxidizing atmosphere, and opening up niches on land for occupation by aerobic organisms. Evidence for cyanobacteria also comes from the presence of stromatolites in the fossil record deep into the Precambrian. Stromatolites are layered structures thought to have been formed by the trapping, binding, and cementation of sedimentary grains by microbial biofilms, such as those produced by cyanobacteria. The direct evidence for cyanobacteria is less certain than the evidence for their presence as primary producers of atmospheric oxygen. Modern stromatolites containing cyanobacteria can be found on the west coast of Australia. Chloroplasts in eukaryotic plants evolved from an endosymbiotic relationship between cyanobacteria and other prokaryotic organisms producing the lineage that eventually led to photosynthesizing eukaryotic organisms in marine and freshwater environments. These earliest photosynthesizing single-celled autotrophs later led to organisms such as Charophyta, a group of freshwater green algae.

When Girish Chandra Bose writes about the roots once again there is a striking similarity with J. C. Bose's theory of Sap: Roots usually have to make their way through the soil, in which considerable obstruction and resistance await them. Their young, growing, delicate tips are therefore provided with a layer of protective tissue which is known as the Root-cap. Girish Chandra Bose sounds poetic when he concludes on the roots by saying that roots usually grow underground and serve to fix the plant to the ground, so that the plant may not be at the mercy of the winds and the waves.

The plant roots hold the soil particles together, preventing soil erosion and helping to retain nutrients. The presence of organic materials, roots and

roots hairs in the soil helps in the retention of water by slowing down drainage. Vegetation acts as an interface between the atmosphere and the soil, increasing the permeability of the soil to rainwater and thus decreasing runoff. It shelters the soil from wind, resulting in decreased wind erosion, as well as advantageous changes in microclimate. Plant roots bind the soil together by interweaving with other roots, forming a more solid mass that is less susceptible to both water and wind erosion

Geology is a science that studies all aspects of the terrain (mountains, deserts, rain forests, etc.) as well as all aspects of the soil composition within a geological terrain. Only certain types of plants can live in specific terrains (for example, cactus in extreme deserts) and only specific plant types can live in soils that are, for example, very wet, nitrogen rich, nitrogen poor, etc. So, there is a very strong relationship between the geological aspects on a terrain and the plant life found within that terrain.

The summary of the text on geology by Girish Bose shows his ability to inform learners of the pros and cons of the subject within hundred pages. No other text in Bengali existed before he took up his pen. One remarkable thing of the book is the creative and skilful vernacularisation of the English terms and terminology of one of the intricate sciences beyond the tripartite courses of science consisting of physics, chemistry and mathematics. The second remarkable aspect is his ability to illustrate the text with Indian phenomena. His love for geology came from his basic commitment to botany. He begins the book with emphasis on the symbiotic relation between botany and geology. Without knowing the nature of the soil, it is difficult to explain the birth, growth and decay of plants. Even today, soil conservation remains one of the basic elements of the syllabus of botany and forestry. So as a botanist he was inevitably attractive to geology as a subject. It was not just the primer of another science for school children. His interest ran deeper than that. His final destination was agricultural science on which he had written profusely. Both botany and geology were integral to a command over agricultural science. This can be unfolded while plumbing through his work on agriculture. Mention may be made of the fact that he was a close friend of the eminent geologist Pramatha Nath Bose who had inducted him to write a chapter on Indian agriculture in the Centenary History of the Asiatic Society edited by him. Similarly, Girish Chandra was deriving the

geological expertise of his friend to write this manual on geology. They were kindred spirits. Girish Chandra Bose's geology is the corner stone of his reputation as an agricultural scientist. Its value in popularization of basic sciences is immense and persisting even today.

Note

All information is drawn from the vernacular text on geology (*Bhutattva*) by Girish Chandra Bose, Calcutta, 1881

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