BARADANANDA CHATTERJEE

(1912–1967)

Elected F.N.I. 1960

Early Life and Education

Baradananda Chatterjee was born in 1912 in Guskara, a village in the district of Burdwan, West Bengal. Having lost his parents before he was nine years old, he grew up under the care of his elder brother who doted upon his gentle, handsome and bright-eyed younger brother with all the affection of a father. His early education was not particularly eventful but he was remembered as a diligent and disciplined student in his school and college careers. In later life he made virtues of these qualities.

Dr Chatterjee passed his B.Sc. examination in 1932 with Second Class Honours in Chemistry from the City College, Calcutta, and in 1934 he obtained his M.Sc. degree of the University of Calcutta with a first Class with Physical Chemistry as his special subject. Soon after, he began his research work under Professor J. N. Mukherjee, then Khaira Professor of Chemistry, University of Calcutta. He was admitted to the degree of Doctor of Science on the merit of his thesis on "Electrochemical properties of silicic acid sols; the role of aluminium in interaction of hydrogen clays with neutral salts, and the use of sodium perrocyanide as a dispersing agent in the mechanical analysis of soils". During this period he was appointed research assistant under a research scheme sponsored by the Indian (then Imperial) Council of Agricultural Research. In 1937, he was awarded by the University of Calcutta the coveted *Nagarjuna Gold Medal* for his work on the "Electrochemical properties of colloidal silicic acid" which was adjudged the year's best piece of research work. Two other papers on the electrochemical properties of silicic acid sols published by him in the *Journal of the Indian Chemical Society,* won him the Society's *J. M. Das Gupta Memorial Gold Medal.* During 1942–46, he worked as an honorary lecturer in the University of Calcutta in the Department of Chemistry. In 1946, he was awarded a Government of India overseas research scholarship which enabled him to spend two years at the Universities of Wisconsin, Missouri and Cornell in USA and carry out post-doctoral research work in the laboratories of such eminent soil scientists as Professors C. E. Marshall, E. Troug and R. Pradfield.

Professional Career

On his return to India, Dr Chatterjee was appointed as Physical Chemist at the Indian Agricultural Research Institute, New Delhi. Here, he reorganised the

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Soil Science and Analytical Sections of the Division of Chemistry and gave courses in Physics and Chemistry of Soils and Clays to the post-graduate students.

Dr Chatterjee joined the Bengal Engineering College, Sibpur, Howrah, West Bengal in 1947 and became Professor and Head of the Department of Chemistry, Metallurgy and Geology in 1956 and later its Vice-Principal in 1964.

He was associated with a rumber of learned societies and institutions in various capacities. They include : Indian Chemical Society, Indian Science News Association, Indian Science Congress Association, Indian Association for the Cultivation of Science, Indian Society of Soil Science, Indian Institute of Metals, National Institute of Sciences of India (now Indian National Science Academy), International Society of Soil Science and Society of Sigma Xi (USA), Calcutta University as member of the Senate, Faculties of Agriculture and Engineering, and Undergraduate Boards of Studies in Engineering and Geology. He was for sometime Associate Editor, *Indian Journal of Chemistry,* Member of the Standing Committee on Manures and Fertilizers, Government of West Bengal, Teacher Representative on the Governing Body of the Bengal Engineering College.

Scientific Contributions

As mentioned earlier, Dr Chatterjee began his research work in the laboratory of Professor J. N. Mukherjee who was at that time interested in the properties of soil colloids. The latter are silicates in which silica or silicic acid is the major constituent. In order, therefore, to understand the colloidal and surface characteristics of silicates, Dr Chatterjee chose to study the colloidal properties of silicic acid sols in great detail. Preliminary work showed that silicic acid sol was unstable and readily formed a gel in presence of trace and accidental impurities, so that reproducible experiments were difficult to perform with it. Here, Dr Chatterjee's manipulative skill, ingenuity and close attention to detail resolved the difficulty. With the help of careful electrometric titrations he could establish their characteristic features, the regular cation effects, confirming the lyotrope series, and also the specific cation effects which violated the series, and the increase in titratable acidity in presence of neutral salts. The interaction of bases and salts could be explained with the help of Mukherjee's postulate of the electrical double layer associated with a colloidal particle. According to this theory, some of the counterions are osmotically active while others are osmotically inactive. By careful manipulation and patient experimentation, Dr Chatterjee could find out the critical concentration of potassium chloride which could not only distinguish the two categories but also enabled him to separate them and analyse them quantitatively by means of electrometric titration.

Dr Chatterjee was eventually drawn into the mainstream of soil colloid studies which were actively being pursued in the laboratory of Professor J. N. Mukherjee.

His first exposure to soil research was in connection with a comparative study of some well-known methods of mechanical analysis of soil sponsored by ICAR. Aware of the exceptional skill and meticulous care with which Dr Chatterjee handled analysis of all kinds, Professor Mukherjee entrusted him with this work. In the course of his painstaking work, he devised a simple method of his own, which was based on the dispersive ability of sodium ferrocyanide on soil clays.

The most extensive work carried out by him in the field of soils, refers to the study of clays and clay minerals isolated from, particularly, West Bengal soils. The electrochemical part of the work was an extension of that done on silicic acid sols, which formed the basis as it were. But a complex situation is faced in the case of soil clays and clay minerals. This refers to the liberation of aluminium from acid soil clays, the mechanism of which was not properly understood. By means of carefully designed experiments carried out to study the interaction of acid clays with salts and bases, Dr Chatterjee could unravel the mechanism. He demonstrated that aluminium ions were not formed by any dissolution process as believed earlier, but were exchanged from clays for other cations particularly hydrogen ions. Repeated conversion of the clays into the acid form and treatment with salts brought gradually less and less aluminium ions into solution, and after several such treatments the concentration of liberated aluminium ions was negligible. He could establish a relationship between the amount of exchange acidity i.e. hydrogen ions liberated, and aluminium ions liberated in the process. In fact, the acid clays were not pure hydrogen ion exchangers, but hydrogen-aluminium ion exchangers. This concept was later confirmed and developed by other workers.

Soil clays are usually mixtures of several clay minerals, one of which generally predominates, but the influence of one mineral on the behaviour of others may be considerable. Dr Chatterjee observed that the electrochemical properties of mixtures were not always additive and the mutual influence was sometimes appreciable. The distinctive features of clay, which are aluminosilicates, from mixtures of silicic acid and aluminium hydroxide sols were also established by him.

In building up what is now known as the Calcutta School of Soil Colloids headed by Professor J. N. Mukherjee, Dr Chatterjee played a key role. It was established by this School that electrochemical measurements supplementing those of X-ray, Optical (petrographic) and Differential thermal analysis provide adequate information for identifying the clay mineral make-up of soils. Dr Chatterjee and his research students took advantage of these techniques and began a series of systematic investigations on the clay mineral composition of Indian soils on a profile basis. This scheme was financed by the ICAR, and was to continue further in view of the value and importance of the contribution. But following Dr Chatterjee's death, the scheme had to be terminated.

The soil ingredients are conveniently divided into inorganic and organic. The silicates and other metal oxides which constitute the inorganic part represent the bulk of the soil. The organic part is usually a small fraction and may vary from 0.1 or less to 10% or higher in peaty soils. Even though small in quantity, the influence of organic matter in modifying soil properties is not inconsiderable. But adequate information on soil organic matter was not known at that time. It is equally, if not more, complex than the silicates. Dr Chatterjee began to investigate the colloidal properties of soil organic matter, also called humus, by means of the same techniques as were applied to understand the silicic acid and clay sols. He could thereby establish the existence of lyotrope series in the interaction of colloidal humus with salts and bases. A striking similarity between two diverse soil ingredients was thus demonstrated. His researches gave an impetus, so to say, to a more vigorous study of soil organic matter by some of his colleagues in the laboratory.

Dr Chatterjee also initiated the measurements of ion activity by means of clay membrane electrodes, a technique which he had acquired in the laboratory of Professor Marshall. He showed that the free energy of monovalent cations in homoionic clays was much higher than that of bivalent cations, and that amongst the cations of the same valence, the variations follows the rule of lyotropic series. He used the clay membrane electrodes to measure activity of copper ions in very small concentrations, showing how this trace metal cation in soil could be determined. This line of investigation also sparked off a number of studies by some of his colleagues on the electrochemistry of clay mineral membranes and resin membranes and of many interesting measurements in the field of analytical chemistry by using these membrane electrodes.

At the University of Madison, Wisconsin, Dr Chatterjee worked for several months in the laboratories of Professors Truog and Jackson, and obtained a first hand knowledge of the problems of soil fertility and crystalline forms of soil clays. On the basis of his work there, he published a joint paper on the behaviour of clay minerals under the electron microscope. He continued similar investigations at the University of Cornell, another very well-known centre for soil research.

The second most important phase of Dr Chatterjee's research career opened up soon after he joined in 1949 the Bengal Engineering College. There he continued his researches on soils and soil colloids but at the same time he began to develop the following lines of investigation : (*i*) corrosion of metals and alloys by soil and its remedy; (*ii*) study of the catalytic decomposition of carbon monoxide in presense of metals; and (*iii*) decarburization and dephosphorisation of cast iron alloys by gaseous hydrogen. In each of these investigations, Dr Chatterjee left the impress of an astute physical chemist and a cautious experimenter.

His work on the cathodic protection of mild steel and cast iron against soil corrosion by the use of sacrificial anodes made of aluminium alloys was a significant contribution.

The role of catalysts, such as iron, cobalt and nickel in the decomposition of carbon monoxide, the mechanism of the reaction, possible inhibitors etc are questions of great metallurgical interest. They were thoroughly studied by him and the results were published over a period of eight years in a number of papers. Of similar metallurgical interest was Dr Chatterjee's systematic work on decarburisation and dephosphorization of cast iron and alloys by hydrogen, which included study of their mechanisms, and more particularly the role of moisture in the reactions.

Good portions of Dr Chatterjee's contributions in the field of soil colloids and clay minerals, especially those concerned with their physical and physicochemical properties have found place in standard publications such as the following :

(*i*) *The Colloid Chemistry of Silicate Minerals* by C. E. Marshall, Academic Press, 1949.

(*ii*) *The Clay Minerals* by R. E. Grim, McGraw-Hill, 1954.

(*iii*) *The Physical Chemistry of Silicates,* by W. Eitel, The University of Chicago Press.

(*iv*) *The Colloid Chemistry of Silica and Silicates* by R. K. Iler, Cornell University Press.

The work on gas-metal reactions has been reported in Metal Progress (1950) as important contributions to metallurgy.

Research Guidance and Teaching

Even as a research assistant in the Department of Chemistry at the University College of Science and Technology, Calcutta, Dr Chatterjee was called upon to take classes with post-graduate students and assist them in their thesis work. He was asked to deliver a course of lectures on electrochemistry of clay and clay minerals to graduate students at the Universities of Madison, Missouri and Cornell, USA. As Physical Chemist at the Indian Agricultural Research Institute, New Delhi, he taught post-graduate students Physics and Chemistry of Soils and Clays. The longest and most sustained teaching was done at the Bengal Engineering College where he gave courses on physical and inorganic chemistry and electrometallurgy.

Personal Life and Qualities

In all his capacities, Dr Chatterjee used to assist and advise a large number of students in their thesis work. Starting from 1949 when he joined the Bengal Engineering College, he began to guide Ph.D. students, and about two dozen got their degrees working directly under his guidance.

To the new entrants to Professor J. N. Mukherjee's laboratory Dr Chatterjee was a great source of inspiration. Not only were they initiated by him to the mysteries of research but his personal dedication and behaviour were also worth emulation. They wondered at his performance in the laboratory and tried to imbibe the meticulous care with which he designed his experiments and carried them to successful completion Because he was a very cautious worker, he valued his experiments highly and as such would not waste time on doing anything redundant. He used to analyse of problem very carefully before he set out to plan the minimum number of experiments which he considered crucial. He hated to do random experiments or shooting in the dark as some were wont to. As a teacher, he gained an enviable popularity amongst students, not only in the class but also outside it. His doors either in the laboratory or at his residence were always open to his students. To them he was an affectionate person having an infinite store of forgivness.

It was his many inimitable personal qualities which made him so attractive to all who came in contact with him. To the extent he was serious in his academic and scientific pursuits and in attending to his responsibilities he was indifferent to affairs mundane, especially when they concerned himself. In spite of his great erudition and high position, Dr Chatterjee was always a modest person and felt shy in accepting honours and laudatory remarks about himself and his work. He fulfilled his ambition to lead a simple, quiet and honest life and to this end he stoically avoided coming to limelight. In his death we have undoubtedly lost a scientist of great promise. Those who came in contact with him from whatever walks of life could not remain unattracted by the touch of his golden heart.

Saturday, December 9, 1967 was the fateful day. It began like any other day. Dr Chatterjee took his morning classes, attended to his official duties, witnessed on his way home students' sports and exchanged pleasantries with his students and colleagues. After a hurried lunch he was getting ready at 1.30 to leave for the laboratory, when he suddenly felt dizzy and fell down on the floor and asked his servant to call for medical help. It was a case of cerebral thrombosis and all possible aid was of no avail. The end came nine hours fifteen minutes later, in the night.

Dr Chatterjee left behind his wife, Dr Asima Chatterjee, the celebrated organic chemist and Ex-Khaira Professor of Chemistry of the University of Calcutta and only daughter Dr (Mrs) Julie Banerjee, receipient of several academic awards including the Young Scientists' award of the Indian National Science Academy, and at present lecturer in Chemistry, University of Calcutta. The son-in-law, Dr Avijit Banerjee, also a brilliant chemist, is a reader in the University of Calcutta.

Research Publications

A list of his publications is appended, which has been arranged in accordance with the broad subjects of research topics. It was characteristic of Dr Chatterjee to use Indian journals for publication of his papers. He followed this principle assiduously and urged upon others to do so, believing that it was no less prestigious than publishing in foreign journals, and that this practice was one of the means by which the standard of our journals could be raised.

S. K. Mukherjee
Asima Chatterjee

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