

programme is the Ganga Basin where the evolutionary history of most landforms remains poorly understood because of the general non-availability of sub-surface geological data. The lack of drill cores has been a serious impediment in advancing our understanding of the history of alluvial plain sedimentation. This note is attempted to highlight the major research areas being covered under SSS programme and to invite a greater participation from the research community.

The Ganga Plains constitute one of the world's most extensive alluvial tracts and are home to hundreds of millions of people, mostly dependent on agriculture. They constitute a dynamic fluvial region traversed by big rivers (Ganga-Yamuna) that are sourced in the Himalayan orogen, as well as rivers such as the Betwa, Chambal, Ken, and Son that are sourced in the central Indian Craton. Additionally, many smaller, plains-fed rivers are sourced within the plains. The underlying Ganga Basin contains up to several kilometers of alluvial strata. The Ganga plains are of great significance from an academic standpoint, as they hold important clues regarding the tectonic and climatic factors that governed the interaction between the Himalayan orogen and the Foreland. Understanding the landforms of the Ganga Plains - their origin, development and dynamic imprints - is therefore of critical significance to plan effectively for sustainable development of the region. It is necessary to study the plains to track changes in the alluvial landscape on different time scales - (for example decadal, century, millennial and higher order time scales of  $10^4$  -  $10^5$  years). For a comprehensive understanding of the plains, multiple approaches must be adopted that combine modern process studies, Holocene environmental change, and alluvial stratigraphic development in the shallow sub-surface (~100 m depth).

The academic interest in the Ganga Basin has been focused along three major lines, (a) sediment discharge budgets, (b) description of the geomorphic and sedimentologic features and (c) geophysical prospecting to describe the subsurface mainly for hydrocarbon exploration. Despite several advances, few issues related to the Ganga Plains research, such as, spatial

homogeneity across vast plains, inland response to fluvial systems to sea level changes, control of alluvial architecture below Ganga Plains have been intensely debated in recent years. There are several questions that need answers, for example, how long has the Ganga River been near its present position, and has it ever inundated the interfluvium to the south? How have the Himalayan and cratonic rivers competed in the geological past to evolve the Ganga plain stratigraphy? Is the modern geomorphic setting of considerable antiquity, or have the major rivers been more mobile in the past and able to migrate more freely? What has been the rate of such migrations and what has been the role of thrusting and deformation along the Himalayan Front to the north? How do variations in monsoonal intensity reflect in the sediment record of valleys and interfluviums? Can distinctive stratigraphic patterns be used to test models of landscape evolution across the vast expanse of the Ganga plains?

Most of these questions require an in-depth analysis of sub-surface stratigraphy which has not been possible so far due to limited exposures across the plains. Systematic drilling in this region has been non-existent except for some cores raised by us supported by earlier research funding from the Department of Science and Technology and other sources. In this context, the initiation of the SSS programme is a very important development. Most projects in the SSS programme plan to use drilling and coring which is an expensive and time-consuming process. It is absolutely essential that the cores collected are logged, preserved, and made available for further studies to the researchers across the country. Therefore, the SSS programme is also supporting a 'National Facility of core archival and analysis' at IIT Kanpur. This facility would archive all the cores raised in the Ganga basin by researchers at IIT Kanpur as well as elsewhere and would develop an inventory of all cores. The major components of this facility are (a) large cold rooms with compartments for sub-zero as well as near zero temperature storage of sediment samples, (b) Drill core scanner for generating continuous records of magnetic susceptibility and natural gamma ray, (c) logging and sedimentology lab,

(d) environmental magnetism lab, and (e) microscopy lab. Attempts would also be made to develop a luminescence lab for dating of sediments in near future. All further developments regarding this facility would be announced through the pages of this journal.

Besides supporting the research at IIT Kanpur, it is hoped that this facility would help the researchers across the country to use the core samples to perform a variety of analysis such as palynology, geochemistry, stable isotopes which are critical for paleoclimate research. The IIT Kanpur would play the role of the nodal agency to coordinate the paleoclimatic research on the Ganga plains and this is an open invitation to all concerned to develop collaborative research in this area. It is also hoped that all funding agencies would support such proposals to foster inter-disciplinary research in the Ganga plains.

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### **Synthesis and Characterization of Technologically Important Phosphates**

The prosperity of human civilization is greatly influenced by mineral resources, technology and the culture since prehistoric period. In fact, one can say that the mineral resources and the technology are two sides of the growth and development of human civilization. In general, the state of development of a nation could be assessed by the quality and quantity of the minerals produced and used by it. As such mineral resources are the backbone of modern technology. But most disconcerting aspects are, the technologically and strategically important natural minerals for the industries are depleting at an alarming rate and added to this, the natural minerals are non-renewable resource unlike agricultural resources. Thus there is a great thrust on geoscientists and material scientists for the synthesis and growth of synthetic counterparts of mineral resources in large scale and hence emerged a new branch of science as 'Crystal Growth'.

There are over three hundred natural phosphate minerals. These minerals are

mainly used in fertilizer, alloy and refractory industries and these cannot be used as such in any technological applications due to impurities they contain, resulting in poor properties. However, the basic structure of these minerals are ideal for technological applications as electronic devices, as solid electrolytes, sensors, laser materials and as piezoelectric, pyro-electric, luminescence, opto-electronics, magnetic materials, as ceramics, catalyst, resistant corrosion, solid electrolytes, etc. Hence, it is more appropriate to look for synthetic counter parts of these natural minerals. Keeping this in mind, scientists began synthesizing phosphate materials in the laboratory. The pioneer work on the synthesis of phosphates began in the eighteenth century. Berzelius in 1816 synthesized sodium pyrophosphates. Later in 1889 Johnson synthesized  $\text{LaP}_5\text{O}_{14}$ . However, the technological importance of phosphates gained momentum only during 1940s, when  $\text{NH}_4\text{H}_2\text{PO}_4$  was first used in the piezoelectric application. During 1970s the technological importance of phosphates was realized to greater extent as the colour luminophors, piezoelectric, solid-state lasers, sensors, ceramics, solid electrolytes, semiconductors, superconductors, super ionic conductors, etc. Interest in the synthesis/growth of phosphate materials gained a great leap particularly after the development of alkaline rare earth phosphate materials, which are the potential laser materials. The report of NASICON, which consists of silicate-phosphate end members in 1976, attracted much attention of scientists through out the world, because it has been considered as a superior three-dimensional fast ionic conductor. Manifold variation to these NASICON compounds has led to the development of several

hundreds of new compounds popularly known as NASICON Analogues. Most of the reported phosphates were synthesized by solid-state reactions, melt techniques and flux methods. However, the phosphates grown/synthesized by these techniques have shown non-stoichiometry in composition, polycrystalline nature, only crystallization of high temperature phases, unavoidable presence of ions of the flux as impurities in the crystals, evaporation of alkali components and exhibit poor ionic conductivity values.

For the growth/synthesis of phosphate by hydrothermal technique is a better than others, owing to its advantages such as the relatively low temperature requires for synthesis. Moreover, as growth occurs in a closed system, gas fugacity plays an important role in the synthesis process. It is also noticed, the phosphate materials obtained by these techniques are generally exhibit stoichiometry in composition, as required in relatively high technological applications.

The author and co-researchers have carried out synthesis/growth of alkali bearing transitional/rare earth bearing phosphates using hydrothermal techniques at different P-T-X conditions and were able to develop more than 30 different group of phosphates and phosphide in the form of single crystals and a few as nano materials. The crystal morphology and habits play a vital role in the growth of high quality crystals. The morphology in these phosphates crystals varied with the growth conditions, degree of super saturation, initial concentration of metal salts, etc. Habits like platy, prismatic, tabular, needle like, fibrous, rhombohedral, columnar, acicular, dendritic, euhedral are common and showed positive growth correlation up to

critical concentration of initial components, beyond which the growth size reduced sharply. Most of these compounds attained higher growth rates within 9-12 days and further increase in the duration of the experiments, yielded marginal change in the growth rates, but the quality of the crystals is decreased.

It is essential to understand the characteristic properties of the compounds, which are seem to be potential materials in the device applications. DTA studies revealed, these phosphates have exhibited relatively moderate to high thermal stability. FT IR results exhibited three to four prominent vibration bands with high degree of sharpness and multiplication indicating polymerization of  $[\text{PO}_4]^{3-}$  to  $[\text{P}_2\text{O}_7]^{4-}$  to  $[\text{P}_3\text{O}_9]$ . Single crystal X-ray results revealed these phosphates having framework structure with tunnel type of cavities, which is prerequisite for fast ionic conductivity. Magnetic properties will provide rich information relating to their electronic structure and nature of the bonding involved in the molecule, oxidation state, and magnetic field sensor properties and also symmetry properties of compounds. Phosphates are diamagnetic. But in the present investigations, phosphates are paramagnetic and exhibit positive correlation with temperature and field strength and prospective magnetic materials. It is due to the bonding of P-O-M (M= transitional metal ions). Impedance spectroscopic results have revealed, these phosphates seem to be potential fast ionic conducting materials.

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