viscoelastic liquids was dealt with. In this connection, a new type of instability was predicted for viscoelastic fluids. Kulkarni spoke on ‘Surface-engineered small particles’, especially dealing with synthesis of a variety of materials with specific size and shape. She spoke about how physico-chemical properties can be tuned by changing the size (in nanoscale), choosing materials such as silica, alumina, polymers, zinc oxide and titanosilicate.

Mishra spoke about the interaction between B cells and CD8$^+$T cells in the lecture entitled ‘Differentially activated B cells acquire different capacity to activate CD8$^+$T cells’. A mechanism of B cell surface TGF-b1-mediated hyporesponsiveness leading to reduction of immune response of CD8$^+$T cells was discussed. In the last presentation, Ramdorai spoke about ‘Elliptic curves and number theory’. She posed a number of questions related to elliptic curves and discussed the tools which would provide answers to these questions. She also gave references to ancient mathematics and how some of the questions of number theory were realized much earlier.

The meeting, which was attended by about 250 participants, concluded with an address by S. Chandrasekaran (IISc), Secretary of the Academy. In the sidelines of the meeting, events such as the release of a Vision Document on Astronomy and Astrophysics (Box 1) and an interactive session on Science Education Initiative of the Academy (Box 2) also took place. Now it is time to look forward to scientific deliberations and related events during the forthcoming 71st annual meeting of the Academy in Tiruchirapalli during 11–15 November 2005.

Mrinalini G. Walawalkar (*S. Ramaseshan fellow*), C-137, IIT Quarters, Indian Institute of Technology, Bombay, Powai, Mumbai 400 076, India.
e-mail: mmm@chem.iitb.ac.in

MEETING REPORT

The fluid earth*

The most consequential dynamical processes of the earth system are mediated by fluid flows. These include not only the obvious wind and ocean currents or river, lava, geyser and debris flows, but material flows beneath the outer thin, colder, brittle lid of the earth, which set the basic conditions for planetary evolution: distribution of land and sea, topography, volcanic and earthquake regimes, climate and glacial cycles, and evolution of mineral and hydrocarbon resources as well as of life forms among others, such as the earth’s magnetic and gravity fields. Indeed, rightly intuiting this fundamentally fluid nature of the earth, Newton, in the 17th century, interpreted its equatorial bulge to be the result of a rotating fluid sphere, and proceeded to calculate its ellipticity, a figure remarkably close to the currently accepted value.

This view of the earth remained eclipsed for a while between the late nineteenth and mid-twentieth century by the inference that apparently the earth was not only solid up to great depths, but had a rigidity greater than that of steel, as required by the propagation of seismic waves and investigations of earth tides, both involving short-term periodic stresses. Meanwhile, conceptual advances in our understanding of solid-state creep and subsolidus convection in the earth’s mantle, together with evidences of sea-floor spreading and application of Euler’s conditions for rigid body motion of spherical caps already formulated over a century ago, helped reinstate the viscous fluid-like behaviour of the earth’s mantle, in a new and more elaborately defined form with the recognition, in the 1970s, of plate tectonics. This unique thermodynamic engine evolved in the solar system by planet earth for the transfer of its internal heat, predicated by its special endowments of just the right mass and just the right distance from the sun, provides the fundamental geodynamical framework which is believed to account for virtually all terrestrial phenomena known or observed today. Inevitably, thereafter, fluid dynamicists set to address the problems of the ubiquitous two-phase flows in the earth system[1,2], as an analogue for a host of geological processes both at high and low Reynolds numbers. These analytical developments basically exploiting the conservation laws of mass, momentum and energy in advecting fluid regimes, and further refined since, now enable scientists to set bounds on critical geophysical conditions such as the amount of melt fraction required to separate it from the residual solid phase, before it can become a potent dynamical agent. This fraction, assumed by geologists for over a century to be ~10%, was thus shown to be no larger than ~2–3% on fluid dynamical considerations, a figure now also confirmed by ion probe studies of the geochemical composition of melts trapped in olivine crystals beneath axial spreading centres. ‘Geological fluid dynamics’, a term voiced by Herbert Huppert of Cambridge University, continues to demonstrate its illuminating potential in refining our understanding of critical earth processes: high Reynolds number flows as in the flow of atmospheric particles, sediment, and crystallization in magma chambers (Figure 1), as well as those of low Reynolds numbers such as melt generation and movement, sediment compaction, metamorphism and reservoir engineering. In the process it has also led to a better comprehension of how low-viscosity fluids react with high-viscosity ones to alter the chemistry and thereby the rheology of

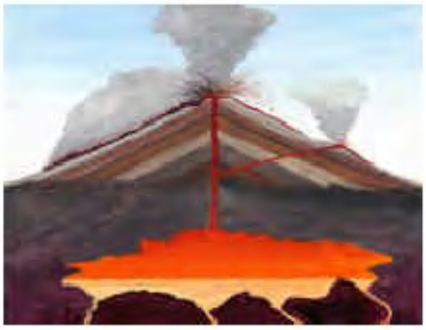

Figure 1. Magma conduit in cross-section.

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*A report on the Discussion Meeting of the Indian Academy of Sciences, Bangalore held in January 2005.

both: sediment diagenesis, fluids in metamorphic rocks, migmatization, upper mantle and lower crust geochemistry, river and coastal pollution, waste disposal and groundwater contamination. Indeed, this renewed paradigm of the 'fluid earth', by exploiting the well-known principles of fluid dynamics and thermodynamics, has the promise[3], to transform the science of the earth into a quantitative endeavour of hypothesis formulation, testing and validation.

Moved by an urge to widen the intellectual equipment of Indian earth scientists to academically incorporate and exploit the potential of geological fluid dynamical principles in the resolution of critical earth issues such as 'wherein the lithosphere does strength reside?' or 'how do we reconcile the widely recognized association of extentional metamorphic core complexes implying flow, with the putative rigidity of the lower crust?', the Indian Academy of Sciences, Bangalore sponsored and held a discussion meeting on the subject. The meeting was timed to take advantage of the presence in India, of Herbert Huppert, a pioneer in the field, who led the meeting with a few priming talks on the subject. The meeting was attended by 8 participants mainly from the National Geophysical Research Institute, Hyderabad and the CSIR Centre for Mathematical Modelling and Computer Simulation (C-MMACS), Bangalore. A few earth scientists from the academia, who had earlier responded to the first invitation, finally expressed their inability to attend, thereby dashing hopes that the subject would be considered for incorporation in revised earth sciences curricula, as has happened in the past decade in several forward-looking institutions such as Cambridge University.

Discussions at the meeting began by drawing attention to a host of earth science issues (vide list given at the end), essentially involving material flows, and how their solutions could be greatly facilitated using the powerful concepts of structural homologies and geometrical similitude. Towards the close of the four-day meeting, Huppert also delivered a highly evocative Academy public lecture presided over by Roddam Narasimha.

Unfortunately, the possibility of this meeting marking a turning point in the formulation of earth science curricula of the 21st century, through an intimate appreciation of the fluid geological issues by academics, was lost because of the want of what had been hoped for, i.e. a spirited interest among them. This might perhaps have been subliminally encouraged by an assumption that it would involve daunting mathematical frameworks not easily assimilable in the extant system. However, these apprehensions would appear to be somewhat misplaced if one considers the practical possibility of designing a flexible course structure that can be quantitative without being overly mathematical, by stimulating exploration of an intuitive perception of flows through simple experiments and calculations designed to suit specific strengths of students. Huppert, in his evening lecture demonstrated this most evocatively, by pouring some honey on a transparency placed over a projector, and letting it display its subsequent spread on the screen. The three-year graduate courses today expectedly impart a reasonable background of the principles of physics and chemistry as well as a fair degree of facility to use the symbolic language of mathematics. It is felt that this could be imaginatively used to prepare students to handle real-world problems of the dynamical state of the shallow earth, formerly a free resource of water and soil, but today a competitive space for waste disposal inevitably suffering unwholesome alterations, all mediated by fluid flows, not to mention the many fundamental issues of earth structure and processes illustrated above. Inclusion of the study of fluid earth as a part of the core curriculum of earth sciences, should not only result in generating the requisite analytical and computational capabilities for addressing these problems of modern concern, but also constitute a creative perception of the transformed role of earth scientists today from exploration and unrestrained exploitation of fixed earth resources to visualization of their dynamic states in the context of the enveloping environment constantly being altered by the changing space-time relations of chemical elements exchanged between them, from resources at various depths in the earth concentrated over aeons of time, to their comparatively rapid dispersal in the shallow earth domain that we live-off.

Topics dealt with in the discussion meeting included: Solidification of inner core, Compaction and melt extraction, Mantle plumes, Magma chambers, Conduit flows, Eruptive dynamics, Pyroclastic flows and turbidity currents, and Flow in porous media.

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Vinod Gaur, Indian Institute of Astrophysics, Bangalore 560 034, India.
e-mail: vgaur@iiap.res.in