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Indian multi-disciplinary scientific expeditions to the Southern Ocean

The Southern Ocean (SO), located between Antarctica and the southern tips of the three southern continents, plays a major role in regulating the Earth's climate. Relative to other oceanic regions, the Indian sector of SO is unexplored from the point of view of physical, chemical, biological, geological oceanography and climatology, offering therefore an opportunity to scientists to fill the information gaps in these fields which also have relevance to climate change and ocean acidification. To gain insight into various natural processes occurring in SO, to build up a reliable database, and to carry out a multi-beam survey in the approach channel to the site of India's new station in Larsemann Hills of East Antarctica, the National Centre for Antarctic and Ocean Research, Ministry of Earth Sciences, launched two expeditions to SO in 2004 and 2006, onboard *ORV Sagar Kanya* and *Akademik Boris Petrov* respectively, each lasting for about three months of the austral summer. A variety of atmospheric, hydrographic and sedimentological studies were carried out, including drilling for obtaining sediment cores. The participation of scientists with diverse scientific disciplines from institutions across the country, such as the Indian Institute of Science, Physical Research Laboratory, Naval Research Laboratory, National Institute of Oceanography, National Centre for Antarctic and Ocean Research, and a number of universities strengthened the cross-disciplinary nature of the research. This special section comprises peer-reviewed papers that resulted from the unique data sets collected during these expeditions, which highlight the new findings that were made during these expeditions.

The two articles that deal with atmospheric observations find that (i) the atmospheric boundary layer (ABL) responded to surface heat fluxes, with standard ABL structures in regions of upward heat flux, and stable surface layers with no mixed layer when the direction reversed (Bhat *et al.*, **page 1378**); (ii) aerosol concentrations were low over SO as expected, but the composite aerosol mass concentration shows large variations because of variable production of sea salt aerosols, depending on wind speed (Suresh Babu *et al.*, **page 1384**).

Two articles dealing with physical oceanography show (i) evidence for coastal upwelling in the Prydz Bay (Anilkumar *et al.*, **page 1390**); (ii) the hydrogen and oxygen isotopic compositions of SO confirm that the evaporation over SO does not occur under isotopic equilibrium conditions (Srivastava *et al.*, **page 1395**).

One article pertaining to chemical oceanography reports that addition of iron enhances the nitrate, ammonium and urea uptakes, whereas the new production fraction was unaffected (Satya Prakash *et al.*, **page 1400**).

The article dealing with geological oceanography show that the bathymetric survey of the Prydz Bay reveals a safe navigational passage to the Larsemann Hills, where the new Antarctic Research Station is proposed to be built soon (Mishra *et al.*, **page 1405**).

In biological oceanography, Ingole and Singh (**page 1413**) highlight the distribution of nematodes in SO sediments.

One article deals with freshwater lakes in the Antarctic continent. Narayana *et al.* (**page 1420**), report morphology and surface textures of quartz grains from the freshwater lakes of McLeod island, from which they could infer glacial erosion in the past.

These articles, besides providing a flavour of the cross-disciplinary science resulting from the scientific expeditions to the SO, serve as a background database to monitor climate change in this sensitive region, especially as there are plans to launch regular expeditions to SO.

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—Guest Editors

Phasing out 'phases' of deformation in the Himalaya

Study of deformed rocks in orogenic belts has involved working out 'phases' of deformation on the basis of cross-cutting relationships for decades now. Matin and Mukul (**page 1369**) emphasize that deformed rocks, particularly in the Himalaya, should be studied not merely in terms of the 'phases' of deformation based on cross-cutting relationships because emplacement of each thrust sheet in a fold-and-thrust belt can result in several sets of structures during a single orogenic event. This idea has been tested by looking at small-scale structures from the frontal Ramgarh thrust sheet in the Gorubathan area of the Darjiling Himalaya from which six sets of structures were identified using cross-cutting relationships. It is further emphasized that each 'set' of structure recognized through cross-cutting relationship must be tagged to a deformation event in the orogen by closely studying their deformation characteristics. They illustrate this by working out the spatial relationships between successive sets of structures to show that the style and asymmetry of the observed minor structures are consistent with deformation events related to the emplacement of the Ramgarh thrust during N–S shortening during a single phase of (Himalayan) deformation. This suggests that small-scale structures with overprinting relationship associated with the emplacement of a thrust sheet are an important tool in unravelling the history of deformation kinematics in an orogenic belt. Further, a fold-and-thrust belt specific approach of looking at small-scale structures can be used more effectively to better understand the kinematics of the development of these structures, especially in the Himalayan mountain belt.