Proc Indian Natn Sci Acad **82** No. 3 July Spl Issue 2016 pp. 1039-1048

DOI: 10.16943/ptinsa/2016/48502

Institutional Report

National Centre for Earth Science Studies

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(Received on 10 May 2016; Accepted on 25 June 2016)

Introduction

The National Centre for Earth Science Studies (NCESS), under the Earth System Science Organization (ESSO) of the Ministry of Earth Sciences (MoES), Government of India was established with a vision to unravel the mysteries surrounding the earth and its processes for the sustainable development of natural resources, conservation of environment and management of natural hazards. The Centre has pursued diversified scientific activities in the realms of geosphere, hydrosphere and atmosphere.

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Activities of NCESS

Over the years, the Centre has initiated studies within geosciences, environmental sciences, marine sciences and atmospheric sciences. State of art laboratory facilities were established to support studies on the internal and surface processes of the south Indian lithosphere, the adjoining Arabian Sea and their interaction with the atmosphere. The activities of NCESS are presently organized under i) Crustal Processes, ii) Coastal Processes, iii) Atmospheric Processes and iv) Natural Resources and Environmental Management.

The Crustal Processes (CrP) Group focuses on petrological, geochemical, paleo-magnetic, fluid-inclusion, Quaternary geology and geo-hazard investigations. The Coastal Processes (CoP) Group investigates coastal vulnerability, beach-surf zone dynamics, estuarine dynamics, near shore wave climate (remote forcing), sediment budgeting of placer minerals etc. The Atmospheric Processes (AtP) Group concentrates on cloud physics by monitoring lightning frequency, cloud formation, propagation, rain drop etc., in high altitude and coastal field stations. The Natural Resources and Environmental Management (NREM) Group studies integrated river basin analysis for addressing land use planning, mitigation of environmental pollution, ecosystem-based natural resource management, river and wetland conservation etc., using remote sensing, geophysical and other essential laboratory tools.

NCESS gave emphasis on both basic and applied research in its activities. The institute thus contribute substantially to natural hazard assessment pertaining to coastal erosion, coastal flooding, landslides, land subsidence, soil piping, lightning, drought, earthquake monitoring etc and to offer mitigation proposals to administrative departments, while undertaking programs to understand atmospheric parameters, coastal processes and natural resource management. Several short-term investigations, related to landslides, groundwater prospecting, micro-seismicity and watershed management were also taken up. NCESS has collaborative links with various laboratories in the country and abroad in providing technical and scientific expertise to Government Departments and to help in human resource development.

Scientific Contributions

Some of the major contributions during 2012 to 2015 are summarized below.

Crustal Processes

The palaeomagnetic results for Palaeoproterozoic mafic dykes sampled over a large area in the basement along the margins of Cuddapah basin were integrated with available results to compute discrete mean palaeomagnetic directions. And with the recently reported high precision U-Pb baddeleyite age data, NCESS provided a comprehensive account of Palaeoproterozoic igneous activity in India and consolidated palaeomagnetic poles for six distinct ages with robust statistical criteria. We list 205 palaeomagnetic site-mean directions where each site corresponds to a single dyke. The six discrete dyke emplacement events in the south Indian shield were constrained to within 600 Ma from 2.45 to 1.85 Ga. Each event was demarcated by a distinct magnetisation with site-mean directions less than 30° from the mean of the subset. The collective palaeomagnetic data permit us to construct a new Apparent Polar Wander path of the Indian shield for the Palaeoproterozoic Eon with enhanced certainty. The proposed APW path accords with the palaeomagnetic poles determined for mafic dykes in the Bastar and Bundelkhand cratons and therefore is in conformity with the data across the cratons in the Indian shield.

Another significant achievement during this period is that the potential of Laser Raman Micro Spectroscopy (LRMS) in photoluminescence emission studies on oil inclusions. A non-contact, non-destructive methodology was developed to determine the American Petroleum Institute (API) gravity of oil in hydrocarbon fluid inclusions (HCFIs) based on photoluminescence emission studies. Using the emission profile of oil in inclusions, the quality of oil such as high or low API gravity could be assessed and further studies on the emission ratio helped reveal the actual API gravity. It was observed that the API gravity values for oil in the RV-1 well from Mumbai off shore samples are between 35 and 55 and hence are commercially viable. This methodology can be used in real time drilling for the inferring quality of oil.

Coastal Processes

Like other tropical coasts, the south western coast of India, especially coastal Kerala responded to the Late Quaternary climate and sea level changes. Here, many of economically viable minerals like heavy mineral sands, lime shells, glass sands, tile/ brick earths etc., constitute Quaternary sediments. A study on the Late Quaternary sediments of southern Kerala, south of Achankovil Shear Zone (ASZ), for palaeoclimate changes and coastal evolution was taken up. The study area hosts a series of coast parallel and coast perpendicular estuarine basins. These basins have a full record of Holocene transgressive-regressive

events preserved in its 30-40m thick sediment fill. Multi-proxy analysis of sediments indicated fluctuating climate and sea level conditions during Holocene. Similarity in the radiocarbon ages of uprooted, buried riparian plant remains (7490 ± 90 yrs BP) with the embedding sediments (7480 ± 80 yrs BP) indicates rapid sedimentation. Progradation of sediments in the form of a bay head delta during early Holocene and high sedimentation under the rising spells of sea were caused separation of some of the prominent arms of the pre-estuarine basins into discrete fresh water bodies around the head of the present estuary. Upper part of the fluvial plains close to the upper estuary is blanketed by 2-3m thick yellowish brown, mud dominated sediments with higher $\delta^{13}C$(–19.56‰) and $\delta^{15}N$ (8.85‰) values than the lower part ($\delta^{13}C$–28.17‰; $\delta^{15}N$ 3.92‰). This indicated of marine origin of the sediment blanket which was later subjected to subaerial weathering, degradation of organic matter and iron containing minerals that imparting yellow or yellowish brown color to sediments. This color and occurrence of calcareous nodules in the sediment cores retrieved from the marginal areas of the upper estuary indicate a dry phase at around 5-4 kyrs BP. This was followed again by a spell of heavy rainfall before stabilizing the climate to the present.

Atmospheric Processes

To understand the distribution of rainfall and rain drop size pattern, NCESS has been conducting rain related studies on clouds, their occurrence, altitudinal distribution and related parameters such as condensation particle concentration, liquid water content etc. Ground stations at three locations viz. the NCESS Campus (Coast), Braemore and Agumbe (Western Ghat/Sahyadri) measured cloud base height using LIDAR sounding of clouds. This provided time-distribution of rainfall events over a site along with cloud base height and vertical visibility. Condensation particle counters were used to estimate the concentration of condensation nuclei. These measurements helped to understand the SW monsoon clouds and in modelling cloud characteristics and their behaviour in the region. The field stations are equipped with Ceilometer, Automatic Weather Stations, Disdrometer and Electric Field Mill and Water Based Condensation Particle Counter. During the thunderstorm months in Braemore, cloud occurrence began by 10h, reaches a maximum (~70-90%) in the afternoon, ascertaining convective cloud formation over hill slopes. It was inferred that 70% of the events during the pre monsoon, SW monsoon and post monsoon are from stratiform clouds and 20% during the pre- monsoon and post-monsoon seasons is from convective clouds.

Natural Resources and Environmental Management

Rivers are among the most complex ecosystems on earth and are sensitive to urbanization and industrialization. Strategies for their protection and management must be on river basin mode. A study on Periyar river basin revealed that the basin environment has been severely impaired by human interventions, particularly uncontrolled random mining and quarrying in all three physiographic provinces of the river basin.

ESSO-NCESS prepared an Integrated Island Management Plan (IIMP) for all the inhabited islands of Lakshadweep. For this, the entire island zones including the aquatic area were considered and a digital data base on 1:4000 scale was utilized to map different physical characteristics of the island. Areas indicating the dwelling units including the infrastructure projects such as schools, markets, hospitals, public facilities and road net work were brought into the digital map with all their characteristics. The data on the coral ecosystems which were mapped utilizing the satellite imageries of 2007 were also incorporated. Vulnerability map showing the elevation of the island with respect to the MSL was used to assess the vulnerability to human life and property by indicating areas safe for dwelling and infrastructure. Identification of Buffer zone/Setback line for Conservation/Preservation in the islands keeping the natural threats such as high waves, storm surges, horizontal shoreline displacement and sea level changes in the islands was delineated. The final report and IIMP in respect of 10 inhabited islands viz., Agatti, Amini, Androth, Bitra, Chetlet, Kavaratti, Kadamat, Kalpeni, Kiltan and Minicoy was submitted to the UT Lakshadweep Administration.

Major R& D Facilities

NCESS, over the years, established basic and modern laboratory facilities pertaining to earth science related disciplines. These include laboratories of petrology,

mineralogy, seismology (broadband seismic monitoring) sedimentology, paleomagnetism, wet geochemistry, oceanography, electronics, remote sensing, cartography, geomatics, photogrammetry, Initiatives are also being taken to strengthen some of the existing laboratories and to develop a new Sophisticated Analytical Facility (SAF) and coastal field research facility. NCESS envisages further augmentation in the coming years by the addition ICP-MS and mass spectrometry laboratories. Some of the important facilities with the different laboratories of NCESS are given below.

Petrology and Mineralogy

- Thin Section Lab, Microscopes, Sedimentology Laboratory
- XRF/XRD/Raman Spectrophotometer
- Particle Size Analysis
- SEM with EDS and CL

Coastal and Near Shore Studies

- Shallow Seismic Profiler, Wave rider Buoy,
- Wave gauge, ADCP, Piston Corer
- Coastal Field Research Facility

Cloud Microphysics

- Electronics & Instrumentation Laboratory
- Field Monitoring Stations
- Laser Disdrometer
- Ceilometer

Chemical Laboratory

- AAS, GC, GC-MS, Spectrophotometer,
- Mercury Analyzer, CHNS Analyzer, TOC Analyzer,
- VA Analyzer, Spectrofluro meter

Geomatics Laboratory

- ArcGIS
- ERDAS
- ENVI
- GMS
- Data Centre

Natural Hazards

- Seismological Observatory
- Air pollution monitoring
- Water pollution monitoring

Future Outlook

NCESS intends to take forward the solid earth science research in the country through the following four core scientific programmes in the near future.

- Geodynamics of Indian subcontinent and landscape evolution (Evolution of Western Ghats and lithosphere through Precambrian)
- Water and Environment (River Basins of rivers originating from Western Ghats)
- Coastal morphology and hydrodynamics along the West Coast of India
- Natural Hazards (Landslide in the Western Ghats, coastal flooding in west coast, cloud processes and lightning in Western Ghats)

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