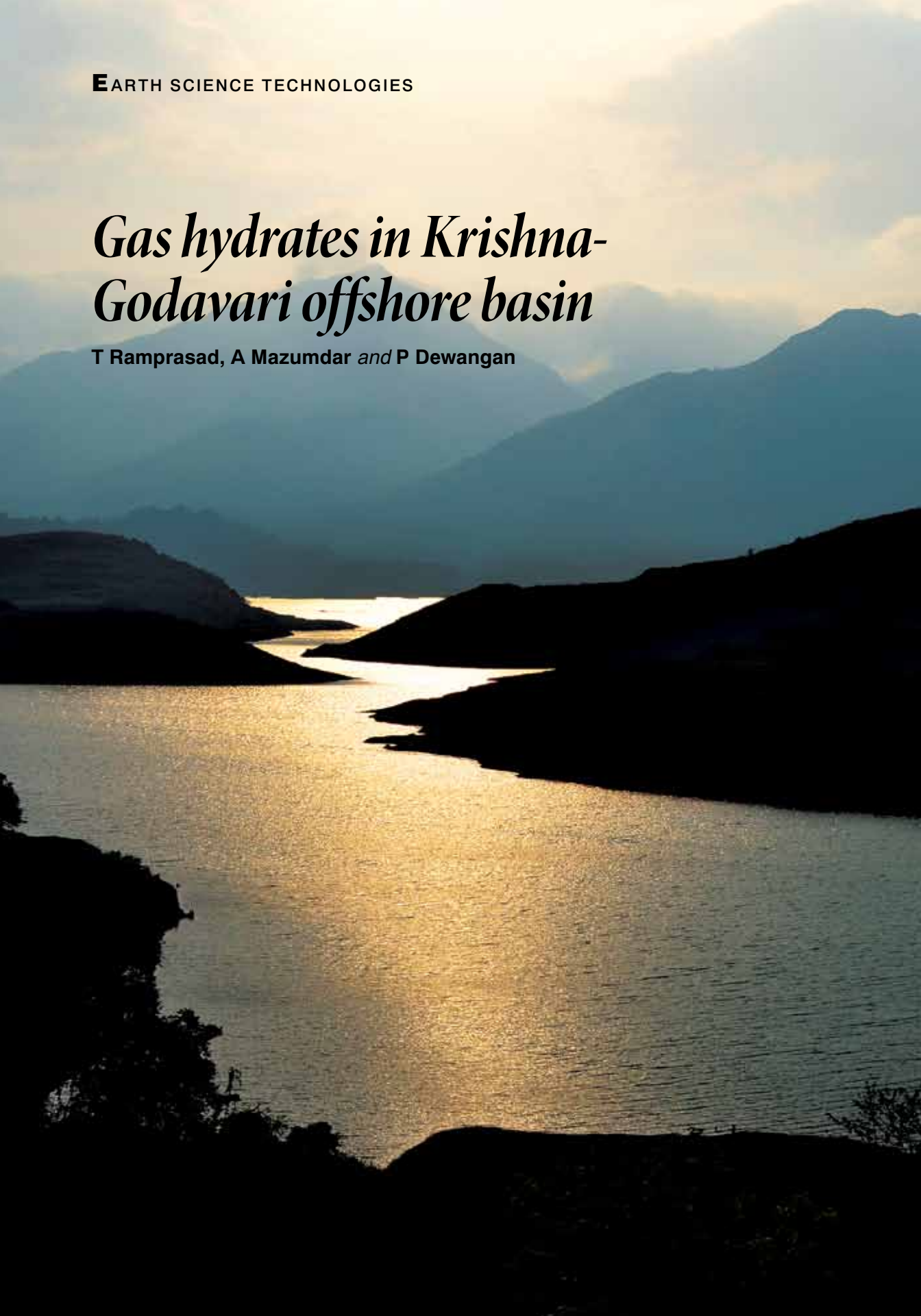
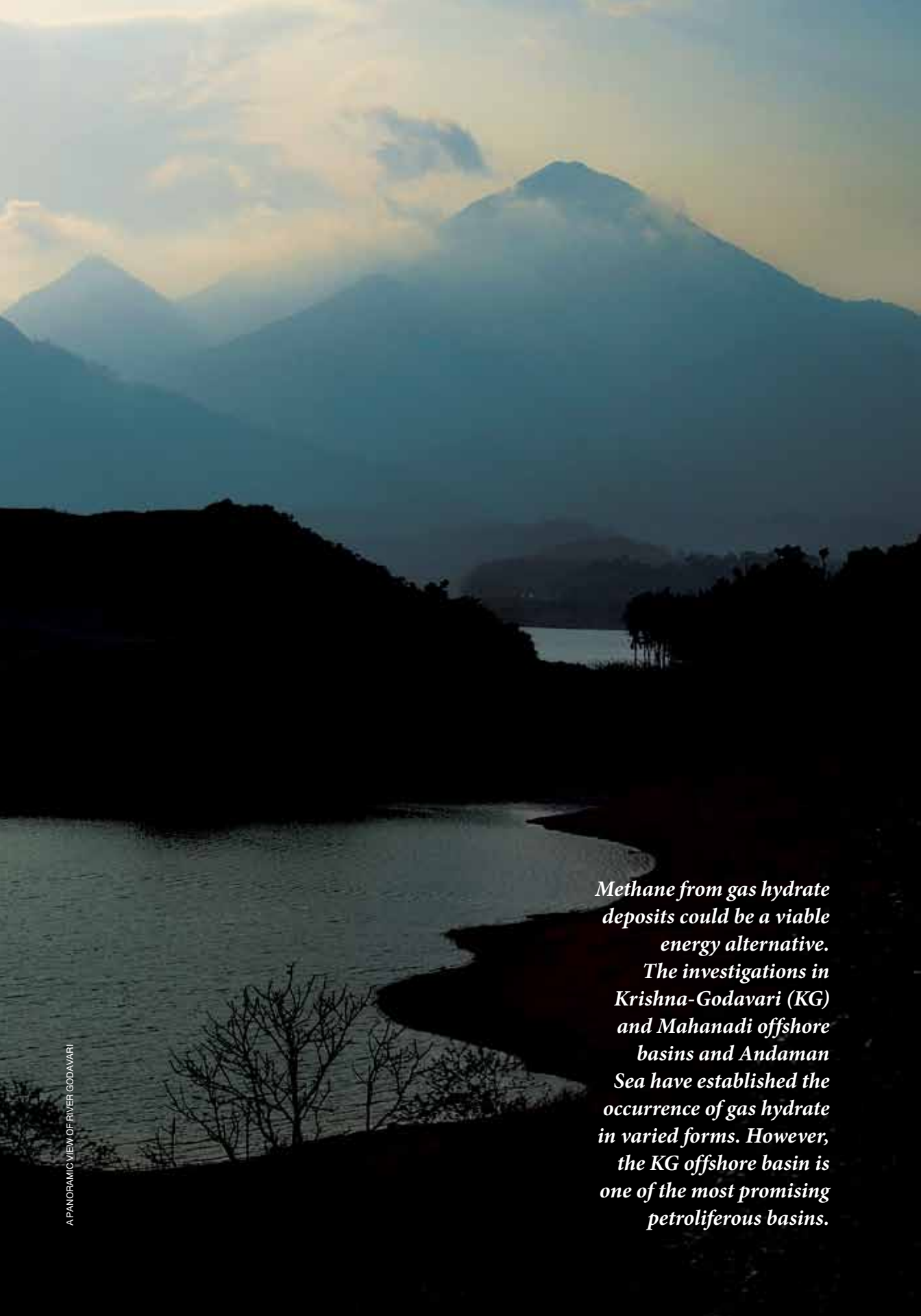


**EARTH SCIENCE TECHNOLOGIES**

# *Gas hydrates in Krishna- Godavari offshore basin*

**T Ramprasad, A Mazumdar *and* P Dewangan**





*Methane from gas hydrate deposits could be a viable energy alternative.*

*The investigations in Krishna-Godavari (KG) and Mahanadi offshore basins and Andaman Sea have established the occurrence of gas hydrate in varied forms. However, the KG offshore basin is one of the most promising petroliferous basins.*

**G**as hydrates are ice-like substances that store huge quantities of methane—1 cubic meter of solid hydrate approximately contains 164 cubic meters of methane and 0.8 cubic meters of pure water. Gas hydrates occur in massive quantities in the KG offshore basin within the fractures or fissures in the sediments below the sea floor. The amount of global carbon trapped in the sediments of the oceanic regions or in the permafrost regions in the form of methane hydrates is twice that are found in the fossil fuels. The biological debris/remnants of the dead animals and plants from land areas transported by the river system, as well as the dead flora/fauna in oceanic areas get buried deep under few kilometres of thick ocean sediments and is degraded by the bacterial activity for eons under very high temperatures. The methane molecules thus generated find their way into the overlying sediments through the fractures or fissures or sediment pore spaces and gets trapped within the lattice cavities of water molecules and form ice-like structures under low temperature and high pressure conditions. Most of the salts that exist in sea water in sediment pore spaces get expelled during the process of hydrate formation. A gas hydrate stability zone exists in which the gas hydrates are stable between the sea floor and a few hundred meters below. The gas hydrates, world over, are explored using the seismic or acoustic techniques—by the identification of an anomalous seismic reflection called ‘bottom simulating reflection’ (BSR), caused due to a large difference in the acoustic wave velocity between the sediment filled hydrate and the surrounding sediments filled by water/free gas.

Any fluctuations in the temperature and pressure conditions cause dissociation of hydrates and the methane is released which migrates towards the sea floor. As the methane ascends from deep into the shallow sediment layers, it undergoes numerous biological and chemical alterations. Within the shallow sediment column, the methane concentration increases with depth and the sulphate concentration reduces, where they reach their lowest concentrations known as sulphate-methane interface (SMI). Our studies include the detailed account of various types of these SMI variation curves using them as proxies along with several other geochemical parameters for inferring the numerous geo-biological processes

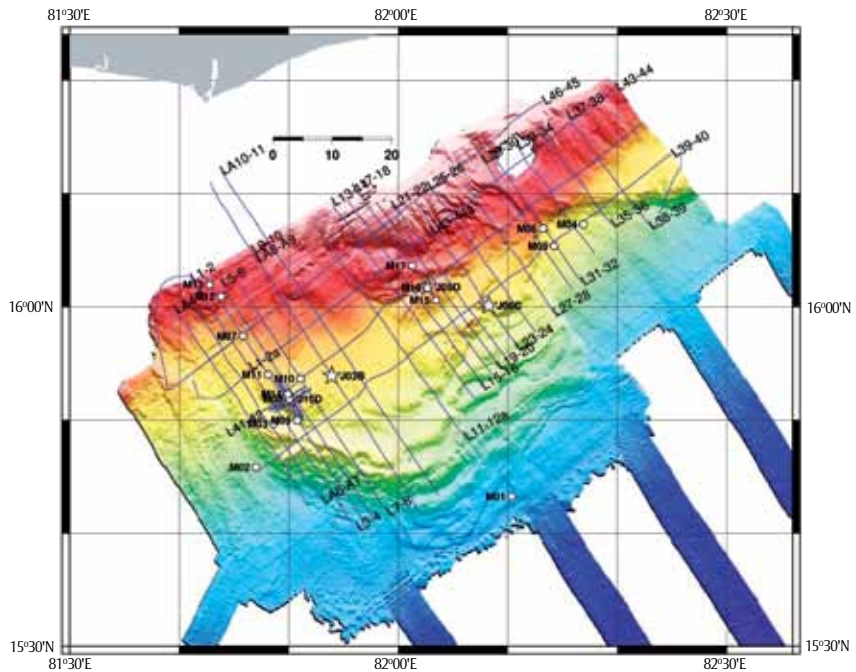
associated with the formation and dissociation of gas hydrates. The KG offshore basin experiences frequent neo-tectonic activity due to fluid/gas movement below the fine grained clay/shale sediments causing fractures and faults. Methane moves up these fractures in the KG offshore basin, making way into the gas hydrate stability zone.

In order to harvest these massive hydrates within the vertical fissures, a viable technology is required. World over, gas hydrate exploration is focused on the discovery of gas hydrate deposits in sand formations, which could be exploited using the available gas production technology—through controlled dissociation of hydrates by a combination of depressurization and thermal heating. Molecular replacement of methane by carbon dioxide is a second technique that scientists are currently working on and may be used to produce gas from the massive hydrates in KG offshore basin in future.

#### NEW FINDS IN THE KG OFFSHORE BASIN

Drilling/coring activities have confirmed gas hydrate in the continental slope of KG basin, Bay of Bengal and recovered fracture filled gas hydrate. The geophysical methods like multibeam swath bathymetry helps in understanding the bathymetry of basin, whereas, the high resolution multi-channel seismic (MCS), high resolution seismic (HRS) and sub-bottom profiler data gives detail vertical profile of sediment package. The paleomagnetic measurements reveal the diagenesis of magnetic minerals in a gas hydrates with a zone of reduced magnetic susceptibility where most of the magnetic minerals are dissolved. The geophysical and geological exploration lines/ sampling locations in Krishna-Godavari (KG) are shown in Fig 1.

Bathymetric mounds in the offshore basin are formed due to prevalent shale tectonism and are often associated with fluid/gas migration features such as acoustic chimneys, acoustic voids and acoustic turbid layer. Detailed analysis of MCS data in the vicinity of Site NGHP-01-10 suggest large-scale fault system (>5 km) predominantly oriented in NNW-SSE direction near NGHP-01-10 site which plays an important role in gas hydrate formation, distribution and thermal regime in the KG basin. The P-wave velocity obtained using unified imaging technique show patchy distribution of hydrates and appropriately predicted the hydrate saturation at Sites NGHP-01-10 to NGHP-01-13.




**Fig 1:** Map showing bathymetry of Krishna-Godavari (KG) Basin. Sediment core locations of JOIDES Resolution (prefixed by J) and Marion Dufresne (prefixed by M) are shown.

The hydrates maintain continuity along the strike direction of regional faults and show heterogeneous deposit across the fault. The bathymetry data show slumping and sliding features in the mid-slope region in the form of mass transport deposits in KG offshore basin. The pore water sulphate concentration profiles in KG basin show occurrence of transient (sigmoidal and kink types) and steady state (quasi-linear) sulphate concentration profiles which are attributed partly to the anaerobic oxidation of methane and organo-clastic sulphate reduction. The geophysical data show the acoustic signatures of upward fluid migration from shallow sub-surface, whereas, coring during NGHP expedition-01 confirms the presence of sub-surface gas hydrate deposits in KG basin which can be linked to deep methane sources. The geochemical analysis suggests that shallow methane source can be attributed to high burial flux of organic matter due to high sedimentation rate. The short lived 'kink' in the sulphate profiles is interpreted as a result of recent enhancement in vertical methane flux possibly driven by reactivation of fault-fractures systems which provide the conduits for fluid flow. Microbially mediated anaerobic oxidation of methane (AOM) coupled with sulphate consump-

tion within the sulphate methane transition zone (SMTZ) in marine sediments is a widely recorded biogeochemical reaction and has profound influence on the atmospheric CH<sub>4</sub> budget, marine carbon cycle and composition of sediment pore fluids.

#### END NOTE

The bathymetric mounds formed due to passive/shale tectonism are the prominent locations for the formation and accumulation of gas hydrates in the KG offshore basin. Large-scale fault system acts as a conduit for fluid/gas migration and plays an important role in gas hydrate formation and its distribution. The amplitude variation with angle pattern of BSRs also suggests the presence of fracture-filled gas hydrate deposits here. The bathymetry data reveal several slope failures in KG offshore basin which may be related to fluid/gas migration within the gas hydrate stability zone. 

*The authors are chief scientist, senior scientist, and scientist C, respectively, at CSIR- National Institute of Oceanography, Goa. NIO contribution No. 5428. rprasad@nio.org*