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Paleogeographic reconstruction during Rohtas Formation (Lower Vindhyan) and Kaimur Sandstone (Upper Vindhyan) in Son Valley, Vindhyan Basin, India.

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Abstract

The paleogeographic reconstruction during the deposition of different units within Rohtas Formation and Basal part of Kaimur Formation in Son Valley, Vindhyan Basin has been attempted based on available G&G data.

After the deposition of the Basuhari Shale, a gently sloping platformal set up was available for the deposition of the Lower Rohtas unit in an intertidal to platformal set up. The microfacies are dominated by mudstone with occasional dolomitisation. In the area around the Jabera low, shale limestone alternation is likely. The Middle Rohtas unit, dominated by shale, witnessed a major transgressive event where almost entire area was under subtidal set up, barring the lows around SW of Jabera, Kharkhari and some local lows. The Upper Rohtas unit, deposited under predominantly regressive phase, attained a large thickness of carbonate in the Nohta and Jabera areas. The prominent basement related features, the Kumhari, Begumganj highs experienced less bathymetry in an intertidal setup. Thus relatively clean carbonate (lesser clay) facies are expected in such platformal areas. North of Damoh High, in the northern rising flank of the, an intertidal to occasional restricted lagoonal setup was present during this time. The resultant facies however is likely to be dominantly limestone - shale alternations as a result of clastic interference from the hinterland in the north. The Basal Kaimur sands appear to have been deposited on a broad tidal flat as tidal channels and possibly tidal bar sands.

Introduction

The Proterozoic Vindhyan Basin (1, 62,000 SKM) is situated between the Delhi - Aravalli orogenic belt to the north-west and Son-Narmada Geofracture to the south in Central part of India. The Bundelkhand Massif, located in the north-central part of the basin, divides it into two sectors: Chambal Valley to the west and Son Valley to the east (Fig.1). The basins fill constitutes a considerable thickness (2-6Km) of un-metamorphosed, varyingly deformed sedimentary succession, divisible into carbonate dominated Lower Vindhyan and clastic dominated Upper Vindhyan sequences, separated by a large hiatus.

Hydrocarbon exploration in Son Valley was initiated by ONGC in early sixties with geological mapping, gravity-magnetic and aeromagnetic surveys. This was followed by acquisition of 2D seismic data over the area under different campaigns. The initial stage of exploration in Son Valley was primarily targeted on major anticlines. The first well J#A, drilled on Jabera Dome, made a discovery of gas from the Lower Vindhyan Jardepahar Formation. Subsequently, exploration activities have been continued initially for the deeper and later on for the shallow Rohtas prospects. The geo-scientific data obtained so far led to a better understanding of petroleum systems in the Son Valley area.

Tectonics and sedimentation

Vindhyan Basin is genetically associated with two mega tectonic elements: Great Boundary Fault (GBF) to the northwest and Son-Narmada Lineament (SNL) to the south. The Vindhyan strata of Son Valley define a broad ENE–WSW trending regional syncline in the central part. Detailed account of tectonic framework including the fault systems, paleo-structures, structural inversion and deformation history have been described by many workers from time to time (Jokhan Ram *et al*., 1996, 2005, Mahendra Pratap *et al.,* 1998, 1999, Verma N.K. *et al., 2002*).

Son Narmada Lineament, a major crustal feature formed along the Archean structural trends marks the sedimentation limit of Vindhyan Basin in south and south -east remained active throughout geologic history till the present day. The greater thickness of sediments towards south implies an active southern margin along which relatively continuous subsidence led to such thickness. The northern and eastern margins of basin have gentle gradient. Intense structural deformation of the Lower Vindhyan Sequence in vicinity of SNL is evidenced by the presence of tight folds, normal and reverse faults and thrust contacts. Initial tectonic evolution of Vindhyan Basin is controlled by basement related rift tectonics, which formed a number of horst and grabens. Two main fault trends are evident, faults parallel to the SNL (E-W to ENE-WSW) as well as along NW-SE aligned oblique faults. The major half grabens are located along the down thrown side of these rift related faults. Some of these faults show syn-sedimentary vertical movements. In later phase of evolution, compressional reactivation of pre-existing extensional faults under the influence of wrench related strike–slip movement along the Son-Narmada Lineament (SNL) formed inversion structures like Damoh, Jabera and Kharkhari. Major oblique faults divide Son Valley into a number of tectonic blocks i.e Udaipur-Tendukhera, Jabera-Damoh and Satna-Rewa-Kaimur blocks (Mahendra Pratap et al., 1999). Among these, the Jabera-Damoh block is tectonically the most disturbed.

The Vindhyan sedimentation started with an initial syn-rift and followed by a post rift phase and a maximum thickness of around 6000m and is divided into carbonate rich Lower Vindhyan followed upwards by clastic dominant Upper Vindhyan (Fig.2). The Vindhyan sea, a shallow eperic sea with maximum water depth of 100m (Chakraborty, 2006) had continued pulses of subsidence to accommodate the thick pile of sediments spanning a large geological time. Notable contribution on the paleogeography of the Vindhyan Basin has been made by I.B. Singh (1985).

Methodology

Paleogeographic reconstruction during the deposition of the gas bearing Rohtas Limestone and Basal Kaimur Sandstone has been attempted to understand the depositional architecture, distribution of lithofacies & microfacies and thus identifying areas of better reservoir development. To prepare the paleogeographic maps, residual gravity map, thickness of each mapped unit, the drilled well data, well logs and the clastic- carbonate ratio, sand -shale ratio and laboratory generated sedimentological and bio-stratigraphic data were integrated.

Paleogeographic Reconstruction

The residual gravity map provides the available lows and highs in the area during the deposition of the sediments (Fig.3). Based on the well data, Rohtas Limestone has been divided in to three units, Lower Rohtas, Middle Rohtas and Upper Rohtas Limestone (Fig.4).The time thickness of all the units within the Rohtas Formation is prepared and available as data inputs for preparing the paleogeographic maps.

The Lower Rohtas Formation which comprises of an upper thick tight limestone unit followed by middle shale and the lower limestone unit. Lower Rohtas Limestone has thickness of 110-130m, isochronopach map showing uniform thickness over the study area (Fig. 5a). Presence of gas was observed during testing in the upper tight limestone in well N#C. The limestone is characterised by mudstone and argillaceous limestone facies. This unit was deposited on a gently sloping platformal set up was available after the deposition of Basuhari Shale. The microfacies deposited are dominated by mudstone with occasional dolomitisation. Lithofacies, microfacies and related G&G data set suggests that Lower Rohtas unit was deposited under an intertidal to platformal set up over the central part of the study area around wells Nohta# A, B, C. In the southern part, around the Jabera Low, shale- limestone alternation is likely during the Lower Rohtas deposition (Fig.5b) deposited under a sub tidal set up.

The Middle Rohtas unit with a general thickness of 200-250m is dominated by shale, which is rich in organic matter and important from the source rock point of view. The shale has intermittent beds of thin limestone and witnessed a major transgressive event with minor oscillation. Almost entire study area was under sub tidal set up, barring the lows around SW of Jabera, Kharkhari and some local lows. The isochronopach map showing the subtle variation in thickness (Fig 6a). The prominent geomorphic highs like Kumhari and Begumganj were probably having a shallower bathymetry and most suitable for platformal set up. In the area to the north, covering the NELP block, the likely facies to be developed are alternations of limestone and shale deposited under sub tidal to intertidal set up (Fig.6b). The limestone in the drilled well comprises primarily the argillaceous limestone and mudstone facies and better reservoir facies are localised in nature.

The Upper Rohtas unit is mainly a thick limestone unit with thin intermittent shale has shown presence of gas from different stratigraphic levels. The top part of the unit is characterized by presence of dolomitic limestone in all most all the wells. The main limestone facies comprises the mudstone, dolomitic and argillaceous limestone. The unit was deposited under predominantly regressive phase, as the Vindhyan sea was withdrawing attained a large thickness (350-400m) of carbonate in the Nohta and Jabera areas. The isochronopach map showing the variation in thickness over the area(Fig 7a). The prominent basement related features, the Kumhari and Begumganj highs experienced less bathymetry and the limestone were deposited under an intertidal setup. Thus relatively clean carbonate facies are expected in such platformal areas. During this period, the area around Nohta-Jabera on the eastern part of the Begumganj High, witnessed a platformal set up which facilitated the deposition of dominantly mudstone facies. North of Damoh High in the NELP Block area, an intertidal to occasional restricted lagoonal setup was present during this time. The resultant facies however is likely to be dominantly limestone - shale alternations as a result of clastic interference from the hinterland in the north (Fig. 7b).

Paleogeographic map has been prepared for the Basal Kaimur Unit considering the sand/shale ratio, sand thickness, frequency of shale layers and integrating the results of amplitude attribute. Based on the above, the Basal Kaimur Sands appear to have been deposited on a broad tidal flat as tidal channels and possibly tidal bar sands (Fig. 8).

Conclusions

Lower Rohtas unit was deposited under an intertidal to platformal set up over the central part of the study area around wells Nohta# A, B, C. During Middle Rohtas deposition, almost entire study area was under sub tidal set up, barring the lows around SW of Jabera & Kharkhari thus favouring deposition of thick source facies over a large part of the Son Valley. During the deposition of Upper Rohtas Limestone, large part of the study area around Nohta-Jabera on the eastern part of the Begumganj High, witnessed a platformal set up which facilitated the deposition of better reservoir facies.

The paleogeographic reconstruction has brought out the distribution of platformal facies during the Rohtas Limestone and sand geometry during Kaimur deposition. On integration with other G&G data the present study will help in planning future exploratory/ appraisal activities within the PEL Block, Son Valley.

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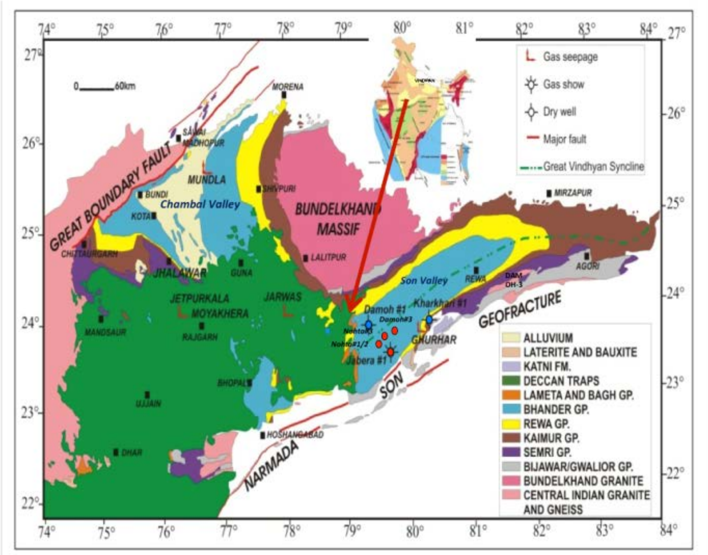


Fig.1

AGE	GROUP	SUB GROUP	FORMATION
MESO TO NEO PROTEROZOIC	UPPER VIMDHYAN	BHANDER	MAIHAR SANDSTONE
			SIRBU SHALE
			NAGOD LIMESTONE
			GANURGARH SHALE
		REWA	REWA SANDSTONE
			JHIRI SHALE
		KAIMUR	KAIMUR SANDSTONE ★
UNCONFORMITY			
PALEO PROTEROZOIC	LOWER VIMDHYAN	SEMRI	ROHTAS LIMESTONE ★
			BASUHARI SHALE
			MOHANA FAWN LIMESTONE
			CHARKARIA OLIVE SHALE ★
			JARDEPAHAR ★
			PORCELLANITE
			KAJRAHAT LIMESTONE
			ARANGI SHALE
			KARAUNDHI ARENITE
UNCONFORMITY			
EARLY PROTEROZOIC	BIJAWAR GROUP		
ARCHEAN	BUNDELKHAND GNEISS		

Fig.2

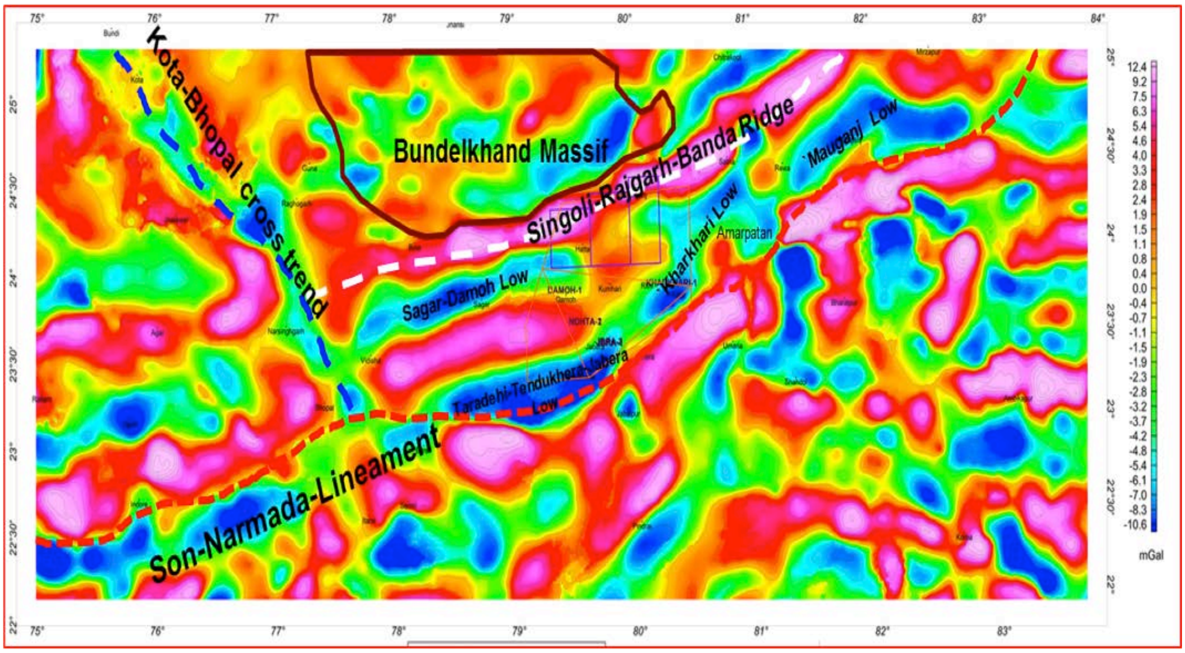


Fig.3

Fig.1. Geological map of Vindhyan Basin. Fig. 2. Generalised sub surface stratigraphy of Son Valley area, Vindhyan Basin. Fig 3. Residual gravity anomaly map of Vindhyan Basin (source KDMIPE report)

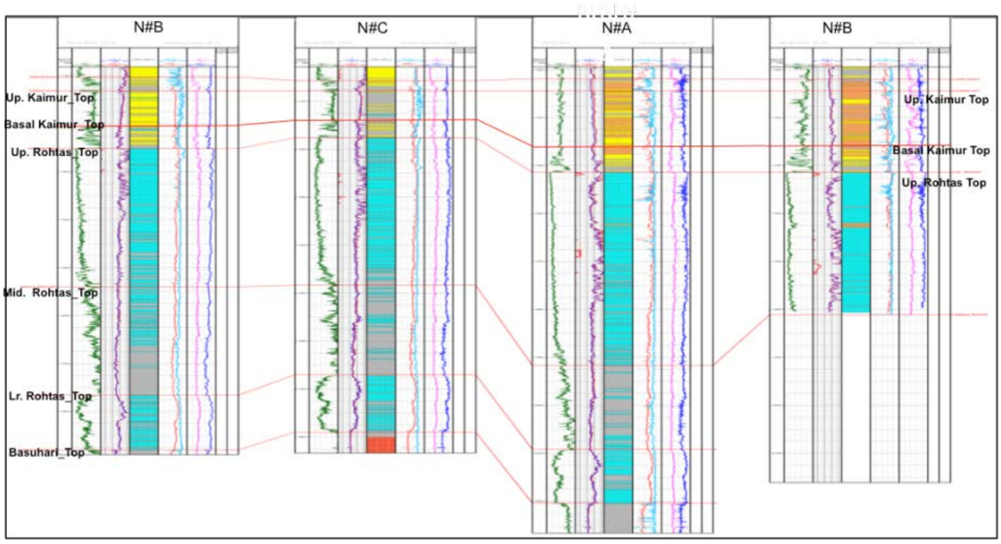


Fig.4

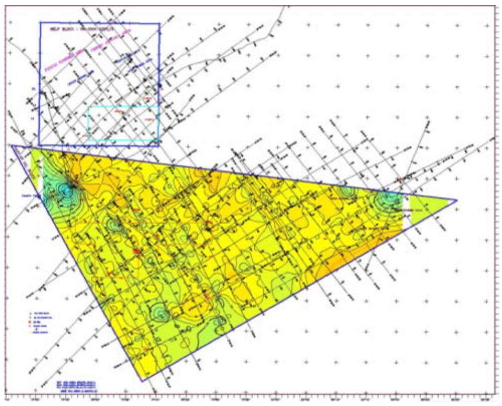


Fig.5a.

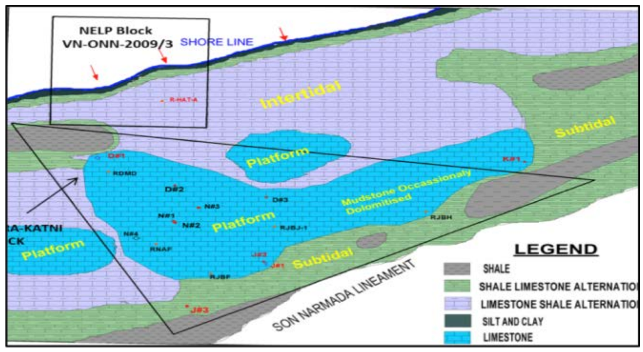


Fig.5b

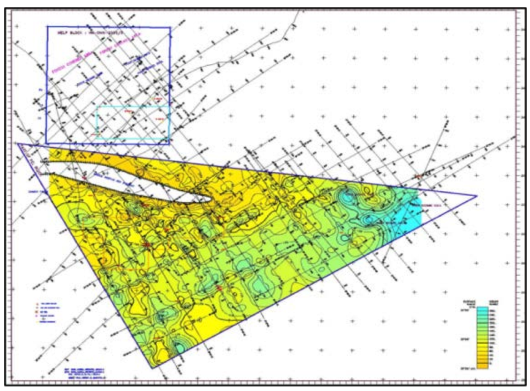


Fig.6a

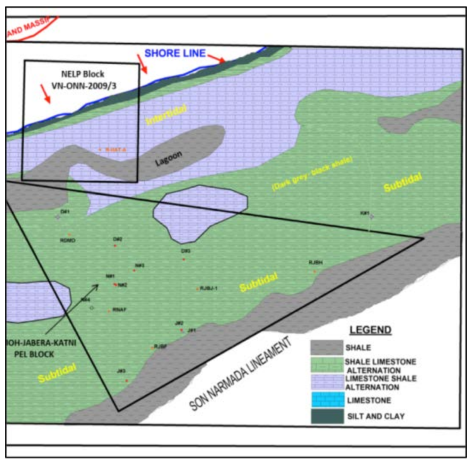
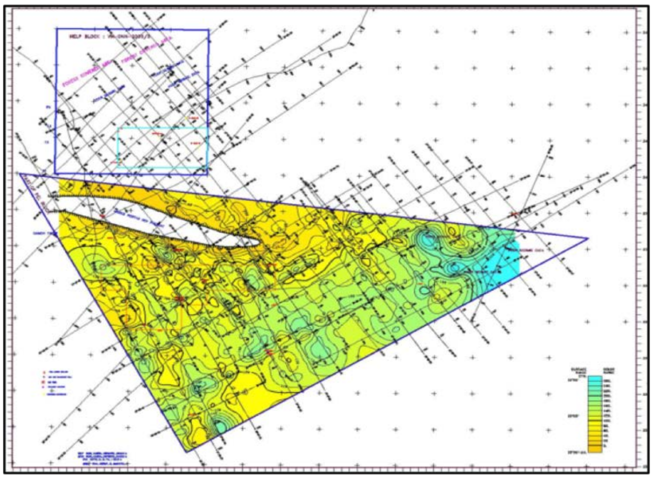


Fig.6b

Fig.4. Electrolog profile through wells D#C, N#C, N#A and N#B showing sub units within Rohtas and Kaimur formations. Fig. 5a.Time Thickness Map of Lower Rohtas Fm. Fig 5b. Paleo- geography during Lower Rohtas Fm. Fig.6a. Time thickness Map of Middle Rohtas Fm. Fig. 6b. Paleo-geography during Middle Rohtas Fm.



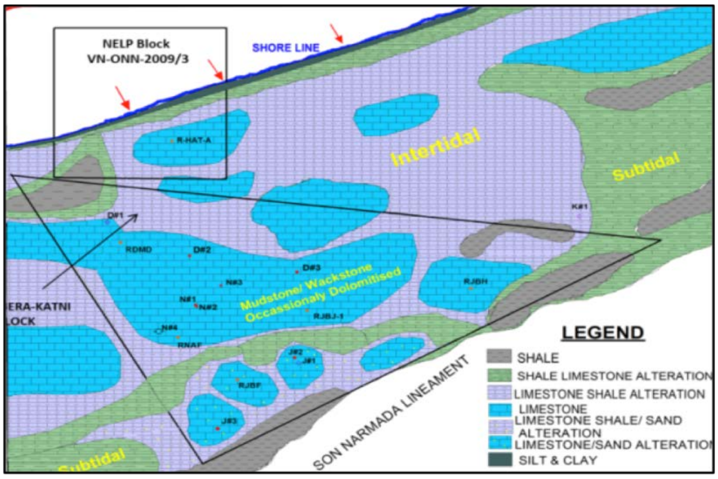


Fig.7a

Fig 7b

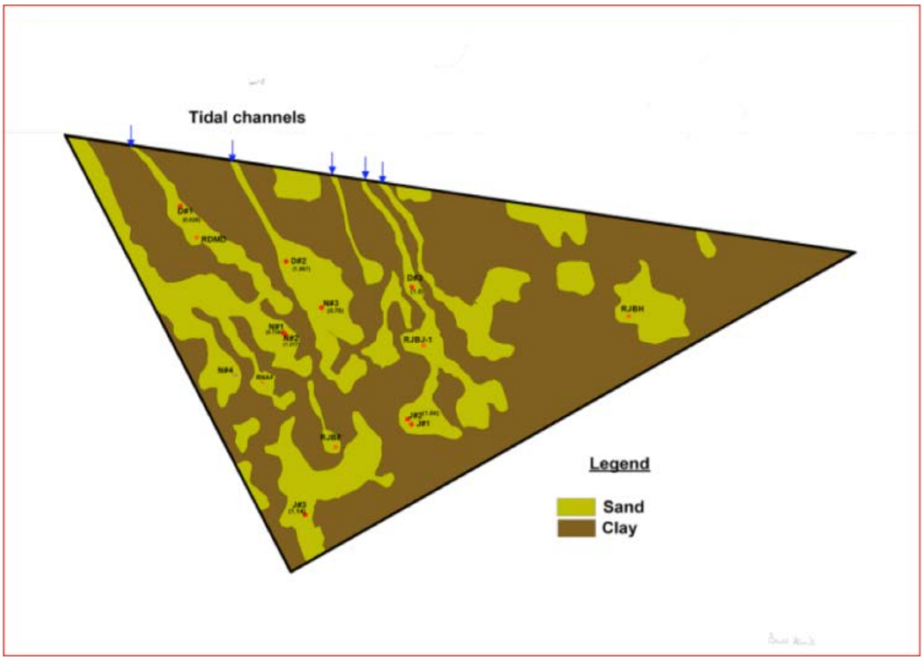


Fig.8

Fig. 7a.Time Thickness Map of Upper Rohtas Fm. Fig 7b. Paleo- geography during Upper Rohtas Fm. Fig.8. Paleo- geography during Basal Kaimur Sandstone