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Infracambrian Hydrocarbon systems and Emerging Hydrocarbon Potential in Bikaner-Nagaur and Jaisalmer basins (Miajlar sub basin), of Rajasthan.

Extended Abstract

The Infracambrian (Neoproterozic to Early Cambrian), stretching from 1000 Ma to the base of the Cambrian at 542 Ma, is relatively poorly known from a petroleum perspective. On a worldwide basis, the rocks of Infracambrian age have been less adequately probed for petroleum than those of younger sedimentary strata, despite the existence of proven Infracambrian hydrocarbon plays in many parts of the world. Infracambrian sediments of the globe have produced very little oil and gas. Only in Russia, Oman and China the Infracambrian rocks are extensively explored and produce commercial quantities of hydrocarbons. The oldest oil has been recovered from the McArthur Basin of Australia, followed by the Novesuck oil of Michigan and numerous other petroleum shows reported from Australia, Canada, India (Bikaner-Nagaur basin), Morocco, Pakistan, Venezuela and USA, demonstrating the generation and migration of Proterozoic petroleum worldwide, indicating that the hydrocarbon potential of certain unmetamorphosed Infracambrian sedimentary rocks in various parts of the world has to be considered seriously.

Search for ancient hydrocarbon in Proterozoic basinal setup is an ultimate task. Analysis of basin tectonics, depositional process, genesis and preservation of hydrocarbon demands a far reaching conceptualization.

The Paleogeographic plate restoration for Infracambrian and Cambrian time indicates that the restricted marine evaporates deposits (Salt Range) of NW India (Bikaner –Nagaur basin, Rajasthan), Pakistan and southern Oman (Huqf depositional basin) were in close proximity to each other on a broad carbonate shelf along the northern margin of Gondwana during the Infracambrian (McKerrow et al., 1992) (Fig. 1). Similarly, the age and lithology of Salt Range Formation and Marwar Group of Bikaner –Nagaur correlates with those of Huqf Group, which contains exceptionally high quality source rock units (Peters et al., 1992). The Bikaner-Nagaur basin, Jaisalmer basin (Miajlar sub basin) and north-western part of extrapeninsular region (Krol, Spiti, Zoktan basins) of India constitute an extension of the tectono-depositional system of the Arabian plate during Neo-Proterozoic regime (Padhy, 1977 et al.).

The Western Rajasthan Shelf forms the eastern flank of the Indus geosyncline and is divided into three basins namely : Bikaner-Nagaur, Jaisalmer and Barmer basins. **The Barmer basin**, is an elongated narrow graben and is separtated from Jaisalmer sub basin by Devikot Nachna uplift (Fig. 2 & 3). **The Bikaner and Nagaur basin** (about 90,000skm) is essentially a paleozoic basin located to the east of Pokharan- Nachna high and is relatively shallow and represents the southern flank of the Indus basin. The Bikaner - Nagaur basin therefore, represents a vast sedimentary tract from the Aravalli to the Salt range. **The Jaisalmer basin** (about 42,000skm), represents the westerly dipping eastern flank of the Indus shelf. The Jaisalmer basin is differentiated from north to south into four tectonic blocks. The **Kishangarh sub-basin**

is part of north westerly homoclinally gentle dipping shelf with NE-SW depositional strike. The **Jaisalmer Mari high** feature is located along the shoulder zone of Kanoi fault and is attributed to the upthrusting and wrench faulting. It is a rather a zone of uplifted blocks. The **Shahgarh sub-basin** is deepest depression and is less disturbed having NNW-SSE trending faults while structurally simpler **Miajlar sub-basin** is located in southern part of the basin.

A direct lithostratigraphic comparison of the Huqf Supergroup of Oman with the supposed time equivalent succession of the Marwar Supergroup in West Rajasthan (Bikaner – Nagaur basin; Fig. 4), reveals remarkable affinities in facies evolution through time. Critical similarities and differences are (1) a similar age of the pre-sedimentary basement with the Malani volcanic suite of India dated at 750 Ma being coeval with much of the crystalline and volcanic basement dated in Oman (920-720 Ma), (2) a much reduced sedimentary thickness in India (about 1 km), pointing to a more cratonic setting of India with respect to Oman, (3) lateral facies changes from Bilara carbonate (basin margin) to the Hanseran Evaporite Group (basin center), similarly to what is found in the South Oman Salt basin of Oman, within the Ara Group. Ara Group equivalent strata are also found in the Salt Range Formation of Pakistan, which also shows an almost identical repetition of evaporates and carbonate for a total thickness of (600m) with 6-7 dessication cycles, comprising well with the A0-A6 Ara Group stratigraphy of the south Oman Salt basin. The salt range Formation extends in the subsurface to the south almost reaching the Indian border, making a roughly N-S oriented salt basin.

The discovery of non-biodegradable, heavy oil from Bhagewala –A well (Bikaner-Nagaur basin) represents a new exploration play in north west India. Thermal maturation- dependent bio markers ratios indicate that the oil was generated from a source rock within the early window. Source dependent biomarkers in the oil indicate that it originated from a marine carbonate rich source that contains oil and bacterial organic matter with no higher plant input and was deposited under anoxic conditions. Age diagnostic biomarkers in the oil indicate that the source rock was at least Devonian, and probably Infracambrian in age. These results are consistent with the local generation of the oil from marginally mature, organic rich, laminated dolomites in the Infracambrian Bilara Formation within or near the Bhagewala –A well. More importantly, significant amounts of petroleum could have been generated from the equivalents of the proposed Bilara source rock , which are buried more deeply to the west of Bikaner Nagaur basin in Pakistan.

The Bhagewala –A oil is geochemically similar to another heavy oil from the Karampur-A well in Pakistan and to the oils derived from carbonate – evaporite facies of the Infra-cambrian Huqf Group in the eastern flank province of southern Oman. These findings are consistent with the published evidence that the salt basins of north western India, Pakistan and southern Oman were in close proximity during Infracambrian along the middle eastern edge of Gondwana Land. The Infracambrian anoxic conditions with super seal salt formations were ideal for preservation of rich source rocks. These thick salt formations are present from Oman (Huqf Formation) in the west, where they constitute a most prolific petroleum play, to India (Bilara-Jodhpur formations) in the east. In Pakistan this formation is known as the Salt Range Formation and is similar in both lithology and age of Huqf Foramtion of Oman and Bilara –Jodhpur Formation of India.

Within the Miajlar sub basin, there is no direct indication of the existence of early Paleozoic or Pre-Cambrian sediments, although available seismic data indicates the existence of a sedimentary looking facies below a confidently caliberated Permo-Triassic unconformity (DCR mapped by ONGC; Fig. 5). However, outcrops of Randha and Birmania formations of Proterozoic to Lr. Cambrian age have been reported to the south east of Miajlar sub basin (Fig. 3).

In view of this, Miajlar sub basin where likely development of deeper petroleum system (Proterozoic) is anticipated attains greater importance. Equivalent of these Formations in Potwar basin of Pakistan have produced commercial hydrocarbons. Moreover, the equivalent formations in Bikaner- Nagaur basin i.e. Jodhpur sandstone and Bilara limestone formations have also given heavy oil in Bhagewala Field under Oil India Ltd. and light oil from the HEG Formation (Infracambrian in age) in well Nanuwala –A, Gaganagar district , Rajasthan.

In the Miajlar sub basin three wells have been drilled of which two wells have been drilled by ONGC (MJ-A & B) in their nominated Miajlar acreage. The third well (Kerla-A) has been drilled in the NELP V block, which lies adjacent (west) to the nominated Miajlar acreage of ONGC. The primary objective of these wells was to explore the hydrocarbon potential in Jaisalmer and also to establish the existence of Neo-Proterozoic sedimentary sequence below Permian unconformity (DCR marker by ONGC), in Miajlar sub basin and also to establish their hydrocarbon potential. Wells MJ-A, MJ-B & Kerla-A are reported to have reached TD in metamorphic basement (Amphibolite /Green Schist facies) without encountering the anticipated Neo-Proterozoic sedimentary sequence, at a depth of about 2500m, 1675m & 2265m respectively. The wells went dry without any indication of hydrocarbons.

The presence of unmetamorphosed sedimentary sequence below the Permian unconformity is still a possibility. Marvi-A well in Pakistan was drilled on the edge of the gravity low subsequently named as Miajlar low and found an unmetamorphosed Cambrian- Late Neo-Proterozoic (about 550 ma) sedimentary sequence. The same gravity low covers the SW part of the Miajlar sub basin **(Fig. 6).**

Conclusions :

- **The Neoproterozoic**, stretching from 1000Ma to the base of the Cambrian at 542 Ma is relatively poorly known from hydrocarbon perspective. The oldest proven hydrocarbon commercial accumulations are in Siberia, Oman & China (Neoproterozoic) etc. Numerous other petroleum shows are reported from Canada, India, Pakistan, Morocco, Venezuela etc. There by, demonstrating the generation and migration of Proterozoic Petroleum world wide.
- The interest is rooted in the improved understanding of the prolific " Infracambrian" intra- salt and pre - salt plays, in the South of Oman salt basin and similar plays actively pursued within age equivalent units to east ie. Western Rajasthan esp. Bikaner-Nagaur basin and Miajlar sub basin.
- The possibility of close association of the oil industry with the academia to carryout age determination, correlation and depositional environment etc. for firming up the position of India, Pakistan with reference to Oman during Infracambrian times, which is still debated. These studies will help in a long way in carrying out Infracambrian exploration.

Fig. 1 Infra- Cambrian plate reconstruction

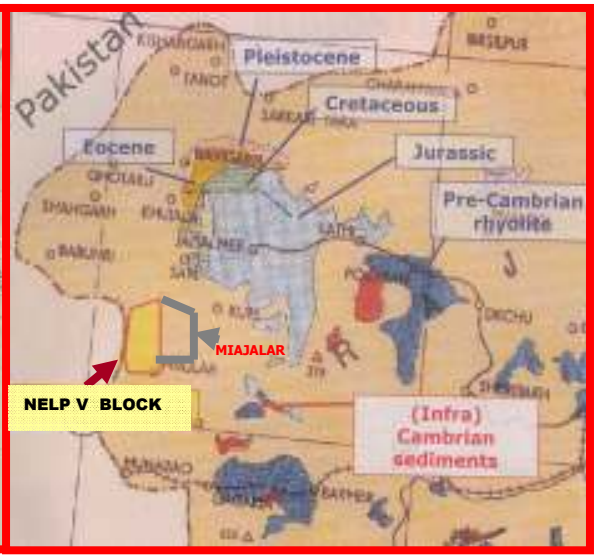

Fig. 2 Geological Map of Western Rajasthan

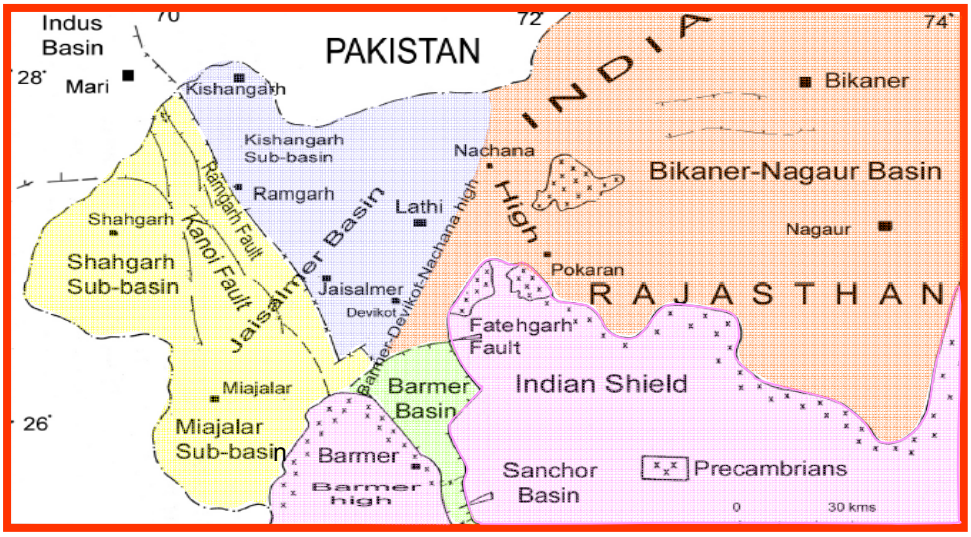

Fig. 3 GEOLOGICAL MAP OF RAJASTHAN BASIN

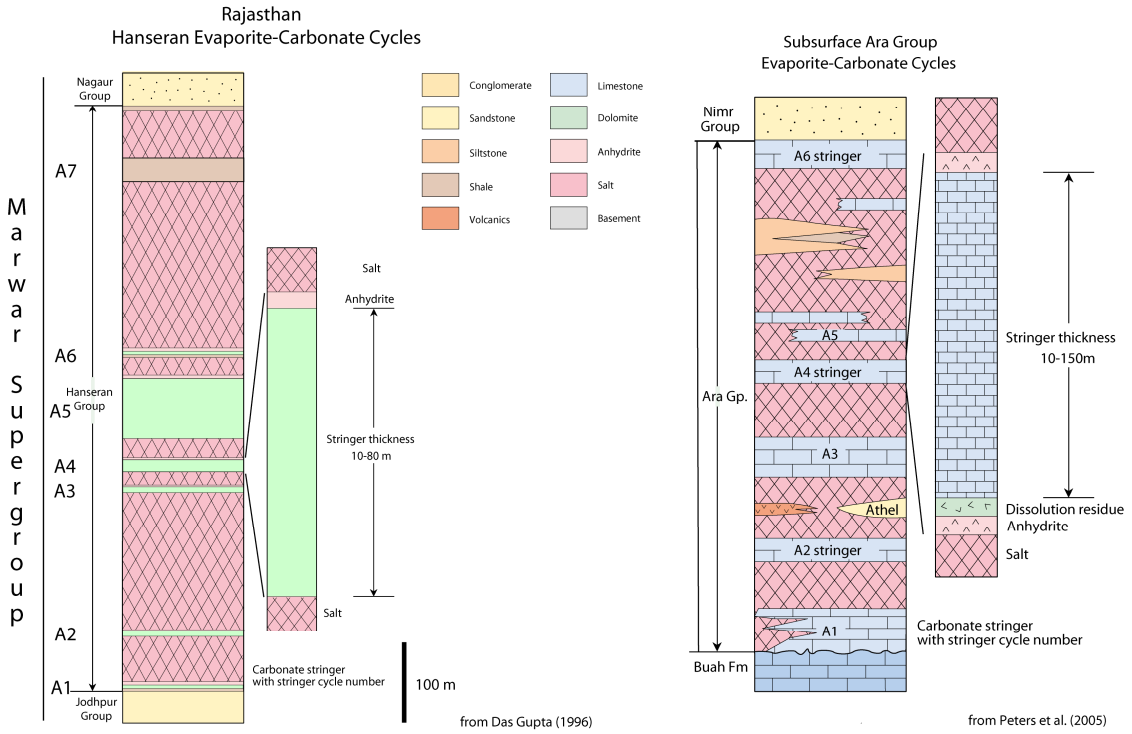

Fig. 4 Lithostratigrapgy of Marwar Super Group of Rajasthan, India and Ara Group of Oman

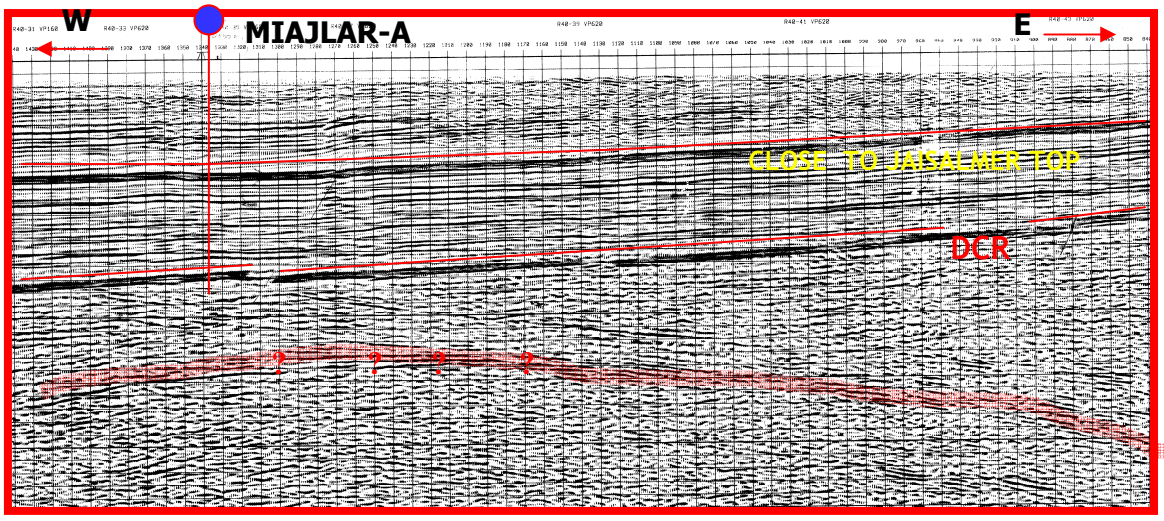

Fig. 5 Part of seismic line showing Neo-Proterozoic sedimentary sequence below Permian unconformity (DCR Marker)

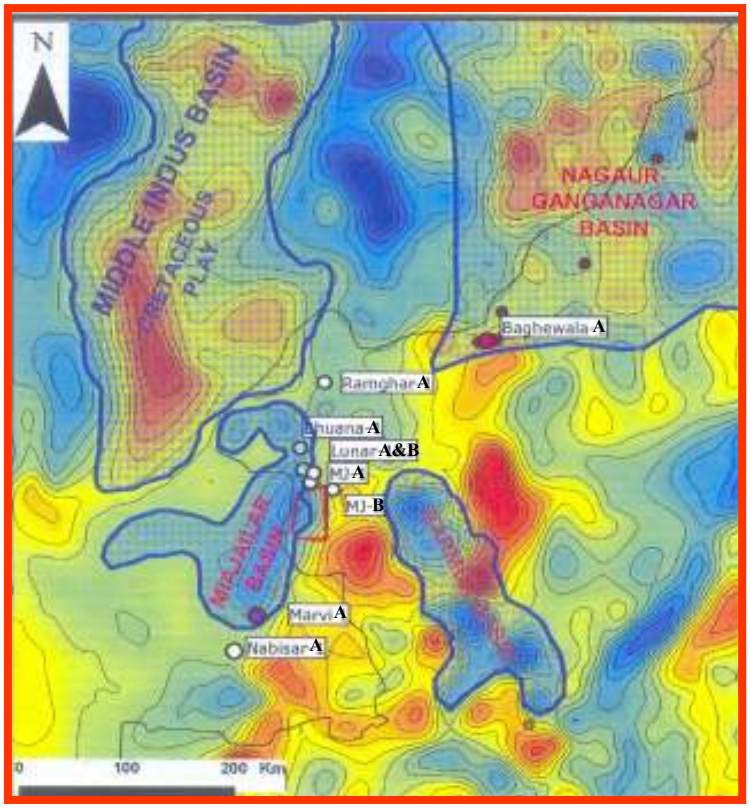

Fig. 6 Rajasthan Bouger Gravity Map