Multi-Scale Volcanic Facies Characterization of Deccan Volcanic Complex in the Barmer Basin of Rajasthan: Implication for Exploration in a Flood Basalt Province*

Adesh Pandey1, Soumen Dasgupta1, Utpalendu Kuila1, Raj Kumar Yadav1, Premanand Mishra1, and Pinakadhar Mohapatra1

Search and Discovery Article #11174 (2019)**
Posted January 7, 2019

*Adapted from oral presentation given at 2018 International Conference and Exhibition, Cape Town, South Africa, November 4-7, 2018
**Datapages © 2019 Serial rights given by author. For all other rights contact author directly. DOI:10.1306/11174Pandey2019
1Exploration, Cairn Oil and Gas, A vertical of Vedanta Limited, Gurgaon, Haryana, India (adesh0805@gmail.com)

Abstract

The Barmer Basin marks the northern limit of the Western Indian Rift system. It is a prolific hydrocarbon province with 38 discoveries and 6.4 BBOE in place. Cairn has discovered 3 fields in Deccan age volcanics, with over 700 MMBOIP. Raageshwari Deep Gas is the largest field, producing approximately 40 MMCFD of gas from a large rift block. The reservoirs are very similar to Deccan volcanic outcrops exposed in western and central India and form the northermmost limit. We map two seismic facies within the volcanic unit. The lowermost transparent unit is over 1000 m thick and unconformably overlies deeper reflections. It consists of very thin, compound braided and anastomosing lobes up to a few meters in thickness but covers broad areas. The upper reflective unit varies from 0-700 meters in thickness. It is dominated by much thicker (10-50 m) simple tabular basalt flows and pyroclastics. Porosity development and reservoir distribution are variable. The upper simple lava flows consist of a basal zone, a middle dense core with low vesicular porosity, and an upper highly porous (vesicular, brecciated/fractured) crust. The lower compound flows and ignimbrites have porosity controlled mainly by the amount of syn-depositional welding. Future volcanic hydrocarbon exploration requires an understanding of the emplacement processes, internal architectures, and controls on rock properties of the lava flows. We characterize the volcanic complex across the Barmer Basin integrating seismic, well logs, and core data. Learnings derived from this study can be applied widely to other basins and help delineate more resources within the Barmer Basin.

Selected References


Cairn RDG Report, VBPR.


Multi-scale volcanic facies characterization of Deccan volcanic complex in the Barmer Basin of Rajasthan: Implication for exploration in a flood basalt province

Adesh Pandey,
Soumen Dasgupta, Utpalendu Kuila,
Raj Kumar Yadav, Premanand Mishra, Pinakadhar Mohapatra
Cairn Oil and Gas, a vertical of Vedanta Limited
Deccan volcanism: Continental flood basalt with area >500000 sq. km.
Contemporaneous to Cretaceous- Paleocene (KT) global dinosaurs extension event
Volcanic event result of reunion hotspot activity when Indian plate migrating northwards during Indian-Seychelles rifting
Barmer Basin Tectono-Stratigraphy and Deccan volcanism

- Barmer Basin: NNE-SSW trending rift basin with ~6800 sq. km. area
- Deccan Volcanic Rocks known as Raageshwari Volcanic Complex in Barmer Basin with area >2700 sq. Km.
- 3 Oil and Gas fields in Volcanic rocks with over 700 MMBOIP
- Raageshwari Deep Gas Field producing approximately 40MMCFD
Why this Study?

- Prospects identification in Volcanic rocks
- Macro Scale volcanic Facies classification
- Core, well log, seismic data integration to constrain the 3D nature and structure of volcanic sequence in Barmer Basin
- Volcanic reservoir characterization for Reservoir derisking
Volcanic Facies Identification Approach

- 3 major scale Observations

Representative Outcrops
- Volcanic flow types
- Volcanic emplacement, architecture and process
- Multi-order features

Facies from Core
- mms to meters
- Within lava flow scale
- 4th and 5th order features

Facies from Well Log
- mts to 100s of meters
- Lava flow to lava field scale
- 3rd order features

Facies from Seismic
- Kms to tens of kms
- Province to seismic scale
- 1 and 2nd order features
Outcrops: Simple Pahoehoe Lava Flows

- High volume, high effusion rate eruptions
- Laterally extensive in Deccan Volcanic Province (DVP)
- Dominant in upper Deccan Stratigraphy
Outcrops: Compound Pahoehoe Lava Flows

- Low volume, Low effusion rate eruptions
- Laterally constrained in DVP
- Dominantly in lower Deccan Stratigraphy
Volcanic Facies from Core

Simple Lava Flow unit

- Heavily weathered vesicular flow top, vesicles filled with secondary minerals
- Densely porphyritic simple lava interior
- Natural fractures filled with zeolites

Compound flow lobes

- Soil Horizon
- Flow base
- Weathered Flow Tops
Well Log Facies for Volcanic Sequence

Simple Lava Flows

- Flow Top
- Flow Core
- Interbeds

Dense Core Flow Facies

Compound Lava Flows

- Flow Crust
- Flow Core
- Thin Flow Base

Very Thin Flows

Serrated Log Response thin core-crust pairs

Barreto et al. 2017
Nelson et al. 2009
Simple Flow Well Tie

Stacked Simple flow units (800m)

Reflective Seismic character
Compound Flow Well Tie

Dominantly compound flow units (1000m)

Transparent Seismic character
Seismic Facies for Volcanic sequence

Seismic Facies  | Reflector Characteristics | Internal Geometry | Emplacement Environment |
---|---|---|---|
Reflective  | Wedge  | Top: High amplitude peak, smooth, continuous reflection  
Base: Low amplitude trough, discontinuous reflection | High to moderate laterally changing amplitude, semi-continuous to continuous reflections, erosional pinchouts, chaotic semi-continuous character at places | Subaerial |
Transparent  | Sheet  | Top: Low amplitude trough, discontinuous reflection  
Base: High amplitude Trough/Peak(?), smooth, continuous reflector | Very low amplitude chaotic transparent reflections, moderate amplitude discontinuous isolated reflections at places | Subaerial |
Volcanic Distribution in Barmer Basin

Volcanic Thickness

Time Structure Volcanic Top

Volcanic Flow Type Distribution

Simple Flow/Reflective facies Area

Compound Flow/Transparent facies Area
Regional Correlation

Surface Expression of Deccan Flood basalts

Subsurface Expression of Raageshwari Volcanic complex
Reservoir Distribution and Risk

Stacked Simple Flow Lava Units

Flow Tops, Laterally continuous reservoir; Reservoir risk low

Compound Flow lava units

Restricted Reservoirs Fractures and Joints Important; Reservoir Risk High
Conclusion

• Simple and Compound flood basalt eruptive lavas
• Effusion rate and volume controls emplacement architecture
• Integrated multi-scale volcanological characterization and correlation of volcanics in Barmer Basin
• Reflective and Transparent seismic volcanic facies in Barmer Basin
• Simple flow unit crust provide primary reservoir zones
• Reservoir in Compound flows is dependent on secondary mechanism i.e fractures etc
References


• Cairn RDG Report, VBPR

Acknowledgement:
The author would like to thank Rajasthan Exploration team members for their technical guidance and support. We would like to thank the management of Cairn Oil and Gas, Vedanta Limited for allowing us to present our work.