Mössbauer Spectroscopic Study of Sub – Surface Samples of the DND#28 Well of the Jaisalmer Basin Located in Western Rajasthan, India

Hemant Dhaka[a], and Samay Singh Meena[b]

Department of Physics, Jai Narain Vyas University, Jodhpur, Rajasthan, India.

[a] hdhaka810@gmail.com
[b] ssmeenaphy12@gmail.com

Abstract

The Jaisalmer Basin is a pericratonic basin located on the northwest slope of the Jaisalmer Mari foundation arch that deepens southwest. With a dip angle of 30 to 50, the basin is late Paleozoic-Mesozoic and is made up of Permian rocks that unconformably rest on Proterozoic foundation. The sedimentary samples of the Pariwar Formation from the Danewala well DND#28 in the Jaisalmer Basin were the subject of the current Mössbauer spectroscopic investigation. The primary iron-bearing minerals include siderite, pyrite, and Fe^{3+} and Fe^{2+} in clay. When humic organic matter is present, the presence of Fe^{3+} in clay is more favourable, and siderite indicates that the source rocks are not as mature.

Keywords: Basin, Clay, Mineralogy, Mössbauer, Sediments.
Received 30 January 2025; First Review 14 February 2025; Accepted 19 March 2025.

*** Address of correspondence**
Hemant Dhaka
Department of Physics, Jai Narain Vyas University, Jodhpur, Rajasthan, India.

Email: hdhaka810@gmail.com

How to cite this article
Hemant Dhaka, and Samay Singh Meena, Mössbauer Spectroscopic Study of Sub – Surface Samples of the DND#28 Well of the Jaisalmer Basin Located in Western Rajasthan, India, J. Cond. Matt. 2025; 03 (01): 126-128.

Available from:
https://doi.org/10.61343/jcm.v3i01.119

Introduction

The source rocks are thought to be the sediments that contain organic stuff. The only substance used to generate hydrocarbons is these source rocks. The maturity and quality of a basin's source rocks have a substantial impact on its hydrocarbon potential and accumulation pattern. One important factor in the characterisation of source rocks is the degree of diagenesis of the inorganic minerals. ^{57}Fe Mössbauer spectroscopy may be used to analyze Iron-containing minerals, including pyrite, carbonates, clay minerals, and oxides that are found in the inorganic materials associated with organic rich sediments [1-2].

Siderite is form diagenetic and redox condition during deposition as early diagenesis, shortly after sediment deposition, through the interaction of iron-rich pore waters and carbonate ions and also the reduction of iron oxides and hydroxides can lead to the formation of siderite and anoxic environments, where the lack of oxygen prevents the oxidation of iron and allows the formation of iron carbonate minerals. Reducing conditions, such as those found in sediments with high levels of organic matter, can also favour the formation of siderite [3-6]. The presence of siderite, calcite, and dolomite suggests a shallow marine to lacustrine depositional environment [7].

Mössbauer spectroscopy study also compared with other analyse technologies like SEM-EDS and XRD. SEM-EDS provides elemental analysis, including iron, but does not offer information on the iron oxidation state or coordination environment other hand Mössbauer spectroscopy provides detailed information on the iron-bearing phases [8-9]. And XRD cannot directly determine the iron oxidation state, whereas Mössbauer spectroscopy can provide information on the iron oxidation state and coordination environment. [10]. The current study used ^{57}Fe Mössbauer spectroscopy to examine The Lower Cretaceous sedimentary sequence of well DND#28, dug in the Danewala structure of the Jaisalmer basin, contains sedimentary materials from the Pariwar formation at different depths. Mössbauer spectroscopy is a valuable tool for identifying iron-bearing minerals [11-13].

The method has been applied to coal, oil shale, and rocks that are sources of petroleum to investigate the iron's chemical composition. The studies give helpful information regarding the use of fossil fuels. This method is often used to study geological samples, encompassing every kind of sediment. The state of sedimentary iron metal oxidation is a well-known indication of the oxidation reduction condition of sedimentation [14-18].

In order to better We have restricted our investigation to Cretaceous sediments in order to comprehend the relative distribution of iron-bearing minerals with depths and ascertain whether the presence or lack of these minerals is correlated with the environment of deposition, which in turn determines the rate of sedimentation, a critical parameter in assessing the quality of organic matter for hydrocarbon prospecting in a basin. The presence of organic-rich shales and the mineralogical evidence for anoxic conditions suggest a high potential for source rock formation.

Method

In a sample holder (25 mm in diameter), finely ground sediment samples were sandwiched between two paper discs to form Mössbauer absorbers.

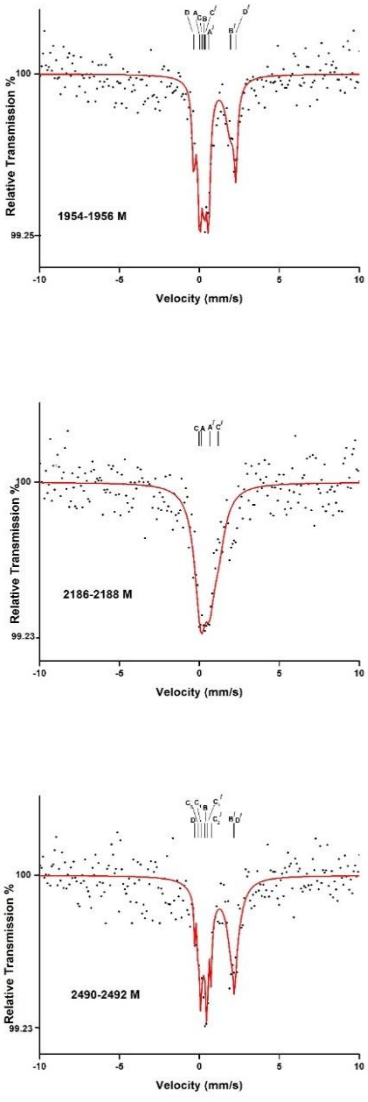

Figure 1: Mössbauer spectra of the samples at room temperature

Table 1: Mössbauer parameters of the samples of Pariwar formation of well DND#28

Depth	Peaks	IS (mm/s)	QS (mm/s)	LW	RA	X²	Assignment
1954-1956 M	AA$^{/}$	0.29	0.55	0.24	27.7	1.61	Pyrite
	BB$^{/}$	1.11	1.92	0.76	45.1		Siderite
	DD$^{/}$	0.96	2.63	0.24	19		Fe^{2+} in clay
	CC$^{/}$	0.31	0.09	0.24	8.2		Fe^{3+} in clay
2186-2188 M	AA$^{/}$	0.34	0.66	0.73	49	1.26	Pyrite
	CC$^{/}$	0.58	1.19	1.06	51		Fe^{3+} in clay
2228-2230 M	CC$^{/}$	0.55	0.34	0.78	61.6	1.17	Fe^{3+} in clay
	NN$^{/}$	0.04	0.41	0.92	38.4		Non identify
2370-2372 M	$C_1C_1^{/}$	0.18	0.77	0.61	38.2	1.14	Fe^{3+} in clay
	$C_2C_2^{/}$	0.32	0.27	0.67	61.8		Fe^{3+} in clay
2490-2492 M	BB$^{/}$	1.24	1.78	0.84	81.2	1.12	Siderite
	$C_1C_1^{/}$	0.29	0.37	0.07	8		Fe^{3+} in clay
	$C_2C_2^{/}$	0.39	0.81	0.07	6.9		Fe^{3+} in clay
	DD$^{/}$	0.95	2.52	0.07	3.9		Fe^{2+} in clay

The thickness of the absorbers remained constant. Using a typical constant acceleration spectrometer, Mössbauer spectra were recorded at room temperature (300K) using a 10 mCi source in a Pd-matrix. The experimental setup's specifics are comparable to those previously described by Nigam et al. [19]. A 25 µm thick α-iron foil spectrum's centroid has been used to report the isomer shift (IS). A computer program created by Meerwall was used to suit each spectrum [20].

Discussion

The Danewala structure from the Jaisalmer basin is where the well DND#28 is situated. ^{57}Fe Mössbauer spectroscopy was used to analyse sedimentary samples from the Pariwar Formation at different depths in the upper Cretaceous succession. Figure shows the typical Mössbauer spectra of well DND#28 that were taken at ambient temperature. AA$^{/}$

attributes pyrite, BB$^{/}$ attributes siderite, CC$^{/}$ attributes Fe^{3+} in clay, DD$^{/}$ attributes Fe^{2+} in clay, and NN$^{/}$ attributes an unidentified peak. The depth at which the sample is obtained is shown in the graphic itself.

Conclusion and Future Prospective

All of the samples used in this investigation have a noticeable amount of Fe^{3+} in clay, Presence of Fe^{3+} in clay is more favorable when the humic type of organic matter is present and presence of siderite shows the poor maturity of source rocks. The presence of siderite, calcite, and dolomite suggests a shallow marine to lacustrine depositional environment. So the rock is immature and in future they will be matured as compression of hydrocarbon prospects. The presence of organic-rich shales and the mineralogical evidence for anoxic conditions suggest a high potential for source rock formation.

References

1. G M Bancroft, *"Mössbauer Spectroscopy: An Introduction for Inorganic Chemists and Geochemists"*, McGraw-Hill. 1973.
2. S Mørup, J Franck, *"Mössbauer spectroscopy study of the chemical state of iron in Danish Mesozoic sediments"*, Fuel, 64: 528–538,1985.
3. Curtis, C. D., *"Geochemistry of diagenesis in sediments. In A. Parker & B. W. Sellwood (Eds.)"*, Sediment diagenesis,15–34,1983.
4. Canfield, D. E., *"Reactive iron in marine sediments"*, Geochimica et Cosmochimica Acta, 53: 619–632, 1989.
5. Berner, R. A., *"A new geochemical classification of sedimentary environments"*, Journal of Sedimentary Petrology, 51: 359–365,1981.
6. Froelich, P. N., *"Early oxidation of organic matter in pelagic sediments of the eastern equatorial Atlantic: suboxic diagenesis"*, Geochimica et Cosmochimica Acta, 43: 1075–1090, 1979.
7. Tucker, M. E., *"Sedimentary petrology: An introduction to the origin of sedimentary rocks"*, Wiley-Blackwell, 2001.
8. Reed, S. J. B., *"Electron microprobe analysis"*, Cambridge University Press, 1993.
9. Hawthorne, F. C., *"Mössbauer spectroscopy. In F. C. Hawthorne (Ed.), Spectroscopic methods in mineralogy and geology"*, Mineralogical Society of America: 255–274, 1988.
10. Coey, J. M. D., *"Mössbauer spectroscopy of iron in clay minerals. In J. E. Firth (Ed.), Clay minerals: Their structure, properties, and uses"*, Royal Society of Chemistry: 191–206,1984.
11. S Ram, *"Distribution of iron in siderite in sub-surface sediments of Jaisalmer Basin (India) using Mössbauer spectroscopy"*, Fuel, 77: 1507–1512,1998.
12. B Bhatia, *"Mössbauer spectroscopic study of sediments collected from test wells drilled in the Bikaner-Nagaur Basin"*, Fuel, 98: 140–148,2012.
13. R P Tripathi, *"Fe Mössbauer spectroscopy study of organic rich sediments (source rocks) from test well CT-1, Chinnewala structure of Jaisalmer basin, India"*, Geosciences Frontiers, XXX: 1–6,2015.
14. S S Meena, *"Mössbauer Spectroscopic Study of the Sedimentary Samples Collected from Barmer Hill Formation of Northern Barmer Basin, Western Rajasthan (India)"*, IJIRET, 5: 1558–1560,2016.
15. S S Meena, *"Fe Mössbauer Spectroscopic Study of Sedimentary Samples from Goru Formation in Well MNW-1 of Jaisalmer Basin, Rajasthan, India"*, Journal of Pure and Applied Science & Technology, 7: 18–26,2017.
16. R Pandey R, A S Maurya, *"Hydrocarbon Uncertainty Based on Facies Analysis: Middle Jurassic Sequence (Jaisalmer Formation), Jaisalmer Basin, Rajasthan"*, Journal Geological Society of India, 95:301–307,2020.
17. M Bohra, *"Mössbauer spectroscopy study of Samples from Cambay Shale Formation, Cambay Basin, in context of Shale Oil"*, Journal Geological Society of India, 96: 603–608, 2020.
18. S Ram, *"Estimation of Environment of Sedimentary Deposition in Parh Formation of Tertiary Sediments of Jaisalmer Basin, Rajasthan, India"*, Applied Ecology and Environmental Sciences, 10: 802–805,2022.
19. A N Nigam, R P Tripathi, H S Singh, R S Gambhir and N G Lukose, *"Mössbauer studies on Ghotaru Well No.1 of Jaisalmer Basin"*, Fuel, 68:209–212,1989.
20. E V Meerwall, *"A least-squares spectral curve fitting routine for strongly overlapping Lorentzians or Gaussians"*, Computer Physics Communications, 9: 117–128,1975.