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Integrated Study of Geological Sub-Surface Samples of Goru Formation of Well DND#27 in the Jaisalmer Petroliferous Basin of Western Rajasthan, India

Hemant Dhaka*[1], Samay Singh Meena[2]
[1,2]*Department of Physics, Jai Narain Vyas University, Jodhpur 342001*
**hdhaka810@gmail.com*

DND#27 is a test well situated in the structure of Danewala in the Jaisalmer Petroliferous Basin in western Rajasthan. The sandstone sedimentary samples taken from the Goru formation of Tertiary sedimentary sequence were employed to look into the mineralogy of iron-containing minerals using Mössbauer spectroscopy. FTIR analytical study of the chemical composition of the minerals variation with temperature of the samples. In the current Mössbauer investigations, iron is primarily found as siderite carbonate and as pyrite-containing clay minerals. A notable difference in the amount and type of siderite and pyrite, along with the presence of (Fe, Mg, Ca) carbonates, is recognized as the context of sedimentary deposition. Iron is detected in the current Mössbauer research mostly as siderite (carbonate) and as pyritecontaining clay minerals. The environment of sedimentary deposition is examined to reveal a notable difference in the amount and type of siderite and pyrite, as well as the presence of (Fe, Mg, Ca) carbonates. FTIR studies at various temperatures of samples show the disappearance of siderite around 600 °C, which verifies that carbonate, is present.

Keywords: Sedimentary, Formation Mineralogy and Redox Condition.

1. Introduction

Overlooking the Jaisalmer Mari platform, the Jaisalmer basin is a pericratonic basin that forms the eastern flank of the Indus shelf. Many test wells were drilled in various Jaisalmer basin structures encountered stratigraphically, starting from top, the wells penetrate through the rock formations; Shumar (sub-recent), Bandah, Khuiala and Sanu (Middle-Eocene to Paleocene), Goru (Albian-Cenomanian-Upper Cretaceous), Pariwar (Lower Cretaceous), Baisaki-Bedesir (Upper Jurassic), Jaisalmer (Middle Jurassic) and Lathi (Lower Jurassic). The present investigation has concentrated on the sedimentary sequence of the Cretaceous period of well DND#27. This formation consists of sandstone and shale deposits in a transgressive phase with some regression [1].

Mössbauer spectroscopy is a valuable tool for identifying iron-bearing minerals [2]. The method has been applied to coal, oil shale, and rocks that are sources of petroleum to look into the iron's chemical composition. The studies give helpful information regarding the utilization of fossil fuels [3]. This method is frequently utilized 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. This technique is the only one that offers vital details regarding the Fe^{2+}/Fe^{3+} ratio in sediments [4]. Mössbauer spectroscopy is the only quantitative method available for obtaining information on the chemical composition of iron in all substances containing iron. The Fe^{2+}/Fe^{3+} ratio and the semi-quantitative distribution of iron in various minerals and lattice sites may both be found using Mössbauer spectroscopy, which is widely acknowledged as a viable method [5]. Shale deposits from different basins are also studied using Mössbauer spectroscopy [6-12]. Based on these studies, the theory is that the biologically rich gas and oil shales originated in an anoxic environment, whereas the Kerogen-poor shales developed in an environment with a high oxygen concentration. Additionally, the Jodhpur Mössbauer group examined the chemical composition of iron in underlying sediments from a number of petroliferous basins in India [13-25]. According to these investigations, Mössbauer spectroscopy may be employed as an extra instrument for characterizing sediments that are rich in organic matter.
Infrared spectroscopy is a common technique for examining the structure, bonding, and chemical properties of minerals in clay [26]. IR spectroscopy is the best technique for mineral analysis because it's rapid, cheap, time-consuming, and non-destructive. An investigation into the qualitative mineral analysis of sedimentary samples has been attempted in this study. Infrared radiation is the region in which atoms naturally vibrate in molecules and crystals. Certain frequencies, in accordance with the energy states of electrons in solids and in large molecules, fall in the IR. The IR method is sensitive to short-range ordering or nearest-neighbour relationships. Many different types of substances, both organic and inorganic, have been characterized through the use of infrared spectroscopy. The rotation and vibration of the molecules within a mineral are linked to its absorption of infrared radiation [27].

From a stratigraphic perspective, the Goru Formation found in well DND#27 was deposited during the Late Cretaceous to early Tertiary sedimentary era. It is situated on top of the Cretaceous sedimentary sequence, which comprises source rocks. The well DND#27 was drilled by Oil India Limited (OIL), India in the Danewala structure have shown good quality and an appreciable number of gaseous hydrocarbons. The goal of this work is to comprehend the relative distribution of iron-containing mineralsby reporting on a ^{57}Fe Mössbauer spectroscopic analysis conducted on selected five samples of various depths from 1488 – 1974 meters from the Goru Formation in the Tertiary strata of well DND#27.

2. Materials and Methods

Mössbauer spectroscopy

In order to create Mössbauer absorbers, sediment samples that were finely powdered were placed between two paper discs in a sample container that had a 25-mm diameter. The absorbers' thickness was consistently maintained. A 10 mCi source is used within a Pd-matrix at room temperature. Mössbauer spectra were recorded using a standard constant acceleration spectrometer. Details of the experimental setup are comparable to those that Nigam previously published [28]. The isomer shift has been documented in relation to the centroid of an α-iron foil spectrum with a thickness of 25 µm. Each spectrum was fitted using a 1975 computer program created by Meerwall [29]. The spectrum is assumed in this program to be the sum of Lorentzians. Quadrupole doublets often require the widths and intensities of its two components to be the same. Computer-fitted curves are shown by solid lines in the spectra presented here, whereas experimental points are represented by dots. In order to get statistical acceptance, the value of the chi-square parameter, or χ^2, must fall between $\upsilon+2.2-3.3\sqrt{\upsilon}$ and $\upsilon+2.2+3.3\sqrt{\upsilon}$. In this investigation, the χ^2 values are typically found within this range. However, when iterations fail to provide additional improvements in χ^2, a little divergence in χ^2 has been tolerated on a few occasions. Weak lines lead to this kind of problem.

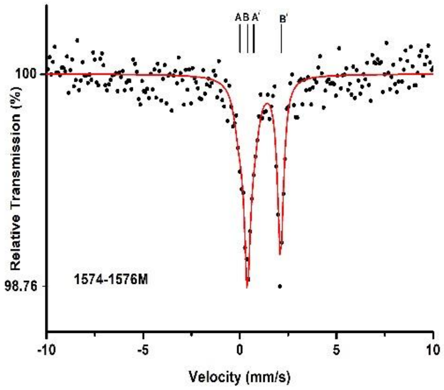
3. FTIR spectroscopy

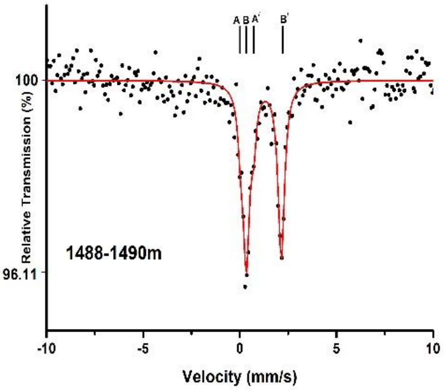
The ATR pellet technique was followed for the examination of minerals. To offer a good characterization of a material using infrared spectroscopy, the spectrum should be recorded in the range of 4000-400 cm^{-1}. Commonly, various functional groups in the molecule can be detected or excluded using infrared analysis by utilizing the group vibration idea. Mineral-containing groups share distinctive absorption bands with certain chemical groups. The primary source of the spectra is vibrational starching and bending modes in molecules. The method provides a fingerprint for the identification of molecular structures.

4. Results and Discussion

The well DND#27 is located in the Danewala of the Jaisalmer basin. Sedimentary samples from the Goru Formation at various depths in the upper cretaceous sequence were examined using 57Fe Mössbauer spectroscopy. The typical Mössbauer spectra of well DND#27 recorded at room temperature are displayed in Figure 1. Siderite is attributed by $BB^{/}$ and Pyrite by $AA^{/}$. The figure itself indicates the depth from which the sample was taken. Every sample's Mössbauer spectra were resolved into doublets, which primarily corresponded to siderite and pyrite. All of the samples used in this investigation have a noticeable amount of siderite, which is a more humic and favorable form of organic matter, as well as a less humic and algal type. It is linked with a favorable redox condition, and it is well established that pyrite is diagenetically more stable. It displays the Jaisalmer basin's source rock sedimentary sequence.

The Mössbauer result was also verified by FTIR analytical studies of the samples. Peaks are attributed by A, B, C, and D respectively to siderite, clay, quartz (double peaks), and pyrite. FTIR spectra are obtained at different temperatures, as shown in Fig. 2. As temperature increases, siderite starts to decompose and disappears at 600 °C, and the pyrite peak shifts towards the higher wavenumber/towards quartz peak. Mössbauer spectroscopy study and the FTIR analytic study showed the same result.


A B A'
B'
100
98.76
Relative Transmission (%)
1574-1576M
-10
-5
0
5
10
Velocity (mm/s)


A B A'
B'
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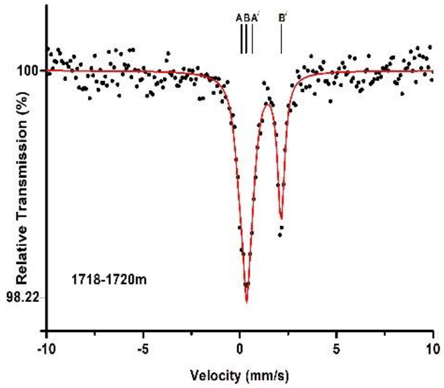
96.11
Relative Transmission (%)
1488-1490m
-10
-5
0
5
10
Velocity (mm/s)


ABA'
B'
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98.22
Relative Transmission (%)
1718-1720m
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-5
0
5
10
Velocity (mm/s)

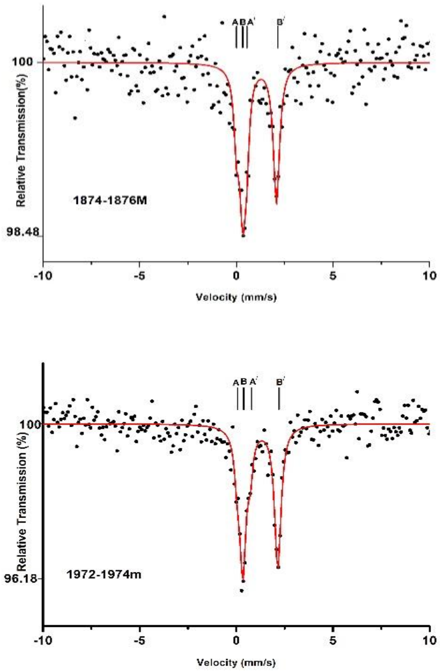

Figure 1: Different depth's Mössbauer spectra ofDND#27 well in Jaisalmer basin

Table 1: Mössbauer parameters for minerals present in DND#27 well in Jaisalmer basin

Sample	Peaks	IS (mm/s)	QS (mm/s)	LW (mm/s)	RA	χ2	Assignment
1488-1490M	AA$^{/}$	0.38	0.69	0.309	15.86	1.16	Pyrite
	BB$^{/}$	1.24	1.81	0.407	84.14		Siderite
1574-1576M	AA$^{/}$	0.38	0.78	0.631	29.82	1.09	Pyrite
	BB$^{/}$	1.25	1.72	0.381	70.18		Siderite
1718-1720M	AA$^{/}$	0.31	0.60	0.659	44.74	1.09	Pyrite
	BB$^{/}$	1.24	1.80	0.448	55.26		Siderite
1874-1876M	AA$^{/}$	0.27	0.53	0.292	25.6	1.00	Pyrite
	BB$^{/}$	1.20	1.75	0.396	74.4		Siderite
1972-1974M	AA$^{/}$	0.38	0.69	0.309	15.86	1.16	Pyrite
	BB$^{/}$	1.24	1.81	0.407	84.14		Siderite

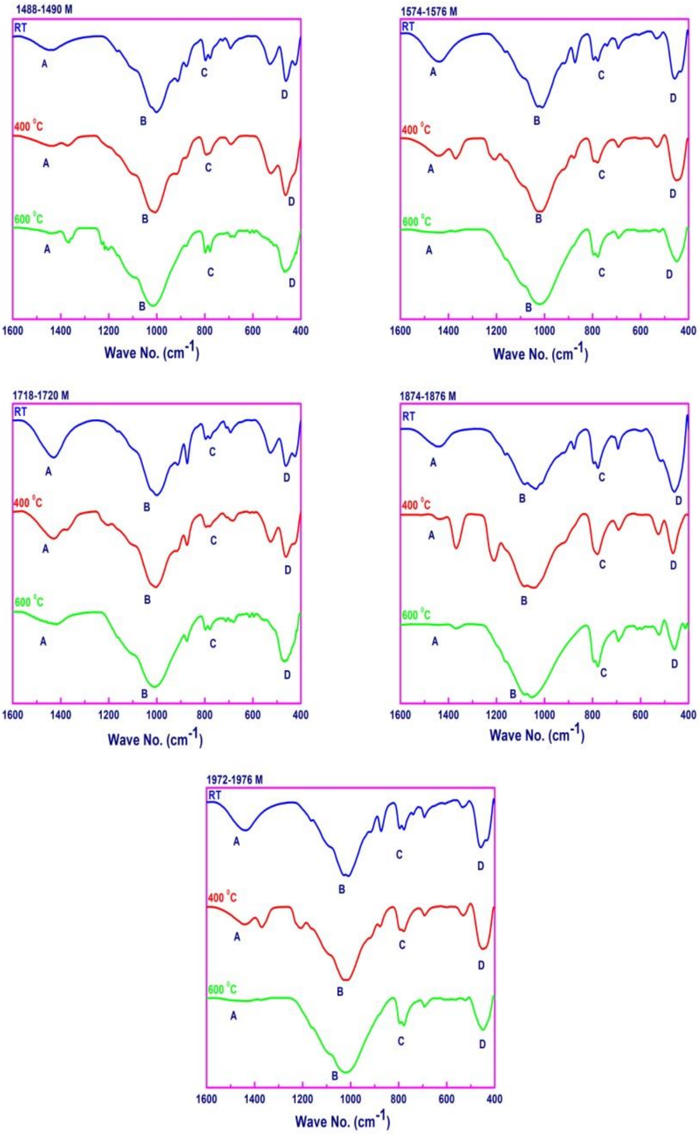

Figure 2: FTIR spectra of well DND#27 recorded at different temperatures

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Declaration

The manuscript has been prepared through contributions of all authors. All authors have given approval to the final version of the manuscript. All authors declare that they have no conflicts of interest.

Data Availability

The data in the current study are available from the corresponding author on reasonable request.

Authors Contributions

All authors have taken full responsibility for the content of this manuscript.

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