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Research paper

^{57}Fe Mössbauer spectroscopy study of organic rich sediments (source rocks) from test well CT-1, Chinnewala structure of Jaisalmer basin, India

R.P. Tripathi [a,*], Beena Bhatia [a], R. Sharma [a], K.R. Patel [a], S.S. Meena [a], Girish Ganwani [a], S.C. Mathur [b]

[a] Department of Physics, Jai Narain Vyas University, Jodhpur 342 005, India
[b] Department of Geology, Jai Narain Vyas University, Jodhpur 342 005, India

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ABSTRACT

^{57}Fe Mössbauer spectroscopic study was carried out on the organic rich sedimentary samples collected at different depth intervals from newly drilled test well Chinnewala Tibba-1 (CT-1) located in Jaisalmer Petroliferous basin India. It is found that iron is mainly distributed in high spin Fe^{3+} and Fe^{2+} state in clay minerals. The plot of $Fe^{2+}/(Fe^{2+} + Fe^{3+})$ indicates the presence of poor redox conditions in the samples. Results obtained are also compared with those already reported in the literature. This comparison shows that there may exist a correlation between prospecting of the basin, the redox environment in sediments and the nature of iron bearing minerals distributed in the sedimentary sequence.

1. Introduction

^{57}Fe Mössbauer spectroscopy is particularly useful for characterization of iron bearing species because it probes the local environment of iron nuclei sensitivity. This method offers certain advantages over other conventional techniques such as chemical, optical, electron microscopic analysis etc. Indeed each technique has its own strength, but where Mössbauer spectroscopy can give results, it offers a quick reliable and simple method. Being non destructive technique in the sense that the sample either in powder form or thin slice is not altered during the experiment also in a single run, one can get information about all the iron phases present in the sample by proper deconvolution of the Mössbauer spectrum.

This technique is widely used for the study of geological samples including all types of sediments. As it is well known that oxidation state of iron metal in sediments is a measurement of oxidation-reduction condition of sedimentation. It is the only technique which provides crucial information about ferrous/ferric ratio in sediments. To get better insight about the application of ^{57}Fe Mössbauer spectroscopy for geological samples, we refer to excellent review by Tominaga and Minai (1984). Mössbauer spectroscopy is also used widely to study organic rich sediments (source rocks) from different petroliferous basin. In fact source rocks are tiny generators of oil/gas or both. Source rock characterization is one of the important aspect for the exploration of oil/gas. To get more information about source rocks we refer to Hobson and Tratsoo (1981) and Tissot and Welte (1984).

The mineral matters present in source rocks also contain iron bearing minerals which can be characterized by Mössbauer spectroscopy.

In an early work Mørup et al. (1985) have studied the chemical state of iron in the organic rich sediments from Danish North Sea offshore and onshore wells. They have shown that in the offshore sediments, iron was mainly present in most of the samples in the form of Fe^{2+} in clay minerals and pyrites. In some samples siderites/ankerite was also present. This distribution of minerals suggests that North Sea offshore sediments were deposited in highly reducing environment. It is worthwhile to note that offshore region is major oil field of North Sea. In view of above study the detail study of chemical state of iron in subsurface sediments for four different petroliferous basin of India was carried out by our group

* Corresponding author.
E-mail address: rptphy@rediffmail.com (R.P. Tripathi).
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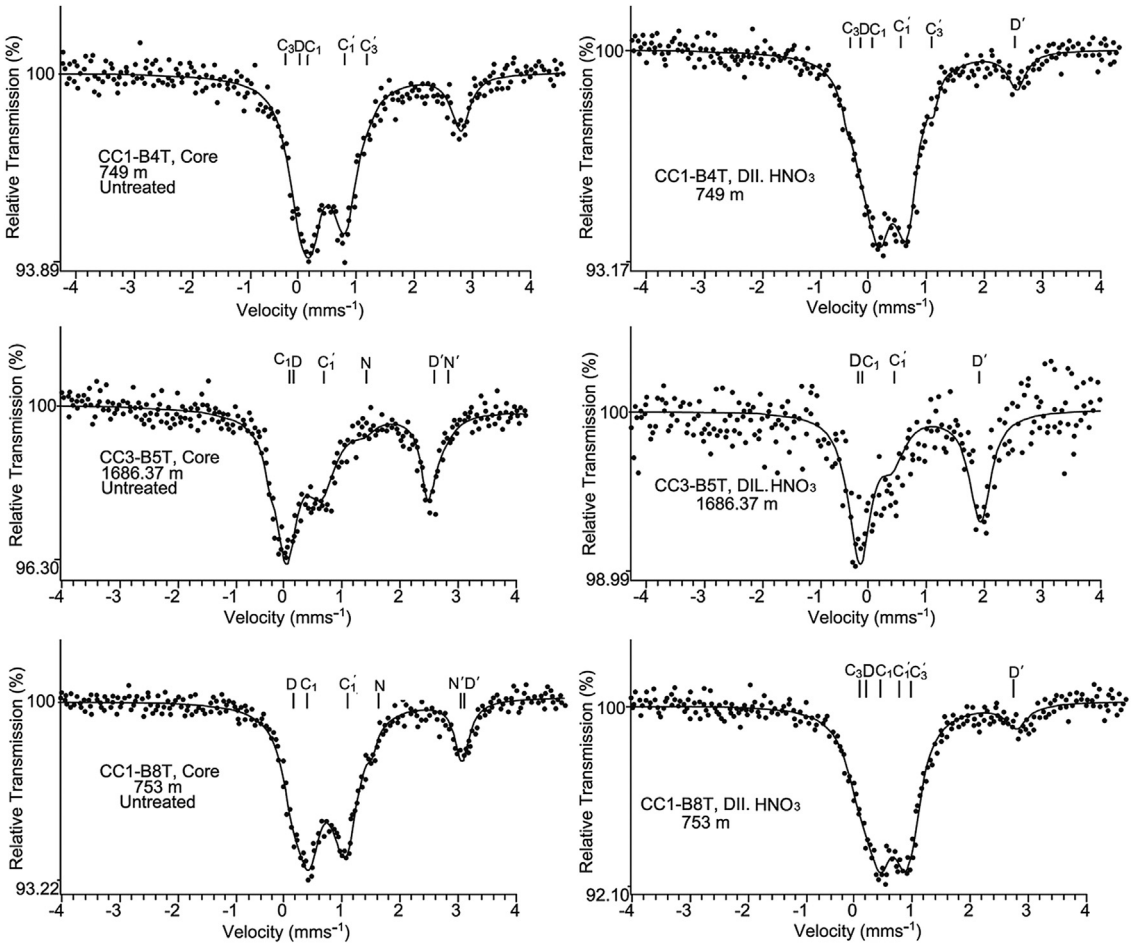

Figure 1. Mössbauer spectra of untreated and acid treated samples collected from well CT-1. Depths at which the samples were collected are given in figure itself.

(one of the authors RPT was associated with this work). These four basins are Eastern Krishna Godawari basin (EKG), Cambay basin, Bikaner-Nagaur basin and Jaisalmer basin. All these basins are located in different parts of our country, while EKG and Cambay basins are major fields of gaseous hydrocarbons, no oil/gas was discovered in Bikaner-Nagaur basin. In Jaisalmer basin no oil so far discovered but some structures have yielded hydrocarbons (mainly methane accompanied by significant amount of carbon dioxide and nitrogen). Our results of studies for these basins are already reported (Nigam et al., 1991; Ram et al., 1998; Tripathi et al., 2008; Kulshreshtra et al., 2004; Bhatia et al., 2012).

It is interested to note that relative distributions of iron bearing minerals obtained for both EKG and Cambay sediments show almost similar trend, though both the basins are geographically far apart. Sediments of these basins exhibit presence of iron pyrite, Fe^{3+} and Fe^{2+} in sulphate minerals and Fe^{3+} in clay minerals. This distribution is markedly different from those observed in Danish North Sea offshore sediments. This indicates that sediments of EKG and Cambay basins were deposited in less reducing conditions as compared to North Sea offshore sediments. Further Bikaner-Nagaur basin where no conventional oil/gas is so far discovered shows presence of iron in $\alpha_{Fe_2O_3}$ that is in hematite and Fe^{3+} in clay minerals (Bhatia et al., 2012). This indicates that sediments of Bikaner-Naugaur basin show highly oxidizing condition of deposition. These studies point out that there may be some correlation between oxidation-reduction conditions of sedimentation and hydrocarbon prospecting of basin.

If there is any correlation between redox environment and hydrocarbon prospecting of the basin then sediments of Jaisalmer basin would exhibit poor reducing environment. This is in context that in Jaisalmer basin no oil is so far discovered and quality of gaseous hydrocarbon is poor. Though earlier studies reported by our group show appreciable presence of siderites in sediments collected from Jaisalmer basin, indicating poor reducing environment in this basin. But the better index to determine oxidation and reducing condition of sediments is to determine the relative distribution of iron in Fe^{2+} and Fe^{3+} in clay minerals. Therefore in present investigation we have extended our study on the subsurface sedimentary samples collected from recently drilled well CT-1 located in Chinnewala Tibba at different depth interval and at different stratigraphic level of Jaisalmer basin. Sample used for present investigation belongs to Paleocene and Cretaceous. The organic matters present in these samples are basically of humic type with type-III Kerogen.

The aim of our study is to get better understanding of oxidation and reducing conditions of Jaisalmer sediments.

2. Experimental details

The Mössbauer absorbers were prepared by sandwiching finely ground sediment samples between two paper discs in a sample holder (25 mm in diameter). The thickness of the absorber was always kept constant. Mössbauer spectra were recorded at room temperature (300 K) with a conventional constant acceleration, the