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Mössbauer Spectroscopic Study of the Sedimentary Samples Collected from Sanu Formation of Northern Jaisalmer Basin, Western Rajasthan (India)

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Abstract: Sanu Formation is limited to the northwestern of Jaisalmer Basin. The Sanu Formation overlies the Jurassic with an unconformable contact and is overlain by white Siliceous. The formation is a thick sequence of coarsening upward. It commences with a 3 to 4 m thick basal conglomerate bed. The Mössbauer spectroscopic study of the sedimentary samples collected from Sanu formation was carried out. The complex pattern of Mössbauer parameters attributed Hematite, pyrite, Fe^{3+} in clay and magnetite minerals were recorded.

Key Words: Mössbauer, Sediment, Formation & minerals etc.

Introduction: Jaisalmer basin was formed when the Indian creation broke-up toward the one Cretaceous and led to the formation of the Cambay rift and constituent basin in north western part of India. Jaisalmer basin is one of the constituent basins. It is a narrow north-south trending graben that comprises sediments of middle Jurassic to lower Eocene age (Mathur et al., 2006; Compton (2009). The basin's presence was suspected from gravity and in the late 1980s but not confirmed until 1999 from seismic, magnetic and drilling data that the basin is a lacustrine failed rift. The Cretaceous to Paleocene sediments of northern part of Jaisalmer basin are named as Sanu Formation. The details study about the geology, origin of major oil reservoir in the Sanu Formation is discussed in detail by Patra (2020). It is well known that iron-bearing minerals are significant and important component of sedimentary samples and carry a lot of information about their depositional history [1-8].

Mössbauer spectroscopy is widely used for the study of geological samples including all types of sediments for mineralogical identification, investigation of the oxidation states and site population of the iron and identification of iron bearing minerals, and the semi quantitative analysis of iron distribution in each mineral and lattice site [9]. It is well known that the oxidation state of iron metal in sediments is a measurement of the oxidation-reduction condition of sedimentation. It is the only technique that provides crucial information about the ferrous/ferric ratio in sediments. To get better insight into the application of 57Fe Mössbauer spectroscopy for geological samples [10]. 57Fe Mössbauer spectroscopy is particularly useful for the 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 a 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. Mössbauer spectroscopy is also used widely to study organic-rich sediments (source rocks) from the different petroliferous basins. In fact, source rocks are tiny generators of oil/gas or both. Source rock characterization is one of the important aspects of the exploration of oil/gas. This distribution of minerals suggests that North Sea offshore sediments were deposited in a highly reducing environment. It is worthwhile to note that the offshore region is a major oil field off the North Sea. The detailed study of the chemical state of iron in subsurface sediments for four differ tiny of minerals including iron-bearing minerals, e.g. if the rate of sedimentation is fast it quickly cuts off sediment from the environment and this may favor the formation of minerals like pyrite which are diagenetically stable in reducing environment. Simultaneously organic matter also escapes oxidation and becomes more favorable for the generation of oil. But if the sedimentation rate is slow sediments will remain in contact with the atmosphere for more time. This may result in oxidation of organic matter making it unfavorable for the generation of oil and favors minerals like siderite, iron oxide etc. depending upon the degree of redox condition. This correlation can also be viewed that the physicochemical transformation of organic matter during the geological history of the sedimentary basin cannot be regarded as an isolated process. It is controlled by the same major factors that determine the variation of the composition of the inorganic solid phase of sediments; that is to say, biological activities in the early stage, and temperature and pressure afterward decide the evolution of both the organic matter and the inorganic solids [9-11]. 57Fe Mössbauer spectroscopy is particularly useful for the 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 [12-17].

Experimental: For present study few sedimentary samples were collected from Sanu Formation. Fraction of these powdered samples was used for Mössbauer study. The Mössbauer absorbers were prepared by using fraction of these finely ground powder sediment in a sample holder (25 mm in diameter). The thickness of the absorbers was always kept constant. Mössbauer spectra were recorded at room temperature (300K) with a conventional constant acceleration spectrometer using a 10 mCi source 57Co in a Rh matrix. The isomer shifts (IS) has been reported with respect to the centroid of a 25-µm thick α-iron foil spectrum. Each spectrum was fitted using a computer program. This program assumes the spectrum to be the sum of Lorentzians. In most of the cases, width and intensity of the two halves of a quadrupole doublet or six halves in case of sextet were constrained to be equal. While in the case of sextet intensity of line 1 and 6, 2 and 5 and 3 and 4 were constrained to be equal. The relative intensities of various mineral components or sites were calculated by adding the areas of the two halves of the corresponding doublet or six halves of the corresponding sextet and are expressed as a fraction of the total area of resonant absorption. Solid lines in the spectra reported here represent computer-fitted curves and dots represent the experimental points. The χ^2 values are generally obtained in this range. However, a little deviation in the χ^2 has been accepted on few occasions when the iterations do not yield to further improvements in χ^2. Such a situation arises when weak lines are present.

Result:

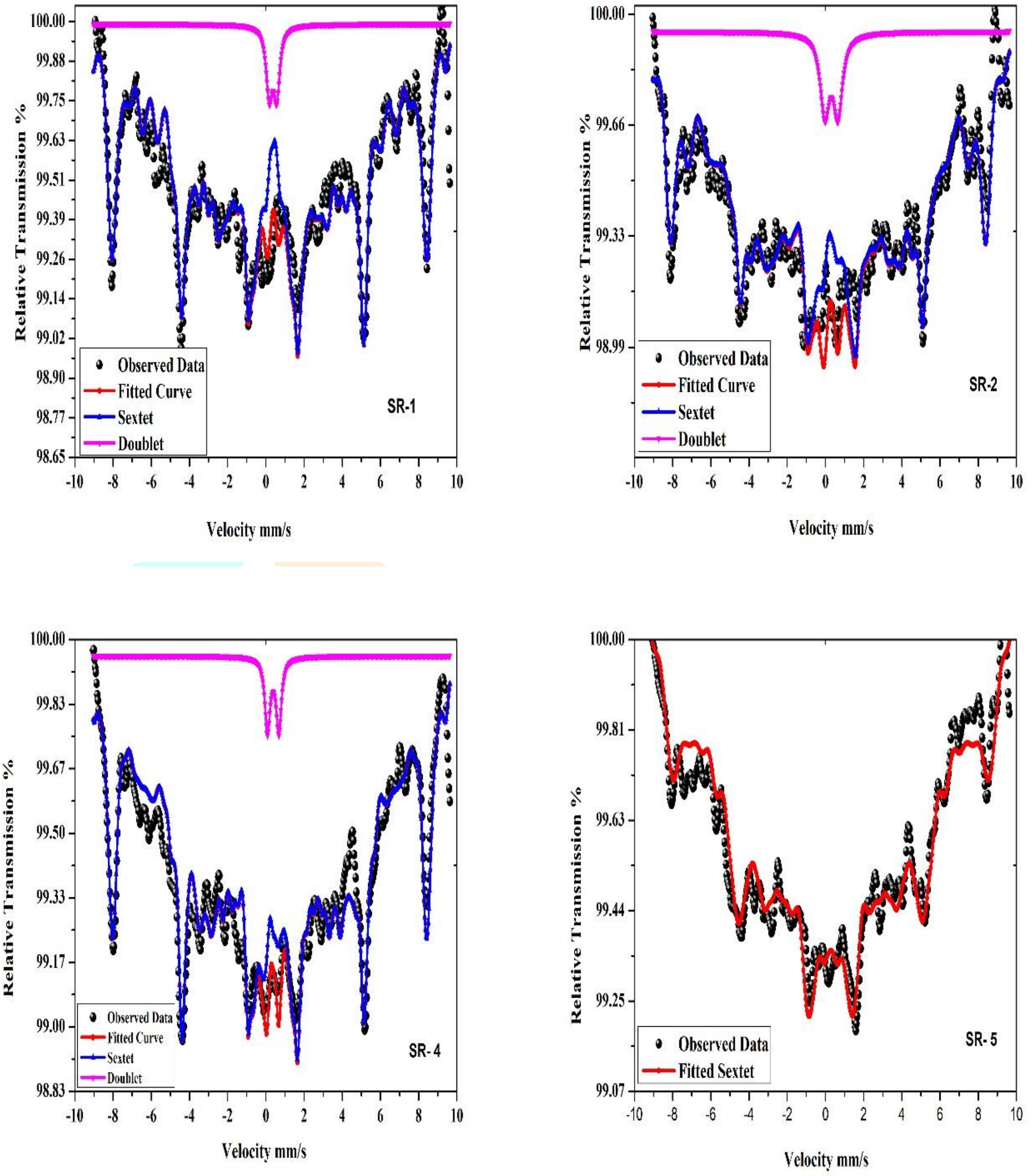

Figure 01: Mössbauer Spectra of the samples (SR - 1, SR – 2, SR – 4, SR - 5) at Room Temperature of Sanu Formation of Jaisalmer Basin

Table 01: Mössbauer parameters of Samples from Sanu Formation

Sample Code	Sub Spectrum	IS ‘δ’ (mm/s)	Q. S. (mm/s)	Hyperfine Field ‘H_f’	L. W. (mm/s)	Relative Area (%)	χ^2	Peak Assignment
SR-1	S1	0.27	-0.18	33.90	0.31	97.32	1.090	Hematite
	D1	0.37	0.39	-------	0.38	2.68		Fe^{3+} in clay
SR-2	S1	0.23	-0.16	33.52	0.37	96.05	1.093	Hematite
	D1	0.31	0.69	--------	0.58	3.95		Pyrite
SR-3	S1	0.01	0.11	29.60	0.58	100	1.023	Goethite
SR-4	S1	0.28	-0.16	33.09	0.28	98.15	1.026	Hematite
	D1	0.38	0.59	--------	0.33	1.85		Pyrite
SR-5	S1	0.29	0.01	32.16	0.58	100	0.997	Magnetite

Conclusion: Mössbauer spectra of samples SR-1 to SR-5 except SR-4 are displayed in Fig.1. The Mössbauer parameters are given in Table 1 for samples. It can be seen from Fig.1 and Table 1 that Mössbauer spectra of these samples presence of sextet and three samples also exhibit quadrupole doublet. Sextet has been shown by S1 and quadrupole doublet by D1. These sextets show anomalous (very low) magnetic hyperfine field (MHF). To the best of our knowledge the presence of such sextet with such low MHF value in sedimentary samples was not reported in literature, but magnetic hyperfine field range nearby hematite, goethite and magnetite. These sextets may be attributed to very small (ultra-fine) oxide particles. Such ultrafine oxide particles are usually not expected to form in usual weathering processes. Quadrupole doublet Mössbauer parameters show presence of Fe^{3+} clay, Pyrite in samples.

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