A STUDY OF IRON IN CLAY MINERALS USING MÖSSBAUER SPECTROSCOPY

by

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EXTENDED ABSTRACT

Three useful parameters are readily determined from the Mössbauer interaction; the isomer shift, the nuclear electric quadrupole splitting, and the nuclear magnetic dipole splitting. The isomer shift, which is related to chemical bonding and changes in valence, and the quadrupole splitting, which is sensitive to structural environment, are the prime consideration in this work. The isomer shift is a function of the charge density of electrons at the nucleus. The quadrupole splitting depends on the asymmetry of the electric field at the nuclear site. The splitting for Fe^{3+} is caused by the neighboring ions, but for Fe^{2+} the relevant field gradient is related primarily to the electron distribution in the iron ion. Previous studies have established the following ranges for the values of these parameters: the isomer shift (measured from the center of the iron metal pattern, -0.25 mm/sec in our work) for Fe^{3+} from 0 through $+0.5$ mm/sec and for Fe^{2+} from 0.40 through 1.7 mm/sec. Table 1* summarizes the data obtained in the present study.

Mössbauer absorption spectrography can be used to establish the presence of Fe^{2+} and Fe^{3+} in clay minerals. In the sheet structure silicates, octahedrally coordinated iron can be distinguished from tetrahedrally coordinated iron. Siderite and goethite, common contaminants of the clay minerals, can usually be detected. Goethite has a well-organized structure, though, due to its fine grain size, may appear to be amorphous to X-rays. The various families of clay minerals show minor differences in isomer shift and quadrupole splitting values.

* See table on page 144.

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TABLE 1.—MÖSSBAUER PARAMETERS DETERMINED FOR CLAYS AND ASSOCIATED MINERALS
mm/sec ± 0.05

Clay	Oxidation state	Lattice position	Isomer shift mm/sec ± 0.05	Quadrupole splittings mm/sec ± 0.05
2:1 Dioctahedral				
Nontronite	Fe^{3+}	Oct.	~0.30	~0.30
Illite	Fe^{2+}	Oct.	~1.10	~1.05
	Fe^{3+}	Oct.	0.35	0.30
Glauconite	Fe^{2+}	Oct.	~1.15	~1.10
	Fe^{3+}	Oct.	~0.35	~0.30
Montmorillonite	Fe^{3+}	Oct.	+0.2	
$<0.2\ \mu$			Broad peak with apex at 0.2	
2:1 Chain				
Xylotile	Fe^{2+}	Oct.	~1.2	~1.0
	Fe^{3+}	Oct. Tet.	~0.2	~0.4
Attapulgite	Fe^{2+}	Oct.	?1.45	?0.5
	Fe^{3+}	Oct.	~0.3	~0.2
1:1 Trioctahedral				
Chamosite	Fe^{2+}	Oct.	~1.20	~1.25
Cronstedtite	Fe^{2+}	Oct.	~1.30	~1.25
	Fe^{3+}	Oct.	~0.40	~0.35
	Fe^{3+}	Tet.	~0.05	~0.40
2:1 Trioctahedral				
Biotite, single crystal octahedral	Fe^{2+}	Oct.	1.15	1.20
	Fe^{3+}	Oct.		~0.2–0.6
Biotite powder	Fe^{2+}	Oct.	1.15	1.20
Ferrionite (synthetic biotite)	Fe^{2+}	Oct.	1.10	1.20
	Fe^{3+}	Tet.	~0.05 or more	0.40 or less
Griffithite	Fe^{2+}	Oct.	1.20	1.35
	Fe^{3+}	Oct.	~0.45	~0.57
1:1 Dioctahedral				
Iron kaolin (?)	Fe^{3+}		0.375	0.225
Iron minerals				
Goethite	Fe^{3+}	Oct.	0.375	0.275
Siderite	Fe^{2+}	Oct.	1.25	0.90

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