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CHARACTERIZATION OF EGYPTIAN COAL FROM SINAI  
USING MÖSSBAUER SPECTROSCOPY \*

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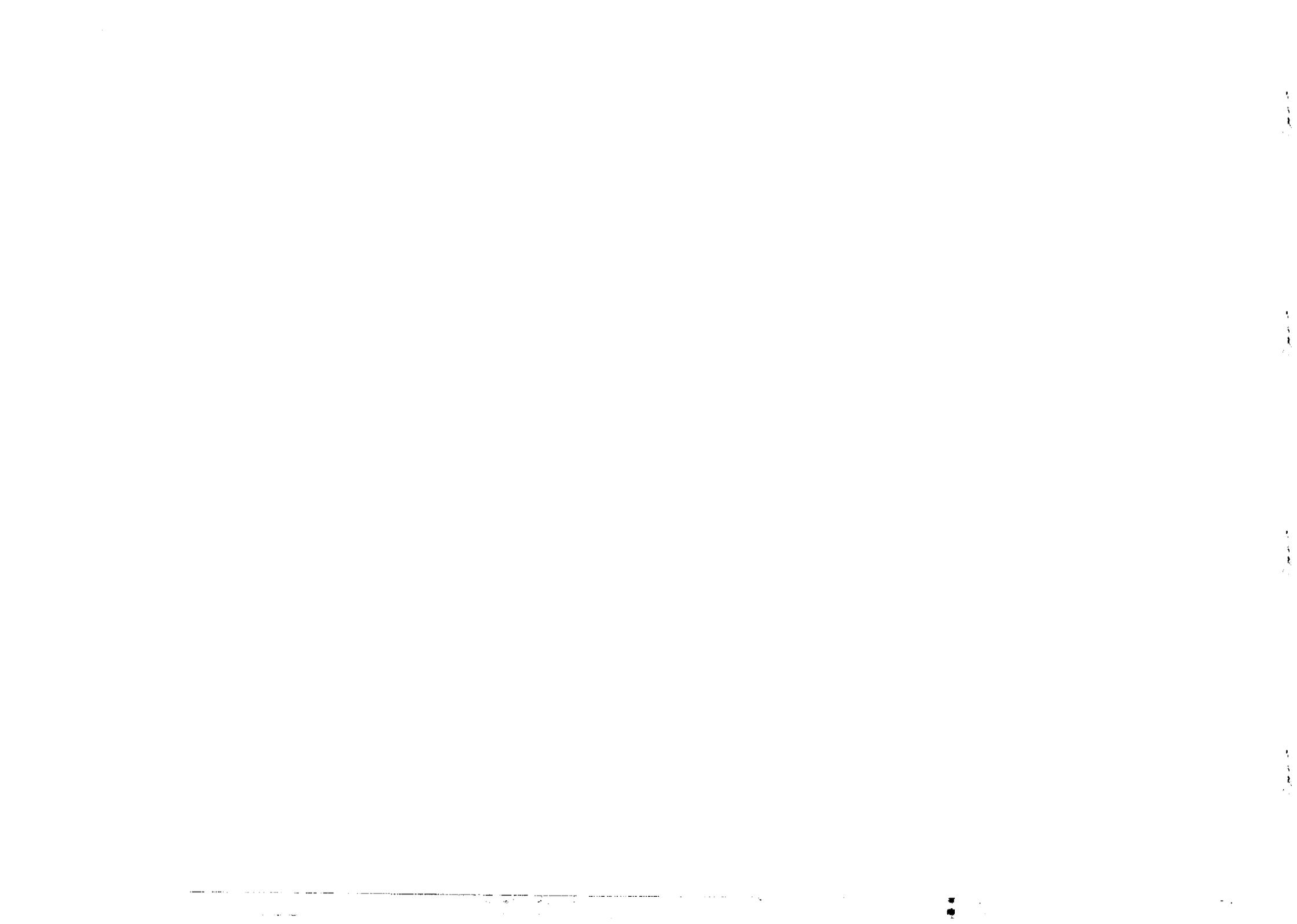
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## ABSTRACT

The presence of iron bearing minerals in coal makes the Mössbauer Spectroscopy (MS) extremely useful for characterization of coals from different localities. In this paper the MS has been applied to characterize Egyptian coal from Sinai (Maghara). The chemical analysis of this coal is given. The MS results showed that pyritic sulphur (pyrite and marcasite) is the only bearing mineral in Egyptian coal. A review is given for the iron bearing minerals in coals from different countries measured by MS.

## I. INTRODUCTION

The use of coal after the world oil crisis has become indispensable for global energy requirement specially as the renewable resources have not yet been fully developed. However, direct coal utilization is not always feasible due to strong environmental constraints. The last few years have seen an enormous re-awakening of interest in increasing the use of coal in many areas ranging from the traditional one of burning it more or less unchanged from its mined state, to various techniques of converting it into other fuels—solid, liquid or gaseous as well as creation of the carbo-chemical industry. The high cost of these techniques hinders their use in the present economic structure. Considerable research is necessary to obtain a better understanding of the coal conversion process, to improve existing technologies of coal conversion and to decrease environmental pollution of its pyrites. A careful study of the organic and inorganic components is necessary in order to completely characterize a coal. From the material science point of view, coal is a composite material with a very complex organic matrix. The carbon structure of coal can be viewed as consisting of hydroaromatic structures with aromatically increasing from low rank to high rank coals<sup>1)</sup>. The organic part of coal also contains sulphur, oxygen, nitrogen and sometimes iron in variable amounts depending on the coal. The inorganic part contains minerals where the iron is a major constituent and also is the most suitable element for Mössbauer Spectroscopy.

There can be five<sup>2)</sup> iron minerals in different types of coal from different localities, which are:

(a) - The iron disulfide, pyrite is the most abundant and marcasite is the least abundant. Other sulfides like pyrrhotite, sphalerite, mackinawite, greigite, smythite, chalcopyrite, troilite and arsenopyrite are rare in coal and their presence is important in selecting the coal for utilization. The iron disulfides appear in various morphological forms.

(b) - Clay minerals are more abundant in coal than sulfides such as: illite, kaolinite, chlorite, montmorillonite where iron substitutes aluminium in these clays and both divalent and trivalent iron ions can exist in more than one crystallographic sites.

(c) - Carbonates as siderite and ankerite.

(d) - Sulphates as szmolnokite, rozenite, melanterite, coquimbite, roemerite and jarosites, and their presence in coal is an indication of weathering.

(e) - Oxides hydroxides and oxyhydroxides, and their presence in coal is an indication of coal oxidation by weathering.

During the utilization of coal for different applications, the following technological processes are applied: combustion, ashing, coke formation, char formation and liquidification. In many cases the raw coal is desulfurized before such processes to increase its quality. Desulfurization applies many techniques such as float sink, chemical leaching and leaching by bacteria.

The aim of our study is to characterize Egyptian coal in each of the technological processes, such a study has not yet been done. The present paper deals with the identification of the iron bearing minerals in Egyptian coal using the Mossbauer Spectroscopy (MS).

## II. PREVIOUS WORK APPLYING MS

It is obvious that it is difficult to apply only one technique to characterize a coal as there is not a single type of coal, but many coals which can differ in both organic and inorganic components. In recent years resonance techniques have become powerful in the study of the different organic components appearing in coal<sup>3)</sup>. The organic and inorganic components of coal are of central importance from the point of view of the nuclear gamma resonance technique (MS) which is associated with the great importance of iron as a major constituent of the mineral matter.

The first study of coal using MS was made by Lefelhocz et al.<sup>4)</sup> in 1967, and after a ten year gap many papers<sup>5-7)</sup> used MS. X-ray diffraction methods present a competing technique to MS. However, the bulk mineralogy of the ashes, clays in particular, appear to be of low crystallinity<sup>8)</sup> which is indicated by poor diffraction intensity of the coal ashes as compared with mineral mixture prepared in the same way. By contrast, MS can be applied successfully to poorly crystallized materials. Concerning the use of MS for the characterization of coal from different countries and localities, Montano<sup>2)</sup> (1980) found that for USA coals, the iron compounds were always inorganic in origin. Cashion et al.<sup>9)</sup> (1980) studied Australian coals, identified organically bound iron. Chander Bhan<sup>10)</sup> (1982) studied Indian coals and identified the Bihar coal to contain siderite, while the Madhya Pradesh coal to contain pyrite. Mudogo et al.<sup>11)</sup> (1982) studied coal from Zaire and identified pyrite and iron sulphate.

## III. EXPERIMENTAL

Egyptian coal has been found in Sinai between 1957 (Ayun Musa) and 1962 (Maghara). The type and technical properties of the coal have been established<sup>12)</sup> (1965) by determining its petrographic constitution and its chemical analysis. Representative samples from Maghara coal seam were used to prepare MS absorbers having average surface density of about 200 mg/cm<sup>2</sup> of coal. The Mossbauer spectrometer was a conventional constant acceleration type with a 20 MCi Co:Rh source. The Mossbauer spectra were measured at room temperature and liquid nitrogen temperature.

## IV. RESULTS AND DISCUSSIONS

a) The chemical composition of Maghara coal was found to have the following composition: moisture (9.4 %), ash (5.70 %), volatiles (46.78 %), fixed carbon (38.48 %) and pyrite (3.3 %). Maghara coal is lumpy brown coal, high both in volatile content and calorific value. It exhibits some coking tendencies and possesses low coking qualities.

b) MS spectrum

Fig. 1 shows the MS spectrum of Maghara coal measured at liquid nitrogen temperature which has exactly the same shape of the room temperature spectrum. The Mossbauer parameters as obtained from the least square fit are presented in Table I for both the room and liquid nitrogen temperatures.

TABLE I

Mössbauer parameters of Maghara coal. The IS values are given with respect to <sup>57</sup>Co:Rh.

T(K)	IS(mm/sec)	QS(mm/sec)	Line width (mm/sec)
300	0.210 (4)	0.626 (4)	0.313 (4)
78	0.173 (8)	0.630 (4)	0.0334 (6)

These parameters correspond to pyrite<sup>2)</sup> FeS<sub>2</sub>. The metastable phase of FeS<sub>2</sub>, marcasite, has Mossbauer parameters of the same value like pyrite but with

slightly lower isomer shift (IS) and quadrupole splitting (QS). There is an increase of about 6.7 % in the line width value at liquid nitrogen temperature which makes it difficult to exclude the possibility of existence of marcasite.

The Mössbauer spectra do not show the characteristic sulphate lines which are generally due to weathering conditions <sup>13)</sup>, as these samples were collected from 600 meters depth. However, a ferrous component (IS = 1.848 and QS = 1.805 mm/sec) was observed for samples collected from the surface of the mine.

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FIGURE CAPTION

Fig.1 - The Mössbauer spectrum of Egyptian coal from Sinai (Maghara) measured at liquid nitrogen temperature.

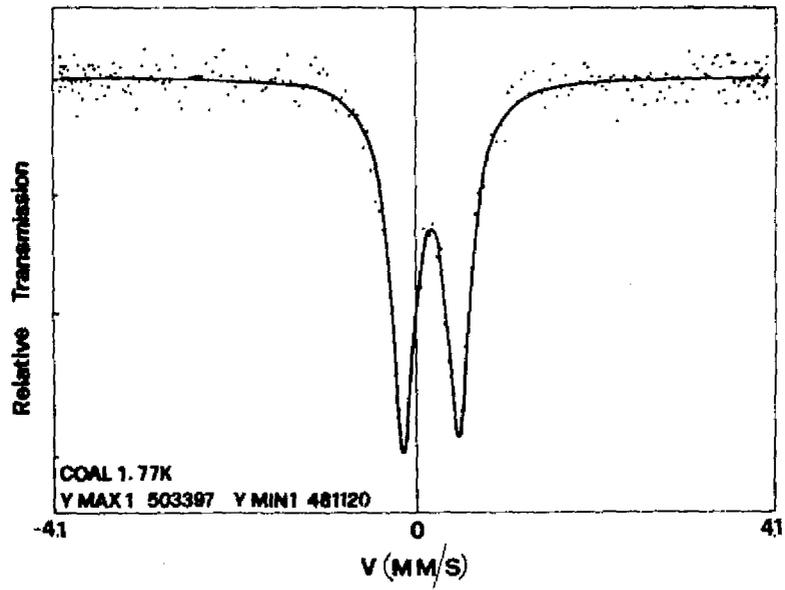


Fig.1