

THE Eh-pH ENVIRONMENT OF DEPOSITION OF SOME SEDIMENTARY DEPOSITS FROM EGYPT

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ABSTRACT

Thirty four samples representing four types of sedimentary rocks from Egypt are subjected to laboratory determination of Eh-pH values in order to determine their environment of deposition.

The rock types under study are: (1) The Fe-Mn deposits associating Carboniferous rocks of West Central Sinai (2) Shales and clays usually covering the mentioned Fe-Mn ores of West Central Sinai (3) Phosphatic rocks from different localities in Egypt (4) Oligocene shales and clays from Gebel Qatrani in the Western Desert.

The environment of deposition of the Fe-Mn deposits of West Central Sinai is shown here to be shallow marine waters. Most of the shales and clays associating the Fe-Mn deposits of West Central Sinai have pHs indicating that their depositional environment is marine like the precipitating medium of the Fe-Mn ores. The few samples of these shales and clays that show pHs on the acidic side represent rocks subjected to bleaching effects by later acidic solutions.

Phosphatic sediments from different localities of the country have their pHs indicating typical marine environment of deposition.

Oligocene shales and clays of Gebel Quatrani in the Western Desert have pHs that range between acidic and alkaline media of deposition reflecting the fluviomarine origin of these sediments.

INTRODUCTION

The Eh-pH experimental data of some sedimentary deposits from Egypt are dealt with in the present communication in a trial to define the environment of deposition of these deposits. Four types of sedimentary deposits are subjected to experimental testing of their Eh-pH values, these are: (1) Fe-Mn deposits associating with Carboniferous rocks from West Central Sinai (2) Shales and clays overlying and underlying the mentioned Fe-Mn deposits of West Central Sinai (3) Phosphatic rocks from different localities from Egypt, and (4) Fluviomarine Oligocene shales and clays from Gebel Qatrani in the Western Desert of Egypt. Despite that the environment of deposition of these deposits is already worked out from different geological channels, yet it is the first time that the Eh-pH experimental method is applied to these deposits.

Special attention is given here to the problematic Fe-Mn deposits of West Central Sinai and their accompanying shales. The Eh-pH environment of deposition of these deposits was worked out on theoretical basis including the chemical constitution and mineralogical composition of the ores (ANWAR and EL SOKKARY 1972). Some genetical relations among the main ore-forming elements are studied by EL SOKKARY (1972).

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The object of the present work is to determine the Eh-pH values of four types of sedimentary deposits from Egypt on experimental basis in the laboratory and to try to coordinate the obtained data with previous known environmental conditions of deposition of these deposits.

TECHNIQUE OF WORK

As already stated in the introduction, the studied samples are taken from four sedimentary deposits as follows: (1) Six samples representing the Fe-Mn deposits associated with Carboniferous rocks of West Central Sinai (2) Eight samples representing the shales and clays associated with the mentioned Fe-Mn deposits (3) Four phosphatic samples from different localities in Egypt (4) Sixteen samples representing Oligocene shales and clays from Gebel Qatrani in the Western Desert. Thus all the studied samples are 34 in number.

The location of phosphatic samples is as follows: Two samples from East Luxor phosphates, Nile Valley. One sample from Safaga phosphate, Eastern Desert. One sample from Qatrani phosphatized sandstone, Western Desert.

These samples are ground and made to pass sieve of 100 mesh size. Five gram portion of each powdered sample is transferred to a beaker to which 100 ml. of distilled water is added, the powder is stirred in water. This suspension is left for not more than 48 hours before actual measurements of Eh-pH values are taken, this is done in order to let equilibrium be established in the solid-liquid system.

The instrument used in Eh-pH measurements is a Pye Unicam pH meter, model Pye-292, with electrodes used in Ph measurements: glass electrode plus reference calomel electrode, and electrodes used in Eh measurements: platinum electrode plus reference calomel electrode. Two buffer solutions: one with pH=4 and the other with pH=9 are used to calibrate the instrument before pH measurements. Zobell solution (0.003 M pot. ferricyanide+0.003 M pot. ferrocyanide+0.1 M pot. chloride) with observed potential 0.183 volt is used to calibrate the instrument for Eh measurements.

In practice the measured voltage of the inert electrode-reference electrode pair is added algebraically to the potential of the reference electrode to get the Eh of the half cell reaction occurring at the platinum electrode (GARRELS 1960).

PRESENTATION OF DATA

Table 1 gives the experimental numerical data of the pH and Eh values of 34 samples of four sedimentary deposits from Egypt. The number of samples for each rock type is already given in the previous section on Technique of Work. The Eh values are reported in millivolts (mV).

Allover the 34 samples, pH ranges between 3.5—8.4 while Eh ranges between 307—635 mV. Water with pH value more than 7.0 is alkaline, while water with pH value less than 7.0 is acidic. Sea water is known to be faintly alkaline with pH 8.5 (MASON 1964).

Fig.1 is a graphic presentation of the Eh-pH relation of the 34 samples representing the mentioned four sedimentary deposits.

The relation is a straight line with slope 43.33 mV/pH. From this diagram the prevailing natural pH values of the studied samples range between 7.00—8.50 i.e. representing alkaline environment of deposition, while the prevailing Eh values range from 300—425 mV representing low-moderate oxidation potential.

TABLE I.

Eh-pH values of some sedimentary rocks from Egypt

Serial No.	pH	Eh(mV)	Serial No	pH	Eh(mV)
Fe-Mn deposits of W. C. Sinai: Qatrani shales and clays					
1	7.78	350	19	7.20	385
2	7.50	375	20	8.15	355
3	7.72	355	21	7.95	365
4	8.12	355	22	7.38	385
5	7.10	405	23	8.20	355
6	7.80	365	24	8.15	345
Shales clays assoc. Fe-Mn ores:					
7	8.40	418	25	7.92	353
8	6.35	467	26	4.05	525
9	7.35	405	27	7.22	375
10	7.80	410	28	5.90	435
11	3.50	635	29	7.71	335
12	7.10	510	30	7.80	393
13	7.70	537	31	7.22	395
14	7.50	515	32	7.55	365
Phosphates from different loc.:					
15	7.63	375	33	4.85	455
16	7.90	335	34	4.20	513
17	7.70	325			
18	8.12	307			

DISCUSSION

Measured pH values of the Fe-Mn deposits of West Central Sinai range between 7.10—8.12, while measured Eh values of the same samples range between 350—405 mV. Thus the environment of deposition is alkaline with moderate oxidation potential indicating deposition in shallow water seas. It is therefore concluded that the Carboniferous Fe-Mn deposits of West Central Sinai are of marine origin. This ends the debate on the origin of these problematic ore deposits.

ANWAR and EL SOKKARY (1972) worked out the Eh-pH environment of deposition of the Mn-Fe deposits of West Central Sinai and deduced on theoretical basis that the depositional environment is most probably alkaline with moderate oxidation potential characterising shallow water seas. These authors (op. cit.) mentioned that higher oxidation potentials were not fully reached during deposition of the ore and the Eh is somewhere below 0.8 volts. It can be seen that these views worked on theoretical basis are in agreement with the present experimental Eh-pH data.

Table I shows that the various phosphatic samples under study have pH values that range between 7.63—8.12 and Eh values range between 307—375 mV. It is observed that the pH range is rather narrow pointing towards definite alkaline

medium of deposition with moderate oxidation potential which characterise typical marine environment of deposition. Again the pH-Eh ranges of the Fe-Mn deposits of West Central Sinai are close to those of the studied marine phosphatic deposits (being 7.10—8.12 for the pH range and 350—405 mV for the Eh range of the former) assuring that deposition of the Fe-Mn ores has taken place as well under definite marine facies.

The shales and clays associating the Fe-Mn deposits of West Central Sinai being overlying or underlying these deposits show somewhat different behaviour. Most of the samples (six out of eight) have alkaline tendencies with pHs that range between 7.10—8.40, however some of the samples (two out of eight) have their pHs on the acidic side being 3.50 and 6.35 respectively, yet the Eh range lies between 405—635 mV. Since most of the shale and clay samples have their pHs on the alkaline side which is very close to the same pH range of the Fe-Mn deposits themselves (being 7.10—8.12 for the latter), this indicates that the general environment of deposition of these shales and clays is marine, the same as the precipitating medium of the Fe-Mn ores.

However the few samples that show pHs on the acid side of the scale reflect that some parts of the shale and clay layers are subjected to bleaching acid solutions.

SHUKRI (1941) during a study on the use of pH values in determining the environment of deposition of some Liassic clays and shales of England mentioned that the bleached beds (affected by acid waters) are certainly poorer in both carbonates and bases and they accordingly give a lower pH value.

Natural normal limits of Eh-pH among the investigated samples are shown in Fig. 1 as represented by the rectangle in solid lines, these are as follows: the pH

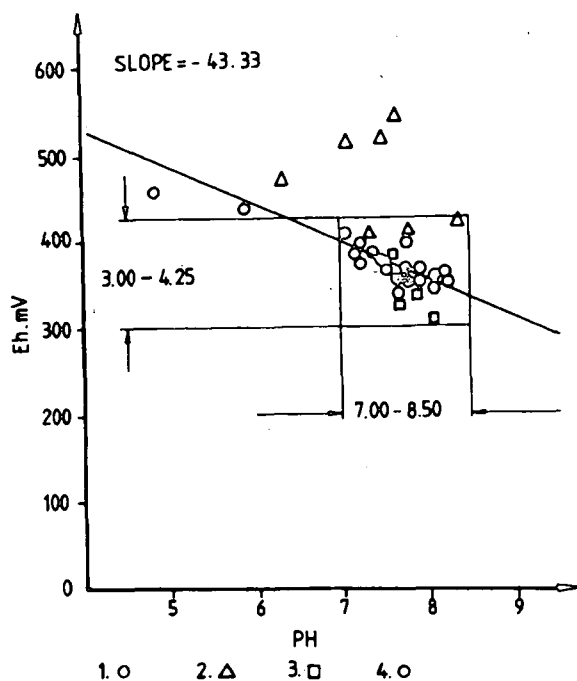


Fig. 1. Eh versus pH relation of the examined 34 samples.
1=Sinai Fe-Mn ores, 2=Sinai Fe-Mn shales, 3=phosphates, 4=Quatrani shales-clays.

range between 7.00—8.50 and the Eh range between 300—425 mV. Within this rectangle lie points representing phosphates with definite marine origin, the Fe-Mn ores and part of the shales and clays associating the mentioned ores. This gives more weight to the marine origin of the Fe-Mn ores and their accompanying shales-clays. Another part of the latter shales and clays lies above the defined frame i.e. they represent still alkaline medium of deposition but with somewhat higher Eh values up till about 540 mV. These might represent marine medium of deposition but with more oxidation potential i.e. more aeration and shallower waters.

With respect to Oligocene shales and clays of Gebel Qatrani, they show pHs that range between acidic and alkaline media. The general range of pH among these rocks is between 4.05—8.20. The majority of samples, 75 % of them, give pH values in the alkaline range between 7.20—8.20, while 25 % of the samples have their pHs in the acidic range between 4.05—5.90, Eh values on the other hand range between 335—525 mV.

That some Qatrani shales and clays are deposited from alkaline media and others appear to be deposited from acidic media assures the fluviomarine origin of these shales and clays. The moderate oxidation potential of these rocks indicates deposition from well aerated shallow waters.

CONCLUSION

It is revealed that the environment of deposition of the Fe-Mn deposits of West Central Sinai is alkaline with moderate oxidation potential indicating deposition in shallow water seas. With respect to shales and clays associating the Fe-Mn deposits of West Central Siani, most of them have their pHs on the alkaline side close to the same pH range of the Fe-Mn ores which indicates that their depositional environment is marine like the precipitating medium of the Fe-Mn ores. The few samples of these shales and clays that show pHs on the acidic side represent rocks subjected to bleaching action by later acidic solutions.

The various studied phosphatic samples have their pHs on the alkaline side of the scale referring to definite alkaline medium of deposition with moderate oxidation potential which characterises typical marine environment of deposition.

The Oligocene shales and clays of Gebel Qatrani in the Western Desert have pHs that range between acidic and alkaline medium of deposition. This assures the fluviomarine origin of these sedimentary rocks.

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