MINERALOGY AND GEOCHEMISTRY
OF THE LEAD-ZINC MINERALIZATION AT RANGA, RED SEA COAST

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ABSTRACT

The mineral association of Ranga lead-zinc deposit is microscopically described. The trace elements assemblage in cubic and zonal galena is quantitatively determined. Besides, the trace elements in other minerals associated with galena were semiquantitatively estimated. The deposit is attributed to the exhalative sedimentary processes by which other Egyptian Miocene lead-zinc ores were similarly formed.

INTRODUCTION

The Egyptian lead-zinc deposits of Miocene age occur in a narrow strip extending along the Red Sea coast between Qoseir and Ras Benas. They are mainly confined to the Middle Miocene formations which unconformably overlie the Precambrian
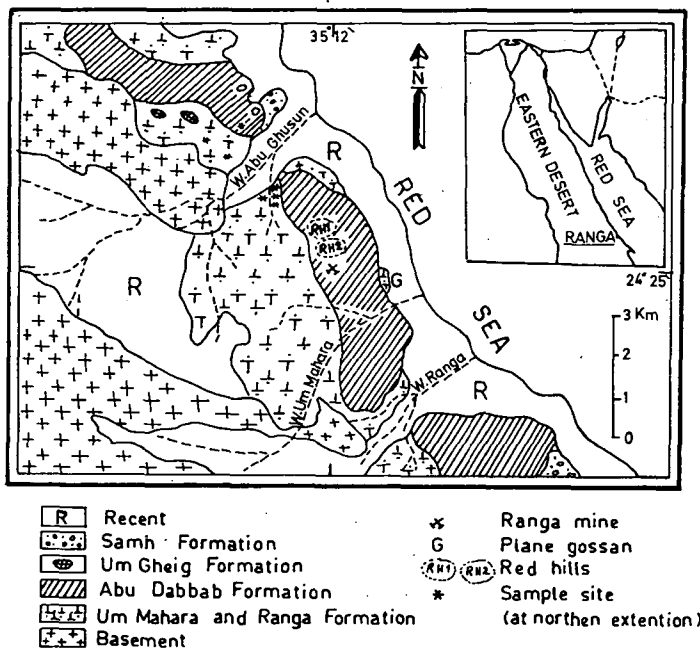

R   Recent
Samh Formation
Um Gheig Formation
Abu Dabbab Formation
Um Mahara and Ranga Formation
Basement

Ranga mine
G   Plane gossan
Red hills
Sample site
(at northen extention)

Fig. 1. Geological map of Wadi Abu Ghusun — Wadi Ranga area [after BEADNELL, 1924 with modifications after SAMUEL and SALEEB ROUFAIEL, 1977]

igneous and metamorphic rocks of the Basement Complex. The most important localities are Zug El Bohar, Wadi Essel, Wadi Wizr, Um Gheig, Abu Anz, Gabal El Rossas and Ranga [AMIN, 1955; SABET, et al., 1966; EL SHAZLY, 1966 and HILMY, et al., 1972].

EL SHAZLY and ABDALLAH [1964] described the mineralization at Ranga and recorded its occurrence as small lenticular masses within the gypseous rocks of the area. SOLIMAN and HASSAN [1969] gave the results of geochemical prospection along a 600 m profile section passing through the main lead-zinc deposit. SALEEB, ROUFAIEL and SAMUEL [1975] described some of the ore minerals of the deposit.

This mineralization occurs in a dolomitic bed intercalated within the gypsum-anhydrite horizon of Abu Dabbab Formation *(Figs 1, 2)*. A faulting system is believed to have played a principal role in the deposition of this deposit. As other Egyptian Miocene Pb-Zn deposits, it is thought to be stratigraphically, lithogically and structurally controlled [HILMY, et al., 1972].

The aim of this work is to record the mineralogical and geochemical characteristics of the deposit. Its probable mode of occurrence is also suggested.
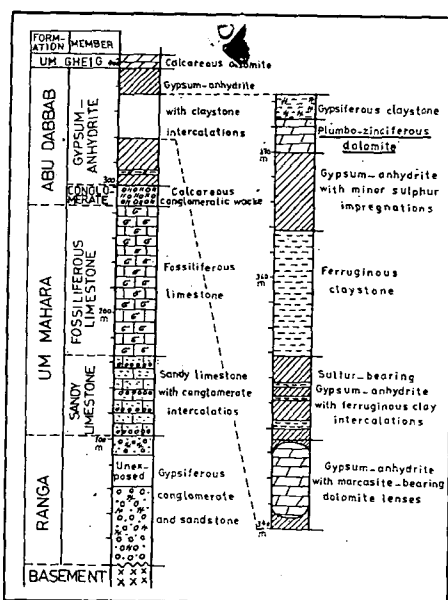

Fig. 2. Lithostratigraphic columnar section of Middle Miocene succession at Ranga area including Abu Dabbab Formation [after SALEEB ROUFAIEL & SAMUEL, 1975 & 1977]

SAMPLING

Galena, marcasite and zinc-rich samples were collected from old pits at two main sites at Ranga. Ferruginous samples were also collected in a network system

from the blanket-like "plane" gossan near the asphaltic road. The two red hills RH1 and RH2 were also sampled at 10 m intervals on the only accessible western slopes. Details of the sampling process are given in RASMY, et al., [1981].

MINERALOGICAL STUDY OF THE DEPOSIT

The mineral assemblage, related to Ranga mineralization, is summarized in the following list:

I *Primary minerals:*

A Sulphide minerals: galena, sphalerite and marcasite.
B Gangue minerals: barite, fluorite and celestite.

II *Secondary minerals:*

A Lead-zinc minerals: cerussite, anglesite, smithsonite, hemimorphite and gloslarite.
B Associated minerals: native sulphur, jarosite, limonite, selenite and secondary quartz.

Galena occurs in two major forms. The first is "pisolitic" galena which exhibits a zonal structure. The pisolites are either spherical, oval, pear-shaped or eye-like and may reach 2 cm in mean diameter. The zonal structure is partially disclosed by rim-alteration to zonal cerussite *(Fig. 3)*. This form of galena is common in the dolomite band exposed in the pit nearest to the main sulphur mine. It indicates a very low temperature of formation [RAMDOHR, 1969]. The second form of galena exhibits the normal cubic crystal borders with cleavage planes parallel to (100). It has a slightly higher reflectivity than pisolitic galena. The cubic galena was recorded in a selenitic band exposed in a pit near the foot of the hill RH2. It is impregnated by coarse crystalline selenite which seems to have replaced older dolomite. Cubic galena is probably formed by the crystallisation of older colloform galena as the former replaces and encloses relics of the latter *(Fig. 4)*. Cubic galena is also later than melnicovite pyrite *(Fig. 5)*.
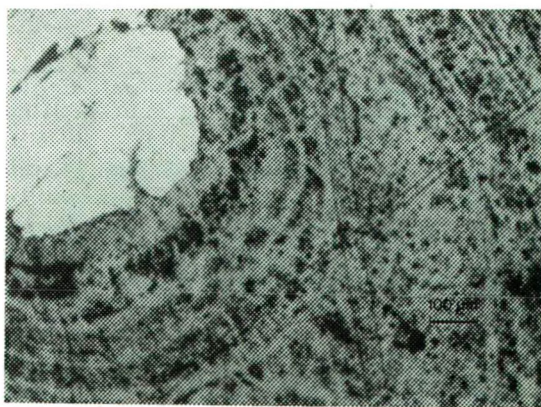

Fig. 3. Part of a "pisolitic" grain of galena (white) showing rim oxidation to cerussite (different shades of gray), reflected plane polarized light
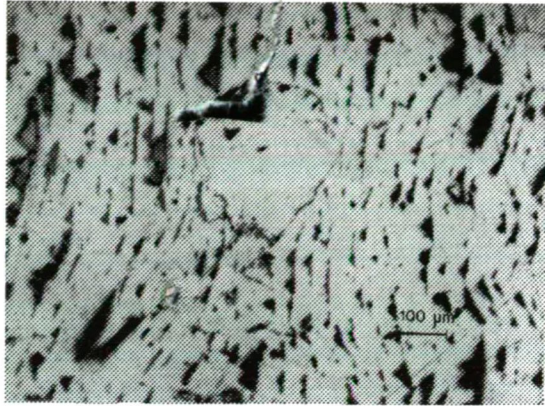
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Fig. 4. Cubic galena showing the triangular pits and enclosing a grain of "pisolitic" galena, reflected plane polarized light
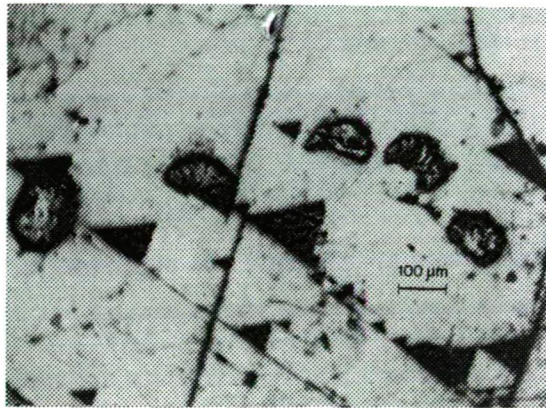

Fig. 5. Galena (white) enclosing parts of melnicovite spheres, black are triangular pits, reflected plane polarized light

Alteration of galena to anglesite is rather uncommon. It occurs along cracks and cleavage planes of galena. Galena is usually oxidized to cerussite in a way that the old texture of galena is still preserved *(Fig. 6)*. Besides, cerussite may invade galena giving rise to caries texture [EDWARDS, 1954] as shown in *Fig. 7*.

Remnants of fine solitary sphalerite dodecahedrons, which may cluster into aggregates, are occasionally observed within zincian and ferruginous rock masses. Sphalerite may also exhibit a framboidal form. Its low reflectivity and honey yellow internal reflection indicate its low Fe content.

Massive colloform bodies of marcasite usually replace dolomite at different sites in the area. It is partially recrystallized to radial star-like aggregates. Sometimes, it encloses rounded bodies of melnicovite pyrite which exhibits a rhythmic zonal texture *(Fig. 8)*. Marcasite is occasionally altered to jarosite and commonly to goethite and limonitic material. Massive colloform vein-like pitch-black bodies of

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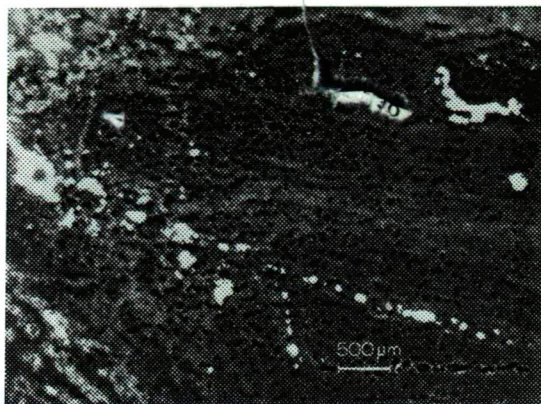
Fig. 6. Rim oxidation of cubic galena (black) to cerussite (different shades of gray), transmitted plane polarized light
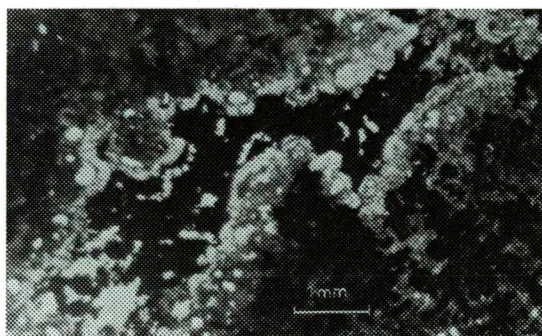

Fig. 7. Colloform aggregates of cerussite enclosing black fragments of goethite and replacing an elongated grain of galena (black) giving rise to caries texture, transmitted plane polarized light
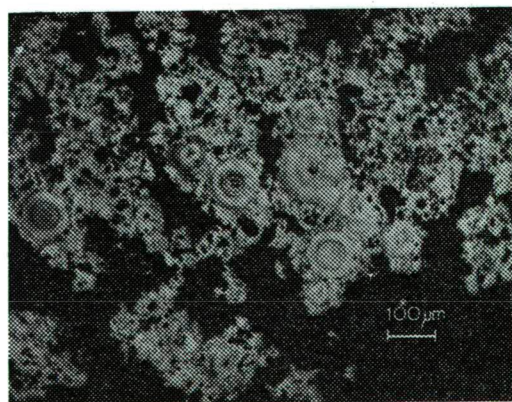

Fig. 8. Marcasite (white) enclosing spherulitic bodies of melnicovite, black is dolomite, reflected plane polarized light

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goethite, after marcasite, are recorded at the top of the red hills where arid conditions of oxidation prevail.

Appreciable amounts of barium and strontium, indicated by spectral analysis, indicate the possible presence of barite and celestite which could not be microscopically distinguished. Traces of fluorite were chemically detected.

Cerussite, either as a direct oxidation product of galena or a recrystallisation form, is the most common secondary lead mineral *(Fig. 9.)*. Smithsonite usually forms cellular or saccharoidal crystals which fill cracks and incrust dolomitic and limonitic bodies. Sometimes it shows oolitic form. Radial, feathery or sheaf-like blades and rosettes of hemimorphite, in zinc-rich limonitic masses are not uncommon *(Fig. 10)*. It usually encloses relics of sphalerite and replaces limonite, cerussite and dolomite. Occasionally, very fine acicular crystals of goslarite, or probably epsomite, protrude from the massive zinc-rich limonitic bodies.

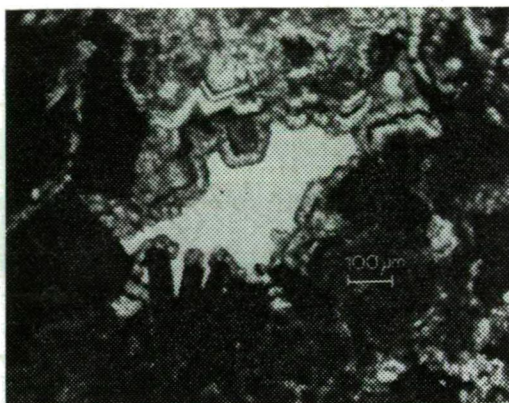
Fig. 9. Euhedral crystals of cerussite (gray) replacing iron oxides (black) and filling cavities, transmitted plane polarized light
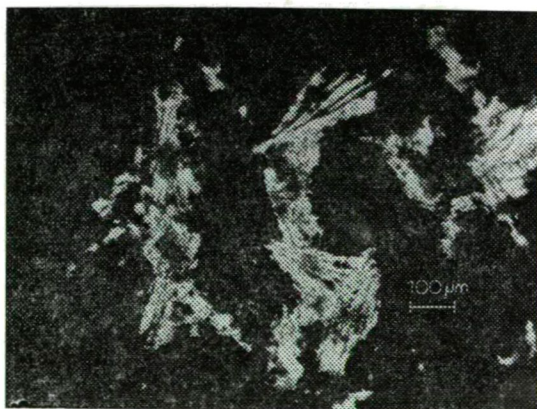

Fig. 10. Sheaf-like hemimorphite (white) replacing goethite (black), transmitted plane polarized light

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The greenish-yellow aggregates of sulphur, associated with gypsum in several horizons of Abu Dabbab Formation, show no direct contact with the sulphide mineralisation. It is most probable that sulphur is produced through bacterial or hydrocarbonic reduction of sulphuric acid developed during wet oxidation of iron sulphides. Limonites, produced by oxidation of pyrite, are responsible for pigmenting most of the rock bodies at Ranga. Euhedral crystal aggregates of selenite, probably related to percolating ground water, fill cavities in aggregates of cubic galena and associated rocks. Secondary quartz is occasionally recorded.

PARAGENETIC STAGES

Three paragenetic stages could be identified at Ranga area:

1) *The mineralization stage:* This stage began with the deposition of melnicovite pyrite followed by marcasite, sphalerite and lastly colloform galena. The latter was later crystallized to cubic galena.

2) *The oxidation stage:* The oxidation of iron sulphides, by the action of percolating water, has led to the liberation of sulphuric acid responsible for the formation of anglesite, goslarite and sulphur. The sulphate minerals were later altered to cerussite and smithsonite by the action of natural water charged with calcium bicarbonate. The oxidized minerals were later subjected to partial recrystallisation.

3) *The silicification stage:* Hemimorphite and secondary quartz were formed by the action of silica-rich solutions on earlier zincian minerals.

GEOCHEMICAL STUDY OF THE DEPOSIT

This study includes the determination of trace elements in Ranga galena and the associated mineral phases which are related to the process of mineralization.

A) Trace elements in Ranga galena

Details of the emission spectrographic technique, used for the quantitative determination of trace elements in Ranga galena, are given in RASMY and YONAN [1981]. A summary of the analytical conditions is given here:

Apparatus: Jena grating spectrograph PGS—2 and arc generator ABR 3. Slit width is 14 microns.

Excitation: AC 220 V, 12 Amp.

Electrodes: JMC 21/39 for sample and 21/19 for counter.

Carrier: Specpure PbI_2 mixed as 20% with each of the samples and synthetic standards.

Arcing time: 57 sec., the first 10 sec. are not exposed.

Internal standard: Background intensity in vicinity of lines.

Plates: Gevaert Scientia 23D56 9×24 cm.

Calibration: Jena microphotometer GII was used. Calibration curves were constructed by the 6 step diminisher method.

Detection limits are: 0.3 ppm for Ag; 1 ppm for Sn, Cu, Mo, In, V; 3 ppm for Cd, Bi, Tl; 10 for Zn, Sb; 30 for As and 300 ppm for Te. The concentration of trace elements in Ranga galena is shown in Table 1. The maximum content, arithmetic

TABLE 1

Trace elements content of Ranga pisolitic galena (samples 1—19)
and cubic galena (samples 20—30) (values are in ppm)

Sample No.	Ag	Zn	Cd	Tl	Bi	Sn	Cu
1	1	15	10	16	—	—	5
2	2	14	17	48	—	—	1
3	4	24	11	17	15	1	3
4	—	29	14	25	—	—	3
5	2	92	15	19	11	—	1
6	—	14	22	30	—	—	1
7	6	100	11	5	7	1	15
8	2	15	10	23	—	2	3
9	—	225	19	25	—	—	3
10	3	28	5	22	31	—	3
11	—	100	23	27	10	2	1
12	2	—	13	18	15	—	2
13	5	25	10	33	8	—	1
14	2	27	8	22	12	—	3
15	17	14	12	11	4	—	15
16	2	18	8	40	5	—	1
17	—	16	8	5	9	—	30
18	17	14	11	26	—	—	40
19	1	42	3	32	5	—	10
20	1	15	10	100	4	—	5
21	—	15	15	80	9	3	1
22	4	13	32	45	3	1	2
23	2	—	15	78	7	—	4
24	2	100	17	39	13	1	3
25	2	110	15	75	3	—	1
26	—	100	15	40	12	—	3
27	4	—	8	134	13	2	25
28	1	18	12	52	13	—	1
29	2	20	11	76	13	—	5
30	2	25	15	45	10	—	1

mean and the interquartile range of Ranga galena, together with those of Um Gheig galena [RASMY, 1981], are given in Table 2. In calculating the arithmetic mean, dashes are considered to contribute with values equal to the half of the corresponding detection limits. The interquartile range is the range considered after excluding the first and fourth quartiles which may contain extremely low or high values.

It was observed that thallium is the most common guest element in Ranga galena. Its interquartile range is 22—52 ppm and is replacing lead isomorphously [ATANASOV and ESKENAZI, 1964]. Cubic galena contains more Tl than zonal galena. The Cd content is low, however, it cannot be solely attributed to sphalerite inclusions in galena. This is proved by the fact that some samples of galena contain more cadmium than zinc. Silver, bismuth, antimony, arsenic and other trace elements are either recorded in minor amounts or absent.

The impoverishment of silver and bismuth, and the irregular distribution of other trace elements, indicate low temperature, shallow and telethermal conditions of formation of galena [HERTEL, 1966; KAUTZSCH, 1967]. From Table 2, it can be concluded that Ranga galena, which occurs within gypseous rocks, is poorer in trace elements than Um Gheig galena occurring in lime grits.

TABLE 2

	Ag	Zn	Cd	Tl	Bi	Sn	Cu	Sb	As
Ranga galena (30):									
MC	17	225	32	134	31	3	30	10	30
AM	3	41	13	41	8	—	5		
IQR	1—3	14—28	10—15	23—52	3—12	—	1—5		
Um Gheig galena (38):									
MC	300	1300	840	410	203	32	8	100	1200
AM	41	254	154	85	21	1	—	18	148
IQR	4—52	18—118	21—220	16—124	0—15	—	—	0—18	31—130

*N.B.*Dashes indicate that the concentration of the elements is beyond their detection limits.
The elements Mo, In, V, Sb, As & Te were not recorded in Ranga galena.

B. Trace elements in other minerals and rocks associated with galena

Owing to its disguising character, sphalerite could not be separated from mineralized rocks even under a binocular microscope. Actually, 27 zinc-rich samples were prepared for analysis, together with 6 samples of fresh marcasite and about 120 ferruginous samples enriched in both lead and zinc. The ferruginous samples were collected from the plane gossan and the two red hills *(Fig. 1)*.

The semiquantitative spectrographic technique used [RASMY and YONAN, 1981] is rather similar to the quantitative technique used for galena. The standard matrix was composed of 10% $CaCO_3$ and 90% SiO_2. Standards and samples were buffered by a synthetic mixture of graphite, silica and $CaCO_3$. Arcing time was 105 sec. Detection limits are: 1 ppm for each of Ag, Mo, Cu, Sn, Pb, Ga, Ni and Cr, 3 for Tl and V, 10 for Mn, Cd, Bi, Ge and In, and 30 ppm for As, Sb, Zn and Ba. Values of lead and zinc were checked by the dithizone wet chemical method.

From the analytical results, which are given in Table 3 A—C, the following can be observed:

1. The zincian minerals are enriched in Mn, poor in Cd and nearly devoid of Ga and Ge.

2. Marcasite contains minor amounts of lead and zinc which are probably attributed to submicroscopic inclusions of galena and sphalerite. Manganese is a major constituent in marcasite while arsenic is not detected.

3. The ferruginous samples show a small content of V, Mo, Cr and Cu. This may be attributed to the occasional presence of minute crystals of vanadinite $Pb_5(VO_4)_3Cl$, descloisite $Pb(Zn, Cu)(VO_4)OH$, wulfenite $PbMO_4$ and/or crocoite $PbCrO_4$.

4. In the oxidized ferruginous samples, some elements are generally impoverished, *e.g.,* silver and cadmium. On the other hand, some other elements were introduced to the area during or directly after the mineralization process. These elements include Ba, Mn, Mo, V, Cr, Ni and Cu. They are either in the form of independant minerals, *e.g.* barite, pyrolusite, etc., or they were captured during the precipitation of iron oxide and hydroxide minerals.

Maximum content, arithmetic mean and interquartile range of elements in 27 samples of Zn-rich minerals associated with Ranga galena (values are in ppm)

	Pb	Mn	Cd	Cu	Ag	Mo	Tl	Sn
MC	1500	10 000	200	300	8	10	5	10
AM	470	2 027	68	20	3	2	3	4
IQR	300—700	1200—2000	50—100	2	3	2	2	4

N.B. The elements As, Sb, Bi, In, Ge, V & Ga are present in values beyond their detection limits.

Maximum content, arithmetic mean and interquartile range of trace elements in 17 marcasite samples from Ranga (ppm)

	Pb	Zn	Mn	Cd	Cu	Ag	Mo
MC	300	5000	25 000	50	10	1	10
AM	130	1200	10 000	17	2	1	3
IQR	50—200	200—1000	3000—10 000				

N.B. The elements As, Sb, Bi, Ge, Tl, V, Sn & Ga are beyond their detection limits.

Maximum content, arithmetic mean and interquartile range of trace elements in Zn- and Pb-rich ferruginous samples from Ranga (ppm)

	Pb	Zn	Mn	Ba	Cu	Ag	Mo	V	Cr	Ni	Ga
Samples from plane gossan (79):
MC	1200	1500	2000	4000	50	5	100	100	100	100	15
AM	465	500	670	770	10	1	9	27	34	6	4
IQR	400—500	300—600	200—1000	400—1000	7	—	7	20	25	5	3
Samples from red hill RH1 (16):
MC	2300	1000	1000	3000	30	5	50	10	100	20	10
AM	683	416	144	400	8	1	8	5	25	3	2
Samples from red hill RH2 (21):
MC	3000	1800	1000	5000	100	1	150	100	80	10	100
AM	852	629	78	293	22	1	38	28	24	4	17

N B. The elements As, Sb, Bi, In, Ge, Tl & Sn are beyond their detection limits.

ORIGIN OF THE DEPOSIT

The poor content of trace elements in Ranga galena may be attributed to the low temperature and shallow depth conditions of formation, to local factors and to the nature of the enclosing gypseous rocks. Remobilization of older lead, derived from the underlying crystalline rocks of the basement, may be the source of this galena. Sulphur, as a constituent of the sulphides, may be contributed by local reduc-

tion of gypsum, probably by the action of preexisting hydrocarbons. The whole process is a part of the exhalative sedimentary processes responsible for the deposition of other Miocene lead-zinc deposits [HILMY, et al., 1972]. Post mineralization processes may be responsible for the introduction of some elements like barium, vanadium, molybdenum and chromium.

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