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LEAD ISOTOPES OF SOME LEAD-ZINC DEPOSITS OF THE OUARSENIS MTS, ALGERIA

(Fig. 1)

Abstract: Lead isotope ratios of galenas from ore deposits of the Ouarsenis Mts, Algeria, are presented. They are compared with similar mineralizations in Tunisia, Morocco and Europe in connection with genetical problems and the possibility of regenerated or secondary hydrothermal origin. A zonal arrangement in the distribution of lead isotope ratios is emphasized: with oldest patterns and ages in Morocco and youngest in Tunisia.

Throughout the vast northafrican region between Tunisia and Morocco lead and zinc are the most important elements from a metallogenetic point of view. They form many economically very important deposits as well as innumerable ore indications.

Past studies were restricted mainly to large deposits and their practical problems. As many of these were exhausted or approach exhaustion more stress is recently given to detailed investigations and to the solution of theoretical questions concerning the formation of ore concentrations with the final aim to find a clue to a rational prospection for buried and hidden deposits. The study of lead isotope ratios represents one of lead isotope ratios represents one of the methods which can provide a better understanding of the often very complex genetical problems of ore deposits.

Significant number of lead isotope ratios from North Africa were published only for moroccan (F. G. Houtermans et al. 1956) and tunisian (J. Kantor et al. 1968) lead-zinc deposits.

The autors object in carrying out his investigations was to verify H. Schneiderhöhn's and J. Bolze's (1951) views about the secondary hydrothermal (or regenerated) origin of the lead-zinc mineralizations in Tunisia. Their theory, according to which variscan deposits of the basement were during the Tertiary (Neogene) transfered without important additions of radiogenic leads by barren hydrothermal solutions into the higher laying mainly cretaceous, to lesser extent also jurassic and tertiary rocks, proved to be untenable.

Lead isotopes in tunisian galenas display according to our investigations in general similar ratios as late tertiary deposits in Central and SE Europe. Close genetical relations between these europian deposits and the neogene magmatism (volcanism) are evident and universally accepted.

There is in addition, a marked difference in the isotopic composition of lead between the tunisian deposits and most of the europian deposits in triassic carbonate rocks. The last type being regarded as of syngenetic- (stratiform) or regenerated origin. Their lead pattern is old-Bleiberg(B)-type of F. G. Houtermans (l. c.).

Whilst the tunisian deposits are characterized by younger leads (higher contents of radiogenic isotopes), the opposite is found in Morocco. F. G. Houtermans et al. l. c.) could prove that the most widely distributed isotopic pattern of moroccan galenas

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is similar to variscan lead of Europe. In the SW parts of Morocco praecambrian lead types are not uncommon.

From this brief survey follows: There is in North Africa a marked tendency in lead isotope ratios to acquire from the West (Morocco) to the by alpine orogenetic movements little affected eastern parst (Tunisia) successive younger and younger patterns.

Up to the present very few published isotopic data are available from the central part (Algeria) although they are not less important for a plausible and reliable interpretation of the metallogeny. To fill at least partly this gap is the aim of our isotopic investigations of a limited number of galenas from the culminating massiv of the Ouarsenis Mts.

The Ouarsenis Mts are located about 100 kms SW from the capital Algiers as a part of the Tellian Atlas which extends between the Mediterranean Sea and the High Plateaus. The Ouarsenis belongs to the Southern Tell which is separated from the Northern Tell by the depressions of the Chélif and Médéa.

The culminating point Grand Pic (Kef Sidi Amar) is with 1983 m the highest point of Western Algerie.

The geology of this part of the Ouarsenis has been recently studied in detail by L. Calembert (1952, 1955) who summarized also the results of older authors. M. Mattauer (1958) published a monograph about the eastern part of the Ouarsenis with certain remarks and supplementary observations regarding the culminating massiv (fig. 1).

A survey of the ore deposits, based mainly on his own investigations, partly on those of D. Dussert (1910), D. Dussert, G. Bétier (1932) and F. Blondel (1935) was given in a paper by L. Calembert (1954).

The culminating massiv of the Ouarsenis is according to the cited papers built by triassic, jurassic and cretaceous rocks.

Trias played an important rôle in the tectonic development through it's extension in the area is rather limited. It consists of gypsum, dolomites, shales, crystalline schists and basic rocks.

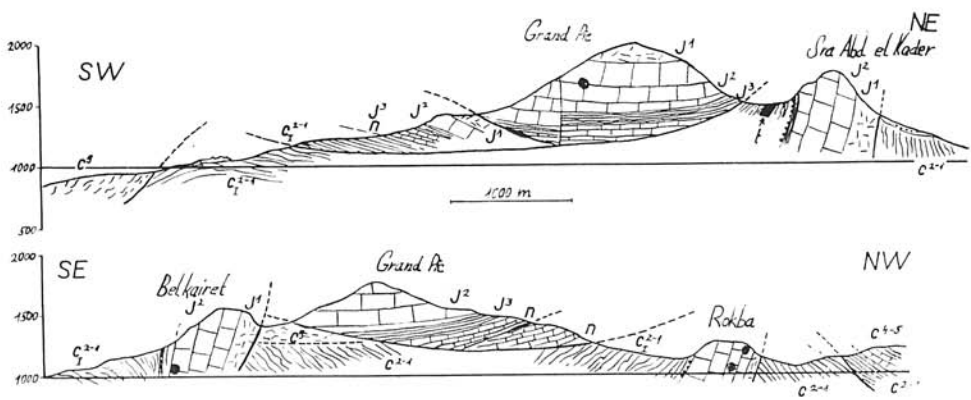

Fig. 1. Section of the culminating massif of the Ouarsenis Mts. After M. Mattauer 1958. t — Triassic, J_1 — Lower Lias, J_2 — Middle-Upper Lias-Dogger, J_3 — Malm, n — Neocomian, $C_{2.1}$ — Clansayesian-Albian, $C_{4.3}$ — Upper Albian-Cenomanian, C_9 — Senonian, Mi — Miocene, circles indicate approximative position of analyzed samples.

To the Infralias belong according to their position calcareous dolomites and dolomites with local indications of ores. These rocks are overlain by massive, light coloured limestones of paleontologically proved middle Liassic age. They contain all economically important lead zinc deposits of the area.

The upper Liassic layered limestones, cherty limestones and conglomerates are barren of lead-zinc mineralizations.

The Dogger consists mostly of layered limestones, cherty limestones and subordinate sandstones.

Marls and variegated, nodulous or compact limestones prevail in the Malm.

In the lower part of the Neocomian variegated limestones, slab-like limestones were deposited whereas sublithographic marls are characteristic for the younger sedimentation.

For the Aptian and Albian marls, slates with lens-shaped intercalations of sandstones and locally conglomerates are typical representants (Albo-aptian Flysch).

The distribution of the stratigraphic members in the area is given in the schematized map constructed by L. Calembert (l. c.) as well as in vertical sections in the interpretation of M. Mattauer.

Several units with different stratigraphical and tectonic evolution have been recognized by L. Calembert (l. c.) and M. Matauer in the culminating massiv. Among them those of Grand Pic, Rokba el Atba and Djebel Belkairet which supplied samples for isotopic investigations.

The first unit is owing to execellent exposures well accessible to observations and consequently fairly well investigated. The summit of the Grand Pic as well as it's precepites are formed by a subhorizontal jurassic series. An inverse sequence was in this unit found by L. Calembert: Lower liassic rocks form the summit of the Grand Pic. They are underlain successively by younger and younger members with tithonian marls and limestones approximately 500 m below the summit.

The reversed unit comprising members from the Infralias, including the albo-aptian Flysch lies on a cretaceous series having a normal sequence.

L. Calembert (l. c.) held the reversed series for the lower wing of an overturned antiefine. In the interpretations of M. Mattauer large scale overthrusts and nappes were for the tectonic evolution of the Ouarsenis important.

Contrary to the subhorizontal jurassic series of the Grand Pic, the units of Rokba el Atba and Dj. Belkairet are steeply inclined and have a different structural position. Both are supposed to represent „rooted" extrusive bodies of prevailingly jurassic limestones. Their contacts with the country-rocks are from three sides abnormal. On one side (usually the S or SE) they are overlain by the cretaceous flysch in a more or less normal way.

Narrow bands of triassic rocks (mostly gypsum) occur often at the tectonic contacts between the extrusive bodies of jurassic limestones and their cretaceous flysch envelope.

Ore deposits

Grand Pic (Kef Sidi Amar)

A greater number of more or less individualized ore bodies is known from the Grand Pic. Besides the deposites „gites des rochers" economic ores are concentrated in the so called collumns. As indicated the ore bodies are columnar or tubular in shape, mostly steeply inclined with in the upper parts or lateral transitions into typical veins or irregular metasomatic bodies.

Column No 2 described by L. Calembert is a peculiar mineralization. In the lowest parts it is a tube reaching 20 m in diameter. The filling consists chiefly of barite with irregularly scattered galena-sphalerite-pyrite. Galena prevails over sphalerite and the spare pyrite is accompanied by some marcasite. The earlier marcasite is often replaced by pyrite a feature observed in many lead-zinc deposits of North Africa, especially Tunisia. According, Calembert are the sulphides younger than the barite mineralization. All minerals are coarse-grained.

The primary sulphide-sulphate mineralization of Column No 2 is surrounded by an smithsonite envelope of changing thickness. From it run at places radial veins. The tubular body changes in the upper parts in a typical vein which further communicates with a cave system.

Ore deposits of the Grand Pic are restricted to middle liassic limestones.

The lead isotope ratios of galena from Column No 2 are:

204	206	207	208
1.364 %	24.97 %	21.23 %	52.44 %
1.000	18.30	15.56	38.45
5.463	100.00	85.03	210.05

Rokba el Atba (Nord)

About 2.5 kms NW of the Grand Pic. Columnar mineralization of irregular shape. Near the surface not unlike Column No 2, communicating with a cave rimmed with iron bearing smithsonite, cerussite, hydrozinkite. With depth the ore body approaches the tectonic contact between the extrusive liassic limestones and the flysch and becomes less inclined.

The up to 10—15 m thick primary zone with sphalerite, galena, pyrite, marcasite, calcite and fluorite extends in the deeper parts below about 1050 m a. s. l.

No mineralization of the contacts has been observed, the ore bodies being confined to limestones of middle liassic age as at the Grand Pic.

Two galena samples were analyzed, the first from the upper, the second from the lower parts of the deposit. Results:

	204	206	207	208
sample 1:	1.356 %	24.96 %	21.21 %	52.47 %
	1.000	18.41	15.64	38.70
	5.433	100.00	84.98	210.24
sample 2:	1.361 %	24.98 %	21.21 %	52.45 %
	1.000	18.35	15.58	38.54
	5.449	100.00	84.90	210.00

Belkairet

Approximately 3 kms SE of Grand Pic. More ore bodies, the most important being the Deposit of the Cave ("Gîte de la Grotte").

As at Rokba the tubular ore body is irregular, subvertical near the surface, less inclined in depth. The irregularity is accentuated by a rich system of veins, veinlets, stockworks and disseminations reaching up to 20 m from massive ores.

Pyrite dominates in the deepest part of the deposit. It is concentrated in a tectonic zone and contains at places workable lead-zinc concentrations.

Towards the surface pyrite is replaced by sphalerite with subordinate galena whilst smithsonite is typical for the uppermost oxydized zone.

The mineralization of Belkairet is more complex than those of Grand Pis and Rokba. The main ore-body seems to be composed of a series of successive lenses in a tectonically disturbed zone. The relations of this body to other ore types (stockworks, veins, mineralized breccias at the eastern extrusive contact) are not clear and need further investigations (L. C a l e m b e r t).

Minerals of the deposit: sphalerite, galena, pyrite, marcasite, calcite, smithsonite.

The isotopis composition of galena from the contact deposit (mineralized breccia):

204	206	207	208
1.352 %	25.07 %	21.17 %	52.41 %
1.000	18.54	15.66	38.76
5.393	100.00	84.46	209.05

L. C a l e m b e r t (l. c.) supposes for deposits of the Ouarsenis Mts. certain relations between the tectonic of the basement, the evolution and changes of the facies and the mineralization. Changes into calcareous-dolomite facies as result of tectonic movements in the sedimentary basin are regarded as favourable, and from the interaction of all factors important deposits may result. Though „extrusions" of triassic rocks are often observed, no genetic relations between these upwards movements and mineralizations could be found.

The lead-zinc deposits were formed after extrusion of the Triassic, towards the end of the folding and later. The tertiary age of a part or of the whole mineralization is not excluded (L. C a l e m b e r t l. c.).

The isotopic composition of lead from the deposits Grand Pic and Rokba el Atba is practically identical, indicating the same source and age.

Higher contents of radiogenic lead are in the sample from Belkairet. A somewhat younger age san therefore be admitted for this mineralization. It would not be in contrast with the geological observations of the contact deposit.

In all galenas from the Ouarsenis Mts the isotopic constitution is of considerably older pattern than in the evidently neogene deposits of Central and SE Europe.

These late tertiary leads are ussually within the limits:

204	206	207	208
1.325—1.350	25,15—25,42	20,98—21,19	52,04—52,53
1.000	18,77—19,05	15,70—15,90	38,56—39,49
5.250—5.333	100	82,96—83,97	204,72—209,40

The lead of the Ouarsenis deposits has similar patterns as in hydrothermal galenas in variscan deposits of Europe as well as in many stratiform (and metasomatic) deposits from the Triassic of the Alps, Carpathians, etc. The latter type being by some authors regarded as remobilized or regenerated from older, variscan, deposits. The isotopic constitution does not exclude such an interpretation (Bleiberg type of F. G. H o u t e r m a n s).

The limits as given for the East Alpine Triassic by A. G r ö g l e r, A. G r ü n e n f e l d e r, E. S c h r o l l (1961) and similar deposits of the Carpathians after J. K a n t o r et al (l. c.):

204	206	207	208
Alps:			
1.338—1.354	24.79—24.96	21.21—21.35	52.48—52.66
1.000	18.38—18.60	15.68—15.88	38.78—39.37
5.376—5.441	100.00	85.05—85.59	210.27—212.47
Carpathians:			
1.344—1.370	24.82—25.08	21.24—21.42	52.32—52.40
1.000	18.12—18.79	15.64—15.81	38.24—38.95
5.359—5.520	100.00	84.69—86.30	208.69—211.08

By similar relations are characterized certain lead-zinc deposits of the stratiform type in jurassic limestones of Morocco. Their isotopes have been studied in Bern by G. Choubert, P. Eberhardt, J. Geiss, F. G. Houtermans, P. Signer (1956).

204	206	207	208
Touissit, near Bou Beker:			
1.341	24,88	21,23	52,55
1,000	18,55	15,83	39,18
5,391	100,00	85,33	211,20
Mibladen:			
1.352—1.358	24.83—24.86	21,28—21,37	52.45—52.50
1.000	18.30—18.37	15.67—15.81	38.65—38.80
5.444—5.464	100.00	85.60—86.07	211,0—211.2

The deposit of Toussit (Bou Beker) is regarded by J. Voirin (1965) as of post-oxfordian-praeeocenian age (Pb-Zn) with a later superimposed lead mineralization in the Miocene.

After R. Felenc, P. Lenoble (1962) the lead-zinc deposits of Mibladen were formed during the interval between the Lias and Infracenomanian. Basal conglomerats of cretaceous age contain pebbles of barite from the mineralized Middle Lias. The authors are inclined to regard the main mass of the ores as syngenetic with younger superimposed mineralizations of lesser importance. In the Haute Moulouya to which the deposit s of Mibladen belongs 4 mineralizations were distinguished by A. Emberger (1962):

1. posttriassic-praeliassic (veins), 2. intraliassic 3. praecenomanian and 4. postcenomanian (atlasian). A. part of the mineralization in liassic carbonates and marls is regarded as syngenetic.

In contrast to Morocco, most of the tunisian lead-zinc deposits are confined to carbonate rocks of cretaceous age. The isotopic pattern of lead is here considerably younger (J. Kantor, M. Rybář, K. Dillnberger 1968).

Jurassic carbonates outcropp only limited areas in Tunisia. In NW of the Country (S of Tunis) they contain the lead-zinc deposits of Djebel Ressas, Zaghouan and Djebilet el Kohol. All belong to the group of deposits with the youngest pattern of lead in Tunisia.

204	206	207	208
1.330—1.335	25,34—25,46	21,03—21,07	52.17—52.26
1.000	18,98—19,14	15.78—15,81	39,15—39,23
5.224—5.268	100,00	82.56—83.15	204.87—206.14

The lead-zinc deposits of the culminating par of the Ouarsenis Mts. in Algeria display by their geological setting and isotopic constitution certain similarities to analogous deposits from the Lias of Morocco. Their origin from juvenile hydrothermal solutions during the Tertiary is according to the lead isotope ratios almost excluded.

The ratios are in better harmony with a mesozoic age of the deposit. Though a simple remobilization of these large deposits in H. Schneiderhöhn's sense is improbable, certain influence of the praetriassic basement on the generally older pattern of lead (B-type F. G. Houtermans) in Morocco and Algeria can bei admitted.

Lead isotope investigations do not support H. Schneiderhöhn's and J. Bolze's views regarding the secondary hydrothermal origin of tunisian deposits as already outlined by J. Kantor, M. Rybár, K. Dillnberger (l. c.).

In North Africa a general increase of radiogenic lead in galenas can be observed from the W to E. The moroccan deposits are characterized by the oldest, the tunisian by the youngest patterns.

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