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LEAD-ZINC DEPOSITS HOSTED BY SEDIMENTARY ROCKS IN THE ALPS IN THE VIEW OF LEAD ISOTOPES

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The origin of metals is an essential contribution to understand ore deposits. Lead isotopes are an important tool for it. In the magmatic environment, e.g. volcanogenic massive sulphide (VMS) deposits, the isotopic identity of rock lead and ore lead is evident. Therefore, uranogenic and thorogenic model ages are approximately concordant, and they are evaluated as realistic data. Otherwise, differences between both model ages are common in ore leads from low-temperature sediment-hosted deposits.The uranogenic model range from older than the mineralization (B(leiberg)-type ore lead) to younger (J(oplin)-type ore lead. The uranogenic model ages are older than the thorogenic model ages, e.g. Bleiberg deposit (uranogenic 332 ± 20 my, thorogenic 120 ± my, stratigraphic age 210 to 220 my). Thus, these model ages are an indication for the source of lead. Preferably, the uranogenic lead isotopes ^{235}Pb and ^{238}Pb are only presented and interpreted. Fig. 1 illustrates lead isotope distribution in the Alpine sediment-hosted Pb-Zn deposits using the model age t_2 and the uranogenic environmental parameter μ_2 (= $^{238}U/^{204}Pb$). Model age t_2 and μ_2-value are parameters of the two stage lead evolution model [2].

Crustal lead has an μ_2-average at 9.85. This value corresponds to a lead, that is multi-recycled and well-mixed by magmatic and sedimentary processes. Crustal ore lead isotope compositions are present in galena from occurrences in the Northern limestone Alps and in Permian sandstone and carbonates. A peculiarity is a rare galena crystal found in geodes from the Cardita shale at Bleiberg deposit. Its lead isotope composition is identical with the rock lead from Bleiberg deposit [2]. Model ages of ore leads, corresponding approximately with stratigraphic ages, are obtained only from uneconomic occurrences in the Anisian and Carnian stage of the eastern Northern Limestone Alps.

The main trend of the Triassic ore leads contains all important Pb-Zn deposits of the Alps. This main trend includes the Pb-Zn districts hosted by carbonate rocks in the Northern Tyrolian Limestone Alps, in the Drauzug (including Northern Karavancs) and Southern Alps. The field of the main trend is characterized by a positive correlation of t_2 and μ_2. The μ_2-values increase from crustal lead to upper crust lead in the following order: Northern Tyrolian Limestone Alps < Drauzug < Southern Alps. Ore leads from deposits hosted by Anisian stage display mostly lower μ_2-values than ore leads from the Carnian stage. Exceptions are deposits which had economic importance, i.e.Topla in the Northern Karawanks and Auronzo in the Southern Alps. The largest deposits in the Alps, i.e. Bleiberg (3.5 x 10^6 tons Pb+Zn) and Mežica (2.0 x 10^6 tons Pb+Zn) are positioned north of the Periadriatic lineament.

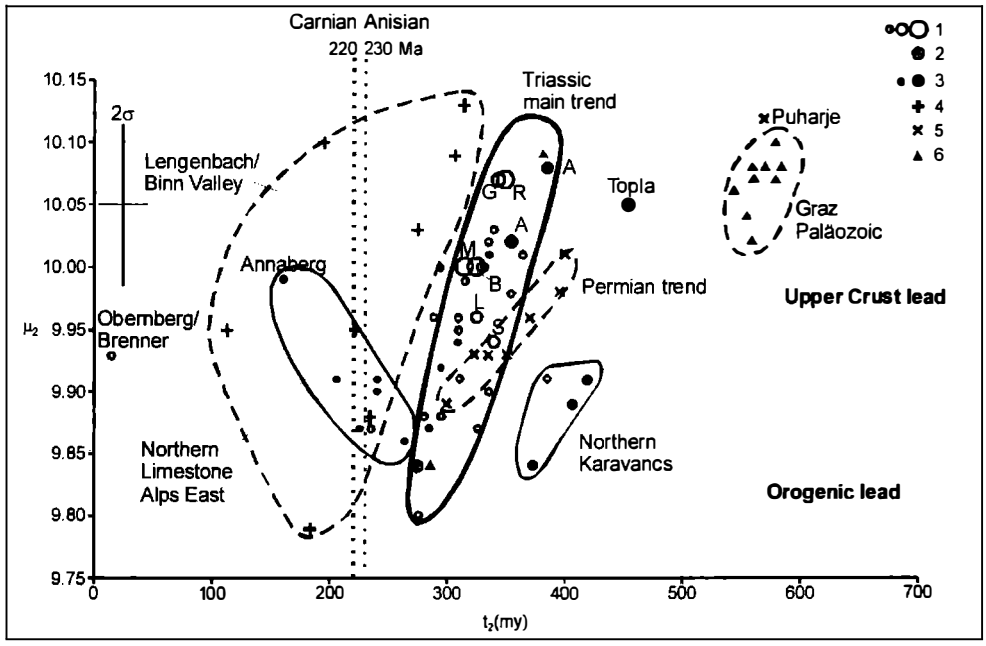

Table 1

Model age t_2 and μ_2 of Alpine deposits. Source of the lead isotope data [3, 4]. Abbreviations: A Auronzo, B Bleiberg, L Lafatsch, M Mezica, G Gorno, R Raibl, S Salafossa); 1 - small, medium and large deposits hosted by Carnian carbonates, 2 - small and medium deposits hosted by Anisian carbonates, 3 - geode (=rock) lead from Bleiberg, 4 - deposits hosted by Permian rocks, 5 - deposits hosted by Devonian rocks

The μ_2-values of their ore leads are around 10, and their model ages are indistinguishable.
The third deposit Raibl (1.5 x 10^6 tons Pb+Zn tons) situated south of the Periadriatic lineament shows an ore lead with a μ_2-value of 10.8. Medium deposits, i.e. Lafatsch (Northern Tyrol) and Salafossa (Southern Alps), are characterized by lower μ_2-values close to 9.9.
The deposits of the Triassic main trend reveal commonly relations between μ_2-values and trace element geochemistry. High μ_2-values are overwhelmingly combined with a decrease of Ag and Cu contents and an increase of Ge, Tl and As. In spite of high μ_2-values, the lead-zinc ores from the Gorno district in the Bergamasco Alps (Italy) deviate significantly from the other districts in regard to geochemical parameters..
Leads from some Occurrences in the Northern Karavancs display higher model ages indicating a change in the source rock. A special trend is suggested for ore leads from deposits hosted by Permian carbonates. B-type ore leads are also typical for the sedimentary massive sulphide (SMS) deposits in the Graz Paleozoic hosted by Devonian sediments.
Obernberg (Brenner Triassic) and Lengenbach /Binn Valley (Switzerland) are carbonate-hosted Pb-Zn mineralizations in areas of amphibolite facies. The ore leads of these occurrences are characterized by radiogenic ore leads. The lead isotope data from the Lengenbach mineralization scatter widely. This deposit was originally a synsedimentary mineralization hosted by Anisian rocks [4].

Thus, the ore leads of the Alpine Triassic indicate relations to stratigraphy, basement and its clastica and - last not least - to regionally and temporally different paleohydrothermal systems. Homogeneity of lead isotope composition is an important constraint regarding for paleohydrogeological modelling. For instances, the Drauzug district hosted by Carnian stage presumes a basin that enables leaching of metals up to 10 x 10^6 tons by fluid rock reactions. The high homogeneity of the lead isotopes of these deposits excludes a paleohydrogeological model that assumes convective fluid events penetrating deeply into the basement.

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