within this basin thick shallow–marine successions were deposited. At the beginning of the sedimentation the southern shoreline of this epicontinental sea area lay slightly S of the present–day South–Hunsrück borderfault. Already in the Siegenian the formation of synsedimentary fractures further indicates a prograding extension of the Rhenohercynian crust. During the Lower Emsian this splitting of the southwestern Rhenohercynian basin into horsts and graben reached its maximum. Thus the very thick sequences within the "Mosel–Graben" and central Hunsrück area contrast with extremely condensed sediments on the narrow ridges (e.g. on the "Taunuskamm–Soonwald–Horst"). Further S on the southern margin of the Rhenohercynian basin a very strong crustal thinning during the Ulmen–Substage (Lower Emsian) probably led to the formation of a narrow ocean ("Lizard–Giessen–Ostharz–Ocean"). With the opening of this ocean the area of the present–day South–Hunsrück Phyllite Zone became part of the continental rise of the Rhenohercynian passive margin and also comprises the transition zone to the oceanic crust (occurrence of MOR–type metabasalts within the southernmost imbricate of the Phyllite Zone).

The Lizard–Giessen–Ostharz–Ocean probably reached its maximum width in the Givetian (>200km?). On the other hand, in the southern Hunsrück, lower Upper Devonian flysch sediments seem to indicate that plate convergence had already begun at this time. So at the southern margin of the ocean basin south–dipping subduction and the evolution of the MidGerman Crystalline Rise presumably started at the beginning of the Upper Devonian.

The oceanic closure and subduction proceeded until the accretionary wedge of the Mid–German Crystalline Rise collided with the southern margin of the Rhenohercynian Basin in the upper Lower Carboniferous. At the beginning of the collisional stage the area of the present–day Vordertaunus and South–Hunsrück Phyllite Zone was partly subducted, received a first cleavage and suffered a pressure–accentuated metamorphic event. Then after its accretion the Phyllite Zone. was welded to the northerly adjoining units and shared a common deformation history with them. During the Upper Viséan and Namurian the accretionary wedge of the Mid–German Crystalline Rise thrusted extensively over the Rhenohercynian lower crust and detached the Rhenohercynian basin–filling from its basement. The thick sequences of the southwestern Rhenohercynian Zone simultaneously formed a large–scale duplex structure consisting of the imbricate stack of the footwall "Hunsrück Nappe" (including the Hunsrück– and Taunuskamm–Soonwald–unit) and the overlying "Giessen Nappe". Farther similarities in the sequence and facial development of the Giessen Nappe and the South–Hunsrück Phyllite Zone as well as the occurrence of MOR–type metabasalts in both units suggest that the Phyllite Zone of the Hunsrück is part of the root zone of the Giessen Nappe.

Altogether the orogenic processes shortened the southwestern Rhenohercynian Zone to 38% of the former basin width and also induced a considerable crustal thickening. Finally, collision–related isostatic uplift and lateral crustal extension set in and caused the formation of the Permo–Carboniferous intramontane graben and half graben (cf. the Saar–Nahe–basin).

HOSTROCK ALTERATION IN THE RUBIALES ZN–PB DEPOSIT, NW–SPAIN – A MASS BALANCE STUDY

M. DOPPLER, L. FONTBOTÉ

Département de minéralogie, Université de Genéve, rue des Maraîchers 13, 1211 Genéve 4, Switzerland

The Rubiales Zn–Pb mine (Lugo, NW Spain) is situated in Lower Cambrian sediments of the Transition Beds of the West Asturian–Leonense Zone which have undergone several phases of deformation and low grade metamorphism during the Hercynian orogeny (Arias, 1988, Arias et al.,1991, Tornos & Arias 1993). Mineralization is interpreted as the result of replacement of mainly carbonate rocks by migration of low temperature hydrothermal fluids along a NNW–trending shear zone. Reserves and accumulated production until 1992 when the mine closed amounted 18.3 Mt with an ore grade of 7.3% Zn and 1.3% Pb.

The Transition Beds are divided into the Lower, Middle and Upper Transition Members (Arias et al.,1991). The Lower Transition Member consists mainly of shales with intercalated carbonate layers, the Middle Transition Member of limestones with several shaly and sandy intercalations, the Upper Transition Member consists of dolostones and limestones with intercalated shales. The Transition Beds are underlain by feldspathic sandstone of the Cándana Group and overlain by dolomitized shallow–water carbonate rocks of the Vegadeo Formation which host stratabound Zn–Pb occurrences (Ribera et al., 1992, Tornos et al, 1992). The Rubiales orebody is essentially located in Middle Tran–

Table 1. Average XRF analyses in weight % of the lithologies occurring in the Rubiales mining area. SSTI = Candana and Lower Transition sandstones, SSTM = Middle Transition sandstones, CD = carbonate rock, SL = slates, QR = strongly altered carbonate rock, ore–SL = ore bearing slate. Low sums of QR and ore–SL are due to presence of sulfides.

lithol.	N	SiO2	Al2O3	TiO2	FeO(tot)	CaO	MgO	Na2O	K2O	MnO	P2O5	LOI	sum
SSTI	16	67.70	13.98	0.92	3.55	2.52	2.09	3.41	3.40	0.06	0.31	3.82	101.74
SSTM	14	70.26	9.85	0.56	3.13	4.09	1.59	1.37	2.66	0.10	0.33	5.28	99.21
SL	30	59.04	17.89	0.89	5.26	2.23	3.03	1.70	4.80	0.04	0.24	4.66	99.79
CD	47	10.48	2.19	0.13	1.33	46.62	1.50	0.47	0.57	0.20	0.12	37.57	101.16
QR	22	55.61	4.92	0.29	4.87	10.73	2.92	0.60	1.54	0.30	0.21	12.34	94.33
ore-SL	4	51.90	17.91	0.85	3.77	3.19	2.88	0.71	5.47	0.08	0.19	7.82	94.75

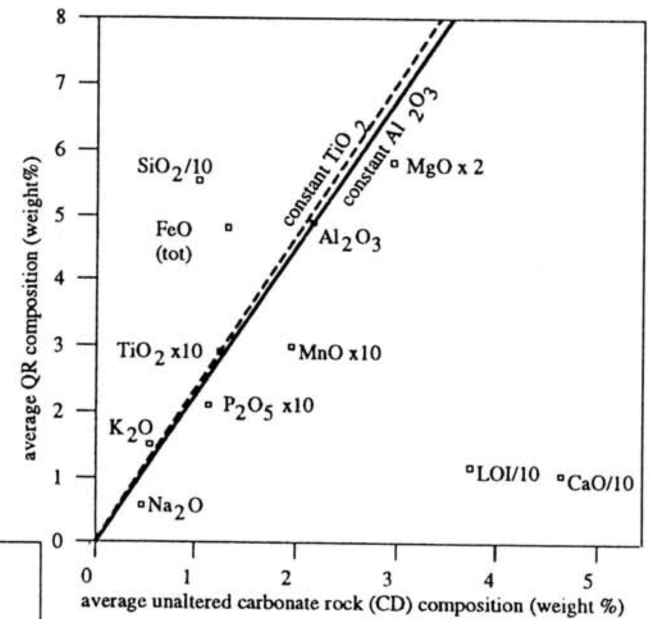

Fig. 1. Isocon diagram using average carbonate rock composition as least altered, and average QR composition as strongest altered component. Al_2O_3, TiO_2, and the origin are colinear and form a best fit isocon (not shown). FeO and SiO_2 are significally enriched, whereas CaO and LOI are extremely depleted. The black line is the isocon for assumed constant Al_2O_3, the dotted line for assumed constant TiO_2.

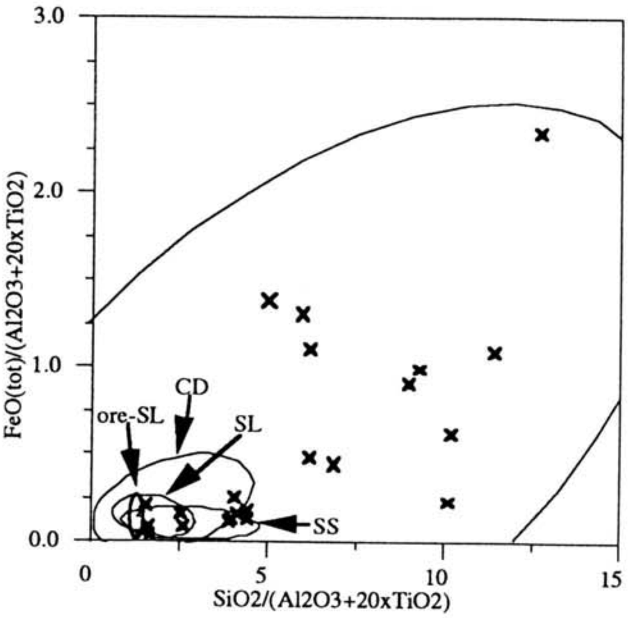

Fig. 3. SiO_2 and FeO (tot) over Al_2O_3+20xTiO_2 plot of QR samples (x) showing also 90% density ellipses for carbonate rocks (CD), slates (SL), sandstones (SS), ore bearing slates (ore–SL) and QRs. Two strongly altered QR samples plot outside the diagram.

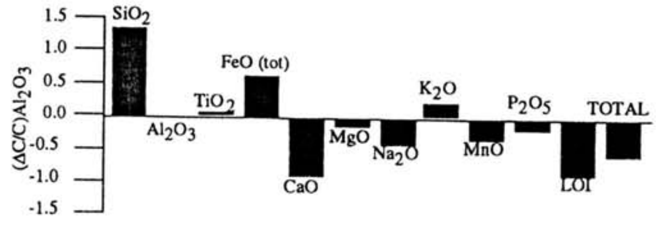

Fig. 2. Calculated relative gains and losses assuming constant Al_2O_3

sition Member carbonates which have undergone strong alteration, mainly silicification. Due to their high silica content these altered rocks were called in the mine "quartz rock" (QR). An overview of the major element geochemistry of the different lithologies occurring in the mining area is given in Table 1. The scope of this contribution is to present a mass balance study of the host rock alteration in the Rubiales deposit.

The "Isocon Diagram" method of Grant (1986) requires the concentrations of the least altered rock and of the most altered rock to firstly determine the most immobile and mobile components, and secondly to calculate relative gains and losses.

The rock compositions used in this study are the mean values of least altered carbonate rocks of the Middle Transition Member and, as most altered rocks, the mean QR values (Fig. 1). Geochemical data and petrographic observation were used to assess that the samples included in the QR group were originally carbonate rocks.

Al_2O_3, TiO_2 and the origin are almost colinear. A best fit line (not shown in Fig. 1) between Al_2O_3 and TiO_2 would intersect the x-axis at 0.01. Al_2O_3 and TiO_2 can be considered as immobile components. The slope of 2.25 of this best fit line corresponds to a mass loss of about 56%. The gains and losses calculated for assumed constant Al_2O_3 (Fig. 2) show a strong increase of SiO_2, an increase of FeO(tot), a possible weak increase of K_2O and losses for all other components, the strongest of which is for $CaCO_3$. Figure 3 shows the alteration effects by plotting the most enriched components SiO_2 and FeO(tot) over the least mobile components. The unaltered rock types plot in a narrow area, whereas most of the QR sample plots reflect the strong enrichment in SiO_2 and FeO(tot). Interestingly the host rock with originally shaly lithology (ore–SL) does not show an obvious alteration pattern.

It can be concluded at Rubiales that strong decarbonatization combined with silicification and Fe–input result in a mass loss of about 56% (up to 63 % volume loss taking into account the densities of quartz and calcite). This loss accounts for the apparent increase by a factor of 2.25 of Al_2O_3 and TiO_2, which show an immobile behaviour. The calculated volume loss corresponds with the 60 to 70% thickness reduction of the altered carbonate layers at Rubiales proposed by Arias (1988).

Acknowledgements: We want to thank the staff of EXMINESA, especially J. Drake for their support during field work. This study is supported by Grant 20–36397.92 of the Swiss National Science Foundation.

References

Arias, D., Suárez, O., Corretgé, L.G., Fernández–Jardón, L., – Pérez–Cerdán, F. (1991): Structure, hydrothermal alteration and composition of the Rubiales Pb–Zn orebody (Lugo, Spain): Genetic model. Mineralium Deposita, v. 26, p.199–210.

Arias, D. (1988): La caracterización geoquimica y mineralógica del yacimiento de Pb–Zn de Rubiales Lugo, España). Thesis. University of Oviedo, 263 p.

Grant, J.A. (1986): The Isocon diagram– a simple solution to Gresen's equation for metasomatic alteration. Econ. Geology, v. 81, p.1976–1982.

Ribera, F., Tornos, F. – Locutura, J. (1992): Las mineralizaciones estratoides de Zn–Pb de la serie de Vegadeo en la zona de Ponferrada (zona Astur Occidental Leonesa, NO de Espaa. Geogaceta, v.l 1, p.12–14.

Tornos, F., Ribera, F., Spiro, B. – Sheperd, T.J. (1992): Geologia y geoquimica isotopica de las mineralizaciones de cincplomo en la caliza de Vegadeo (Zona Astur Occidental Leonesa). Extended abstract III Congr. Geol. España. 3, p. 422–426.

Tornos, F. – Arias, D. (1993): Sulphur and lead isotope geochemistry of the Rubiales Zn–Pb ore deposit (NW Spain). European Journal of Mineralogy, v. 5, p. 763–773.

TECTOGENESIS OF THE MID–EUROPEAN VARISCAN FOLD BELT

J. DVOŘÁK

Czech Geological Survey, 65869 Brno, Leitnerova 22, Czech Republic

The Mid–European Variscides developed on the granitic layer of the crust of the Laurasian Plate when it collided with the Gondwana Plate. A thin basement crust in the deformed zone may explain its high mobility. The tendencies of the continental drift trending North were connected with the tectogenesis of unconsolidated crust when passing through the mobile circum–equatorial zone.

It is not possible to presuppose a dilatation during initial stages of the basins but only a compression. In the course of Variscan tectogenesis, the bordering Forelands were underthrusted (subducted) below the mobile deformed zone and a Median Mass. A steep geothermal paleogradient caused the melting of the underthrusted crust. The melts migrated under the Median Mass which thus was intruded by large granitoid plutons (e. g. Moldanubicum).