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The Y/Ho ratio as an indicator of metallic mineralizing fluid origin. Case of the Chouichia, Ain El Bey, Kef El Agueb, El Hairech and J.Hallouf-Sidi Bouaouane ore deposits at the thrust zone of North western Tunisia (North African margin)

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Yttrium (Y) has a geochemical behaviour similar to that of rare earths (REE). The Y and Ho generally remain associated during geochemical processes and the Y/Ho ratio remains stable. However, in hydrothermal fluids Y is more mobile and is slightly subtracted from fluids by metal particles resulting in fractionation between Y and Ho [1], [2]. Consequently, the Y/Ho ratio is increasingly used as a tracer of mineralizing fluids origin.

In this study, Y/Ho ratios of the ore deposits (Tab. 1) at the thrust zone of north-western Tunisia, are compared with those of modern submarine hydrothermal fluids, marine waters, Mid-Atlantic Ridge, magmatic rocks and those of Metamorphites (Fig. 1).

For Chouichia's ore deposits, Y/Ho values are lower than those of modern seawater but comparable to those of mafic and felsic igneous rocks, metamorphic and volcanic rocks (Fig. 1) indicating a mineral genesis rather marked by magmatic and metamorphic chemistry than by marine one.

The values of the Y/Ho ratio in the sulphide-sulphosalts veins at Chouichia and Ain El Bey, are generally low (Y/Ho = 14 to 19) reflecting rather reducing and high temperature conditions. At Kef El Agueb, the values of the Y/Ho ratio in the iron veins are higher varying from 23 to 62.666 reflecting the role of iron oxy-hydroxides and oxidizing conditions in the trapping of Ho and a more marked hydrothermal fluid mixing with marine waters.

Y/Ho ratio for Jebel Hairech and J. Hallouf - Sidi Bouaouane ore deposits, is of chondritic type (around Y/Ho = 28) highlighting a weak fractionation between Y and Ho linked to a weaker contribution of hydrothermal fluids and /or marine waters.

References

[1] Nozaki Y., Zhang J., Amakawa H., (1997) The fractionation between Y and Ho in the marine environment, Earth and Planetary Science Letters, Volume 148, Issues 1-2, 1997, Pages 329-340, ISSN 0012-821X, https: //doi.org/10,1016/S0012-821X(97)00034-4.

[2] Bau M., Dulski P., (1999) Comparing yttrium and rare earths in hydrothermal fluids from the Mid-Atlantic Ridge: implications for Y and REE behaviour during near-vent mixing and for the Y/Ho ratio of Proterozoic seawater. Chemical Geology. Volume 155, Issues 1-2. Pages 77-90. https://doi.org/10.1016/S0009-2541(98)00142-9.

Table 1: Y and Ho concentrations (in ppm) and the Y / Ho ratio of the Chouichia, Ain El Bey, Kef El Agueb, J. Hallouf-Sidi Bouaouane and Jebel El Hairech deposits.

Region	sample	Mineralization and host rock	Y (ppm)	Ho (ppm)	Y/Ho
Chouichia	C-C1	Pyrite limestone	11.35	0.39	29.102
	C-C10	Metamorphosed limestone	32.3	1.1	29.363
	C-FC1	Fe-Ca Vein	8.1	0.3	27
	C-FC2		5.8	0.2	29
	C-FC3		11.6	0.5	23.2
	C-F1	Fe vein (siderite)	1.46	0.04	36.5
	C-S1	sulphides- sulphosalts vein	3.2	0.1	32
	C-S2		1.57	0.08	19.625
	C-S3		1.78	0.09	19.777
Ain El Bey	A-S1	sulphides- sulphosalts vein	0.29	0.02	14.5
Kef El Agueb	K-C1	Metamorphosed cretaceous rock	13.1	0.4	32.75
	K-F1	Fe vein	2.3	0.1	23
	K-F2		18.8	0.3	62.666
	K-F4		0.76	0.02	38
	K-FBS1	sulphides- sulphosalts breach vein	6	0.3	20
	K-FB1	Ca-Cu breach vein	2.8	0.1	28
	K-FB2		19.5	0.6	32.5
J. Hallouf- Sidi Bouaouane	B1	Host rock with karst mineralization	9.36	0.25	37.44
	B2	Host rock with vein mineralization	4.74	0.17	27.822
Jebel El Hairech	H-F	Fe vein	1.44	0.05	28.8

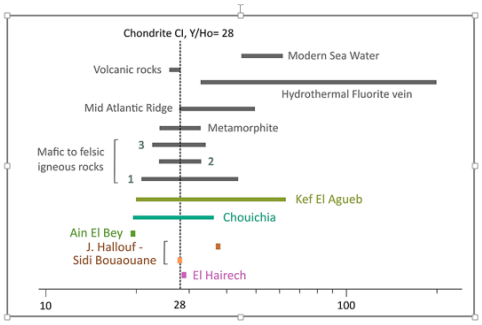

Figure 1: Position of Y/Ho ratio values for Chouichia, Ain El Bey, Kef El Agueb,J. Hallouf,-Sidi Bouaouane and El Hairech deposits. (1, 2, 3): mafic to felsic igneous rocks; 1 (after Govindaraju, 1989), 2 (after GarbeSchönberg, 1993), 3 (after Tepper et al., 1993). Modern seawater (Bau et al., 1997; Bau and Dulski, 1999; Douville et al., 1999). Mid-Atlantic Ridge (Bau et al., 1997; Bau and Dulski, 1999; Douville et al., 1999). Metamorphite (Yang Ruidong et al., 2009; Zhang Xiaodong et al., 2011). Hydrothermal vein fluorites (Bau et al., 1995).