Ore Geology Reviews 63 (2014) 532–543

Contents lists available at ScienceDirect

Ore Geology Reviews

journal homepage: www.elsevier.com/locate/oregeorev

Fluorite REE-Y (REY) geochemistry of the ca. 850 Ma Tumen molybdenite–fluorite deposit, eastern Qinling, China: Constraints on ore genesis

Xiao-Hua Deng [a,b], Yan-Jing Chen [a,c,*], Jun-Ming Yao [c], Leon Bagas [d], Hao-Shu Tang [a,e]

[a] Key Laboratory of Orogen and Crust Evolution, Peking University, Beijing 100871, China
[b] Beijing Institute of Geology for Mineral Resources, Beijing 100012, China
[c] Key Laboratory of Mineralogy and Metallogeny, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China
[d] Centre for Exploration Targeting, ARC Centre of Excellence for Core to Crust Fluid Systems, The University of Western Australia, Crawley, WA 6009, Australia
[e] State Key Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, 46 Guanshui Road, Guiyang 550002, China

ARTICLE INFO

Article history:
Received 24 June 2013
Received in revised form 17 February 2014
Accepted 18 February 2014
Available online 25 February 2014

Keywords:
Fluorite
REY
Molybdenite–fluorite deposit
East Qinling Mo Belt
North China Craton

ABSTRACT

The Tumen molybdenite–fluorite vein system is hosted by carbonate rocks of the Neoproterozoic Luanchuan Group, located on the southern margin of the North China Craton (NCC) in central China. Previous studies divided the mineralization into four stages according to the crosscutting relationships between veinlets and their mineral assemblages. In this contribution, two distinctive types of fluorite mineralization are recognized: 1) the first type (Type 1) includes colourless, white or green fluorite grains present in Stage 1 veins; and 2) the second type includes Type 2a purple fluorite present in Stage 2 veins and does not coexist with sulfides, and Type 2b purple fluorite crystals associated with sulfides in Stage 2 veins. The rare earth element (REE) content in the fluorite ranges between 13.8 and 27.9 ppm in Type 1, 16.9 and 27.2 ppm in Type 2a, and 42.5 and 75.1 ppm in Type 2b, which suggests that the fluorite was precipitated from acidic fluids (given that REEs are mobile in saline HCl-bearing fluids at high temperature (~400 °C)). Comparing the REE chemistry of the Stage 1 against Stage 2 fluorite, the LREE/HREE ratios decrease from 9.8 to 4.0, La/Yb ratios decrease from 16.0 to 6.9 and La/Ho ratios decrease from 10.2 to 3.0, indicating that the hydrothermal process was at high-T and low-pH conditions. The Eu/Eu* ratios in the fluorite decrease from 1.11 ± 0.35 for Type 1 through 0.89 ± 0.19 for Type 2a to 0.75 ± 0.17 for Type 2b, suggesting a gradual increase in oxygen fugacity (fO_2) and pH of the mineralising fluid. The Tb/Ca, Tb/La and Y/Ho ratios of the fluorite types indicate that they were formed from the interaction between magmatic fluids and carbonate wallrocks. The fluorite samples show similar REE + Y (REY) patterns to those of dolostone units in the Luanchuan Group and the nearby Neoproterozoic syenite, suggesting that the REY in the fluorite was mainly sourced from the host-rocks, although the syenite could be an additional minor source.

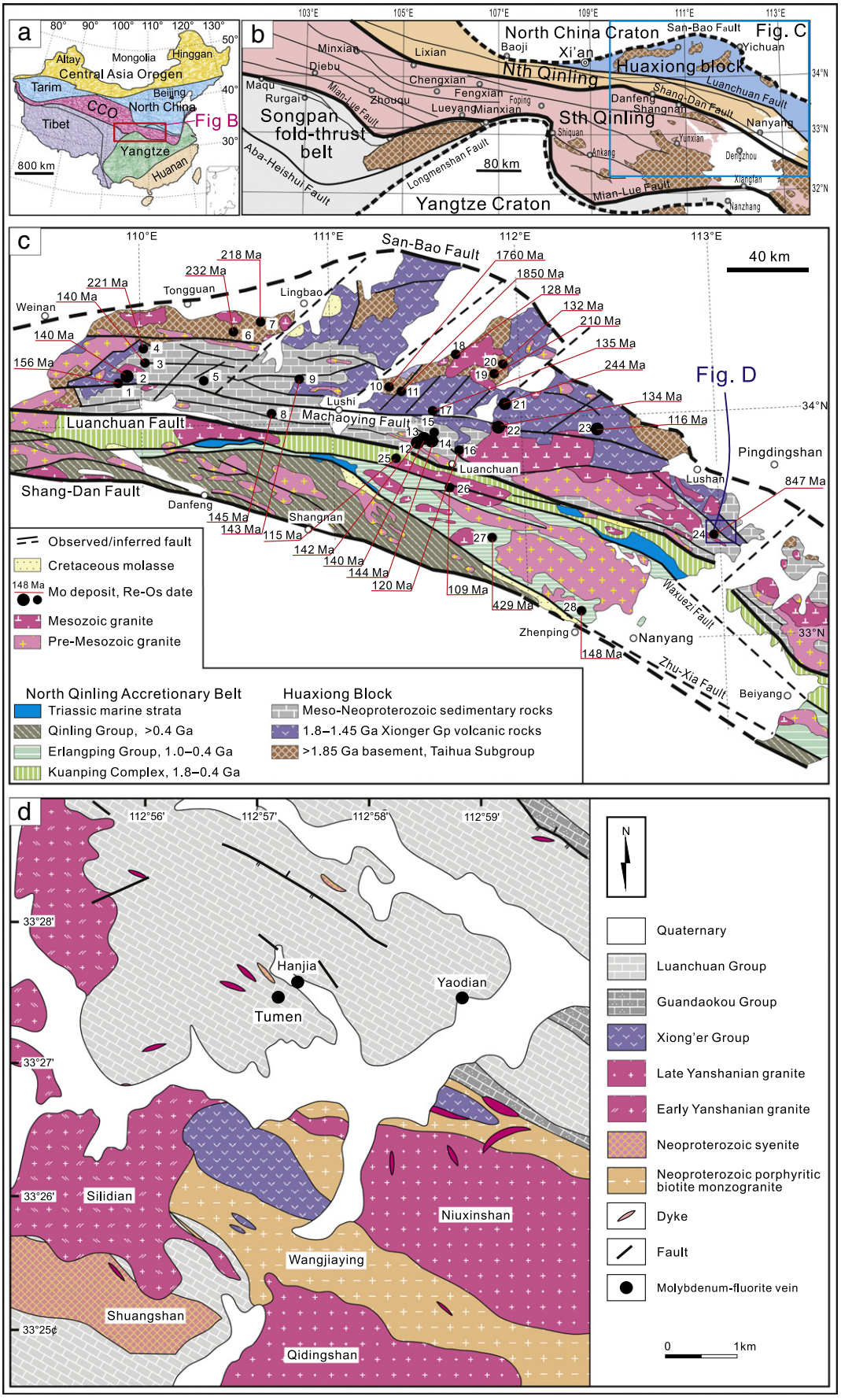
1. Introduction

The eastward trending East Qinling Mo Belt (EQMB; Chen et al., 2000) extends along around the suture zone between the NCC and the Qinling Orogen (Fig. 1a, b). The belt is one of the most important Mo provinces in the world, which consists of six giant (>0.5 Mt) and many large (0.1–0.5 Mt), medium (0.01–0.1 Mt), and small (<0.01 Mt) deposits with a combined reserve of ~6 Mt Mo (Chen et al., 2009). The majority are Mesozoic porphyry- and skarn-type deposits formed in a post-subduction and collisional tectonic setting (Chen, 2013; Chen et al., 2000, 2007; Hu, 1988; Li et al., 2007, 2012a, 2012b, 2013; Mao et al., 2008). Most of the Mo deposits are located in the Huaxiong Block to the north of the Luanchuan Fault (Fig. 1b, c). The isotope ages obtained from these deposits range from Palaeoproterozoic to Early Cretaceous (Deng et al., 2013a, 2013b; Li et al., 2011b), suggesting that the Mo mineralisation in the EQMB can be traced back to 1.85 Ga.

Chen and Li (2009) suggested that the porphyry Mo systems in EQMB have high CO_2/H_2O and F/Cl ratios, and exhibit pronounced alteration characterised by K-feldspar, carbonate and fluorite, which are consistent observations made by other researchers (e.g. Pirajno, 2009, 2013; Y.F. Yang et al., 2013; Y. Yang et al., 2013; Yang et al., 2012). Why the Mo-mineralisation is usually related to fluoritization, however, is not well understood. Recently, Mo deposits have also been found in the carbonatite-, quartz- and fluorite-dominated veins in the Huaxiong Block (Chen et al., 2009; Deng et al., 2008, 2013c; Li et al.,

* Corresponding author at: Key Laboratory of Orogen and Crustal Evolution, Peking University, Beijing, 100871, China. Tel.: + 86 10 6275 7390.
E-mail addresses: yjchen@pku.edu.cn, gigyjchen@126.com (Y.-J. Chen).

http://dx.doi.org/10.1016/j.oregeorev.2014.02.009
0169-1368/


a
Altay
Mongolia
Hinggan
Central Asia Orogen
Tarim
Beijing
CCO
North China
Fig B
Tibet
Yangtze
Huanan
800 km
b
North China Craton
San-Bao Fault
Fig. C
Minxian
Lixian
Baoji
Xi'an
Huaxiong block
Diebu
Nth Qinling
Yichuan
Chengxian
Luanchuan Fault
Maqu
Rurgai
Zhouqu
Fengxian
Foping
Danfeng
Shang-Dan Fault
Songpan
fold-thrust
belt
Lueyang
Mianxian
Sth Qinling
Shangnan
Nanyang
Shiquan
Yunxian
Ankang
Dengzhou
Aba-Heishui Fault
Longmenshan Fault
80 km
Xiangfan
Mian-Lue Fault
Yangtze Craton
Nanzhang
c
San-Bao Fault
40 km
Weinan
Tongguan
Lingbao
Fig. D
Luanchuan Fault
Machaoying Fault
Lushi
Luanchuan
Pingdingshan
Lushan
Shang-Dan Fault
Danfeng
Shangnan
Waxuezi Fault
Zhenping
Nanyang
Zhu-Xia Fault
Beiyang
Observed/inferred fault
Cretaceous molasse
Mo deposit, Re-Os date
Mesozoic granite
Pre-Mesozoic granite
North Qinling Accretionary Belt
Triassic marine strata
Qinling Group, >0.4 Ga
Erlangping Group, 1.0–0.4 Ga
Kuanping Complex, 1.8–0.4 Ga
Huaxiong Block
Meso-Neoproterozoic sedimentary rocks
1.8–1.45 Ga Xionger Gp volcanic rocks
>1.85 Ga basement, Taihua Subgroup
d
Hanjia
Tumen
Yaodian
Silidian
Niuxinshan
Wangjiaying
Shuangshan
Qidingshan
N
Quaternary
Luanchuan Group
Guandaokou Group
Xiong'er Group
Late Yanshanian granite
Early Yanshanian granite
Neoproterozoic syenite
Neoproterozoic porphyritic biotite monzogranite
Dyke
Fault
Molybdenum-fluorite vein
0 1km