Ore Geology Reviews 39 (2011) 188–217

Contents lists available at ScienceDirect

Ore Geology Reviews

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

# Trace and minor elements in sphalerite from base metal deposits in South China: A LA-ICPMS study

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ARTICLE INFO

*Article history:*
Received 8 November 2010
Received in revised form 4 March 2011
Accepted 4 March 2011
Available online 11 March 2011

*Keywords:*
Sphalerite
Mineral chemistry
LA-ICPMS trace element analysis
Indium
South China

ABSTRACT

Laser-ablation ICP mass-spectroscopy has been used to investigate the geochemistry of sphalerite in a range of nine Zn–Pb deposits in South China. The deposits, which are of different ages and belong to different metallogenic provinces, have been assigned to the following genetic types: skarn (Hetaoping, Luziyuan), syngenetic massive sulphide (Dabaoshan, Laochang and Bainiuchang) and Mississippi-Valley-type (Huize, Mengxing, Niujiaotang) based on the features of the ore, even though their origin is heavily debated based on other criteria. The giant Jinding deposit is considered separately. Sphalerite from each genetic class of deposit shows a distinct chemical signature. Sphalerite from the skarn deposits is characterised by elevated, lattice-bound concentrations of Co and Mn. The distal character of these skarn systems is reflected by the low In content of sphalerite. The three syngenetic massive sulphide deposits feature sphalerite strongly enriched in In, Sn and Ga, whereas the deposits of MVT-type are typically enriched in Ge, Cd, Tl and As. These divergent characters are reflected in absolute element abundances as well as in element ratios.

Time-resolved depth profiles for sphalerite from the Chinese deposits confirm the presence of elements such as Co, In, Ge, Ga, and Cd in solid solution, but the dataset expands the understanding of sphalerite mineral chemistry by also indicating that other elements, whose ability to enter the crystal structure of sphalerite has been previously debated (Ag, Sn, Tl, Sb), may also be in solid solution.

Sphalerite is a refractory mineral and trace element analysis of sphalerite shows promise as a tracer of ore genesis even in overprinted ores. Systematic work on larger sample suites may help define the geochemical signature of different metallogenic epochs in regions as geologically complex as South China and help resolve the mechanism by which many of the debated ore deposits were formed.



## 1. Introduction

Sphalerite is one of the most common sulphide minerals and by far the economically most abundant source of zinc. The crystal structure of sphalerite has long been recognised to accommodate a broad variety of elements, the most significant of which are Fe and Cd. Many elements enter the sphalerite structure via simple substitution of similar-sized ions ($Zn^{2+} \leftrightarrow Fe^{2+}$, $Cd^{2+}$, $Mn^{2+}$, $Co^{2+}$ or $S^{2-} \leftrightarrow Se^{2-}$), or by coupled substitution (e.g., $Zn^{2+} \leftrightarrow Cu^{+} + In^{3+}$). Substitution mechanisms for other elements commonly found in sphalerite (e.g. Sn, Ag, Ga, and Ge) remain less well constrained and for others (e.g., Pb, Tl, As, Sb, and Bi), it is not entirely clear whether they enter the sphalerite structure at all or are almost always present as inclusions of discrete minerals. The reader is referred to the sizeable literature on the minor and trace element geochemistry of sphalerite, including-Fleischer (1955), Zhang (1987), Johan (1988), Huston et al. (1995), Beaudoin (2000), Di Benedetto et al. (2005), Ishihara et al. (2006), Ishihara and Endo (2007) and Cook et al. (2009).

It is only relatively recently, however, that widely available, relatively inexpensive, precise analytical methods have been applied to document and correlate trace element distributions in sphalerite from a large number of ore deposits. Such work has confirmed arguments first put forward more than 70 years ago (Oftedahl, 1940) that the trace element endowment of sphalerite can, to a large extent, be correlated with genetic type. Thus, sphalerite from SEDEX-style massive sulphide deposits can be expected to show a different signature from sphalerite in proximal skarns, epithermal vein deposits or Mississippi-Valley-type (MVT) ores (Cook et al., 2009 and references therein).

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doi:10.1016/j.oregeorev.2011.03.001

The purpose of the present contribution is two-fold. Firstly, we expand the dataset for sphalerite described by Cook et al. (2009), using near-identical methodology in the same laboratory to gain a greater understanding of the range of trace elements in natural sphalerite. Secondly, we test the usefulness of sphalerite mineral chemistry to discriminate genetic type. To achieve this, we have analysed sphalerite from nine Zn–Pb and polymetallic ores from South China. Each of the selected deposits has been assigned to a specific genetic type based on overall macroscale features, prevailing ore textures and our evaluation of evidence presented in the literature. There exists, however, substantial debate about the origin of most, if not all, of the deposits we have selected, with a wide variety of alternative explanations presented in both the Chinese and international literature. These controversies are amplified by the geological complexity of South China.

## 2. Regional geology and geodynamic evolution

South China hosts many thousands of base metal deposits and smaller occurrences; some of these are world class giants, e.g., Jinding. They vary in deposit style from skarn and Mississippi-Valley-type (MVT) to stratabound and/or stratiform massive sulphides, the latter including volcanic-hosted (VMS), sedimentary exhalative (SEDEX) and sediment-hosted ores. The deposits under consideration are

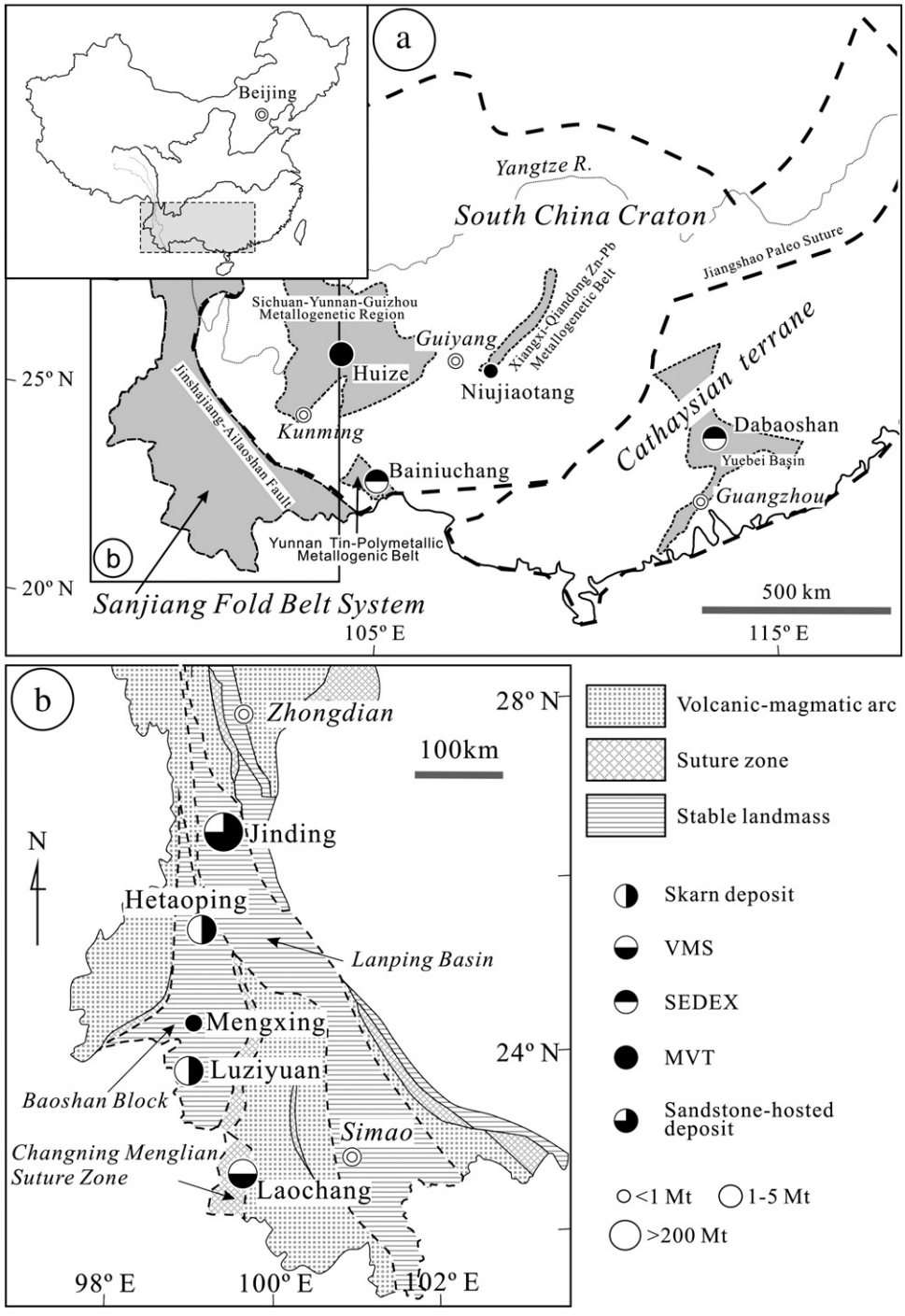


**Fig. 1.** (a) Geological sketch map of South China showing the location and tectonic setting of the deposits studied. The inset (b) is an enlargement of the Sanjiang Fold Belt. Maps are redrawn after Wang (1993), Zhou et al. (1998), C.Q. Zhang et al., 2005b; Hou et al. (2007) and Pan et al. (2009).