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Fe–Ti–Cr oxides from the Permian Xinjie mafic–ultramafic layered intrusion in the Emeishan large igneous province, SW China: Crystallization from Fe- and Ti-rich basaltic magmas

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Abstract

The ~260 Ma Xinjie mafic–ultramafic intrusion in the Emeishan large igneous province, SW China, is a sill-like body hosting Fe–Ti–Cr oxide mineralization. The intrusion comprises, from the base upward, a marginal zone and three cyclic zones. Fe–Ti oxides (magnetite and ilmenite) are disseminated throughout the intrusion and the oxide mineralization includes several Fe–Ti oxide-rich layers. The oxides in the lower parts of cyclic zones I and II are associated with variable amounts of ferrichromite with abundant ilmenite lamellae, indicating crystallization from Fe- and Ti-rich silicate magma. The Fe–Ti oxides contain relatively high Cr_2O_3 contents, which decrease upward in the sequence, consistent with formation by crystallization from silicate magma in a closed system. In the lower parts of Zones I and II, chromite grains are enclosed in olivine, whereas magnetite and ilmenite grains are enclosed in either clinopyroxene or plagioclase. Magnetite and ilmenite are also interstitial to olivine. The textural relationships of the minerals suggest that the Fe–Ti oxides may have crystallized slightly later than chromite and olivine but slightly earlier than clinopyroxene and plagioclase. Therefore, two parallel crystallization series may have developed at the same time: chromite → Fe–Ti solid solution and olivine → clinopyroxene → plagioclase. In this way Fe–Ti oxide grains can be both interstitial to early formed olivine and enclosed in later-formed clinopyroxene and plagioclase. This explains the unusual association of chromite with Fe–Ti oxides in the lower part of the sequence.

Keywords: Fe–Ti oxides; Chromite; Mineral chemistry; Petrogenesis; Xinjie intrusion; SW China

1. Introduction

In large layered mafic–ultramafic intrusions, such as those in the Bushveld Complex in South Africa (Kruger, 2005 and references therein), sulphide and chromite horizons are commonly confined to ultramafic layers at the base of the layered sequence, whereas later-formed Fe–Ti–V oxides occur in the upper parts of the sequence. Some layered gabbroic intrusions, such as the Stella intrusion in South Africa (Maier et al., 2003) and the Panzhihua intrusion in SW China (Zhou et al., 2005), contain only magnetite deposits. In the Panzhihua intrusion, massive ores with more than 80% magnetite occur as concordant and discordant bodies over 100 m thick in the lower part of the body. Mechanisms that concentrate large amounts of ore

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components are enigmatic, and the origin of such oxide deposits in layered mafic–ultramafic intrusions is still a matter of debate. Irvine (1977) and Kinnaird et al. (2002) suggested that either mixing of relatively primitive and evolved magmas or crustal contamination in dynamic layered intrusions may have triggered the accumulation of oxides. Reynolds (1985a) proposed that the concentration of Fe, Ti and V in late-stage residual melts was

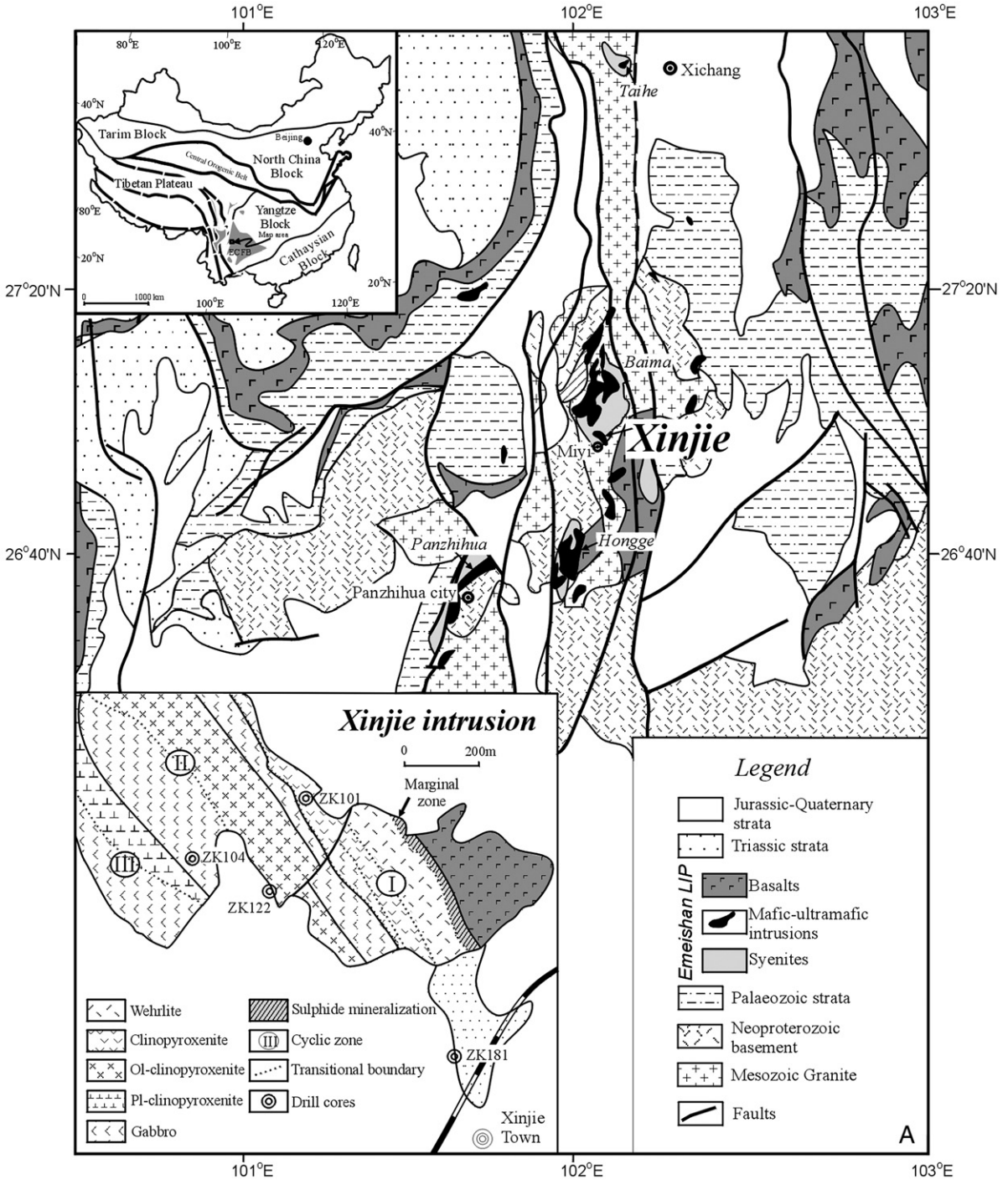

Fig. 1. (A) Regional geological map showing a simplified sequence of the Xinjie intrusion and sample locations (after Zhou et al., 2002; Zhong et al., 2004) and (B) a stratigraphic column showing the rock types, mineralization and sample locations (modified after PXGT, 1981).