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四川红格层状侵入体中角闪石和金云母的矿物学特征及其成因意义

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摘要：

红格层状岩体是峨眉山大火成岩省内带最大的赋存钒钛磁铁矿矿床的层状岩体，从底部到顶部可分为下部岩相带、中部岩相带和上部岩相带。红格岩体下部岩相带角闪（磁铁）辉石岩和角闪（磁铁）橄辉岩中角闪石含量高达5%~15%，远远高于区内其他含超大型钒钛磁铁矿矿床的层状岩体。岩体中角闪石呈嵌晶状结构，且具有均一干涉色，暗示其为岩浆成因，而非热液蚀变的产物。此外，角闪石的矿物化学特征表现为高Al_2O_3含量（10.5%~12.0%）、高Al/Si（0.30~0.37）和 Mg/（$Fe^{3+}+Fe^{2+}+^{VI}Al$）比值（1.69~2.63）以及低Si/（Si+Ti+Al）比值（0.69~0.74），进一步表明其是直接从幔源基性岩浆中结晶形成的。金云母高MgO含量（18.7%~22.9%）的特征也说明其与幔源岩浆作用有关。角闪石和金云母的成因与红格层状侵入体的地质背景相吻合，为探讨红格岩体形成过程中的物理化学条件提供了重要的矿物学依据。根据矿物电子探针成分及其化学式计算得到岩体角闪石的结晶温度为1000~1100℃，结晶压力小于2.2kbar，结晶时的氧逸度范围在NNO-0.55到NNO+0.73之间。矿物结构关系指示岩体的磁铁矿结晶早于角闪石，因此，结合MELTs模拟计算，认为红格岩体钒钛磁铁矿矿层的形成温度为1100~1165℃，氧逸度高于NNO+0.73。红格岩体下部岩相带和中部岩相带每个旋回自下而上，角闪石的Fe^{3+}/（Fe^{3+}/Fe^{2+}）比值以及全岩Fe^{3+}/Fe^{2+}和Mt/（Mt+Ilm）比值有规律地逐渐降低，而磁铁矿V_2O_3含量逐渐升高，这些特征说明Fe-Ti氧化物的分离结晶导致氧逸度逐渐降低。而上部岩相带IX旋回全岩Fe^{3+}/Fe^{2+}和Mt/（Mt+Ilm）比值自底部到顶部随着磁铁矿V_2O_3含量的降低而升高，显示出与下部岩相带和中部岩相带相反的变化趋势，表明IX旋回在分离结晶过程中氧逸度是逐渐升高的，可能是受上部岩相带富P_2O_5母岩浆的制约。

英文摘要：

The Hongge layered intrusion hosting the largest V-Ti-magnetite deposit in the central part of the Emeishan Large Igneous Province (ELIP) can be divided into the Lower Zone, Middle Zone and Upper Zone from the bottom to the top. The contents of hornblende in the hornblende (magnetite) clinopyroxenite and hornblende (magnetite) olivine clinopyroxenite of the Lower Zone reach up to 5%~15%, which are much higher than those of other layered intrusions hosting giant Fe-Ti oxide deposits in the Central ELIP. Poikilitic texture and homogeneous interference color of the hornblende indicate that it is primary magmatic origin, rather than the product of hydrothermal alteration. Moreover, the hornblende is high in Al_2O_3 contents (10.5%~12.0%), Al/Si (0.30~0.37) and Mg/($Fe^{3+}+Fe^{2+}+^{VI}Al$) (1.69~2.63) ratios, and low in Si/(Si+Ti+Al) ratios (0.69~0.74), suggesting that it crystallized from a mantle-derived mafic magma. The phlogopite is high in MgO contents (18.7%~22.9%), demonstrating that it is also associated with mantle-derived magma. The genesis of the hornblende and phlogopite is consistent with the geological background of the Hongge layered intrusion, and it is thus possible to be used to estimate the thermodynamic conditions of solidification of the Hongge intrusion. The calculations using electron microprobe data indicate that the hornblende crystallized at the temperature of 1000~1100℃, the pressure of lower than 2.2kbar and the oxygen fugacity of NNO-0.55 to NNO+0.73. Magnetite crystallized earlier than hornblende in the Hongge intrusion according to lithologic textures, thus, combined with the MELTs calculation, we estimated that the Fe-Ti oxide ore layers of the Hongge intrusion crystallized at the temperature of

1100~1165℃ and the oxygen fugacity of higher than NNO+0.73. The ratios of $Fe^{3+}/(Fe^{3+}/Fe^{2+})$ of the hornblende as well as Fe^{3+}/Fe^{2+} and Mt/(Mt+Ilm) of the whole rock decrease upwards in each cycle unit of the Lower and Middle zones of the Hongge intrusion, whereas, V_2O_3 contents in the magnetite increase upwards, indicating that oxygen fugacity decreases upwards during fractional crystallization of magnetite. However, the whole-rock Fe^{3+}/Fe^{2+} and Mt/(Mt+Ilm) ratios increase as the magnetite V_2O_3 contents decrease upwards in the cycle unit IX of the Upper Zone, which are opposite to those in the Lower and Middle zones, indicating that oxygen fugacity increased upwards in the cycle unit IX of the Upper Zone which is probably due to the P_2O_5 enriched parental magma of the Upper Zone.

关键词：角闪石 金云母 温度 压力 氧逸度 红格层状侵入体

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