辽宁古元古代地体中富电气石岩石的成因：蒸发岩硼源的证据

许 虹[1] 彭齐鸣[2] Martin R. Palmer[3]
（1.中国地质大学，北京 100083； 2.中国地质调查局， 北京 100011；
3. School of Ocean && Earth Science, University of Southampton, UK ）

提要:辽宁东部古元古界底部地层（南辽河群）中赋存着大型的硼酸盐矿床，含矿层位中广泛分布含电气石的变粒岩和电英岩。空间上这些含电气石的岩石与硼酸盐有着密切的联系，电气石可以作为区域硼矿找矿的标志。已有研究结果表明，该地区的硼酸盐矿床是变质蒸发岩成因。本研究对该区不同产状的电气石和硼酸盐的地质特征，全岩和矿物成分、硼同位素组成进行了分析。本区的电气石包括层状和脉状两大类，而电气石的富集与硼酸盐关系密切，电英岩往往分布在硼酸盐矿体的上盘。而矿体的下盘一般不产出富电气石的岩石。当长英质脉体穿过硼酸盐矿体时，脉体中往往会富集电气石。含电气石岩石的全岩地球化学分析表明，它们的REE及其他微量元素特征以及相关性关系与周围不含电气石的同类岩石十分相似，反映出一种成因上的联系。本区电气石主要属于镁电气石—铁电气石系列，靠近硼矿体的电气石比远离硼矿体的电气石更加富镁，有着更高的Mg/Fe比值。电气石和硼酸盐的硼同位素成分分析显示出二者在同位素组成上的相似性，前者比后者的δ11B稍低，这可能是由于热液活动过程中同位素分馏的结果。电气石的硼同位素组成在空间上显示出变化规律：远离硼酸盐矿体的电气石的δ11B值(-5．2 ‰ +3．6 ‰)比矿体附近的电气石低(平均 +10．5 ‰) 以上空间和成分上的关系表明硼酸盐可能是形成电气石主要的硼来源，电气石是在热液过程中通过淋滤下伏含硼蒸发岩中的硼形成含硼热液，在与上覆沉积物交代过程中形成含电气石岩石。电气石的条带是热液顺层选择交代的结果。本区电气石与硼酸盐的关系表明，层状电气石可以通过含硼热液交代的方式形成。变质地体中的层状电气石岩石的出现可能与变质蒸发岩有关。这一认识对区域硼矿勘查工作和变质地体的沉积环境分析有借鉴意义。

关 键 词：电气石；硼酸盐；古元古代；蒸发岩；辽宁
中图分类号：P578.953；P578.93 文献标识码：A 文章编号： 1000-3657（2004）03-0240-014

Origin of tourmaline-rich rocks in a Paleoproterozoic terrene(N.E.China): Evidence for evaporite-derived boron

XU Hong[1], PENG Qi-ming[2], Martin R. Palmer[3]
(1. China University of Geosciences, Beijing 100083，China;
2. China Geological Survey, Beijing 100011，China;
3. School of Ocean & Earth Science, University of Southampton, UK)

Abstract: We have analysed the major element, trace element and boron isotope composition of borates, tourmaline-rich rocks and their non-tourmalinised equivalents from the lower portion of the Paleoproterozoic South Liaohe Group (N.E. China). These rocks host economically important borate deposits that formed in an evaporitic environment. The sequence contains abundant tourmaline in leptynites, stratiform tourmalinites, quartz-tourmaline veins and pegmatites that have spatial and temporal relationships to the borates.Tourmalines distal to the borates have lower δ11B values (-5.2 ‰ to +3.6 ‰) than those proximal to the borates (+1.8 ‰ to +9.4 ‰)that are slightly lower than those of the borates (av. +10.5 ‰). Mg/Fe ratios of the distal tourmalines are low (<1.0) relative to proximal tourmaline-rich rocks (>1 to 2.6). These differences reflect the fact that the evaporites are a major source of B and Mg. The geochemistry of immobile elements in the stratiform tourmalinites is similar to that of their unmineralised equivalents (interpreted as meta-tuffites), suggesting that the tourmalinites formed via alteration of Al-rich tuff layers by boron-rich fluids derived from leaching of the underlying borates. Field evidence and geochemical data support a three-stage model of tourmaline formation. The first stage was coeval with deposition of the borates, during which boron from hot springs was adsorbed by clay minerals in the tuffs that were later metamorphosed to tourmaline-bearing leptynites. In the second stage, hot fluids leached boron from the evaporites and passed through overlying tuffs to form the stratiform tourmalinites. During later emplacement of granites at the base of the sequence, felsic veins and pegmatites intruded the borates and tourmalinites. Boron from the borates diffused into the felsic veins, forming coarse-grained tourmaline at their margins. This association of tourmaline with the borate deposits emphasizes the significance of tourmaline-rich rocks as a prospecting guide for borates in this area and has implications for the origin of tourmalinites in other metamorphic terrenes.
Key words: tourmaline；borates；Paleoproterozoic；evaporite；Liaoning