The Ningxiang Lamproites, Hunan Province, China: Petrology and Mineral Chemistry

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General

The Ningxiang lamproite intrusives were discovered by Brigade 413 of the Hunan Bureau of Geology and Mining in the mid-1980's. They are located approximately 35km west of Changsha, the capital of Hunan, some 10km south of the village of Ningxiang (Figure 1). There are at least 27 bodies, and apart from 6 pipes, they are mostly small dykes and veins. The pipes are all larger than one hectare, the largest being 4 to 5 hectares. The bodies intrude Upper Proterozoic Banxi and Sinian age rocks, and steeply dipping middle to upper Devonian siltstones. Tertiary Red Beds are well preserved and clearly overlie the lamproites in some cases. They are thus post-Devonian and pre-Tertiary, consistent with isotopic ages of 345 Ma (Sm-Nd) and 328 Ma (Rb-Sr) (Liu Guanliang, Pers. comm., 1996). Trace amounts of diamonds have been reported from the bodies. The lamproites occur on the boundary between the Yangtze Paraplatform and the South China Fold Belt at the intersection of three crustal/lithospheric fractures, just south of a graben feature. The Ningxiang bodies are perhaps associated with a broad zone that extends to the lamproites in Guizhou Province.

Petrography

The rocks are extensively altered, and mostly comprise crater facies volcaniclastic lapilli tuffs and pyroclastics, at times containing abundant lithic fragments. The overall petrography of the juvenile lapilli in the pyroclastics and of rare samples from magmatic facies lamproite indicates that the intrusives are probably olivine leucite lamproites. Alteration products are carbonate, silica, chlorite and clay minerals. Two generations of olivine are present; as altered macrocrysts, having resorbed grain boundaries, and as phenocrysts displaying complex shapes including re-entrant features and some growth aggregates. Tabular grains seen in some of the intrusions may be altered feldspar (sanidine?). Phlogopite, usually occurring as small stubby interstial laths and plates in the groundmass, appears less abundant than is commonly found in most lamproites. Small grains of possible leucite are common, and diopside can be identified in some of the fresher samples. Apatite and opaque minerals are fairly abundant.

The whole rock geochemistry of 22 samples (SiO_2 43-46 %, MgO 16-21%, K_2O 2-3.8%, TiO_2 2-2.5% Na_2O < 1%) would place the rocks between olivine lamproite and madupitic lamproite (Mitchell and Bergman, 1991).

Mineral Chemistry

Spinel dominates the heavy mineral concentrates from the rocks. Pyrope garnets and chromian diopsides are less common but their quantities and proportions vary substantially between the bodies. The chromian diopsides, with very few exceptions, have less than 2 wt% Cr_2O_3, but are nevertheless consistent with mantle compositions. Picroilmenite is present, but rare. A single grain of jeppeite was found in one heavy mineral concentrate sample.

The spinels have upper mantle compositions and display a negative $MgO-Cr_2O_3$ relationship (MgO 12-17 wt%, Cr_2O_3 35-60 wt%). TiO_2 content of most spinels is less than 1 wt%, but varies up to 5 wt%, particularly in textured rims (Figure 2). This is a characteristic typical of lamproites. Some of the Ningxiang spinel populations show a sub-parallel association of core-rim tie-lines on the Cr_2O_3-TiO_2 plot, with the most well developed rim textures occurring on the low-Cr_2O_3 spinels (Figure 2). This observation is consistent with relatively low-Cr_2O_3 xenocrystic spinels being replaced and/or over-grown with higher TiO_2 spinels crystallising as phenocrysts in a progressively evolving lamproitic magma.

The garnets are lherzolitic (Dawson and Stephens, (1975), group 9) and can be divided into two distinct populations having Cr_2O_3 contents of 7-11 wt% and 2-6.5 wt% respectively (Figure 3). Very few grains have more than 0.3 wt% TiO_2. Sub-calcic garnets are absent. Eighty three garnets were analysed for trace elements using the Laser ICP/MS at Macquarie University, Sydney (Griffin, 1996). The garnets from the high Cr_2O_3 group in particular have depleted Zr and Y signatures. Many of the low-Cr_2O_3 garnets are low temperature (less than 1050 °C) and enriched in Y suggestive of a high geotherm (Griffin and Ryan, 1995). The condrite normalised REE contents are mostly relatively depleted with flat profiles (HREE depleted and LREE enriched). Some of the high Cr_2O_3 wehrlitic garnets have sinuous REE patterns similar to those characterising diamond inclusion and some harzburgitic garnets (see Shimizu and Richardson, 1987; Hoal et al. 1994; Sobolev and Shimizu, 1993). Using the scheme outlined by Ryan et al. (1996), a garnet Ni/Cr geotherm of about $44mW/m^2$ is inferred (Figure 4). Garnet Ni/Cr data for the Penjiabang-01 (Dahongshan) lamproite in Hubei Province, about 300 kms. north of Ningxiang, but still within the Yangtze craton, also suggests a hot geotherm of about 45 mW/m^2 for this tectonic environment. Projecting the Ningxiang data onto the diamond/graphite curve suggests that few, if any, of the garnets derive from within the diamond stability field. However, based on Y/Ga and Zr/Y relationships the garnets overlap the 'Proton' and 'Archon' fields of Griffin and Ryan (1995). While these lamproites are unlikely to be significantly diamondiferous, the existence of other economic bodies in the area cannot be discounted.

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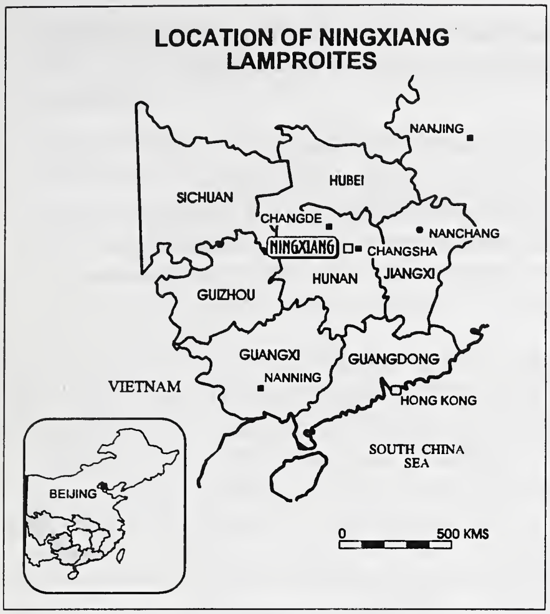

Figure 1. Location of the Ningxiang lamproites, Hunan Province, China

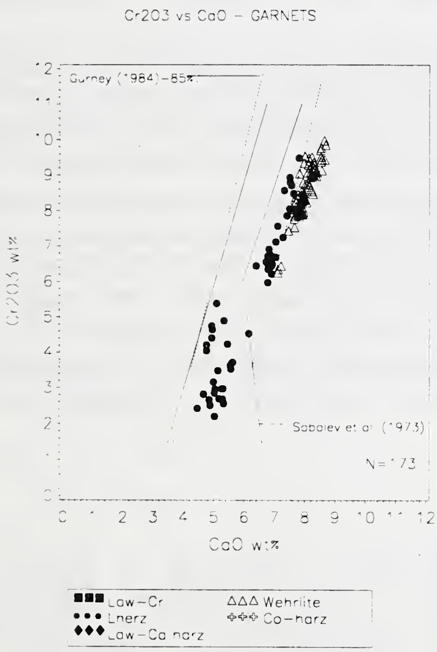

Figure 3. Ningxiang lamproites. Broken lines: boundaries from Gurney, 1984, (see also Griffin and Ryan, 1995).

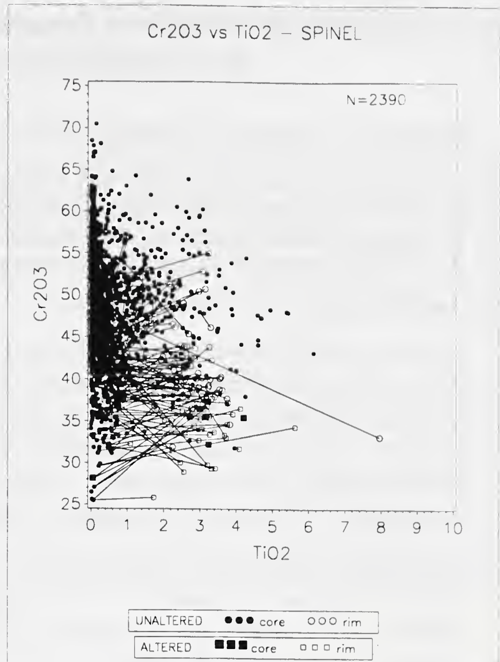

Figure 2. Ningxiang lamproites. Solid lines show core-rim pairs.

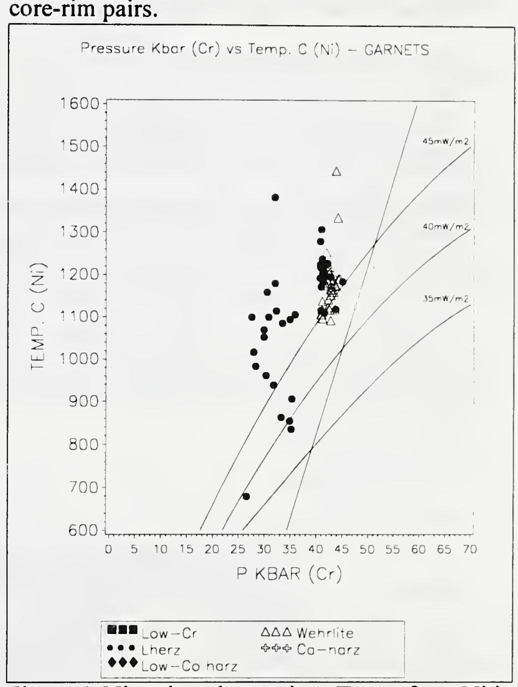

Figure 4. Ningxiang lamproites. Temp. from Ni in garnet, and pressures (minimum) from Cr in garnet (Griffin and Ryan, 1995, Ryan et al., 1996). Based on the relatively abundant high Cr_2O_3 garnet group (Fig. 3) a geothermal gradient of about 44 mW/m^2 is suggested.