MANTLE XENOLITHS FROM ALKALI BASALTS IN THE NOGRAD–GOMOR REGION OF HUNGARY AND CZECHOSLOVAKIA.

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INTRODUCTION: Neogene to Quaternary alkali basalts are widely distributed within the Carpathian–Pannonian region of eastern Europe. These basalts contain abundant ultramafic and mafic nodules, as well as a large variety of mafic and salic megacrysts. The present study focuses on the great variety of ultramafic xenoliths from the Nograd–Gomor Region (NGR). We have collected more than 100 ultramafic xenoliths from 4 of the most important localities in the NGR (Fig. 1), and 43 samples were selected for detailed study. These have been studied in thin section, and numerous electron microprobe analyses have been performed on the various phases. These petrographic and chemical data form the basis for characterization of these xenoliths and provide insight into their petrogenetic evolution and metasomatic histories. Trace element and isotopic studies are in progress.

GEOLOGIC SETTING: In the NGR, numerous volcanic vents have produced extensive flows and dikes and thereby formed a wide plateau. Volcanic activity started at 2.8 Ma and continued to 1.0 Ma (Balogh et al., 1986). The early stage of development of the Pannonian Basin involved upwelling of a mantle diapir (Stegena et al, 1975; Adam, 1976). This is thought to have initiated the thermal regime from which the volcanic rocks were later derived.

Host Rocks – The NGR basalts range in texture from aphanitic to porphyritic. Mainly olivine, but also clinopyroxene, and plagioclase, occur as phenocrysts within a groundmass of clinopyroxene, plagioclase, apatite, oxide phases, $\pm$ glass, $\pm$ nepheline, $\pm$ trace amounts of K-feldspar and phlogopite. The basalts possess low silica contents (46.6–49.7%), high alumina (16.3–18.6%), high total alkalis (5.9–7.2%), and low Mg# (53.3–65.7). When compared to typical xenolith-bearing alkali basalts from other world-wide locales, they are notably lower in Mg# basalts (67–74). This factor, in addition to their high differentiation indices (39–51) and high normative nepheline contents (up to 10.7%), may indicate that the original magma was modified by fractional crystallization and assimilation at depth.

Xenoliths – The xenoliths from NGR can be divided into three texturally and genetically distinct groups: 1) Cr-Diopside Suite (cf, Wilshire and Shervais 1975); 2) Clinopyroxenite and Gabboic Series, which may be representative of cumulates of the Al-augite suite of Wilshire and Shervais (1975); and 3) accidental upper crustal xenoliths.

Figure 1
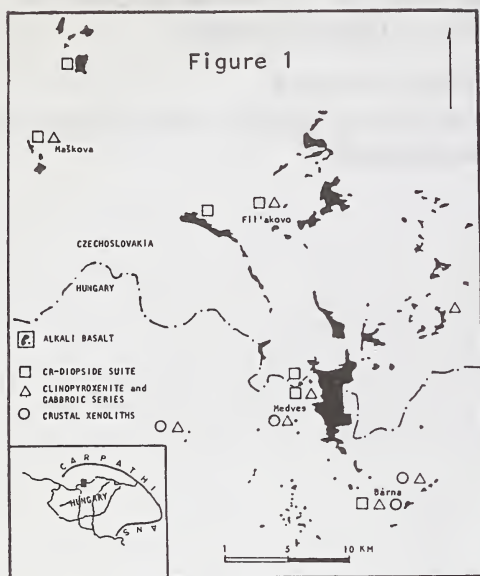
XENOLITH PETROGRAPHY AND CHEMISTRY:
The xenoliths which are the object of this present study are from the **Cr-Diopside Suite**. These xenoliths have been grouped on the basis of mineralogy and texture into three types:

1) **Spinel Lherzolites and Harzburgites** - These are modally dominated by olivine with small amounts of amphibole locally present. Most of the lherzolites, which now appear to be "dry", possess sites where a hydrous phase was present but is now occupied by a secondary assemblage consisting of clinopyroxene, spinel, feldspar, phlogopite, amphibole, olivine, and glass. The over‑all texture of this type of xenolith is classified (after Mercier & Nicolas, 1975) as porphyroclastic and equigranular, with some transitional.

2) **Dunite and Wehrlite** - Olivine makes up 85 to 90 modal % of these xenoliths. Phlogopite with distinct

Fig. 2
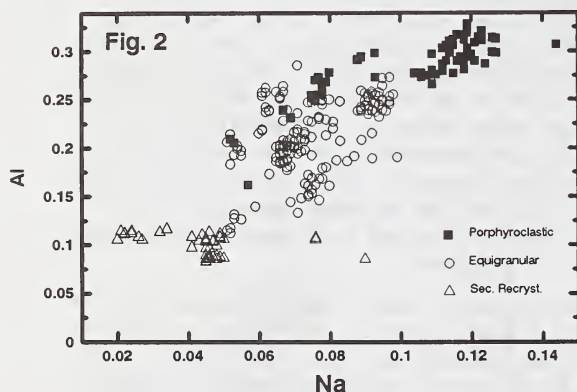
lineation is characteristic. The textures show signatures of secondary recrystallization. Based upon the lineation of the mica within these xenoliths, it would appear that the phlogopite predates the deformation event.

3) **Olivine Hornblendite** - The original olivine is largely replaced by amphibole which now constitutes more than 70% of the xenolith. Triple junctions, slight deformation, and twinning of the remaining olivine suggest an equigranular texture for the pre-alteration xenolith.

Cr-diopside-rich veinlets (2-7 mm) within the lherzolites and wehrlite have undergone the same overall deformation as the host xenoliths. It is obvious that the emplacement of this veinlet preceded the deformational event.
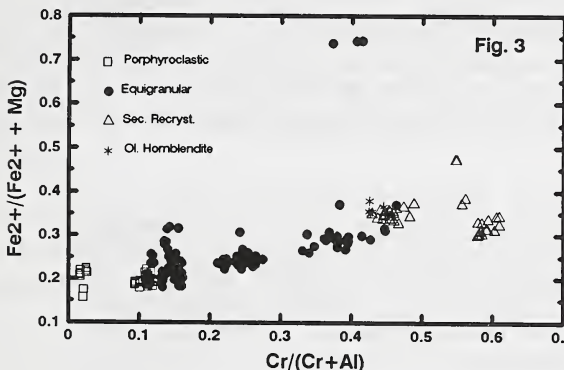
Mineral Chemistry - We have attempted to correlate mineral compositions with texture since it appears that the textures are representative of particular petrogenetic conditions. The ranges of mineral compositions of the spinel lherzolites and harzburgites are similar to many other occurrences (e.g., Basaltic Volcanism Vol., 1981; Nixon, 1987). Olivine and orthopyroxene have Mg# in the range of 0.87-0.91 and 0.88-0.91, respectively. The compositions of these phases are independent of textural type except for a small increase in Al_2O_3 in the orthopyroxene from porphyroclastic xenoliths. Clinopyroxene and spinel compositions vary with texture. In porphyroclastic and transitional xenoliths, clinopyroxenes are enriched in Al and Na compared to equigranular xenoliths (Fig. 2). The variation in Mg# of the clinopyroxene is directly correlated with those of olivine and orthopyroxene. The spinels in porphyroclastic xenoliths are high in Al_2O_3 and have low Fe# values [Fe^{2+}/ (Fe^{2+}+Mg)] (Fig. 3).

Recrystallized xenoliths have distinctive compositions of clinopyroxene and spinel. Compared to compositions in other textures and as shown in Fig. 2, clinopyroxenes are low in Al_2O_3, Na_2O, and FeO and high in SiO_2 and Mg# (0.91-0.93). As shown in Fig. 3, spinels have the highest Cr# [Cr/(Cr+Al)], Fe#. These compositions seem to indicate the possibility of a depletion process having acted upon these mantle samples. The olivine of the highly metasomatized olivine hornblendite is characterized by enriched compositions of Fe and Mn; the orthopyroxene is enriched in Fe, Mn, and Ca. The spinel is depleted in Mg and Al (Fig. 3), which may be related to the formation of hornblende. The amphibole which occurs in all these xenoliths is Ti- and Cr-rich pargasitic, with higher Al_2O_3 than similar xenoliths from other world-wide localities. It is typically associated with remobilized spinel. Indeed, the interstitial setting of amphibole as a replacement phase and unstrained habit indicate formation after the deformation of the xenoliths.

In the recrystallized xenoliths, phlogopites occur with high contents of TiO_2 (1.2-2.6 %), Cr_2O_3 (1.3-2.3 %), and Na_2O (0.7-1.1 %). This chemistry is typical for secondary phlogopites of the upper mantle (Delaney et al., 1980). The high Mg# (0.91) is in accordance with those of the other silicates, implying equilibration within the xenoliths. However, extremely high fluorine contents, up to 3.5 %, are uncommon in phlogopites in ultramafic xenoliths from the alkali basaltic series.

Fig. 3

Legend: □ Porphyroclastic; ● Equigranular; △ Sec. Recryst.; * Ol. Hornblendite

Axes: Fe2+/(Fe2+ + Mg) vs Cr/(Cr+Al)

DISCUSSION: The textures of the xenoliths and mineral chemistry can be integrated into an overall scenario of mantle events within the NGR portion of the Carpathian-Pannonian area of eastern Europe. These stages are depicted schematically in Figure 4 and are discussed below in chronologic order: 1) 1st Metasomatism; 2) Diapirism and Deformation; 3) 2nd Metasomatism; and 4) Entrainment and Volcanic Activity.

Stage 1. 1st Metasomatism Within the xenoliths, it would appear that there was an ancient metasomatism which resulted in the local formation of phlogopite. The upward migrating, metasomatizing fluids was rich in water, but also contained appreciable fluorine and potassium, as evidenced by the high Fluorine contents of the phlogopite. Although no garnet was found in these xenoliths, we cannot exclude that garnet was not completely replaced by this hydrous alteration. The phlogopite is distinctly lineated, indicating its formation before the deformation event.

Figure 4   TIME →   M.y.

24   12   3-1

Legend: Formation of Phlogopite; Formation of Amphibole; Volatile Movement; Diapir

DEPTH (km): 30, 60, 90, 120

1ST METASOMATISM   DIAPIRISM and DEFORMATION   2ND METASOMATISM   ENTRAINMENT and VOLCANIC ACTIVITY

Stage 2. Diapirism & Deformation All of the xenoliths display evidence for strong deformational event. The most intense deformation, as revealed from the xenolith textures, was in the Southeast region of the NGR. The textures are mostly porphyroclastic to the Northeast & progress to equigranular, to transitional and to secondary recrystallized as the region of most intense deformation is approached. We postulate that this deformation was associated with deep-seated diapiric movement, which began after the
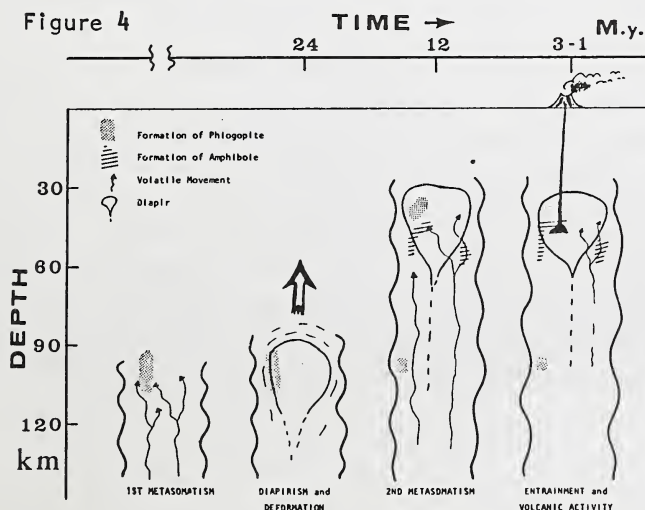
termination of subduction in the Carpathian belt at about
24 M.a. (Stegena et al., 1975). This diapiric upwelling continued until
about 12 M.a. when it reached its highest position at about 30 km depth.
This is based upon heat-flow calculations and estima⌢tion of the amount of
crustal thinning (Dovenyi & Horvath, 1988).

Stage 3. 2nd Metasomatism Possibly associated with or as a direct
consequence of the asthenospheric upwelling, another period of metasomatism
affected the xenoliths. This is evidenced by the pervasive presence of
undeformed amphibole superimposed upon the deformed texture of the mantle
xenoliths. The presence of this pargasitic hornblende limits the depth of
this metasomatism to less than about 70 km.

Stage 4. Entrainment and Volcanic Activity Alkaline basaltic volcanism
occurred within the last few million years. This entrained the mantle
xenoliths and brought them to the surface. Geothermobarometric estimates of
the xenoliths show last equilibration at 950–110 $^{\circ}$C and 8–18 kbars. These
conditions correspond to the depth of entrainment at 27–60 km. Interaction
with the basaltic melt resulted in breakdown of some of the amphibole, as
well as small amounts of spinel and clinopyroxene. A new selvage of phases
is present in place of these decomposed minerals and consists of secondary
clinopyroxene, spinel, feldspar, phlogopite, amphibole, olivine, and glass.
The presence of enriched contents of K and Ti in some of the product
crystals indicate that their formation was the result of metasomatic fluid
from the basaltic melt.

REFERENCES: Adam (1982) Geosci. Mining Bull. Hungarian Acad. Sci. 15,
221-236; **Balogh et al.** (1986) Acta Miner.-Petro. Szeged 28, 75-93; **Basaltic
Volcanism Study Project** (1981) p. 282-310. Pergamon; **Delaney et al.** (1986)
Geochim. Cosmochim. Acta 44, 857-872; **Dovenyi & Horvath** (1988) AAGP Mem. 45.
195-235; **Mercier & Nicolas** (1975) Jour. Petrol. 16, 454-487; **Nixon** (1987)
Wiley & Sons, 844 p; **Stegena et al.** (1975) Tectonophysics 26, 71-90;
Wilshire & Shervais (1975) Phys. Chem. Earth 9, 257-272.