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DISTRIBUTION OF FENITIZED CRUSTAL XENOLITHS IN CARBONATITE INTRUSIONS, WEST-CENTRAL ARKANSAS

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ABSTRACT

Crustal xenoliths from carbonatite intrusions in the Morrilton-Perryville Arkansas area display a variety of mineralogical and textural features that suggest that they are fragments of basement crystalline rock that has undergone sodic metasomatism resulting from their close proximity at depth to a carbonatite complex. With increasing degrees of fenitization, the leucocratic xenoliths range from granolite - syenite - analcite syenite, while the melanocratic xenoliths range from hornblende - biotite to aegerine-apatite.

A definite increase in fenitization is observed from Morrilton in the north to Brazil Branch, 16.8 km to the south. Fenitized xenoliths from Brazil Branch are generally quite small (0.5 cm - 1.0 cm) and contain a substantial amount of analcite. At Morrilton Lock and Dam, the fenitized xenoliths are very large (1.0 cm - 2.5 cm), and granolites are common. The xenoliths at Oppello Dump are intermediate in both size and mineralogical character. This area is therefore interpreted as a single alkalic - carbonatitic complex at depth, with its center near the southern extremity of the sampled area.

INTRODUCTION

Three carbonatite intrusions from the Morrilton, Oppello, and Perryville areas of west-central Arkansas have been studied to determine distribution of incorporated metamorphic xenoliths (Fig. 1). Previously, Mitchell (1979) studied the xenoliths petrographically and found a suite of rocks ranging progressively from granolites (Winkler, 1976) to analcite urtite-ijolite fenite that have been metasomatically altered. Mineralogical evidence indicates metasomatism at high temperatures and lower crustal pressures. Mitchell (1979) concluded that the metasomatically altered xenoliths result from deep seated fenitization of crustal material by emanations from a carbonatite magma. He also suggested that each intrusion was related to a separate carbonatitic complex at depth. The present study was undertaken to determine the distribution of fenitization in a north-south direction from three of the intrusions. This study proposes that the degree of fenitization of the crustal material increases to the south suggesting a single source of fenitizing emanations.

METHODS OF INVESTIGATION

Samples were collected by Mitchell (1979) at the various carbonatite localities in the study area, but only the xenoliths from the Morrilton sill (Lock and Dam No. 9), Oppello Dump, and Brazil Branch were studied because corresponding thin sections were only available from those localities.

Twenty-eight slabs were cut from samples at Morrilton Lock and Dam, 53 were cut from Oppello Dump, and 96 were cut from Brazil Branch. Fifty thin sections were available from the three localities. Single thin sections were compared petrographically with the appearance of the same xenolith megascopically on the slab to establish criteria for distinguishing the eight lithologies of wall rock alteration.

RECOGNITION OF FENITIZATION STAGES

Granolites exhibit a clear, unturbid appearance, and quartz is easily distinguished. Feldspars are porcelainous white and subhedral

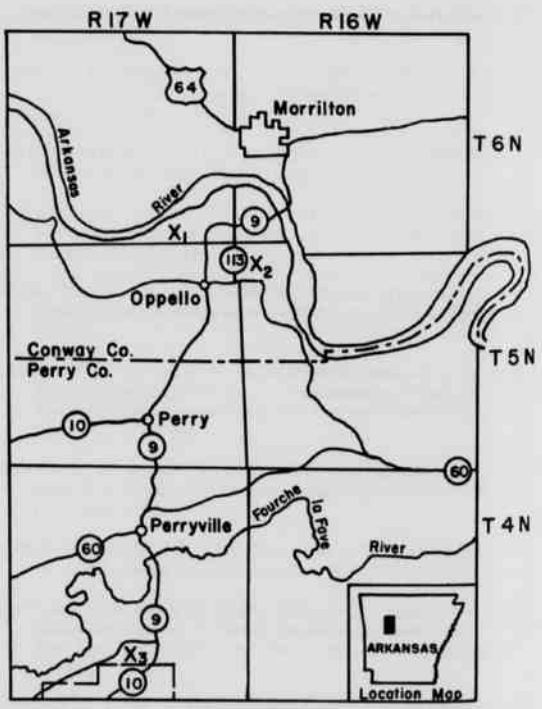

Figure 1. Location of various carbonatite intrusions within study area: X_1 Morrilton Dam Sill; X_2 Oppello Dump; X_3 Brazil Branch Breccia.

with albite twinning on the plagioclase. Mafics compose about 20% of the xenolith and consist of biotite and hornblende. Granolite xenoliths are on the order of 2.0 cm × 2.0 cm.

Quartz Syenite Fenite represents the first stage of alteration in the leucocratic xenoliths. Quartz is granulated due to shock metamorphism. Carbonates replace quartz. Aegerine appears as small green patches that are randomly scattered throughout the xenolith. Feldspars are relatively unturbid.

Syenite Fenite represents the second stage. Quartz has been completely removed. Feldspars become turbid and appear brown. There is a loss of twinning in plagioclase. Aegerine becomes more abundant due to the introduction of sodium.

Albite Syenite Fenite is the third stage in the alteration process. Feldspars are very turbid and indicate a transformation to albite. Aegerine and carbonates are abundant.

The final stage is represented by analcite urtite - ijolite fenite. Isotropic analcite is abundant as a white mineral that has no apparent crystal boundaries. Aegerine becomes dark-green upon the introduction of analcite. These xenoliths are on the order of 1.0 cm × 1.0 cm.

The initial stage at alteration in the melanocratic xenoliths is represented by hornblende - biotite xenoliths. The xenolith is black due to many subhedral crystals of hornblende and biotite. These xenoliths are about 1.0 cm × 1.0 cm.

The second stage of alteration in the melanocratic xenoliths is represented by hornblende - aegerine xenoliths. Aegerine is dominant in these xenoliths. No quartzofeldspathic minerals are present. These xenoliths are about 1.0 cm × 1.0 cm.

The final stage of alteration in the melanocratic xenoliths is represented by aegerine - apatite xenoliths. The xenolith appears dark-green because aegerine comprises about 95% of the material. No quartzofeldspathic minerals are observed. Apatite occurs as small, translucent grains due to the introduction of phosphorus. The xenoliths are about 0.5 cm × 1.0 cm.

REGIONAL RELATIONS

Morrilton Sill (Lock and Dam No. 9).

This sill is exposed on the south flank of the Arkansas River near Lock and Dam No. 9. It is a small sill about 46 cm thick and is intruded into the Atoka Formation of Pennsylvanian age. Abundant fresh metamorphic xenoliths are exposed in the sill, and 28 samples were available for study. The fenitized crustal xenoliths are quite large, significantly larger than those from the other sampled areas. The xenoliths from Morrilton display a wide variety of mineralogy, including abundant quartz, alkali feldspar, plagioclase, biotite, hornblende, aegerine, sodic amphibole, and carbonates.

As shown in the cumulative histogram of the Morrilton Lock and Dam No. 9 locality, the most common rock type is syenite fenite (Fig. 2). There is also an abundance of granolites, most of which are greater than 2.5 cm in diameter. An acid test proved that no analcite is present. The feldspars are all fresh and unalbitized. The xenoliths thus represent minimal metasomatic alteration. Melanocratic xenoliths are rare. Leucocratic xenoliths appear relatively unaltered. Quartz is present as small, equant droplets. Feldspars are fresh and appear porcelainous white. Therefore, the Morrilton sill is interpreted as an area of minor metasomatic alteration.

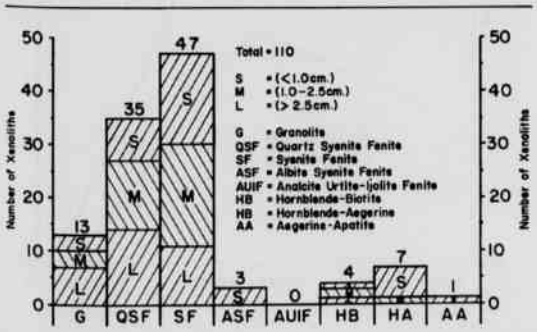

Figure 2. Cumulative histogram for leucocratic and melanocratic xenoliths from Morrilton.

Oppello Dump Sill.

This sill is exposed in a small stream that crosses Arkansas Highway 113, 1.85 km northeast of the community of Oppello. At this exposure, the sill is about 30.5 cm thick and heavily weathered. Actually, the outcrop is in a shale pit previously used as a dump site, hence the name Oppello Dump. The sill is intruded into the Stanley Shale of Mississippian age. Fifty-three samples were available for study. The fenitized crustal xenoliths average 1.5 cm × 2.0 cm. Also incorporated in the carbonatite from Oppello Dump are innumerable sedimentary xenoliths from the Stanley Shale. These sedimentary xenoliths are angular due to their shallow depth of origin. The metamorphic xenoliths exhibit a variety of mineralogies with abundant plagioclase (extensive development of albite), alkali feldspar, sodic amphibole, aegerine, and carbonates.

The cumulative histogram of the Oppello Dump sill shows that the most common rock type is syenite fenite (Fig. 3). However, there is also a great abundance of albite syenite fenite. It would appear that at this locality the xenoliths exhibit more intense metasomatic alteration than those of the Morrilton sill. No granolites were observed at Oppello Dump and also, some analcite is introduced into the more extensively altered xenoliths. The melanocratic xenoliths are quite small, and aegerine dominates the rock. Silicon and potassium have been removed, gradually replaced with calcium and sodium as indicated by the replacement of quartz with calcite and aegerine. Feldspars are turbid and albitized. The Oppello Dump sill is interpreted as an area of moderate metasomatic alteration.

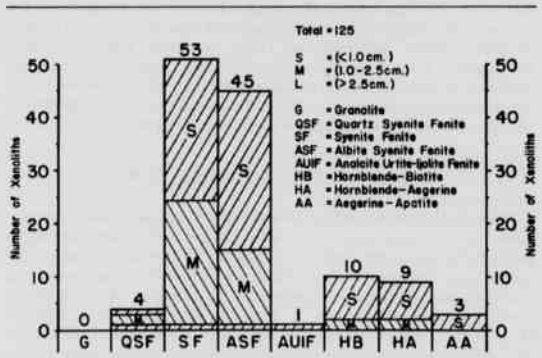

Figure 3. Cumulative histogram for leucocratic and melanocratic xenoliths from Oppello Dump.

Brazil Branch Breccia.

The breccia is exposed approximately 16.8 km south of the Morrilton sill. Mitchell (1979) interpreted this outcrop as a breccia pipe. The outcrop is poorly exposed and somewhat weathered; however, 96 samples were available for study. The fenitized crustal xenoliths from Brazil Branch are, on the average, the smallest of the three sampled areas and average 0.5 cm × 1.0 cm. The mineralogical characteristics of the xenoliths are altogether different from those at

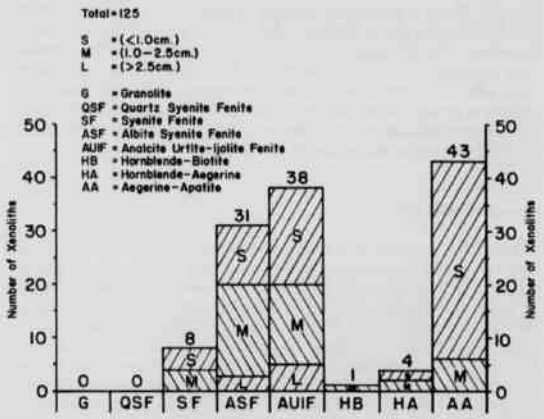

Figure 4. Cumulative histogram for leucocratic and melanocratic xenoliths from Brazil Branch.

Morrilton Lock and Dam No. 9 in that the most abundant minerals are albite, analcite, and aegerine. No quartz was observed, the feldspars are albitized, and in many instances, the feldspars have transformed into analcite. Analcite comprises 60% of the xenolith, in some cases, with dark-green aegerine making up the rest of the xenolith.

The cumulative histogram of Brazil Branch shows that the most common leucocratic rock type is analcite urtite-ijolite fenite (Fig. 4). Albite syenite fenite is also an abundant leucocratic rock type. The very small aegerine-apatite assemblage dominate the melanocratic xenoliths. It appears that this locality is an area of intensive metasomatic alteration. The xenoliths are smaller, and their mineralogy suggests extensive alteration. The presence of analcite suggests that these xenoliths were metasomatically altered at pressures of 6-8 kilobars. At shallower depths, nepheline would have formed instead of analcite (Roux and Hamilton, 1976). The Brazil Branch xenoliths are rounder than those from Oppello Dump and Morrilton. This rounding is due to chemical reaction with the carbonatite and physical abrasion in transport. The Brazil Branch Breccia is interpreted as an area of extensive metasomatic alteration at depth.

VARIATIONS OF XENOLITH TYPES

The cumulative percentage plot of north-south variations of leucocratic xenolith type provides a visual picture of how the rock types are distributed in the study area (Fig. 5). It is evident that as one moves from Morrilton in the north to Brazil Branch in the south, rock type abundance changes according to the intensity of metasomatic alteration. The percentage of granolite decreases from 13% at Morrilton, to 0% at Oppello Dump and Brazil Branch. Conversely, the percentage of analcite urtite-ijolite fenite increases from 0% at Morrilton, to 1% at Oppello Dump, to 50% at Brazil Branch. The distance between Morrilton Lock and Dam No. 9 and Brazil Branch is about 16.8 km,and as one moves toward the south, a definite graduation can be seen. The fenitizing agent of the three localities is sodic in nature, and the source of these fenitizing agents is centered near the Brazil Branch locality.

The cumulative percentage plot of north-south variations of melanocratic xenolith type concurs with this interpretation (Fig. 6). The percentage of hornblende-biotite decreases from 40% at Oppello Dump, to 2% at Brazil Branch. Conversely, the percentage of aegerine-apatite increases from 9% at Oppello Dump, to 90% at Brazil Branch. Toward the southern end of the study area, the intensity of metasomatic alteration is gradually increasing. The study area is interpreted as a single alkalic-carbonatitic complex at depth, with its center near the southern extremity of the sampled area.

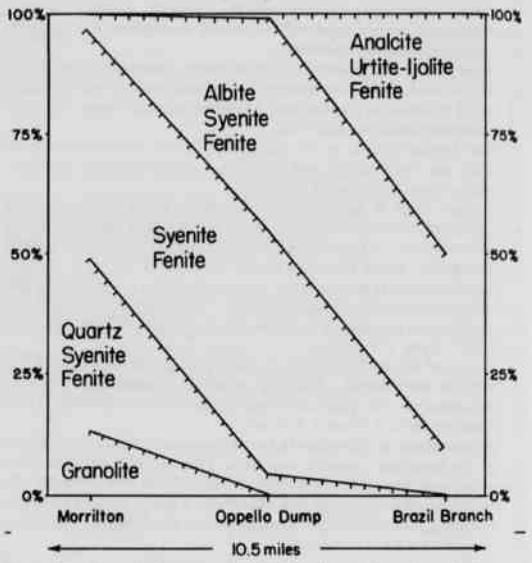

Figure 5. Cumulative percentage plot of north-south variations of leucocratic xenolith type.

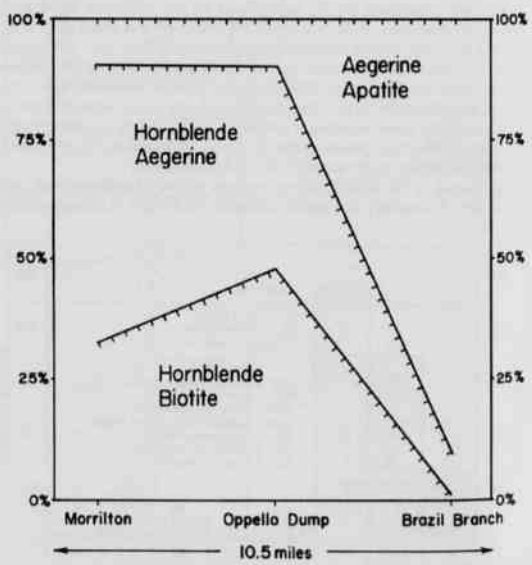

Figure 6. Cumulative percentage plot of north-south variations of melanocratic xenolith type.

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LITERATURE CITED

MITCHELL, J. R. 1979. The petrology of metamorphic xenoliths in carbonatite intrusions in west-central Arkansas. Unpub. Univ. of Arkansas M.S. thesis, 122 pp.

ROUX, J. and D. L. HAMILTON. 1976. Primary igneous analcite — an experimental study. Jour. of Petrology, 17:244-257.

WINKLER, G. F. 1974. Petrogenesis of metamorphic rocks. New York, Springer-Verlag, 320 pp.