Limestone Xenoliths in Hills Pond Lamproite, Woodson County, Kansas

JAMES S. ABER AND SUSAN W. ABER
Earth Science, Emporia State University, Emporia, KS 66801
aberjame@emporia.edu & aberjusa@emporia.edu

INTRODUCTION

The Hills Pond lamproite is part of a sill complex intruded into the northern portion of the Silver City Dome (Fig. 1). This intrusion is related closely in age, composition, and tectonic setting to a nearby intrusion at Rose Dome (Berendsen and Blair, 1991). Rose Dome includes well-known xenoliths of granite derived from the deep crust. However, xenoliths of any type have never been reported before from the Hills Pond lamproite. The seeming lack of xenoliths at Silver City has been puzzling. The following summary is based mainly on Bickford, Wetherill, and Franks (1971); Franks, Bickford, and Wagner (1971); and Wojcik and Knapp (1990).

The intrusive rock of Silver City and Rose Dome was referred to earlier as mica peridotite or kimberlite. It now is recognized as lamproite, a potassium-rich, intermediate to ultramafic, alkaline rock with high K/Na and K/Al ratios. Intrusion of lamproite took place approximately 88-90 million years ago during the mid-Cretaceous, when the present surface was covered by about 1 km of overburden strata. The intrusions are hosted at the surface in upper Pennsylvanian strata of the Douglas Group consisting of clastic rocks—sandstone, siltstone, and shale.

The Hills Pond lamproite is located along a steeply dipping fault in the northern portion of a ring-graben structure that surrounds the central uplift of Silver City (Fig. 1). The sill is up to 20 m thick and intrudes the Stranger Formation (Douglas Group), a clastic unit consisting of sandstone, siltstone, and shale. Fossiliferous limestone of the underlying Stanton Limestone (Langsing Group) is exposed at the center of the dome structure, 1-2 km south of the sill. The lamproite includes major constituents of phlogopite (mica), olivine, diopsidic augite, and amphibole. These occur as phenocrysts in serpentinized groundmass with quartz and calcite veins. Surficial portions of the sill are weathered largely to clay minerals. Contact metamorphism of surrounding strata produced a narrow zone of hornfels-grade quartzite, slate, and skarn.

The distinctive mica-bearing rock at Silver City has been known since the late 1800s when it was the subject of a mining swindle from whence the site’s name is derived. In recent decades, the Hills Pond lamproite has been mined for a variety of products used in agriculture and industry. The active surface mine has afforded the opportunity for field observations and sample collection by the authors during the past 20 years. We have visited the site yearly in connection with student field trips. Our efforts have focused on the sill margin and adjacent contact metamorphic rocks.

LIMESTONE XENOLITHS

During the course of routine field observation in April 2000, several fragments of distinctive rocks were discovered near the westernmost limit of the Hills Pond lamproite exposed in the mine (Fig. 1). These fragments proved to be xenoliths of limestone (Fig. 2). Various fossil remains are conspicuous in the limestone, including brachiopods and crinoids (Fig. 3). Remnants of broken limestone fragments are surrounded by quartz-rich veins that are relatively resistant to surficial weathering. Exact in-situ location of the limestone xenoliths could not be determined, as they had been disturbed by mining operations. However, all the fragments occur in close proximity to each other within a few meters of the southwestern edge of the lamproite. No xenoliths were noted toward the center of the sill exposure.
Highly altered rock fragment from Hills Pond lamproite. Small remnants of limestone (L) are visible surrounded by quartz-rich veins. Voids are "empty pockets" from which limestone remnants presumably were removed by near-surface weathering. Coin is 1 inch (2½ cm) in diameter.

Contact metamorphic rock from south edge of mine in Hills Pond lamproite. Note kink folds, brecciation, and strong alteration of the parent clastic strata. Coin is 1 inch (2½ cm) in diameter.

The veins within the xenoliths are similar to those occurring in contact metamorphic rocks along the southern margin of the sill. The contact metamorphic rocks are marked by brecciation, deformation, and strong alteration of the original clastic strata, which consist of fine sandstone, siltstone, and shale in the immediate vicinity (Fig. 4). Secondary quartz mineralization is abundant in the contact metamorphic zone within 10 meters of the sill. However, the appearance of contact metamorphism disappears more than 30 m away from the sill.

Significance of Xenoliths

The limited number of xenoliths and fragmentary remains of fossils prohibit definite identification of the source limestone parent strata. However, the xenoliths resemble typical Pennsylvanian limestones that are present elsewhere in southeastern Kansas. The most likely source for the xenoliths is the Stanton Limestone, which immediately underlies the Stranger Formation in which the sill is situated. Pieter Berendsen (pers. comm., 2000) drilled a core hole on the ridge immediately south of the open-pit mine. The hole started in the Stranger Formation and encountered the Stanton Limestone at 69 m depth. Within the Stranger Formation, thin beds of limestone and brecciated limestone were noted at several levels. The limestone may have been uplifted along the fault that marks the southern edge of the sill.
at this location. It seems probable the xenoliths could be derived from these limestone sources.

Other, slightly deeper Pennsylvanian limestones of the Lansing and Kansas City Groups are considered possible sources as well. Another, deeper source for limestone xenoliths could be Mississippian or Cambro-Ordovician strata. These rocks consist of thick dolostone and cherty limestone beds, and chert of presumed Mississippian age occurs among the xenoliths at Rose Dome. The top of the Mississippian is about 500 m deep at Silver City (Wojcik and Knapp, 1990).

We consider a Mississippian or deeper source for xenoliths at Silver City unlikely for two reasons. First, no chert or dolostone was discovered along with the limestone xenoliths. The lack of chert or dolostone argues against a Mississippian or Cambro-Ordovician source for the xenoliths. Our second argument concerns temperature of the intrusive magma. The intrusive temperature at Rose Dome is considered to be >800°C, which was hot enough to cause metamorphism and partial melting of the granite xenoliths (Franks, Bickford, and Wagner, 1971). Assuming a comparable temperature at Silver City indicates that limestone would be melted readily during transport in the magma. Aside from quartz veins, the xenoliths show no evidence of metamorphism or recrystallization. Limestone survival in magma from a depth of half a kilometer to the xenoliths' present position seems improbable.

Our preferred interpretation is that limestone xenoliths were derived from shallow Pennsylvanian sources within the sill complex. Genesis of the xenoliths began as quartz veins were precipitated in highly fractured wall rocks. Some fragments of the wall rocks were detached, transported a short distance (10s of meters), and emplaced at the rapidly cooling margin of the sill. Those limestone fragments that were transported for longer distances or toward the center of the sill were totally melted.

The Hills Pond lamproite contrasts with the lamproite at Rose Dome where many xenoliths are present. Luczaj (1998) interpreted the latter as an explosive igneous structure. The general lack of deeply derived xenoliths in the Hills Pond lamproite suggests that intrusive movement was insufficient to carry rock fragments into the sill complex. This interpretation supports the notion of Wojcik and Knapp (1990) that magma intrusion at Silver City was a quiescent phenomenon.

ACKNOWLEDGMENT

Field investigation at Silver City has been carried out with the encouragement of P. Berendse, who reviewed an early draft of this note and provided information based on nearby test drilling.

LITERATURE CITED


