Microscopic Studies of Ancient Igneous Dikes in the Front Range of Colorado

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Abstract

A major Cambrian rift zone containing abundant igneous rocks is present in southern Oklahoma and trends northwest from the ancient continental margin. Previous geologists have mapped numerous igneous intrusions in Colorado that follow the same trend, ranging from Cambrian to Ordovician in age, and have speculated that these intrusions may be a part of the same rift. These intrusions include abundant igneous dikes of various compositions that originated from deeper magmatic bodies, filling fracture systems in older igneous rocks and Precambrian gneisses. This study involves the microscopic analysis of samples we collected from different dike types, including diabase, trachyte, and lamprophyre. Diabase is a common intrusive basaltic rock that develops coarser grains due to slower cooling and represents partial melt from the mantle that fills fractures in the upper crust. For our samples, trachyte refers to igneous dikes containing large crystals of K-feldspar within a distinctive red-colored, fine-grained matrix. Magmas of this composition are typically associated with intraplate rift zones. Lamprophyre is a rare intrusive igneous rock that has large crystals of biotite and amphibole in a finer matrix of feldspar and mafic minerals. While rare, this rock is also associated with intraplate rift zones. We also sampled one significantly younger basalt dike that intrudes Cenozoic volcanic rock to compare with the much older diabase dike samples.

Nine of our samples come from the Wet Mountains in the southern part of the Front Range in Colorado, and we also have an additional five samples of diabase dikes along the Front Range ~100 km to the north. Analysis of thin sections of these samples under the petrographic microscope will provide insight into their exact mineralogical compositions as well as their igneous textures. This work will provide a framework for geochemical analyses of the dikes, which is currently underway. The results will help determine whether the Colorado intrusions are directly related to the southern Oklahoma rift.

Geologic Background

Cambrian igneous rocks in southern Oklahoma and adjacent parts of Texas, mostly present in the subsurface, define a northwest-trending rift zone extending from the ancient continental margin (Hanson et al., 2013; Wall et al., 2021). Numerous Cambrian and Ordovician igneous intrusions ranging from large plutonic intrusions to smaller tabular dikes occur along the same trend in Colorado, primarily in the Powderhorn District in western Colorado and the Wet Mountains and other parts of the Front Range of the Rockies farther east (Figs. 1 and 2). It is possible that all these rocks form a single major rift, where North America began to split apart (Larson et al., 1985). This project deals with abundant dikes present in the Wet Mountains and in other parts of the Front Range to the north (Olson et al., 1977; Pivarunas and Meert, 2019; Magnin et al., 2023). We have sampled a range of dikes mapped by previous workers that consist of diabase, lamprophyre and trachyte, as well as one much younger basaltic dike, in order to compare it with the older dikes. Initial stages of this project involve detailed microscopic studies of these rocks, in order to supplement geochemical analyses of the samples now in progress. This information will be used to test the idea that the ancient igneous rocks in Colorado represent a single large rift system extending almost to the border with Utah (Fig. 2).

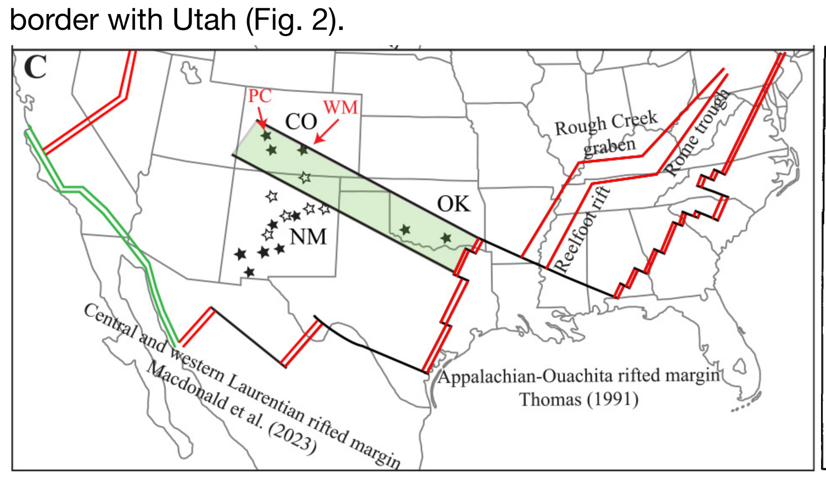

Fig. 1 Northwest-trending Southern Oklahoma Aulacogen. Magnin et al., 2023, Tectonics.

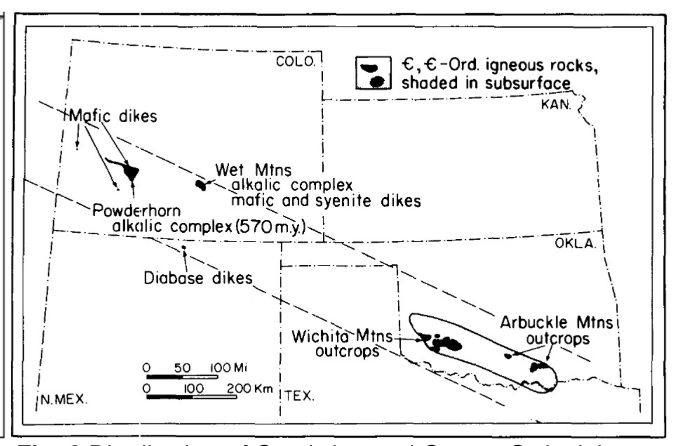

Fig. 2 Distribution of Cambrian and Camro-Ordovician igneous rocks in CO, NM, and OK. Larson et al., 1985, GSA Bulletin

Methods

- **Field work (July 2023)**
  - Drove to the Wet Mountains in Colorado with Dr. Richard Hanson to collect dike samples of varying compositions (diabase, trachyte, lamprophyre).
  - Collected 11 dike samples, including one Cenozoic basalt dike found along a road cut.
- **Microscopic Studies**
  - With the use of a petrographic microscope, I identified the main igneous minerals of each sample and noted any textures or alteration products exemplified
  - The petrographic microscope consists of two polarizing filters, the polarizer and the analyzer. The polarizer is located beneath the stage of the microscope and allows light to vibrate in only one direction as it passes through the thin section. The analyzer is located above the objective lens and allows light vibrating 90 degrees from the polarizer to pass through the thin section. As polarized light passes through the thin section it interacts with the minerals revealing their unique optical properties, such as pleochroism and birefringence.
  - These optical properties assist in identifying minerals within the thin section as well as highlighting any igneous textures present in the minerals.
  - All thin sections used are 0.03 mm thick.
  - The microscopic studies conducted in this research serves as the basis for future geochemical studies currently In progress.

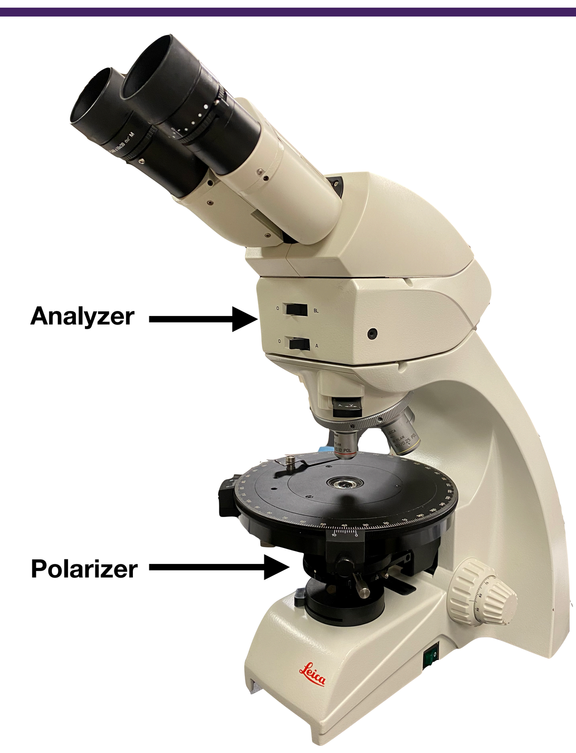

Fig. 3 Diagram of a petrographic microscope.

Fig. 4 Example of a typical geologic thin section.

Igneous Minerals

Olivine
$(Mg,Fe)_2SiO_4$

Diopside
$CaMgSi_2O_6$

Augite
$Ca(Mg,Fe,Al)Si_2O_6$

Hornblende
$(Ca,Na)_2(Mg,Fe,Al)_5Si_6(Si,Al)_2O_{22}OH_2$

Biotite
$K(Mg,Fe)_3(AlSi_3O_{10})(OH)_2$

Quartz
SiO_2

Orthoclase
$KAlSi_3O_8$

Plagioclase
Solid solution series between $NaAlSiO_3O_8$ and $CaAl_2Si_2O_8$.

Nepheline
$NaAlSiO_4$

Plane Light

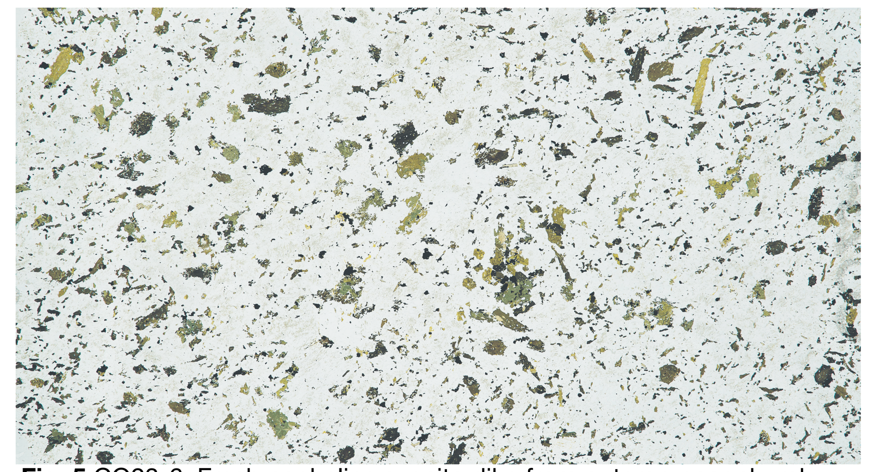

Fig. 5 CO23-6, Fresh nepheline syenite dike from outcrop near church (plane light). Includes nepheline, orthoclase, hornblende, and biotite.

Crossed Polars

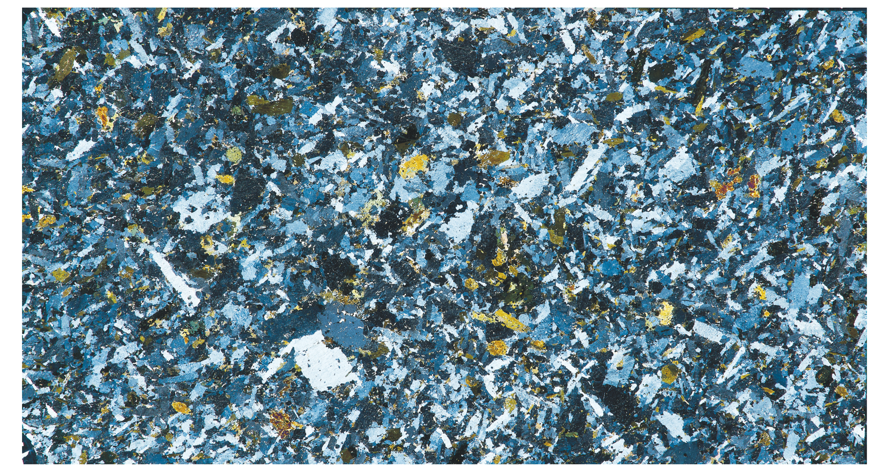

Fig. 6 Same view as Fig. 5 under crossed polars.

Diabase

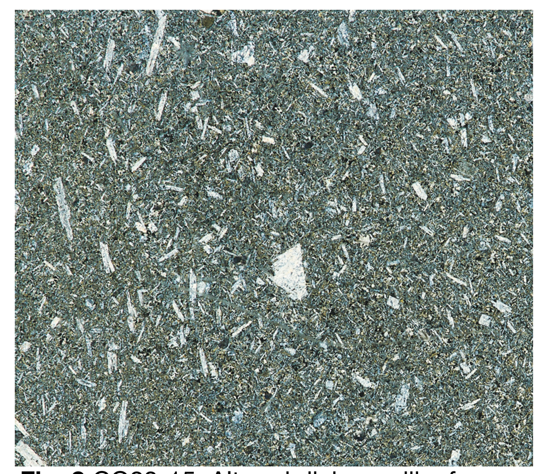

Fig. 8 CO23-15, Altered diabase dike from road cut (crossed polars). Includes olivine, plagioclase, and augite.

Fig. 9 DB-02, Altered diabase dike from northern region (plane light). Includes olivine, plagioclase, and augite.

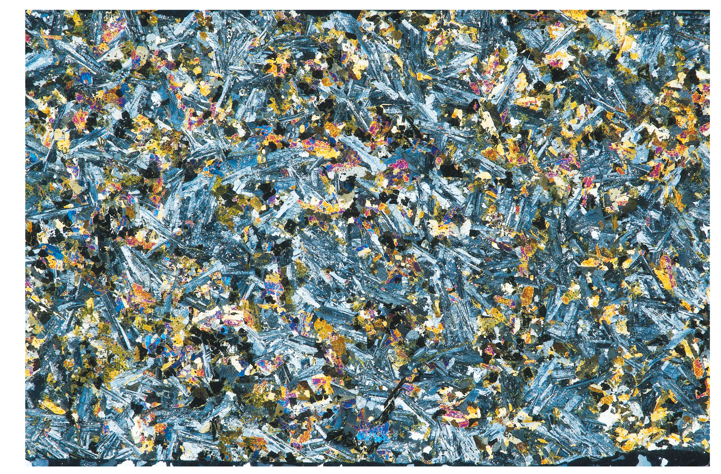

Fig. 10 Same view of Fig. 9 under crossed polars.

Lamprophyre

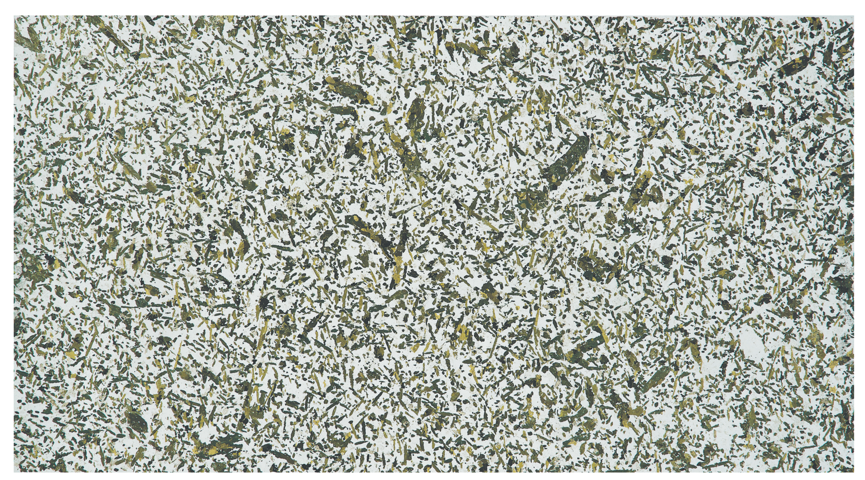

Fig. 11 CO23-16, Fresh lamprophyre dike from hill side (plane light). Includes hornblende, plagioclase, and augite.

Fig. 12 CO23-18, Fresh lamprophyre dike from cliff side (crossed polars). Includes augite (showing resorption) and abundant olivine.

Trachyte

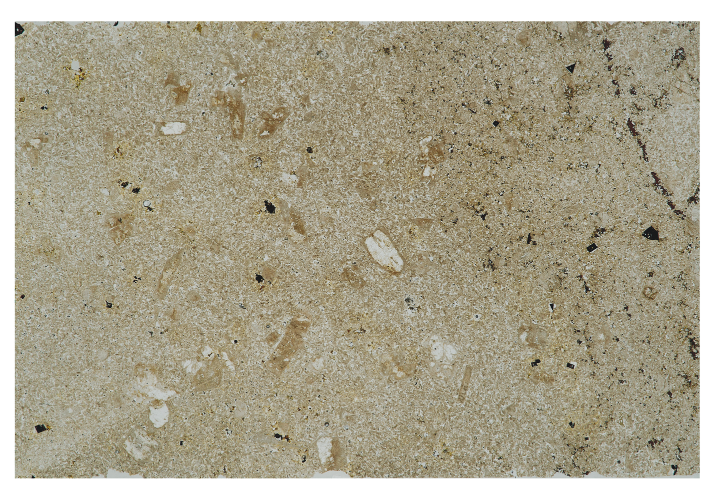

Fig. 13 CO23-21, Slightly altered red trachyte dike from hill side (plane light). Includes large crystals of orthoclase with altered rims in a matrix of smaller orthoclase crystals.

Fig. 14 Same view of Fig. 12 under crossed polars. Features Carlsbad twinning in some orthoclase crystals.

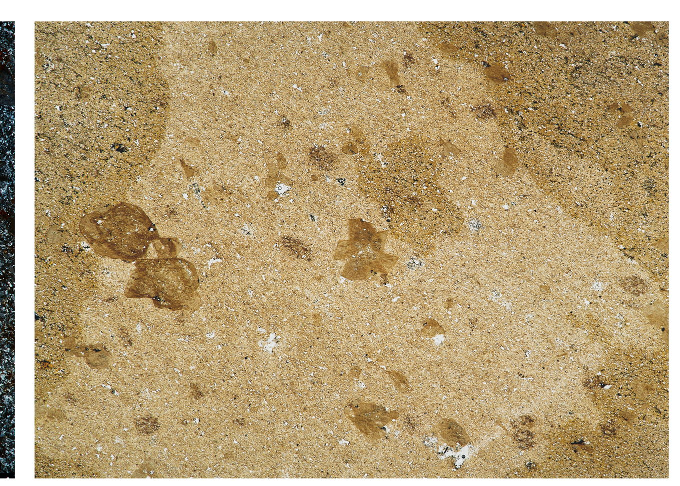

Fig. 15 CO23-19, Altered red trachyte dike from road cut (plane light). Features same mineralogy as CO23-21.

Basalt

Fig. 17 CO23-17, Cenozoic basalt dike from road cut (crossed polars). Includes large crystals of olivine and some glomerocrysts of augite in a finer grained matrix.

Fig. 7 Diabase dike from which CO23-15 was taken.

Fig. 15 Red trachyte dike traced across road from which CO23-19

Fig. 12 Lamprophyre dike in cliff side from which CO23-18 was taken.

Fig. 16 Comparison between margin (left) and center (right) of red trachyte dike from which CO23-19 was taken.

Fig. 18 Basalt dike rom which CO23-17 was taken.

Discussion and Conclusions

Microscopic studies of a variety of dikes present in the Front Range of Colorado consist of a range of different compositions, including diabases, trachytes and lamprophyres. These are all typical dike rocks formed in intraplate rift environments. Some of the dikes appear nearly unaltered in thin section (e.g., Figs. 5 and 11) and should yield excellent geochemical results. Others are altered to various degrees (e.g., Fig. 10). This will require caution when interpreting geochemical data, which may have been disturbed during alteration.

The young basaltic dike is much finer grained than the diabase dikes, because it was more rapidly chilled due to emplacement at higher levels in the crust. This should provide a way to tell older from younger mafic dikes in this region.

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