RAILROAD MOUNTAIN, CHAVES COUNTY, NEW MEXICO: A GEOCHEMICALLY UNIFORM SINGLE-PHASE MAFIC DIKE EMPLACED AT THE CRATONIC MARGIN

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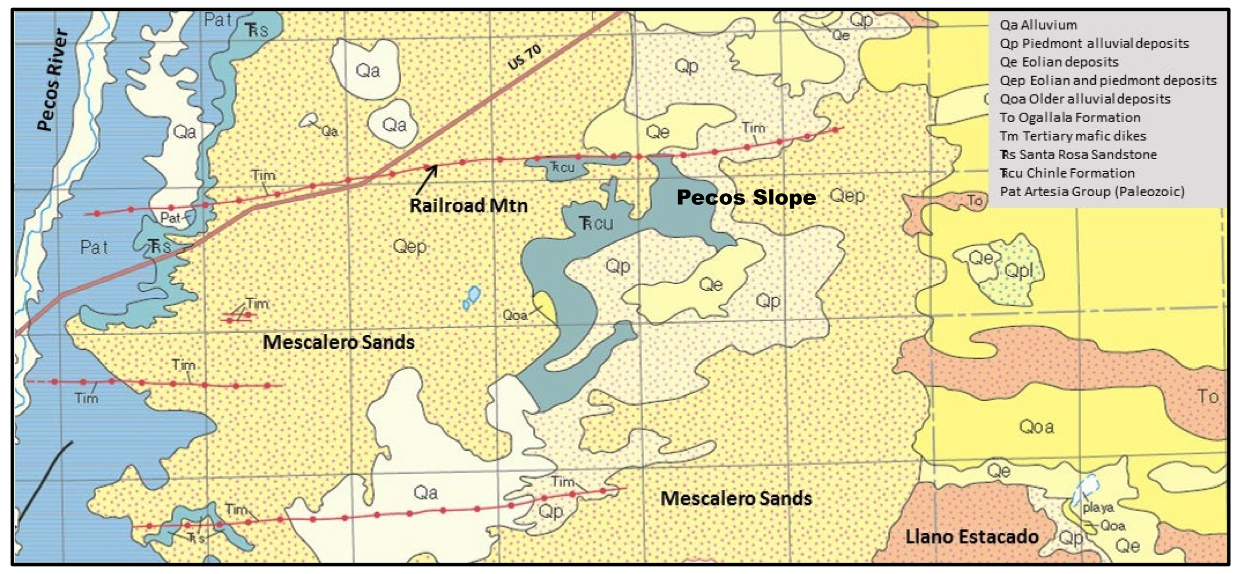
BACKGROUND

Railroad Mountain is a single-phase, mafic dike located on the Mescalaro Pediment of the Pecos Slope. The dike was first mentioned by Fisher (1906) and Semmes (1920). Allen and Foord (1991) and Bartsch-Winkler (1992) provided additional details. The dike forms a resistant ridge ~50 km long, 30-45 m wide and up to 25 m high. It is partially covered by the Mescalaro sands (Quaternary) along most of its length and in local contact with the Upper Chinle Group, the Santa Rosa Sandstone and the Artesia Group. The eastern end is buried under the Mescalaro sands, the western end is buried under river deposits east of the Pecos River. The trend of the dike changes from ENE to WSW and is in line with Capitan Mountain located to the west. Contact metamorphic effects are minimal. A single K-Ar date of 27.9 ±1.4 Ma is reported in Aldrich et al. (1986).

Railroad Mountain represents the eastern-most intrusion in the Lincoln County Porphyry Belt (LCPB). Tertiary igneous rocks of the LCPB are part of the post-Laramide Rocky Mountain alkalic province that extends along the eastern front of the Rockies. Igneous activity occurred along the boundary between the stable craton to the east and rocks deformed during the Laramide orogeny to the west. In the region of the LCPB, the stable craton is manifested by the relatively undeformed Paleozoic and Mesozoic Pecos slope (Allen and McLemore, 1991). Dikes in the region lie along the WNW- trending Capitan lineament and reflect the orientation of the least principal horizontal stress in the Southern Great Plains (Aldrich et al., 1986). The Capitan lineament is considered a leaky transverse fracture of the Rio Grande rift.

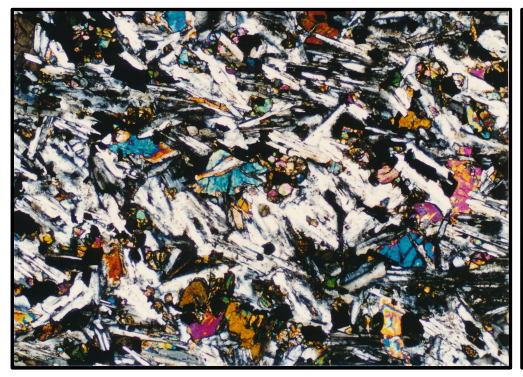


From The Geologic Map of New Mexico 1:500,000, 2003, NM Bur. of Geology and Mineral Resources

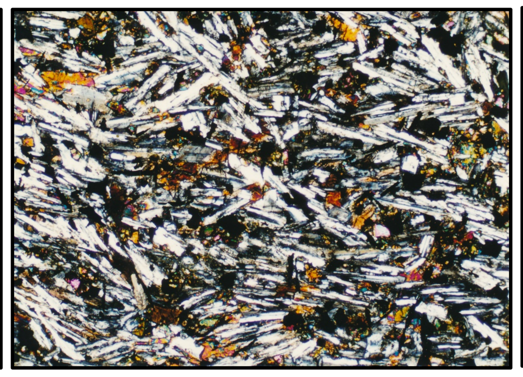
PETROGRAPHY

The rocks display three fundamental textures in thin section: (I) diabasic from the upper middle of the dike, dominated by subhedral plagioclase laths and scattered larger anhedral plagioclase; (II) finer-grained diabasic/trachytic texture from the core of the dike; (III) finer-grained diabasic/trachytic near the margins of the dike (chill zone) with fine-grained plagioclase laths and an aphanitic matrix of anhedral augite, olivine and magnetite-ilmenite. Type I and II samples are consistent with approximately 60% plagioclase, 20% augite, 10% olivine and 10% opaques (magnetite-ilmenite) along with minor apatite.

Plagioclase (~An_{50}) is generally unaltered except for minor argillic alteration. Titanaugite is anhedral to subhedral; rare grains are subophitic. Probe data on five grains yielded an average composition of $Wo_{43.1}En_{38.4}Fs_{16.7}Ac_{1.7}$ and 1.34-2.16 wt.% TiO_2. Olivine ($Fo_{48.1}Fa_{50.8}Tp_{1.2}$) is typically anhedral, smaller than augite and generally unaltered. Subhedral magnetite-ilmenite is relatively abundant (~10%). Probe data yielded a temperature of 829-946°C and $\log_{10} fO_2$ = -16 to -13 for magnetite-ilmenite pairs.



Type I (fov = 3.5mm)



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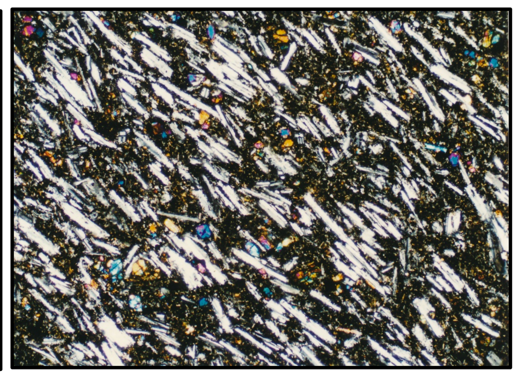


Type III (fov = 3.5mm)

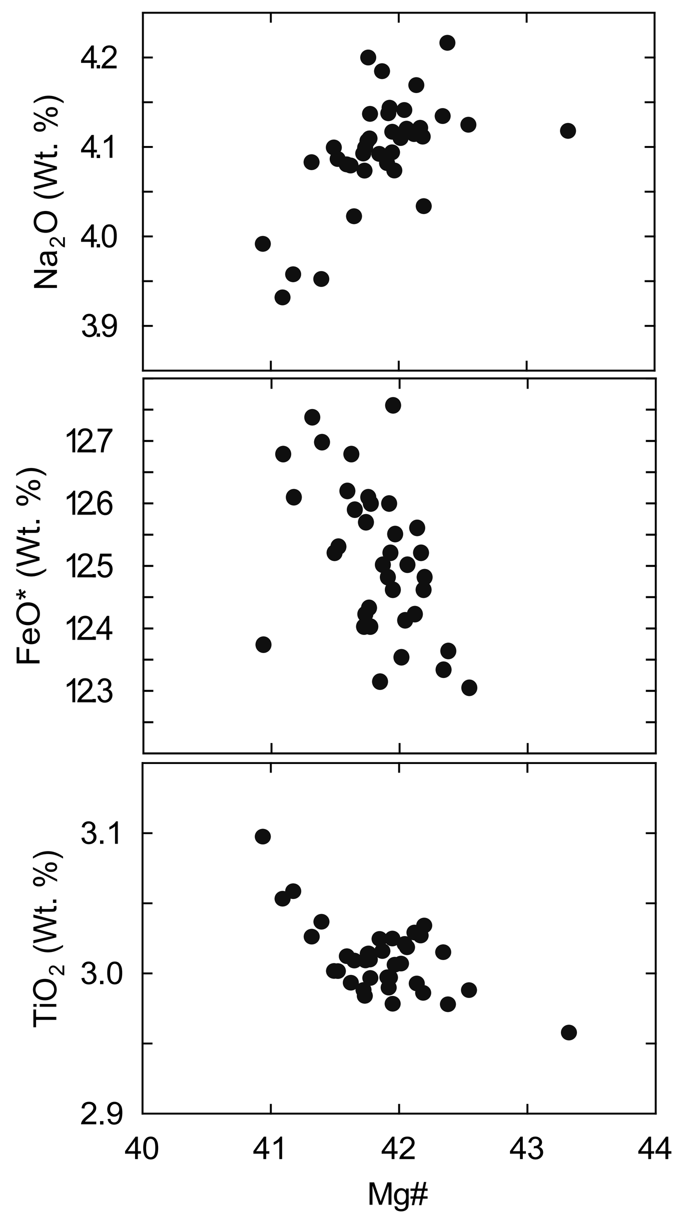
GEOCHEMISTRY

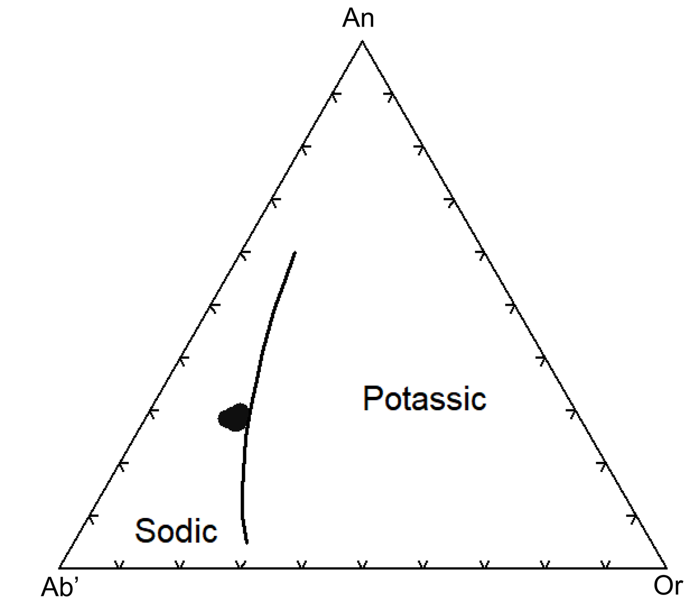
Samples were collected along ~14.5 km strike length of the dike and from two quarry pits within the dike. Forty samples were analyzed by XRF and ICP-MS at Washington State University. Three samples collected at the contact in the quarry pits had lower oxide totals (92.30-95.58 wt%) due to reaction with the country rocks. Normalized major oxide concentrations are remarkably consistent with the maximum variation less than 0.5 wt.%. Mg#s average 41.8 ±0.43 and are plotted against selected oxides below. The rocks have an alkali-lime index of 47-48 (alkali) and belong to the sodic alkali olivine basalt series of Irvine and Baragar (1971). On the TAS diagram of Le Bas et al. (1986) the rocks plot in the trachybasalt field. Ne is present in the norm.

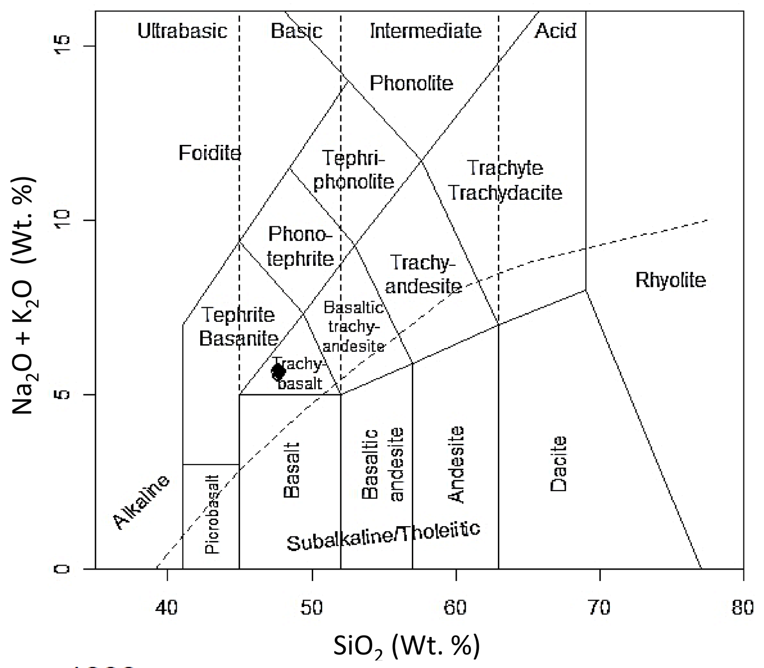
Low Mg#s and very low Cr concentration (mean = 13.1 ppm) suggest significant differentiation. Because Ni is strongly fractionated by olivine and Cr is strongly fractionated by pyroxene, olivine fractionation is suggested by Ni/Cr = 1.93.

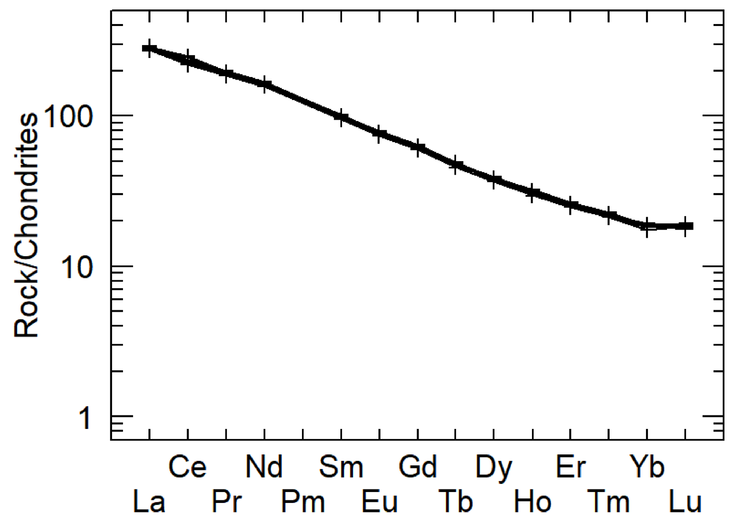
The chondrite normalized REE pattern shows moderate LREE enrichment $(La/Yb)_N$ = 12.7-13.3, minimal HREE enrichment $(Tb/Yb)_N$ = 2.4-2.5 and negligible Eu anomalies Eu/Eu* = 0.94-0.98. The $(La/Yb)_N$ ratios suggest garnet was not important in the source region. The positive correlation of REEs with P_2O_5 and normative apatite suggest apatite played a major role in controlling REE concentrations.

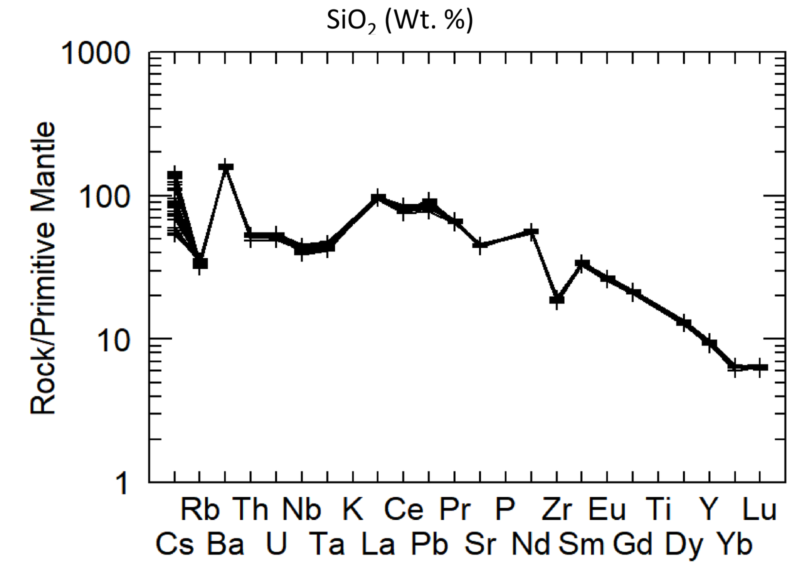
The primitive mantle-normalized spidergram is slightly concave with moderately to highly incompatible trace elements enriched relative to primitive mantle. Barium shows the greatest enrichment and may reflect metasomatism of the source region. Zr depletion may be a reflection of the source region.











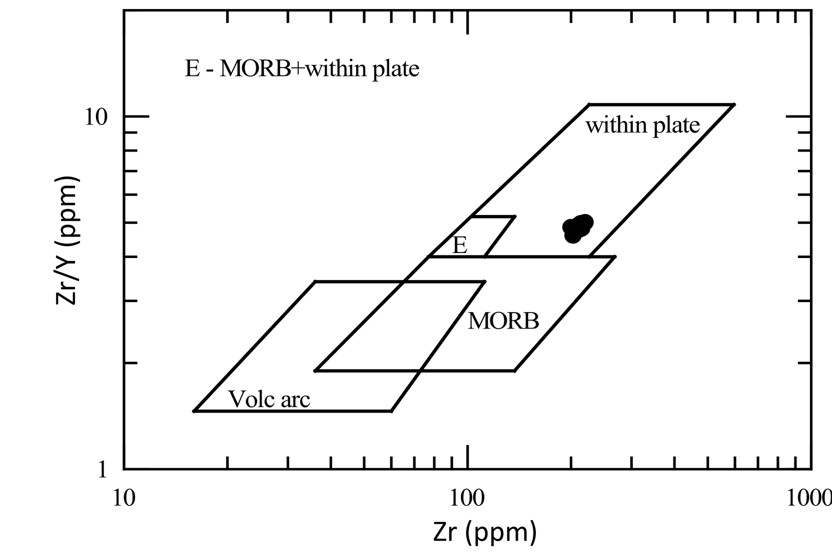
DISCUSSION

All of the samples plot in the "within plate" field of the tectonic discrimination diagram of Pearce and Norry (1979). This is consistent with the fact that the volcanic arc present during the Laramide was located to the west and these rocks were emplaced to the east, at the far western edge of the craton.

Crystallization likely occurred in the subcontinental lithospheric mantle at depths of greater than 30 km (Bender et al., 1978). The crust is ~45-50 km deep in the Great Plains on either side of the Rio Grande rift. Moderate LREE enrichment and lack of HREE enrichment is incompatible with presence of garnet in source region suggesting the maximum depth of crystallization was ≤ 80 km (Wyllie, 1981; Takahashi et al., 1993; Hirschmann and Stolper, 1996).

Allen and Foord (1991) reported a $^{87}Sr/^{86}Sr_{initial}$ value of 0.70411 and Nd ($CHUR_T$) value of +0.5 suggesting a primitive mantle melt which had experienced some enrichment. This is supported by the LREE values and positive Ba anomaly. Metasomatism and LREE enrichment may be the result of fluxing of the overlying mantle caused by dewatering of the Farallon plate.

As the Laramide orogeny came to a close, slab rollback led to foundering of the Farallon plate and eventually tearing of the plate beneath the North American craton. By about 30-25 Ma the plate was detached beneath central New Mexico resulting in the exposure of the continental lithosphere to hot asthenospheric mantle, producing igneous activity in the LCPB. Apatite AHe data (Ricketts et al., 2016) and fission-track data (Kelley and Chapin, 1997) for the Sierra Blanca complex in the LCPB indicate rapid cooling due to extension from 25-10 Ma in the southern portion of the Rio Grande rift, supporting the idea that intrusion occurred during the transition from Laramide compression to Rio Grande extension.



REFERENCES

Aldrich, M.J., Jr., Chapin, C.E., and Laughlin, A.W., 1986, Stress history and tectonic development of the Rio Grande rift, New Mexico: Journal of Geophysical Research, v. 91, p. 6199-6211.

Allen, M.S., and Foord, E.E., 1991, Geological, geochemical and isotopic characteristics of the Lincoln County Porphyry Belt, New Mexico: implications for regional tectonics and mineral deposits: New Mexico Geological Society, Guidebook 42, p. 97-113.

Allen, M.S., and McLemore, V.T, 1991, The geology and petrogenesis of the Capitan Pluton, New Mexico: New Mexico Geological Society, Guidebook 42, p. 115-127.

Bartsch-Winkler, S., 1992, Geology of east central New Mexico (with a section on intrusive and extrusive alkaline rocks of the Lincoln County Porphyry Belt by Arnbrustmacher, T.J.), in Bartsch-Winkler, S., ed., Mineral and energy resources of the BLM Roswell resource area, east-central, New Mexico: U.S.G.S. Open File Report 92-0261, 228 p.

Bender, J.F., Hodges, F.N., and Bence, A.E., 1978, Petrogenesis of basalts from the project FAMOUS area: Experimental study from 0 to 15 kbars: Earth and Planetary Science Letters, v. 41, p. 277-302, doi: 10.1016/0012-821X(78)90184-X.

Fisher, C.A., 1906, Preliminary report on the geology and underground waters of the Roswell artesian area, New Mexico: U.S. Geological Survey Water supply Paper 158, 29 p.

Hirschmann, M.M., and Stolper, E.M., 1996, A possible role for garnet pyroxene in the origin of the "garnet signature" in MORB: Contributions to Mineralogy and Petrology, v. 124, p. 185-208, doi: 10.1007/s004100050184.

Irvine, T.N., and Baragar, W.R.A., 1971, A guide to the chemical classification of common volcanic rocks: Canadian Journal of Earth Sciences, v. 8, p. 524-548.

Kelley, S.A., and Chapin, C.E., 1997, Cooling histories of mountain ranges in the southern Rio Grande rift based on apatite fission-track analyses-A reconnaissance survey: New Mexico Geology, v. 9 p. 1-14.

Le Bas, M.J., Le Maitre, R.W., Streckeisen, and A., Zanettin, B., 1986, A chemical classification of volcanic rocks based on the total alkali-silica diagram: Journal of Petrology, v. 27, p. 745-750.

Pearce, J.A., and Norry, M.J., 1979, Petrogentic implications of Ti, Zr, Y, and Nb variations in volcanic rocks: Contributions to Mineralogy and Petrology, v. 69, p. 33-47.

Ricketts, J.W., Kelley, S.A., Karlstrom, K.E., Schmandt, B., Donahue, M.S., and van Wijk, J., 2016, Synchronous opening of the Rio Grande rift along its entire length at 25-10 Ma supported by apatite (U-Th)/He and fission-track thermochronology, and evaluation of possible driving mechanisms: Geological Society of America Bulletin, v. 128, p. 397-424, doi: 10.1130/B31223.1.

Semmes, D.R., 1920, Notes on the Tertiary intrusives of the Lower Pecos Valley, New Mexico: American Journal of Science, v. L no. 300, p. 415-430.

Takahashi, E., Shimazaki, T., Txuzaki, Y., and Yoshida, H., 1993, Melting study of a peridotite KLB-1 to 6.5 GPa, and the origin of basaltic magmas: Philosophical Transactions of the Royal Society of London, v. 342, p. 105-120.

Wyllie, P.J, 1981, Plate tectonics and magma genesis: Geologische Rundschau, v. 70, 128-153, doi: 10:1007/BF01764318.

SUPPORT

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