Alamo Schist North of Alamo Lake, Arizona*

William J. Elliott[1] and Joseph L. Corones[2]

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[1]Retired Engineering Geologist, P.O. Box 541, Solana Beach, California 92075 (redbeds77@gmail.com)
[2]Retired Engineering Geologist

Abstract

A small isolated outcrop of blue-gray schist occurs north of Alamo Lake, Arizona. Visual comparison of this metamorphic rock was made with samples of Orocopia Schist on the northwest side of the Plomosa Mountains, Arizona, and at Cemetery Ridge, Arizona. At the hand-lens level of identification, save expected natural variations, these three schists appear to be all but indistinguishable, one from the other. Relative Probability U-Pb age of detrital zircons obtained from the Alamo Schist is 167 Ma (Middle Jurassic). This does not appear to be incompatible with U-Pb schist ages at Cemetery Ridge and at Plomosa Mountains.

Massive quartz "breccia" bodies, with occasional well-rounded quartz clasts, occur within Alamo Schist. This seemingly unlikely intermingling may represent well-cemented collections of disaggregated ocean-bottom ribbon quartz in combination with far-traveled quartz-pebble turbidite sequences from some distant shore.

Proterozoic granite-gneiss gravel on the present-day schist outcrop surface may be lag from an eroded upper plate, with the underlying Alamo Schist representing the subducted lower plate. We tentatively suggest that this exposure may be an isolated occurrence of Orocopia-like Schist – perhaps an artifact of an exhumed portion of the Farallon Plate.

Introduction

The purpose of this article is twofold:

1) To describe the location and outcrop characteristics of a recently discovered blue-gray schist, and

2) To report the U-Pb age of this schist.

The scope of work consisted of literature review, field mapping, identification of rocks and minerals with a hand-lens, and U-Pb age dating.

Methods

Field Work

Field work began with literally stumbling across an outcrop of blue-gray schist and a massive quartz breccia along Alamo Road on October 24, 2016. The original purpose of this journey was to explore for exposures of Middle Miocene red beds near Alamo Lake, Arizona (Elliott and Corones, 2018, in press). Read on, this relates.

Reconnaissance level field mapping was completed to identify approximate schist outcrop boundaries; samples were collected for age dating. Forays were made to recent discoveries of Orocopia Schist at Cemetery Ridge, Arizona (Haxel and Jacobson, 2013-a, 2013-b), and at the northwest end of the Plomosa Mountains, Arizona (Strickland and others, 2017), to observe geologic and geomorphic settings, as well as to collect hand-samples to compare with samples of Alamo Schist.

Orocopia Schist samples were also collected from Shavers Well (Box Canyon Road, SR-195) and Painted Canyon, both located at the northern end of the Orocopia Mountains, California. These hand-samples were compared with Alamo, Cemetery Ridge and Plomosa Mountains schists.

Laboratory

A representative sample of Alamo Schist was processed for detrital zircons by J.R. Morgan at San Diego State University. Laser-ablation U-Pb techniques were used to obtain an age at the LaserChron Center at the University of Arizona, Tucson, Arizona. Literature was searched for Pelona-Orocopia-Rand (POR) and related schist citations to provide a geologic/geomorphic foundation and background for this essay.

Discussion

A Bit of History

A succinct historical overview of the Pelona, Orocopia and Rand schist story can be found in Haxel and others (2002, p. 100-102). The saga begins north of Los Angeles, California, with Hershey's 1902, investigation of quartzofeldspathic schists in the Sierra Pelona – which he named "Pelona Schist." Beginning in the 1950s, and continuing today, Pelona Schist has been recognized and studied in isolated, scattered outcrops from Sierra de Salinas, California, southeast to Cemetery Ridge, Arizona (Haxel and others, 2002, p. 100-102; Chapman, 2016, Figure 1, Table 1; Jacobson and others, 2011, Figure 1). Haxel and others (2002, p. 122-125) conclude with a discussion of Orocopia Schist at Neversweat Ridge (Haxel and Dillon, 1978).

More recent additions to the Orocopia Schist story include schist at Cemetery Ridge (Haxel and Jacobson, 2013-a, 2013-b; Jacobson and others, 2017), as well as schist at the northwest end of the Plomosa Mountains (Strickland and others, 2017; Figure 1, this article)

Discussion of detrital zircon provenance, protolith origin, Farallon Plate slab underplating, schistose metamorphism, northwestern versus southwestern schist variations and exposures, uplift and exhumation of POR and associated schists is beyond the scope of this essay. These, and associated subduction topics, for example, can be found in: Haxel and others, 2002; Grove and others, 2003; Jacobson and others, 2011; Spencer and others, 2011; Haxel and Jacobson, 2013-a, 2013-b; Chapman, 2016; Jacobson and others, 2017; Strickland and others, 2017.

Outcrop Description

Figure 2 shows approximate outcrop area of Alamo Schist. In plan view, its boundaries look like a long and narrow, badly distorted, north-south trending sine curve. Total outcrop length is ~1.14 miles; average width is ~0.2 miles. It occupies an area of ~ 0.3 square miles. Nominal outcrop elevations range from about 2,300 to 2,500 feet. Vegetation in this desolate Sonoran Desert environment includes: isolated Creosote, Paloverde and Mesquite bushes, Joshua trees, Saguaro, and other cactus varieties.

We have named this schist, the Alamo Schist. It is located on the southeastern edge of the McCracken Mountains (USGS, 1990-b, 2014). These mountains were mapped by Wilson and Moore (1959) and by Spencer and Reynolds (1989, p. 6 and 7) as being underlain by Proterozoic granite-gneiss.

Alamo Schist is well-exposed along Alamo Road (Mohave County Road 15), between Yucca, and Alamo Lake, Arizona. A roadside outcrop can be found at virtual mile post 40.5. National Geodetic Survey Bench Mark BM-V-481 (1981) is cemented into a large schist boulder on the west side of the road (Figure 3). Google Earth GPS coordinates for this benchmark are: 34° 25’ 55.13” N., 113° 44’ 13.56” W.; elevation 2404’. Township and Range coordinates are: SW¼, SW¼, SW¼, Section 28, T13N, R14W, GSRBM (USGS, 1990-b).

This quartzofeldspathic, blue-gray schist resembles Orocopia Schist in both hand-sample and in geologic-geomorphic description. Texture is typically flaggy and schistose, with short wavelength, low amplitude, wavy mullion-like structural edge views. Flaggy surfaces oftentimes display “lumpy” porphyroblastic texture.

Clear, glassy, nearly equidimensional quartz grains, and gray-black plagioclase can be seen in hand-samples. Accessory minerals include garnet and sphene (occasional), and hornblende (rare). Several 1 to 2 cm, equidimensional, egg-shaped, and odd-shaped monomineralic and “salt and pepper” igneous clasts are also present.

An integral part of the Alamo Schist outcrop is a milky-white quartz breccia (Figure 4, Photos 2, 3). **I**ncluded with this breccia are well-rounded, pebble-sized milky-white quartz clasts (Figure 4, Photo 4). This seemingly out-of-place quartz outcrop might have originated as an amalgamation of pelagic ribbon quartz and occasional gravelly quartz-rich turbidites from some distant shore.

As observed at Cemetery Ridge, Arizona, and at the northwest end of Plomosa Mountains, Arizona, Alamo Schist also weathers deeply to produce subdued outcrops and low rounded hills (Figure 5). Relatively fresh outcrops are usually found in road cuts, in deep arroyos and occasionally on ridge lines (Figure 6).

Visual comparison of Alamo Schist with outcrops of Orocopia Schist at Cemetery Ridge and at the northwest end of the Plomosa Mountains, Arizona, and at the northwest end of the Orocopia Mountains, California, (at Shavers Well and in the narrows of Painted Canyon), shows that, with the exception of expected natural variations, samples of each are all but indistinguishable one from the other (Figure 7).

Proterozoic granite-gneiss boulders were found on the present-day erosion surface of the Alamo Schist (Figure 8). These clasts likely represent remnants (lag gravel) of continental crust, under which the Alamo Schist protolith was underplated while riding along on top of the Farallon Plate. Outcrops of red rhyolite (Figure 5) and black basalt (Figure 9) surround Alamo Schist. In one place, a small outcrop of rhyolite intrudes Alamo Schist – suggesting that it is younger than the schist. Besides volcanic rocks, the remaining geology in the general area of the Alamo Schist consists of Quaternary alluvium, fan deposits and terraces.

According to Wilson and Moore (1959) nearby (not in contact with Alamo Schist) rhyolite tuffs and agglomerates were mapped as being Tertiary age. Similarly, nearby basalt (including tuff and agglomerate) was mapped as being Quaternary age. According to Spencer and Reynolds (1989, p. 6), however, this same nearby basalt outcrop is Late Tertiary age.

Although located approximately 16 miles south, an approximately 2' thick volcanic ash intercalated within tilted red beds was found to have a U-Pb date of 12.53 ± 0.16 Ma, (n=21, middle Miocene) (Elliott and Corones, 2018, in press). This suggests that at least some of the volcanics in the immediate vicinity of the Alamo Schist are of Middle Miocene age.

In two locations, Middle Miocene red beds were found resting unconformably on Alamo Schist. Between these small outcrops, a manganese vein and associated dozer-pit prospects were noted. Red beds overlying the Alamo Schist suggests that it saw daylight prior to deposition of the red beds, sometime prior to about Middle Miocene.

Age

A Relative Probability U-Pb age date for detrital zircons from Alamo Schist protolith is 167 Ma (n=106, middle Jurassic) (Figure 10). This age does not appear to be incompatible with the range of schist ages found at Cemetery Ridge and at the northwest end of the Plomosa Mountains, Arizona (Jacobson and others, 2017; Strickland and others, 2017).

Conclusions

Blue-gray schist occurs along Alamo Road, south of Yucca, and north of Alamo Lake, Arizona. The exposure is ~1.14 mile long ~0.2 mile wide, and occupies ~0.3 square miles. It weathers to low, rounded hills and is best exposed in road cuts and arroyos. Quartz breccia that accompanies the schist is thought to be an intermixing of ocean-floor ribbon quartz and occasional quartz-pebble-bearing turbidites. Cenozoic rhyolite and basalt abut Alamo Schist contacts. Proterozoic granite-gneiss lies as lag gravel on the surface of the Alamo Schist outcrop.

Relative Probability detrital Zircon U-Pb Alamo Schist age is ~167 Ma (Middle Jurassic). This does not appear to be incompatible with U-Pb schist ages at Cemetery Ridge and at Plomosa Mountains. Based on visual comparisons of rock type, texture, weathering patterns, and age, it is possible that Alamo Schist is an Orocopia-type schist.

Acknowledgements

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Selected References

Chapman, Alan, D., 2016, The Pelona-Orocopia-Rand and related schists of southern California – a review of the best-known archive of shallow subduction on the planet: International Geology Review, Taylor & Francis Group, 38 p. doi.org/10.1080/00206814.2016.1230836

Elliott, W.J., and J.L. Corones, 2018, U-Pb age of continental red beds north of Alamo Lake, Arizona: Pacific Section AAPG Convention, Bakersfield, California, April 22-25, 2018, and follow-up article in press.

Google Earth, 2018, Screen shot images.

Grove, Marty, Carl E. Jacobson, Andrew P. Barth, and Ana Vućić, 2003, Temporal and spatial trends of late Cretaceous-early Tertiary under-plating of Pelona and related schist beneath Southern California and Southwestern Arizona, *in* Scott E. Johnson, Scott R. Paterson, John M. Fletcher, Gary H. Girty, David L. Kimbrough, and Arturo Martin-Barajas, eds., Tectonic Evolution of Northwestern Mexico and the Southwestern USA: Geological Society of America, Special Paper 374, p. 381-406.

Grove, M., G.E. Bebout, C.E. Jacobson, A.P. Barth, D.L. Kimbrough, R.L. King, Haibo Zou, O.M. Lovera, B.J. Mahoney, and G.E. Gehrels, 2008, The Catalina Schist - evidence for middle Cretaceous subduction erosion of southwestern North America, *in* A.E. Draut, P.D. Clift, and D.W. Scholl, eds., Formation and Application of the Sedimentary Record in Arc Collision Zones: Geological Society of America, Special Paper 436, p. 355-361.

Haxel, G.B., and J.T. Dillon, 1978, The Pelona-Orocopia schist and Vincent-Chocolate mountain thrust system, southern California, *in* D.G. Howell, and K.A. McDougall, eds., Mesozoic Paleogeography of the Western United States: Pacific Section, Society of Economic Paleontologists and Mineralogists, Pacific Coast Paleogeography Symposium 2, p. 453-469.

Haxel, Gordon B., David B. Smith, Charles Whittington, Andrew Griscom, Denny V. Diveley-White, Robert E. Powell, and Terry J. Kreidler, 1988, Mineral resources of the Orocopia Mountains wilderness study area, Riverside County, California: United States Geological Survey, Bulletin 1710, Chapter E, 22 p.

Haxel, Gordon B., Carl E. Jacobson, Sephen M. Richard, Richard M. Tosdal and Michael J. Grubensky, 2002, The Orocopia Schist in southwest Arizona - early Tertiary oceanic rocks trapped or transported far Inland, *in* Andrew Barth, ed., Contributions to Crustal Evolution of the southwestern United States: Geological Society of America, Special Paper 365, p. 99-128.

Haxel, Gordon B., and Carl E. Jacobson, 2013-a, Alpine peridotite in the Arizona desert - new discovery of Orocopia Schist and included serpentinized peridotite in southwest Arizona: Geological Society of America, Abstracts with Programs, Fresno, CA., v. 45/6, p. 71.

Haxel, Gordon B., and Carl E. Jacobson, 2013-b, Partially serpentinized mantle peridotite in newly discovered subduction complex, southwest Arizona: Contents of poster presented to the Cordilleran Section of the Geological Society of America, Fresno, May 2013, 9 p.

Hershey, O.H., 1902, Some crystalline rocks of Southern California: American Geologist, v. 29, p. 273-290.

Hsu, Kenneth, 2002, Pelona Schist, Perry Ehlig, and the archipelago model of orogenesis, *in* Andrew Barth, ed., Contributions to Crustal Evolution of the Southwestern United States: Geological Society of America, Special Paper 365, p. 155-159.

Jacobson, Carl E., Andrew P. Barth, and Marty Grove, 2000, Late Cretaceous protolith age and provenance of the Pelona and Orocopia schists, Southern California - implications for evolution of the Cordilleran margin: Geological Society of America, Geology, v. 28/3, p. 219-222.

Jacobson, Carl E., Marty Grove, Mathew M. Stamp, Ana Vućić, Felix R. Oyarzabal, Gordon B. Haxel, Richard M. Tosdal, and David R. Sherrod, 2002, Exhumation history of the Orocopia Schist and related rocks in the Gavilan Hills area of southeasternmost California, *in* Andrew Barth, ed., Contributions to Crustal Evolution of the Southwestern United States: Geological Society of America, Special Paper 365, p. 129-154.

Jacobson, Carl E., Marty Grove, Ana Vućić, Jane N. Pedrick, and Kristin A. Ebert, 2007, Exhumation of the Orocopia Schist and associated rocks of southeastern California - relative roles of erosion, synsubduction tectonic denudation, and middle Cenozoic extension, *in* M. Cloos, W.D. Carlson M.C. Gilbert, J.G. Liou, and S.S. Sorensen, eds., Convergent Margin Terranes and Associated Regions - A Tribute to W.G. Ernst: Geological Society of America Special Paper 419, p. 1-37.

Jacobson, Carl E., Marty Grove, Jane N. Pedrick, Andrew P. Barth, Kathleen M. Marsaglia, George E. Gehrels, and Jonathan A. Nourse, 2011, Late Cretaceous - early Cenozoic tectonic evolution of the Southern California margin inferred from provenance of trench and forearc sediments: Geological Society of America Bulletin, v. 123/3/4, p. 485-506.

Jacobson, Carl E., Jeremy K. Hourigan, Gordon B. Haxel, and Marty Grove, 2017, Extreme latest Cretaceous-Paleocene low-angle subduction-zircon ages from Orocopia Schist at Cemetery Ridge, southwestern Arizona, USA: Geology (Geological Society of America), v. 45/10, p. 951-954.

Jacobson, Carl E., Felix R. Oyarzabal, and Gordon B. Haxel, 1996, Subduction and exhumation of the Pelona-Orocopia-Rand schists, southern California: Geology (Geological Society of America), v. 24/6, p. 647-550.

Reis, Jonathan Hunter, 2009, Jurassic and Cretaceous tectonic evolution of the southeast Castle Dome Mountains, Southwest Arizona: M.S. Thesis, Iowa State University, 108 p.

Richard, Stephen M., and David R. Sherrod, 1993, Introduction to Tertiary stratigraphy of the area south of Interstate-10, Arizona and California, *in* David R. Sherrod and Jane E. Nielson, eds., Tertiary stratigraphy of highly extended terranes, California, Arizona, and Nevada: United States Geological Survey, Bulletin 2053, p. 171-175.

Sherrod, David R., and Richard M. Tosdal, 1991, Geologic setting and Tertiary structural evolution of southwestern Arizona and southeastern California: Journal of Geophysical Research, v. 96/B-7, p. 12,407-12,423.

Spencer, Jon E., and Stephen Reynolds, 1989, Introduction to the geology and mineral resources of the Buckskin and Rawhide mountains, *in* J.E. Spencer and S.J. Reynolds, eds., 1989, Geology and Mineral Resources of the Buckskin and Rawhide Mountains, West-Central Arizona: Arizona Geological Survey Bulletin 198, p. 1-10.

Spencer, Jon E., Stephen M. Richard, George E. Gehrels, James D. Gleason, and William R. Dickinson, 2011, Age and tectonic setting of the Mesozoic McCoy Mountains Formation in western Arizona, USA: Geological Society of America Bulletin, 17p. doi: 10.1130/B30206.1

Stephenson, Doug, 2000, The Orocopia Schist and the geology of Picacho State Recreation Area, southeast California: San Diego Association of Geologists annual fall field trip guidebook, 6 p.

Strickland, Evan D., John S. Singleton, Andrew T.B. Griffin, and Nikki M. Seymour, 2017, Geologic map of the northern Plomosa Mountains metamorphic core complex, Arizona: Arizona Geological Survey, Tucson, Arizona, and Geosciences at Colorado State University, online publication, map scale 1:10,000, contour interval 10 meters.

United States Geological Survey, 1979, Alamo Lake, Arizona, 30’x60’ topographic map, scale 1:100,000, contour interval 50 meters.

United States Geological Survey, 1990-a, Artillery Peak, Arizona, 7½’ topographic map, scale 1:24,000, contour interval 40’.

United States Geological Survey, 1990-b, Signal, Arizona, 7½’ topographic map, scale 1:24,000, contour interval 20’.

United States Geological Survey, 2014, McCracken Peak, Arizona, 7½' topographic map, scale 1:24,000, contour interval 40'.

Wilson, E.D., and R.T. Moore, 1959, Geologic map of Mohave County, Arizona: Arizona Bureau of Mines, University of Arizona, Tucson, Arizona, scale: 1:375,000, contour interval 500 feet.

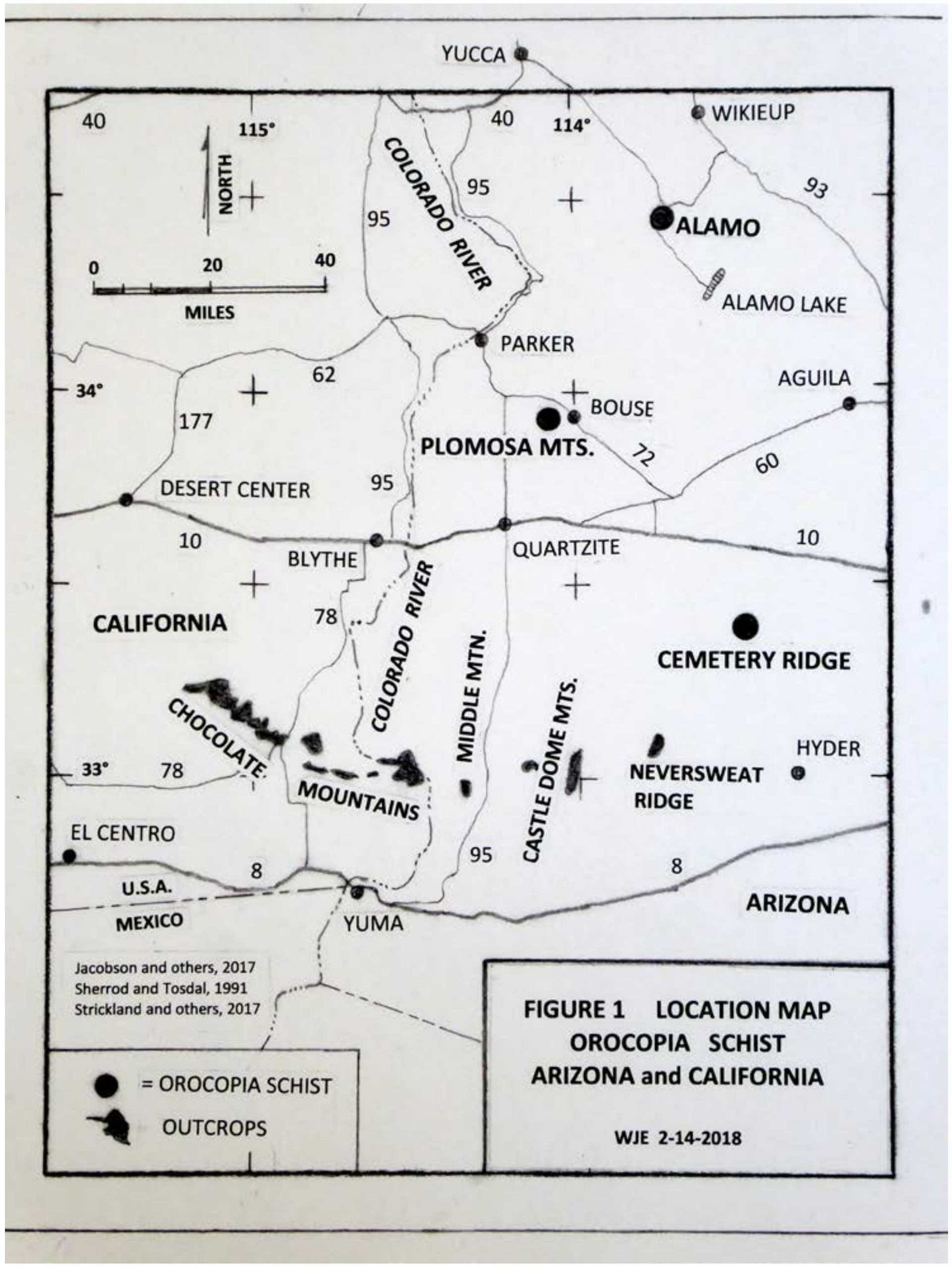

Figure 1. Location map of Orocopia Schist in Arizona and California.

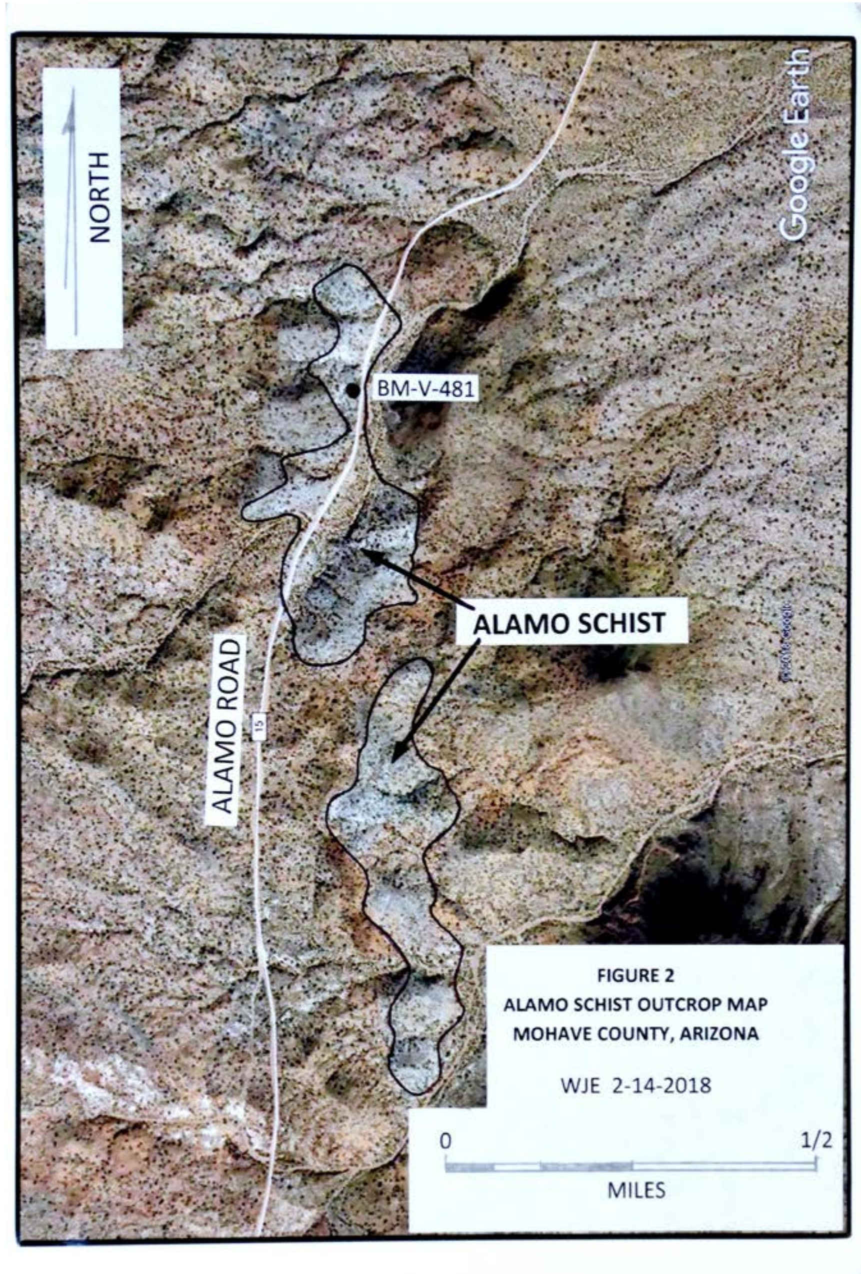

Figure 2. Google Earth image of Alamo Schist outcrop along Alamo Road between Yucca and Alamo Lake in Mohave County, Arizona.

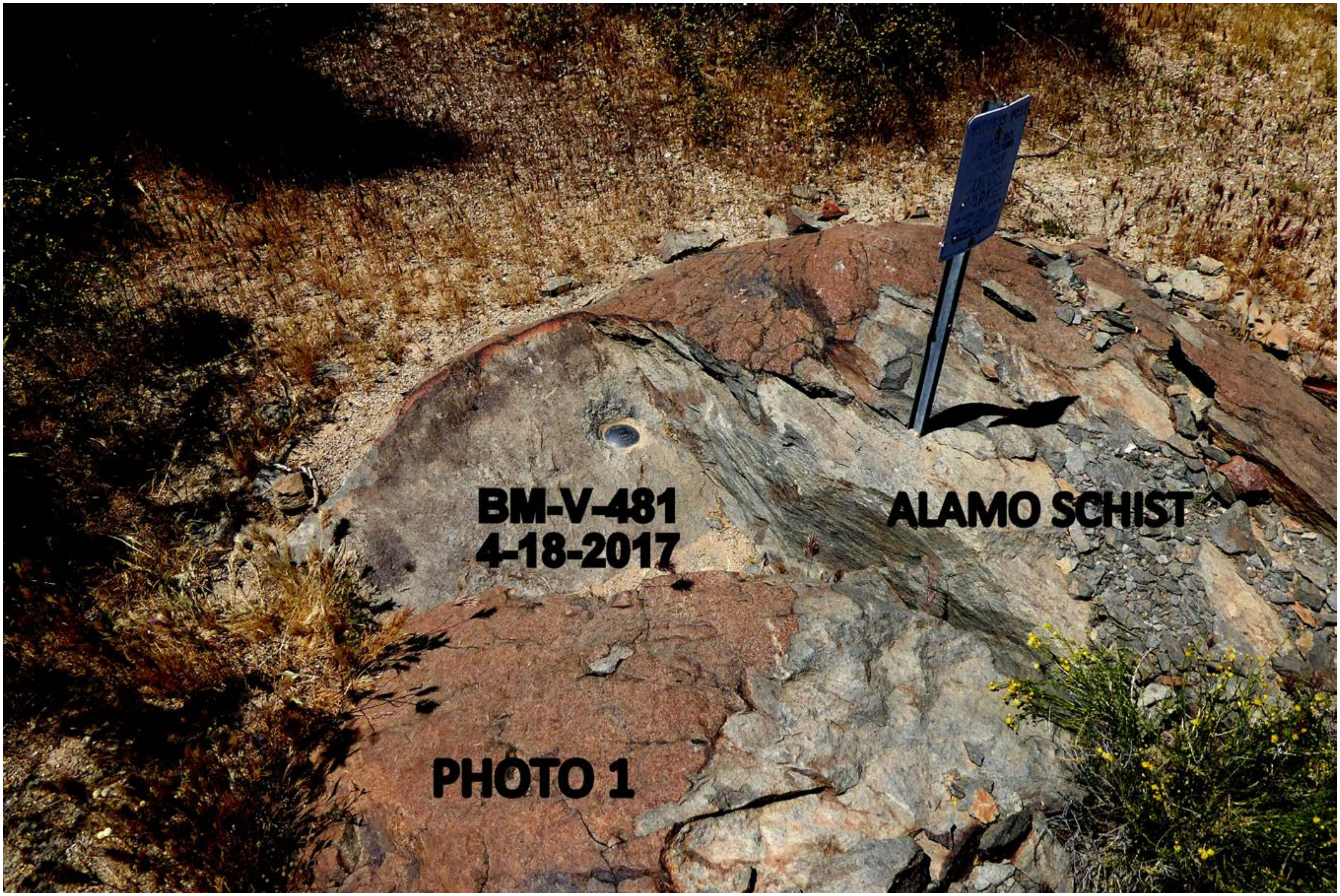

Figure 3. National Geodetic Survey Bench Mark BM-V-481 (1981) is cemented into a large boulder of Alamo Schist on the west side of Alamo Road (Figure 2).

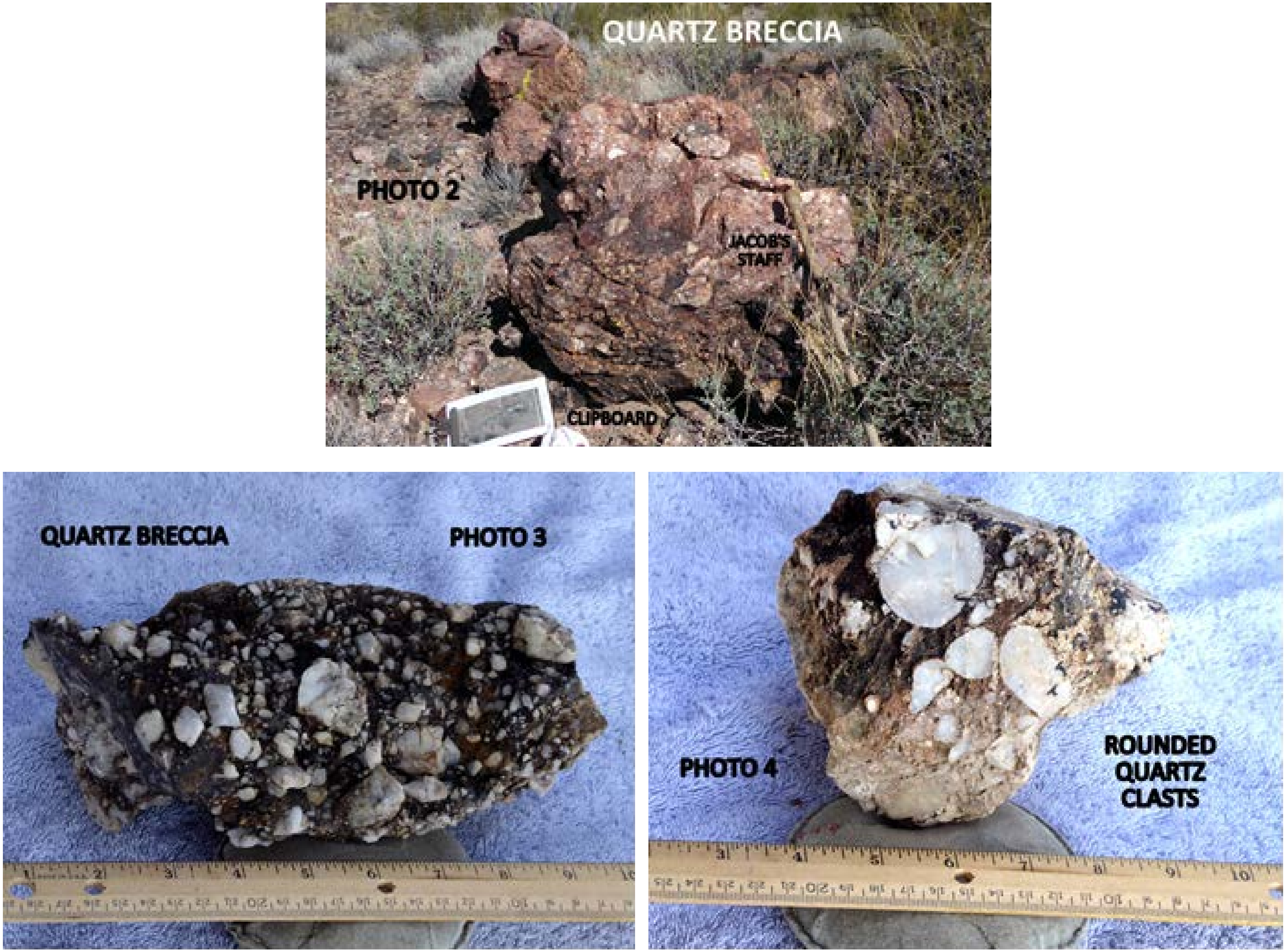

Figure 4. An integral part of the Alamo Schist outcrop is a milky-white quartz breccia (Photos 2 and 3). Included with this breccia are well-rounded, pebble-sized milky-white quartz clasts (Photo 4).

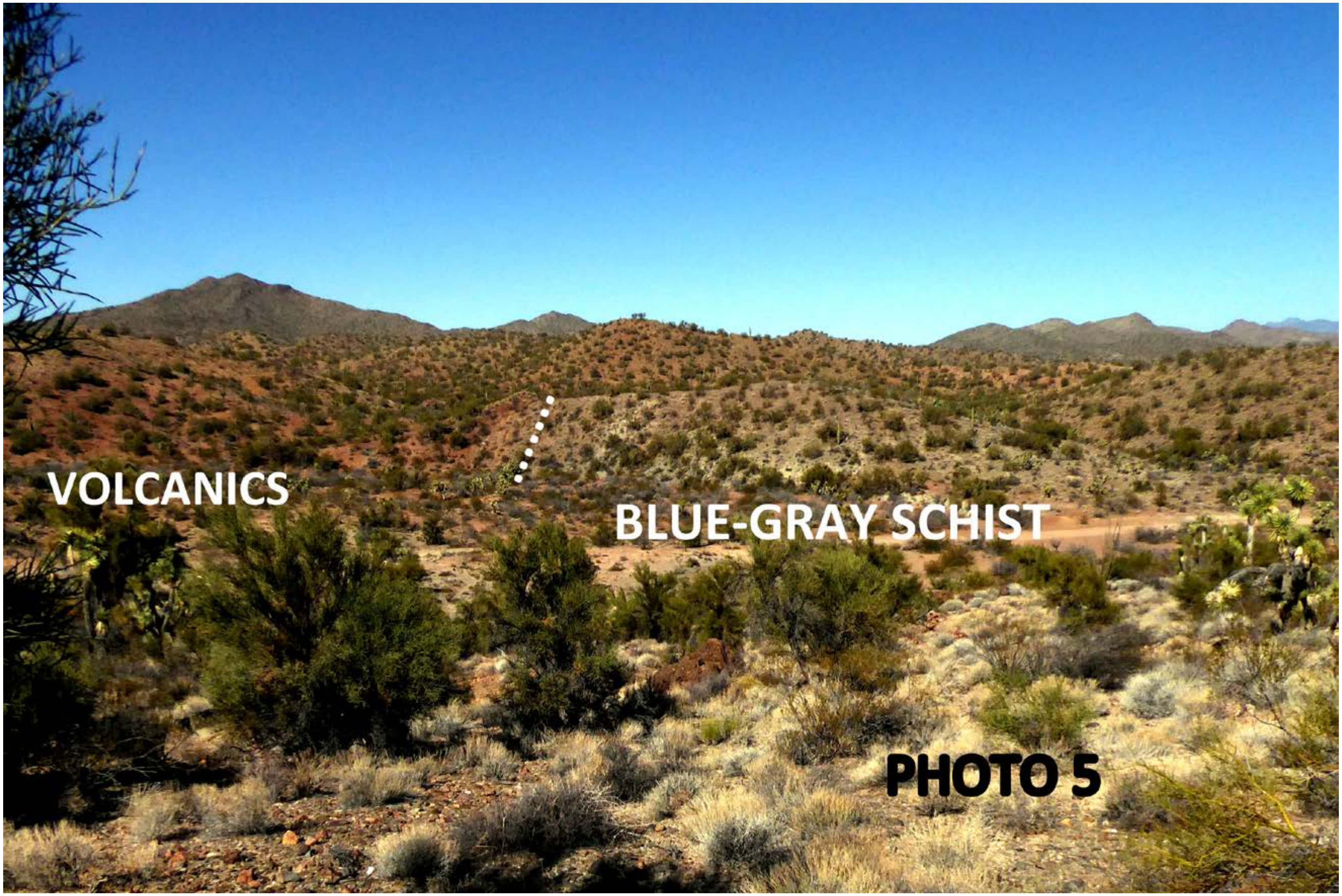

Figure 5. As observed at the northwest end of the Plomosa Mountains, Arizona, and at Cemetery Ridge, Arizona, Alamo Schist (shown above) also weathers deeply to produce subdued outcrops and low rounded hills. Red rhyolite is exposed to the left and in the hills beyond the blue-gray Alamo Schist.

Figure 6. Relatively fresh outcrops of Alamo Schist are usually found in road cuts, in deep arroyos, and as shown here, occasionally on ridge lines.

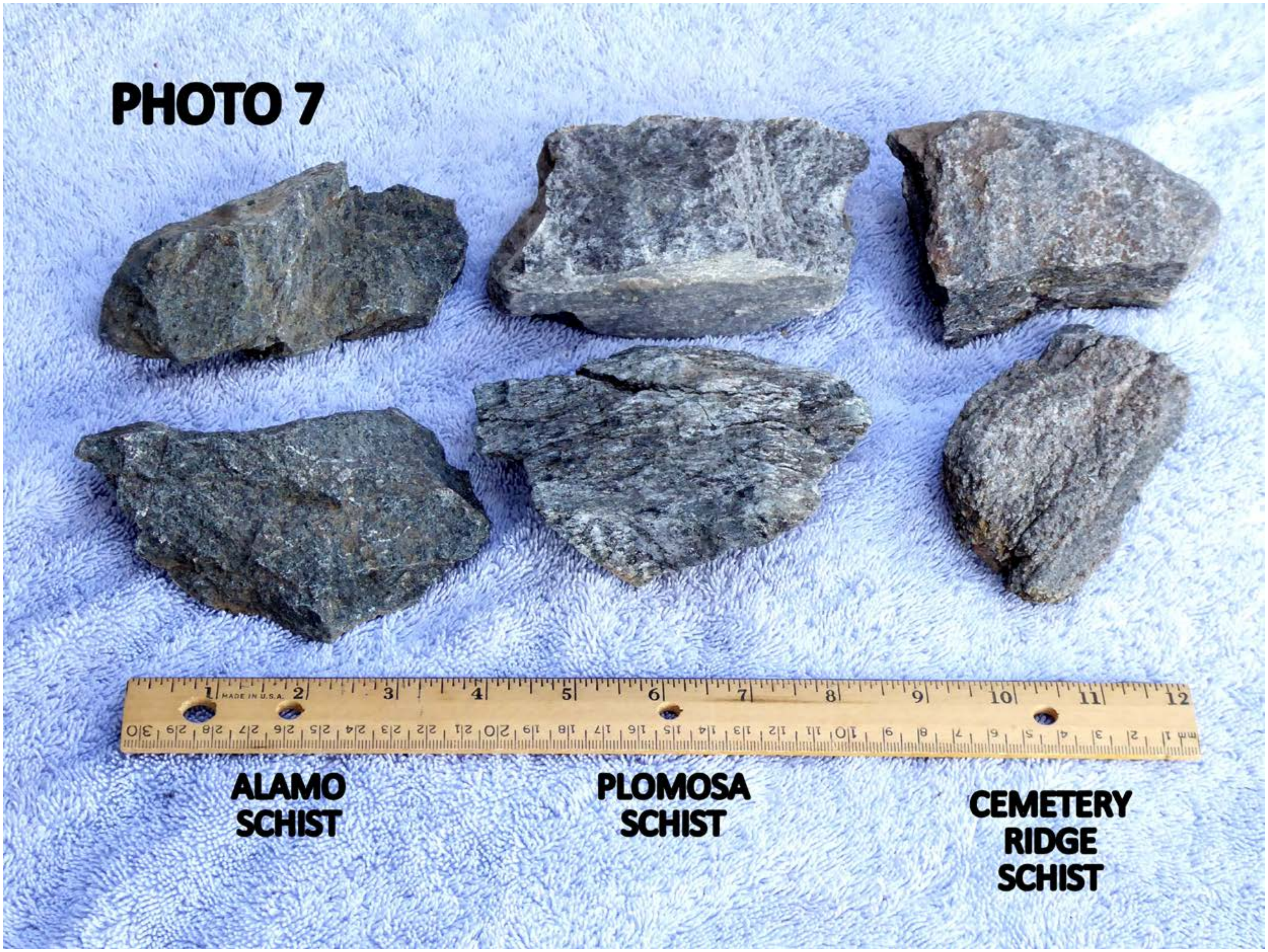

Figure 7. A visual comparison of Alamo Schist hand-samples with hand-samples from the northwestern Plomosa Mountains, Arizona, and Cemetery Ridge, Arizona, shows that with the exception of expected natural variations, they are all but indistinguishable from one another. Although not shown above, these same similarities were observed in hand-samples from Shavers Well, and from the narrows of Painted Canyon in the northern Orocopia Mountains, California.

Figure 8. Proterozoic granite-gneiss boulders were found on the present-day erosion surface of the Alamo Schist. These clasts likely represent remnants (lag gravel) of continental crust, under which the Alamo Schist protolith was underplated while riding along on top of the Farallon Plate.

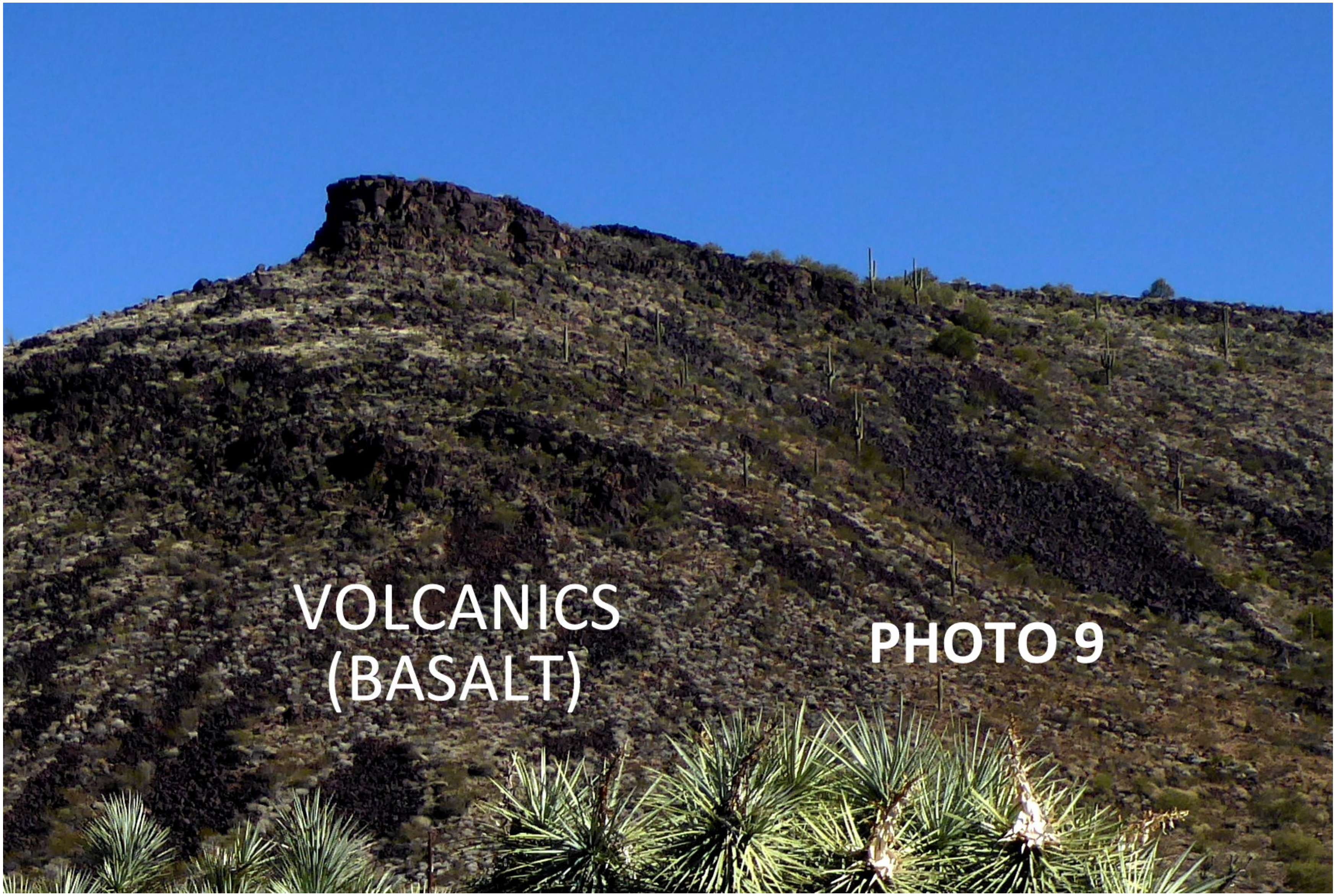

Figure 9. Outcrops of black basalt (this figure) and red rhyolite (Figure 5) surround Alamo Schist. In one place, a small outcrop of rhyolite intrudes Alamo Schist – suggesting that it is younger than the schist. Besides volcanic rocks, the remaining geology in the general area of the Alamo Schist consists of Quaternary alluvium, fan deposits and terraces.

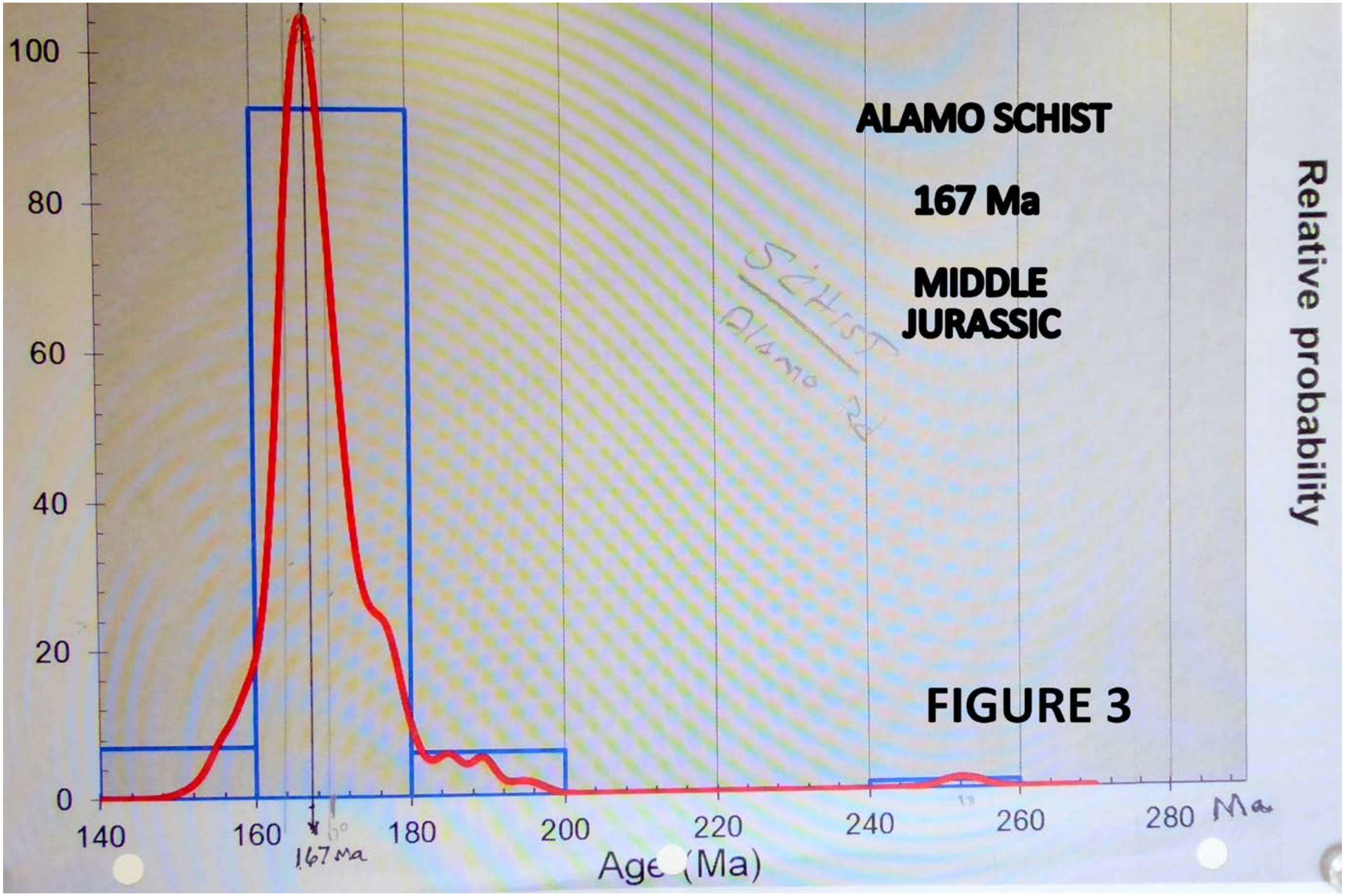

Figure 10. A Relative Probability U-Pb age date for detrital zircons from Alamo Schist protolith is 167 Ma (n=106, Middle Jurassic).