

TABLE 1DR. Compilation of geochronologic ages of Laramide rocks of Sonora east of isochron 70 Ma shown in Figure 14.

**VOLCANIC ROCKS**

ROCK	AGE	METHOD	COORDINATES	LOCALITY	AUTHOR
UAKA 78-20 (rhyo)	40.6 ± 1.1	K-Ar (wr)	29°43'18"N; 109°45'15"W	Oposura mine	Damon et al. (1983)
Andesite	43.2 ± 1.1	K-Ar (wr)	30° 24'; 109° 42'	La Florida	Damon et al. (1983)
Dacite	43.7 ± 0.2	<sup>40</sup> Ar/ <sup>39</sup> Ar (pl)		Santa Rosa	Gans (1997)
Latite	52.5± 1.3	K-Ar (bi)		La Caridad mine	Damon et al. (1983)
Volcanic rock	52.9 ± 0.9	K-Ar (wr)			Pubellier et al. (1995)
Riolite	54.3 ± 0.92	<sup>40</sup> Ar/ <sup>39</sup> Ar (pl)		Santa Rosa	Gans (1997)
Riolite	55.3± 2.1	K-Ar (bi)	28° 27' 28" N; 109° 21' 32" E		Roldan Quintana et al. (2009)
Riolite	56.8 ± 0.9	K/Ar (bi)	28° 24'15" N; 109° 14' 13"		Roldan Quintana et al. (2009)
Andesite	56.7± 1.2	<sup>40</sup> Ar/ <sup>39</sup> Ar (bi)	573087E; 3413081N		Damon et al. (1983)
Dacite	58.67 ± 0.17	<sup>40</sup> Ar/ <sup>39</sup> Ar (bi)		Arizpe , Cerro Las Jarill González-León et al. (2000)	
Andesite	60 ± 0.5	<sup>40</sup> Ar/ <sup>39</sup> Ar (pl)		Santa Rosa	Gans (1997)
Andesite	61.2 ± 3.4	K/Ar (pl)	28° 24'45" N; 109° 05' 10" E		Roldan Quintana et al. (2009)
Andesite	64.2±2.5	U-Pb (zr)		La Caridad mine	Valencia et al. (2005)
Andesite	65.7±2.5	K-Ar (bi)		Cerro Las Conchas	Pubellier et al. (1995)
Volcanic rock	65.9 ± 0.4	K-Ar (wr)		Cerro Las Conchas	Pubellier and Rangin (1987)
Riodacite	65.8± 0.4	<sup>40</sup> Ar/ <sup>39</sup> Ar (bi)	576331E; 3421872N		Cox et al. (2006)
Riodacite	66.0 ± 0.4	<sup>40</sup> Ar/ <sup>39</sup> Ar (bi)	30° 55' 44"; 110° 12'03"	EI Alacran	USGS (this work)
Dacite	69.1 ± 0.40	<sup>40</sup> Ar/ <sup>39</sup> Ar (bi)	30°53'13" ; 110°13'00"		USGS (this work)
Rhyodacite	69 ± 0.2	<sup>40</sup> Ar/ <sup>39</sup> Ar (bi)		North of Cananea	Wodzicki (1995)
Dacite	69.1± 0.4	<sup>40</sup> Ar/ <sup>39</sup> Ar (bi)	574863E; 3417160N		Cox et al. (2006)
Ignimbrite	69.7 ± 0.6	U-Pb (zr)		Central Sonora	McDowell et al. (2001)
Crystal tuff	70.2 ± 0.6	U-Pb (zr)		Central Sonora	McDowell et al. (2001)
Tuff	71± 0.35	<sup>40</sup> Ar/ <sup>39</sup> Ar (san)	31° 10' 17", 110° 15' 47"		USGS (this work)
Andesite	72.6 ± 1.2	<sup>40</sup> Ar/ <sup>39</sup> Ar (bi)	30°54'28" and 110°14'24"	Cananea	USGS (this work)
Tuff	72.5 ± 0.5	U-Pb (zr)		central Sonora	McDowell et al. (2001)
Tuff	72.6 ± 0.8	U-Pb (zr)		central Sonora	McDowell et al. (2001)
Dacite	72.6± 1.2	<sup>40</sup> Ar/ <sup>39</sup> Ar (bi)	572635E; 3419487N		Cox et al. (2006)
Andesite	72.1± 0.4	<sup>40</sup> Ar/ <sup>39</sup> Ar (bi)		Bacoachi	USGS (this work)
Tuff	73.4 ± 0.18	<sup>40</sup> Ar/ <sup>39</sup> Ar (san)	31° 14' 57" ; 110° 22'18"		USGS (this work)
Andesite	73.6 ± 1	U-Pb (zr)		La Caridad	Rascón Heimpel et al., 2010
Volcanic rx	74.6 ± 3.7	K-Ar (wr)		Cerro Las Conchas	Pubellier and Rangin (1987)
?	76	U-Pb (zr)	"...near EI Tuli..."		McDowell et al. (2001)
Dacite	89.0 ± 0.8	U-Pb (zr)		Central Sonora	McDowell et al. (2001)
Tuff?	90.1 ± 0.7	U-Pb (zr)		Central Sonora	McDowell et al. (2001)

**PLUTONIC ROCKS**

g	41.8 ± 0.7	U-Pb (zr)	3244858N; 576850E	Granito Oquimonis	González-Becuar (2010)
gd	49.1 ± 0.8	U-Pb (zr)	3258270N; 573580E	Puerta del Sol, Ures	González-Becuar (2010)
99-98 (g)	49.9±2	Rb/Sr(hb)	28°26'30"N; 109°06'37"W		Roldán-Quintana et al., 2009
Gabbro	51.1 ± 0.8	<sup>40</sup> Ar/ <sup>39</sup> Ar (pl)	3278.0N; 660.0E	Las Rastritas ranch	Almirudis-Echeverría, 2010
UAKA74-162 (po)	51.0±1.1	K-Ar (pl)		San Felipe	Damon et al., 1983b
gd	51±6	<sup>40</sup> Ar/ <sup>39</sup> Ar (bi)		Cumobabi mine	Zuñiga Hernández, 2010
P-3 (po)	52.6±1.6	U-Pb (zr)		La Caridad mine	Valencia et al., 2005
SO-15 (gd)	54.3±2.9	K-Ar (hb)	3136.1N; 643.6E	La Caridad mine	Roldán-Quintana et al., 2009
P-1 (mz)	54.3±1.7	U-Pb (zr)		El Crestón	Valencia et al., 2005
SO-8 (g)	55	K-Ar (wr)	3179.5N; 557.8E	La Caridad mine	Housh and McDowell, 2005
gd	55	K-Ar		Cumobabi mine	Leon and Miller, 1981
G-1 (gd)	55.5±1.9	U-Pb (zr)		La Caridad mine	Valencia et al., 2005
G-2 (gd)	55.6±1.7	U-Pb (zr)		La Caridad mine	Valencia et al., 2005
(qm)	55.6±0.3	K-Ar (wr)		Cumobabi mine	Scherkenbach et al., 1985
(di)	56.0±5.1	K-Ar (bi)		Cumobabi mine	Scherkenbach et al., 1985
MV-5	56.3±0.5	<sup>40</sup> Ar/ <sup>39</sup> Ar (hb)		Suaqui	Valencia-Moreno et al., 2006
SR-83 (gd)	56.7 ± 0.2	<sup>40</sup> Ar/ <sup>39</sup> Ar (hb)		Santa Rosa	Gans, 1997
UAKA73-148 (qm)	56.8 ± 1.2	K-Ar (bi)	30°26'48"N; 109°26'47"W	Batamote	Damon et al., 1983
gd	56.9	K-Ar(wr)		Bella Esperanza	Housh and McDowell, 2005
CH98-11d (gd)	56.9	K-Ar (wr)	3348.3N; 625.5E	Puerta del Sol, Ures	Housh and McDowell, 2005
g	57±3	U-Pb (zr)		San Javier	Anderson et al., 1980
UAKA 81-02 (di)	57.4±1.4	K-Ar (mx)	28°36'03"N; 109°36'04"W		Damon et al., 1983
SO-63 (gd)	57.6±0.9	K-Ar (ms)	28°24'13"N; 110°14'30"W	La Caridad mine	Roldán-Quintana et al., 2009
D-1 (di)	58.3±2	U-Pb (zr)		Sierra Mazatlán	Valencia et al., 2005
gd	58±3	U-Pb (zr)			Anderson et al., 1980
SO-35 (gd)	58.2±3.3	K-Ar (hb)			Roldán-Quintana et al., 2009
SO-5 (gd)	59	K-Ar (wr)	3159.9N; 631.8E	Cananea mine	Housh and McDowell, 2005
po	59.9±2	K-Ar (bi)		Maycoba	Damon et al., 1983a
59-96	59.1 ±0.33	<sup>40</sup> Ar/ <sup>39</sup> Ar (hb)			Valencia-Moreno et al., 2006
SO-26 (gd)	60	K-Ar (wr)	3173.0N; 513.3E	La Caridad	Housh and McDowell, 2005
(po)	60.2±0.8			City Hermosillo	Rascón Heimpel et al., 2010
MV-15 (gd)	60.5±0.33	<sup>40</sup> Ar/ <sup>39</sup> Ar (hb)		Rebeico	Valencia-Moreno et al., 2006
UAKA81-01 (mz)	61.2±1.4	K-Ar (wr)	28° 53' 06"N; 109° 48' 54"W	San Javier	Damon et al., 1983
UAKA 80-07 (gd)	62.0 ±1.7	K-Ar (hb)	28°37'N; 109°53'18"W		Damon et al., 1983
MV-19	62.0±1	U-Pb (zr)	28°53'51"N; 109°54'16"W	Barita de Sonora	Poole et al., 1991
SO-80 (gd)	62.0±3	K-Ar (hb)	28°17'10"N; 109°47'00" W		Roldán-Quintana et al., 2009
MA-1 (gd)	62.7±1	K-Ar bt	12R 3142.4N, 730.2E		Roldán-Quintana et al., 2009
MV-10 (gd)	62.9±1.5	K-Ar (hb)		Cumobabi mine	Damon et al., 1983
(mz)	63.1 ±1.7	K-Ar (bi)			Scherkenbach et al., 1985

g	63.3 ±1.4	$^{40}\text{Ar}/^{39}\text{Ar}$ (bi)	3278.0N; 660.0E	Las Rastritas ranch	Almirudis-Echeverría, 2010
TP-2B (gd)	63.3 ±3.3	$^{40}\text{Ar}/^{39}\text{Ar}$ (hb)	28°25'N; 109°11'E	Santa Rosa	Meade et al., 1988
SO-64 (gd)	63.4±1	K-Ar (bt)	3140.5N; 591.3E		Housh and McDowell, 2005
SO-80a (tn)	63.4±2.5	Rb/Sr(hb)	28°16'38"N; 109°44'19"W		Roldán-Quintana et al., 2009
CH-98-17 (gd)	63.6	K-Ar (pl)	3306.6N: 652.0E		Housh and McDowell, 2005
CR H 12 (g)	63.6±3.2	K/Ar (wr)		Sierra Chiltepin	Pubellier et al., 1995
M-120 (mz)	63.9± 2	U-Pb (zr)		La Caridad mine	Valencia Gómez, 2005
gd	64± 3	U-Pb (zr)		Cuitaca grd	Anderson and Silver, 1977
UAKA 81-06 (gd)	64.1±1.4	K-Ar (bt)	29°05'20" N; 110°56'08" W	Hermosillo	Damon et al., 1983
SO-74 (di)	64.9±1.7	K-Ar (bt)	28°18'15"N; 110°08'00"W		Roldán-Quintana et al., 2009
SO-2 (gd)	65	K-Ar (wr)	31566.0N; 606.9 E		Housh and McDowell, 2005
UAKA 80-20 (gd)	65.9±1.6	K-Ar (bt)	28°50'322N; 110°12'20"W	Cobachi	Damon et al., 1983
SO-7	66	K-Ar (wr)	31.66.3N; 588.0E		Housh and McDowell, 2005
99-SF-04 (g)	66.0±2	U-Pb (zr)	487250E; 3370400N	El Llano mine	Poulsen et al., 2008
99-SF-05 (gd)	66.5±0.5	U-Pb (zr)	487150E; 3370400N	El Llano mine	Poulsen et al., 2008
UAKA80-20	66.7± 1.6	K-Ar (bt)	28° 50' 32"N; 110° 12' 20"W	Cobachi	Damon et al., 1983
SO-3 (gd)	67	K-Ar (wr)	3164.7N; 624.1E		Housh and McDowell, 2005
B-59 (gd)	67.97 ± 0.19	$^{40}\text{Ar}/^{39}\text{Ar}$ (bi)		Bacanuchi	González-León et al., 2000
di	68.2±1.3	$^{40}\text{Ar}/^{39}\text{Ar}$ (bi)	3278.0N; 660.0E	Las Rastritas ranch	Almirudis-Echeverría, 2010
PED-3960 (qm)	68.7 ± 1.7	K-Ar (bi)	30°57'49"N; 110°34'44"W	Torreón	Damon et al., 1983
MV-11 (gd)	68.7±1.1	$^{40}\text{Ar}/^{39}\text{Ar}$ (hb)		Hermita	Valencia-Moreno et al., 2006
99-SF-03 (qm)	68.3±3.2	U-Pb (zr)	487175E; 3356200N	El Llano mine	Poulsen et al., 2008
	68.3±0.3			Benjamin Hill	Castillón González et al., 2010
mz	69±1	U-Pb (zr)		Chivato, Cananea	Anderson and Silver, 1977
03-11 (mz)	88.7± 1	U-Pb (zr)		Bacanora	Pérez-Segura et al., 2009
03-107 (tn)	90.6±1	U-Pb (zr)		Bacanora	Pérez-Segura et al., 2009

Tn, tonalite; mz, monzonite; qm, quartz monzonite; gd, granodiorite; g, granite; di, diorite; po, porphyry; bi, biotite, hb, hornblende; wr, whole rock; zr, zircon; pl, plagioclase; mx, matrix; ms, muscovite

## REFERENCES

- Almirudis Echeverría, E., 2010, Petrogenésis y geocronología  $^{40}\text{Ar}/^{39}\text{Ar}$  del plutonismo Laramídico en el área Sobai Satechi, Sonora [Bachelor thesis]: Hermosillo, Universidad de Sonora, 103 p.
- Anderson, T.H., Silver, L.T., 1977, U-Pb isotope ages of granitic plutons near Cananea, Sonora: Economic Geology, v. 72, p. 827-836
- Castillón González, J., Herrera Urbina, S., Iriondo, A., and Paz Moreno, F.A., 2010, Petrogenésis de intrusivos laramídicos y Proterozoicos al sur de Benjamin Hill, Sonora central, México in Valencia-Moreno, M., and Manea, M., eds. La Orogenia Laramide del SW de Norte América, Simposio GeoLaramide, Universidad Nacional Autónoma de México y Universidad de Sonora, resúmenes, p. 41.
- Cox, D.P., Miller, R.J., and Woodburne, K., 2006, The Laramide Mesa Formation and the Ojo de Agua Caldera, Southeast of Cananea Copper Mining District, Sonora, Mexico: USGS Scientific Investigations Report 2006-5022, 7 p.
- Damon, P.E., Shafiqullah, M., Roldán-Quintana, J., and Cochemé, J.J., 1983, El batolito Laramide (90–40 Ma) de Sonora: Asociación de Ingenieros de Minas, Metalurgistas y Geólogos de México (AIMMGM), Memoria técnica XV, p. 63–95.
- Gans, P.B., 1997, Large-magnitude Oligo-Miocene extension in southern Sonora: implications for the tectonic evolution of northwest Mexico: Tectonics,

- v. 16, no. 3, p. 388-408.
- González Becuar, E., 2011, Geología, geoquímica y geocronología del área de Puerta del Sol, Sonora central, México [Bachelor thesis]: Hermosillo, Universidad de Sonora, 65 p.
- González-León, C., McIntosh, W.C., Lozano-Santacruz, R., Valencia-Moreno, M., Amaya-Martínez, R., and Rodríguez Castañeda, J.L., 2000, Cretaceous and Tertiary sedimentary, magmatic, and tectonics evolution of north-central Sonora (Arizpe and Bacanuchi quadrangles), northwest Mexico: Geological Society of America Bulletin, v. 112, no. 4, p. 600-611.
- Housh, T.B., and McDowell, F.W., 2005, Isotope provinces in Laramide and mid-Tertiary igneous rocks of northwestern Mexico (Chihuahua and Sonora) and their relation to basement configuration in Anderson, T. H., Nourse, J. A., McKee, J., and Steiner, M.B., eds., The Mojave-Sonora megashear hypothesis: development, assessment, and alternatives: Geological Society of America Special Paper 393, p. 671-692, doi: 10.1130/2005.2393(25).
- León, F., and Miller, J., 1981, Opodepe Molybdenum-Copper Porphyry Deposit, in Ortlieb, L., and Roldán-Quintana, J., eds., Geology of Northwestern Mexico and Southern Arizona: Geological Society of America, Cordilleran Section Annual Meeting, Field Guides and Papers, p. 223-238.
- McDowell, F. W., Roldán-Quintana, J., and Connelly, J.N., 2001, Duration of Late Cretaceous–early Tertiary magmatism in east-central Sonora, Mexico: Geological Society of America Bulletin, vol. 113, pp. 521-531, 2001.
- Pérez-Segura, E., González-Partida, E., and Valencia, V.A., 2009, Late Cretaceous adakitic magmatism in east-central Sonora, Mexico, and its relation to Cu-Zn-Ni-Co skarns: Revista Mexicana de Ciencias Geológicas, v. 26, p. 411-427.
- Pubellier, M., and Rangin, C., 1987, Mise en évidence d'une phase cenomano-turonien en Sonora central (Mexique). Conséquences sur les relations structurales entre domaine cordillerain et domain tethysien: C.R. Acad. Sci. Paris, t. 305, Serie II, p. 1093-1098.
- Pubellier, M., Rangin, C., Rascón, B., Chorowicz, J., Bellon, H., 1995, Cenomanian thrust tectonics in the Sahuaripa region, Sonora: implications about northwestern megashears, in Jacques-Ayala, C., González-León, C.M., Roldán-Quintana, J. (eds.), Studies in the Mesozoic of Sonora and adjacent areas: Geological Society of America, Special Paper 301, p. 111-120.
- Poulsen, K.H., Mortensen, J.K., and Walford, P.C., 2008, San Francisco gold deposit, Santa Ana region, Sonora, Mexico: Laramide orogenic, intrusion-related mineralization? In Spencer, J.E., and Titley, S.R., eds., Ores and orogenesis: Circum-Pacific tectonics, geologic evolution, and ore deposits: Arizona Geological Society Digest, v. 22, p. 547-559
- Rascón Heimpel, M., Valencia-Moreno, M., Ochoa Landin, L., Calmus, T., and Martínez Muller, R., 2010, Geología y geoquímica del prospecto pórfido cuprífero Los Alisos, distrito minero de Nacozari, Sonora, México in Valencia-Moreno, M., and Manea, M., eds. La Orogenia Laramide del SW de Norte América, Simposio GeoLaramide, Universidad Nacional Autónoma de México y Universidad de Sonora, resúmenes, p. 37.
- Roldán-Quintana, J., McDowell, F. W., Delgado-Granados, H., and Valencia-Moreno M., 2009, East-west variations in age, chemical and isotopic composition of the Laramide batholith in southern Sonora, Mexico: Revista Mexicana de Ciencias Geológicas, v. 26, p. 543-563.
- Scherkenbach, D.A., Sawkins, F. J., and Seyfried,W. E., Jr., 1985. Geologic, fluid inclusions, and geochemical studies of the mineralized breccias at Cumobabi, Sonora, Mexico: Economic Geology, vol. 80, p. 1566-1592.
- Valencia, V.A., Ruiz, J., Barra, F., Gehrle, G.E., Ducea, M., Titley, S.R., and Ochoa-Landin, L., 2005, U-Pb zircon and Re-Os molybdenite geochronology from La Caridad porphyry copper deposit: insights for the duration of magmatism and mineralization in the Nacozari District, Sonora, Mexico: Mineralium Deposita, v. 40, p. 175–191.
- Valencia-Moreno, M.A., Iriondo, A., and González-León, C.M., 2006, Temporal constraints on the eastward migration of the Late Cretaceous-Early Tertiary magmatic arc of NW Mexico based on Ar/Ar hornblende geochronology of granitic rocks: Journal of South American Earth Sciences, v. 22, p. 22-38.
- Wodzicki, W.A., 1995, The evolution of Laramide igneous rocks and porphyry copper mineralization in the Cananea district, Sonora, Mexico [Ph.D. thesis]: Tucson, The University of Arizona, 181 p.
- Zuñiga Hernández, L.G., 2010, Estudio geológico, geoquímico y metalognético del cuadrángulo Huépac-Moctezuma, centro-norte de Sonora, México [Ms. thesis]: Hermosillo, Universidad de Sonora, 126 p.