Revista Mexicana de Ciencias Geológicas, volumen 11, número 2,
1994, p. 253-256
Universidad Nacional Autónoma de México, Instituto de Geología,
México, D.F.

CALC-ALKALINE VOLCANIC ROCKS IN THE PRE-UPPER JURASSIC BASEMENT OF SOUTH-CENTRAL MEXICO—A LATE PALEOZOIC-EARLY MESOZOIC CONVERGENT PLATE MARGIN?

*Zoltan de Cserna,**
*Jerjes Pantoja-Alor,**
Mariano Elías-Herrera, and*
*José Luis Sánchez-Zavala**

INTRODUCTION

The limited extension of geological map coverage, the metamorphism of varying degrees that affected the rocks and their almost complete lack of fossils, make the basement beneath the marine fossiliferous Upper Jurassic and/or Lower Cretaceous sedimentary and volcanic cover rocks to be an unsolved geological problem in south-central Mexico, a region comprising about 20,000 km^2 (Figure 1). Radiometric ages (Pb-α, K-Ar, Rb-Sr, U-Pb) obtained from these rocks are apparently contradictory or not conclusive (de Cserna *et al.*, 1962; de Cserna, Fries, Rincón-Orta, Westley, Solorio-Munguía and Schmitter-Villada, 1974; de Cserna, Fries, Rincón-Orta, Solorio-Munguía and Schmitter-Villada, 1974; Guerrero-García *et al.*, 1978; Urrutia-Fucugauchi and Linares, 1981; López-Infanzón and Grajales-Nishimura, 1984; Morán-Zenteno *et al.*, 1990; Morán-Zenteno, 1992). The various paleogeographic and paleotectonic reconstructions advanced so far are merely hypothetical models (de Cserna, 1958, 1976; Ortega-Gutiérrez, 1981; Campa-Uranga and Coney, 1983; Sedlock *et al.*, 1993). One important question regarding this basement refers to the nature of the plate-tectonic scenario in which these rocks were formed; accordingly, the authors have chosen to examine the chemical character of the volcanic rocks contained in the younger greenschist-facies package of the pre-Upper Jurassic and/or Lower Cretaceous basement in south-central Mexico.

GEOLOGIC SETTING

The pre-Upper Jurassic and/or Lower Cretaceous basement in south-central Mexico, roughly between meridians 99° and 100°30'W (Figure 1), consists of an older package of amphibolite-facies metasedimentary, metavolcanic, and metaplutonic complex (the Xolapa Complex; de Cserna, 1965). This complex is covered by a younger greenschist-facies package, consisting of metasedimentary and metavolcanic units (the Taxco Schist [Fries, 1960], the Ixcuinatoyac Formation [Klesse, 1968] and the Ayotusco Formation [Díaz-García, 1980]), a metavolcanic and to a lesser extent metavolcaniclastic unit (the Taxco Viejo Greenstone [Fries, 1960; de Cserna and Fries, 1981]), and a quartzitic continental redbed with associated volcanic rocks unit (the Chapolapa Formation [de Cserna, 1965]). This younger greenschist-facies basement package contains several unconformities and is beveled by an erosion surface over which the Upper Jurassic and/or Lower Cretaceous marine cover was deposited. Such a cover consists chiefly of limestone, in the east, and grades westward into a carbonate-volcaniclastic-volcanic sequence that, at places, shows the effects of a low-grade (prehnite-pumpellyite facies) metamorphism (Sánchez-Zavala and Elías-Herrera, 1991).

For this inquiry, six localities in south-central Mexico were examined, which were mapped previously by the present authors (Figure 1), and collected representative rock samples from the volcanic intervals of the various lithostratigraphic units of the younger greenschist-facies basement package.

SAMPLED STRATIGRAPHIC UNITS

The so far known oldest lithostratigraphic unit of the younger greenschist-facies basement package is the Taxco Schist or its correlative unit, the Ixcuinatoyac Formation. Volcanic intervals in the Taxco Schist were sampled at two localities. The first of these is at an excellent outcrop along the Tejupilco-San Lucas del Maíz dirt road in southwestern State of Mexico (Figure 1, locality A); here, the analysed sample (Table 1, sample A) comes from a well-foliated andesite metalava (de Cserna, 1982; Elías-Herrera, 1989). The second sampling locality is about 160 km south-southeast of the previous one. It is at the left abutment of the La Venta dam on the river Papagayo (Figure 1, locality F), about 6 km southwest of Tierra Colorada in south-central State of Guerrero, and about 7 km east of the type locality of the Xolapa Complex (de Cserna, 1965). The analysed sample (Table 1, sample F) is a foliated volcaniclastic rock of dacite composition. It should be noted that the original reconnaissance mapping of this area carried out almost 40 years ago shows these rocks as Chapolapa Formation (de Cserna, 1965); however, based on our present knowledge of the regional distribution of the Taxco Schist, we consider the La Venta dam locality to be the Taxco Schist and not the Chapolapa Formation.

The Taxco Viejo Greenstone unconformably covers the Taxco Schist. This relation is either the expression of a flat tectonic contact between the two, or it reflects that the Taxco Viejo Greenstone is the youngest lithologic unit within the Taxco Schist. The Taxco Viejo Greenstone was sampled at three localities (Figure 1, localities B, C, and D), which are

**Instituto de Geología, Universidad Nacional Autónoma de México, Ciudad Universitaria, Delegación Coyoacán, 04510 D.F., México.*

Figure 1.- Map showing the localities where volcanic rock samples (black triangles with capital letters) were collected from the younger greenschist-facies package of the pre-Upper Jurassic and/or Lower Cretaceous basement in south-central Mexico.

Table 1.- Major- and trace-element analytical data of six volcanic rock samples from the younger, greenschist-facies package of the pre-Upper Jurassic and/or Lower Cretaceous basement in south-central Mexico. For location of samples see text and Figure 1.

SAMPLE	A	B	C	D	E	F
SiO_2 [%]	58.24	49.80	59.42	61.72	61.41	54.64
TiO_2	0.76	1.18	0.90	0.97	0.79	0.96
Al_2O_3	16.18	14.85	16.78	15.23	17.00	16.24
Fe_2O_3	3.66	1.60	2.01	2.53	5.84	2.32
FeO	3.96	8.04	2.66	1.69	0.45	5.38
MnO	0.14	0.16	0.06	0.07	0.09	0.14
MgO	3.88	6.55	4.84	3.00	2.77	5.45
CaO	6.85	8.39	3.11	6.45	1.04	7.49
Na_2O	2.85	2.68	3.71	3.08	6.11	4.38
K_2O	1.50	1.63	2.18	1.45	2.58	0.48
P_2O_5	0.08	0.20	0.14	0.17	0.14	0.14
LOI	2.67	4.18	3.34	3.69	2.28	2.47
Total	100.61	98.86	98.87	99.71	100.22	99.79
Ba [ppm]	681	407	585	597	685	283
Nb	17	24	8	17	12	10
Rb	32	50	39	29	82	11
Sr	365	269	339	513	209	268
Y	22	20	17	18	37	23
Zr	159	136	177	150	258	146
La	10	15	11	10	18	9
Ce	19	30	23	21	38	17
Nd	<10	<10	<10	12	<10	11
Sm	3.3	3.9	3.2	3.3	5.3	3.1
Eu	0.9	1.2	1.0	1.0	0.8	0.9
Yb	2	2	2	2	3	2
Lu	0.3	0.2	0.2	0.2	0.4	0.3
Sc	21.6	28.3	19.6	22.4	20.4	30.5
Tb	<1	<1	<1	<1	<1	<1
Th	2.5	3.2	3.0	2.3	8.5	2.1
Tm	<10	<10	<10	<10	<10	<10
U	1	1	1	<1	2	<1
Cs	1.5	4.9	2.0	1.4	4.2	<0.5
Hf	2.5	2.0	3.1	2.4	4.6	2.0
Ta	<1	<1	<1	1.1	<1	<1

LOI: Loss on ignition at 950°C.

Major-element analyses were performed by A. Lozano-Cobo in the Geochemistry Laboratory of the Instituto de Geología, Universidad Nacional Autónoma de México.

Trace-element analyses were performed in the North Vancouver, Canada, laboratories of Bondar Clegg & Co.

within the confinement of the Taxco quadrangle (de Cserna and Fries, 1981). The first of these is about one kilometer north of Zacualpan along the road to the El Regenerador adit (Díaz-García, 1980); the sample was obtained from a poorly foliated andesite metalava (Table 1, sample B). The second and third localities are practically side by side, about 3 km east of Tonatico along the highway to Taxco. In this area, the outcropping lithology of the Taxco Viejo Greenstone consists of foliated metalahar. A representative sample of the matrix of this lahar (Table 1, sample C) resulted in an andesitic to dacitic composition, while a representative clast, not as well foliated as the matrix, turned out to be a dacite (Table 1, sample D).

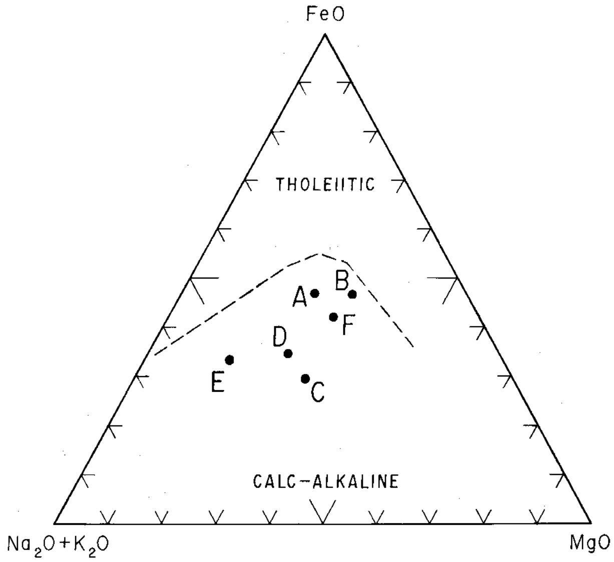

Figure 2.- AFM diagram showing typical calc-alkaline differentiation trend of volcanic rocks in the younger greenschist-facies package of the pre-Upper Jurassic and/or Lower Cretaceous basement in south-central Mexico. The samples identified by capital letters are the same as those in Figures 1 and 3, and in Table 1.

The Chapolapa Formation is the so far known youngest lithostratigraphic unit of the younger, greenschist-facies package of the pre-Upper Jurassic and/or Lower Cretaceous basement in south-central Mexico. At places, the lower parts of the Chapolapa Formation appear to change laterally into the Taxco Viejo Greenstone (de Cserna, 1965); however, much more work is needed to prove such relations conclusively. A sequence of redbeds with interbedded lava flows of the Chapolapa Formation has excellent exposures along the bed of river Chapolapa in the outskirts of Acahuizotla (de Cserna, 1965; Figure 1, locality E), about 25 km SSE of Chilpancingo in south-central State of Guerrero. At this locality, the sampled volcanic rock (Table 1, sample E) is from a dark gray dacite flow that is interbedded in a sequence of reddish-purple, poorly sorted conglomerate whose pebbles are poorly rounded milky quartz; the entire sequence has a weakly developed foliation.

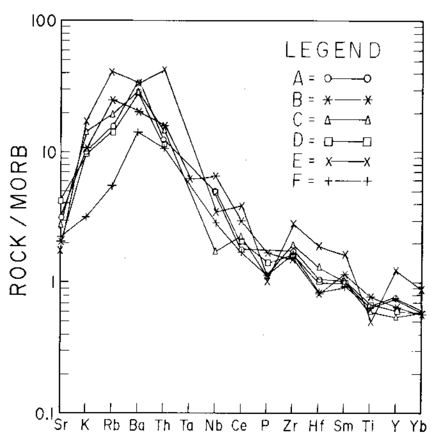

Figure 3.- MORB-normalized trace element variation diagram for volcanic rock samples from the younger greenschist-facies package of the pre-Upper Jurassic and/or Lower Cretaceous basement in south-central Mexico. Samples identified by capital letters are the same in Figures 1 and 2, and in Table 1.

CONCLUSIONS

The analytical results obtained on these rock samples are given in Table 1. The major element analytical data were plotted on the classical AFM diagram (Figure 2) on which the typical calc-alkaline trend can be observed. The trace element analytical data were plotted on a MORB-normalized trace element variation diagram (Figure 3). It can be observed, on this diagram, the significant enrichment in Sr, K, Rb, Ba, and Th, which, because of their low ionic potential, tend to mobilize by aqueous solutions in compressive environments associated with convergent plate margins (Pearce, 1982).

Considering the above new data, the authors feel that the earlier proposed continental growth for south-central Mexico through the welding of successive orogenic belts from the west still appears to be a feasible geotectonic model (de Cserna, 1958, 1965, 1976; Rogers *et al.*, 1974), and that the more recently proposed models continue being hypothetical until greater extensions are covered with good quality geological mapping and the supporting geochemical investigations.

ACKNOWLEDGMENTS

The authors are grateful for the critical review of the manuscript by Prof. John J.W. Rogers; and for the correction of the same by M. Alcayde and A. Gómez-Caballero. The illustrations were kindly prepared by E. Monroy-Soto and J. Osorio. The costs of trace element analyses and expenses of field work were defrayed from CONACYT grants D112-903504 and P021-CCON892314.

BIBLIOGRAPHICAL REFERENCES

Campa-Uranga, M.F., and Coney, P.J., 1983, Tectono-stratigraphic terranes and mineral resource distributions of Mexico: Canadian Journal of Earth Sciences, v. 20, p. 1040-1051.

Cserna, Zoltan de, 1958, Notes on the tectonics of southern Mexico, *in* Weeks, L.G., ed., Habitat of Oil: Tulsa, American Assocciation of Petroleum Geologists, p. 523-532.

——— 1965, Reconocimiento geológico en la Sierra Madre del Sur de México, entre Chilpancingo y Acapulco, Estado de Guerrero: Universidad Nacional Autónoma de México, Instituto de Geología, Boletín 62, 76 p.

——— 1976, Mexico—geotectonics and mineral deposits, *in* Woodward, L.A., and Northrop, S.A., eds., Tectonics and mineral resources of southwestern North America: New Mexico Geological Society Special Publication 6, p. 18-25.

——— 1982 (1983), Hoja Tejupilco 14Q-g(9), con Resumen de la geología de la Hoja Tejupilco, Estados de Guerrero, México y Michoacán: Universidad Nacional Autónoma de México, Instituto de Geología, Carta Geológica de México, serie de 1:100,000, map and text, 28 p.

Cserna, Zoltan de, and Fries, Carl, Jr., 1981, Hoja Taxco 14Q-h(7), con Resumen de la geología de la Hoja Taxco, Estados de Guerrero, México y Morelos: Universidad Nacional Autónoma de México, Instituto de Geología, Carta Geológica de México, serie de 1:100,000, map and text, 47 p.

Cserna, Zoltan de; Schmitter-Villada, Eduardo; Damon, P.E.; Livingston, D.E.; and Kulp, J.L., 1962, Edades isotópicas de rocas metamórficas del centro y sur de Guerrero y de una monzonita cuarcífera del norte de Sinaloa: Universidad Nacional Autónoma de México, Instituto de Geología, Boletín 64, p. 71-84.

Cserna, Zoltan de; Fries, Carl, Jr.; Rincón-Orta, César; Westley, Harold; Solorio-Munguía, José; and Schmitter-Villada, Eduardo, 1974, Edad precámbrica tardía del Esquisto Taxco, Estado de Guerrero: Boletín de la Asociación Mexicana de Geólogos Petroleros, v. 26, p. 183-193.

Cserna, Zoltan de; Fries, Carl, Jr.; Rincón-Orta, César; Solorio-Munguía, José; and Schmitter-Villada, Eduardo, 1974, Nuevos datos geocronométricos paleozoicos del sur de México: Boletín de la Asociación Mexicana de Geólogos Petroleros, v. 26, p. 195-204.

Díaz-García, Víctor, 1980, Las rocas metamórficas de la región de Zacualpan, Estado de México: Universidad Nacional Autónoma de México, Instituto de Geología, Revista, v. 4, p. 1-12.

Elías-Herrera, Mariano, 1989, Geología metamórfica del área de San Lucas del Maíz, Estado de México: Universidad Nacional Autónoma de México, Instituto de Geología, Boletín 105, 78 p.

Fries, Carl, Jr., 1960, Geología del Estado de Morelos y de partes adyacentes de México y Guerrero, región central-meridional de México: Universidad Nacional Autónoma de México, Instituto de Geología, Boletín 60, 236 p.

Guerrero-García, J.C.; Silver, L.T.; and Anderson, T.H., 1978, Estudios geocronológicos en el Complejo Xolapa: Boletín de la Sociedad Geológica Mexicana, v. 39, p. 22-23 (abstract).

Klesse, Elmar, 1968 (1970), Geology of the El Ocotito-Ixcuinatoyac region and of La Dicha stratiform sulphide deposit, State of Guerrero: Boletín de la Sociedad Geológica Mexicana, v. 31, p. 107-140.

López-Infanzón, Manuel, and Grajales-Nishimura, J.M., 1984, Edades K-Ar de rocas ígneas y metamórficas del Estado de Guerrero: México, D.F., Sociedad Geológica Mexicana, Convención Nacional, 7, Resúmenes, p. 215 (abstract).

Morán-Zenteno, D.J., 1992, Investigaciones isotópicas de Rb-Sr y Sm-Nd en rocas cristalinas de la región de Tierra Colorada-Acapulco-Cruz Grande, Estado de Guerrero: México, D.F., Universidad Nacional Autónoma de México, Unidad Académica de los Ciclos Profesional y de Posgrado del Colegio de Ciencias y Humanidades, Ph.D. dissertation, 187 p. (unpublished).

Morán-Zenteno, D.J.; Koehler, H.; von Drach, V.; and Schaaf, P., 1990, The geological evolution of Xolapa-Terrane, southern Meco, as inferred from Rb-Sr and Sm-Nd isotopic data: München, Geowissenschaftes Lateinamerika Kolloquium, 12, (w/p) (abstract).

Ortega-Gutiérrez, Fernando, 1981, Metamorphic belts of southern Mexico and their tectonic significance: Geofísica Internacional (Mexico), v. 20, p. 177-202.

Pearce, J.A., 1982, Trace element characteristics of lavas from destructive plate boundaries, *in* Thorpe, R.S., ed., Andesites: New York, John Wiley, p. 525-548.

Rogers, J.J.W.; Burchfiel, B.C.; Abbott, E.W.; Anepohl, J.K.; Ewing, A.H.; Koehnken, P.J.; Novitski-Evans, J.M.; and Talukdar, S.C., 1974, Paleozoic and lower Mesozoic volcanism and continental growth in the western United States: Geological Society of America Bulletin, v. 85, p. 1913-1924.

Sánchez-Zavala, J.L., and Elías-Herrera, Mariano, 1991, Metamorfismo de facies de prehnita-pumpellyta en las rocas volcánicas cretácicas de arco de islas de la porción sudoccidental del Estado de México: México, D.F., Universidad Nacional Autónoma de México, Instituto de Geología, Convención sobre la evolución geológica de México, Memoria, p. 201-203 (abstract).

Sedlock, R.; Ortega-Gutiérrez, Fernando; and Speed, R.S., 1993, Tectonostratigraphic terranes and tectonic evolution of Mexico: Geological Society of America, Special Paper 278, 153 p.

Urrutia-Fucugauchi, Jaime, and Linares, Enrique, 1981, K-Ar dating of hydrothermal alteration, Ixtapan de La Sal, Mexico State, Mexico: Isochron/West, no. 31, p. 15.

Manuscript received: September 5, 1994.
Corrected manuscript received: October 14, 1994.
Manuscript accepted: October 19, 1994.