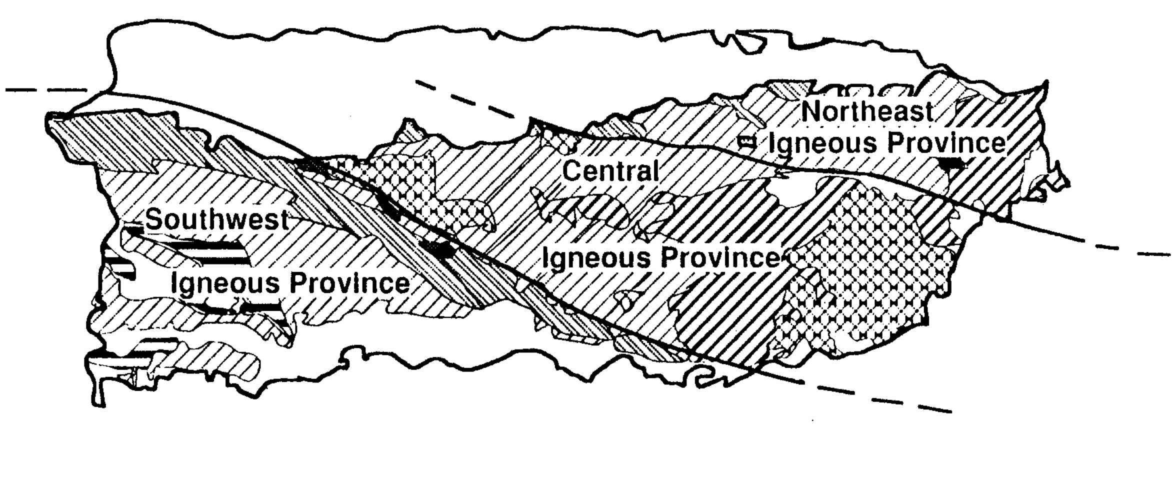
GEOLOGY OF THE EAST COAST OF PUERTO RICO

FIELD GUIDE

CHAUTAUGUA WORKSHOP

APRIL 22-24 1992



DR. JAMES JOYCE
DEPARTMENT OF GEOLOGY
UNIV. OF PUERTO RICO
MAYAGUEZ, PUERTO RICO
OO681-5000

GEOLOGY OF THE EAST COAST OF PUERTO RICO

The purpose of this course and field trip is to familiarize ourselves with the types of rocks that are formed during the transition of the earths crust from iron-magnesium rich, thin (5-7 km) oceanic crust to the potassium, sodium and silica rich thick (30 km) continental crust. This processes is a consequence of the internal production of heat and differentiation of the earths interior into successively less dense shells of rock. Although much of the earths continental mass was formed over 3 billion years ago, this process continues today and results in the current volcanism and seismicity that characterizes the margins of the Caribbean Sea.

Lower density rocks are generated in island arcs by partial melting of the mantle and recycled crust when oceanic crust is consumed by subduction during plate translation and convergence. The resultant molten material rises to the surface to produce volcanoes that both pour forth lava and explode to produce rock fragments, glass, ash and gasses. As the volcanic process continues the crust thickens by addition of volcanic material at the surface and the molten rock evolves to lower density compositions. Much of the later formed, less dense material remains below the surface in large reservoirs or batholiths which further increases the thickness of the crust until it reaches 25-30 km.

Further thickening of the crust may be caused by convergent tectonic processes that can cause folding and thrust stacking of rocks. The combination of these processes at convergent margins may result in crust of double thickness (60 km). Maintenance of over thickened crust is prevented by the elevation of the crust above sea level and resultant erosion and transportation of material away from the center of crustal thickening. When erosion rates are faster than tectonic and magma thickening the crust will reach an equilibrium thickness of 30 km and an elevation of about 1 km. The geology of the east coast of Puerto Rico shows us some beautiful examples of how the crust becomes thickened by magmatic intrusion, lava extrusion and deposition of explosive and eroded volcanic material on the sea floor. The present thickness of crust below Puerto Rico is thought to be about 25 Km.

The geology of eastern Puerto Rico is divided into three sections by the faults of the Cerro Mula Fault Zone. South of the fault zone the east coast is dominated by the plutonic intermediate rocks of the San Lorenzo Batholith and surrounding metamorphosed wall rock. The San Lorenzo Batholith is nearly circular in plan with a diameter of about 20 Km and includes three principal units (Fig. 2) (Cox et al,1977):

1. Diorite and gabbro bodies generally within or close to the border zone of the batholith. (Age 78 Ma., probably a minimum age because these rocks were probably reheated by younger intrusions).

2. Granodiorite - quartz diorite unit which comprises about 75% of the batholith (Average age 73.1 Ma.).

3. Quartz monzonite - quartz diorite unit, large outcrop near Punta Guayanes. (Average age 66 Ma.).

Contact metamorphosed, metasomatized and hydrothermally altered volcanic and sedimentary rock of presumed Early Cretaceous age comprise the boundaries of the batholith. The northern boundary contacts the Pitahaya Formation which is correlated to the Torrecilla Breccia of central Puerto Rico and is therefore of Albian or older age. The Pitahaya Formation is composed of andesitic lavas, lava breccias, volcaniclastic sedimentary rock and discontinuous lenses of limestone. The limestone lenses are metamorphosed to marble and locally replaced by magnetite, some of which form economic deposits (M'Gonigle, 1978).

The Cerro Mula Fault Zone separates rocks of central and northeastern Puerto Rico. Formations on either side of this fault zone can not be correlated across the fault zone. Up to 33 Km of left lateral displacement has been suggested for the fault based on displacement of intrusions and hydrothermal zones. East of Pena Pobre, the Cerro Mula Fault splays into the Pena Pobre Fault on the north and the Pitahaya Fault to the South. Two Cretaceous, andesitic, volcaniclastic sedimentary rock formations, the Rio Abajo and Mambiche Formations only occur between these faults. The Cerro Mula Fault Zone strongly controls the geomorphology of the region and notably separates the El Yunque highlands to the north from the lower hills to the south.

North of the Cerro Mula Fault Zone, the east coast is dominated by a conformable sequence of Early Cretaceous basaltic-andesitic lavas and volcaniclastic sedimentary rocks (Fig. 3). The entire sequence was deposited in moderately deep marine environments.

Evidence supporting this is the general lack of limestones and the amygdaloidal nature of the pillow lavas. The sedimentary rocks of these sequences are mainly submarine debris flows, turbidites and pelagic mudstones. The volcanic source of the sediments was probably distant from the depositional site and distinct from the source of the local lavas. On the northeast tip of the coast the Early Cretaceous rocks are conformably overlain Late Cretaceous volcaniclastic sedimentary rocks and massive lava. Exposures of these rocks in the Carolina-San Juan area indicates the deposition of volcanic sediment interspersed basaltic-andesitic lava flows continued through Late Cretaceous and into the early Tertiary. Nearly 14 Km of lava and volcanic sediment accumulated on the sea floor over a period of about 75 Ma. with over half of this material initially forming in the Albian period (about 20 Ma.). It remains uncertain how much more of this material underlies the oldest exposed Cretaceous formation because underlying oceanic crust is exposed here. Therefore the total thickness of the Cretaceous-Tertiary island arc volcanic material may exceed 14 Km. The volcanic - sedimentary sequences are also gently folded which may have also produced some minor thickening of the crust.

Because of the piling up of volcanic material and the injection of molten rock during this period of earth history, Puerto Rico nearly attained the thickness and composition of typical continental crust. In the future Puerto Rico may be added to a continental mass by collision and accretion or collide with other island arc crust to form a micro-continent. We will explore the coastal geology of eastern Puerto Rico from the south to the north.

STOP-1 CABO MALA PASQUA (PR-30)

The southern end of this point exposes metamorphosed and metasomatised mafic lavas. These lavas are amydaloidal and contain many epidotized portions.

STOP-2 PUNTA TUNA (PR-760, Puerto Maunabo)

The southern end of this point exposes the border between plutonic rocks of the San Lorenzo Batholith and metamorphosed sedimentary and volcanic rocks. Numerous large inclusions of the surrounding country rock can be found in the plutonic rocks.

STOP-3 PUNTA YEQUAS (PR-901, road down to beach on the south)

Exposures along the beach and on the south side of the point are composed of various plutonic rocks.

STOP-4 PUNTA GUAYANES (PR-906, Playa Guayanes)

Exposures on the south side of the point includes many different plutonic rocks including coarse grained granites with double ended quartz crystals.

STOP-5 CERRO MULA FAULT ZONE (PR-31, Pena Pobre)

Cretaceous rocks are poorly exposed in this area. The fault zone, however, is clearly marked by an alluvial valley with well developed river terrace levels that evidence the Quaternary uplift of Puerto Rico.

STOP-6 PLAYA DE NAGUABO (PR-3, Hucares)

Exposures along the coast are of the Daguao lava breccias which are intruded by numerous intermediate dikes.

STOP-7 QUEBRADA SECA (PR-3, quarry on west side)

Quarry exposure of intrusive quartz keratophyre with intermediate dikes.

STOP-8,9 ALDEA CINTRON (PR-3, Construction sites south of town)

North of the highway rock cuts in a new development expose pillow lavas of the Figuera Lava.

South of the highway road cuts for the new highway expose the contact between the Figuera Lava and thick and thin beds of the lower Fajardo Formation.

STOP-10 PLAYA SARDINERA (PR-987, Marina)

Rock cut in the marina exposes a chaotic deposit in the Tabanuco Formation. Large clasts of many rock types including limestones are common in this deposit. The outcrop lies near the hinge of a large syncline shown by northeast trending ridges along the shore and north trending ridges along PR-987.

STOP-11 PLAYA SOROCO (PR-987)

Cabeza Chiquita (west side) exposes sedimentary rocks and lava of the Tabanuco Formation overlain by sedimentary rocks of the Hato Puerco Formation.

Cabezas de San Juan (east side) expose breccias and lava of the Hato Puerco Formation.

STOP-12, 13, 14 NUEVO COMMANDANTE (PR-3, Carolina)

South of the race track road cuts in a private community expose interlayered sandstones and mudstones of the Cambalache Formation cut by a fault splay of the Leprocomio Fault which forms part of the Cerro Mula Fault Zone.

Within the race track grounds on the south side a road cut exposes massive Martin Gonzales Lava. A quarry within the grounds further south exposes a diabase dike of early Tertiary of age.

Road cuts and quarries of the north side of the race track exposes interbedded sandstones and mudstones and pillow lavas of the Frailes Formations. Thrust faults and folds are exposed in the quarry.

References

Briggs, R.P., 1973, The Lower Cretaceous Figuera Lava and Fajardo Formation in the stratigraphy of northeastern Puerto Rico, U.S. Geol. Survey Bull., 1372-G, G1-10.

Briggs, R.P. and Aguilar-Cortés, E., 1980, Geologic map of the Fajardo and Cayo Icacos quadrangles, Puerto Rico: U.S. Geol. Survey Misc. Geol. Inv. Map I-1153.

Cox, D.P., Marvin, R.F., M'Gonigle, J.W., McIntyre, D.H., and Rogers, C.L., 1977, Potassium - argon geochronology of some metamorphic, igneous, and hydrothermal events in Puerto Rico and the Virgin Islands, U.S. Geol. Survey Journ. of Research , 5, 689-703.

M'Gonigle, J.W., 1978, Geologic map of the Humacao quadrangle, Puerto Rico: U.S. Geol. Survey Misc. Inv. Series Map I-1070

M'Gonigle, J.W., 1979, Geologic map of the Naguabo and Punta Puerca quadrangles Puerto Rico: U.S. Geol. Survey Misc. Inv. Series Map I-1099.

Larue, D. K., Smith, A.L., and Schellekens, J. H., 1991. Ocean island arc stratigraphy in the Caribbean region: don't take it for granite. In R. Cas and C. Busby-Spera (Eds.) Volcaniclastic sedimentation. Sedimentary Geology., 74: 289-308

Rogers, C.L., Cram, C.M., Pease, M.H., Jr., and Tischler, M.S., 1979, Geologic map of the Yabucoa and Punta Tuna quadrangles, Puerto Rico: U.S. Geol. Survey Misc. Inv. Series Map I-1086.

Seiders, V.M., 1971a, Geologic map of the Gurabo quadrangle Puerto Rico, U.S. Geol. Survey Misc. Geol. Inv. Map I-657.

Seiders, V.M., 1971b, Geologic map of the El Yunque quadrangle, Puerto Rico: U.S. Geol. Survey Misc. Geol. Map I-658.

Seiders, V.M. 1971c, Cretaceous and Lower Tertiary stratigraphy of the Gurabo and El Yunque quadrangles, Puerto Rico: U.S. Geol. Survey Bull. , v. 1294-F, p.

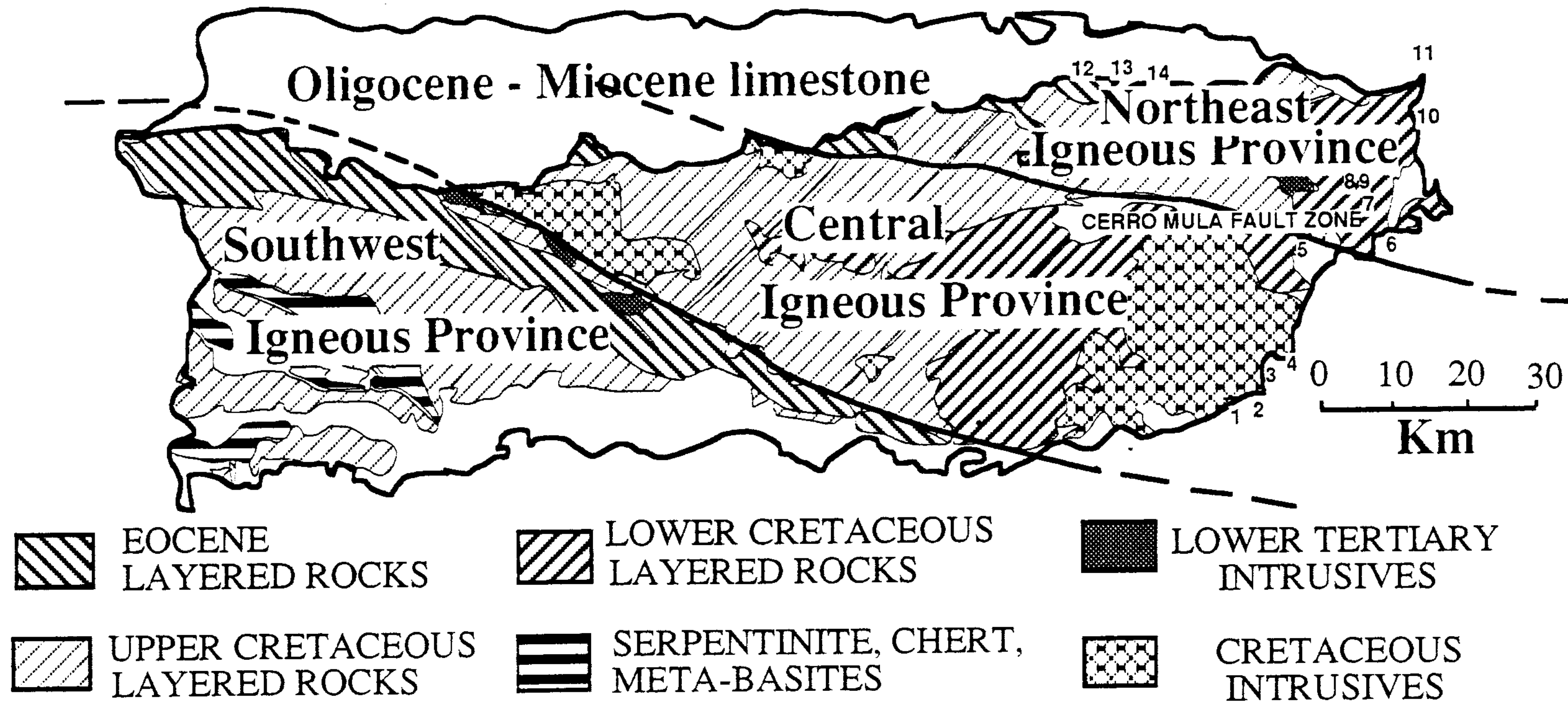


FIGURE 1 GEOLOGIC MAP OF PUERTO RICO (SCHELLEKENS, 1992)

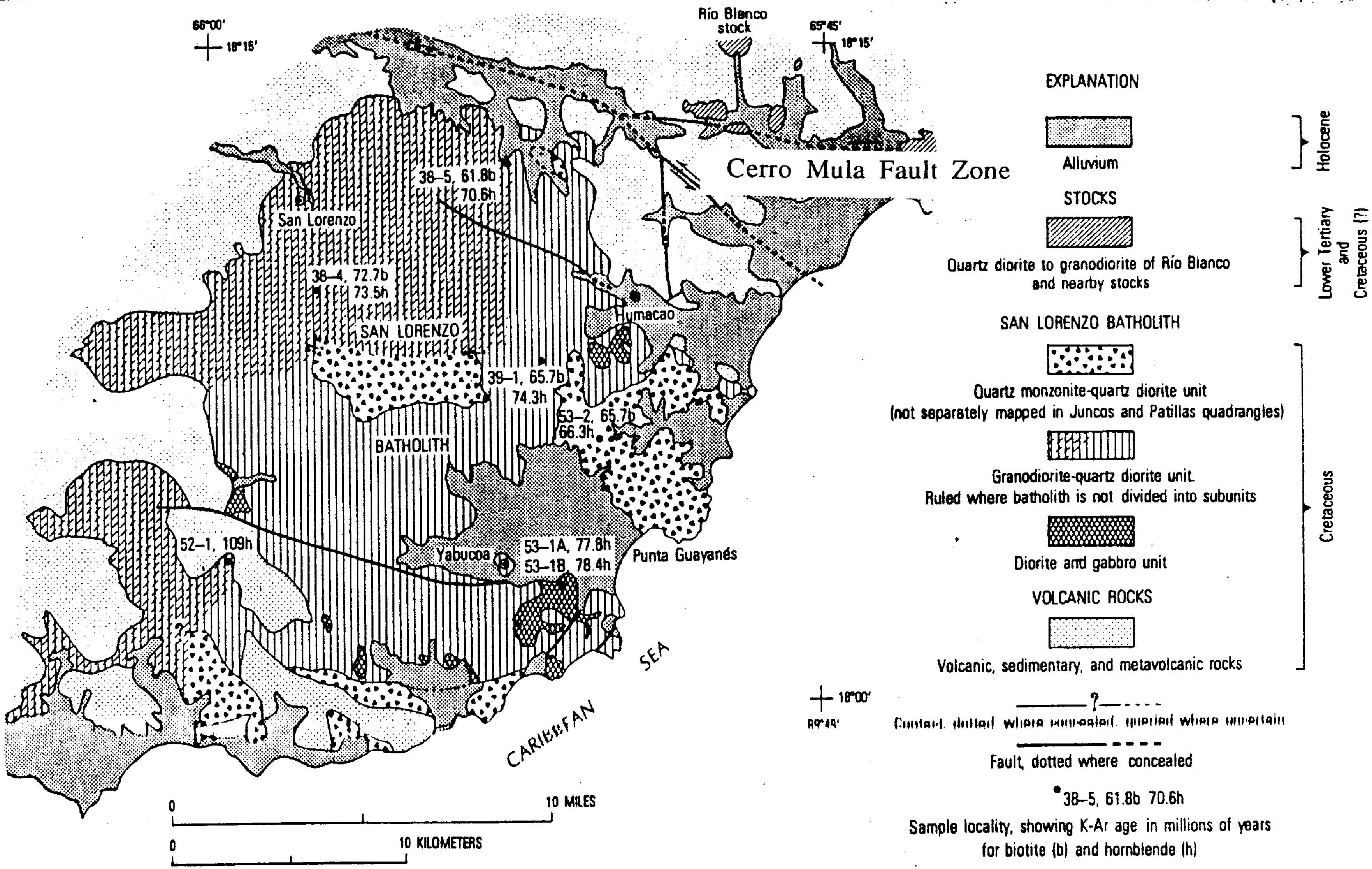
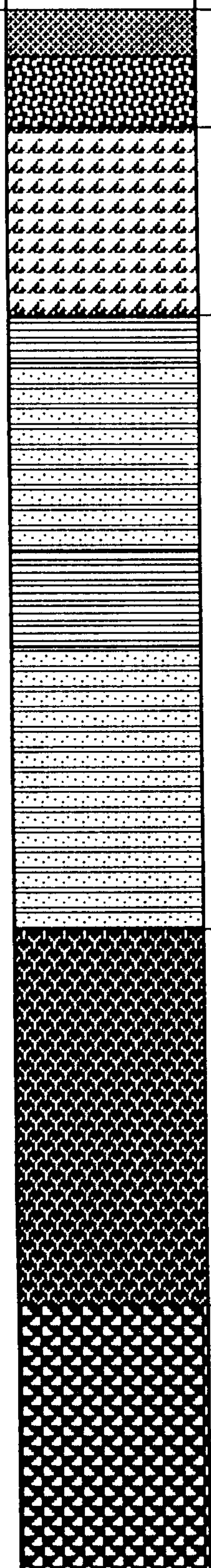


Figure 2 Geologic map of the San Lorenzo Batholith (Cox et al, 1977)

STRATIGRAPHY - EAST COAST



THICK NESS		AGE (Ma.)	DESCRIPTION
8 Km		CENOMANIAN (97.5-91)	HATO PUERCO FORMATION: Andesitic breccia and massive lava
7 Km		ALBIAN (113-97.5)	TABANUCO FORMATION: Calcereous thin to thick bedded mudstone, volcanic sandstone and breccia. Syndepositionally deformed.
6 Km 5 Km 4 Km		ALBIAN (113-97.5)	FAJARDO FORMATION The Fajardo is composed of two sequences of thick bedded, tuffaceous, volcaniclastic breccias, sandstone and mudstones overlain by thin bedded mudstone dominated units. Clasts include andesite, pumice and scoria.
3 Km 2 Km			FIGUERA LAVA Basaltic-andesitic lava with intercalations of volcaniclastic breccia and tuff. The lava ranges from massive to brecciated to pillowed. Clinopyroxene and plagioclase are dominant constituents and amygdales are common.
1 Km 0 Km			DAGUAO FORMATION Andesitic breccia, lava and subordinate volcanic sandstones and crystal tuff. Volcanics and sediments are composed of plagioclase and pyroxene crystals.

Figure 3

STRATIGRAPHY OF CAROLINA SECTIONS

THICK NESS		AGE (Ma.)	DESCRIPTION
14 Km			
		OLIG-MIO (30-15)	SAN SEBASTIAN-AYMAMON FORMATIONS: Terrigenous clay-sand overlain by limestone
		unconformity EOC-PALEOCENE (36.6 -66.4)	RIO PIEDRAS SILTSTONE: Thin bedded mudstone and sandstone.
13 Km		PALEOCENE(66.4-57.6)	MONOCILLO AND GUARACANAL FORMATIONS: Limestone, mudstone, and basalt.
12 Km		disconformity CAMPANIAN (84-74.5)	FRAILES FORMATION: Thick-thin bedded, andesitic-dacitic sandstone, breccia, conglomerate and mudstone with intercalated pillow lava.
			MARTIN GONZALES LAVA: Basaltic andesite, massive lava.
11 Km		SANTONIAN (87.5-84)	CANOVANAS FORMATION: Basaltic volcanic sandstone rich in clinopyroxene.
		TURONIAN (91-88.5)	CAMBALCHE FORMATION: Andesitic breccia, sandstone, mudstone and lava.
10 Km 9 Km		CENOMANIAN (97.5-91)	HATO PUERCO FORMATION: Thick bedded basaltic-andesitic breccias and sandstones with subordinate interbedded sandstone and mudstone. Also contains rare shallow water limestone clasts.

Figure 4

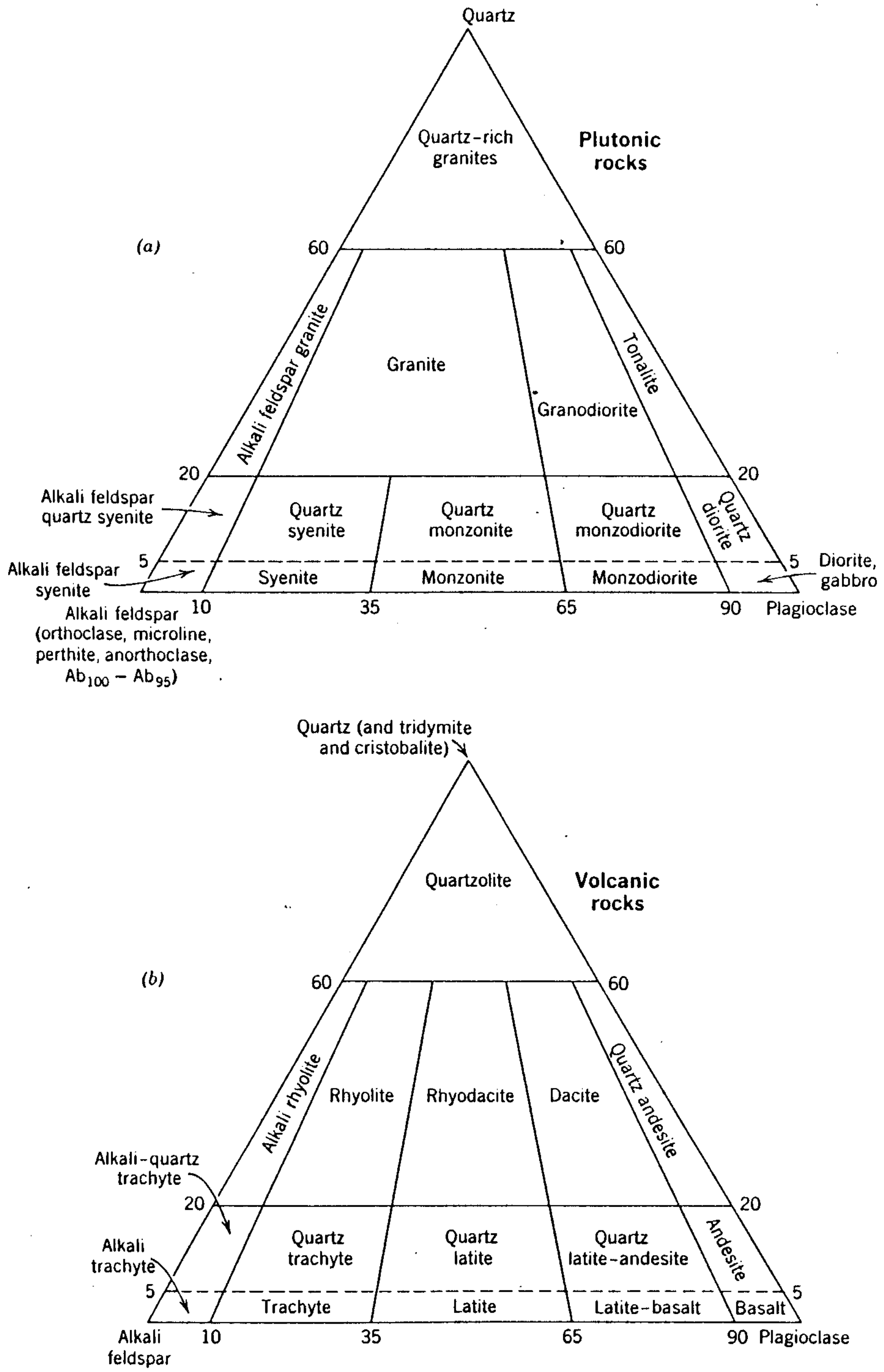


FIG. 12.13. General classification and nomenclature of some common plutonic rock types *(a)* and some common volcanic rock types *(b)*. This classification is based on the relative percentages of quartz, alkali feldspar, and plagioclase, measured in volume percent (adapted from Subcommission on the Systematics of Igneous Rocks, *Geotimes*, 1973, v. 18, no. 10, pp. 26–30 and Hyndman, D. W., 1972, *Petrology of Igneous and Metamorphic Rocks*, McGraw-Hill Book Company, p. 35).