

# DIGITAL MAPPING TECHNIQUES 2019

The following was presented at DMT'19  
(May 19 – 22, 2019 - Montana Technological  
University)

The contents of this document are provisional

See Presentations and Proceedings  
from the DMT Meetings (1997-2019)

<http://ngmdb.usgs.gov/info/dmt/>

## **Compilation of a geologic map of the Greater Antilles and Virgin Islands**

Frederic H. Wilson,  
U.S. Geological Survey,  
4210 University Dr., Anchorage, AK 99508,  
(907) 786-7448  
[fwillson@usgs.gov](mailto:fwillson@usgs.gov)

Greta Orris and Floyd Gray,  
U.S. Geological Survey,  
520 North Park Ave.,  
Tucson, AZ, 85719,

As part of an ongoing mineral resource assessment, we have compiled a digital database and geologic map of the Greater Antilles and Virgin Islands. The Greater Antilles include the islands of Cuba, Hispaniola (Haiti and Dominican Republic), Jamaica, Puerto Rico (and outlying islands), and the Cayman Islands. While geographically part of the Lesser Antilles, the Virgin Islands are included in this compilation because they share greater geologic affinity with the Greater Antilles than the rest of the Lesser Antilles. In undertaking this compilation, several issues have arisen not generally faced by geologic map compilers in North America. The primary issues are language and mapping style. The Cuban and Dominican Republic source materials are in Spanish, though the Cuban information is in Russian-influenced Spanish. The Haitian materials are in French and the materials for the remaining islands are in English. An initial step in the compilation was translation of source materials and interpretation of the various ways in which geologic features were described. For translation, we used Google Translate with assistance from language dictionaries and in the case of Spanish, checks by a native Spanish speaker. Interpretation of translated descriptions was commonly necessary as geologic terms often did not translate correctly (breccia translated as “gaps”) or the geologic terms used were at times different than those commonly used in North American. For example, the Cuban source (Pushcharovsky and others, 1988) used the terms “aleurolite” (siltstone), “silicite” (chert), or “granosyenite” (quartz syenite?).

Mapping style issues were more impactful. Map patterns appear to suggest thrust faulting is an important process, especially in Cuba, yet no thrust faults are indicated on the Pushcharovsky and others (1988) Cuban geologic map. In a field trip taken by some members of our project, the Cuban guides seemed to indicate that they did not map features seen by our project members as thrust faults. On many of the source maps, the nature of fault offset is not indicated, nor are cross-sections common.

On both the Haitian and Dominican Republic geologic maps (Toloczyki and Ramirez, 1991; Vila and others, 1985), though stratigraphic units are mentioned in some unit descriptions, the map units used are generalized and do not reflect specific stratigraphic units. We infer that other defined stratigraphic units may also be included in their map units. The mapping does not indicate the specific outcrop areas of any of the stratigraphic units mentioned. The map descriptions associated with these two maps as well as the spatial data indicate a clear break across the international border; logic dictates no such break exists. We have done our best to eliminate this break where the

data allow. Igneous and especially intrusive map units tend to be lumped regardless of age; this is in part likely due to the very limited radiometric dating undertaken during or prior to mapping, especially in Cuba and on Hispaniola.

There is an extensive catalog of stratigraphic nomenclature in Jamaica and only in the last few years (Mitchell and others, 2016) has there been a concerted effort to revise and rationalize the nomenclature. Prior to this some variants of unit names were applied to different units and some units had multiple names.

The Puerto Rican part of the compilation is sourced from Krushensky and Schellekens (1999), a compilation completed as part of an earlier USGS mineral resource assessment. We are re-examining this compilation to incorporate in the larger effort and to reflect new information. We have also included outlying islands not originally part of the Puerto Rican compilation.

Data for the Virgin Island, both US and British, come from a series of Ph.D. dissertations done at Princeton in the late 1950s. These include Helsley (1960) for the British Virgin Islands, Whetten (1961) on St. Croix, Donnelly (1996) on St. Thomas and St. John, and Rankin (2002), also for St. John.

An important part of our compilation is the correlation of map units throughout the region. Unit descriptions upon which these correlations can be made are variable in detail and in some cases, correlations have been made using the spatial distributions of rock units.

We have compiled a database of radiometric age determinations to accompany the map database. A major problem in compiling this database is the common lack of good location descriptions for the samples. Where location maps are provided in the papers reporting age determinations, they commonly lack registration and location coordinates can only be determined approximately. In Haiti, a very large number of  $^{40}\text{Ar}/^{39}\text{Ar}$  age determinations were made on units that define the Tertiary-Cretaceous boundary; strangely, none of the reports provide any location information. Additionally, analytical data is rarely available for some of the earlier determinations which were typically conventional K/Ar determinations for which decay constants were not reported. We had to make some assumptions to allow recalculation of the age determinations using modern decay constants (Steiger and Jager, 1977). Some of the earliest age determinations dated materials no longer considered acceptable or reported analytical errors greater than 10 percent. A few age determinations were made using the now discredited Pb-alpha technique. Recently, modern U/Pb age determinations are becoming more common.

Present plans are to issue our initial compilation as a USGS Open-file Report and subsequently release an enhanced compilation as an USGS Scientific Investigation Map (SIM) using more detailed sources. Note this map database is structured identically to the recently released Geologic map of Alaska, including using many of the same related tables.

## References

- Donnelly, T.W., 1966, Geology of St. Thomas and St. John, U.S. Virgin Islands: Geological Society of America Memoir 98, p. 85-176, 1 plate, approximate scale 1:60,000.
- Helsley, C.E., 1960, Geology of the British Virgin Islands: Princeton, N.J., Princeton University, unpublished Ph.D. dissertation, 219 p, approximate scale, 1:60,000?
- Krushensky, R.D., and Schellekens, J.H., 1999, Geologic map of Puerto Rico with correlation chart and map unit descriptions, in Bawiec, W.J., ed., Geology, geochemistry, geophysics, mineral occurrences and mineral resource assessment for the Commonwealth of Puerto Rico: U.S. Geological Survey Open-File Report 98-038, scale 1:100,000, <https://pubs.usgs.gov/of/1998/of98-038/>. Available online only.
- Mitchell, S.F., R.N. Abbott, Suresh Bhalai, Shonel Dwyer, T.C.P. Edwards, and 20 others. 2016. Revision of Jamaican lithostratigraphic nomenclature decided at a stratigraphic workshop of the Jamaican Stratigraphic Committee at the 60th Anniversary of the Geological Society of Jamaica: Caribbean Journal of Earth Science, v. 48, p. 37-45.
- Pushcharovsky, Y., et al., ed. 1988. Mapa Geologico de la Republica de Cuba, in Academy of Sciences of Cuba and USSR, scale 1:250,000, 42 sheets.
- Rankin, D.W., 2002, Geology of St. John, U.S. Virgin Islands: U.S. Geological Survey Professional Paper 1631, 42 p, scale 1:24,000.
- Steiger, R.H., and E. Jager. 1977. Subcommittee on geochronology: Convention on the use of decay constants in geo- and cosmochronology: Earth and Planetary Science Letters, v. 36, p. 359–362.
- Toloczyki, M. and I. Ramirez. 1991. Geologic map of the Dominican Republic: Ministry of Industry and Commerce, Department of Mining, Geographic Institute of the University of Santo Domingo, scale 1:250,000 (Spanish).
- Whetten, J.T. 1961. Geology of St. Croix, U.S. Virgin Islands: Geological Society of America Memoir 98, p. 177-239, 1 plate, scale, 1:31,680.
- Vila, J.-M., J. Butterlin, T. Calmus, B. Mercier de Lépinay and, B. van den Berghe. 1985. Carte Géologique d'Haïti au 1/1,000,000 Avec Notice Explicative Détaillée (Geologic Map of Haiti at 1:1,000,000 With Detailed Explicative Notes), in: Girault C., ed., Atlas d'Haiti: Talence, France, Centre d'etudes de geographe tropicale (CNRS) et Universite de Bordeaux, France, scale 1:1,000,000.

# COMPILATION OF A GEOLOGIC MAP OF THE GREATER ANTILLES AND THE VIRGIN ISLANDS

Frederic H. Wilson<sup>1</sup> (fwilson@usgs.gov), Greta Orris<sup>2</sup>, and Floyd Gray<sup>2</sup>, <sup>1</sup>USGS, Anchorage AK; <sup>2</sup>USGS, Tuscon AZ

## Introduction

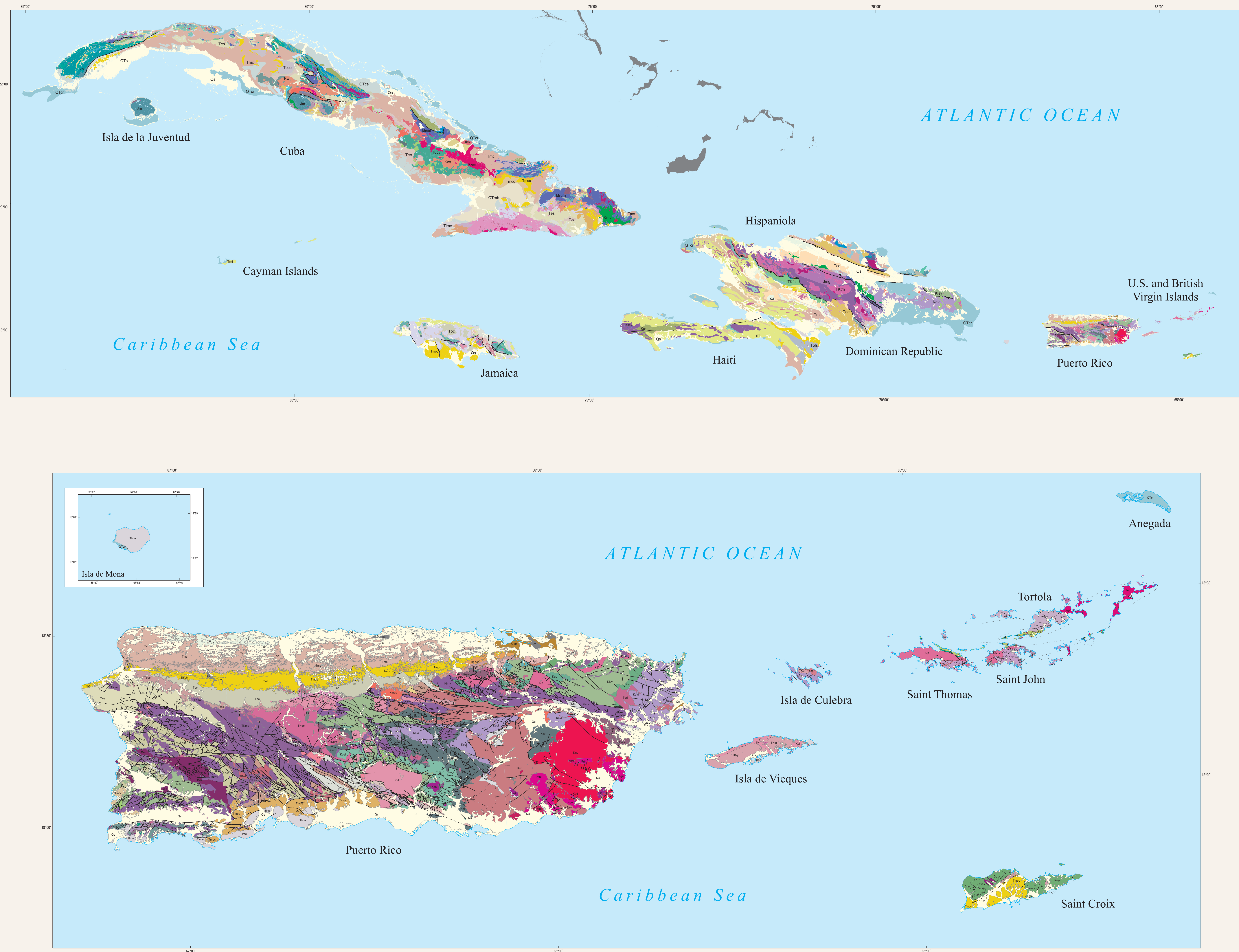
This geologic map of the Greater Antilles is a compilation of information from the literature, integrated to provide a seamless map of the region. The map represents output from a database of geologic data assembled as part of and to facilitate an ongoing mineral resource assessment. The geologic map shown here covers Cuba, Hispaniola (Haiti and the Dominican Republic), Jamaica, Cayman Islands, Puerto Rico, and the U.S. and British Virgin Islands. The product will also include a second sheet showing the geology of Puerto Rico and the Virgin Islands in greater detail.

Compilation exposed several issues that are not generally faced by geologic map compilers in North America. The primary issues were language and mapping style. Cuban and Dominican Republic source materials are in Spanish, though the Cuban information is in Russian-influenced Spanish. Haitian materials were in French and materials for the remaining parts of the map area in English. An initial step was translation of source materials and interpretation of the differing descriptions of geologic features. For translation, we used Google Translate with assistance from language dictionaries and in the case of Spanish, a few checks by a native Spanish speaker. Interpretation of translated descriptions was commonly necessary as geologic terms often did not translate correctly (breccia translated as “gaps”) or the geologic terms used were at times different than those commonly used in North America. For example, the Cuban source (Pushcharovsky and others, 1988) used the terms “aleurolite” (siltstone), “silicite” (chert), and “granosenite” (quartz syenite?). Mapping style issues were also impactful. For example, map patterns appear to suggest thrust faulting is an important process, especially in Cuba, yet no thrust faults are indicated on the Cuban geologic map. During a field trip taken by some members of the project, the Cuban guides seemed to indicate that they did not map features seen by our project members as thrust faults. On many of the source maps, the nature of fault offset is not indicated, nor are cross-sections commonly presented.

At first glance, the Greater Antilles may appear to reflect the character of a magmatic arc; but represents multiple distinct features. Only in Cuba are there rocks of unquestioned Jurassic age, and perhaps older, rocks present. Ophiolite assemblages that may include rocks of Jurassic age are present in Cuba, Hispaniola, and Puerto Rico. Metamorphic assemblages on Hispaniola and Puerto Rico, contain rocks that may be of Jurassic age. Metamorphic rocks that have Cretaceous protoliths are more widespread, present in Cuba, Hispaniola, and the U.S. and British Virgin Islands. Cretaceous plutonic rocks are present in Cuba, Puerto Rico, and Dominican Republic. Gabbro and trondhjemite of inferred Early Cretaceous age are present in U.S. Virgin Islands. Cretaceous volcanic rocks are widespread in Cuba, Hispaniola, Puerto Rico, and Virgin Islands; they are of variable age and do not appear to reflect a single arc system: Cretaceous volcanic rocks are found in Jamaica in inliers on the eastern part of the island. Eocene volcanic rocks are prominent in southern Cuba, Haiti, eastern Jamaica, Puerto Rico, and Virgin Islands. Volcanic rocks possibly as young as early Miocene are present in southern Dominican Republic; the youngest volcanic rocks of the region are the Low Layton Lavas of Jamaica of late Miocene age and alkali basalt of Quaternary age on Hispaniola.

Carbonate rocks are an important component of the sedimentary section in the Greater Antilles, as old as Jurassic in Cuba and as young as Holocene in many areas. Early Cretaceous sedimentary rocks in Cuba tend to be dominantly limestone; volcanic clasts and debris are not present until the Late Cretaceous in Cuba, Jamaica, and Puerto Rico. In contrast, Early Cretaceous volcanoclastic sedimentary rocks are common in the Virgin Islands. Olistostrome deposits are commonly described in latest Cretaceous and Eocene rocks; in Paleocene and early Eocene these are commonly associated with tectonic mélange units. Volcanic debris and tuff are common in sedimentary rocks of Paleocene and Eocene age, often associated with carbonate rocks. Post Eocene sedimentary rocks are dominantly carbonate rocks or mixed clastic and carbonate rocks where the clastic component reflects erosion of earlier units, including older carbonate rocks. Rocks containing lignite are only present in Cuba and on Hispaniola and are generally of Miocene age.

The source maps tend to focus on sedimentary, and to a lesser extent, volcanic rock units. Few report radiometric ages on igneous rocks and particularly plutonic rock units. We compiled available radiometric age determinations and have tried to evaluate their quality and applicability to determining the age of rock units. We recalculated virtually all K/Ar ages to modern decay constants (Steiger and Jager, 1977). Many of the sources of radiometric data do not provide information on the decay constants used and we had to infer these, depending on the source. The few U/Pb dates are relatively modern and we assume they use modern and consistent constants. An additional and serious problem is that the sources frequently do not provide detailed sample descriptions or even rudimentary location information for the radiometric dates. Typically, the only location information is from a small non-registered graphic image. We have located sample sites as best as we can, but in some cases, these may only be within a few kilometers of the actual sample collection site. Analytically, several age determinations are suspect, due to exceedingly large analytical errors or use of inappropriate materials, for example, whole rock dates of coarse-grained plutonic rocks.



## List of Map Units

UNCONSOLIDATED AND SEMI-CONSOLIDATED DEPOSITS	UNCONSOLIDATED AND SEMI-CONSOLIDATED DEPOSITS
Qs Surficial deposits, undifferentiated (Quaternary)—Unconsolidated deposits ranging from clay to coarse cobble and boulder and matrix gravels.	Qs Surficial deposits, undifferentiated (Quaternary)—Unconsolidated deposits ranging from clay to coarse cobble and boulder and matrix gravels.
Qtu Deposits associated with carbonate reefs and reef complexes (Quaternary and upper Tertiary, Pleistocene)—Semi-consolidated and partially consolidated carbonate reef complexes.	Qtu Deposits associated with carbonate reefs and reef complexes (Quaternary and upper Tertiary, Pleistocene)—Semi-consolidated and partially consolidated carbonate reef complexes.
Qtm Marine sand and conglomerate (Quaternary and upper Tertiary, Pleistocene)—Semi-consolidated conglomerate, sand, and mud.	Qtm Marine sand and conglomerate (Quaternary and upper Tertiary, Pleistocene)—Semi-consolidated conglomerate, sand, and mud.
Qtr Artificial fill deposits (Quaternary, Holocene)—Consists of a variety of rock types reworked to artificial fill.	Qtr Artificial fill deposits (Quaternary, Holocene)—Consists of a variety of rock types reworked to artificial fill.
SEDIMENTARY ROCKS	SEDIMENTARY ROCKS
TERTIARY SEDIMENTARY ROCKS	TERTIARY SEDIMENTARY ROCKS
Tm Limestone, marl, and evaporate deposits (Tertiary, Pliocene to Miocene)—Consists of older outcrops of reef limestone and reef representing intertidal facies.	Tm Limestone, marl, and evaporate deposits (Tertiary, Pliocene to Miocene)—Consists of older outcrops of reef limestone and reef representing intertidal facies.
Tlc Calcareous, biocalcareous, limestone and marl (Tertiary, Pliocene to Miocene)	Tlc Calcareous, biocalcareous, limestone and marl (Tertiary, Pliocene to Miocene)
Tcc Continental clastic rocks (Tertiary, Pliocene to Miocene)—Conglomerate, sandstone, and sandy shale, local coars, unconformated sand and lignite.	Tcc Continental clastic rocks (Tertiary, Pliocene to Miocene)—Conglomerate, sandstone, and sandy shale, local coars, unconformated sand and lignite.
Tmt Mixed clastic and carbonate rocks (Tertiary, Miocene)—Claystone, marl, sandstone, limestone, and shale.	Tmt Mixed clastic and carbonate rocks (Tertiary, Miocene)—Claystone, marl, sandstone, limestone, and shale.
Tnc Limestone, marl, and calcarenite—Limestone, marl, and calcarenite.	Tnc Limestone, marl, and calcarenite—Limestone, marl, and calcarenite.
Tmnc Mixed clastic rocks—Conglomerate, sandstone, siltstone, and claystone.	Tmnc Mixed clastic rocks—Conglomerate, sandstone, siltstone, and claystone.
Tmncs Clastic rocks (Tertiary, Miocene to Oligocene)—Sandstone, siltstone, calcarenite, clay, and marl with interbeds of allochthonous limestone.	Tmncs Clastic rocks (Tertiary, Miocene to Oligocene)—Sandstone, siltstone, calcarenite, clay, and marl with interbeds of allochthonous limestone.
Tmncs Limestone (Tertiary, middle Miocene to late Eocene)—Generally, locally limestone.	Tmncs Limestone (Tertiary, middle Miocene to late Eocene)—Generally, locally limestone.
Tmncs Limestone and marl (Tertiary, lower Miocene to upper Oligocene)—Discontinuously limestone, also, lesser marl, clay-rich limestone, calcarenite, and minor sandstone and conglomerate.	Tmncs Limestone and marl (Tertiary, lower Miocene to upper Oligocene)—Discontinuously limestone, also, lesser marl, clay-rich limestone, calcarenite, and minor sandstone and conglomerate.
Tmncs Clastic rocks associated with carbonate-reef formations (Tertiary, lower Miocene to upper Oligocene)—Polymictic conglomerate with silty and sandy matrix, sandstone and shale.	Tmncs Clastic rocks associated with carbonate-reef formations (Tertiary, lower Miocene to upper Oligocene)—Polymictic conglomerate with silty and sandy matrix, sandstone and shale.
Tmncs Carbonate rocks—Limestone and marl, locally dolomitized or may include minor calcarenite.	Tmncs Carbonate rocks—Limestone and marl, locally dolomitized or may include minor calcarenite.
Tmncs Clastic rocks including conglomerate—Cretaceous to conglomerate, locally containing lenses of sandstone that have lignite.	Tmncs Clastic rocks including conglomerate—Cretaceous to conglomerate, locally containing lenses of sandstone that have lignite.
Tmncs Older mixed clastic, carbonaceous, and volcanic rocks (Tertiary, Eocene)—Thin to medium-bedded silty and calcarenite, tuff, and marl of conglomerate, also, includes minor siltstone, and locally, marl.	Tmncs Older mixed clastic, carbonaceous, and volcanic rocks (Tertiary, Eocene)—Thin to medium-bedded silty and calcarenite, tuff, and marl of conglomerate, also, includes minor siltstone, and locally, marl.
Tmncs Necker limestone and chert (Tertiary, Oligocene to Eocene)—Variably bedded limestone interbedded and nodular chert.	Tmncs Necker limestone and chert (Tertiary, Oligocene to Eocene)—Variably bedded limestone interbedded and nodular chert.
Tmncs Volcanic and sedimentary rocks (Tertiary, Eocene)—Limited exposure of volcanoclastic sedimentary rocks derived from underlying Cretaceous and/or Tertiary basins.	Tmncs Volcanic and sedimentary rocks (Tertiary, Eocene)—Limited exposure of volcanoclastic sedimentary rocks derived from underlying Cretaceous and/or Tertiary basins.
Tmncs Limestone containing igneous debris (Tertiary, Eocene)—Limestone, interbedded with igneous breccia and tuff.	Tmncs Limestone containing igneous debris (Tertiary, Eocene)—Limestone, interbedded with igneous breccia and tuff.
Tmncs Limestone and igneous debris, shallow-water facies—Limestone, marl and carbonate breccia, locally, dolomite, also, calcarenite containing abundant igneous clasts.	Tmncs Limestone and igneous debris, shallow-water facies—Limestone, marl and carbonate breccia, locally, dolomite, also, calcarenite containing abundant igneous clasts.
Tmncs Limestone and igneous debris, deep-water facies—Mudry or argillaceous limestone and marl, argillaceous calcarenite having graded bedding and containing dark igneous clasts. Some limestone is present.	Tmncs Limestone and igneous debris, deep-water facies—Mudry or argillaceous limestone and marl, argillaceous calcarenite having graded bedding and containing dark igneous clasts. Some limestone is present.
Tmncs Conglomerate and sandstone (Tertiary, Eocene)—Polymictic, graywacke sandstone interbedded with sandy calcarenite, shale, marl, and conglomerate.	Tmncs Conglomerate and sandstone (Tertiary, Eocene)—Polymictic, graywacke sandstone interbedded with sandy calcarenite, shale, marl, and conglomerate.
Tmncs Mixed clastic and lower carbonate rocks (Tertiary, Eocene)—Various mixtures of conglomerate, calcarenite, limestone, siltstone, and shale.	Tmncs Mixed clastic and lower carbonate rocks (Tertiary, Eocene)—Various mixtures of conglomerate, calcarenite, limestone, siltstone, and shale.
Tmncs Mixed carbonate and clastic rocks and tuff (Tertiary, Eocene)—Thin to medium-bedded silty and calcarenite, tuff, and marl of conglomerate, also, includes minor siltstone, and locally, marl.	Tmncs Mixed carbonate and clastic rocks and tuff (Tertiary, Eocene)—Thin to medium-bedded silty and calcarenite, tuff, and marl of conglomerate, also, includes minor siltstone, and locally, marl.
Tmncs Brecciated carbonate and clastic rocks (Tertiary, middle Eocene to Paleocene)—Sandstone, conglomerate, claystone, marl, limestone, and locally, calcarenite breccia.	Tmncs Brecciated carbonate and clastic rocks (Tertiary, middle Eocene to Paleocene)—Sandstone, conglomerate, claystone, marl, limestone, and locally, calcarenite breccia.
Tmncs Volcanic tuff-bearing rocks (Tertiary, lower Eocene to Paleocene)—Conglomerate containing metatuffite, volcanic, and plagioclase rock clasts, in muddy sand matrix, locally, includes ash flow of quartzite.	Tmncs Volcanic tuff-bearing rocks (Tertiary, lower Eocene to Paleocene)—Conglomerate containing metatuffite, volcanic, and plagioclase rock clasts, in muddy sand matrix, locally, includes ash flow of quartzite.
Tmncs Sedimentary rocks and tuff (Tertiary, lower Eocene to Paleocene)—Calcareous tuff, graywacke, and detrital limestone, fine-grained polymictic sandstone and conglomerate, and metamorphic limestone containing volcanic-rock fragments.	Tmncs Sedimentary rocks and tuff (Tertiary, lower Eocene to Paleocene)—Calcareous tuff, graywacke, and detrital limestone, fine-grained polymictic sandstone and conglomerate, and metamorphic limestone containing volcanic-rock fragments.
TERTIARY TO CRETACEOUS SEDIMENTARY ROCKS	TERTIARY TO CRETACEOUS SEDIMENTARY ROCKS
Tmncs Fresh flows (Tertiary upper Cretaceous)—Calcareous, flysch-like rocks containing minor igneous rock debris.	Tmncs Fresh flows (Tertiary upper Cretaceous)—Calcareous, flysch-like rocks containing minor igneous rock debris.
Tmncs Mixed volcanic and sedimentary rocks with (Tertiary to Cretaceous, Campanian or lower?)—In southeastern Puerto Rico.	Tmncs Mixed volcanic and sedimentary rocks with (Tertiary to Cretaceous, Campanian or lower?)—In southeastern Puerto Rico.
Tmncs Conglomerate, sandstone, and claystone—Volcanoclastic sandstone, siltstone, claystone, conglomerate, and locally, limestone.	Tmncs Conglomerate, sandstone, and claystone—Volcanoclastic sandstone, siltstone, claystone, conglomerate, and locally, limestone.
Tmncs Mixed volcanic and clastic rocks—Volcanoclastic sandstone and conglomerate, also, calcarenite, local.	Tmncs Mixed volcanic and clastic rocks—Volcanoclastic sandstone and conglomerate, also, calcarenite, local.
Tmncs Andesite and basalt flows and tuff—Dark gray volcanoclastic breccia, thin to thick-bedded tuff to massive, coarse-grained tuff, tuff breccia, interbedded flows.	Tmncs Andesite and basalt flows and tuff—Dark gray volcanoclastic breccia, thin to thick-bedded tuff to massive, coarse-grained tuff, tuff breccia, interbedded flows.
Tmncs Limestone, marl, and tuff (Tertiary, Paleocene to Cretaceous, Maestrichtian)—Marl, siltstone, and detrital limestone, fine-grained polymictic sandstone and conglomerate, and bentonitic clay.	Tmncs Limestone, marl, and tuff (Tertiary, Paleocene to Cretaceous, Maestrichtian)—Marl, siltstone, and detrital limestone, fine-grained polymictic sandstone and conglomerate, and bentonitic clay.
CRETACEOUS-SEDIMENTARY ROCKS	CRETACEOUS-SEDIMENTARY ROCKS
Tmncs Mixed sedimentary and volcanic rocks (Cretaceous)—Limestone and chert, tuff, or volcanic-clastic rocks.	Tmncs Mixed sedimentary and volcanic rocks (Cretaceous)—Limestone and chert, tuff, or volcanic-clastic rocks.
Tmncs Sedimentary and volcanic rocks (Upper Cretaceous)—Volcanoclastic tuff, marl, claystone, intermediate- to fine-grained volcanic rocks, and reef limestone.	Tmncs Sedimentary and volcanic rocks (Upper Cretaceous)—Volcanoclastic tuff, marl, claystone, intermediate- to fine-grained volcanic rocks, and reef limestone.
Tmncs Limestone and chert (Cretaceous)—Discontinuously limestone, beds of calcarenite and calcarenite limestone present locally.	Tmncs Limestone and chert (Cretaceous)—Discontinuously limestone, beds of calcarenite and calcarenite limestone present locally.
Tmncs Limestone and limestone conglomerate (Upper Cretaceous, Maestrichtian to Campanian)—Dolomite and dolomitic limestone, siliceous porcellanaceous limestone, and massive limestone interbedded with sandstone and shale.	Tmncs Limestone and limestone conglomerate (Upper Cretaceous, Maestrichtian to Campanian)—Dolomite and dolomitic limestone, siliceous porcellanaceous limestone, and massive limestone interbedded with sandstone and shale.
Tmncs Limestone and minor calcarenite (Cretaceous, Turonian to Hauterivian)—Stratified, bentonitic and argillaceous limestone, chert, marl, and locally, breccia-conglomerate.	Tmncs Limestone and minor calcarenite (Cretaceous, Turonian to Hauterivian)—Stratified, bentonitic and argillaceous limestone, chert, marl, and locally, breccia-conglomerate.
Tmncs Carbonate rocks including biostirite limestone (Lower Cretaceous, Barremian to Berriasian)—Bentonitic limestone, local calcarenite, and marl.	Tmncs Carbonate rocks including biostirite limestone (Lower Cretaceous, Barremian to Berriasian)—Bentonitic limestone, local calcarenite, and marl.
Tmncs Volcanoclastic conglomerate (Cretaceous, Maestrichtian to Albian)—Volcanic gabbro conglomerate containing polymictic sandstone, locally calcarenite.	Tmncs Volcanoclastic conglomerate (Cretaceous, Maestrichtian to Albian)—Volcanic gabbro conglomerate containing polymictic sandstone, locally calcarenite.
Tmncs Un differentiated clastic rocks (Upper Cretaceous, Maestrichtian to Campanian)—Videly exposed dolomite.	Tmncs Un differentiated clastic rocks (Upper Cretaceous, Maestrichtian to Campanian)—Videly exposed dolomite.
Tmncs Volcanoclastic sandstone and shale—Andesite to dacite volcanic-clast sandstone, siltstone, sandstone, siltstone, tuff, sandstone, and a few thin, limestone beds.	Tmncs Volcanoclastic sandstone and shale—Andesite to dacite volcanic-clast sandstone, siltstone, sandstone, siltstone, tuff, sandstone, and a few thin, limestone beds.
Tmncs Siltstone and local dolomitic deposits—Siltstone, calcarenite because of isolated dolomitic oolite representing igneous and sedimentary clasts.	Tmncs Siltstone and local dolomitic deposits—Siltstone, calcarenite because of isolated dolomitic oolite representing igneous and sedimentary clasts.
Tmncs Clastic rocks and reef complexes (Upper Cretaceous, Maestrichtian to Campanian)—Conglomerate, sandstone, volcanoclastic sandstone and siltstone, always associated with limestone and marl.	Tmncs Clastic rocks and reef complexes (Upper Cretaceous, Maestrichtian to Campanian)—Conglomerate, sandstone, volcanoclastic sandstone and siltstone, always associated with limestone and marl.
Tmncs Mixed clastic, carbonaceous, and volcanic rocks (Upper Cretaceous, Campanian to Cenomanian)—Limestone, sandstone, conglomerate, tuff, and breccia.	Tmncs Mixed clastic, carbonaceous, and volcanic rocks (Upper Cretaceous, Campanian to Cenomanian)—Limestone, sandstone, conglomerate, tuff, and breccia.
Tmncs Older undifferentiated clastic rocks (Upper Cretaceous, Santonian to Campanian)—Volcanic-clast sandstone, local volcanoclastic breccia, calcarenite, limestone, and interbedded sandy limestone, siltstone, chert, minor volcanic-clast conglomerate, and locally, lava flows.	Tmncs Older undifferentiated clastic rocks (Upper Cretaceous, Santonian to Campanian)—Volcanic-clast sandstone, local volcanoclastic breccia, calcarenite, limestone, and interbedded sandy limestone, siltstone, chert, minor volcanic-clast conglomerate, and locally, lava flows.
Tmncs Thin volcanic rocks (Cretaceous, Santonian to Albian)—Volcanic-clast wacke, siltstone, calcarenite, calcarenite, sparse limestone, and rare basalt and andesite, also, includes metamorphosed equivalents in Virgin Islands.	Tmncs Thin volcanic rocks (Cretaceous, Santonian to Albian)—Volcanic-clast wacke, siltstone, calcarenite, calcarenite, sparse limestone, and rare basalt and andesite, also, includes metamorphosed equivalents in Virgin Islands.
Tmncs Older mixed clastic, carbonaceous, and volcanic rocks (Cretaceous, Comenian to Albian)—Locally, volcanoclastic sandstone and siltstone and subvolcanic pillowed basaltic andesite flows and minor limestone, conglomerate and breccia, local calcarenite.	Tmncs Older mixed clastic, carbonaceous, and volcanic rocks (Cretaceous, Comenian to Albian)—Locally, volcanoclastic sandstone and siltstone and subvolcanic pillowed basaltic andesite flows and minor limestone, conglomerate and breccia, local calcarenite.
Tmncs Maria Mesa Formation and similar formations (Cretaceous, Turonian to lower?)—Massive and stratified homotitic limestone, calcarenite, quartzose sandstone, siltite, and clayey calcarenite rocks.	Tmncs Maria Mesa Formation and similar formations (Cretaceous, Turonian to lower?)—Massive and stratified homotitic limestone, calcarenite, quartzose sandstone, siltite, and clayey calcarenite rocks.
Tmncs Rio Nuevo Formation and similar clastic rock units (Cretaceous, Comenian to Albian)—Siltstone, shale, volcanoclastic sandstone and shale, minor volcanic rocks, and volcanic-clast conglomerate.	Tmncs Rio Nuevo Formation and similar clastic rock units (Cretaceous, Comenian to Albian)—Siltstone, shale, volcanoclastic sandstone and shale, minor volcanic rocks, and volcanic-clast conglomerate.
Tmncs Chert (Cretaceous, Comenian to Aptian or lower?)—Chert dark, flint, calcarenite, and calcarenite.	Tmncs Chert (Cretaceous, Comenian to Aptian or lower?)—Chert dark, flint, calcarenite, and calcarenite.
Tmncs Necker Island Formation, volcanic chert rocks (Lower Cretaceous)—Volcanic-clast wacke containing clasts of keratophyre, basalt, and trondhjemite.	Tmncs Necker Island Formation, volcanic chert rocks (Lower Cretaceous)—Volcanic-clast wacke containing clasts of keratophyre, basalt, and trondhjemite.
Tmncs Fider Formation (Lower Cretaceous, Albian to Valanginian)—Thin-bedded, micritic limestone interbedded with sandstone and shale.	Tmncs Fider Formation (Lower Cretaceous, Albian to Valanginian)—Thin-bedded, micritic limestone interbedded with sandstone and shale.
CRETACEOUS TO JURASSIC SEDIMENTARY ROCKS	CRETACEOUS TO JURASSIC SEDIMENTARY ROCKS
Tmncs Limestone and shale (Lower Cretaceous to Upper Jurassic)—Limestone; includes bituminous limestone, chert, quartz-rich sandstone, and argillite.	Tmncs Limestone and shale (Lower Cretaceous to Upper Jurassic)—Limestone; includes bituminous limestone, chert, quartz-rich sandstone, and argillite.
JURASSIC SEDIMENTARY ROCKS	JURASSIC SEDIMENTARY ROCKS
Jm Limestone and dolomite (Upper Jurassic)—Massive limestone, calcarenite, calcarenite, micritic, locally dolomitized.	Jm Limestone and dolomite (Upper Jurassic)—Massive limestone, calcarenite, calcarenite, micritic, locally dolomitized.
IGNEOUS ROCKS	IGNEOUS ROCKS
YOUNG VOLCANIC ROCKS	YOUNG VOLCANIC ROCKS
Qv Alkali basalt (Quaternary)—Nepheline basalt and “silicite basalt”.	Qv Alkali basalt (Quaternary)—Nepheline basalt and “silicite basalt”.
Qv The Hispaniola and Valle Nevado volcanic fields (Quaternary, Pleistocene and Tertiary, Pleistocene)—Tuff volcanics and lava.	Qv The Hispaniola and Valle Nevado volcanic fields (Quaternary, Pleistocene and Tertiary, Pleistocene)—Tuff volcanics and lava.
TERTIARY VOLCANIC AND HYPOBYSALIC ROCKS	TERTIARY VOLCANIC AND HYPOBYSALIC ROCKS
Tmncs Hypobasalt dikes and intrusions (Tertiary)—Bifurcated and syenitic, porphyritic thrydoidal and dacite dikes, hypobasalt intrusions, and minor mafic rocks.	Tmncs Hypobasalt dikes and intrusions (Tertiary)—Bifurcated and syenitic, porphyritic thrydoidal and dacite dikes, hypobasalt intrusions, and minor mafic rocks.
Tmncs Intermediate and mafic flows and tuff (Tertiary, Miocene to Eocene)—Basalt, tuff, and argillaceous limestone and calcarenite and volcanic rocks.	Tmncs Intermediate and mafic flows and tuff (Tertiary, Miocene to Eocene)—Basalt, tuff, and argillaceous limestone and calcarenite and volcanic rocks.
Tmncs Pyroclastic rocks (Tertiary, Eocene)—Andesite, tuff, andesite breccia and flows, tuff, and volcanic-clast sandstone, locally, poorly bedded basaltic tuff with tuff.	Tmncs Pyroclastic rocks (Tertiary, Eocene)—Andesite, tuff, andesite breccia and flows, tuff, and volcanic-clast sandstone, locally, poorly bedded basaltic tuff with tuff.
Tmncs Necker Formation (Tertiary, Eocene?)—Subsartial tuff and breccia, including welded tuff.	Tmncs Necker Formation (Tertiary, Eocene?)—Subsartial tuff and breccia, including welded tuff.
Tmncs Tuff and breccia (Tertiary, early Eocene and late Paleocene)—Undifferentiated tuff, tuffite, andesite, basaltic andesite, tuffaceous sandstone, and beds of limestone.	Tmncs Tuff and breccia (Tertiary, early Eocene and late Paleocene)—Undifferentiated tuff, tuffite, andesite, basaltic andesite, tuffaceous sandstone, and beds of limestone.
TERTIARY TO CRETACEOUS VOLCANIC ROCKS	TERTIARY TO CRETACEOUS VOLCANIC ROCKS
Tmncs Basalt and keratophyre (Tertiary to Late Cretaceous)—Dacite and quartz keratophyre.	Tmncs Basalt and keratophyre (Tertiary to Late Cretaceous)—Dacite and quartz keratophyre.
Tmncs Andesite breccia, flows, tuff, and breccia (Tertiary, Paleocene to Late Cretaceous, Campanian)—Volcanic breccia interbedded with basaltic flows and tuff, and, locally, limestone thrydoidal and nodular (Tertiary, Paleocene to Late Cretaceous)—Thrydoidal and nodular thrydoidal.	Tmncs Andesite breccia, flows, tuff, and breccia (Tertiary, Paleocene to Late Cretaceous, Campanian)—Volcanic breccia interbedded with basaltic flows and tuff, and, locally, limestone thrydoidal and nodular (Tertiary, Paleocene to Late Cretaceous)—Thrydoidal and nodular thrydoidal.
Tmncs CRETACEOUS TO JURASSIC VOLCANIC AND HYPOBYSALIC ROCKS	Tmncs CRETACEOUS TO JURASSIC VOLCANIC AND HYPOBYSALIC ROCKS
Tmncs Hypobasalt rocks and keratophyre porphyry (Cretaceous)—Mafic, dikes of gabbro, diabase, andesite, dacite, and lamprophyre, and diabase bodies, as well as keratophyre dikes and plugs.	Tmncs Hypobasalt rocks and keratophyre porphyry (Cretaceous)—Mafic, dikes of gabbro, diabase, andesite, dacite, and lamprophyre, and diabase bodies, as well as keratophyre dikes and plugs.
Tmncs Volcanic rocks (Cretaceous)—Bifurcated and syenitic, porphyritic thrydoidal and dacite breccia, sandstone, conglomerate, minor limestone, siltstone, and tuff.	Tmncs Volcanic rocks (Cretaceous)—Bifurcated and syenitic, porphyritic thrydoidal and dacite breccia, sandstone, conglomerate, minor limestone, siltstone, and tuff.
Tmncs Andesite breccia, flows, and tuff (Late Cretaceous, Santonian to Albian)—Mottled and non-welded ash-flow tuff and volcanic breccia, locally, includes pillowed and amorphous andesite flows and lenses and beds of calcarenite, sandstone, and conglomerate.	Tmncs Andesite breccia, flows, and tuff (Late Cretaceous, Santonian to Albian)—Mottled and non-welded ash-flow tuff and volcanic breccia, locally, includes pillowed and amorphous andesite flows and lenses and beds of calcarenite, sandstone, and conglomerate.
Tmncs Basalt, gabbro and amorphous flows, breccia, and tuff (Late Cretaceous, Maestrichtian to Santonian)—Basalt or basaltic andesite flows, locally containing lenses of intermediate and hypobasaltic rocks (Late Cretaceous, Campanian)—Dacite flows and tuff, dacite and thrydoidal dikes.	Tmncs Basalt, gabbro and amorphous flows, breccia, and tuff (Late Cretaceous, Maestrichtian to Santonian)—Basalt or basaltic andesite flows, locally containing lenses of intermediate and hypobasaltic rocks (Late Cretaceous, Campanian)—Dacite flows and tuff, dacite and thrydoidal dikes.
Tmncs Intermediate and mafic volcanic rocks (Cretaceous, Campanian to Comenian)—Rhyolite to andesite flows, tuff, and domes; also, minor basaltic andesite and basalt.	Tmncs Intermediate and mafic volcanic rocks (Cretaceous, Campanian to Comenian)—Rhyolite to andesite flows, tuff, and domes; also, minor basaltic andesite and basalt.
Tmncs Intermediate and mafic pyroclastic rocks (Late Cretaceous, Campanian)—Dacite flows and basalt, rare siltstone and limestone; may include spilitic basalt, diabasite, chert, and possible tuff.	Tmncs Intermediate and mafic pyroclastic rocks (Late Cretaceous, Campanian)—Dacite flows and basalt, rare siltstone and limestone; may include spilitic basalt, diabasite, chert, and possible tuff.
Tmncs Beria Formation of Cuba (Cretaceous, Turonian to Albian)—Andesite and volcanoclastic rocks, sandstone, diabasite, tuff, and limestone.	Tmncs Beria Formation of Cuba (Cretaceous, Turonian to Albian)—Andesite and volcanoclastic rocks, sandstone, diabasite, tuff, and limestone.
Tmncs Intermediate and mafic pyroclastic rocks (Cretaceous, Comenian to Aptian)—Volcanic rocks, conglomerate, minor limestone, siltstone, and tuff.	Tmncs Intermediate and mafic pyroclastic rocks (Cretaceous, Comenian to Aptian)—Volcanic rocks, conglomerate, minor limestone, siltstone, and tuff.
Tmncs Mafic volcanic rocks (Cretaceous, Comenian to Barremian)—Largely basalt flows, ash, subvolcanic andesite and sedimentary rocks, dominantly chert, but lesser limestone, argillite and siltstone.	Tmncs Mafic volcanic rocks (Cretaceous, Comenian to Barremian)—Largely basalt flows, ash, subvolcanic andesite and sedimentary rocks, dominantly chert, but lesser limestone, argillite and siltstone.
Tmncs Intermediate-composition volcanic rocks (Early Cretaceous, Albian to Barremian)—Primarily pillowed or brecciated andesite flows, interbedded with tuff, limestone, sandstone, and chert.	Tmncs Intermediate-composition volcanic rocks (Early Cretaceous, Albian to Barremian)—Primarily pillowed or brecciated andesite flows, interbedded with tuff, limestone, sandstone, and chert.
Tmncs Basalt and basaltic andesite (Early Cretaceous, Albian and older)—Basaltic andesite flows, pillow of argillite, basalt, flow breccia, tuff, tuff breccia, and volcanoclastic breccia; local igneous lenses.	Tmncs Basalt and basaltic andesite (Early Cretaceous, Albian and older)—Basaltic andesite flows, pillow of argillite, basalt, flow breccia, tuff, tuff breccia, and volcanoclastic breccia; local igneous lenses.
Tmncs Keratophyre (Early Cretaceous)—Keratophyre flows, flow breccia, and tuff interbedded with thin beds of dark gray to almost black spilitic flows.	Tmncs Keratophyre (Early Cretaceous)—Keratophyre flows, flow breccia, and tuff interbedded with thin beds of dark gray to almost black spilitic flows.
Tmncs Spilitic basalt (Early Cretaceous)—Cretaceous massive siltite flows, locally well developed joints and, though commonly lacking pillow structure, pillows are locally well developed.	Tmncs Spilitic basalt (Early Cretaceous)—Cretaceous massive siltite flows, locally well developed joints and, though commonly lacking pillow structure, pillows are locally well developed.
Tmncs Zoroaster Formation and Cidit Basalt (Early Cretaceous, Maestrichtian)—Dolomite and basalt, rare siltstone and limestone; may include spilitic basalt, diabasite, chert, and possible tuff.	Tmncs Zoroaster Formation and Cidit Basalt (Early Cretaceous, Maestrichtian)—Dolomite and basalt, rare siltstone and limestone; may include spilitic basalt, diabasite, chert, and possible tuff.
TERTIARY INTRUSIVE ROCKS	TERTIARY INTRUSIVE ROCKS
Tmncs Granite and granodiorite (Tertiary, Eocene?)—Granite to granodiorite, monzonite, and locally, quartz diorite.	Tmncs Granite and granodiorite (Tertiary, Eocene?)—Granite to granodiorite, monzonite, and locally, quartz diorite.
Tmncs Diabase and tonalite (Tertiary, Eocene?)—Small diorite and tonalite plutons; also, includes rare clasts described as plagiogranite.	Tmncs Diabase and tonalite (Tertiary, Eocene?)—Small diorite and tonalite plutons; also, includes rare clasts described as plagiogranite.
Tmncs Gabbro, diorite, and dioritic gabbro (Tertiary, Eocene?)—Primarily small phanitic, dike and complex dikes swarm, some with internal layering parallel to dikes.	Tmncs Gabbro, diorite, and dioritic gabbro (Tertiary, Eocene?)—Primarily small phanitic, dike and complex dikes swarm, some with internal layering parallel to dikes.
TERTIARY TO CRETACEOUS INTRUSIVE ROCKS	TERTIARY TO CRETACEOUS INTRUSIVE ROCKS
Tmncs Alkali basalt (Tertiary, Paleocene to Late Cretaceous, Maestrichtian?)—Small body of alkali syenite.	Tmncs Alkali basalt (Tertiary, Paleocene to Late Cretaceous, Maestrichtian?)—Small body of alkali syenite.
Tmncs Granite and gabbro (Tertiary, Paleocene to Late Cretaceous, Maestrichtian?)—Granite and gabbro.	Tmncs Granite and gabbro (Tertiary, Paleocene to Late Cretaceous, Maestrichtian?)—Granite and gabbro.
Tmncs Granodiorite and quartz monzonite (Tertiary, Paleocene to Late Cretaceous, Maestrichtian?)—Small granodiorite rocks and diorite batholith of Puerto Rico.	Tmncs Granodiorite and quartz monzonite (Tertiary, Paleocene to Late Cretaceous, Maestrichtian?)—Small granodiorite rocks and diorite batholith of Puerto Rico.
Tmncs Granite, quartz monzonite, and mafic rocks (Tertiary, Paleocene to Late Cretaceous, Maestrichtian?)—Granodiorite and tonalite, in both trending northwest across Hispaniola.	Tmncs Granite, quartz monzonite, and mafic rocks (Tertiary, Paleocene to Late Cretaceous, Maestrichtian?)—Granodiorite and tonalite, in both trending northwest across Hispaniola.
Tmncs Quartz diorite and diorite (Tertiary, Paleocene to Late Cretaceous, Maestrichtian?)—Granite and diorite plutons in Dominican Republic, Puerto Rico, and U.S. Virgin Islands.	Tmncs Quartz diorite and diorite (Tertiary, Paleocene to Late Cretaceous, Maestrichtian?)—Granite and diorite plutons in Dominican Republic, Puerto Rico, and U.S. Virgin Islands.
Tmncs Plagiogranite (Tertiary, Paleocene or Late Cretaceous, Campanian?)—Two pyroxene gabbro.	Tmncs Plagiogranite (Tertiary, Paleocene or Late Cretaceous, Campanian?)—Two pyroxene gabbro.
CRETACEOUS INTRUSIVE ROCKS	CRETACEOUS INTRUSIVE ROCKS
Tmncs Gabbro (Cretaceous)—Gabbro and basalt, primarily in Cuba but also in U.S. Virgin Islands.	Tmncs Gabbro (Cretaceous)—Gabbro and basalt, primarily in Cuba but also in U.S. Virgin Islands.
Tmncs Granite, diorite, and dioritic gabbro (Cretaceous)—Granite and gabbro rocks of undifferentiated granodiorite and quartz diorite and ash-volcanic thrydoidal and dacite.	Tmncs Granite, diorite, and dioritic gabbro (Cretaceous)—Granite and gabbro rocks of undifferentiated granodiorite and quartz diorite and ash-volcanic thrydoidal and dacite.
Tmncs Quartz monzonite and similar rocks (Cretaceous, Santonian to Campanian)—Granite and gabbro, in small bodies in Cuba.	Tmncs Quartz monzonite and similar rocks (Cretaceous, Santonian to Campanian)—Granite and gabbro, in small bodies in Cuba.
Tmncs Granodiorite and mafic rocks (Cretaceous, Santonian to Campanian)—Granodiorite and mafic rocks in Cuba.	Tmncs Granodiorite and mafic rocks (Cretaceous, Santonian to Campanian)—Granodiorite and mafic rocks in Cuba.
Tmncs Quartz diorite (Early Cretaceous, Maestrichtian and Campanian)—Granodiorite of San Lorenzo in Puerto Rico.	Tmncs Quartz diorite (Early Cretaceous, Maestrichtian and Campanian)—Granodiorite of San Lorenzo in Puerto Rico.
Tmncs Quartz diorite and diorite (Cretaceous, Maestrichtian and Campanian)—Small quartz diorite and diorite bodies in Cuba, Dominican Republic, and Puerto Rico.	Tmncs Quartz diorite and diorite (Cretaceous, Maestrichtian and Campanian)—Small quartz diorite and diorite bodies in Cuba, Dominican Republic, and Puerto Rico.
Tmncs Diorite and hornblende (Late Cretaceous, Maestrichtian and Campanian)—Small diorite and hornblende bodies in Cuba and Puerto Rico.	Tmncs Diorite and hornblende (Late Cretaceous, Maestrichtian and Campanian)—Small diorite and hornblende bodies in Cuba and Puerto Rico.
Tmncs Granodiorite and tonalite (Cretaceous, Santonian to Albian)—Granodiorite, tonalite, and mafic rocks in Cuba, Dominican Republic, and Puerto Rico.	Tmncs Granodiorite and tonalite (Cretaceous, Santonian to Albian)—Granodiorite, tonalite, and mafic rocks in Cuba, Dominican Republic, and Puerto Rico.
Tmncs Tonalite and granodiorite (Early Cretaceous)—Trondhjemite and intrusive	