FIELD GUIDE TO THE GEOLOGY OF ST. CROIX, U.S. VIRGIN ISLANDS[1]

by John T. Whetten[2]

INTRODUCTION

A popular misconception in tourist lore is that St Croix was formerly a volcano. Although volcanoes are present on many nearby islands, there are none on St. Croix, and there probably have not been any for tens of millions of years, if ever. Yet paradoxically, most of the rocks are originally of volcanic origin.

The rocks underlying the mountain ranges on St Croix (and probably those deep underneath the Central Valley) are sedimentary rocks formed of the debris from eroding volcanic rocks and from volcanic ash spewed out from an erupting volcano. The sediments were deposited on the deep ocean floor in the late ^Cretaceous (Campanian-Maestrichtian), and are approximately 80 million years old. The limestone (or marl) exposed at the surface of the Central Valley of St. Croix is considerably younger (lovwe Miocene, 20 million years), and is probably the remains of a coral reef that formed as the island was uplifted.

St. Croix has had a long and complicated geologic history. The general pattern of evolution of the island is now known,but many of the details remain a mystery. **The purpose of this guide is to summarize briefly the important aspects of the geology of St. Croix, and to indicate some of the places where the evidence-and the geologic record-may be seen.** A generalized geologic map indicates the distribution of the main rock types, and their strategraphic relationships are diagrammatically illustrated. A simplified map legend precedes the map indicating the type of rock and approximate ages they were formed or deposited.

[1]Reprint of Field Trip Guide used at 5th Caribbean Geological Conference, 1968. Figures from Whetten (1966)

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CALEDONIA FORMATION

The oldest rocks exposed on St. Croix are the alternating dark and light-banded sedimentary rocks of the Caledonia Formation, named for Caledonia Valley where an excellent section is exposed. The formation is present in several areas on St. Croix (see map): in the northwest, in the vicinity of Hams Bluff, Mt. Washington (Frederiksted), Frenchman Hill, Punch, and Maroon Ridge; in a narrow outcrop along the coast at La Valee; and on the eastern half of the island from Christiansted to East Point, including Buck Island and Green Cay.

Perhaps the most obvious characteristic of the Caledonia Formation is the alternating light-gray and bluish-black beds, each seldom more than a few inches thick. The dark-colored rocks are either mudstones (very fine-grained rocks composed of silt and clay) or, less frequently, silicified mudstone or chert. About 60-70% of the Caledonia Formation is composed of bluish-gray to black mudstone. The lighter colored rocks are sandstones and conglomerates, which are commonly graded, with the coarsest grains at the bottoms of beds to fine grains and ultimately to mudstones at the top.

The mineral composition of the sand and conglomerate layers suggests that they are derived in large part from the erosion of volcanic rocks. Some shallow-water fossils (including snails, clams, and corals) are mixed with the volcanic debris, particularly in conglomerate beds exposed on Buck Island.

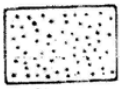
The source of the sediment is unknown, but it may have been transported for a considerable distance. The only volcanic rocks now exposed in the area that are similar to the volcanic material in the Caledonia Formation are on St. Thomas, 40 miles to the north. It is possible that long before St. Croix became an island, while it was still a flat area on the deep sea floor, a volcanic island in the vicinity of St. Thomas was eroded and sediment largely of sand size was transported southward and deposited.

Much of the sand-size sediment was probably transported by turbidity currents (dense slurries of sand and mud that flow along the ocean floor by gravity). As a current decreased in velocity, first the coarser sediment was deposited, and then the finer, eventually producing a graded bed. Certain structures within the sandstone beds such as flute casts and scour marks, and shallow-water fossils (which invariably are broken or chipped, indicating considerable transport) support this hypothesis.

The black mudstones inter-bedded with the coarser layers consist of silt and clay (altered to chlorite) and marine microfossils. The mudstone beds were probably deposited during the interval between turbidity currents, and are normal marine deep-water sediments. The re-crystallized shells of microfossils are abundant in the Caledonia mudstones.

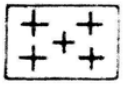
Generalized Geologic map of St. Croix

Explanation

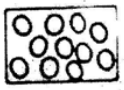


Deposits of sand, mud, etc formed by flowing water, beach deposits

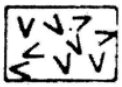
Kingshill marl (crumbly calcium carbonate, clay) (34-5 million years ago)



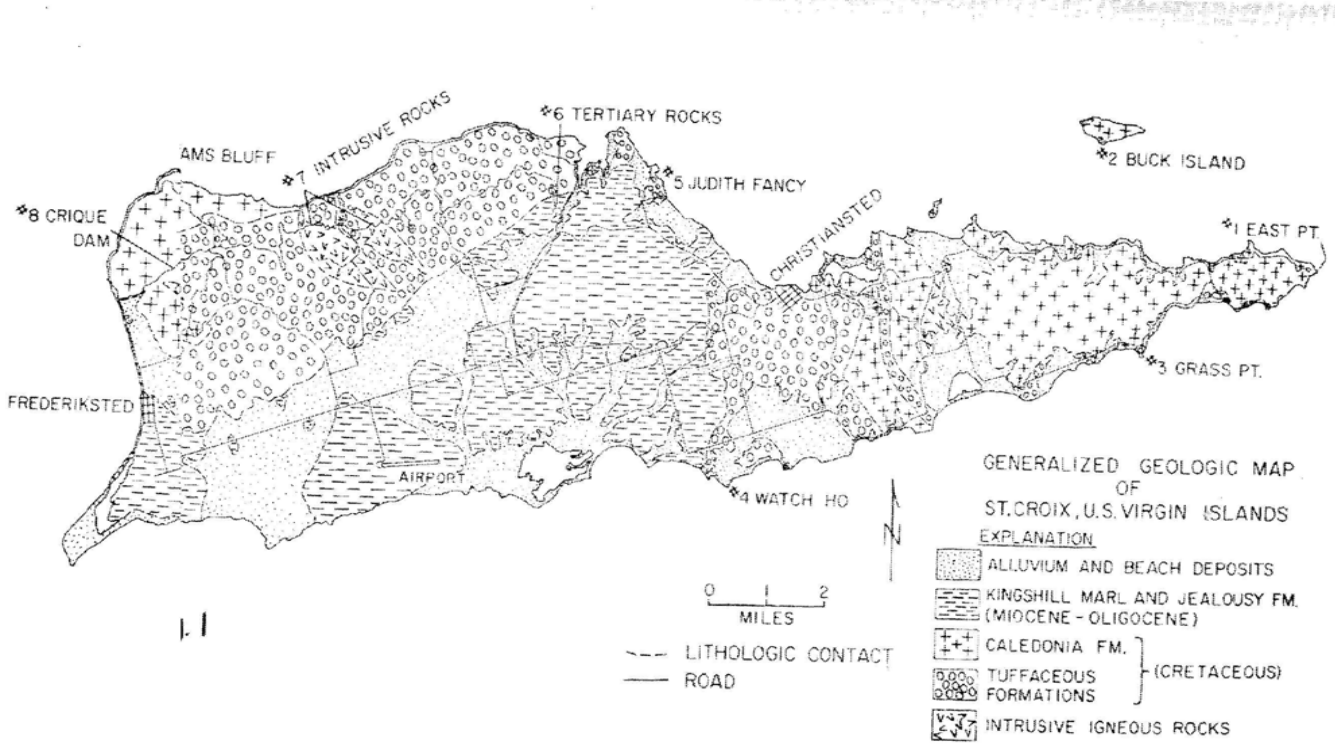
Caledonia Formation – sedimentary layers (145-65 million years ago)



Tuffaceous formations (fragmental rock of volcanic particles such as ash and cinder in layers) (145-65 million years old)



Intrusive igneous rock (cooled from lava slowly inside the earth)


6 TERTIARY ROCKS
AMS BLUFF
7 INTRUSIVE ROCKS
5 JUDITH FANCY
2 BUCK ISLAND
8 CRIQUE DAM
CHRISTIANSTED
1 EAST PT.
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INTRUSIVE IGNEOUS ROCKS

The Caledonia Formation is at least 9000 feet thick as measured on the eastern half of the island, but may well be much thicker, as the bottom of the formation is nowhere exposed on land. The oldest beds of the Caledonia Formation are probably on Buck Island.

TUFFACEOUS FORMATIONS

The Caledonia Formation grades laterally and vertically into a variety of other sedimentary rocks, including the Allandale Formation, the Cane Valley Formation, the East End Member (of the Caledonia Formation), and the Judith Fancy Formation. The complex relationships among these formations are indicated in a generalized way in Figs. 3 and 4.

Although these rocks are variable in lithology, all contain tuffaceous material or fragments of altered glass and crystals deposited originally as volcanic ash. The rocks are probably all of marine origin, and the sediments show signs of reworking by currents. The source appears to be from the south or southeast. Thus, the Caledonia Formation, which is composed of particles eroded from volcanic rocks probably to the north, interfingers with the tuffaceous rocks, which are in large part accumulations of volcanic ash from a southerly source (Fig. 2). The two rock types may be distinguished in part because of the remarkable consistency of the Caledonia Formation in forming relatively thin beds of alternating black mudstone and tight-gray sandstone. The tuffaceous formations are commonly greenish rocks, but may be quite variable in character.

Some of the best exposures of tuffaceous rocks are located at Judith Fancy, Grass Point, Watch Ho (Vagthus Point), and along the north coast near Baron Bluff (Fig. 1). Because the tuffaceous rocks tend to weather rapidly the best exposures are along the coast, in some stream valleys, and in relatively recent road cuts.

Rocks with a high percentage of tuffaceous material are characteristically an apple-green color, probably because of chlorite and epidote minerals. Medium- to coarse-grained sandstones are very common, but coarser rocks (conglomerates and breccias) and siltstones are also present. Some beds are graded, perhaps owing to the differential settling of windblown volcanic ash through water. Fragments of fossil corals and pelecypods are abundant in some places.

Other rock types in the tuffaceous rock sequence include at least two lava flows of unknown thickness, very hard silicified siltstones, and limestone. The best exposure of limestone is along the coast at watch Ho (Vagthus Point).

The bedding in some of the tuffaceous sandstones is highly contorted, suggesting that slumping occurred relatively soon after

deposition. Some of the slumps appear to have come from the south, which is in agreement with the proposed southerly volcanic source.

The total thickness of tuffaceous rocks is approximately 18,000 feet, although there is considerable variation in thickness of some of the units. Furthermore, the bottom of the sequence is not exposed, and the top has been removed by erosion, so it may have been much thicker.

ROCKS OF THE CENTRAL VALLEY

The white to buff limy rocks on the surface of the Central Valley (extending from western St. Croix eastward to Beeston Hill and Canegarden) have been named the Kingshill Marl, and may be up to 600 feet thick. The rocks are flat-lying to gently folded, and probably formed as a large coral reef before St. Croix became fully emerged. Fossil coral, Foraminifera, gastropods, and pelecypods are present in abundance, and indicate an early Miocene age for the formation. Some land-derived sand and clay is mixed with the limestone. The formation has been used extensively for building stone on St. Croix, and there are numerous abandoned small quarries.

Rocks beneath the Kingshill Marl are exposed only in a few places along the north flank of the Northside Range and in well cuttings from the Central Valley. For the most part they are clays and conglomerates. A gravity survey by Shurbet, et. a1. (1956) indicates that the Central Valley is approximately 7000 feet thick. As of 1961 we knew nothing of the sediments which lie at depths greater than the deepest wells have penetrated, approximately 1400 feet below the Kingshtll Marl. A cross section through the Northside Range and Central Valley is shown in Fig. 5.

INTRUSIVE IGNEOUS ROCKS

Two small bodies of igneous rocks intrude the Cretaceous sedimentary rocks. The igneous rocks weather easily, and fresh specimens are difficult to obtain except in recent road cuts. The prominent valleys at Fountain and Southgate have formed on the easily eroded intrusions.

The Fountain intrusion, called the Fountain Gabbro, is shaped like a malformed letter "H". Fresh specimens are (were) obtainable only along the Scenic Road. The rocks consist largely of coarse-grained crystallsS of plagioclase and augite, with accessory biotite, hypersthene, magnetite, and apatite. The sedimentary rocks adjacent to the intrusion have been metamorphosed.

The Southgate Diorite is very poorly exposed, except at Punnett Point and Pu11 Point. Hornblende and plagioclase are essential minerals, and occur in about equal abundance, Augite, magnetite, and apatite are accessory minerals.

Numerous small dikes are present in both the East End and Northside Ranges.

"THE BUILDING OF AN ISLAND" (Quin, 1907)

The record of only a small part of geologic time is preserved on St. Croix. Although the history of the area prior to the Late Cretaceous (when the oldest rocks were deposited) is unknown, it is probably safe to say that St. Croix and other island areas of the Caribbean were undefined portions on the deep ocean floor for a very long period of earth history.

The oldest rocks exposed on St. Croix were deposited by turbidity currents probably flowing from the north. East thin sand bed was rapidly deposited by a single current. Interbedded with the sand layers are mudstones that resulted from the settling out of fine particles between turbidity currents. Each mudstone bed may have taken hundreds or thousands of years to accumulate.

Long after the turbidity and mudstones began to accumulate, one or more volcanoes grew from the sea floor, perhaps to the south or southeast of St. Croix. Volcanic debris was shed northward, and in the area of St. Croix the debris interfingers with the turbidites and mudstones. Organic reefs may have grown about the volcanic island and broken fragments of the reef now constitute the limestone of Watch Ho.

After the youngest Cretaceous rocks were deposited and before the late Oligocene, mountain-building forces compressed the area St. Croix and caused numerous large folds and at least one thrust fault (Fig. 6). Molten igneous material was intruded into the centers of two of the folds, and the Central Valley of St. Croix was depressed by faulting. At the same time, the ocean trough separating St. Croix from St. Thomas was probably formed.

During this period of mountain building, St. Croix was emerging from the sea. As the Northside and East End Ranges rose above sea level they formed two islands joined by a large coral reef at Kingshill (Kingshill marl). Further uplift joined the two islands and completed the building of St. Croix.

SOME LOCALITIES OF GEOLOGIC INTEREST ON ST. CROIX

During the summer of 1959 and the fall and winter of 1960-61, I compiled a geologic map of St. Croix. Figure 1, a generalized version of the map, shows the location of a number of localities of unusual geologic significance. Since the time I completed the map there has been extensive development of the island and a large number of road cuts and excavations have been made. Unfortunately, this new evidence could not be included in this report.

The location, assessibility, and geologic significance of some of the more important geologic localities wi11 be given below. The locality numbers are keyed to Fig. 1.

1. East Point

Location: East Point, the eastern tip of St. Croix, is reached by driving eastward along the north shore of St. Croix to the turn-around at the end of the road. A trail descends eastward approximately 200 feet to the point. (Public land.)

Geologjc stgnifica nce: The Caledonia Formation is well exposed. Thin graded beds of sandstone and mudstone can be traced laterally for a considerable distance. The Caledonia Formation is also we11 exposed on many of the headlands along the north shore, including Pow Point, Tague Point, and Cotton-garden Point.

2. Buck Island

Location: Approximately 2 miles north of the east end of St. Croix. Numerous boats make the round trip from Christiansted to Buck Island daily. It is possible to walk around the island, but certain short sections must be waded. The island and adjacent reef comprise the Buck Island National Monument, administered by the National Parks Service, Christiansted.

Geologic significance: Buck Island is underlain by the Caledonia Formation, but the structural relationship of Buck Island to St. Croix is uncertain. Assuming there is no major structure, then the Caledonia Formation exposed on Buck Island is probably the oldest rock unit in the St. Croix area. Exposures of the formation are virtually continuous around the coast except for the west end. The lithology is little different from the formation on St. Croix, except that some conglomerates are present, consisting of rounded pebbles 1-2 inches in diameter of igneous and metamorphic rocks, and broken fossils, particularly coral, gastropods, and rudists. The alternating sandstone and siltstone beds are characteristically white and black, respectively, on a fresh unweathered surface.

The beds on Buck Island are steeply inclined. Some are vertical, and some are overturned by 5-10 degrees. A number of small drag folds are present on the east end of the island. Foliation is well developed, especially in the finer grained rocks.

Exposures vary considerably in quality around the island. On the south, wave action is gentle and exposures are somewhat weathered. On the north, storms periodically remove the weathered material and the exposures are relatively fresh.

3. Grass Point

Location: South Shore Road, approximately 2 miles southwest of Grapetree Bay Hotel. Grass Point is a conspicuous headland located about 200 yard south of the road. From Christiansted it is most easily reached by taking the North Shore Road to Knight Bay, then turning right on the Grapetree Bay cutoff. Turn west on the South Shore Road for approximately 1.5 miles to Grass Point. (private land)

Geologic significance: The rocks exposed at Grass Point (mapped as the East End Member of the Caledonia Formation) are typical of the tuffaceous sandstones. The rocks are generally green fine-grained tuffaceous sandstones, with some volcanic breccias interbedded with the sandstones on the west side. The beds are highly variable in thickness.

4. Watch Ho (Vagthus Point)

Location: South coast of St. Croix between Manchenil Bay and Canegarden Bay, due south of Christiansted. Property owned by the Nelthrop family. Located 0.5 mile south of the South Shore Road at the end of a dirt track that takes off from the South Shore Road 0.4 mile east of 90^0 bend at Estate Cane Garden. Alternatively, access may be made along the beach from Estate Cane Garden with permission of owners.

Geologic Significance: The watch Ho section (approximately 600 feet thick) is in the upper part of the Judith Fancy Formation. Foraminifera from is are dated to Campanian or Maestrichtian, probably Campanian. The lower 300 feet consists of tuffaceous standstone and shale with a small amount of interbedded clastic limestone. Many of the beds are graded.

The upper 300 feet consists largely of clastic limestone, for the most part conglomeratic, in beds from 6 inches to 8 feet thick. The particle size varies from sand tobolders of up to 10 feet in diameter. Rudists are the most conspicuous fossils; broken fragments are ubiquitous. In some cases the whole shell is preserved. The uppermost part of the section is largely covered. One thin limestone bed occurs very near the top and has an abundance of rudist shells.

5. Judith Fancy

Location: Along the coast at Estate Judith Fancy. Exposures are continuous from Hotel St. Croix by the Sea northwestward for approximately 0.6 mile. (private land)

Geologic significance: This is the type of locality for the Judith Fancy Formation, which forms the bulk of the tuffaceous Sedimentary rocks. Approximately one-fourth of this section

consists of thin-bedded Caledonia-type sandstones and mudstones which are interbedded with the tuffaceous rocks. The tuffaceous rocks are for the most part green, medium- to coarse-grained sandstones, although in the upper part of the formation (near Hotel St. Croix by the Sea) breccias with volcanic boulders up to 3 feet in diameter are exposed. Siltstones are not uncommon throughout the section. The lowest beds in the section contain broken corals, rudists, and gastropods. A few limestone cobbles and pebbles containing fossils are found higher in the section.

There are several stump zones in this section; the largest is approximately 100 feet thick and is located about half way between Hotel St. Croix by the Sea and a small bay 0.5 mile northwest of the hotel.

6. Tertiary Section along, the Scenic Road

Location: Eastern end of Scenic Road. from base of Northside Range at Salt River to an elevation of about 240 feet. Take Scenic Road cutoff from the main Christiansted-Frederiksted Highway; section starts as one ascends the Northside Range after crossing Salt River.

Geologic Significance: This section is probably the Jealousy Formation (Oligocene Age) which underlies the Kingshill Marl. The deposit is poorly stratified and consists of pebbles, cobbles, and boulders of tuffaceous rocks and minor diorite; thin oyster beds, corals, and other shallow-water fossil fragments; pockets of red and green clay up to 20 feet long and 5 feet deep; and a calcareous sandy matrix. The clay is about 90% montmorillionite and 10% angular fragments of quartz, plagioclase, hornblende, and hematite.

The fault contact between the Jealousy and the Judith Fancy Formations is well exposed on the Scenic Road and on the East side of Judith Fancy. It dips 60^0-75^0 southwest.

7. Intrusive Igneous Rocks on the Scenic Road

Location: The Fountain Gabbro is exposed in two places along the Scenic Road, about 0.6 mile west of the junction of the Scenic Road and Parasol Hi11 Road, and about 0.4 mile east of the junction. Both exposures are continuous for some distance.

Geologic significance: The Fountain Gabbro is a discordant unfoliated pyroxene gabbro. Plagioclase and augite are essential minerals; hypersthene occurs in variable amounts and may be essential or accessory. A small contact aureole of metamorphosed sedimentary rocks surrounds the intrusion. Fresh specimens are obtainable only along recent road cuts. The intrusive rock weathers readily and has formed the broad valleys at Fountain.

8. Creque Dam Road

Location: Creque Dam Road connects Sprat Hall with Estate Annaly.
The best exposures are in the stream valley for about 0 4 mile upstream and downstream from Creque Dam Reservoir. The road parallels the stream.

Geologic Significance: Some of the best exposures of the Caledonia Formation are in the stream bed on the north side of Creque Dam Road. Particularly good exposures are just upstream from Creque Dam Reservoir. Pebble conglomerates, sandstones, and mudstones are present; the coarser units are generally graded and current bedding is not uncommon. Flute casts and load casts on the bottom of sandstone beds are usually observable only in two dimensions owing to the extreme hardness of the underlying mudstones, which are in part silicified.

9. Ham Bluff

Location: Northwest corner of St. Croix. Take the road along the west coast of St. Croix north to the Coast Guard Station at Hams Bluff. Obtain permission from Coast Guard to take the trail to the coast leading from the northeast corner of the easternmost house at the station.

Geologic significance: The Caledonia Formation exposed at Hams b1uff consists of fine-grained sandstone and siltstone. The section is structurally complex. There are numerous faults and probably some large slumps. Many of the siltstones are foliated Numerous quartz veins are present.

The elevated beach rock west of Hams Bluff suggests a recent change in sea level.

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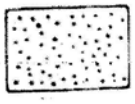
Generalized Geologic map of St. Croix

Explanation



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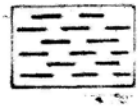

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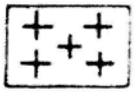
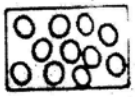


Caledonia Formation – sedimentary layers (145-65 million years ago)



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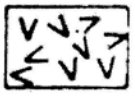

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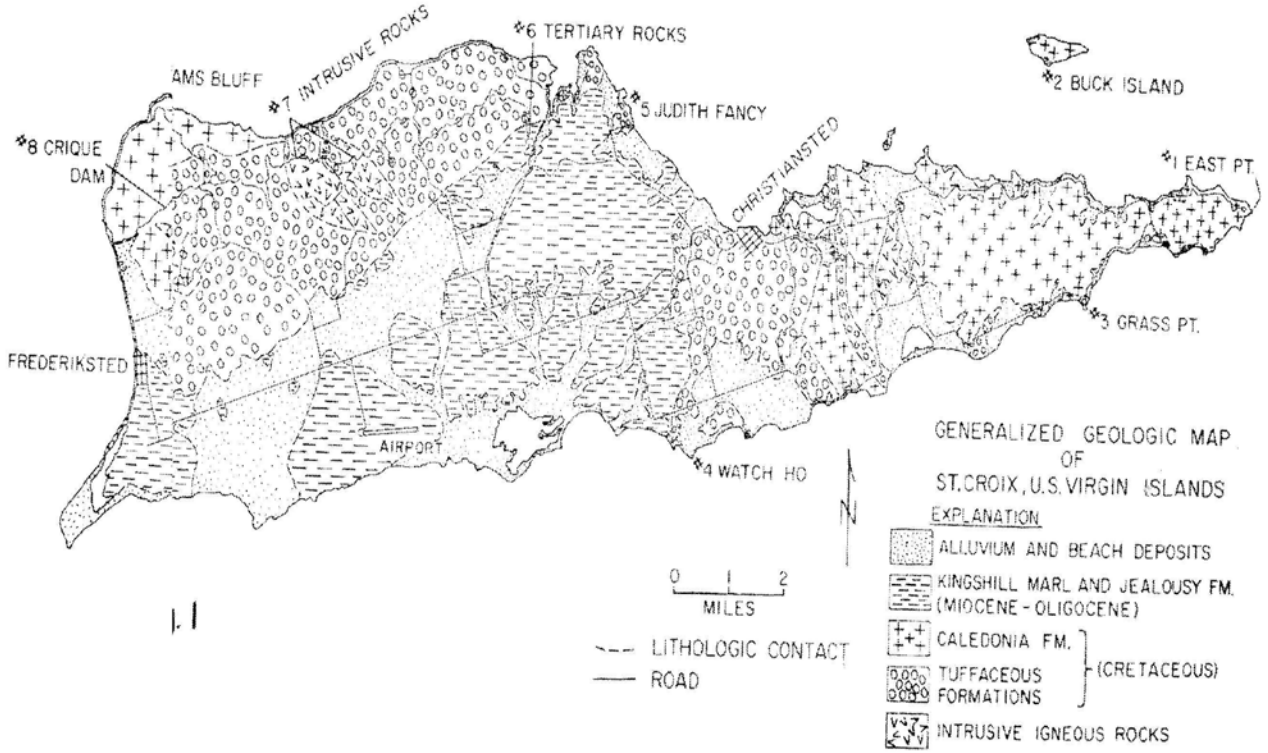
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