Progress report on the geology of the Machiasport, Maine, site

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by

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INTRODUCTION

This report is based on geological information obtained while mapping the Machias 15 minute quadrangle in 1961 and 1962 as consulting geologist to the Maine Geological Survey. The map of this report represents about four days of fieldwork. The mapping was done by pace and compass on the topographic map at a scale of 1/24000. Air photos 46c-47 to 46c-43 (Air Photo Index 136L) of the U. S. Coast and Geodetic Survey cover the site area. The scale of the original geologic mapping and of the enclosed map is not nearly detailed enough to be used as basic site geology, but as a preliminary reconnaissance this report may be of some use.

GEOGRAPHY

The COAST PILOT (1950 edition) gives the following weather data for Eastport, Maine, data which are applicable to the site. Prevailing winds, particularly in summer, are from the south and southwest. Maximum gale winds, up to 52 knots, are from the east and northeast. Thus Stone Island is fully exposed to the prevailing gale winds and the harbor is unprotected from the prevailing south and southwest winds. This is the foggiest area between Canada and Cape Cod, Libby Island lighthouse holding the record for the most hours of foghorn operation. The COAST PILOT reports tidal currents of two and one-half knots in Grand Manan channel. U. S. Coast and Geodetic chart 304 gives the mean tidal range at Stone Island of 12.4 feet and a maximum range of 16.9 feet. I am not qualified to comment on the suitability of the harbor in size and protection for the safe handling of supertankers nor on the distribution of possible oil spills by the swift Bay of Fundy tidal currents, and leave these questions to shipping and oceanographic consultants.
The general topography of the site is evident from the base map and is even more so on the stereo air photos. Most of the land is hilly and much of what level land there is forms bogs. The shoreline is largely bedrock and the hills are generally underlain by bedrock, either at the surface or beneath an estimated not more than five feet of soil. Areas in which bedrock is estimated to be less than five feet below the surface or is exposed are mapped as such. The low-lying areas are poorly drained ground on glacial moraine or outwash sand and gravel. Depth to bedrock in these areas may be anywhere from five to fifty feet. To level the site will require blasting of bedrock from the hills and draining and filling of the bogs and swamps.

There is no source of water adequate for even limited industrial use nearer than the Machias River about eight miles to the northwest. The vitrophyre which underlies most of the site is a glassy rock of very low porosity and permeability and can not be a good groundwater aquifer. Sufficient water for domestic use might be found if the drill happened to hit a brecciated fault zone within the vitrophyre.

The low porosity and permeability of the vitrophyre will also prevent underground sewage disposal through a system of sceptic tanks and seepage fields. A sewage treatment plant with outlet of treated sewage to the sea will probably be required.

BEDROCK GEOLOGY

Bedrock of the site area consists of marine sedimentary rocks, volcanic rocks including vitrophyre, and intrusive diabase and gabbro, all of late Silurian to early Devonian age. These are part of a belt of similar rocks that extends along the coast from New Brunswick to Jonesport, Maine, and is found again near Mt. Desert Island and in Penobscot Bay. This belt is cut by a number of throughgoing major faults which have been traced from Jonesport almost to the Gulf of St. Lawrence in New Brunswick.
Three of these faults - the Holmes Bay fault, the Lubec fault, and the Fundian fault - occur within a zone three miles wide adjacent to and southeast of the site; and the Holmes Bay fault lies just off the east shore of Stone Island. Glacial erosion of the brecciated and hence weakened rocks in this zone of faults produced the narrow submarine valley between Stone Island and the Libby Islands with depths of 180 feet.

ROCKS

The following description of the rocks is arranged in order of their age from oldest to youngest.

**Argillite, siltstone, shale, tuff:** This unit is exposed along the southeast shore of Point of Main and on the outlying islands. It is a sequence of well-bedded marine sedimentary rocks and volcanic tuffs. Argillite and tuff are most common on the islands and siltstone and shale prevail in the section on Point of Main. The rocks are composed primarily of feldspar, quartz, chlorite, and muscovite along with fine-grained volcanic ash and rock particles. Bedding ranges in thickness from thin one-quarter inch laminations to crossbedded units two to three feet thick, especially in the upper siltstones. These are the least competent rocks in the site area and are the most highly cleaved, jointed, and sheared.

**Volcanic breccia:** Coarse volcanic breccia is interbedded with siltstone, shale, and argillite on Starboard Island. It consists of angular to subrounded fragments of basaltic lavas and pyroclastics, up to a foot or so in diameter, in a matrix of smaller fragments, chlorite, and silica. Individual beds range from a foot to 25 feet in thickness and are massive, although some have a crude grading from large fragments at the base to smaller fragments near the top.

**Red sandstone, siltstone, and limestone:** These rocks crop out on the west shore of Point of Main and at Starboard Cove. The sandstones and siltstones are composed of feldspar
and quartz grains, chlorite and muscovite flakes, and basaltic volcanic fragments in a cementing matrix of limey mudstone. Bedding ranges from a few inches thick in the siltstones to three or four feet thick in the sandstones with much cross-bedding. The limestones are thickest at Starboard Cove. They are made up almost wholly of recrystallized pelecypod and gastropod shells in a matrix of recrystallized limestone and red limey mudstone. Bedding ranges from one to six feet thick with some cross-bedding particularly near the top of the limestones.

**Diabase and gabbro:** These igneous intrusive rocks form dikes, sills, and small irregular plutons largely within the argillite-siltstone-shale-tuff unit. They range from medium-grained (crystals about one-eighth inch long) to coarse-grained (crystals up to one inch long). Principal minerals are plagioclase, pyroxene, chlorite, and epidote. Most of the diabase and gabbro has been hydrothermally altered to greenstone but original igneous textures and remnants of original igneous minerals, notably augite and labradorite, remain. These rocks are massive and competent except where highly sheared resulting in conversion to a chlorite schist.

**Vitrophyre and vitrophyre breccia:** This rock unit underlies most of the site and forms the most prominent hills. It is a glassy (now devitrified), hard (6-7 on the Mohs Hardness Scale), and brittle rock. Wherever it crops out along the shore exposed to surf, it makes steep cliffs. Its porosity and permeability are almost nil except in fracture zones. The only minerals visible under a microscope are small phenocrysts of feldspar and discontinuous paper-thin laminations of muscovite. The vitrophyre in most places is highly flow-banded, individual bands ranging from paper-thin to several inches thick and traceable for hundreds of feet. The flow-banding is commonly folded into long sweeping isoclinal folds with amplitudes up to ten or twenty feet.
The vitrophyre breccia has the same composition as the vitrophyre - devitrified glass with local concentrations of small feldspar phenocrysts and muscovite - but consists of angular fragments of vitrophyre in a siliceous vitrophyric matrix. Zones of flowbanding grade into zones of breccia, suggesting that during intrusion the vitrophyre magma became so viscous that laminar flow gave way to brecciation.

The vitrophyre and vitrophyre breccia have responded to tectonic stress by fracturing along small faults and shears rather than by forming closely spaced fracture cleavages as did the less competent argillites, siltstones, shales, and tuffs. It also has many joints. These rocks should be difficult and costly to drill, behaving under the bit much like chert, and on blasting should shatter into many small blocks.

This unit is a complex of several separate intrusions and extrusions. Exposures are not good enough to allow mapping of these separate sub-units on the scale used. Undoubtedly drilling and excavations will show considerable variability in properties within the unit.

Diabase and felsite dikes: These vertical dikes, the youngest of the bedrock units, cut across all the older rocks following a consistent northnorthwest trend approximately parallel to the cross faults. The dikes range in width from one or two feet to thirty feet, and there are more of them than is shown on the map. These fine-grained hard rocks show little shearing or fracture foliation and tend to stand up on land as ridges resistant to weathering and erosion.

STRUCTURE

The major regional faults - the Holmes Bay, Lubec, and Fundian - are all under the sea at the site. Their position is inferred by projection along their strike from exposures on land east of the site area and/or by a high degree of shearing in the rocks on adjacent islands.

Extensions or branches of these faults continue
northeastward into New Brunswick where they bound the several Carboniferous basins. There they have displacements measureable in miles, although the precise amount and direction of displacement is not yet agreed upon by geologists who have studied them. Large faults on this same northeast trend displace Triassic rocks in New Brunswick. The absence of Cretaceous and Tertiary rocks prevents determination of the age of most recent movement younger than Triassic. I have found no evidence in the Machias or Eastport quadrangles that Pleistocene (Wisconsin) glacial deposits have been displaced along these faults.

The overall structure of this site is a syncline whose center is occupied by the vitrophyre and whose southeast flank borders on the zone of regional faults. Proximity to this zone of major displacements of the earth's crust is reflected in the widespread shearing and local faulting of the bedrock at the site.

The least competent rocks - the unit of argillite, siltstone, shale, and tuff - are also closest to the fault zone. These are the most severely deformed rocks of the site. They are folded, have a fracture cleavage that is pervasive and approximately vertical parallel to the zone of major faulting. In addition there are faults and shear zones with displacements too small and too close together to warrant mapping on a 1/24000 scale. A closely spaced fracture cleavage is not well developed in the vitrophyre and vitrophyre breccia. Instead there are numerous zones of shearing and brecciation, a few of which are large enough to map on the scale used. All the bedrock units are also cut by innumerable joints with a wide variety of trends and spaced from a few inches to several feet apart.

The site area is also traversed by several younger northwest striking vertical cross faults. Only those cross faults along which displacement could be demonstrated by offset of contacts are shown on the map.
CONCLUSIONS

Preliminary planning of an industrial site here should anticipate considerable land levelling, water and drainage problems, contrasts in the engineering properties of the surficial and bed rocks, and few areas of cohesive unfractured bedrock either at the surface or at depth.