Observations on the Geology of Cornwall

Cornwall lies within parts of three different quadrangles published by the U.S. Geological Survey and the U.S. Coast and Geodetic Survey. The majority of Cornwall lies within the Cornwall Quadrangle and the South Canaan Quadrangle. Both were mapped and described by Gates (1961 and 1975). The southwestern most part of Cornwall lies within the Ellsworth Quadrangle.

Bedrock

According to Gates, four major metamorphic rock associations are found in Cornwall: 1) gneisses of pre-Cambrian age, 2) marble, 3) schist and gneiss, and 4) granite. These rocks are described in this report as pre-Cambrian rocks, rocks of the continental shelf, rocks of the continental slope, and granite. The distribution of the various rock formations is shown on Figure 1.

Pre-Cambrian Rocks. The most ancient rocks were formed about billion years ago during a mountain-building episode, called the Grenville Orogeny. These rocks consist of a complex of gneisses that are relatively resistant to erosion. Consequently they typically form the highlands in New England and neighboring New York and southern Canada. These older rocks underlie the high areas the northwestern half of Cornwall. They are designated on the geologic map with symbols starting with the letter Y (Ygh, Ygn, Ygr, and Ygs). These rocks are typically granitic gneiss, hornblende schist and amphibolite. Many of the layers weather rusty; some of the schistose layers contain graphite and presumably iron sulfide minerals. They were formed when igneous and sedimentary rocks that were part of the ancient nucleus of the North American continent (referred to as Laurentia) were metamorphosed during a continental collision with the ancient core of the South American continent (referred to as Amazonia). At that time, about one billion years ago, many of the existing continental masses had had drifted together to form a large continental land mass referred to as Rodinia (see Coleman, 2005, for an easy to read compilation of the history of Connecticut's bedrock).

Paleozoic Rocks. When the supercontinent, Rodinia, broke apart about 600 million years ago, an ocean basin was created. Geologists have given the name Iapetus to that ancient, now vanished, ocean. Two rock groups had their origins as sediments deposited in the Iapetus Ocean: marble associated with the continental shelf and schist associated with the continental slope.

Rocks of the Continental Shelf. The North American continental margin at the edge of the Iapetus Ocean was eroded to a low relief during several tens of millions of years after the continental break up. Gradually the continental margin was flooded by seawater and during the Cambrian and Ordovician periods of geologic time shallow water depositional environments existed on the continental shelf of the ancient North America. The actual shore-line migrated westward as the flooding progressed, depositing a beach of quartz sand as it went. When the shore-line was located several hundreds of miles to the west of the continental margin very little sand and mud could be transported to the area, and lime, formed by skeletal remains (shells) of organisms that lived and died there, accumulated on the shelf. Over the millennia the lime was lithified into limestone and later was metamorphosed into marble (OCs and Owm on the geologic map). The marble belt is interpreted to be the eastern edge of the ancient North American continental shelf.

Marble is composed of carbonate minerals which are soluble in rain water. This makes them erode more readily than non-carbonate bearing rocks such as granite or schist. Thus, areas underlain by marble today form the prominent valleys in Cornwall and elsewhere in the region. (Figure 2) The Housatonic River takes advantage of this over much of its course, including the southwestern part of Cornwall.

Rocks of the continental slope and deeper water. Schist and schistose gneiss crop out over the south and eastern part of Cornwall. They are in fault contact with the marble and marble-like rock. They were likely formed about the same time as the marbles but geographically and depositionally in different environments. They are mapped as the Waramaug Formation by Gates (1961, 1975) but where included, as part of the Manhattan Schist by Rodgers (1985). In actuality they have a chemical composition very similar to the Manhattan Schist, as noted by Gates (1961, p. 23). They are referred to as the Manhattan Schist on the map presented herein (Cm and Cma).

The rocks consist of mica-feldspar-quartz gneiss and schist and amphibolite. Some are rusty weathering. (Figure 3) They apparently were deposited as muddy sandstone and shale that were later intruded by basaltic igneous rock. They are inferred to have been deposited in deeper water on the continental slope at about the same time that lime (now marble) was being deposited on the continental shelf of Laurentia, the ancestral North American continent. Metamorphism occurred during later orogenic (mountain-building) events. The earliest event is termed the Taconic Orogeny and resulted not only in metamorphism of the sediments but also thrusting of the continental slope rocks onto the shelf rocks. The feature shown as Logan's Line on the geologic map of Cornwall is the fault beneath the continental slope rocks along which they were thrust over the marble and other rocks that formed the continental shelf.

Granite. An irregularly-shaped granite mass (Og) occurs in the southeastern part of Cornwall. Granite formed as an igneous rock that intruded or forced its way, in a molten state, into the schists and gneisses of the continental slope. The granite is fine- to medium-grained, white and structureless (massive, lacking in foliation). It contains some pegmatite (very coarse grained granite) near its borders and is clearly intrusive. The lack of foliation (layering) in the granite leads Gates to suggest it was intruded after the metamorphism had concluded. It is, therefore, the youngest rock in this area.

Bedrock Lithochemistry

Robinson et al. (1999) compiled the chemical characteristics of near surface rocks in portions of western New England as part of the National Water Quality Assessment program. The data set presented by Robinson et. al. characterizes the rock units in terms of mineralogic and chemical characteristics relevant to surface and well water quality and ecosystem analysis. This map is published digitally and may be accessed at the following web-site. http://water.usgs.gov/lookup/get?wrir994000

Table 1 compiles lithochemical characteristics and their anticipated affects for the rock units that occur in Cornwall. Most domestic water wells are completed in rock near the surface (upper 300 feet). The chemical characteristics of the rock will likely impact the groundwater recovered from those wells.

Mines

There are no active mines within the town of Cornwall. In the past, however, rock has been extracted from several sites in Cornwall (Altamura, 1987). This reviewer was able to find one site (immediately north of Rte. 4 near base of Red Mtn.) during this review. The rock is very rusty weathering so it is imagined that some of the rock may have been assayed for iron. The rock, however, was excavated for construction purposes rather than iron ore. Warren and Colton (1974) found two additional sites (south of Rte. 4 near Quarry Hill). Other mine sites have been located through older reports. Many of the old quarries and mines excavated granite or granitic rock for foundation stones or other construction purposes. These include the granite quarry in the southeastern part of town off Mattatuck Road and the two quarries, one of which was referred to as the Benedict Quarry by Dale, 1923 (as reported by Altamura), south of Rte. 4 on or near Quarry Hill. Marble apparently was excavated for agricultural lime from a quarry immediately east of Cornwall Bridge. Other excavations on Mine Mountain, Green Mountain, and Cream Hill prospected for and perhaps even produced graphite, pegmatite, gold, and silver.

A site, referred to as the Botallock Iron Mine by Altamura (1987), could not be geographically located. Perhaps it is because the Botallock Iron Mine is located in Cornwall, England rather than Cornwall, CT. If not, there is a lost iron mine in Cornwall, CT.

Surficial Geology

The surficial geology of the Cornwall Quadrangle was mapped by Warren and Colton (1974) and published by the U.S. Geological Survey. More than 90% of the surficial deposits in Cornwall consist of glacial till deposited during one or more glacial stages (Ice Ages) of the Pleistocene Epoch. Most of the remaining deposits consist of stratified drift, deposits of sand and gravel from meltwater streams at the end of the last glacial episode. Stratified drift was deposited in most of the major valleys. The drift is porous and permeable and where thick enough makes a good shallow aquifer.

During the last ice age two or more kilometers of ice covered northwestern Connecticut. The ice extended as far south as Long Island at its maximum. The glacial ice formed in response to a much colder global climate. About 20,000 years ago the climate began warming and the glaciers began melting. As a response to the melting the southern edge of the ice began to disappear.

When ice is thicker than a few 100 meters it flows from areas where the ice is thicker toward areas where the ice is thin. For most of New England, the ice flowed generally toward the south and southeast. Because glacial ice freezes around soil and rock particles, it carries them in its flow. This has two important effects. First, it moves tons of material of all sizes southward. Second, the soil and rock particles act as abrasives in the bottom of the glacier and help the glacier to erode the underlying bedrock.

Glacial Deposits

Till is a poorly sorted glacial soil, composed of mud, sand and pebbles, cobbles or even boulders that is deposited by the glacier. Till may be deposited in two ways. It may be deposited beneath the glacier forming a bed over which the glacier moves. This type of till has been compacted by the weight of the over-riding glacier and is relatively impermeable. It may be referred to as "hard-pan" by local drillers, but it is referred to as basal till by geologists. Till may also be deposited when the ice melts, leaving all the debris it was carrying on the ground surface much the way road sand is left by the side of the road when sand laden snow, plowed to the side of the road during a storm, melts. Most of the till in Cornwall is this second type of till. It is generally fifty feet or less in thickness. Indeed, large areas of town have little or no soil and bedrock is exposed. Many of the higher mountains in town (Mohawk Mountain, Coltsfoot Mountain, Green Mountain, Mine Mountain) have thin or no soil on their highlands.

Thick till is found in several locations and probably consists largely of basal till. Notable locations are Dean Hill, an area near Kellogg Corners, and a former channel of the ancestral Housatonic River just south of West Cornwall. A well there penetrated 225' of till without reaching bedrock. Dean Hill may be thicker still, perhaps as much as 650' (Warren and Colton, 1974). Steep slopes developed on thick deposits of till, such as along the north side of Rte. 4 adjacent to Dean Hill, may be unstable during spring thaws and/or heavy rains and subject to land-sliding.

Stratified Drift. As the glaciers began melting 20,000 years age, meltwater eventually collected in streams that flowed toward the sea. During the summers, torrents of water flowed seaward at very high velocities. Because water power depends on the velocity of the water (as well as the volume), high-velocity meltwater streams were able to transport large volumes of sediment, and also, sedimentary particles of large sizes. When water velocity in the meltwater streams diminished, due either to changes in channel characteristics or seasonal changes in the rate of melting, sand and gravel was deposited. Most of the sand and gravel in Cornwall was deposited in valleys once occupied by meltwater streams.

The drift deposits consist of pebble- to boulder-gravel and sand. A deposit at Tanner Brook consists mostly of sand; another at Cornwall Bridge consists mainly of boulders, 1-14 feet in diameter. Deposits are generally stratified and contain rounded stones (river-rocks). Most deposits do not contain mud because mud does not settle from moving water.

Because stratified drift deposits lacks mud, most are porous and permeable. Where stratified drift is below the water table it provides a high yielding aquifer when developed. Hence, areas underlain by water-saturated stratified drift should receive aquifer protection. They generally yield high quality, good tasting water.

Glacial Erosion Features

Meltwater was capable of considerable erosion and several rock gorges in town were likely cut or deepened by glacial meltwater. The rock channel in Birdseye Brook was likely deepened in a pre-existing valley. Birdseye Brook today carries sufficient volume to continue eroding its gorge. A spectacular gorge is located immediately south of Rte. 4 near the Goshen town-line that has a very low volume stream flowing through it. (Figure 4) It is up to 40 feet deep and partially filled with chaotic rock debris on its bottom. Clearly a higher volume stream cut that gorge. The rocks in the bottom of the gorge appear to have collapsed into the chasm. Perhaps there was a rock tunnel in sulfidic schist that collapsed. Warren and Colton map several other gorges and meltwater channels.

Striations and grooves are mapped on numerous hill and mountain tops by Warren and Colton, 1974). A prominent groove is illustrated by Figure 5.

Topography

Cornwall is hilly: elevations range from just less than 400 feet where the Housatonic River flows out of Cornwall to 1683 feet at the summit of Mohawk Mountain. A drainage divide runs northeasterly from the southerly town boundary. South and east of the divide slopes are generally gentle to moderate and streams flow into the Shepaug River drainage. West of the divide, slopes are moderate to steep and streams flow into the Housatonic River drainage. A prominent set of marble valleys cut through central part of Cornwall. (Figure 2) Valley Brook and Furnace Brook flow into the Housatonic through one valley and Great Hollow and Johnson Hollow occupy the other valley. Both valleys owe their presence to the solubility of the marble bedrock that underlies them. The high areas tend to be underlain by either Manhattan Schist or granite gneisses of pre-Cambrian age.

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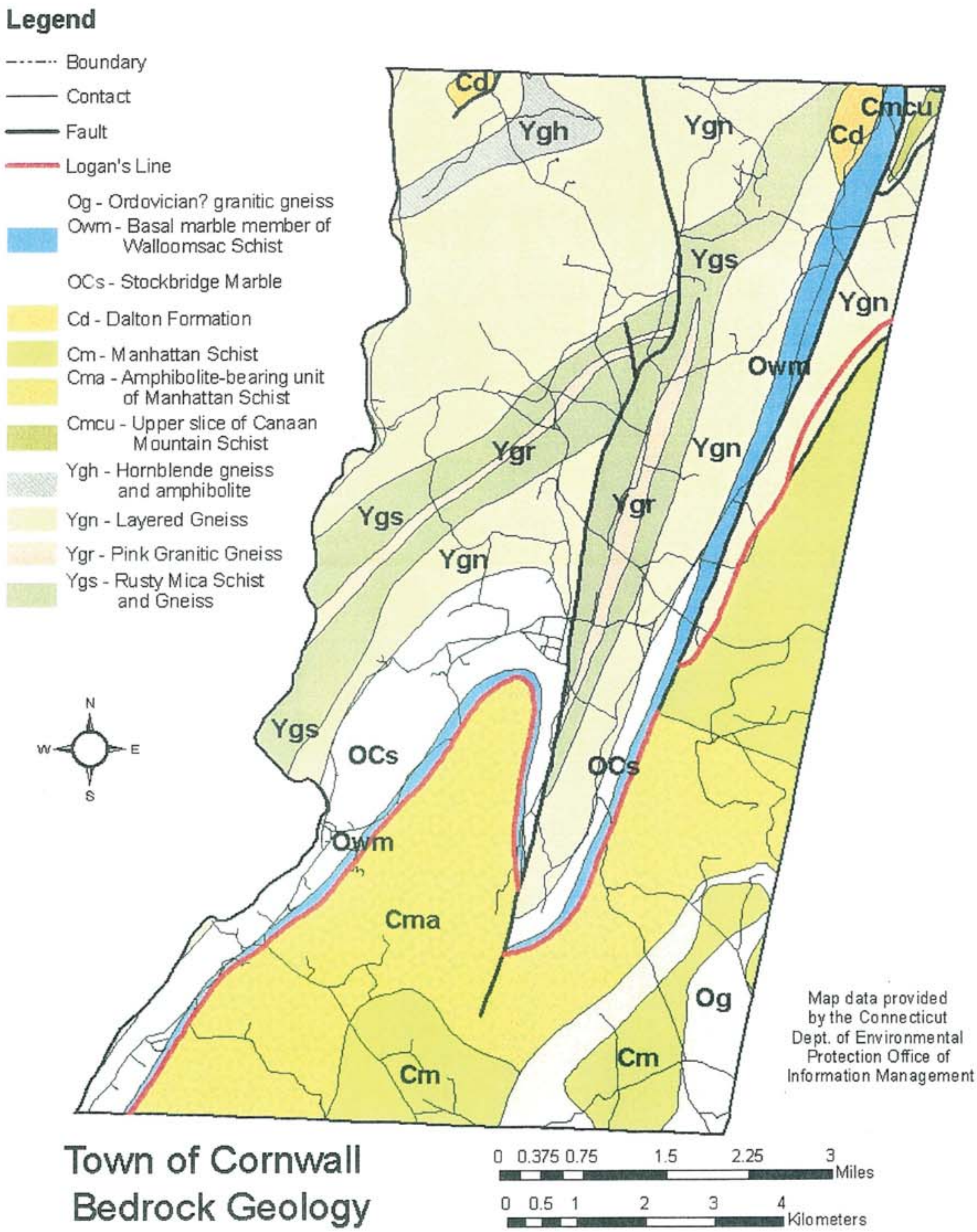

Figure 1. Bedrock geologic map of the Town of Cornwall (from Rodgers, 1985). (Thanks to J. Mickiewicz, CT-DEP, who constructed this map for the author.)

Figure 2. Marble valley just south of Cornwall Village. Fault at base of hills on left side of picture truncates the marble in the distance and effectively ends the valley.

Figure 3. Rusty weathering Manhattan Schist along Route 4 just west of entrance to Mohawk Mountain State Forrest. Rock quarry on Rte. 4 removed rock of this type.

Figure 4. Water worn rock in gorge just south of Route 4 at border with town of Goshen.

Figure 5. Glacial grooves in Manhattan Schist on Mohawk Mountain.

Table 1. Lithochemical rock types and expected characteristics. (From Robinson et al 1999.) Groundwater recovered from specific rocks may expect to have similar chemical characteristics.

Geologic formation symbol (see Fig. 1)	Chemical characteristics of near surface rock	Sensitivity to acid deposition	Soil characteristics	Topographic expression
Og	generally low solute concentrations, low pH, Fl, U, and Ra concentrations may be high	high sensitivity	sandy soils	tendency toward higher elevations
Owm, OCs	high alkalinity, hard water, high concentrations of metals, such as Ar and U, where complexed by HCO_3	low sensitivity, productive aquatic faunas, alkaline favoring flora.	generally thin alkaline clay soils, high Ca, low K	generally lowlands and topographic depressions; may be sites of stream channels, lakes, and springs.
Cm	low/moderate solute concentrations	moderate to high sensitivity	clayey soils	moderate hills
Cma	high Ca+Mg to Na ratio, high Fe and Mn where Eh and pH are low	low sensitivity; may have endemic flora in high Mg, high pH and low K soils; productive aquatic fauna where Ca is high in surface waters	thin, rocky, clayey Mg-rich and K-poor soils	moderate ridges and hills.
Ygs, Ygr	low/moderate solute concentrations, Fe may be high, sulfate may be high.	moderately sensitive, endemic floras mnay occur in low pH metal rich soils over sulfide rich horizons.	rocky acidic metal-rich soils may occur	uplands and ridges (Ygr); low hills (Ygs)
Ygn, Ygh	high Ca+Mg to Na ratio, high Fe and Mn where Eh and pH are low	low sensitivity; may have endemic flora in high Mg, high pH and low K soils; productive aquatic fauna where Ca is high in surface waters	Fe-rich, neutral to basic soils	moderate rolling hills