Geologic Resource Evaluation Scoping Summary
Minute Man NHP & Saugus Iron Works NHS

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The Geologic Resource Evaluation (GRE) Program provides each of 270 identified natural area National Park Service (NPS) units with a geologic scoping meeting, a digital geologic map, and a geologic resource evaluation report. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity for discussion of park-specific geologic management issues and, if possible, include a site visit with local geologic experts. The purpose of these meetings is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and potential monitoring and research needs. Outcomes of this scoping process are a scoping summary (this report), a digital geologic map, and a geologic resource evaluation report.

The National Park Service held a GRE scoping meeting for Minute Man National Historical Park (MIMA) and Saugus Iron Works National Historic Site (SAIR) on July 11, 2007 at Minute Man National Historical Park in Concord, Massachusetts followed by a site visit to the national historical park in the afternoon. Tim Connors (NPS-GRD) facilitated the discussion of map coverage and Bruce Heise (NPS-GRD) led the discussion regarding geologic processes and features at the two units. Participants at the meeting included NPS staff from the parks, Northeast Temperate Network, and Geologic Resources Division, geologists from the University of Massachusetts, Boston College, Wellesley College, and Andover Geologic Consulting as well as cooperators from Colorado State University (see table 1). This scoping summary highlights the GRE scoping meeting for Minute Man National Historical Park and Saugus Iron Works National Historic Site including the geologic setting, the plan for providing digital geologic maps, prioritized lists of geologic resource management issues, descriptions of significant geologic features and processes, lists of recommendations and action items, and a record of meeting participants.

Park and Geologic Setting

Minute Man National Historical Park and Saugus Iron Works National Historic Site encompass 970 and 8.5 acres of eastern Massachusetts, respectively. The Battle Road between Lexington and Concord is a major cultural resource at Minute Man National Historical Park, which commemorates the start of the Revolutionary War on April 19, 1775. Designated on April 14, 1959, this park covers three separate units: North Bridge, The Wayside, and Battle Road. Saugus Iron Works National Historic Site, authorized on April 5, 1968, contains remnants of the first integrated iron works in North America (ca. 1646-68). Historic structures of the iron works cluster on the banks of the Saugus River, north of Boston, Massachusetts. Minute Man National Historical Park and Saugus Iron Works National Historic Site sit within the Concord, MA and Boston North 7.5'-quadrangles, respectively.

A series of accreted terranes comprise the bedrock underlying eastern Massachusetts including the Avalon, Nashoba, and Merrimack Terranes. An accreted terrane is a crustal block or fragment that exhibits distinctive geology, attached onto the margin of a continent as a result of tectonic processes. A terrane is demonstrably different from surrounding rocks and is usually fault-bounded. The

easternmost terrane, the Avalon Terrane, tangentially collided with North America during the Acadian orogenic event some 390 million years ago (Ma). Rocks of this terrane include weakly metamorphosed shelf and shallow marine sediments of the Boston Bay Group, arc volcanics, gabbroic intrusions, and granites. The Bloody Bluff fault that runs through Minute Man National Historical Park separates the Avalon Terrane from the Nashoba Terrane to the west. Deformation along this fault was oblique as the Avalon Terrane subducted beneath the Nashoba Terrane as well as slid past it. Further west, across the Clinton-Newbury fault zone, is the Merrimack Terrane. The Nashoba Terrane contains metamorphosed volcanics, volcanogenic sediments, and intrusions of diorite and tonalite.

Pleistocene glaciers covered eastern Massachusetts and glacial to post-glacial surficial features dominate the landscape at both park units and strongly influence the historic events there. Glaciers left mantles of glacial till across the area. Glacial lakes, formed as ice retreated, left lacustrine sediments as well. Gently undulating hills, muted ridges, broad stream valleys, kettle ponds, and flatlands of meadows and fields characterize the landscape at Minute Man National Historical Park. The Sudbury and Assabet Rivers converge to form the Concord River that runs through the North Bridge unit. Other streams include Mill Brook and Elm Brook. Battle Road runs along a divide between drainages. Saugus Iron Works National Historic Site is sited along the banks of the Saugus River approximately 5 km (3 miles) from its confluence with the Atlantic Ocean. Steep banks, undulating uplands, and relatively flat floodplain areas characterize the landscape at the site. Tidal influxes mix salt and fresh water in the area creating important estuarine wetland habitat.

Geologic Mapping for Minute Man National Historical Park and Saugus Iron Works National Historic Site

During the scoping meeting Tim Connors (NPS-GRD) showed some of the main features of the GRE Program's digital geologic maps, which reproduce all aspects of paper maps, including notes, legend, and cross sections, with the added benefit of GIS compatibility. The NPS GRE Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation set for the GRE Program. Staff members digitize maps or convert digital data to the GRE digital geologic map model using ESRI ArcMap software. Final digital geologic map products include data in geodatabase, shapefile, and coverage format, layer files, FGDC-compliant metadata, and a Windows HelpFile that captures ancillary map data. Completed digital maps are available from the NPS Data Store at http://science.nature.nps.gov/nrdata/.

When possible, the GRE program provides large scale (1:24,000) digital geologic map coverage for each park's area of interest, usually composed of the 7.5-minute quadrangles that contain park lands (figure 1). Maps of this scale (and larger) are useful to resource management because they capture most geologic features of interest and are positionally accurate within 40 feet. The process of selecting maps for management use begins with the identification of existing geologic maps and mapping needs in vicinity of the park. Scoping session participants then select appropriate source maps for the digital geologic data to be derived by GRE staff as well as determine areas in need of further mapping or refinement. Tables 2 and 3 (at the end of this document) list the source maps chosen for Minute Man National Historical Park and Saugus Iron Works National Historic Site as well as any further action required to make these maps appropriate for inclusion.

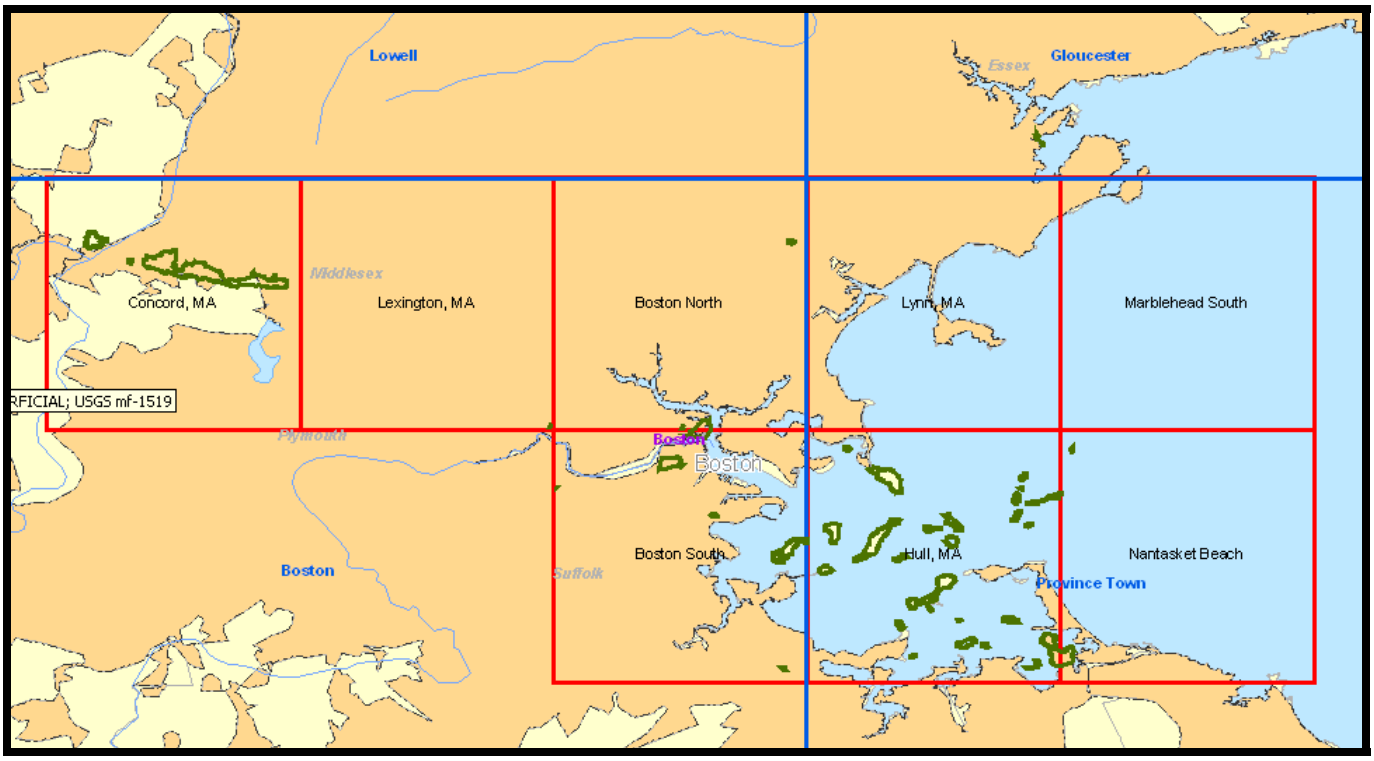


Figure 1. Quadrangles of interest for Minute Man National Historical Park and Saugus Iron Works National Historic Site. The figure shows USGS 7.5' quadrangles (red outline), 30' × 60' sheet (blue outline, blue font labels), and 1° × 2° sheets (purple outline, purple font labels). The green outlines represent park boundaries.

Park resource management identified bedrock and surficial geologic map coverage as needed data sets for MIMA and SAIR. For MIMA, the park is completely contained on the Concord, MA 7.5' quadrangle where there is recent, digital GIS-based surficial geology published by the U.S. Geological Survey (contained in GMAP 74750). It is believed that a new bedrock map for the Concord, Massachusetts 7.5' quadrangle is being assembled by Boston College (student Colin Langford, advisor Chris Hepburn). As of July 10, 2008, GRE staff are awaiting a status update from Boston College (Chris Hepburn) on this map, its map format, and if the NPS can acquire a copy of it for incorporation.

Thus for **Minute Man National Historical Park**, GRE staff would likely use the following maps:

- (74982) Langford, Colin and Chris Hepburn, 2007, Bedrock geologic map of the Concord quadrangle, unpublished, Master's thesis, Boston College, 1:24,000 scale

- (74750) Stone, J.R. and Stone, B.D., 2007, Surficial geologic map of the Clinton-Concord-Grafton-Medfield 12-quadrangle area in east central Massachusetts, USGS, Open-File Report OF-2006-1260-A, 1:24000 scale, http://pubs.usgs.gov/of/2006/1260/A/

During the GRE scoping session, SAIR park staff suggested that they would draw a boundary showing the park area of interest to better define the scope of needed large-scale geologic mapping. Marc Albert (SAIR) has been working with Rudolph Hon (Boston College) on this task. Potentially a graduate student (potentially funded by the EdMap program) could update existing bedrock geologic maps of the SAIR area of interest. Marc Albert sent GRE staff this proposed area of study

for SAIR in an email dated 2007-1109 (figure 2). The area drawn encompasses several 7.5' quadrangles in the SAIR area including the Marblehead North, Salem, Reading, Marblehead South, Lynn, and Boston North quadrangles (where SAIR resides). It is still unknown if a map will be created for this entire extent but at the very minimum it is likely that geologic information would be provided for the Boston North 7.5' quadrangle.

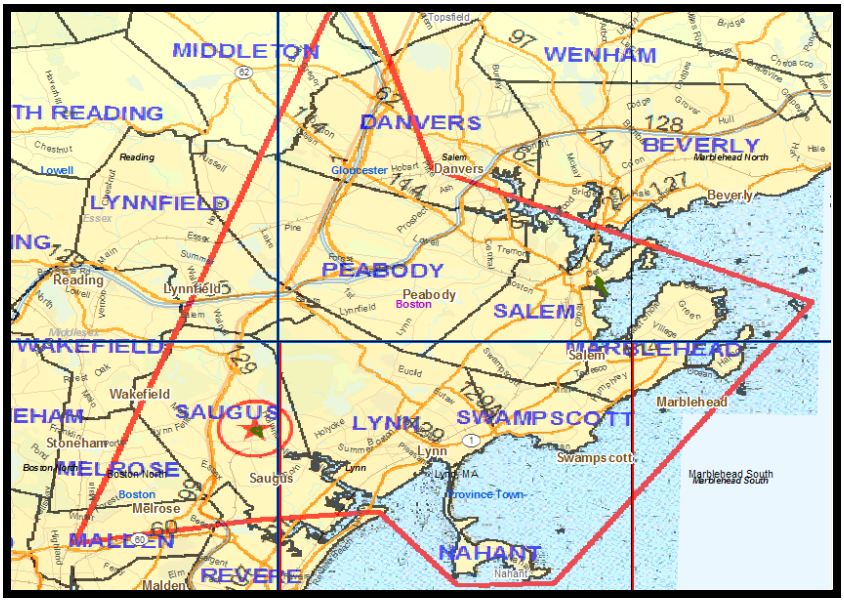


Figure 2. Proposed SAIR study area for refined geologic mapping by Boston College encompassing portions of Marblehead North, Salem, Reading, Marblehead South, Lynn, and Boston North 7.5' quadrangles.

The USGS is in the process of producing new large-scale digital surficial geologic maps in the area. Byron Stone and Janet Stone (USGS) are the points of contact for an update on the status of this new mapping. As of August, 2008, according to the Massachusetts office of the State Geologist, the USGS surficial coverage is probably one year from publication for the Boston North, Lynn and Marblehead South quadrangles. Some of these quadrangles are already published in USGS OF-2006-1260b and available as GIS layers for the Marblehead North, Salem and Reading 7.5' quadrangles. Joe Kopera (Office of Massachusetts State Geologist) was unsure of release status for the other quadrangles (Marblehead South, Lynn, and Boston North). For the currently unpublished quadrangles for the SAIR suggested area, there is published smaller-scale surficial geology contained in GMAP 74763 (Kaye, C.A., 1978, Surficial geologic map of the Boston area, Massachusetts, USGS, Open-File Report OF-78-111, 1:100,000 scale). This publication could supply interim surficial data for the Marblehead South, Lynn and Boston North 7.5' quadrangles until the newer USGS maps are released.

Older USGS bedrock maps in the area have never been converted into a digital format to date (GMAPs 74765 and 2436; Kaye, C.A., 1980, Bedrock geologic maps of the Boston North, Boston South, and Newton quadrangles, Massachusetts, USGS, Miscellaneous Field Studies Map MF-1241, 1:24,000 scale), but the Office of the Massachusetts State Geologist has interest in digitizing the Boston area bedrock geologic map at 1:24,000-scale into a GIS format (Joe Kopera e-mail dated 2008-0626). This publication covers the Boston North, Boston South and Newton 7.5' quadrangles. For SAIR, it is likely that only the Boston North 7.5' quadrangle would be desired from this publication. However, the other quadrangles might be of utility for BOHA. Additionally, in the

interim, the Massachusetts State Bedrock Geologic map might also be useful for the areas currently lacking available large-scale mapping (GMAP 74826; Suzanne W. Nicholson, Connie L. Dicken, John D. Horton, Michael P. Foose, Julia A.L. Mueller, and Rudi Hon, 2006, Preliminary integrated geologic map databases for the United States-Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, Rhode Island, and Vermont, USGS, Open-File Report OF-2006-1272, 1:500000 scale, http://pubs.usgs.gov/of/2006/1272/)

The Office of the state geologist of Massachusetts has a good website for discerning which data is already available and in which formats; address is:
http://www.geo.umass.edu/stategeologist/frame_maps.htm

Tables 2 and 3 list the source maps chosen for Minute Man National Historical Park and Saugus Iron Works National Historic Site and mapping needs in certain quadrangles, in addition to a unique "GMAP ID" number assigned to each map by GRE staff for data management purposes, map scale, and action items.

For **Saugus Iron Works National Historic Site**, GRE staff could use the following maps:

- (2436) Kaye, C.A., 1980, Bedrock geologic maps of the Boston North, Boston South, and Newton quadrangles, Massachusetts (sheet 1 / 2), , Miscellaneous Field Studies Map MF-1241, sheet 1 / 2, 1:24000 scale

- (74765) Kaye, C.A., 1980, Bedrock geologic maps of the Boston North, Boston South, and Newton quadrangles, Massachusetts (sheet 2 / 2), , Miscellaneous Field Studies Map MF-1241, sheet 2 / 2, 1:24000 scale

- (74763) Kaye, C.A., 1978, Surficial geologic map of the Boston area, Massachusetts, , Open-File Report OF-78-111, 1:100000 scale

- (74826) Suzanne W. Nicholson, Connie L. Dicken, John D. Horton, Michael P. Foose, Julia A.L. Mueller, and Rudi Hon, 2006, Preliminary integrated geologic map databases for the United States-Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, Rhode Island, and Vermont, , Open-File Report OF-2006-1272, 1:500000 scale

Additional items of interest pertaining to geologic mapping from the scoping
The parks have some interest in landscape evolution maps, historical interpretation maps, and mineral resource maps.

Geologic Resource Management Issues

The scoping session for Minute Man National Historical Park and Saugus Iron Works National Historic Site provided the opportunity to develop a list of geologic features and processes, which will be further discussed in the final GRE report. During the meeting, participants prioritized the most significant geologic issues as follows:
(1) Fluvial issues
(2) Mass wasting
(3) Seismicity
(4) Paleontological resources
(5) Disturbed lands and mineral extraction

Fluvial Issues

The Concord River at Minute Man National Historical Park is prone to flooding. Flooding along this river seldom extends beyond its natural floodplain. Only low-lying trails and infrastructure are at risk for damage. Wetland areas flank most local streams. Within the park, the altered, re-channeled course of Mill Brook is a potential target for restoration to the natural conditions at the time of the battle. Flooding commonly arises from beaver activity in the area. Beaver dams impound streams causing local floods and wetlands to develop. Within the park, this flooding changes farm fields, turning them into wetlands in areas south of Meriam's Corner. Just outside of park boundaries, a culvert clogged through subsidence floods local roads including the Cambridge Turnpike. This engineering structure is under the jurisdiction of the local town government. A tributary of Elm Creek, Sunnyside Brook is completely diverted into an underground flow system consisting of buried culverts. The park is currently engaged in removing the underground system to daylight the stream course through the park. Phase I of this restoration is complete and the park is starting phase II.

The Saugus River dominates the landscape at Saugus Iron Works National Historic Site. It was a key transportation link throughout the area's history. At this point upstream of its mouth, the Saugus River is tidal with a fluctuation of less than 2 m (6 ft). There are submerged bay head bars at knick points. At high tide, there is some saltwater intrusion onto the river's floodplains and lower structures. This creates a unique brackish estuarine habitat within the riparian zone flanking the river at the site. Species such as rainbow smelt and American eels flourish there. Structures within the park are mainly on bluffs and lower floodplain areas. Fluvial issues include riverbank and head-cutting erosion. In the park vicinity, aggradation added less than 1 m (2 ft) of post-agricultural sediments to the river floodplain. The park is in the midst of a restoration project that will increase the local volume of the river and change channel morphology. This project aims to restore the Terning Basin, which is a cultural wetland landscape. This project will restore old boatways in an attempt to determine how the iron works originally functioned. In the fall of 2007, the project will include excavating sediments, connecting the iron works with a dock and introduce replica boats.

At both park units, increased sedimentation occurs in streams near high use areas such as bridges and trails. Some low-lying features require stabilization and block reinforcement. Disturbed areas stripped of stabilizing vegetation experience accelerated runoff and erosion, which locally increases sediment load and changes the channel morphology of the neighboring stream. Trees provide natural buffers to surrounding urban development and the parks limit tree removal.

Mass Wasting

The rivers and streams at Minute Man National Historical Park and Saugus Iron Works National Historic Site cut through rolling hills, terraces, low bluffs, and alluvial fans. Gravity, frost and plant root wedging, undercutting stream banks, and differential erosion are primary natural causes of slope instability. As such, hillslope processes such as slumping and slope creep are a resource management issue at both parks. Trails are eroding locally at Minute Man National Historical Park. Trails at Saugus Iron Works climb the steeper hill slopes (>45°) and may be prone to mass wasting, especially when water-saturated. The national historic site plans to pave and chip seal all trails. Trail construction should avoid areas prone to undercutting.

Any steep slope at the parks poses a mass wasting hazard. Most slopes are vegetated and essentially stable. Anthropogenic changes to the hill slopes such as road and trail construction, mining, undercutting, and deforestation are the most common triggers of active sliding. Engineering structures designed to redirect water and stabilize riverbanks often lead to instability and reactivation of old slumps.

Seismicity

Neither Minute Man National Historical Park nor Saugus Iron Works National Historic Site is located near an active seismic zone. Small earthquakes do happen locally, but most of these events are too minor to be felt at the surface and range between magnitude 2 and 3. Seismic activity locally focuses on northwest trending faults in the Nashoba Terrane. In 1755, a large earthquake near Cape Anne was strong enough to ring bells, topple chimneys and weather vanes, and damage stone walls from Portland Maine to Hartford, Connecticut. Its magnitude was approximately 6.4 on the Richter scale. If such an event were to occur today, the damage estimates are in the billions of dollars. Large seismic events may trigger landslides, rockfall and damage park infrastructure. The nearest seismic station is at the Weston Observatory (http://www.bc.edu/research/westonobservatory/). The U.S. Geological Survey monitors seismic activity throughout the region. Recent activity is available at the following earthquake-monitoring website: http://earthquake.usgs.gov/eqcenter/recenteqsus/.

Paleontological Resources

Fossils are an unlikely resource at Minute Man National Historical Park. Pleistocene age fossils are always possible in glacial deposits. At Saugus Iron Works National Historic Site, marine fossils are buried in clay layers found north of the park boundary. It is unknown if fossils exist within the park at this time.

Disturbed Lands and Mineral Extraction

Over the past several centuries at Minute Man National Historical Park, the entire landscape was subjected to anthropogenic disturbances from early settlement, agriculture, and colonization to later urbanization until the establishment of the park. The park's mission is to restore and preserve battle conditions from the late 1700s. To achieve this, the park removed buildings and businesses such as car dealerships, hotels, veterinary clinics, and homes and restored them back to meadows, fields, and forests. The park is in the process of restoring many of the original stonewalls. Rocks for this project are imported and not excavated from park lands. Adjacent to the park near a modern housing development was a large sand and gravel quarry excavating glacial outwash deposits that exist throughout the entire area. Smaller quarries were common in the park area prior to its establishment,

but are now largely overgrown and of no particular concern to park resource management. Locally, disturbed areas support thriving poplar groves, gray birch, and sweet fern biotic communities.

At Saugus Iron Works National Historic Site, the area was chosen for the early furnace because of the abundance of surrounding natural resources. Local clays and gabbro from nearby areas were extracted from the landscape as raw materials. During the height of iron operations there, the landscape was extensively disturbed; however, this is part of the historic context that the park wishes to restore and preserve. The one square mile millpond supplied water for the local mill impounded by a 15 m (50 ft) high dam one-quarter mile upstream. At the site, encroaching erosion threatens a historic slag and 17th-century refuse pile. This pile, located near the original loading dock, is an interpretive target. However, it contains unwanted contaminants that could pollute the river if eroded. Other disturbed areas include a local road that that once ran through the park, but was rerouted in the 1940s-50s.

Features and Processes

Aeolian Features

As described below, glacial ice covered eastern Massachusetts during the Pleistocene Epoch. Once the glacial ice melted and retreated northward, and ensuing glacial lakes such as Glacial Lake Sudbury and younger Glacial Lake Concord drained from the area, the stark landscape was devoid of any stabilizing vegetation. The prevailing winds picked up the sand and silt from glacial lake deposits, transporting them on currents to create sand dunes and blankets of loess deposits. At Minute Man National Historical Park, surficial mapping revealed ventifacts, or stones shaped, worn, and polished by the abrasive action of windblown sand. Paleodunes formed after the latest glacial retreat may exist on the landscape. These would be comprised of sand and silt.

Glacial Landscapes

During the Pleistocene Epoch, more than 10,000 years ago, glacial ice sheets descended from the north over eastern Massachusetts, covering the landscape. Glaciers are effective agents of erosion, beveling hills and other topographic highs while transporting vast amounts of sediments picked up en route. When the glacial ice melts and retreats, these sediments remain and may cover the underlying landscape. If glacial retreat is rapid, the sediments once entrained in the glacial ice are relatively unsorted and contain fragments of various sizes ranging from the smallest clay to boulders. Collectively, these deposits are called glacial till. Outwash streams typically accompany glacial melting by draining downslope away from the melting ice front. These sediment choked streams leave sorted channel, delta, and floodplain deposits. A series of glacial lakes (Glacial Lake Sudbury and Glacial Lake Concord) formed in front of the retreating glacial ice edge. Associated with these lakes are clay, sand, beach, and shoreline features throughout the area. Thin glacial deltaic and outwash deposits mantle the bedrock. Deltaic deposits formed by water flowing from melting glaciers and outwash streams into glacial lakes. These deltas have characteristic assemblages. The most glacial-distal set are called bottom set beds. Angled foreset beds cover the bottom sets and top sets cover the entire sequence. As glacial ice pulls further back, the delta collapses and the whole sequence repeats itself. Locally, stranded deltas more than 60 m (200 ft) high formed an impoundment for Glacial Lake Concord. This lake had two relatively stable stages at 56 m (185 ft) deep and 44 m (145 ft) deep.

Within the boundaries and surrounding areas of Minute Man National Historical Park, glaciers left chunks of remnant ice that melted to form kettle ponds. Folly Pond within the park is a closed depression (no inlet or outlet) in a sand plain. Because the surficial morphology of the entire area is glacially-derived, most of the small natural ponds are kettles. Today, seasonal rain is causing the ponds to grow laterally, but many are infilling with sediment. Other glacial features in the park include kame deltas, sand and outwash plains, deltaic divides, drumlins, thick till deposits, glacial erratics, meltwater channels, and striated bedrock exposures. Glacial features are prominent on the landscape at Minute Man National Historical Park. For this reason, they strongly influenced the history of the area from pre-settlement Native Americans to colonists to the start of the Revolutionary War.

At Saugus Iron Works National Historic Site, the Saugus River incises a relatively flat surface. The predominant sediment type is clay (Boston blue clay?). In 1646, glacial and marine clays provided casting materials for pots. This site may represent a flat-topped sandy glacial delta. Higher areas may have more glacial features. More research on the surficial geology of the area would illuminate the glacial features present on the landscape.

Type Localities and Other Unique Features

Type localities refer to the originally described sequence of rock that constitutes a geologic unit. It serves as an objective standard for comparison with spatially separated parts of that same unit. Preferably, a type section describes an exposure in an area of maximum unit thickness and completeness. Type localities may also refer to major geologic structures such as regional faults. Within Minute Man National Historical Park, the Bloody Bluff fault zone is remarkably exposed. During the construction of Route 2A, blasting exposed a large segment of the fault. Today, a powerline trends over the fault and routine maintenance removes obscuring vegetation locally. This intensely deformed zone separates the Avalon and Nashoba terranes. Fault rock types such as mylonites (rocks squeezed and stretched under high temperature and pressure) and pseudotachylytes (veins of material melted by friction from sudden movement along a fault surface). Deformation along this fault zone was in two phases. An earlier more ductile phase created the mylonitic texture at 10-15 km (6-9 miles) depth in the earth's crust. Further to the north, this zone is called the Burlington mylonite zone. Younger, more brittle deformation associated with shallower depths occurred along the Bloody Bluff fault zone. Movement along this zone was oblique as the Avalon Terrane to the east subducted beneath and slid northwards past the Nashoba Terrane to the west.

Geology and History Connections

Since 1635, Concord has been a fixture in eastern Massachusetts. This area supported agrarian pursuits with rich fertile soil and abundant natural resources such as forests and rivers. Deglaciation processes gave rise to a variety of substrate types throughout the area. The glacial till underlying much of the flatter areas was a poor substrate for growing barley. Colonists planted apple trees, and pasturelands dominated instead of tilled fields. Glacial erratics and outwash boulders provided fence material. Animal grazing was part of this lifestyle and the park is testing potential grazing of the landscape with the University of Massachusetts, Boston. In 2002-04, 300 sheep grazed test plots on established meadowlands within park boundaries. These sheep may alleviate some of the ecosystem strains due to invasive plants.

The history of the start of the Revolutionary War is deeply connected with the surficial geology and topography of the Lexington-Concord area. During initial colonial unrest, militia living outside Boston formed Minute Companies. Colonists began stockpiling scattered arms and Concord, just 26 km (16 miles) from Boston was an ideal location. On April 18, 1775, 4,000 British soldiers under General Gage marched westward from Boston towards Concord to retrieve stockpiled munitions. Men such as Paul Revere road horses westward to warn colonists. An initial skirmish at Lexington Green left eight colonists dead. Later, at the bridge over the Concord River northeast of the town, the colonists fought back and released the "shot heard 'round the world" killing British soldiers. At Meriam's Corner, the third battle of the day, colonists used the local ridges and topography to shield their movements and ambush the British as they retreated along Battle Road. This ridge exists because of deltaic divide deposits left between retreating ice of the Pleistocene Ice Age and Glacial Lake Concord. Homes flanked this ridge for protection from the northern wind and the road ran along its southern flank. The road is on a divide between drainages, flanked by boggy swamplands. Meriam's Corner forms a point where the deltaic ridge ends, merging with lake bottom sediments of the flatter surrounding areas. The delta ends abruptly because its sediment source was an intermittent esker and it did not exist long enough to spread further east.

Following the Meriam's Corner incident, the colonists continued to plague the retreating British as far as Boston for 7 hours. The bloodshed to the east of Meriams Corner gave the Bloody Bluff fault zone its name. Brooks Hill, Fisk Hill, and the bluff all played significant roles in the battle skirmishes of spring 1775. The park as a cultural landscape wishes to preserve the effects of humans on the landscape insomuch as they reflect historically significant events. The park wishes to preserve the first 6 km (4 miles) of Battle Road.

The Saugus River area has long been a focal point for settlement and natural resource use. During the Paleo-Indian Period (12,000-9,000 years before present) Native Americans quarried Saugus "jasper" in several quarries some less than 1 km (0.5 miles) downstream from the national historic site. This reddish, buff colored stone had the favored ability to be worked into projectile points and tools. Native American artifacts may be present in the sediments at the site flanking the river. These were covered by sediments settled behind the dam and redistributed by high flows stemming from an early breach of the dam. During restoration, the park will attempt to avoid exposing these artifacts.

The area was chosen by early settlers to develop an iron mill because of the natural resources in the surrounding areas (bog iron ore, gabbro, and timber for charcoal) as well as its proximity to a coastal transportation port. A low-grade fall line occurs just upstream from the iron works. Barges could travel up the Saugus River to the mill carrying raw materials and return downstream with manufactured products from the iron works. The furnace was in operation for approximately 20 years. Its closure was a market driven issue.

Excavation at the national historic site is ongoing. In the 1940s, excavations to find the original foundation of the iron works necessitated rerouting Central Street in Saugus, Massachusetts. This excavation exhumed thousands of artifacts from the riverine sediments including remnants of the waterwheel. Other historic features at the site include the Wallace Nutting House. Preserving cultural features and landscapes often means resisting natural geologic processes such as weathering, erosion, flooding, and settling.

The park wishes to determine the exact source, type, and properties of the clay used at the iron furnace. This clay provided molds for iron products. Other materials necessary for flux and smelting including ultramafic gabbro (low silica - high calcium and magnesium) and limestone (?) were locally derived, but the exact locations, compositions, and properties of these materials remain unclear. Gabbro may have come from the Nahant Peninsula to the southeast of Saugus River. The park also wants to know the source area for the rocks comprising the furnaces and outbuildings.

Recommendations

(1) Consider tapping the Geoscientists-in-the Parks program to perform research and field study to determine the source materials used at SAIR.
(2) Use the Massachusetts State Geologist website for general geologic information: http://www.geo.umass.edu/stategeologist/index.html
(3) Study sedimentation patterns and distribution along river corridors noting areas of sediment loss and gain.
(4) Increase awareness of and monitor seismic activity through the websites managed by the U.S. Geological Survey and Weston Observatory (Boston College).
(5) Promote research into the overall tectonic history of the region as timing relationships between the Avalon Terrane and Nashoba Terrane remain unclear.
(6) At SAIR, gather baseline information and monitor water and soil quality around old refuse pile to determine if surrounding resources are being contaminated.
(7) Interpret the geologic map for both park units for visitors focusing on geologic resources, geologic history, and connections between geology, biology, evolution of the landscape and historic events.

Action Items

(1) GRE staff will reference Massachusetts Geological Survey website for information http://www.geo.umass.edu/stategeologist/index.html
(2) GRE will produce digital geologic map for Minute Man National Historical Park and Saugus Iron Works National Historic Site including surficial and bedrock coverage (see above geologic mapping section).
(3) GRE will consider funding for graduate student work in the Lexington Green area and SAIR's defined area of interest.
(4) GRE report author will obtain a copy of C. Langford's Masters thesis (Fall 2007) from Boston College covering the geology of the Concord quadrangle.
(5) GRE report author will obtain Kaye (1978) Surficial geologic map of the Boston Area, Massachusetts. U.S. Geological Survey, Open-File Report 78-111.
(6) GRE report author will obtain Kaye (1976) The Geology and Early History of the Boston Area of Massachusetts, a Bicentennial Approach. U.S. Geological Survey Bulletin 1476

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http://www.masshist.org/objects/2005november.cfm (accessed July 31, 2007)

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Table 1. Scoping Meeting Participants

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Table 2. GRE Mapping Plan for Minute Man National Historical Park

Covered Quadrangles	GMAP[1] ID	Reference	GRE appraisal	GRE Action	Scale
Concord, MA	74982	C. Langford and C. Hepburn, 2007, Bedrock geologic map of the Concord quadrangle, unpublished, Master's thesis, Boston College, 1:24,000 scale	2008-0731: need update from Boston College on this map and if it exists and is available for MIMA; would give GRE large-scale bedrock for MIMA to accompany large-scale surficial from GMAP 74750. hoping it will be digital and GIS based. Awating final response from Chris Hepburn (Boston College). OMSG is willing to expedite review of map and publish as open file report.	Conversion	24000
Concord, MA	74750	Stone, J.R. and Stone, B.D., 2007, Surficial geologic map of the Clinton-Concord-Grafton-Medfield 12-quadrangle area in east central Massachusetts, U.S. Geological Survey, Open-File Report OF-2006-1260-A http://pubs.usgs.gov/of/2006/1260/A/	2008-0731: covers multiple 7.5' quads, but also does cover MIMA qoi for Concord 7.5'; is digital gis based; should use. Should likely supercede GMAP 8096. can accompany GMAP 74982 (Concord 7.5' bedrock), map can accompany GMAP 74982. Note: glaciofluvial units are lumped on this map and explained in accompanying text.	Conversion	24000

Table 3. GRE Mapping Plan for Saugus Iron Works National Historic Site

Covered Quadrangles	GMAP[1] ID	Reference	GRE appraisal	GRE Action	Scale
Boston North	74765	Kaye, C.A., 1980, Bedrock geologic maps of the Boston North, Boston South, and Newton quadrangles, Massachusetts (sheet 2 / 2), , Miscellaneous Field Studies Map MF-1241, sheet 2 / 2, 1:24000 scale	2008-0702: for SAIR useful for bedrock geology of single Boston North QOI; not known to be digital; sheet 1 (GMAP 2436) gives bedrock polygons; sheet 2 (GMAP 74765) gives tunnel engineering information. Massachusetts GS wants to digitize this map, but needs funding support	Maps need digitized (GRE or OMSG ?)	24000
Marblehead North Salem Reading	74751	Stone, B.D., Stone, J.R., and DiGiacomo-Cohen, M.L., 2007, Surficial geologic map of the Salem Depot - Newburyport East - Wilmington - Rockport 16-quadrangle area in northeast Massachusetts, , Open-File Report OF-2006-1260-B, 1:24000 scale	2008-0731: this is in SAIR area of interest to yield 3 7.5' quads for Marblehead North, Salem, and Reading surficial geology; may convert these. Per OMSG, all 3 quads are in GIS format with metadata, found in OF 2006-1260B. Units are consistent and edge-matched.	Conversion	24000
Boston North	2436	Kaye, C.A., 1980, Bedrock geologic maps of the Boston North, Boston South, and Newton quadrangles, Massachusetts (sheet 1 / 2), , Miscellaneous Field Studies Map MF-1241, sheet 1 / 2, 1:24000 scale	2008-0731: for SAIR useful for bedrock geology of single Boston North QOI; not known to be digital; sheet 1 (GMAP 2436) gives bedrock polygons; sheet 2 (GMAP 74765) gives tunnel engineering information. Massachusetts GS wants to digitize this map, but needs funding support. Per OMSG, MF 1241 is not GIS ready and needs integrated data from Bailey at Northeastern Univ.	Maps need digitized (GRE or OMSG ?)	24000
Multiple	74763	Kaye, C.A., 1978, Surficial geologic map of the Boston area, Massachusetts, , Open-File Report OF-78-111, 1:100000 scale	2007-0703: likely supercedes GMAP 74764; not known to be digital	Await newer digital maps; no action	100000
Multiple	74826	Suzanne W. Nicholson, Connie L. Dicken, John D. Horton, Michael P. Foose, Julia A.L. Mueller, and Rudi Hon, 2006, Preliminary integrated geologic map databases for the United States-Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, Rhode Island, and Vermont, , Open-File Report OF-2006-1272, 1:500000 scale	2008-0702: might use for interim SAIR bedrock for extra areas of interest not covered by larger scale pubs.	Await newer digital maps; no action	500000