GEOLOGICAL MAPPING OF UNDERWATER BEDROCK AND STRATIGRAPHY, NEWARK GROUP, ARTHUR KILL CHANNEL AND NEWARK BAY, NEW YORK AND NEW JERSEY HARBOR

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Geological mapping and stratigraphy as developed by William Smith has its roots in observations and measurements for coal mining and canal dredging. Two centuries later, engineering for energy and infrastructure continues to be among the main drives for extending and refining geology and stratigraphy. This is, in part, due to 1) an economic drive to collect large quantities of geological data, and 2) engineering projects commonly sample or expose unexplored masses of rock and sediment.

The geological understanding of the New York City region is grounded with data from infrastructure-related engineering projects. Ongoing engineering projects continue to refine the geology of the area (e.g., Merguerian, 1999; Brock et al, 2001).

The geology below the waterways of the New York City region is less known. The waterways are typically indicated as blue (for water) on geological bed rock maps of the area. Harbor projects such as the ongoing deepening project provide data for mapping the bedrock and stratigraphy in the waterways. Over a hundred years of dredging in the New York-New Jersey harbor has created rock exposures on the channel floor. Dredging has created the underwater equivalent to road cuts.

Such sub-aqueous rock exposures can be mapped through geophysical (acoustical) imaging and measurements on and below the channel floor in conjunction with borings. Our mapping of the stratigraphy of the Newark Group in Arthur Kill Channel and lower Newark Bay demonstrates these techniques. This mapping was conducted for the engineering of the New York and New Jersey Harbor deepening project.

Mapping of the Newark Group utilized 100% coverage rectified sonar images (orthosonographs) of the channel bottom, numerous sonar and seismic sub-bottom profiles, and measurements and observations of sediment borings and rock core. Top-of-rock maps and interpreted weathering profiles were constructed by integrating all of this data.

The orthosonographs of the channel floor are equivalent to rectified aerial photographs. Such sonar images of lower Newark Bay and the northern reaches of Arthur Kill Channel reveal rock strata exposures not available in the adjoining land of Elizabeth and Bayonne, NJ, and Staten Island, NY. Locally the rocks are overlain by Quaternary sediments: (a) Pleistocene till, outwash sands, and varved clayey silt; and (b) Holocene silts, sands and gravels.

The orthosonographs show that throughout the area the exposed strata strikes N36^{o}W (in NJ State Plane projection). The N36^{o}W trending strike was determined independently from the changes in apparent dip in a seismic profile along Arthur Kill. Arthur Kill channel extends westward across strike from southern Newark Bay and then turns southward at Howland Hook and winds in and out of strike. Measurements from cores and seismic profiles are consistent with the 15^{o} regional dip.

The Newark Group strata exposed in this region includes the upper Lockatong formation (Triassic) and the overlying lower 500 meters of the Passaic formation (Triassic-Jurassic). Both formations are predominantly lacustrine and strongly cyclical at several scales (Van Houten, 1964; Olsen, 1986; Olsen et al., 1996). Olsen et al. (1996) have shown that “the thin cyclical packages that make up the lacustrine sequence can be traced over large areas”. Our data suggests these packages can be correlated throughout Arthur Kill Channel and Newark Bay.

The Palisades diabase (Jurassic) that is intruded into the Lockatong formation is exposed in the western end of Kill van Kull Channel and along eastern Newark Bay. West of this, and stratigraphically above the intrusive Palisades diabase, are the predominantly gray sandstones and black "shales" (and their contact-metamorphosed equivalents) of the upper Lockatong formation. The contact between the Lockatong formation and the predominantly red siltstones and shales of the Passaic formation occurs in Arthur Kill Channel just northwest of the western end of Shooters Island. This is where "the red clastic rocks become dominant over gray” (Olsen et al., 1996). The uppermost Lockatong formation consists of resistant gray sandstone strata with high acoustic velocities that are exposed on the channel floor. The less-resistant red shales of the lowermost Passiac formation are not exposed on the channel floor. These strata were eroded deeper and are now covered with Pleistocene sediments. The Lockatong-Passaic contact can be projected two kilometers northeastward along strike to resistant highs of gray sandstones exposed in Newark Bay near the entrance to South Elizabeth Channel.

In the area of interest there are several hundred sediment borings and rock cores from projects conducted over the last forty years. These borings and core were used for rock description and to calibrate the geosphysical measurements. The cores were primarily cut for engineering purposes and are relatively short. Core lengths range from less than a meter to typically no more than four meters. With the use of the sub-bottom profiles as a guide, the cores can be pieced together to create an almost continuous vertical stratigraphic record of the uppermost Lockatong formation and the lower 500 meters of the Passaic formation.

In core and in exposures on land, rock color and gain size are proxies for the cyclic stratigraphic packaging (Olsen et al., 1996). Our data suggest that on and below the channel floor the acoustic velocity, and top-of-rock and weathering profiles can be used as proxies for the stratigraphic packaging (these are also proxies for engineering properties). Highly weathered intervals encounter in core can be correlated along strike to low velocity regions determined by seismic profiles. These highly weathered areas appear as sediment covered-regions in sonar images of the channel bottom.

Further utilization of the mapping techniques described above will refine and extend the detailed stratigraphy of the upper Lockatong formations and lower Passaic formations throughout Arthur Kill and Newark Bay. Identical techniques can be used to map the detail rock and sediment stratigraphy throughout the New York Harbor waterways.

References

Brock, Pamela Chase; Brock, Patrick W. G.; and Merguerian, Charles, 2001, The Queens Tunnel Complex: a newly discovered granulite facies Fordham orthogneiss complex that dominates the subsurface of western Queens: p. 1-8 in Hanson, G. N., chm., Eighth Annual Conference on Geology of Long Island and Metropolitan New York, 21 April 2001, State University of New York at Stony Brook, NY, Long Island Geologists Program with Abstracts, 128 p.

Merguerian, Charles, 1999, Techniques of TBM tunnel mapping - the Queens Tunnel, NYC, p. 8-12 in Hanson, G. N., chm., Sixth Annual Conference on Geology of Long Island and Metropolitan New York, 24 April 1999, State University of New York at Stony Brook, NY, Long Island Geologists Program with Abstracts, 143 p.

Olsen, P. E., 1986, A 40-million-year lake record of early Mesozoic climatic forcing. Science, v. 234, p. 842-848.

Olsen, P. E., Kent, D V., Cornet, B., Witte, W. K., and Schlische, R. W., 1996, High-resolution stratigraphy of the Newark rift basin (Early Mesozoic, Eastern North America): Geological Society of America, v. 108, 40-77.

Van Houten, F. B., 1964, Cyclic lacustrine sedimentation, Upper Triassic Lockatong Formation, central New Jersey and adjacent Pennsylvania, *in* Mermaid, O. F., ed., Symposium on cyclic sedimentation: Kansas Geological Survey Bulletin 169, p. 497–531.