STRATIGRAPHY, STRUCTURE AND ROCK MASS PROPERTIES OF THE HARTLAND FORMATION, SECOND AVENUE SUBWAY, NYC, NY

MERGUERIAN, Charles, Geology Department, Hofstra University, 141 Gittleson Hall, Hempstead, NY 11549, Charles.Merguerian@hofstra.edu and MERGUERIAN, J. Mickey, Geology Department, University of Texas at El Paso, 500 West University Avenue, El Paso, TX 79968

The long-delayed Second Avenue Subway project in NYC has provided an opportunity for a thorough three-dimensional study of the stratigraphy, structure, and metamorphism of the Hartland Formation in NYC. Our site inspections and mapping over the past 1.5 years of TBM-bored tunnels and ground-down ancillary station complex excavations indicates that the Hartland in this part of NYC is a migmatitic amphibolite facies rock mass that is well-layered at the scale of 0.5 cm to 1.0 m. The project exposes a schistose to gneissic rock mass consisting of the assemblage muscovite-quartz-plagioclase-biotite±kyanite±staurolite±garnet with interlayers of quartz-plagioclase-mica granofels, greenish amphibolite±biotite±garnet and subordinate gray quartzite. The schistose facies is lustrous and consists primarily of aligned fine- to coarse-textured muscovite and thus splits readily along the foliation and also lithologic contacts. The mica gneiss, granofels, amphibolite, and quartzite interlayers are typically massive and hard, contain much less mica than the schist and may not show pronounced foliation. The internal structure is dominated by gentle SSW- to SE-plunging recumbent isoclinal long-limbed F_2 folds of an earlier S_1 foliation. This has resulted in a gently inclined (<30°) southward dipping composite penetrative regional foliation (S_1xS_2) striking NW to ENE that formed mostly parallel to compositional layering (S_0) and includes sill-like masses and thin veins of foliated granitoid. Steeper dips are found in F_2 hinge areas and limbs of upright F_3 folds where the earlier S_1xS_2 regional foliation and compositional layering are locally oversteepened. The superposed ductile structures are cut by foliation joints (J_1) produced parallel to the regional foliation and by steep NNE- to NE-trending (J_2) joints and dip-slip faults infilled by stilbite+calcite, by younger steep NW-trending (J_3) joints and strike-slip faults infilled by K-feldspar, microcrystalline epidote, quartz and pyrite, and by moderately dipping J_4 joints. Gently inclined well-layered Hartland rocks in NYC cut by intersecting steep discontinuities have proven to be excellent candidates for efficient subsurface mining by TBM, traditional drill and blast techniques, and by mechanical means and methods of excavation.

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