ESTIMATION OF DREDGABILITY FROM HIGH-RESOLUTION MARINE REFLECTION SEISMIC

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ABSTRACT

Major issues of concern in deepening of navigation channels in areas of bedrock include the 3D distribution of rock and sediment and whether bedrock can be dredged without treatment such as blasting. We have estimated dredgeability of bedrock in deepening projects in New York and New Jersey Harbor, Jamaica, and Boston Harbor using reflection seismology and rock core measurements from borings.

Our geophysical and geological investigations of New York New Jersey (NYNJ) Harbor (Murphy et al 2011a and b), Jamaica, and Boston Harbor (e4sciences|Earthworks, 2015, Ward et al, 2019)) based on geotechnical borings and hundreds of reflection seismic lines have revealed the subsurface distribution of bedrock within the dredge prisms. For NYNJ Harbor study had hundreds of borings and rock cores available for analyses. Whereas Jamaica had very limited borings and Boston Harbor had 39 recent targeted borings. The technique was applied to shale, siltstone and sandstone of the Passaic Formation and serpentinite in NYNJ Harbor, limestone in Jamaica, and Cambridge Argillite and crosscutting diabase dikes in Boston Harbor.

Standard Penetration Test (SPT) and rotary core borings show the rock character. The bedrock was characterized during sampling by SPT blow counts for decomposed rock and by drill rate and Rock Quality Designation for more intact bedrock that was cored. Rock Quality Designation (RQD) provides a measure of the jointing, fractures, bed separations in cores, and carbonate porosity. RQD relates well to fracture density and rippability.

Rock was characterized by a variety of lab tests including unconfined compressive strength, and ultrasonic compressional wave velocity measurements. Although such measurements are valuable for benchmarking the subsurface and calibrating seismic data, they are on a scale smaller than that a dredge bucket. High-frequency reflection seismology remotely measures in situ bedrock on a larger scale, that it is roughly the size of a dredge bucket

Rippability is an effective engineering property of the material, it depends on the equipment being used. Rippability in dredging is a measure of the material response of the channel bottom to penetration by a specific excavator with a specific bucket. The Caterpillar Tractor Company defines rippability qualitatively as rippable, marginal, and/or non-rippable. Caterpillar Tractor Company has long related seismic velocity to production and rippability.

High-frequency seismic data provides information on the compressional-wave velocity. We have developed techniques to derive the compressional-wave velocity from high-frequency seismic data. The technique automatically extracts diffraction hyperbolas from the seismic cross-sections and applies a dip-filter estimator to derive the seismic velocity on a layer-by-layer basis. This seismic velocity is then inverted to map a compressional-wave velocity at a resolution that depends on the data coverage and resolution.

For our studies dredgeability was based on 1) compressional-wave velocity of in situ bedrock measured using a single-channel reflection seismic diffraction technique, and 2) unconfined compressive strength of core. For the areas of concern fast rock is defined as the in-situ bedrock having averaged compressional-wave velocity greater than of 2,500m/s to 3000m/s for Jamaican limestone (Figure 1), 3,000m/s for the serpentinite (Figure 2), and 2,700 m/s for the Cambridge Argillite (Figure 3). Fast rock is unlikely to be dredged without prior treatment. Slower velocity material might be dredged without treatment but is not guaranteed to be.

Keywords: Dredging, seismic analysis, orthosonograph, stratigraphic surfaces, volume determination

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Figure 1. Reflection seismic cross section on top and with modeled velocity on bottom. The line is from the berth section nearshore in Jamaica. The line maps the behaviors of the limestone formation on Jamaica.
Figure 2. Reflection seismic cross section with modeled velocity in areas of Kill van Kull Channel in New York Harbor. The line is a section of the West-East line within the Kill van Kull channel, the line superimposes the geological interpretation as well as the geological borings. Note how the velocity model estimation captures the sediments channel within the Serpentinite rock.

Figure 3. Reflection seismic cross section with modeled velocity in Boston Harbor. The line is from the north side of the Reserved Channel in Boston Harbor, this image is further described in the companion paper (Ward et al, 2019).

REFERENCES

e4sciencesEarthworks, LLC, (2015), Marine geophysical and geological investigation, Boston Harbor, Boston, Massachusetts, USACE Contract #W912DS-12-D-002, DB#01Report.


CITATION