A Petologic Database for the USGS National Crustal Model

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Introduction

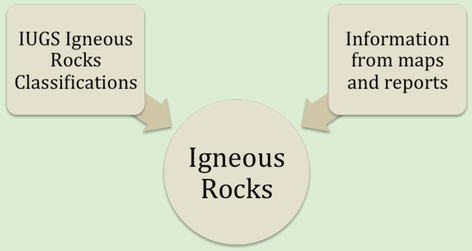
Seismic hazard forecasts use ground motion models that rely on some representation of the shear-wave seismic velocity structure beneath a site of interest. This has typically been the time-averaged shear-wave velocity for the upper thirty meters of the crust, $V_{S30,}$ and more recently includes the depths to 1.0 and 2.5 km/s, termed $Z_{1.0}$ and $Z_{2.5}$, which account for long-period site response. An upcoming improvement to the National Seismic Hazard Map involves making use of these Z parameters by extracting Z values from the USGS National Crustal Model (NCM), which is presently under development. The NCM is composed of geophysical profiles defined by a 3-D geologic model with petrologic and mineral physics databases, and Biot-Gassmann theory calibrated with measured seismic velocity and density data. The geologic model is derived from a modified version of the National Geologic Map of the United States and maps of the depth to bedrock and basement estimated using well, seismic, and gravity data.

Methods

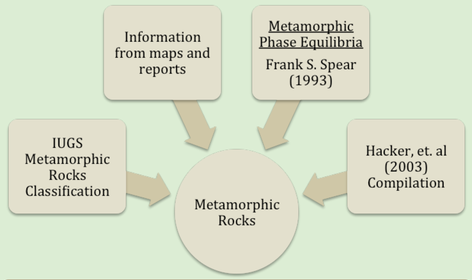
Overview

There are 209 geologic units within the National Geologic Map, 177 of which we define in terms of mineral assemblage and volume fraction. Units fall into one of four categories: igneous rocks, sedimentary rocks, metamorphic rocks, and unconsolidated sediments. For each category, well-established nomenclature was used to determine the general mineral constituents found in each specific rock type. For the nonspecific geologic units and depositional environments, interpretations were made to best approximate mineral assemblages.

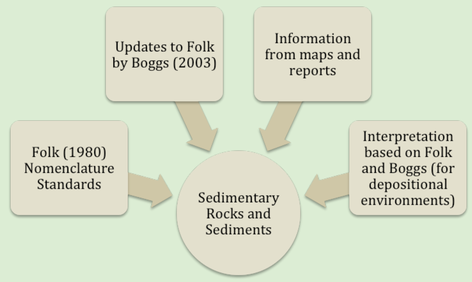
Igneous Rocks



Metamorphic Rocks



Sediments and Sedimentary Rocks



Shear-wave Velocity Profiles

The defined mineral assemblages were used to calculate shear-wave velocity profiles and V_{S30} for each unit. Because velocity varies with density and shear modulus and these parameters are dependent on porosity, velocities for each unit were calculated for a range of porosities from 0 to 70 percent. More than 2,900 V_{S30} measurements were previously compiled by the USGS for individual sites throughout the United States, but V_{S30} measurements were found to be present in only 52 of the 177 geologic units. The average measured V_{S30} value for each geologic unit was calculated and then compared to V_{S30} calculations to estimate the appropriate porosity of the measured geologic units.

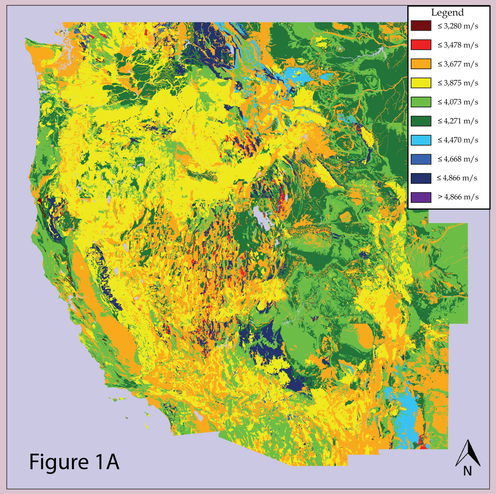


Figure 1A

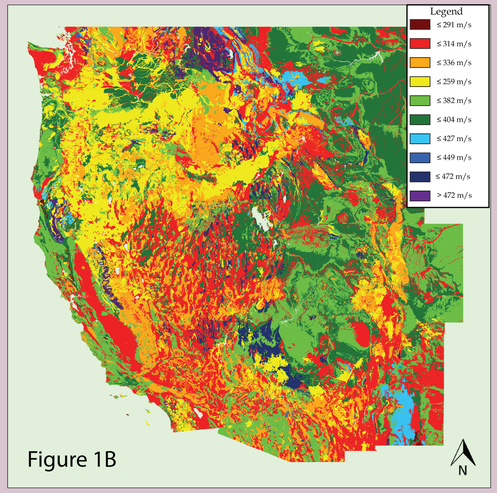


Figure 1B

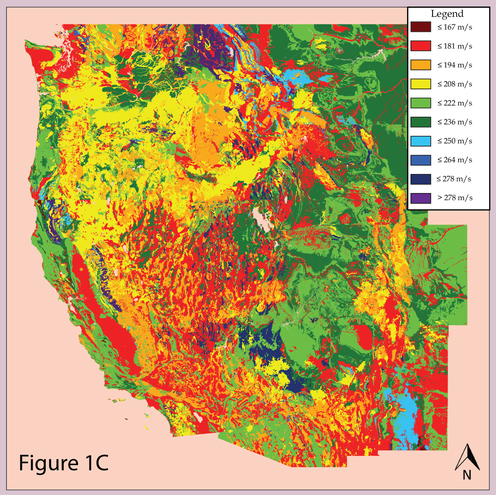


Figure 1C

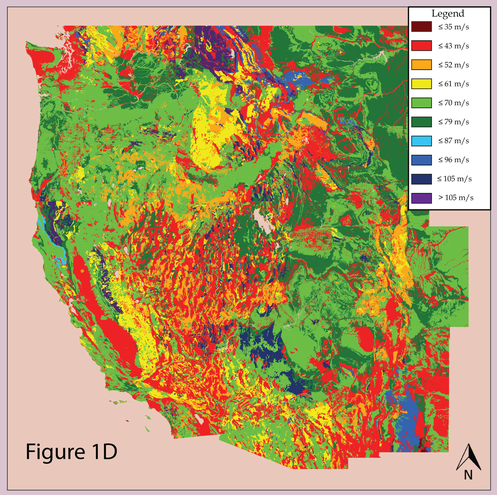


Figure 1D

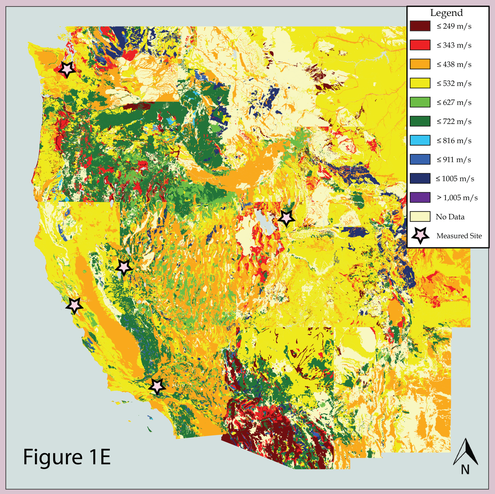


Figure 1E

Figure 1A-1E

Figure 1A: Calculated V_{s30} profile for theoretical zero percent porosity.
Figure 1B: Calculated V_{s30} profile for twenty percent porosity.
Figure 1C: Calculated V_{s30} profile for forty percent porosity.
Figure 1D: Calculated V_{s30} profile for seventy percent porosity.
Figure 1E: Average measured V_{s30} velocity profile. Stars indicate areas with a high concentration of measured data. Pale yellow polygons indicate geologic units without measured data.

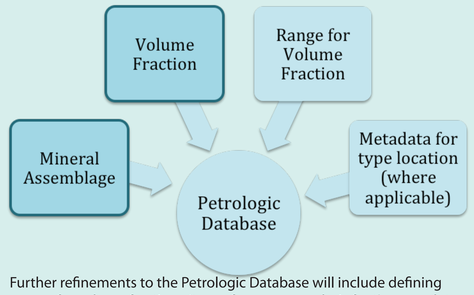
Note: All maps adapted from Schruben, et al. (1994)

Future Work

Summary

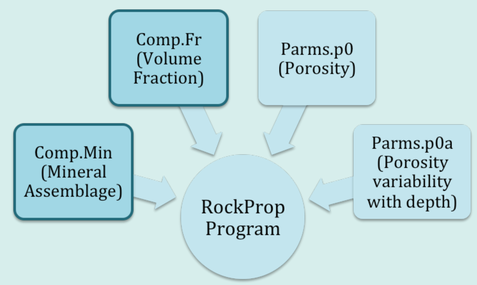
Prior to the application of the NCM to the National Seismic Hazards Map and Model, several calibrations and refinements will be necessary, both to the petrologic database and the overall model parameters.

Database Refinement



Further refinements to the Petrologic Database will include defining ranges for volume fractions (to perform error analysis for the complete model) and a compilation of metadata for units that were defined by a type location.

Calibration



The RockProp Program (used to calculate velocity profiles for the NCM) uses four parameters to perform calculations. It draws from the Petrologic Database for Comp.Min and Comp.Fr; however, the model will need to be further calibrated to define Parms.p0 and Parms.p0a

Geologic Map

The NCM relies on the geologic units as defined in The National Geologic Map of the Conterminous U.S. (Schruben, et al., 1994). This map could be better applied to the NCM (and other models that rely on mineral physics) if the map were refined in the following ways:

Remove geologic units not present on the map
- Forty-five units not present in National Geologic Map of the Conterminous U.S. (Schruben, et. al, 1994)

Redefine rock units with more specific nomenclature
- Units such as "metamorphic rock", "sedimentary rock", and "plutonic rock" (among others) can be better defined

Define sediment units in terms of sand/silt/clay fraction
- Depositional environments (i.e. "playa") are too general to truly define mineral assemblage

Separate nonspecific units geographically
- Units such as "sandstone" and "gneiss" differ based on geographic location

Acknowledgements

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