Supporting Information for Parsimonious velocity inversion applied to the Los Angeles Basin, CA

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Introduction

This supplement studies the use of rules-based velocity models (such as CVM1) to analyze the outputs of the inversion in the main text.

Text S1.

The original versions of the SCEC CVM were based on empirical rule based velocity models to interpolate between the inferred boundaries of large geologic units (Magistrale et al., 1996, 2000). While rule-based models are necessarily simplified compared to the potential complexity of the real Earth in almost all cases, they are often useful from an interpretational standpoint, as rules correspond to real geological features, and additionally serve as a basis for combining disparate datasets within a common framework, such as was done in the initial construction of the CVM models. Indeed, the level-set tomographic framework (Muir & Tsai, 2020) used in our study is an extension of rule-based models to include more flexibility, and combine their benefits with those of standard tomographic models defined via basis function representations.

Within the LA basin, Magistrale et al. (1996) used the sedimentary compaction law of Faust (1951), which has the form $V_P = k(da)^{\frac{1}{6}}$, where d is the depth of maximum burial (corrected for any subsequent positive elevation), a is the age, and k is an calibration factor unique for each basin. Magistrale et al. (1996) used three boundaries - the basin bottom, pegged at an age of 20 Ma, the base of the Mohnian, at 14.5 Ma, and the base of the Repettian, at 4 Ma, with ages linearly interpolated in between these boundaries. The location of these boundaries, as well as the age of the surface, are derived from digitization of older geological studies, principally Yerkes, McCulloh, Schoellhamer, and Vedder (1965) and Wright (1991). The uplift associated with the Pasadenan deformation is assumed to happen instantaenously at the present (i.e. the entire column is uplifted by an equivalent amount, rather than accounting for any potential deposition during uplift). Magistrale's model is relatively simple; however, such simplicity also results in greater interpretability. Given EKS sampling is a black-box approximate Bayesian method, it is feasible to "post-process" our inversions to interpret them in terms of the rule-based CVM definitions. We apply this to the major A-A' profile of Figure 12. We fix the lower basin boundary at the basin extracted from our inversion, and initialize the surface age, Repettian and Mohnian boundaries at their values in the early CVMs. We then perturb these using 1D Gaussian processes using a Matérn-3/2 kernel with unknown lengthscale and $\sigma = 1$ applied to the log surface-age and boundary depths, clamping the minimum V_P at 1.5 Km / s and using Brocher (2005) to convert to V_S and density. Due to the density of information (in this case fitting to an image, rather than the physical observables in the main inversion), we can use the relatively rough 3/2 kernel to capture the details without being concerned about artifacts. The output velocity model, including the locations of the reference and inverted boundaries, is shown in Supplementary Figure S1. The boundaries of both the Mohnian and Repettian units agree well with the well-constrained locations (from borehole measurements) in the southern part of the profile. In the northern part of the profile, the deep Mohnian profile agrees with results in (Wright, 1991), however the CVM1 velocity model specification requires a deep Repettian as well, which is not concordant with the outcropping of Puente and Topanga units at the surface in this area. It is unsurprising that the CVM1 rules provide an outcome inconsistent with the geology here, as they are developed primarily for the deeper basin, whereas our data suggests that the basin units are very shallow in the northern part of the profile. In the central part of the profile, where the reference interface locations are poorly controlled in (Wright, 1991), the observed velocity model in Figure 12 is best represented by a steep Repettian interface and a deep Mohnian, which conforms with our interpretation of the sharp gradient of the northern basin boundary being controlled by the influence of Quaternary faults, as even the youngest interface in the CVM1 model is highly deformed.

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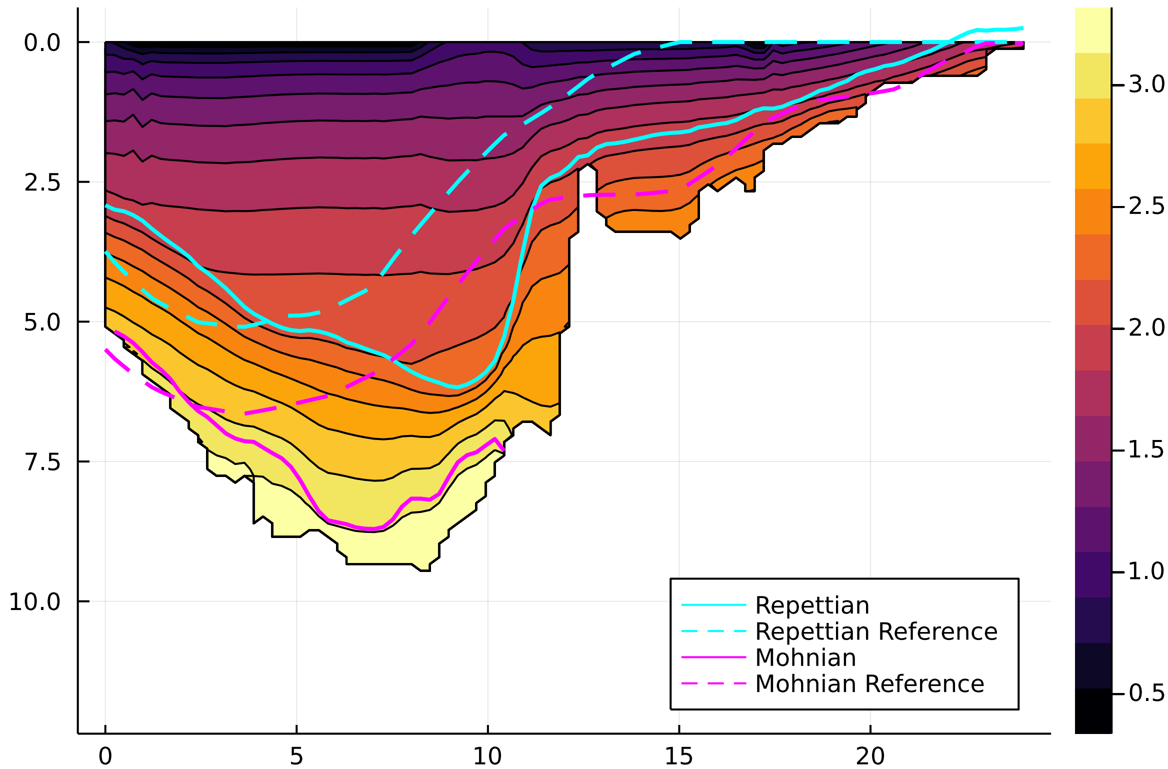

Figure S1. Fit of a modified SCEC CVM2 model to the A-A' profile results of Figure 12, with dashed lines showing the CVM2 reference surfaces (the bottom of the Repettian and Mohnian units) and the solid lines showing the inverted interfaces.