POST-CRITICAL, PRE-CRITICAL, AND CRITICAL SEISMIC REFLECTIONS USING VIRTUAL SOURCES, PART I: OVERVIEW

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Enhancing signal-to-noise ratios is often a key in the success of any physical experiment. For seismic work, instead of the usual practice of stacking the data in various ways to reduce the noise, we use strong signals from natural earthquakes to achieve the same purpose. Reflections under the free surface from both teleseismic *P*- and *S*-waves can serve as virtual sources. In this configuration, every station in an array carries its own virtual source for each earthquake-station pair.

The method of Virtual Deep Seismic Sounding (VDSS), which uses post-critical, total reflection of the seismic phase *SsPmp*, has gained momentum and proven successful for detecting the Moho in very different tectonic settings [e.g., Tseng et al., GRL, 2009; Yu et al., EPSL, 2012; JGR, 2016; Chen and Yang, in review, 2019]. Recently, the large move-out of *SsPmp* facilitated the simultaneous determination of both bulk *P*-wave speed and the thickness of the crust (*H*) [Kang et al., SLR, 2016], mitigating the ever-present trade-off of these two parameters in seismic reflection. Moreover, by adding additional phases that are sensitive to *S*-wave speed, VDSS can estimate *H*, and both bulk crustal *P*- and *S*-wave speeds (V_P and V_S, respectively). This new development enhances the ability of VDSS to constrain bulk crustal silica content (Chen and Chen, 2019, in review).

If the distribution of virtual sources is favorable, VDSS can constrain the speed of V_P in the uppermost mantle (Chen and Yin, in preparation, 2020), a quantity expensive to determine in stable continents due to the lack of regional earthquakes to generate the phase *Pn*. The amplitude of *Pn*, a critically refracted phase, is small. But when significant sedimentary cover is present, it amplifies the size of multiples of *Pn* by several folds, providing additional information about the sedimentary cover and the crust as a whole [Yu et al., BSSA, 2019].

Finally, pre-critical reflections, such as the phase *PpPmp*, detected the Moho under a short-period array in the southern Indian shield [Tseng and Chen, BSSA, 2006]. Subsequently, a variant of *PpPmp,* the phase *PpPdp*, where *d* is any interface between the surface and the Moho, revealed the basement of the sedimentary cover and several intra-crustal interfaces [Yang et al., GRL, 2012; Zou et al., BSSA, 2014].

In summary, reflections under the free surface from teleseismic *P*- and *S*-waves have proven to be invaluable virtual sources for critical, post-critical, and pre-critical seismic reflections.

Note. Oral presentation preferred and should be scheduled before the poster of Part II.