A New Approach Towards Optimized Passive Seismic Survey Design with Simultaneous Borehole and Surface Measurements*

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Abstract

With the increasing potential for use of multiple microseismic arrays in hydraulic fracturing and waste water injection programs for shale reservoirs, there is a need to look into a standardized scheme for optimizing the design and layout of the different arrays so as to improve upon the observations, processing and interpretations which can be made through each of the individual or the combined arrays. The aim is to maximize the information that can be gleaned from the data collected through these arrays in order to obtain the best possible results during the actual stimulation through improved (high resolution) event mapping, source mechanisms, velocity, stress and other property estimates, etc.

We have looked at this problem at multiple levels to identify and develop framework elements of the workflow aimed at designing an optimized multi-array survey (Figure 1) which works to improve the applicability of the sensor arrays. Our workflow provides relevant deployment schemes for any multi-array monitoring experiment by using the ray matrix build using the raypaths to optimize for hypocentral inversion schemes and the Moment tensor inversion matrix to optimize for source mechanisms. We present results from various sensor configurations and validate the proposed approach. We also demonstrate how properly designed wellbore arrays can make large surface arrays redundant and how optimal designs can be obtained.

Our integrated approach allows the introduction of new optimization elements that might be deemed necessary in new monitoring programs and this flexibility provides our method scalability and improved applicability over wider environments. Examples of such elements include arrival time differentials (based on moveout), event amplitudes, attenuation pseudo factors, polarity, etc. Moreover, our approach holds the potential for minimizing deployment costs and providing the best designs to aid the geophysicists in their processing workflows.

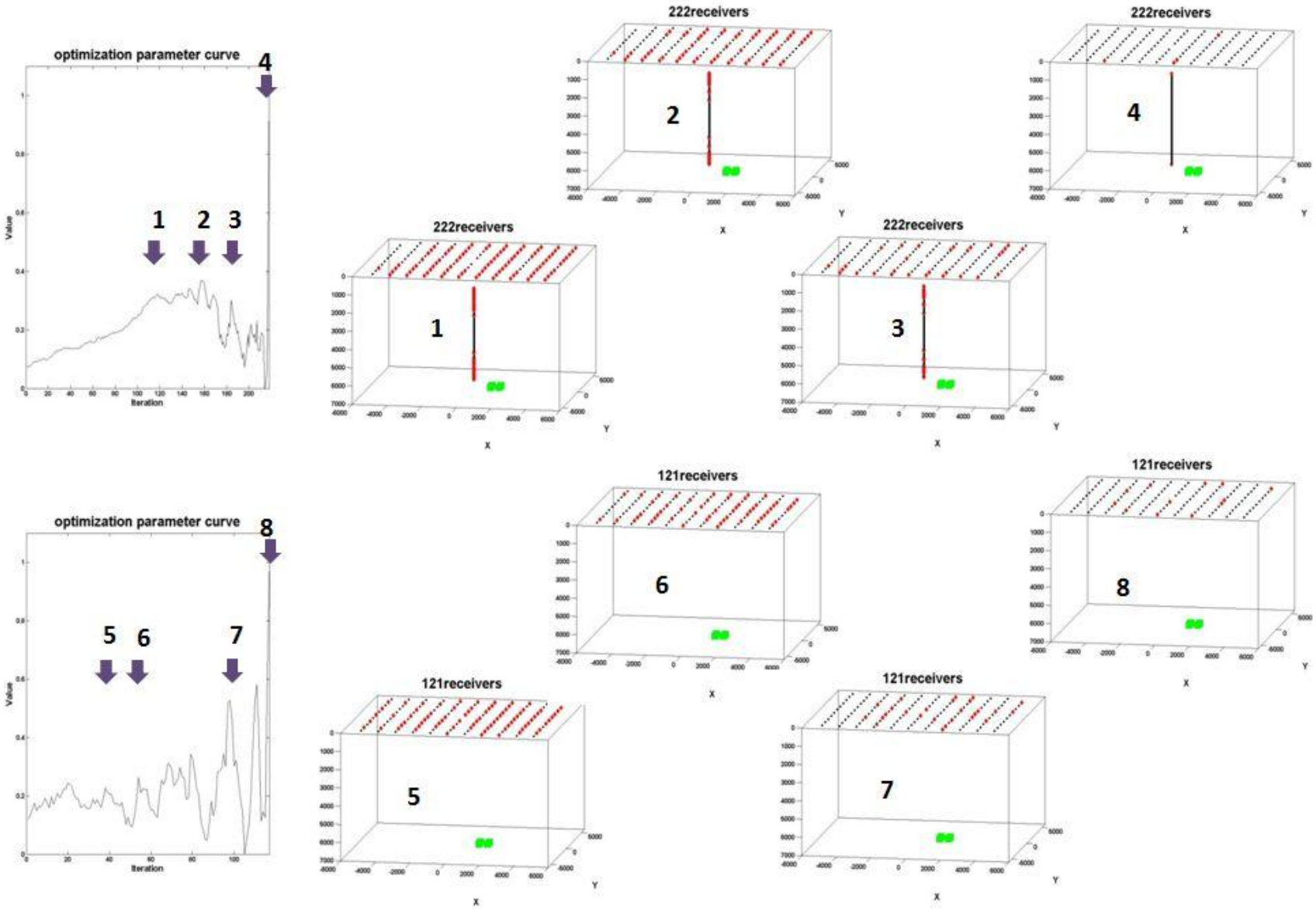

Figure 1. Optimal monitoring array designs with multiple (surface and downhole) arrays.