IGF-SN-420-08/22

PhD thesis: "High-resolution velocity model building and advanced depth imaging in hardrock environment"

Candidate: Brij Bhushan Singh

Assessment by E/Prof Milovan Urosevic

1. **Candidate's background knowledge/work and research independency**

Candidate's research involved investigation of the applicability of the advanced seismic imaging techniques for delineation of underground mineral deposits. The candidate used the state-of-the art methodology to tackle imaging issues in a hard rock environment. The methodology presented, and the way it was presented, suggests that the candidate possess appropriate skills and the knowledge base for the doctorate degree.
From the work presented in the three publications it appears that the candidate has substantial help, most of all from his supervisor, but also from the other co-authors. Hence some doubt into the independency of his work is present. However, to my knowledge as an experienced PhD supervisor, this is not uncommon situation in the last decade, so I will conclude that this is not to held against the candidate for achieving the final goal.

2. **Originality/contribution to the world of science**

The research presented involved work with a poor-quality data (barely acceptable) recorded for mapping and or delineation of mineral resources at a depth. The candidate managed to produce useful outcome through the implementation of pre-stack imaging techniques in very low signal to noise ratio (SNR) environments. Hence, to my mind, the main outcome of this research and the most important lesson learnt is that depth imaging, relatively novel and rarely tested imaging approach, appears to be working well in hard rock environments, even under the worst conditions! While poor data quality cast some shadow on this conclusion it is my belief that the candidate has addressed the imaging issues in hard rock environment in a proper manner.

3. **Drawbacks/modifications/additions**

In your studies (three papers) you dealt with a very low SNR data. While you have tried to enhance SNR prior to stacking and/or imaging the methodologies applied are in fact conventional. There are other methodologies in the domain of the dynamic signal lifting, multi-channel filtering, etc that you could have attempted. If this was not available for your study, you could have acknowledged it but that does not prevent you from suggesting that more advanced SNR techniques could have been used or should be attempted on poor SNR data prior as well as after imaging.

You have demonstrated that FAT and/or FWI are important to include in the depth imaging flow. However, this shallow velocity information needs to be extended at depth to achieve proper imaging. Extending the velocity field at a depth through semblance velocity analysis,

particularly in low SNR environment is hard or even meaningless. CVS is the method of choice. Did you use it and if now, why not?
A low SNR prevents us in general from assessing the imaging errors related to the erroneous velocity field. What was you approach in such case? Did you have borehole information to relate? Or the underground workings to tie your reflectivity to it?
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Message 1. The recommendation is not correct. Depth migration (PSDM) is in fact rarely recommended in a low SNR environment simply because the imaging error is hard to access due to a poor or unknown velocity field. Hence it is a hit and miss case. I would very strongly suggest that you change that recommendation and limit it to your observation which may be specific to your case study, even though I was not convinced that this is indeed the case.
Recommendation 3 is in a way connected to 1. You have irregular, low SNR data. And yes, time domain imaging is essential at least as the first step. Depth imaging may be attempted if the time domain PSTM proves superior over more conventional approach. It is to be accessed on the case-by-case situation. PSDM is NOT granted to perform well in: low SNR environments, crooked line case and 2D environment. Those present unfavourable situations for the implementation of PSDM methodology. This is particularly true for RTM which superior performance is preconditioned by good SND, regular geometry and 3D environment.
If those conditions are met than the take home message 4 stands.

4. General comments

The work presented is worth of the degree attempted but the modifications and additions suggested above and highlighted in the pdf documents are necessary to achieve such goal. The candidate should think more of the claims made and be much more critical when it comes to interpretation of poor-quality seismic images. This is important for him, but it is equally important for the future of the hard rock seismic.

Milovan Urošević