Method for spatial First Break Picking using Nural Network, QC, editing and smoothing

Introduction

The reprocessing of vintage data in Central Asia aimed to preserve true amplitude relationships, high signal-to-noise ratio, and high-resolution recording for possible comprehensive kinematic and dynamic interpretation. Modern techniques were expected to be utilised, with potential new solutions designed to achieve this goal.

The data study revealed numerous hidden errors. Navigation seemed to originate from a synthetic preplot of the survey design. Missing data occurred in some sections, and geometry and FFID numeration errors were prevalent but challenging to detect within the project's time frame. Discrepancies in the SPS files indicated incorrect links between shots and receivers, which were addressed where possible. Additionally, using various sources in surveys resulted in significant differences in amplitude behaviours, scaling, and gain among different data blocks.

The first break picks analysis uncovered substantial geometry errors, particularly at the survey edges. Manual error detection for approximately 90,000 shots was deemed unrealistic, and tested automatic methods proved insufficient due to data errors and signal energy variations. Therefore, a method involving first break picking using (NN) Nural Network, quality control (QC), editing, and smoothing was devised to quickly identify geometrical and signal errors and efficiently perform first arrivals picking. This method is described herein and recommended for practical use.

Despite numerous noisy traces, equipment interference, and varying signal intensity, the data proved suitable for processing true amplitudes through careful cleaning or conditioning prior to signal processing.

Data and Method

Data acquisition parameters: about 1400 sq. km, 5 receiver lines with 120 receivers in one spread, receiver point step 50m, receiver line step 600m, shot point step 50m, shot line step 600m, resulting in a CDP grid of 25x25 m with a nominal fold of 24, sweep 10-90 Hz, sweep length 12sec.

For the quality of the First Break piking and each survey block, the following steps were performed:

1. Select a narrow zone to choose the passband for the first arrivals at every 50 shot points.
2. Run the standard threshold automatic picking of first breaks (FB) with phase preservation.
3. Manually adjust the FB selection from step (2) at sparse shot intervals.
4. Initiate neural network (NN) training on sparse FB data and shot intervals.
5. Run the NN (recognition and automatic picking) on all traces in the survey block.
6. Perform manual verification of NN FB at every 50 shot points.
7. In case of unsatisfactory results, evaluate the passband and navigation issues for shot points used in NN training and repeat the process (Here is the point where shots with wrong geometry can be easily noted).
8. For satisfactory results, sort data using a grid based on shot points, receivers, and CDP in the pseudo record "Shot Line" and record "Receiver Line" and apply spatial filtering and smoothing of first break picking (Figure 1).
9. Load FB picking data into your software to evaluate FB picking and navigation using delay time analysis, making corrections as necessary.

Application

Data were analysed to address the processing challenge. To identify errors, the data were sorted and visualised across various domains. Figure 1 depicts a hundred sources sorted by calculated SignOffset and their LMO (linear move-out correction) version. We anticipate tracking strong reflectors at approximately 200 ms as the first arrivals. However, we observe decay in the initial entries, complicating manual and automatic picking. Visualising receiver lines from individual shots reveals difficulties in tracking the first break (Figure 1, b) and highlights geometry errors, such as incorrectly placed FFID in the dataset (Figure 1, b). Figure 2 illustrates the detected errors during the 1-3 steps of the Method flow.

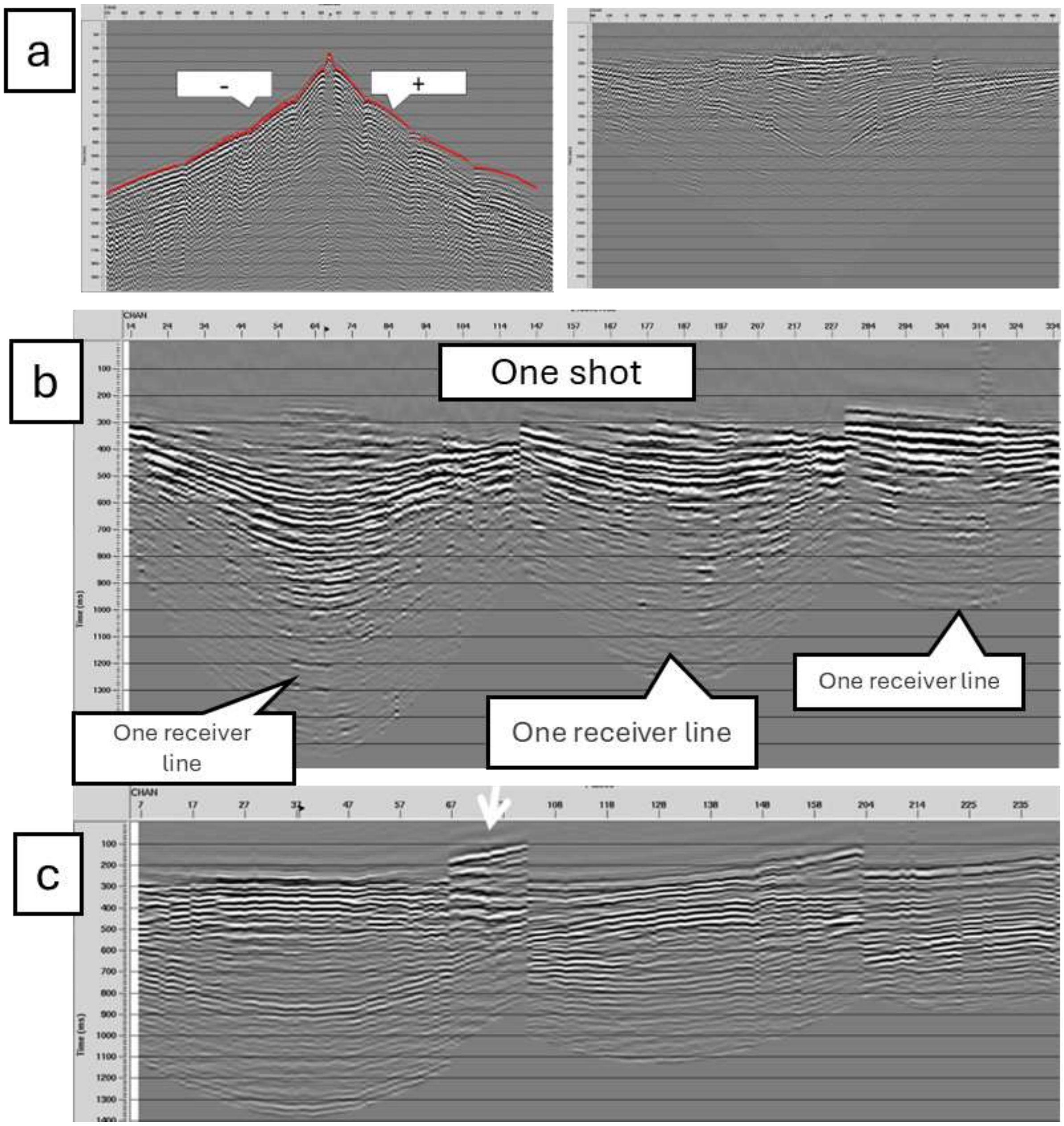

Figure 1 Sorting data into different domains to control first break picking quality. *a left* – 100 sources are sorted by calculated SignOffset, *a right* – LMO corrected 100 sources that are sorted by calculated SignOffset, *b* – section of one shot and three receiver lines. *c* – found FFID corrupted receiver positions (white arrow), LNMO function is also applied.

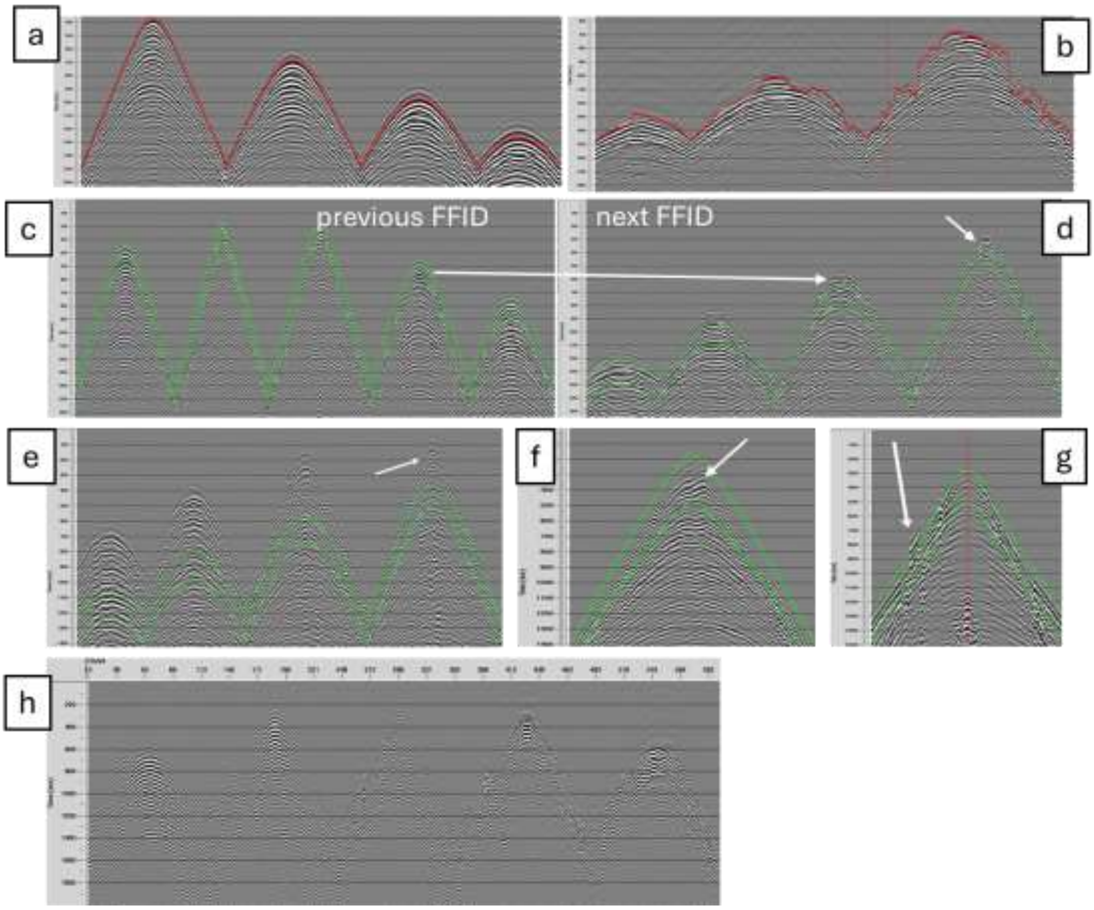

Figure 2 *a* – ideal case of first break picking (in red), *b* – automatic picking in Promax software (energy decay at the flags), *c*, *d*, *e*, *f*, *g* – followed FFIDs with the same offset gate in green, illustrating misplaced data in the datasets. *f* and *g* – geometry errors detected, mirrored placed traces and possible elevation traces problem, *h* – recording failures.

Figure 2a displays a section with shots where the first entry and wave artefacts preceding it are clearly visible. Figure 2b illustrates the most common case: attenuation of the first arrivals, which poses challenges for single-phase tracking, as demonstrated in this automatic picking example. Figures 2c, d, and e demonstrate an efficient method for identifying incorrect geometry by analysing offsets on the shot points. The search gate for first arrivals captures the same offsets selected in green. However, the subsequent FFID section shows offsets that do not align, indicating a need for geometry verification; perhaps these sources should be relocated.

After removing and correcting errors in the data, steps 3-6 of the method are executed. We employed Neural Network picking using Promax software. A training set was created using manually edited automatically picked FB at every 50 shot points (steps 3-4). Subsequently, the Neural Network was run for recognition and automatic picking on all traces in the survey block (step 5). We then conducted QC on the results. If the outcome is unsatisfactory, we adjust the gate for automatic picking to narrow it down (step 7). If the picks are deemed correct or fall within the gate and are close to the required phase, we export the data as a Source, Receiver, and Time file and load it into interpretation software (in our case, Landmark Kingdom Suite). Figure 3 illustrates the loaded picked first breaks on each shot. The visualisation depicts the data plotted as sources versus receivers, with colours representing the picked time. It allows us to treat the data as a horizon. We have the capability to delete incorrect picks, apply thresholds, and smooth them. This spatial visualisation and manipulation provide excellent control over the picks. Once the work is completed, we transfer the ready picks back to the processing software and conduct QC on the results again (Figure 4).

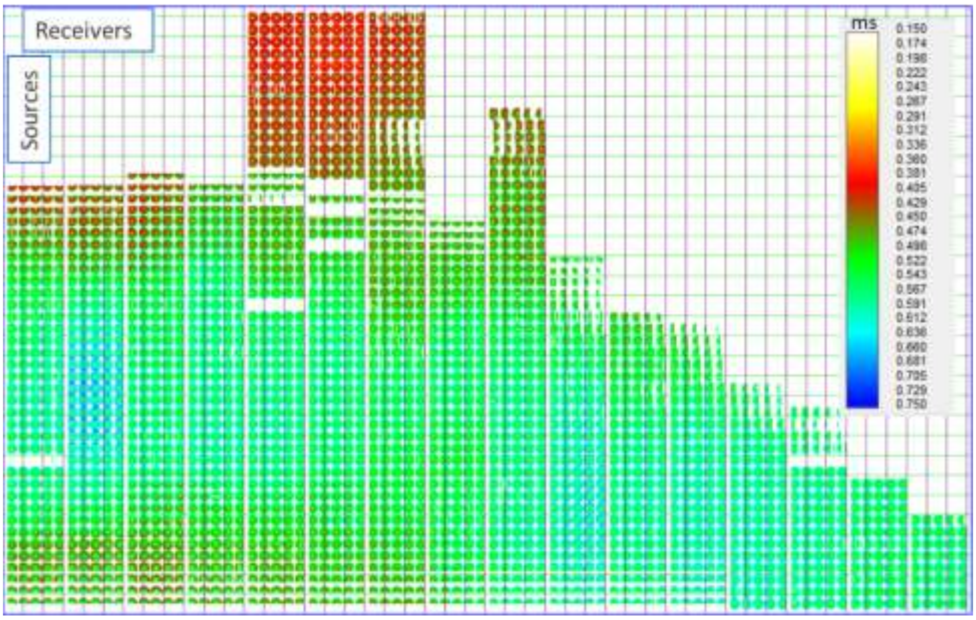

Figure 3 The visualisation of the first break picks as a horizon on receivers versus sources plot and 7x7 mean spatial filter.

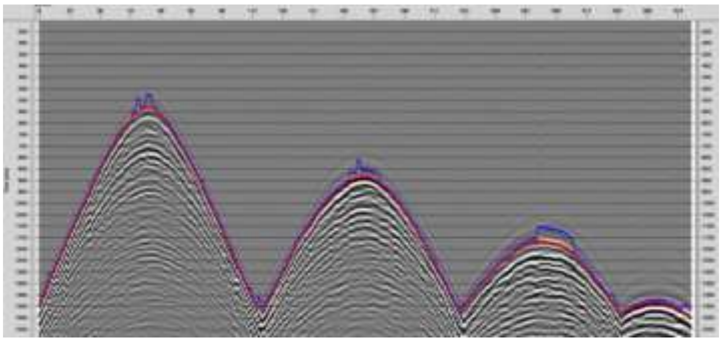

Figure 4 The example of the input (blue) and final corrected (red) first arrival picking.

Conclusion

The special first break picking method proved highly effective in handling poor-quality seismic data with geometry and recording signal errors. The key steps involved defining offset gates to track geometry errors, Neural Network picking, and visualising picks as a horizon in the interpretation software, followed by horizon manipulation. Most geometry errors were successfully rectified or eliminated, defective signals were detected and removed, and first break picks were efficiently identified for the entire area without extensive manual intervention. Developing the workflow took several weeks, but applying it to the 1400 sq. km dataset only required one and a half weeks.

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References

Landmark Promax software, modules of Neural Network First Break Training and Neural Network First Break Picker.