High Frequency Restoration (HFR) – a new technology for seismic interpreters

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Despite being armed with an impressive and powerful set of interpretation tools, geophysicists are often frustrated at the inability to extract and understand the subtle stratigraphic details contained in 3D seismic data. This is because the available bandwidth of the data is inadequate to image or resolve the thicknesses of many of the lithounits seen in the wells.

A new method (patent pending) for restoring the high frequencies within the seismic bandwidth has been developed. This method is different from any of the conventional methods practiced in the industry. It is well known that VSP data records higher frequencies than surface seismic data. This is because the energy recorded by VSP traverses the unconsolidated weathering zone just once. The new method utilizes the higher frequency range of the VSP data to restore the higher frequencies of the surface seismic data. For the VSP downgoing signals recorded at different depth levels, the ratio of trace amplitudes at successive depths would describe the decay of frequency components between those observation points. This fact is utilized to first determine the amplitude decay resulting from frequency attenuation from downgoing VSP traces and then try and restore those frequency components that have been attenuated in the data.

The change in the trace amplitudes and the length of the wavelet on the first arrivals at successive depth levels is used to estimate the change in the frequency components. An inverse operator (in time domain) is designed to compensate that. For application to seismic data, for example, VSP upgoing wavefield is correlated with the CDP section, so that each depth level point is seen in terms of two way time where the determined operator needs to be applied. This way the node points for all the different operators are determined. In between these points, the operators are interpolated so that each time sample on the seismic trace has an operator. Thereafter, the filter application is run (as convolution (in time domain)) on the seismic data. As inverse operators are applied continuously at every sample of the stacked data, windowing is avoided.

The above frequency restoration process when run on seismic data has an effect similar to a time variant attenuation correction. Figs.1 (a) and (b) show a segment of a seismic section with and without frequency restoration process. Notice the improvement in the resolution and the character of the seismic reflections. The poor reflection zones now have a greater reflection detail, which would match better with the corridor stack or a vertical 3D VSP section. Fig.2 (a) and (b) show such a match. The frequency restoration of seismic data can be evaluated by running the Coherence Cubes™ on the seismic volumes before and after HFR (not shown).

The frequency restoration process is a promising technology that helps define trends better and lead to confident interpretations. Such applications can redefine prospects, which in some cases may have been declared unsuccessful when the interpretations are based on data with poor bandwidth.

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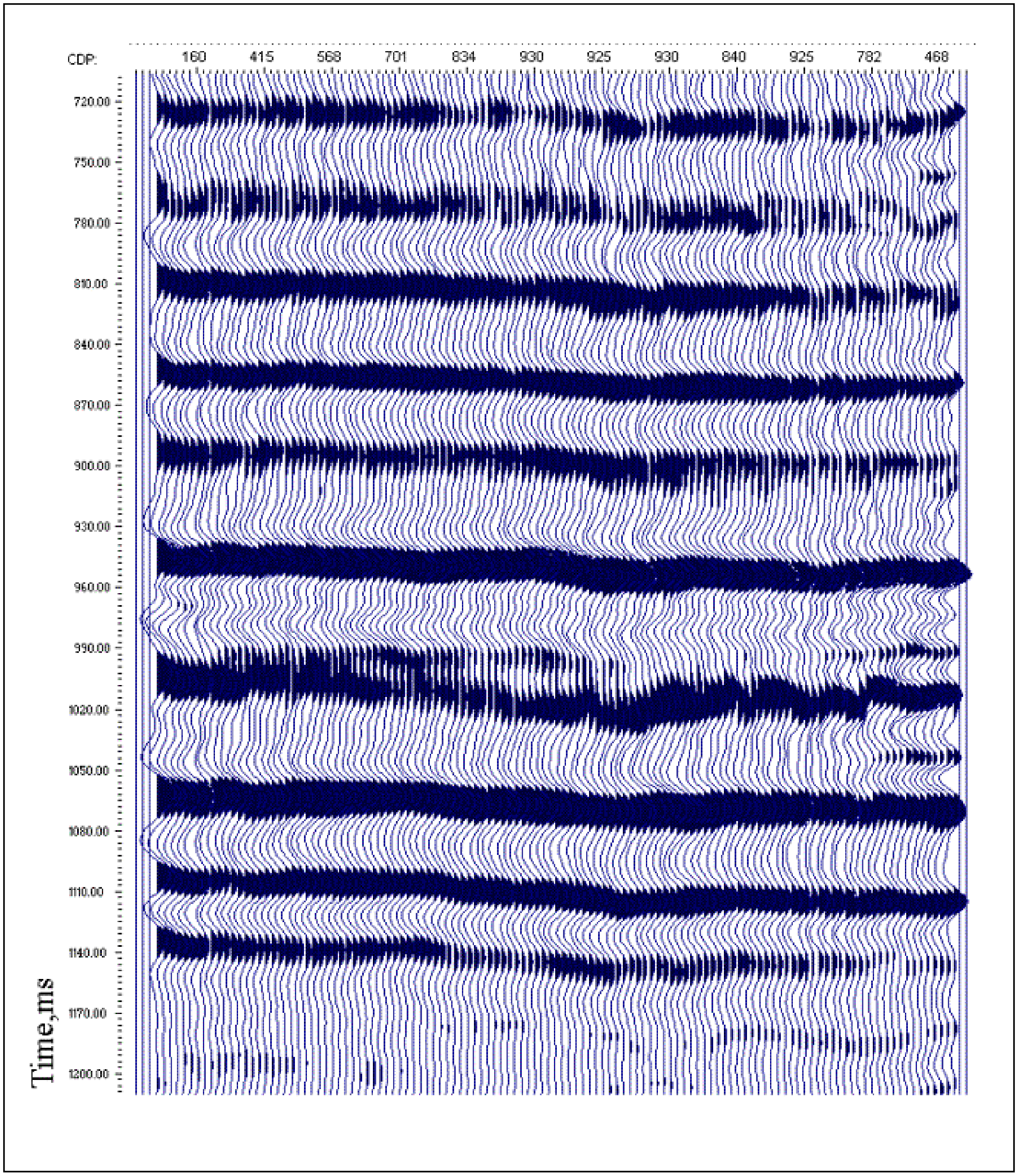
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Time, ms

Fig.1(a)

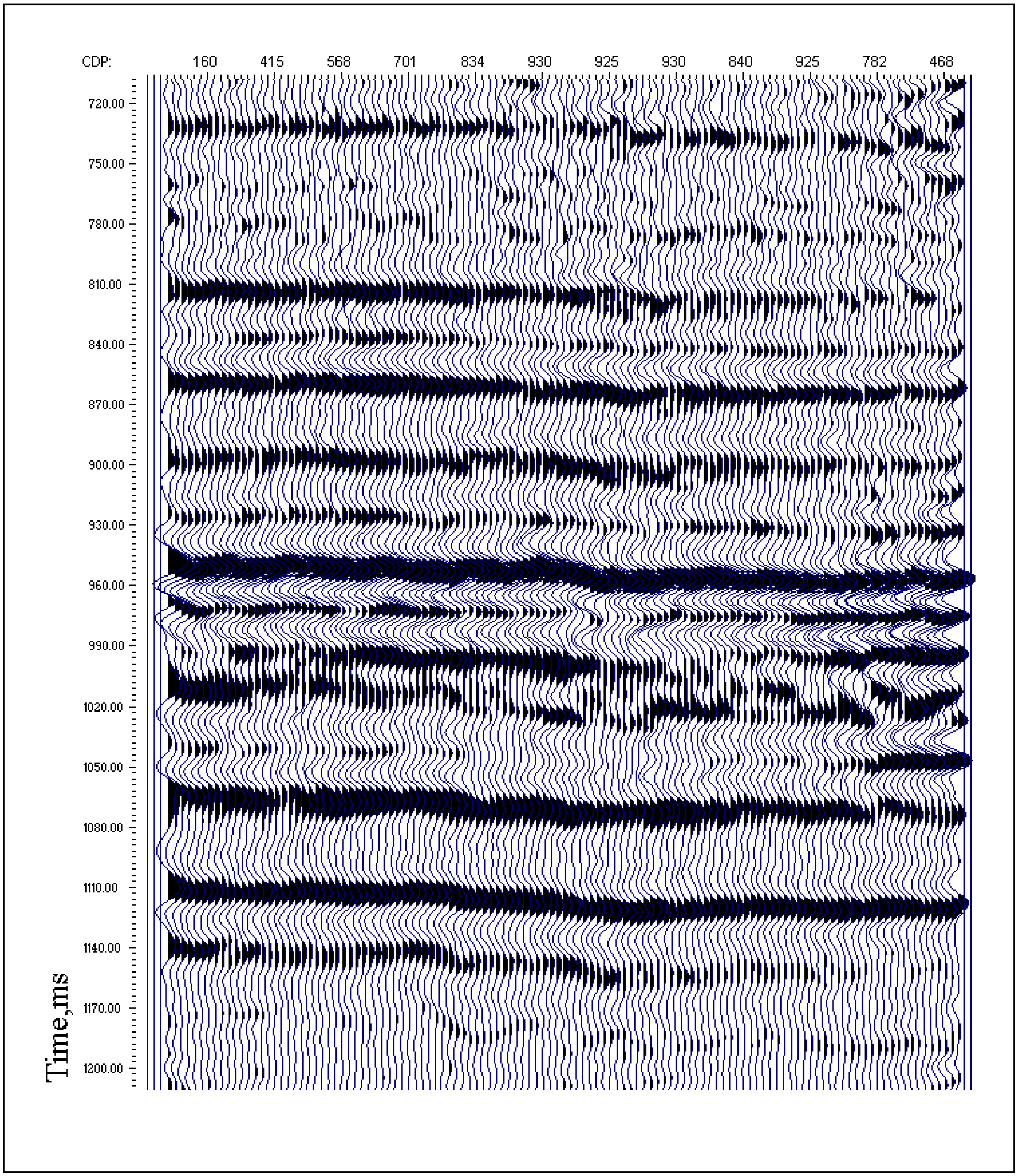
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Fig.1(b)

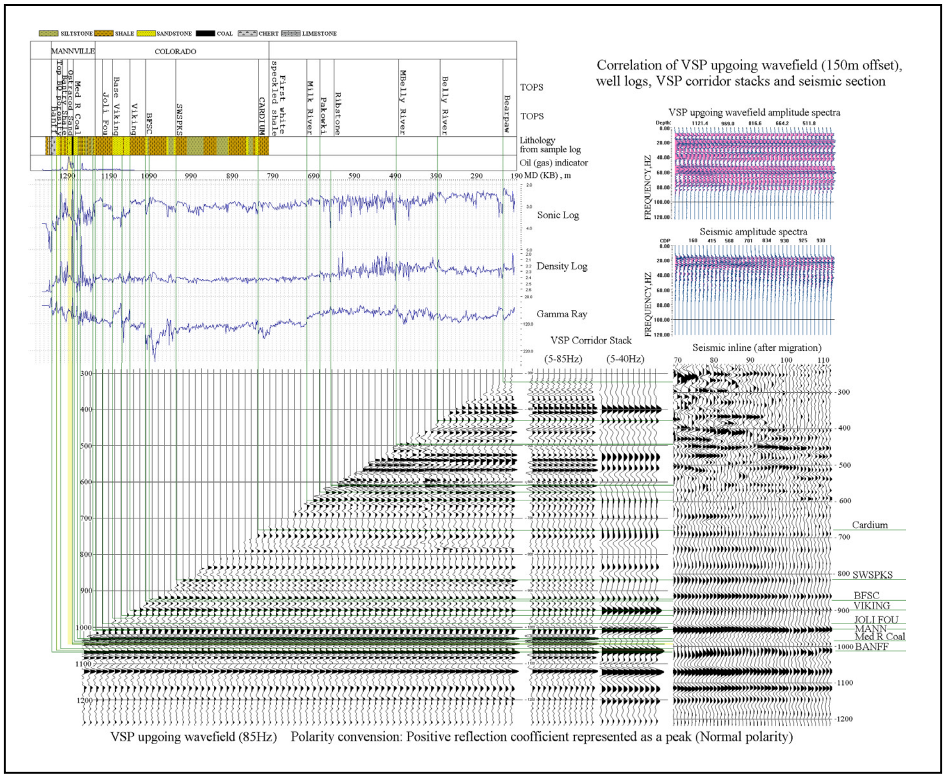

Fig.2(a): Correlation of welllogs , VSP upgoing wavefield, corridor stack and seismic before HFR

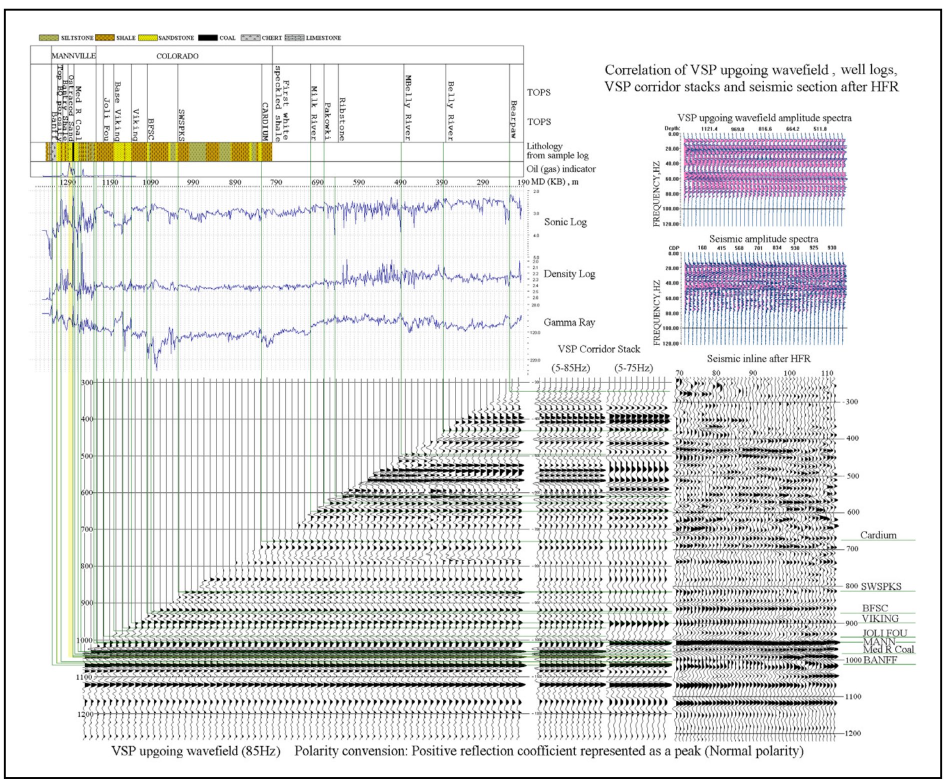

Fig.2(b): Correlation of welllogs , VSP upgoing wavefield, corridor stack and seismic after HFR