B012 CONTROLLED SEISMIC ILLUMINATION OF HYDROCARBON RESERVOIRS

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Introduction

The purpose of redatuming is to transform surface data in such a way that the acquisition level is transported from the surface to another level ('datum') somewhere in the subsurface. This can be done by removing the propagation effects at the source and at the receiver side (Berryhill, 1984).

It is possible to derive from the general redatuming scheme, an alternative scheme where the redatuming is performed per shot record (Berkhout, 1982; Wapenaar and Berkhout, 1989 and Kinneging, 1989).

If the main interest is structural information, it is very attractive to combine a group of adjacent shot records into one new shot record, simulating the response of a synthesized *areal surface source*. We will show that the synthesis process can be done in such a way that our reservoir (the target) is illuminated in some optimum way. This means that after downward propagation through an inhomogeneous overburden the synthesized source wave field has a desired strength and shape at the top of the reservoir.

By synthesizing a group of original shot records into *one areal* shot record, the total amount of data reduces significantly and therefore an enormous speedup of the redatuming process can be achieved.

Synthesis of shot records

Synthesizing shot records at the surface can be used to construct an areal source response. For instance, by simply stacking common receiver gathers from adjacent shot records, a plane wave response can be obtained. This idea was already mentioned by Taner (1976). If however, the model under investigation contains considerable inhomogeneities, the wave front of such a plane wave source will be (seriously) distorted when arriving at the top of the region of interest (target).

Controlled illumination

If the macro model of the overburden is known, it is possible to construct an operator, which enables us to synthesize the shot records in such a way that a shaped wave front *at the surface* illuminates the reservoir in a predefined, controlled way.

With our matrix formulation of the forward model, it can be easily shown that this synthesis operator equals the wave field at the surface that is constructed by backward propagation of the desired source wave field at the target.

To show the afore going, a model and one of the 128 shot records are shown in Fig. 1. In the model the desired source wave field is indicated, i.e. a horizontal plane wave just above the target. Fig. 2 shows the synthesis operator, obtained by back propagation of the plane wave at 500m depth. Note that the synthesis operator is designed in such a way that the *areal source at the target* starts at $t = 0$. The diffractions in the operator must be present to realize the lateral limitation of the desired areal source.

Application of the synthesis operator to the shot records yields the *response at the surface* of the desired source wave field positioned at the top of the target. Fig. 3 shows the result after synthesis.

Redatuming after synthesis

To obtain the redatumed response at the top of the target, the upward propagation effect from the target to the detectors at the surface must be removed. This is done by a downward extrapolation, which results in the response *at the top of the target* due to the predefined desired source wave field. The result of the downward extrapolation is

shown in Fig. 4. The result after migration is shown in Fig. 5. Note that the structure in the reservoir is accurately imaged.

Comparison with conventional redatuming

It can be shown that the results, as obtained by the proposed method, are fully equivalent to the redatuming of shot records at the surface to the top of the target followed by synthesis at the target. Fig. 6 shows the result obtained by stacking 128 redatumed shot records at the target (compare with Fig. 4). This is impressive as downward extrapolation with the method of controlled illumination has only been performed on *one* areal shot record.

Conclusions

It is argued that an operator can be constructed, which enables the synthesis of shot records at the surface in such a way that a given part of the subsurface (reservoir, target) will be illuminated in a predefined way. By synthesizing shot records at the surface, an important data reduction (factor equal to the number of shots used for the synthesis) is achieved, speeding up the total processing time for the downward extrapolation by roughly the same factor.

When the process is repeated for a small number of illumination angles, it provides *angle-dependent* reflection information in a very efficient an accurate way.

References

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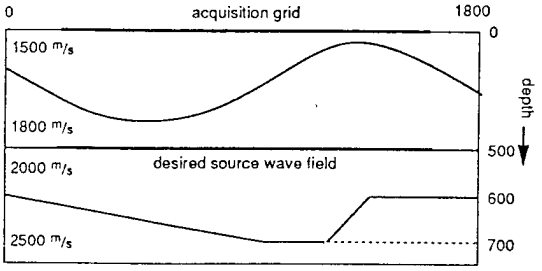

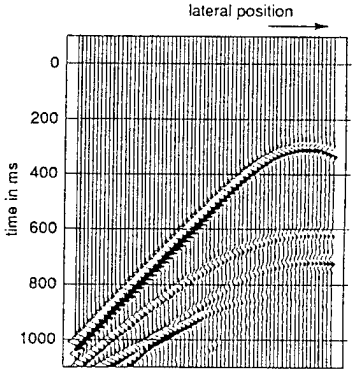

Fig. 1: The model and one shot record

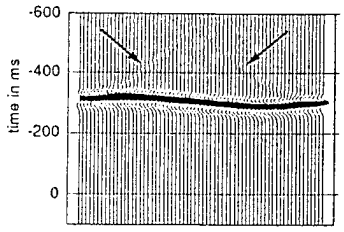

Fig. 2: The synthesis operator

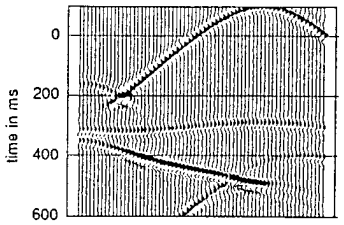

Fig. 3: The synthesized result

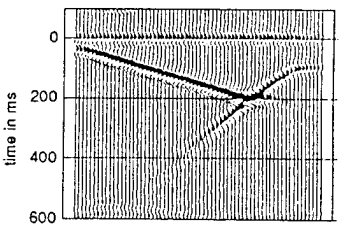

Fig. 4: The redatumed result

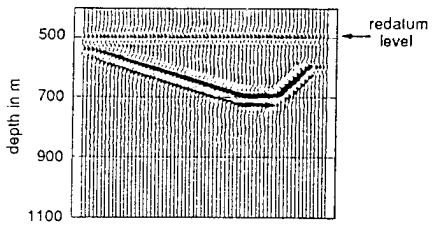

Fig. 5: The migrated result.

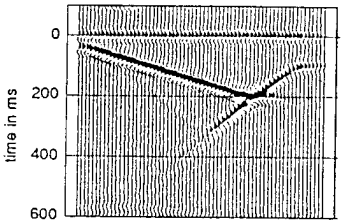

Fig. 6: Result from synthesis after redatuming.