EA Importance of Good Time to Depth Conversion Method to Reduce GRV Uncertainties of Producing Fields in the South Sumatra Block*

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Abstract

As time goes by, many cases of volumetric model from various fields in the South Sumatra Block calculation do not match with the reserves calculation after production decline e.g. using P/Z. The discrepancy is mainly caused by limited and low-quality seismic data resulting in non-optimum calculation of Gross Rock Volume (GRV). One of the main factors affecting GRV calculation is the structure map which in turn depends on the accuracy of time to depth conversion of the time map from seismic interpretation. The velocity model, which is the bridge between time domain to depth domain, is the key to get an accurate depth structure map/ gross rock volume. The velocity model should be generated properly and tied to the geological model of the surrounding area. This paper shows the application of several cases of time to depth conversions (TDC) using the layer cake method that can generate a proper velocity model to reduce uncertainties in GRV calculation.

Introduction

Historically, most of the field depth structures in the South Sumatra Block were usually generated using single equation for time to depth conversion. This method is fast, simple, and it fits for some areas. But it sometimes has disadvantages if we have limited and low quality seismic and well data. The disadvantage is that it does not account for lateral velocity variation of every layer of the formation to honor the geological model of deposition systems. The velocity of single equation has the same velocity trend in every location which does not honor lateral velocity variation. Therefore, the equation will generate a depth structure map that has a similar pattern with the time structure map. Time to depth conversion method that honors the lateral velocity variation is using interval velocity. The variation of velocity in each layer measured by VSP/ checkshot usually relates to the lithology variation and is correlated with seismic horizon.

In the South Sumatra area, the vertical change of interval velocity is observed across formations/ intervals, from the Upper to Lower Palembang Formation, and from Lower Palembang to the Baturaja Formation. The lateral variation of interval velocity is related to lithology and to compaction from the overburden. Since no significant lateral lithology variation over the limited area of the producing fields, the lateral velocity variation is mainly affected by compaction which is represented by present day structure assuming the overburden has the same geological compaction process and no significant uplift and erosion over the area. The regional geology trend will be accounted as the main trend when generating the interval velocity model. The distribution of interval velocity is also distributed using variogram. This paper presents application of layer cake method using interval velocity in several producing fields and prospects in the South Sumatra block.

Discussion

The LC Field is a four-way dip closure with the Baturaja Formation as reservoir. The structure is defined by five seismic lines with 750 m seismic spacing. The depth of reservoir is about 4,200 ft SS. The reserves calculation using volumetric/GRV was not matched with the reserve calculation using P/Z. Therefore, the depth structure map was revisited by exercising many depth conversion methods. Based on the evaluation of several TDC's used in this field, the layer cake model by interval velocity using variogram is the best method for defining the LC structure. Using variogram, the distribution of interval velocity is more reliable by adding regional geology information. The major direction of the LC structure is NW-SE that has same trend with the regional geology of South Sumatera, while the minor direction is perpendicular to the major direction. In major direction, the data is less variation than the data variation in minor direction. The dip line in the LC field has higher velocity variation in NE-SW as it is minor direction. The result of time to depth conversion in the LC Field shows that GRV using new depth structure map (Figure 1a) matches with the reserve calculation after production decline.

The LC success case was applied to other two fields and one prospect. GK is an oil and gas field with Baturaja limestone as reservoir. Seven vertical wells and six horizontal wells have been drilled with cumulative oil production of more than 100 BCF. A new time to depth conversion using interval velocity is applied in the GK Field. With the new depth structure map (Figure 1b), the GRV increases from 272,500 acre ft to 292,600 acre ft. The increasing of GRV will give direct impact on possibility of increasing reserves calculation in GK Field.

The TL field is another field which is in the Musi Platform. The reservoir is Lower Miocene Baturaja Formation. The velocity interval of the Baturaja Formation is ranging from 7,500 ft/s to 10,500 ft/s. The existing depth structure map shows that the southwestern saddle is high so the TL structure will have small bump without closing contour on Gas Water Contact @1762 ft SS. The existing depth structure map gives resource number that did not match with the reserves calculation after production decline using P/Z. Time to depth conversion using the layer cake method is applied to solve this problem. The velocity interval was gridded using structural trend. The result (Figure 1c) shows that the Southwestern saddle is deeper due to high velocity interval in the overburden interval. A new depth structure map shows similar reserve calculation with the P/Z evaluation and led to an optimization of next development well location.

The X prospect is a very subtle anticline, where the regional structure of the surrounding area is monocline, down dip to northeast. Reefal facies carbonate in X prospect and the surrounding area were characterized by dim amplitude and low seismic frequency that control the Baturaja structure. Strike line seismic section shows the long axis anticline is bounded by subtle down dip to Northwest and Southeast, while there are several small bumps in the middle of the structure. The most critical point in structure definition is the depth of the southwestern saddle that bounded the anticline with regional up-dip to the west. Time structure map shows that X structure is a Northwest-Southeast lineament of small bumps. Layer cake method using interval velocity was applied for time to depth conversion to get the depth structure map. The depth structure map using layer cake method (Figure 1d) give high confident level the existing of four-way dip closure.

Conclusions

The time to depth conversion using layer cake method has been used successfully to provide more confidence resource number (based on the GRV) that is indicated by good match with production data. The variogram analysis to distribute the lateral velocity by adding regional geology information can help to guide the trend of the reservoir structure. Other cases of velocity interval using structural trend shows that it can fix the problem in the critical saddle of the field structure.

A good time to depth conversion method is critical in generating a depth structure map that has implications in all stages of hydrocarbon from the exploration stage (prospect definition, depth of prognosis, drilling program) to the production stage (resource calculation vs production data). Every method of time to depth conversion is unique and may only be suitable in certain cases or areas. Single equation may work in some cases, but if we want to incorporate a geological model in generating a velocity model for time to depth conversion, the layer cake method using interval velocity is a powerful tool.

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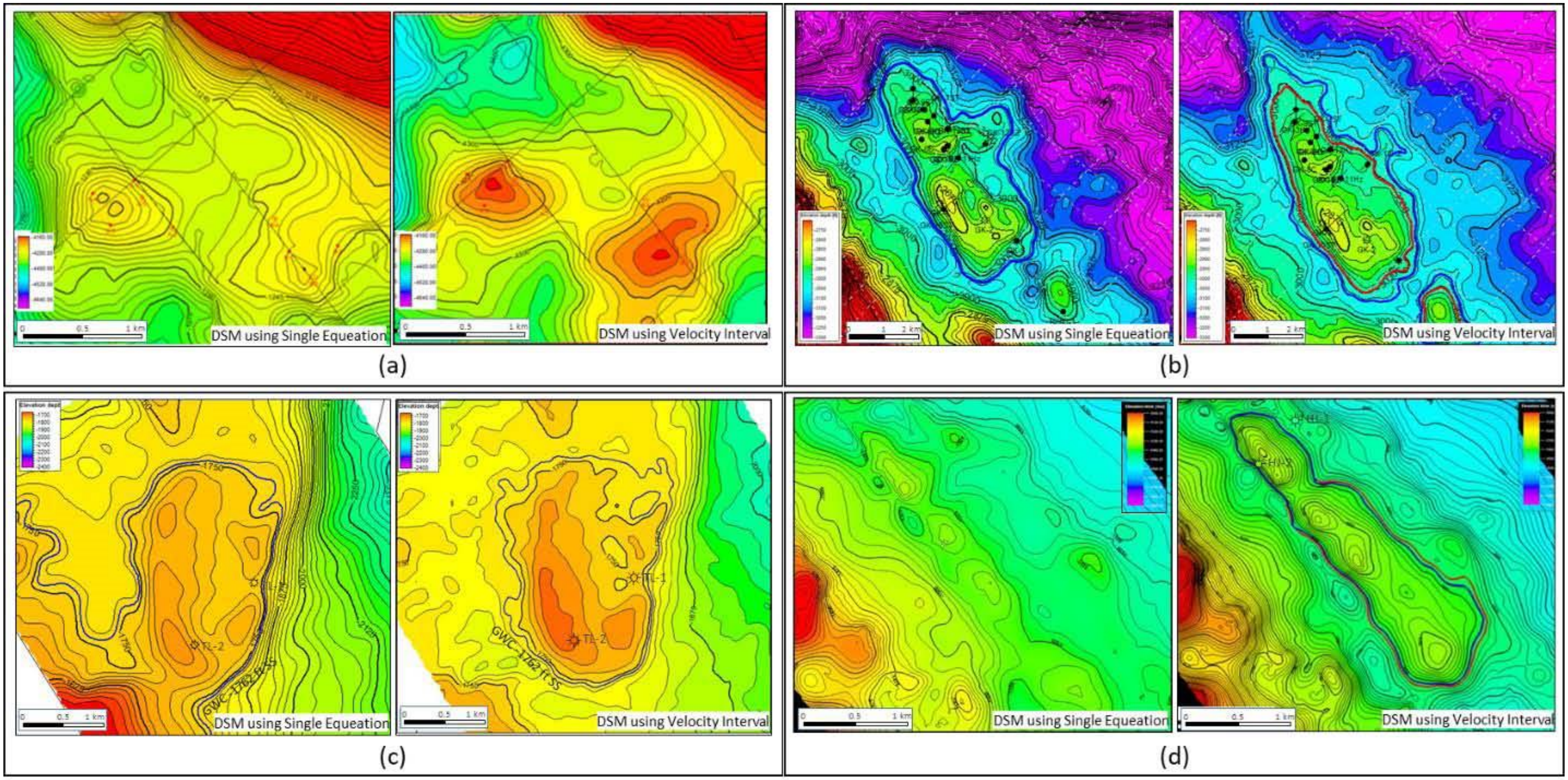

Figure 1. Depth Structure Map of fields and prospect. (a) LC Field, (b) GK Field, (c) TL Field, (d) X prospect.