Exercise 8: Estimating Ultimate Recovery (EUR)

Objective

In this exercise, you will estimate the recoverable reserves, i.e., the estimated ultimate recover (EUR) of this possible field. The gas EUR will assign a value to the field (assuming some future price for gas). This value will be compared to the costs to continue exploration and then develop and operate the field for a certain number of years. That value minus all the costs gives us the profit. If the estimated profit is acceptable, then we can propose drilling a wildcat well.

Materials

- Exercise instructions, with figures
- Computation sheet
- Pencils and erasers

Introduction

We will now provide you with enough information for the Tiger prospect so that you can estimate the EUR of this possible field. You will use a set of numbers to obtain several estimates of ultimate recovery. These numbers come primarily from seismic data analysis. You will make three estimates:

A "most likely" case

A minimum (low-side) case – could be as small as X.

A maximum (high-side) case – could be as large as Y.

Step	Action
1	There is evidence for a fluid contact on the seismic. Assuming that the mapping of the DHI was done properly, we get an area of 90 km^2 (Figure 1). Given data resolution and data quality issues, we might make the area a little smaller (low-side case) (Figure 2A) or a little larger (high-side case) (Figure 2B). These areas have been entered into row one of the computation sheet.

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<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>2</td><td>In part of the seismic data analysis, the reservoir interval was subdivided into three depositional environments: fluvial, delta plain and delta front). We will assume different averages for net-to-gross and porosity for each depositional environment. Further analysis led to a subdivision of the reservoir interval into three units: upper, middle, and lower.

Figure 3 shows an interpretation for how the three depositional environments stack in the three intervals of the reservoir. Figure 4 displays the product of net-to-gross multiplied by the porosity. For example, the pink region on the west is where all three units are fluvial. For the fluvial rocks, the N:G is 0.50 and the porosity is 0.16, so the product is 0.08.

Given Figure 4, make three estimates for the average of N:G times porosity for the entire field:

A most-likely field-wide average,

A reasonable minimum average and

A reasonable maximum average.

Enter your estimates on line 2 of the computation sheet.</td></tr>
<tr><td>3</td><td>With the top of the reservoir mapped (the TOS horizon) and the GWC mapped, we can get the time-thickness (in ms) of the gross reservoir where it contains gas. This is shown in Figure 5.

We will assume an interval velocity of 2500 m/s to get a gross reservoir in meters (Figure 6).

Given Figure 6, make three estimates for the field-wide average of reservoir thickness. We want to work in units of kilometers, so divide your estimates of thickness in meters by 1000. Enter your three estimates (in kilometers) on line 3 of the computation sheet.</td></tr>
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Exercise 8: Estimating Ultimate Recovery (EUR) continued

Step	Action
4	Now you can calculate the HC pore volume at reservoir conditions in units of cubic kilometers. Multiply rows 1, 2, 3 and 4 for the three different estimates and place the products on line 5 of the calculation sheet.
5	We believe the recovery efficiency for this reservoir will be high. For our estimates, use the recovery efficiencies already entered on line 6 of the computation sheet.
6	Next, multiply line 5 by line 6. The product is the recoverable gas volume in cubic kilometers at reservoir conditions (reservoir pressure and temperature). Enter this on line 7.
7	Since one cubic kilometer equals one billon cubic meters, line 5 is also the value of reservoir gas in Bcm (billion cubic meters). As the gas rises to the surface during production, it expands as both the temperature and pressure drops. Multiply line 7 by 111 to convert from reservoir gas volume to surface gas volume. Enter the value on line 8.
8	For those accustomed to English units of volume, you have one more step. Multiply the number on line 8 by 35.3 and write the product on line 9. This is the surface gas volume in billion cubic feet (BCF).

AAPG

Exercise 8

ROW	PARAMETER	Most Likely Case	Low-Side Case	High-Side Case
1	Area in sq km	90	70	105
2	N:G * Porosity			
3	Gross Thickness in kilometers			
4	HC Saturation	0.9	0.8	0.95
5	HC Pore Volume in cubic kilometers			
6	Recovery Efficiency	0.7	0.6	0.8
7	Recoverable Gas Reservoir Conditions in cu. Km			
8	Recoverable Gas at Surface in Billon cubic meters			
9	Recoverable Gas at Surface in Bcf			

Exercise 9: Tiger COS

Objective

In this exercise, you will assign some chance of success values to nine elements for the Tiger Anticline. Keep in mind that there is strong seismic evidence for a fluid contact. The DHI gives us more confidence that there is a reasonable chance for the presence of an economic quantity of oil or gas.

Materials

- Exercise instructions
- Previous figures
- Pencil

Introduction

You have looked at several key play elements for the Tiger Anticline. There is a huge structural trap that could hold an economic amount of HCs. You evaluated the maturity and generation potential for a source rock interval. You considered the EOD for the potential reservoir interval. There is strong geophysical evidence for a fluid contact. There is greater than a 90% chance for an unrisked reserve of an economic amount of gas.

Now your team with consider the chance of success for nine factors, as explained in Lecture 9. You have done some basic analyses. You will be given some extra information for each of these nine factors.

Step	Action
1	**RESERVOIR PRESENCE** Onshore outcrop and well data gives us good evidence that fluvial and delta plain sands should be in our block. If the seismically identified fluid contact is true, this also suggests the presence of a porous sand. So our COS should be very high. Your team's estimate: COS for reservoir presence is: _____ % Enter on Fig 1

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Step	Action
2	**RESERVOIR QUALITY** The reservoir quality of onshore outcrop and well data is good to very good. The depth of burial for our target reservoir is not so great that we are concerned about major decreases in porosity or permeability. So our COS for reservoir quality also should be high. Your team's estimate: COS for reservoir quality is: _____ % Enter on Fig 1
3	**TRAP QUALITY** The trap is a huge anticline that is easy to map and define. There is one small-offset fault near the crest. Since reservoir and seal are risked separately, the presence and quality of the trap should be rated very high. Your team's estimate: COS for trap quality is: _____ % Enter on Fig 1
4	**SEAL ADEQUACY** The Lakes Entrance Formation was deposited during a major transgression. Onshore it is a thick, fine-grained shale. It has excellent sealing properties onshore and the quality should be even better more distally (offshore). Thus seal quality should be excellent. Your team's estimate: COS for seal adequacy is: _____ % Enter on Fig 1

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Step	Action
5	**SOURCE QUALITY** The source is well documented onshore. It is coal and non-marine shales. It has the potential to generate some oil and a lot of gas. Offshore, the source interval is more distal, getting to open marine environments. Thus it could contain less terrigenous organic material (gas-prone) and more marine organics (oil-prone). Thus the source quality is good onshore and perhaps much greater offshore. Your team's estimate: COS for source quality is: _____ % Enter on Fig 1
6	**SOURCE MATURATION** You did some work on source maturation in exercise 4. Based on your analysis (and perhaps the exercise solution), you can risk this element. Your team's estimate: COS for source maturation is: _____ % Enter on Fig 1
7	**HYDROCARBON MIGRATION** We can assume that HC migration is due to simple buoyancy. In exercise 4 you considered the fetch area for Tiger. Based on your analysis (and perhaps the exercise solution), you can risk this element. Your team's estimate: COS for HC migration is: _____ % Enter on Fig 1

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Exercise 9: Tiger COS **continued**

<table>
<tr><th>Step</th><th>Action</th></tr>
<tr><td>8</td><td>NOT LOW GAS SATURATION
You have considered volumes of likely generated and trapped gas. The volumes are large. As long as the seal is adequate, there should be a lot of HC in the trap.
Thus the instructor would estimate there is a 95% chance that the gas is NOT filled with low gas saturation.
Your team’s estimate:
COS for NOT low gas sat is: _____ % Enter on Fig 1</td></tr>
<tr><td>9</td><td>NO BIODEGRADATION
HC in the trap can be degraded in two ways:
1. If the reservoir gets too hot, longer chained HCs can crack, eventually down to methane.
2. If the reservoir is too cool, bacteria can degrade oil.
The depth of the reservoir, given the thermal gradient, is too shallow to have thermal cracking. It is shallow enough that the reservoir temperature could be less than 70° C. Thus there is some risk of biodegraded oil. The instructor would estimate there is a 98% chance that there is NO biodegradation.
Your team’s estimate:
COS for NO biodegradation is: _____ % Enter on Fig 1</td></tr>
<tr><td>10</td><td>TOTAL COS for Tiger
To get the total COS, multiple all the percentages as decimal values (not %). The product is the total COS.
Enter this number on Figure 1.</td></tr>
</table>

1. Reservoir Presence	0.95
2. Reservoir Quality	______
3. Trap Quality	______
4. Seal Adequacy	______
5. Source Quality	______
6. Source Maturation	______
7. HC Migration	______
8. Not Low Gas Saturation	______
9. No Biodegradation	______
TOTAL COS	_______

Figure 1. Table for recording your COS values and determining the final COS for the prospect.