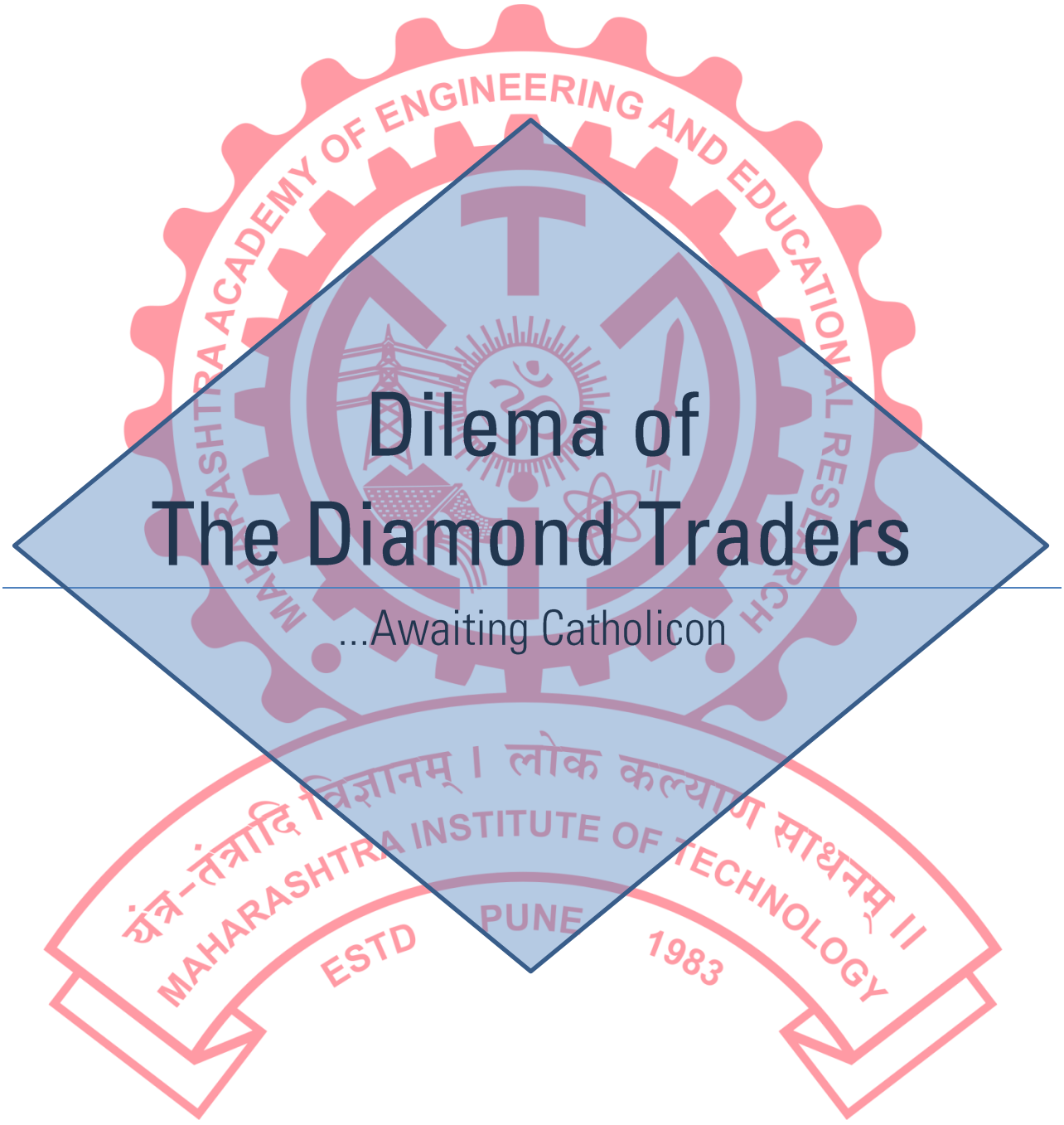

Dilema of The Diamond Traders

...Awaiting Catholicon

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Introduction

Five diamond traders together conceived to start an exploration and production company in 2000. They put together a sum of US $ 10 million. They were looking to get operating licence of some small oilfield from which they can start and further gain more expertise in the sector they were totally new. They employed a team of two geologists, 1 geophysicist and 1 reservoir engineer and named their company as Diamond Oil and Gas Pvt Ltd, henceforth referred to as Diamond. The team kept on looking for some opportunity in the market which was dominated by mightly national oil company and state run oil companies. Diamond entered the market by taking 100% operating and production rights in one of the small fields. The story of the company unfolds chronologically given as below and the names of the fields were coined by the company owners themselves.

1. Saphire Field: Diamond entered the upstream industry in 2002 by acquiring a small onshore block from National Oil Company. The National Oil Company was not interested in producing from this field as the initial flow rates from well drilled in this block was quite less. The deal was signed at $ 5 million. National Oil Company before leaving the field has drilled six exploratory wells A-1 to A-6. Out of these 4 were put on production from 1996. The B-1, B-2, B-3 and B-5 wells were capable of producing about 900,000 STB during the next 30 years, a volume of oil referred to as the Proved Developed Producing (PDP) Reserves. As additional wells are drilled to develop the currently Proved Undeveloped (PUD) Reserves, they will interfere with the existing wells and with each other. The Proved Reserves are expected to be a strong function of the number of wells drilled, owing to pronounced well interference effects in the thin reservoirs. The reserves listed in the following table are recoverable during a period of 30 to 35 years:

Proved Reserves as of January 1, 2002

(MSTB)

No. Of new wells	0	5	7	11
PDP Reserves	904	752	730	696
PUD Reserves	0	1773	2114	2719
Total Proved	904	2525	2844	3415

The Formation of Middle Eocene age hosts the reservoir rock in the Diamond oil field. Siltstone is the dominant oil bearing rock type with intervening shale/clay stone and a varying amount of clayey matrix in the reservoir facies. Coal beds varying in thickness from a few centimeters to 10 meters or more are abundant in the Kamal Formation as revealed by cuttings and log signatures. The shales are also carbonaceous in nature and clay stone is abundant throughout the

succession. Lithologic symbols and descriptions found in the original composite logs for the Diamond wells refer without exception to siltstone, rather than sandstone, implying an absence of coarser grained sediments within the reservoir.

The overall sequence represents a euxinic facies with minor changes between a marshy environment marked by finer clastics and a lagoonal environment, marked by distinct coal layers. The marshy lagoonal condition was interrupted by the presence of small phases of flood-tidal events leading to the deposition of siltstone. Siderite and pyrite are commonly found in rocks deposited in this type of environment and, not surprisingly, the presence of these minerals is mentioned in the available reports for Diamond.

Siltstone usually has low primary porosity. However, dissolution of siderite cement may have contributed significantly towards the generation of secondary porosity and thus upgraded the reservoir quality in relatively coarser siltstones. Siderite dissolution may have occurred during the passage of meteoric water through these rocks as younger sediments were burying them.

The restricted swamps in this type of depositional environment would receive an unequal supply of siderite and argillaceous matter from the fluvial sources, due to the topographic disposition of the basin. Hence, primary porosity and its digenetic enhancement would vary in different areas and lead, for all practical purposes, to a spatially unpredictable distribution of porosity in the reservoir.

In appraisal phase, Diamond has drilled wells B-1 to B-18 till date. Few of the wells are on self production while others have turned out to be poor producers.

The existing correlation as outlined in the different reports is:

K Horizons	B-1	B-2	B-5	B-3
	TVDSS (m)	TVDSS (m)	TVDSS (m)	TVDSS (m)
K-VIII	1344.6-1354.6	1373.1-1383..6	1370.3-1388.3	1363.8-1376.3
K-IX	1356.6-1367.6	1388.1-1401.1	1391.3-1408.3	1383.3-1385.3
K-X	1399.6-1411.6	1413.6-1428.1	1419.3-1435.3	1409.-1419.

Oil of 24° API (bubble point ~ 900 psi) from well B-1 must have been derived from the K-IX Unit and K-X, because the K-VIII is not developed at that location. The crude has wax content and with low formation pressures and low GOR it makes difficult to flow the well. Each layer has its own fringe oil water contacts.

Oil of 39º API (Bubble point ~ 1800 psi) from well B-5 was probably sourced from Unit K-VIII, because a PLT survey showed all fluid entry from that unit.

This calculated effective oil permeability values for the K-VIII Unit in well B-5 of 6.5 md, 0.7 md for the K-IX Unit in well B-1 and 1.3 md for the K-X Unit in well B-3.

The problem in Diamond has been that wells after perforate have been put on artificial lift like application of compressor and have tried conventional HF on some of the wells with limited success that too for short time. Diamond pay is silty sand with K in the order of few md and sometimes below 1 md also. The crude has wax content and with low formation pressures and low GOR it makes difficult to flow the well. Any typical production profile even after HF shows a peak production with sharp drop and a tail end production which seems to go on for ever. The RF for the wells or for the entire field is heading towards 6 - 7 % at the best which is very poor in this era of technological advancement.

Present Scenario:

1. Less hopes with conventional fracturing job.
2. Doubt over coal behavior during fracture job. How it is effecting fracture growth?
3. Whether to go for cheap conventional fracturing job or well designed (fluid, proppant, perforation, etc.) optimized fracture job applying most recent technologies.
4. Well fracturing before start of first production or fracturing only after well has produced for few years.
5. Looking into any other artificial lift method which is effective after fracturing. There is a feasibility of getting gas for gas lift from a national oil company which has operating fields nearby.
6. Is conitnuous gas lift appropriate?
7. Leave the field with low recovery factor.

Diamond has planned to drill 3 more vertical wells next year. The geologist doesn't support the idea of drilling horizontal wells because of uncertainty in facies development.

2. Topaze Field: This is one of the another oil and gas block relinquished by National Oil Company in which Diamond took the operating rights by signing a production sharing contract of 40% in 2008. This block consits of various oil and gas producing pools. Previous company categorized it into one major pool and one minor. Diamond named them as Topaze-S for smaller pool and Topaz-B for bigger pool. The smaller pool has a good development of shale in shallower section (550m-600m) with interesting TOC of 3.5%.

The field has same development of different layers as was in Saphire field but with more uniformity. Each layer has developed its own gas cap of 1m to 3 m at structurally higher positions. All three layers can be assumed to be developed in same fashion (thickness, etc.). Layer K-VII can be neglected.

Topaze has been major revenue generator for Diamond since 2008. While Topaze has access to most of the well's log data for the smaller pool (drilled recently), it has no access to well log data of bigger pool old wells. This happened because of very massive earthquake with epicenter at Bhuj in which logs were lost. The only data available are production data.

Present Scenario:

1. Diamond wants to select best candidate for fracture based on available open hole log data, stress profiles and past production profiles in the smaller pool.
2. It also wants to select best candidate for fracture from the bigger pool.
3. It is also considering methods of tertiary recovery in the bigger pool. Water injection is being done in different layers (See production and injection data).

3. Diamond was doing good and now had an employee count of 70 which comprised of 20 production engineers, 5 reservoir engineers, 4 geologists, 3 petrophysicists and 2 geophysicists including other support staff. The company went public on NSE on 1st April, 2011 in which it raised $ 10 million.

4. Block 46-DW: In 2012, because of sustained cash flow and more liquidity, Diamond took a major step in bidding for a deepwater block. It won a deepwater contract which no other company bid for. The commitment was in terms of drilling atleast 2 wells every year. Though confused, Diamond went ahead with the drilling program eying big on an interesting widespread seismic reflector promised by their geophysics group. The reservoir geology is expected to be of prehistoric slope channels.

   Diamond has drilled 5 wells till date, DW-1 to DW-5. It has encountered few interesting gas zones and big water zones revealed through extensive formation tester data acquisition (Provided). As testing is quite expensive in deepwaters, it was done only in one well (test data to come as surprise for screened teams)

   Present Scenario:

   1. Establishment of economic feasibility of reserves.
   2. Further drilling of appraisal wells.

3. Relinquishing the block to other company. Few companies might be interested in buying the operating rights of the block, especially those with considerable experience in operating in deepwater blocks.
4. It would be a big setback of loosing the operating rights infront of investors, who can start doubting the technical capabilities of the company.
5. Government can give a concession on drilling requirements in deepwater blocks, if Diamond shows commitment to develop unconventional sources of energy like shale gas.

Considering the above scenario, a team is expected to be of thee to four members who is presenting before a team of government officials, partner companies and investors which explains company strategy for upcoming 5 years. This should be in terms of investment of money in different assets which company posses.

The decisions have to be supported by technical and financial arguments wherever necessary.

Presenting team composition is expected to have atleast

1. Reservoir Engineer
2. Production Optimization Engineer
3. Group CEO

<u>Expected Clarifications (but not limited to):</u>

1. How to increase recovery factor in Saphire Field? Should company look for advanced fracturing being offered by different service companies? Is it justified cost wise? What is the effect of coal seams?
2. What is the present recovery factor for both the pools in Topaze?
3. Candidate identification for conventional fracturing job in small and bigger oil pool. Explain what is the workflow used for candidate identification. In smaller pool it should be based on log response and production history while in larger pool it should be only based on production history and other considerations which may seem appropriate to the team.
4. What should be ideal future strategy for DW-46 block? Where to locate next well? Should it be kept or relinquished?
5. Should Diamond think about tertiary oil recovery in Topaze? If yes, which one?
6. Should Diamond venture into shale gas? If so, what should be the approach?

Data Available

1. One parent folder for each field.
2. Team should explore each folder to know more. Missing data if any should be logicaly assumed.
3. Help Folder

Suggestions:

1. Read and know more about fracutring operations and fracture height growth
2. Use of nodal analysis is suggested using industry standard software
3. Plotting of log data on Log Data Viewer. (http://www.slb.com/services/characterization/data_utilities/log_data_toolbox.aspx)

Submissions of Solutions:

1. Submit the solution in 4 page write up showing few indicative numbers to Nitish Kumar (nkumar6@slb.com) and copy Samarth D. Patwardhan, Associate Professor, MIT, Pune (samarth.patwardhan@mitpune.edu.in)
2. Subject of Mail : MIT Case Study Entry (Team Name – University Name)
3. For doubts if any: Email to nkumar6@slb.com (Please mail only after you have made sufficient assumptions for missing data). Mail with team name in subject of mail is suggested.
4. Please find time line through university representatives
5. Early submission would fetch brownie points ☺