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Research Analysis

Prospect assessment and risk analysis: Example from Niger Delta, Nigeria Basin

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Exploring for oil and gas is a risky business. Risk is the chance of failure, and there are many more dry wildcats than there are wells that make discoveries. The quantification of risk in relation to reward is one of the main benefits of formal assessments of undiscovered oil and gas potentials, but in this paper we consider only the geologic existence risks, and environmental risks.

Key words: Geologic risks, environmental risks, porosity, reservoir, prospect.

INTRODUCTION

There are different kinds of risk: geologic risks govern the existence of oil and gas; finding risks dictate whether or not any existent hydrocarbons will be found; and economic risks determine whether the discoveries can be produced. There also are environmental and political risks (Aigbedion, 2004; Scott, 1999).

Industry has many reasons for making quantitative assessments of undiscovered oil and gas. First and foremost, assessments can guide exploration by ranking the opportunities and potential rewards in terms of barrel or cubic meters. Economic analyses can convert these amounts into monetary expectations, which strongly influence selective acreage acquisition, bidding strategy, and choice of well locations (Scott, 1999). Broader assessments of countries, or of the whole world, influence long-range exploration planning, including technological requirements and capital needs. Nothing exposes data requirements and research needs more effectively than attempts to quantify the many geologic controls of oil and gas. Additional important uses are discovery-rate prediction and supply forecasting. In this paper we shall investigate geological risk before environmental risks, and attempt to find out when it's appropriate for assessor to evaluate risk in exploration business.

Geological risks

The evaluation of geologic risk lies at the foundation of every one of these assessment applications. Assessors may evaluate risk at several levels. They may evaluate risks for a single potential reservoir at a single prospect, or they may study a group of potential reservoirs at a single prospect. They may analyse a whole play, which is a group of related prospects having basically the same geologic controls of trap, reservoir, and source for hydrocarbons, or they may evaluate an entire basin. The best way to illustrate risking principles, however, is to consider the assessment of a single potential reservoir at a single prospect (Stovall, 1996).

The method described here is a systematic assessment of potential exploration rewards in terms of barrels or cubic meters, and of the associated geology risks that may deny these rewards. All basic geologic data and interpretations in the oil/gas industries are laid out for management's use in comparing prospects realistically and for judging the reliability of the estimates.

The total trap volume available for oil is the product of the area of closure at the spill point, the average reservoir thickness, and the average effective porosity. This

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Table 1. Uncertainty of each estimate.

	Most Minimum	Most Likely	Most Maximum
Closure area. square miles	10	15	20
Average reservoir thickness. feet	10	50	76
average effective porosity	0.12	0.16	0.20
Hydrocarbon fill of trap volume	0.2	0.6	1.0
Recovery	0.35	0.40	45
Absolute product. million BBL	4	140	800
Monte Carlo product. Million BBL	20	20	420

volume multiplied by an estimate of the degree of oil-fill in the trap gives the amount of oil in place. Multiplying the oil in place by the last factor, recovery efficiency, gives the final answer in terms of potentially recoverable oil. Method of calculating volume of the hydrocarbon in place is given by Aigbedion (2004) as,

$$V_H = \sum_{j-i}^{n} V_j\phi_j (1 - S_W)_j \qquad (1)$$

Where k = 3.54449373 x 10^1at 60 F and 14.65 psi (Gas).
= 6.289811 bbl (Oil).
VR = Net hydrocarbon sand (Area x thickness).
$1 - S_W$ = Fraction of pore space occupied by hydrocarbon.
S_W = Average water saturation.
ϕ_j = Porosity.

The estimate for average net reservoir thickness requires inclusion of a net – to – gross ratio and a geometry correction that accounts for any thinning at the edges of the oil column. The estimate for net effective porosity must allow for the irreducible water saturation and for the volume shrinkage of oil brought from the reservoir to the surface.

All the volume factors must be multiplied together to determine the potential reward. Obviously, if any one of the factors is zero, there is no reward. This relation sets up the second assessment step, that of risk analysis. If any one of these controls or risk factors is inadequate, making the related volume factor zero or near zero, then the chance for the prospect's success is wiped out.

The closure area depends on the actual existence of the postulated structural or stratigraphic feature. If the anticline turns out to be a velocity anomaly and there is no closure, there is no prospect. Cementation may destroy the porosity, or porosity development by solution or fracturing may not be present. The biggest question in any assessment is whether or not hydrocarbon is available and can be retained in the trap. The degree of trap fill is dependent on the amount and types of organic matter in the source rock, the maturation level, adequate migration, plumbing with respect to trap timing and seal, and preservation from flushing, overcooking, and biodegradation. If the prospect passes all the theses rugged tests and indeed contains hydrocarbons in place, the permeability, fluid viscosity, and drive must all be adequate for effective recovery.

We will now make quantitative estimates of these five volume factors and the five related risk factors for prospect Alpha. All estimates deal with much uncertainty, so we will use ranges of values and a probability approach. We will also show the close relation between the volume and risk factors.

Since none of these volume factors is known exactly, it s important that we make not only our best or most likely estimate but also include an estimate of the minimum and maximum for each volume factor (Table1). The range in the estimates includes the uncertainty in our seismic and facies maps and in our historical experience with porosity, hydrocarbon fill, and recovery efficiency. The range not only serves to record the relative uncertainty in each estimate but also allows for the possibility that the reward will be greater than indicated by the most likely values alone.

A Monte Carlo computer program is used to combine the individual ranges into an overall probability distribution for Alpha's potential oil. The computer makes many trials; in each trial it selects at random a value from each of the five volume- factor ranges and multiplies them together to get a possible number of barrels. On one trial, for example, the computer may select a relatively small closure area, a large reservoir thickness, a mid- range porosity, a large hydrocarbon fill, and a small recovery.

Each of the volume factors is represented as a triangular distribution function with the apex at the most likely value. Thus, the computer's random selections from each volume factor tend to be most frequent near the apex value and decline to zero at the extremes. So there is no real chance that the computer would ever select all five minimum or all five maximum values in any one trial. Thus the Monte Carlo maximum is always smaller than the absolute product of all the maximum values. Each of the computer's many trials – say, 500 – provides a possi-

Table 2. Risk analysis, prospect Alpha.

GEOLOGICAL CONTROL	CHANCE OF ADEQUACY'S (1.0 – RISK)
Trap closure	1.0
Reservoir	0.5
Porosity	1.0
Source. Incl. Seal timing. Presentation	0.5
Recovery	1.0

Overall chance of exceeding minimum potential = 1.0 x .5 x 1.0 x .5 x 1.0 = 0.25

ble value for recoverable barrels. Adequacy is one minus risk, just as the individual adequate multiplied to get the overall chance of exceeding the minimum prospect potential from the Monte Carlo simulation. Risk analysis of prospect Alpha is shown in Table 2.

There is a substantial chance that the reservoir facies is missing in Prospect Apha. In estimating reservoir-facies thickness as a volume factor, the best interpretation is an average of 50 feet with the possibility of up to 76 feet, if the sand is there. However, about half of the possible interpretation showed little or no sand to be present.

The problem is to express this very risk that there will be little or no reservoir sand in the prospect. The two-step approach used in this method requires that some kind of non-zero minimum be set for the volume-factor estimate. The associated adequacy factor is then used to assign the probability of exceeding that minimum. The effect is to treat anything less than the minimum zero. In Alpha, a minimum of 10 feet was set for reservoir thickness, and the chance of exceeding that minimum is here specified as 50%. The key to setting a minimum is to have it low enough to include all thickness that would have economic potential under the circumstances. The advantage is that it excludes the whole range of very thin reservoir units that are hard to observe regionally and would be uneconomic even if found. The minimum trap closure was not set arbitrarily, however, since the smallest geophysical estimate of 10 square mile quite adequate. Minimum with justification and adequate non-zero minimum are not changed.

Source adequacy is also a risk at Alpha because the prospect lies on known production and tested dry structures which apparently lack source. Source obviously is one of the elements that contribute to the volume factor called hydrocarbon fill, and the most likely and maximum cases were based on observing nearby productive structure. The minimum case, however, was set rather arbitrarily. The minimum was adjusted by trail and error to give a 20 million barrel minimum to the resulting cumulative-probability curve – a value that was close to the economic threshold for the prospect. This minimum is the one against which our judgment of sources adequacy can be gauged. Alpha was assigned a 50% probability that minimum for source potential. The other control factors appear to offer no problems. They represent zero risk, or 1.0 adequacy.

The risked mean is reduced to 25% of the unrisked mean. We are saying by this risked curve that if we had a hundred Alphas, 75 of them would contain zero barrels and only 25 would contain the range of barrels shown by the unrisked curve. Including the 75% of zero cases reduces the risked mean as shown.

A major advantage of the two-step assessment is that an economic evaluation can be made of the unrisked curve to determine the reward if the prospect is actually a field as modeled by the volume factor. This evaluation can be weighted according to the risk analysis against the economic estimate of exploration costs if the prospect proves to be dry.

Another advantage of separating out the risk is that it allows for an analysis of the interaction of the geologic controls. Such a careful analysis is important, for example, when the assessment curves for a group of prospects are to be summed together to provide an assessment of a concession. How these prospects are summed depends on how we treat the individual chances of adequacy of the control factor. If we consider all the risk in each prospect to be independent of the others, then there will be an 82% chance of having at least one productive prospect in the concession. If, however, we considered that the risk of inadequate source applies to the group as a whole, then that part of the risk is applied after the summation, and the chance of having at least one productive prospect is reduce to about 49%. And the chance of at least one prospect being productive is much greater if the risks are treated as being independent. This does not appear realistic for this particular example, since the postulated source bed is the same for all prospects. If the source bed is inadequate for one prospect, it is apt to be inadequate for all. On the other hand, if the source is good at one prospect it is likely to be good for all, so the maximum potential is much greater where the group risk is applied. This different concept of risk might lead to an entirely different economic analysis. There are no easy rules for deciding when to apply independent and when to apply group risks. Each group must be analyzed on its own merits, and the problem is a geological rather than statistical one.

There are many variations of interrelated risk within prospect groups. These interrelations require a careful analysis of whether risk is to be applied before or after Monte Carlo summation. Once that is done, it is relatively procedure to compute an assessment. By recognizing that risk interrelations reduce to the question of when each risk is to be applied in summation, the geologist makes his problem of dealing with interrelations simpler. Though simple, it is a powerful means of applying our understanding of geologic events to make a better analysis of the economic potential of the group.

Assessment is a tough job that has its inherent limitations. It has to deal with all poorly understanding variables in the generation, migration, and entrapment of petroleum. The all-important risking step is still quite subjective, even when guided by experience. We often are able to put prospects in a good relative order of risk, but the correct absolute values are sometimes elusive. We must usually be content if the real answer falls anywhere within our postulated range. Since we cannot know this real answer ahead of the drill, we are forced to play the average, in both the volume and risk factors. The end result is that our mean assessments of individual prospects or plays tend to overestimate the failures and underestimate the successes. Only in the long run, if our risking levels are correct, will the sum of the risked mean assessments for many ventures come close to tracking reality.

Environmental risks

Ever since the discovery of oil in Nigeria in the 1950's, the country has been suffering the negative environmental consequences of oil development, a new US government report concludes. In the Niger Delta region, the centre of the country's oil industry, environment damage has been especially large and not taken seriously until now (Nwankwo and Ifeadi, 1988).

According to an environmental report by the US government agency Energy Information Administration (EIA), released today, Nigeria faces tough challenges to mitigate the damages accumulated over five decades, especially in the Niger Delta.

The Niger Delta's main environmental challenges result from oil spills, gas flaring and deforestation, according to the report found. "Oil spills in the Niger Delta have been a regular occurrence, and the resultant degradation of the surrounding environment has caused significant tension between the people living in the region and the multinational oil companies operating there," (Nwankwo and Ifeadi, 1988).

It was only in the past decade that environmental groups, the Nigerian federal government, and the foreign oil companies that extract oil in the Niger Delta had begun to take some steps to mitigate these damages.

According to EIA, there have been over 4,000 oil spills In the Niger Delta since 1960, and gas flaring from oil extraction has resulted in serious air pollution problems in the area.

Gross socio – economic underdevelopment

The Niger Delta communities have remained grossly socio – economically underdeveloped and pauperized amidst the immense oil wealth owing to systematic disequilibrium in the production exchange relationship between the state, the Trans-national companies and the people. Enormous money had been derived from oil export but the area has been subjected to severe land degradation, socio-economic disorganization, increasing poverty, misery, military occupation and bloody violence.

In addition, Ikporukpo (1981) stated that "most farmers are concerned with problems of displacement without resettlement during oil spills". Adeniyi (1997) further noted that "apart from loss of farms, oil spills have led to extensive deforestation with no adequate replanting practice. This in effect has shortened fallow periods. Compounded land use degradation and led to a loss of soil fertility and consequently erosion of the top soil".

Elliot (1998), stated that, "The slash and burn agriculture traditionally practiced by shifting cultivators-up to 10% of the world's population is based on ecological sound principles. It minimize threats to the forest by leaving land fallow over periods of time long enough for regeneration. Landless peasants whom have been forced from their own land, increase the number of people pursuing such a subsistence life style, this contributes to deforestation through further encroachment on forest lands and reductions in fallow times".

The out migration of the rural displaced farmers in the Niger Delta as a result of environmental degradation caused by oil extraction in the region has led a significant percentage of the local inhabitants to remain in cyclical poverty and penury. This has meant greater environmental degradation as a result of the intensive exploittation of the few remaining fertile land in the region by the residents. It has also led to increasing urban blight in the urban areas in the Niger Delta as more and more displaced rural inhabitant flood the urban areas in search of non-existent jobs.

The Niger Delta regions remain fraught with ethnic unrest due to this environmental degradation. The Ogoni people of the region have protested that not only have foreign oil firms degraded the local environment, but that the Nigerian federal government also has acquiesced by not enforcing environment laws and regulations.

Clashes between Ogoni's and security forces have resulted in numerous deaths. Protest actions occurs with regularity, with local youths seizing oil platforms or taking hostages and forcing oil companies to withdraw their staff and/or to halt oil production until their demands are met. This is a serious environmental risk that can lead to loss of billions of Naira. These protest are the result of the environmental degradation that has occurred, and is perceived to be continuing to occur, in the region as the result of oil development by multinational oil companies, the EIA report recognizes.

The perceived indifference of both the Nigerian federal government and the oil companies to the environment in the Niger Delta has been exacerbated by Nigeria's lack of coherent pollution control policy.

Until recently, there was little incentive for power plants to implement pollution abatement strategies of for oil companies to undertake environment remediation efforts, as the Nigerian federal government was unwilling or unable to enforce environmental laws, according to EIA. However, the Nigerian federal government has recently indicated that it is no longer willing to tolerate oil companies absolving themselves of their responsibility to reduce pollution.

Nigeria federal Ministry of Environment, noted that future drilling rights will be "closely determined by "companies" environmental compliance, in addition to their submission of an environmental impact assessment for the proposed site.

The Nigerian government during the past years has taken action to show it is now serious about enforcing environmental regulations. In March 2003, the Nigerian subsidiary of Shell was ordered to pay US$ 1.5 billion to the Ijaw people for the company's actions in the state of Bayelsa over 50 years period. A government committee that investigated Shell ruled that the company was responsible for a number of oil spills and environmental incidents, including an epidemic in 1993 – 1994 in which 1,400 people were killed that was blamed on a Shell oil spill. The government committee further blamed the prevalence of cancer in the region on exposure to the company's oil spills, noting that shell continually refused to pay compensation for these spills, and where it had, the payment was inadequate, according to the US government report. US oil companies and the Nigerian subsidiaries traditionally have been the main oil producers in the country. The EIA report, although noted that the Nigerian government has become much more active in enforcing it environmental laws and regulations, however it holds that the Niger Delta will not tolerate large damages to its environment for many years to come. But also the oil companies had now understood that new demands had to be lived up to.

The Ogoni people had been aggrieved since a campaign against alleged pollution and environmental degradation that they began in the early 1990s led to the execution in 1995 of nine of their leaders, on the orders of late military ruler, General Sani Abacha. The nine had been convicted of murder by a military tribunal. Obasanjo's government apologized to the Ogonis through the HRVIC For "the sordid and sad events that took place".

But these peaceful developments did not prevent militants of the Ijaw ethnic group from attacking drilling facilities of the US oil company Chevron Corporation in the western part of the Delta to press demands for jobs and amenities. The attack by youths from 10 Ijaw communities also affected oil service firms Giogio Ltd and Westminster Dredging and Marine.

By May 2002, tension in the Niger Delta was heightened by several oil spills which, in combination with communal and industrial disputes, disrupted crude oil production by three transnational. The Nigerian subsidiary of the US transnational Exxon Mobil Corporation shut its Qua Iboe oil export terminal, after it was besieged by protesters from the local Eket community who accused the company of neglecting the environment. Environmental risk has devastating effect on the Niger Delta people and poses serious danger to the multinationals. About the same time, Chevron reported that a faulty valve on one of its pipelines had caused the leakage of an estimated 140 barrels of crude near its Escravos operational base in the western part of the Delta. The company denied allegations by several coastal communities that it was responsible for an oil slick that caused massive fish deaths in areas adjoining Escravos. Before that – on 29 April 2002 – the year's biggest oil spill occurred at Royal/Dutch Shell's Yorla oilfield in Ogoni land, where crude oil released by a burst well-head shot several meters into the air before raining down on surrounding farms and vegetation. The spill was only brought under control many days later when a team of experts was flown in from the United States to cap the well – head. Similar accidents, which shell attributed to improperly shut facilities during its forced withdrawal from Ogoni land in 1993, led to a number of spectacular fires. Although no lives were lost, massive damage was done to the environment. As billions of naira is always lost anytime there are oil spills.

Apart from differences with the oil companies, there were also violent incidents between communities in the region. Soldiers were deployed at Warri in the western delta in June, 2006 to curb renewed violence between the Urhobo and Itsekiri communities over counter-claims to ownership of the oil town. Several people died in fighting between two Ijaw communities, Odimodi and Ogulagha, over ownership of land on which shell was building a gas-gathering facility. Violence reported in the Kalabari and

Ikwerre communities in Rivers state was attributed to a similar cause. But with the Niger Delta Development Commission (NDDC), set up by the former government of Obasanjo to redress the decades of neglect suffered by the oil region, finally gearing up to make its impact felt, the government has also been implementing a policy of strengthening its military presence in the region.

In December 2002, the NDDC organized an international conference supported by UNDP with the aim of creating a consensus on the strategies necessary for rapid development in the region. “The main departure point is that we want a master plan to provide a framework for the things we want to do”, NDDC former chairman Onyema Ugochukwu told IRIN. “It is not only necessary to harmonize activities for other agencies involved. Part of the process itself involves consultation with the people. Often people do development on people, but it’s not something you do to people; you do it with people”.

Critics of the government’s Niger Delta policy allege that while the change fortunes which it has promised the region’s inhabitants has been slow in coming, the government has been quick to tighten its grip on the area’s oil resources.

Signs of discontent are once more beginning to emerge in the region where expectations that Obasanjo (former Nigeria President) will make a difference to the decades of neglect have largely been disappointed. “Many communities in the Niger Delta think it’s time to go back to renew the battles with the government. ”But they may well find a government as ready to fight as it is to talk.

Conclusion

This paper has also discussed the effect of intensive oil resource extraction on the environment of the oil bearing Niger Delta communities and the environment risks of resource degradation, pollution, alienation, poverty and misery in the Niger Delta communities in Nigeria. The analysis has been on how these factors have been inextricable interwoven in a complex web of relationship with the intensification of the exploration, extraction and production of natural oil resources from the region.

In spite of these problems, that is, geologic and environmental, most companies regard some kind of quantities assessment as essential for ranking exploration opportunities and for guiding the outlay of exploration funds. Methods such as the one described here have the advantage of systematical laying out and scaling the key factors controlling the potential size and chances for success of a venture. Geologist, geophysicist, and geochemists can contributed to the quantification of the individual factors about which each knows most. The assessment methods can be used directly in economic analysis. Management can review the results, render judgements, and determine the acceptable levels of risk versus reward.

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