The Application of GIS in Petroleum Upstream Investment Decision making

Yanqing Yu [1], XincaWu[2] , Fei Wang[3] , Xiaoming Luo[4] , Feng Li[5] , Ge Zhang[1]

[1]Institute of Geosciences and Resources, China University of Geosciences , Beijing,, 100083, China , Email: Yuyanqing@vip.sina.com

[2]Institute of Information Engineering, China University of Geosciences 430074, Wuhan, China

[3]Department of Statistics, Renmin University of China, Beijing, 100872, China, Email:Steven_wang_fei@163.com

[4]Institute of Engineering, China University of Geosciences, Beijing,100083, China, Email: Luo_bella@cugb.edu.cn

[5]China Earthquake Infrastructure Service, China Seismology Bureau, No 9 of Wangquanying, Beijing, China , Email: Lfeng10@sina.com

ABSTRACT

This paper discusses a GIS based decision support system that supports the petroleum upstream investment decision-making. Functions of prospect screening and evaluation in both technical aspects (Volume, structure, trap, reservoir and charge, etc.) and economic aspects (Net present value, Investment / profit Ratio, etc.) are designed and integrated into a GIS platform to supports and facilitate the decision making process. The decision support system has been tested in a virtual offshore exploration prospect. The study represents a test bed for decision makers at all levels to establish prospect screening and evaluation guidelines that may be applicable to other related prospect investment issues.

KEY WORDS: GIS, Petroleum, Decision Support System

1. INTRODUCTION

The development of market economy in china greatly affected the upstream of petroleum industry in recent years. The resource hunting exploration and production process has been gradually replaced by the investment-profit driven process. The change arouses the urgent need of developing a decision support system that covers not only the conventional technical evaluation process but also the economic evaluation process that can be incorporated together to produce the input for the final prospect investment decision-making. Geographic Information System (GIS) is a computer-based system providing advanced capabilities for handling spatial and descriptive data [1]. GIS is currently regarded as the only comprehensive tool available that supports the integrated digital analysis of multi-component processes by considering any needed attribute combination of the various components [2]. A decision support system (DSS) is a computer program application that analyzes business data and presents it so that users can

make business decisions more easily. It is an "informational application" (in distinction to an "operational application" that collects the data in the course of normal business operation) [3]. A GIS based DSS are much more powerful when dealing with the information that contains spatial features than the conventional DSS. Thus GIS is selected as the platform to develop a decision support system that provides functions of prospect screening and evaluation in both technical aspects and economic aspects.

2. THE DEVELOPMENT OF A GIS BASED DECISION SUPPORT SYSTEM

To facilitate the decision-making process for Prospect screening and evaluation, following conceptual function modules has been designed and incorporated into Arcview^{TM}, a desktop GIS platform developed by Environmental System Research Institute. The Data Management Module is designed to manage the map data and database; the volume calculation module is designed to calculate the gross bulk volume and Standard Hydrocarbon Originally in Place (STHCOIP); the geological risking module is used to characterize the risk for structure, trap, reservoir and charge; and the Economic Analysis module is designed to do economic cutoff calculation, Net Present Value (NPV) calculation, Investment Profit Ratio (IPR) and the sensitivity analysis (Fig.1.).

Volume database is designed with the following attribute elements, i.e. the reservoir top area, depth, reservoir thickness, Net gross, porosity, GOR, oil saturation, formation volume factor, etc.

Geological Risking database is designed with risking attributes of structure, trap, reservoir, and source rock.

Economic database is incorporated with attributes of recovery factor, well production rate, Capital Expenditure (CAPEX), Operating Expenditure (OPEX), oil prices, inflation rate, NPV, IPR, etc.

Scenario analysis functions are also designed to fully acknowledge risks and uncertainties. The final investment decision will be determined based on the correspondent NPV and IPR, as well as the scenario analysis results.

3. CASE STUDY IN A VIRTUAL PROSPECT

A virtual offshore Prospect has been selected as a test bed for the DSS system. The prospect is a four-way dip closure near the proved kitchen (Fig.2). The water depth is less than 200 meters and the nearest harbor is about 100Km's away.

Firstly the relevant data were gathered and imported into the system and the correspondent database were constructed according to the procedure describe in section 2.

Secondly the oil and gas volume in the reservoir was calculated. The results show a medium-size reservoir with Originally In-place Oil (OIIP) 70.15million m^3 and Originally In-place Gas 7.46Giga m^3. (GIIP)(Fig.2).

Thirdly the geological risks have been assessed based on 3-D composite structure maps. The results show the combined geological risk is 66%(Fig.3).

Then the production forecast and the economic analysis was done with the CAPEX, OPEX, economic cutoff, NPV and IPR. The results show a medium-low return prospect with NPV of 33.63 Million$, EMV of 6.43 Million$ and Profit/Investment Ration of 7% under base case. The scenario analyses shows the key controlling factor for investment is

the oil price. When oil price is 25$/bbl, the IPR become as high as 42% with NPV of 207 Million$; but when oil price drops into 10$/bbl, the IPR will become as low as -34% with negative NPV of –168 Million$ (Fig.4).

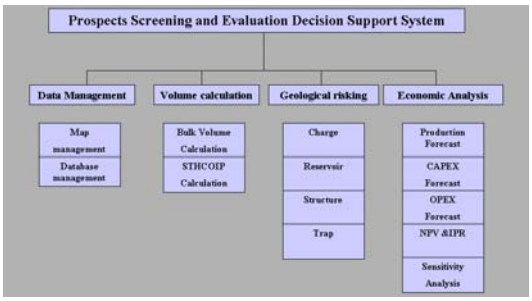

Fig. 1. Function structure of the DSS system

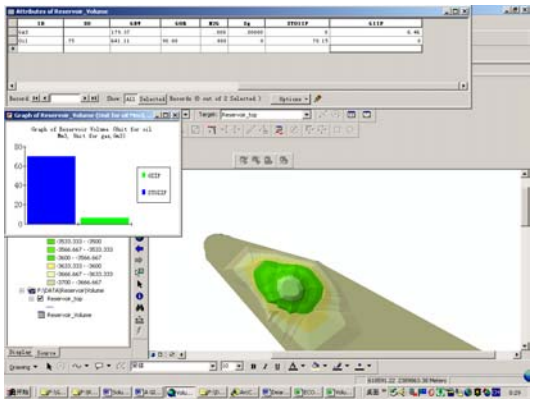

Fig. 2. Volume calculation

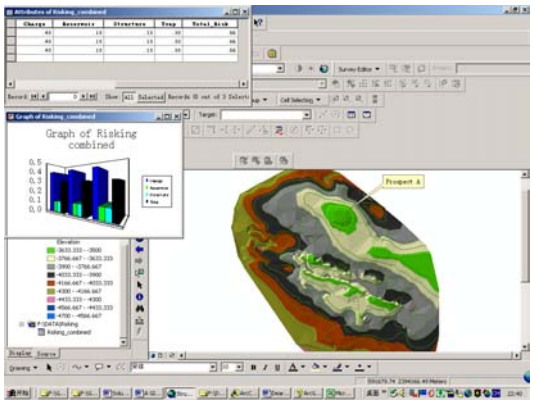

Fig. 3. Basic geologic risk assessing.

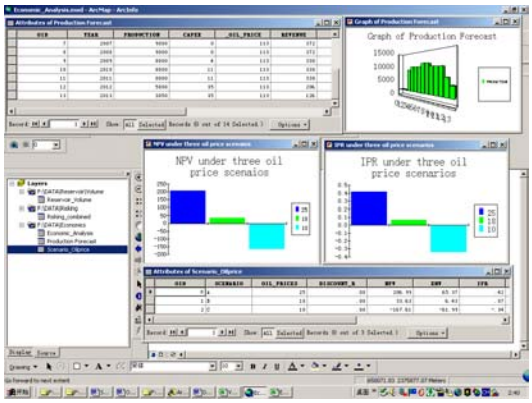

Fig. 4. Production forecast and Economic analysis.

4. CONCLUSIONS

As put by Aronoff S. (1989), fully functional GIS systems facilitate the input, management, manipulation/analysis, and display/output of spatial and descriptive data [4]. GIS based Decision Support System enables the upstream decision makers to make prospect screening and evaluation in a visual and systematic way. The incorporation of Economic analysis with the technical evaluation facilitate and improve the decision making process.

Though not yet fully developed, the system shows good potential as a powerful tool for explorationists and managers to screen and evaluate their prospects.

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