# Case made for regional geology in hydrocarbon exploration

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The goal of a regional geologic evaluation is to determine those areas of the earth that offer the greatest economic opportunities for drilling successful wells in the most prospective area as defined by that study.

Without this step the explorationist may find himself searching for drillable prospects in a portion of a basin that has relatively low merit. Regional studies, usually done on a basinwide scale, or for contiguous multi-basins, show us what to look for and should include recommendations for the exploration methods and the sequence to follow in prospect hunting.

## What and why

A regional study is a predictive tool, and one cannot properly evaluate a prospect without knowing its position in relation to the structure and stratigraphy of a basin together with its relationship to any shows or production.

The principal differences between looking for prospects and the study of regional geological parameters that make up prospective basins are shown in Fig. 1.

On the other hand, the search for drillable prospects requires a detailed examination and synthesis of all geological and geophysical data in relatively small areas with success through the drilling stage more assured if the prospect is located in the more favorable areas of the basin. The difference is largely one of scale since basin analysis uses the broad-brush approach; prospect-finding is an intensely detailed analysis.

Fig. 1

### REGIONAL VS. PROSPECT INVESTIGATIONS

- Regional geological studies evaluate the hydrocarbon potential of large areas of the earth, usually working with basins of substantial areal extent or portions of basins that may have only minor hydrocarbon associations to date in some portion of the basin.
- Regional studies outline the structural signatures that can be anticipated in a basin and the associated stratigraphic sequences. Both structural and stratigraphic aspects must be related to hydrocarbon production or shows since this will help outline the most prospective section and the types of traps most likely to produce.
- Regional studies by their nature represent a broad approach. For example, only the deepest wells may be considered unless only shallow wells have been drilled.

Fig. 2

### WHY REGIONAL STUDIES MAY BE OUT OF FAVOR

- Someone has worked an area for years and he/she knows it is the best place to look for prospects. Why go elsewhere?
- Industry is active in a given area, and this blinds explorationists to merits of other areas.
- The company has a large block of cheap acreage, and all that is required is to slide a prospect under it.
- Some managers feel that time, money, and talent spent on regional analyses are wasted since the natural inclination is a preference to go immediately to defining a series of drillable prospects.

Regional studies are usually out of favor for the reasons shown in Fig. 2. The fallacy in those lines of thinking is that one good prospect developed in a favorable area possesses much lower risk than five located in an area of poor lithologies, antagonistic structures, and an adverse geological history. Low risk improves the chance of success and a favorable return on investment.

In addition, regional studies enable explorers to look at both the positive and negative aspects of large areas. This in turn permits establishment of priorities for evaluation. Regional work can be used to condemn areas (although no area can ever be completely condemned) as well as to explain productive trends. This requires knowledge of geologic history. Some regional problems worrisome to exploration activities will be highlighted.

Other minerals of interest occasionally make an appearance in a regional study: car-

bon dioxide (in the Colorado Front Range), coal (in the Powder River basin), helium (in east-central Arizona), and trona (in Southwest Wyoming). To these may be added oil shale in the Piceance basin of Northwest Colorado and interesting shows of carbon dioxide in the Mist area of Northwest Oregon and in Trans-Pecos Texas.

A bank of regional studies in one's files can give some insight into a discovery of oil or gas by others in a remote area presently not of interest to you. The discovery usually serves as a trigger for the frantic acquisition of an acreage position since as the play spreads any tract available appears desirable. This results in a haphazard assemblage of acreage that may or may not have any exploratory merit. Anyone who possesses some kind of evaluation of these areas in files is in a better position to obtain worthwhile acreage representation in the most favorable areas on short notice.

Preliminary to beginning a regional evaluation, current knowledge of all the area within one's jurisdiction will help the explorer decide those areas worthy of concentrated study.

Regional studies assist us in defining what we should look for and what to expect in any given area; it is a form of reconnaissance that outlines reservoirs, seals, timely migration, source, and the presence of trapping mechanisms. Regional thinking is primarily concerned with facies, environments, and the oil occurrences that are a function of both. It is an exercise in forecasting and hence becomes a management and budgeting tool.

Predicatability comes with understanding, and understanding the exploration environment enables us to predict the location of the most favorable prospective areas. That is, our knowledge and understanding of regional relationships permit us to selectively pursue economic opportunities through comprehensive knowledge by defining basin architecture, depositional patterns, and tectonic history. The geological regions, basins, trends, and plays that offer these opportunities ultimately put the exploration dollar to its best use in budgeting time, money, and personnel. Someone who knows where to concentrate the search for drillable prospects will need fewer technical people to reach that goal.

The reasons for embarking on regional work are many and varied (Fig. 3).

Fig. 3

## WHY TO PERFORM REGIONAL STUDIES

- Find new areas for exploration
- Better understand prospects in a basin and the obtain the ability to rank prospects based on merit.
- Expand areas of interest.
- Predict favorable structural and stratigraphic environments.
- Predict the types of traps possible in unexplored areas and define how to find and exploit them.
- Better understand discoveries made by others in areas where you have generally been inactive.
- Ascertain the proper exploration sequence with the tools available. Not all areas should be explored the same way.
- Learn whether your work indicates a negative bias. The area examined should rank low in terms of exploration expenditures. Regional knowledge can be used to "condemn" areas. On the other hand, positive aspects reduce risk.
- Increase the chance factor of worthwhile discoveries.
- Learn whether, in a basin where you hold large blocks, you should explore what you have, add to it before beginning more details studies, or begin exploration. Options are to explore by farmout, increase holdings, drop acreage, or explore existing holdings.
- Determine anticipated reservoir parameters.
- Examine important exploration factors other than geology. What and where are the markets for oil and gas? What are pipeline costs? What are land costs? Is an acreage position possible? Is the area accessible by road, air, rail?
- Anticipate exploration problems: volcanics, thick unconsolidated sediments, permafrost, breached sections, adverse hydrodynamics, low gravity, drilling problems.
- Learn how regional geology explains productive trends.

Fig. 4

## CHARACTERISTICS OF STRATIGRAPHIC UNITS

- Areal extent.
- Thickness.
- Internal (facies) changes.
- Structure at top and base of unit.
- Relationship to overlying and underlying units.
- Environment of deposition.
- Source of the sediments.
- Paleotectonics of deposition.
- Broad basinal depositional patterns.
- Relationship of source vs. reservoir for each unit.
- Result of interplay of structure and sedimentation affecting the unit.
- Effective seals for potential traps.
- Age relationships with respect to structure, sedimentation, environment, etc.
- Structural and stratigraphic "grain."
- Relationship between production and-or shows with respect to thickness, extent, facies, over- and underlying units, etc.
- Reasons that individual tests failed.
- Worthiness of exploration spending and locations of optimum structural and reservoir conditions.
- Conceptual model for the sequential development depositional patterns in conjunction with observed structural patterns, with emphasis on tectonic intensity and resulting facies changes.

### When to go regional

The timing for a regional evaluation varies from the first bit of interest in a basin to the need to understand what you have been working with for some time. That is, what is the goal and why are you making the evaluation? Is it a matter of money, time, or talent? Is there an urgent need, or is it to satisfy a long term goal?

### Know the territory

Certain factors, which can only be determined from regional studies, are necessary to outline favorable prospective areas and to show where the concentration of effort will be most fruitful (Fig. 4).

More specifically, we should map and compare any parameter we believe may assist in our knowledge of units in the basin. How do we go about this? These factors (Fig. 5), not shown in any particular order, will help establish a work program. The game plan is to select work pertinent to the area to be evaluated, organize the sequence of investigation, and begin.

### How one study worked

The computer is a powerful tool in both regional and local studies.

One regional study involved Trans-Pecos Texas (OGJ, Jan. 20, 1992, p. 59, and OGJ, Jan. 27, 1992, p. 97). The study involved work performed in 1983-84 but not previously published.

The data were fed into a computer, which permitted the authors to watch the develoment of each mapped horizon with time beginning with the lowermost portion of the section. Color enhanced the presentation. The maps and cross-sections fed into the computer by horizons developed a growing picture of sedimentation and structure.

We should point out that in any regional project, any existing maps, whether in-house or published, could be digitized and used in the analysis. PetroSystems of Houston performed the Trans-Pecos Texas computer work, which will be presented elsewhere.

Although our findings were generally negative we did not fully condemn the area. We did suggest that sizable accumulations are probably present. To the present time, these findings appear valid.

No exploration enjoys reaching negative conclusions about an area, but dollars not spent in poorly-prospective areas are dollars available for exploration in worthwhile areas.

Source beds are a problem. Is the unit still a source?

Fig. 5

## STEPS IN ESTABLISHING A WORK PROGRAM

- Use previously published papers for statements, ideas, concepts. Published facies and environmental analyses are valuable.
- Use outline maps and stratigraphic columns to relate data.
- Prepare type logs both lithologic and mechanical. Samples, cores, and core analyses give a good look at the stratigraphic horizons. Outcrops give the best information.
- Prepare regional dip and strike cross-sections. They provide the framework on which the remaining data are related. Regional structural, isopach, and facies maps follow the cross-section network. Fence diagrams are useful in developing concepts and illustrating ideas to management. Understanding the geologic history is important, and these devices help. Studies are essentially four dimensional in scope, with time as the fourth dimension..
- Since many very large oil and gas accumulations are associated with unconformities, they are of prime interest.
- Begin with a surface geologic map. Note that vegetation changes can be useful in outlining surface outcrops.
- Ideally study the area from the basement upward, but since data decrease with depth it is necessary to begin with the horizons on which the most information is in hand. Don't forget that basement is the foundation on which the stratigraphic section is built and that variations in basement rocks and the major structural features present in basement control the overlying sedimentation patterns.
- If there are productive areas within the basin, map their distribution. Map the variation of hydrocarbon gravity. Map the position of seeps, shows, and production in the basin. Any indication of hydrocarbons (show, seeps, production) should be related to the appropriate maps and section. Learn why hydrocarbons are present in the area.
- Are potential source-reservoir relationships apparent?
- Obtain maturation data and-or use Lopatin's technique.
- Learn whether it is reasonable to expect traps similar to and-or different from those found in the basin. Decide how to find the traps.
- Heat flow data, salinities, time-temperature relationships give further insight. Make maps to define oil-gas-water relationships.
- Learn the factors that produce favorable porosity and permeability and how to anticipate their presence.
- Sequence stratigraphic studies form a natural tie with tectonics. Learn whether the lithologies indicate hingelines, shelves, nearshore, or bathyl environments.
- Be alert for a basin's negative aspects: volcanics, tectonics, breached sections, adverse hydrodynamics, problems in accessibility, drilling, land costs and-or availability.
- Watch for recent volcanic activity.
- Regional tools include gravity, magnetics, photogeology, and regional seismic lines. Satellite data give the broadest overview of a study area. Surface geochem data may be useful. Relate data from all tools to objective horizons. Be selective in the tools used and tailor them to the area's stratigraphy and structure.
- Pay attention to analogies with known productive areas.
- Include sufficient area around the basin to place it in context with surrounding geologic elements.
- Note the presence of carbon dioxide, helium, or minerals.
- Benefit from statistics such as oil-gas ratios, cumulative production, drilling and producing costs, reservoir parameters, recovery factors including feet of pay, estimates of drilling depths, current activity level, number and class of fields by years, wildcat success ratios, well spacing, field sizes in terms of original oil in place, and density of control.
- Learn whether the basin's development stage is young, intermediate, or mature.
- Anticipate the size of future accumulations. Make a quick estimate using area in acres times net effective pay in feet times the recovery factor in barrels per acre-foot.
- Learn whether to expect vugular, intergranular, or fracture porosity.
- Learn what range of permeabilities to anticipate.
- Learn expected trap types: structural, stratigraphic, or combination.
- Learn drive types present in various fields and areas.
- Stay familiar with existing acreage position and its cost, acreage availability, type and cost, owners of acreage, lease and rental terms, and work requirements.

Was it a source but the hydrocarbons have migrated? It may no longer look like a source rock. Lack of a readily determined source rock is not sufficient reason to condemn a horizon. The bulk of the world's oil is related to unconformities if you accept the concept that even minor unconformities assist greatly in the accumulation of hydrocarbons. Unconformities serve as the conduit along which fluids or gases move from a source area until a trap prevents further migration.

Unconformities can also serve as a trapping mechanism as well as a seal. Gentle unconformities offer the greatest opportunity for the occurrence of major trapping mechanisms and therefore major accumulations.

While given near the end of the article, more and more emphasis is and will be placed on the use and interpretation of geophysical data in the future, primarily seismic. Processing is all-important. Today we have techniques involving computers that have removed much of the guesswork formerly present in not only prospect-size areas gbut in the regional aspects as well. Geophysical data are vitally important today. For example, prediction of porosity and its lateral continuity are major exploration questions, and seismic facies maps provide information on fracture intensity and localized porosity development.

Three dimensional seismic data provide the explorationist with a high resolution picture of the subsurface and make it possible to delineate large and subtle variations in geometrical and physical properties at considerable depths. The finding and identification of flood plains, intricate channel systems, stratigraphic plays based on point bars, channel fill, crevasse splays, and fan delta systems are possible. Four dimensional seismic, or 3D time-lapse monitoring, brings in the time factor and permits observation of the movement of fluids during the development of a field and gives geologists and engineers additional control for exploration planning.

The use of seismic facies mapping is becoming more important. Where we have limited well information, we have the tendency to "create" sedimentary facies based on those few wells. We overlook the fact that we are not seeing a representative distribution of rocks in the subsurface. However, by using a seismic facies analysis approach at least we can recognize the variability in facies, which in turn can be used to predict the geology for a particular seismic signature. Seismic facies analysis differentiates areas of good porosity vs. bad porosity, development of reef and related features, etc. The technique is based on the fact that through "neural net" seismic analysis a map can be generated based on the distribution of similar wiggle trace shapes.

## Shaping a report

Conclusions and recommendations should be presented on the first sheet of your report. If managers are interested at that point, they will read the balance of the report and examine your maps.

Not all companies want to spend the time necessary to produce a report, particularly for work that consisted of a multitude of maps, cross-sections, etc. We take a negative view of this outlook for a number of reasons:

- A report forces the explorationists to organize their thoughts and to put them in understandable language.
- It permits distribution of one's work to all who should have access to it.
- It provides a foundation for future updating or as a reference if further work is required.
- Since people do leave organizations for one reason or another, a report prevents the loss of valuable conclusions.

Your report should contain your selection of those areas that have the most exploratory merit in order of importance together with brief statements to justify that selection. Assuming that your study indicates the merit of detailed work in prime areas, what are your recommendations for exploration and refinement of those areas? What sequence should be followed, and

what costs would be incurred? What are the manpower and time requirements to refine prospects? Keep your readers in mind: they control the purse strings.

If your conclusions are negative, management is entitled to know why as are workers who follow you.

### Where and who

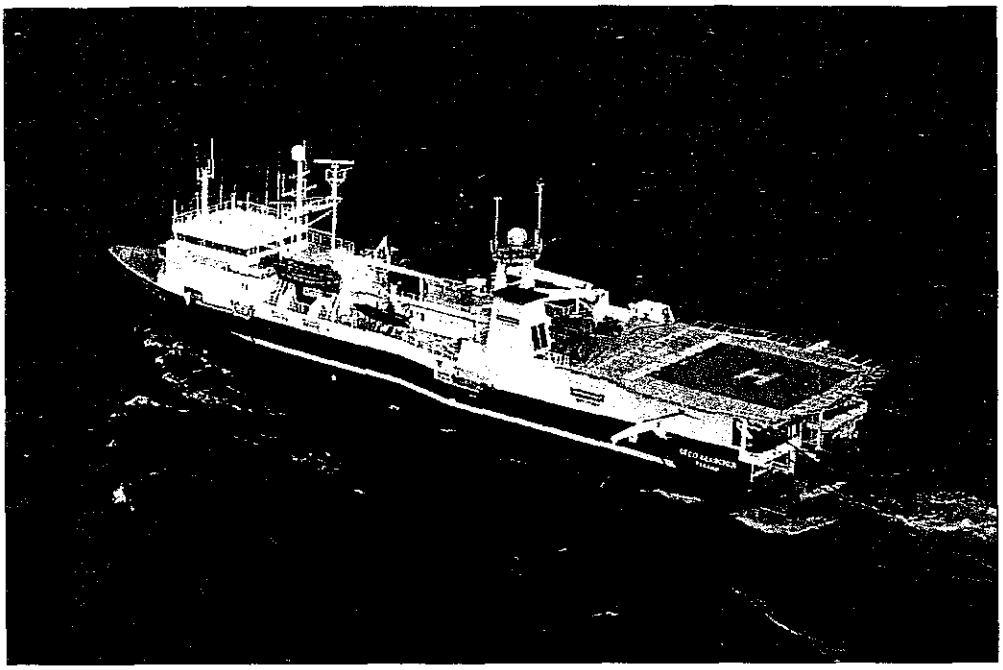
Regional evaluations are best done in offices or areas where the maximum geological and geophysical data are in-house or readily available and where the various disciplines needed are at hand.

Selection of personnel is important. Curiosity, imagination, and interest are necessary together with the ability to visualize rock sequences and events in three dimensions. The ability to coordinate information and to work with people representing other disciplines is vital. Everyone must be as close to being an expert in his field as possible.

Your regional explorationists should have experience in looking for drillable prospects so they can recognize potential areas outlined by the regional work.

Ideally, an explorationist needs a balance between training and exposure to several geological regimes. The geologist, for example, should have worked in several geological provinces, which will provide him with the knowledge of various parts of the geologic column and the structural and stratigraphic styles prevalent for several areas. He will have been exposed to different problems in these areas and their solutions. The exposure enhances an explorationist's "recognition factor."

On the other hand, management must do its part: show interest, need, and appreciation. When available, provide money both for the investigative program and to capitalize on the findings and recommendations. ▪



# Gulf marine seismic acquisition record claimed

*The Geco Searcher achieved what Schlumberger believes to be the highest survey rate attained in the Gulf of Mexico by a single vessel. The Geo-Prakla vessel acquired data over 1,000 sq km/month during 1997 as part of a nonexclusive proprietary survey. Ultimate coverage was 500 blocks. The vessel uses multistreamer towing technology that gives it an 800 m wide spread and a 4.8 sq km footprint. The in-sea equipment did not need retrieving for 6 months. Photo courtesy of Schlumberger.*

# Binger field due new operator, reservoir study

A $200,000 three dimensional reservoir study is planned in Oklahoma over East Binger Unit, the world's first commercially successful application of nitrogen injection pressure maintenance for enhanced oil recovery.

General agreement is that of 90-100 million bbl of oil in place in Pennsylvanian Marchand sand at about 10,000 ft, about 16% has been produced, says Cotton Valley Resources Corp., Dallas, which is acquiring Phillips Petroleum Co.'s interest in the unit.

Operating since the early 1980s, East Binger now produces about 1,000 b/d of sweet crude and 7 MMcfd of gas from 56 producing wells, state figures indicate. The unit, in Caddo County in the eastern Anadarko basin, has 25 injection wells and a 20 MMcfd cryogenic air separation plant.

The 3D reservoir simulation will be used to more closely estimate remaining reserves and optimize production the next 10-20 years.

Cotton Valley's current Binger reserves estimate is 1-2.5 million bbl of oil, gas, and natural gas liquids, net to the interest it is acquiring.

### Exchanging interests

Cotton Valley acquired oil and gas interests in the Zama Lake area of Alberta from Paramount Resources Ltd. and exchanged that property with Phillips for cash and a contract to purchase an interest in East Binger Unit.

Cotton Valley received the right to purchase for $4 million Phillips's 23.4% interest in the EOR project. It will also obtain all of Phillips's interest in the other shallower zones in about 3,000 net acres of leases Phillips contributed to the unit.

Cotton Valley would become unit operator. The deal is to close by May 31.

Cotton Valley also holds interests of 50-100% in Northeast Alden field in Caddo County, which produces oil from Bromide and gas from Arbuckle. ▪