The Future of Petroleum: Optimism, Pessimism, or Something Else?

By Ronald R. Charpentier

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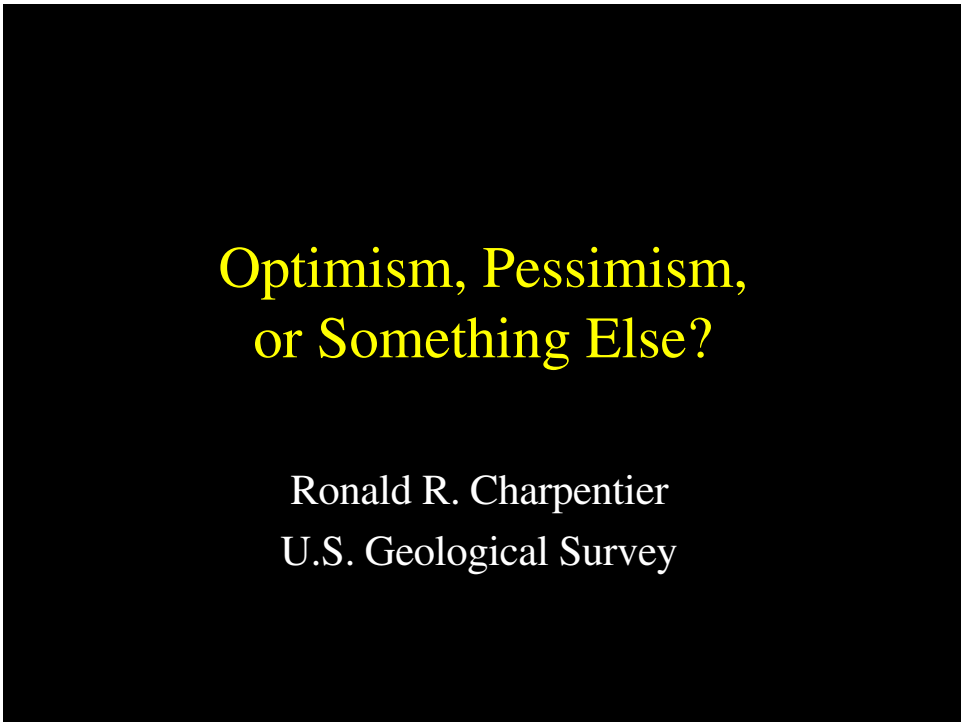
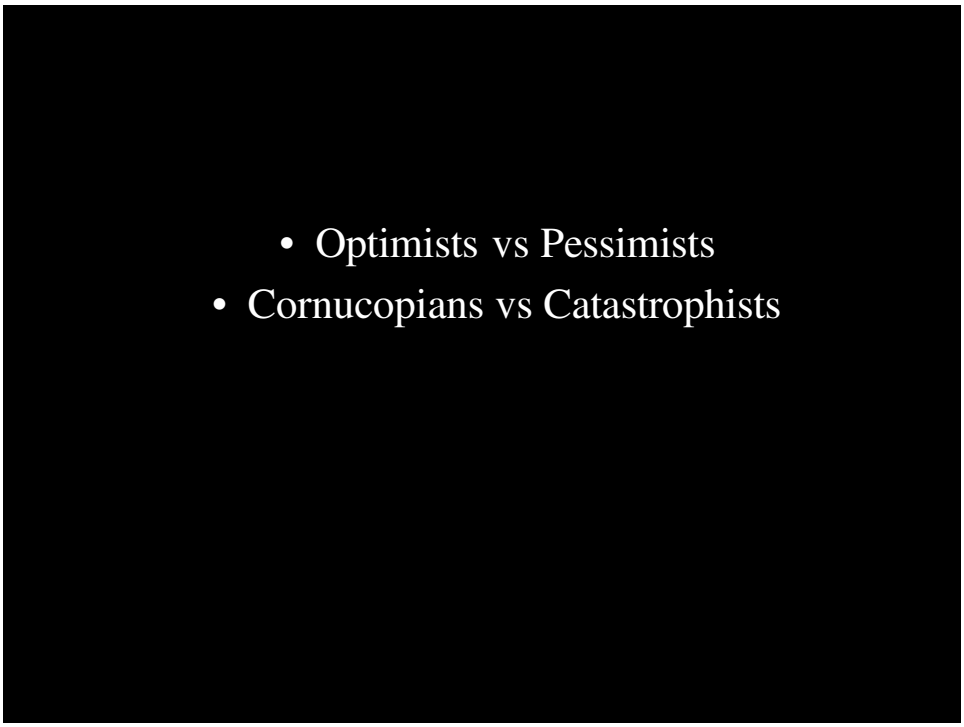
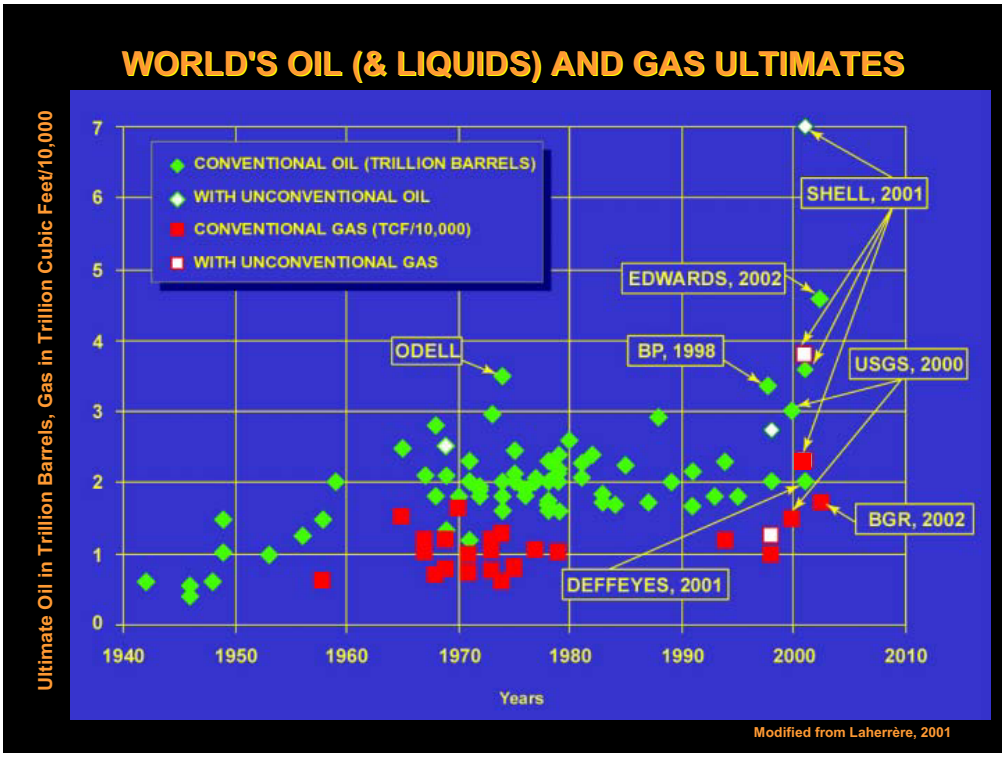


This report is derived from a presentation at a meeting of the Energy Modeling Forum at Stanford University on January 29, 2003. The figures are the slides presented on that occasion, with a few additions. A short text has been added to explain the slides and give additional comments.



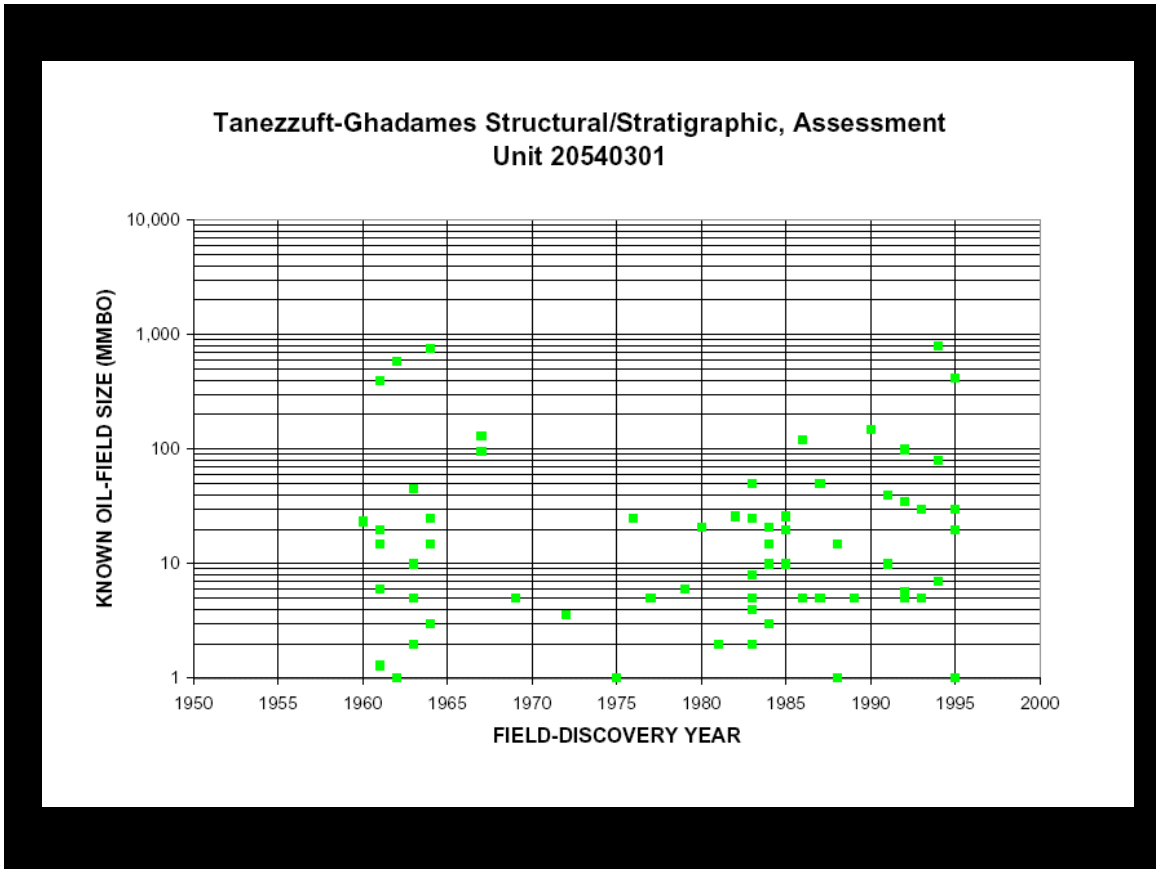
Much has been discussed about the future of oil, and to a lesser degree natural gas, in relation to world energy use. Two groups are often contrasted. These are known as the optimists and the pessimists, or sometimes as the cornucopians and the catastrophists. The term "Malthusians" is also sometimes used for the pessimists.



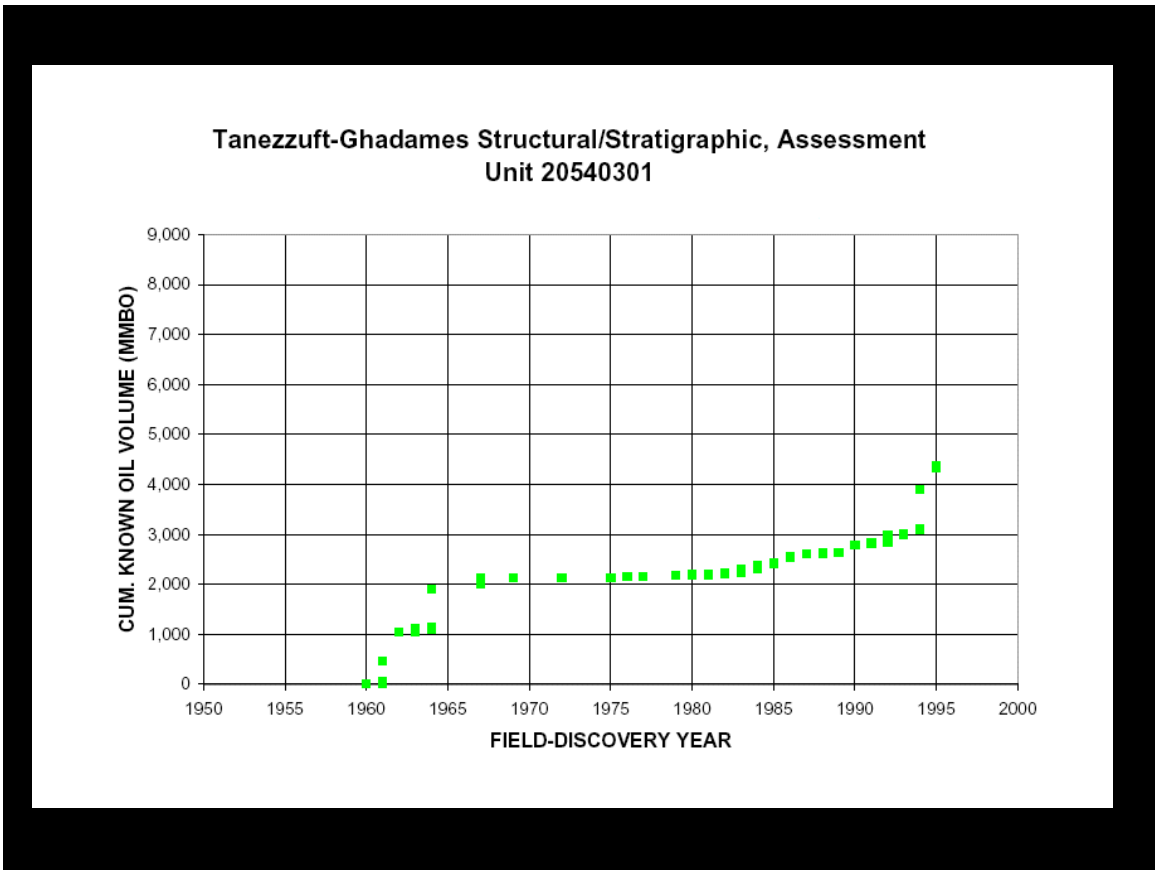
Estimates of resources of oil and gas range widely, but some groups that are considered optimists in some situations and by some people are considered pessimists in other situations and by others. As an example, the U.S. Geological Survey (USGS) is considered by some pessimists to be optimistic for its world-scale assessments, but as will be shown later, the USGS is considered by some optimists to be pessimistic for its assessments of gas in western Canada.

Perhaps a more fundamental difference among resource assessors, however, is what can be termed the non-trendologists versus the trendologists. "Trendology" is here considered to be the use of fairly simple statistical extrapolation without consideration of many complicating factors. Many prominent pessimists are trendologists, but that approach is by no means confined to pessimists.

The use of simple statistical extrapolation methods has the advantages of being easy, fast, and cheap. These extrapolation methods generally have modest data requirements and can be performed quickly by one or a few persons. More detailed geological assessments, on the other hand, have much larger data and effort requirements. The 1995 USGS assessment of U.S. petroleum resources (Gautier and others, 1995) and the 2000 USGS assessment of non-U.S. petroleum resources (U.S. Geological Survey World Energy Assessment Team, 2000) each required about 100 person-years of work over several years to complete. As many of the prominent trendologists are retired from industry or academia or both, these levels of effort are just not available to them.



The disadvantages of trendology are easily demonstrated, however. Consider the discovery history of part of the Trias-Ghadames basin of Algeria. If trendology had been used for an assessment in 1980, the assessment would have given little chance for undiscovered fields larger than 10 million barrels and the resulting estimate would have been low. The largest field in the assessment unit would have been missed.



A creaming curve based on the same data is also shown. The creaming curve levels off to about 2 billion barrels in the 1970's, but later data show that at least 2 billion addition barrels were subsequently discovered.

Trends

- Trends provide important information because the discovery process is not random
- Trends are generally controlled by several factors - but trendologists commonly use only one explanatory variable (like time)
  - Why should production necessarily decrease when 50% of the ultimate production has been reached?

Discovery trends, however, are a very useful part of resource assessment. The exploratory history for conventional oil and gas fields is non-random and that very non-randomness offers significant information that can be used in discovery process models. Trends in resource discovery are affected by many factors, and trends in production even more so. Trendologists, however, use simple models that assume that the controlling factors of trends can be represented by a single factor, such as time. The unstated assumption is that other factors are of minimal importance. As an example, Hubbert-type analyses of production generally assume that production declines when 50 percent of the resource has been produced, even though the actual production volumes are controlled by many complex factors of supply and demand.

Trends By Play

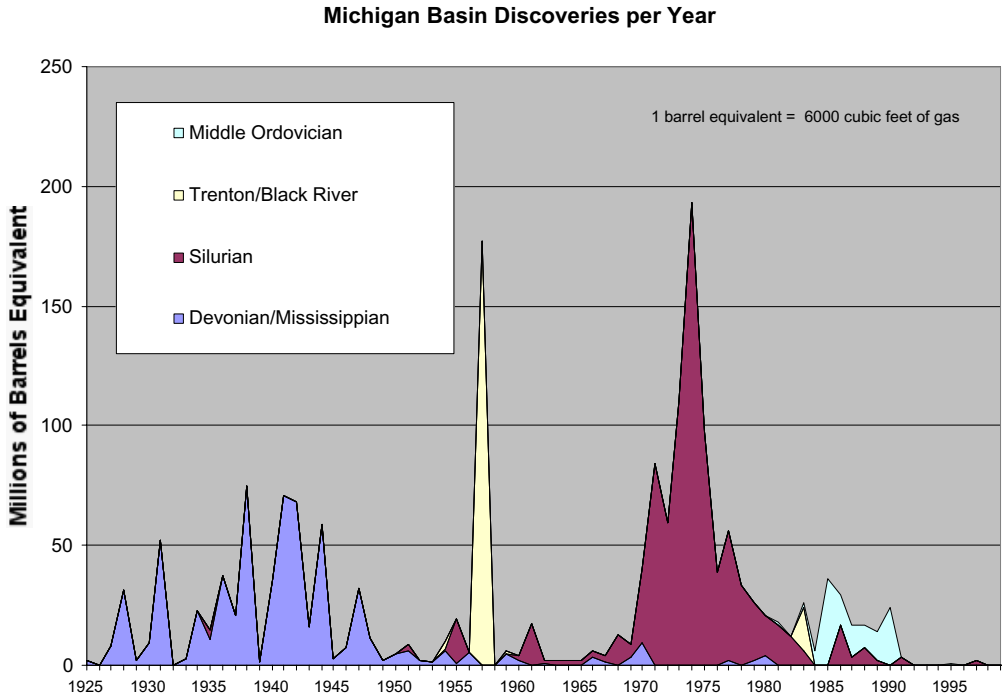
- Larger fields tend to be found earlier in the discovery history

  IF

  – No restrictions to exploration (technologic, leasing, economic, etc.)

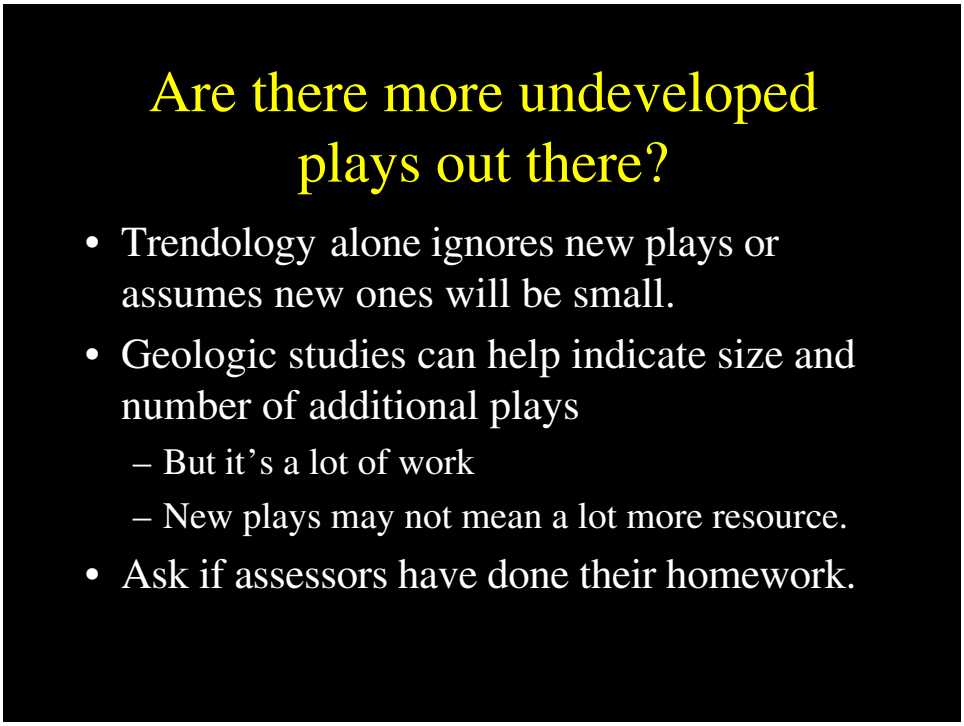
- Larger plays not always developed earlier
  – Often shallower, easier to develop plays first

The often-recognized trend of the larger fields generally being found first is a play-level trend. Arps and Roberts (1958), in their classic paper, showed that within a play the larger conventional fields tend to be found early, even if drilling is random. This can be complicated, however, where part of a play is left unexplored for political, technologic, or economic reasons.

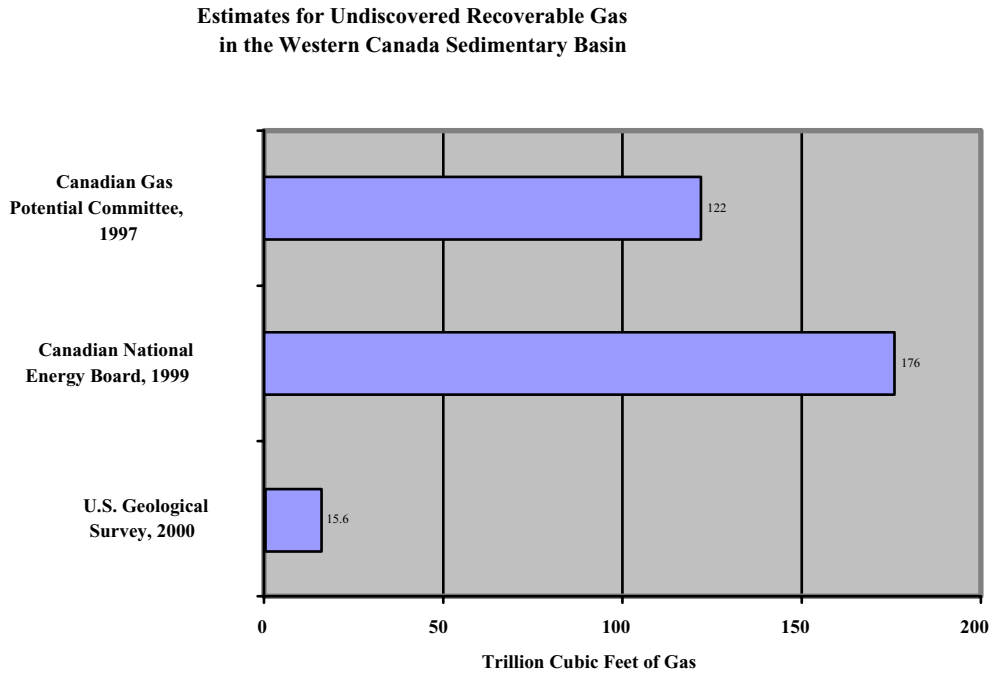


The finding of larger fields early in exploration is not necessarily true at scales other than the play level because larger plays are not necessarily developed earlier. The factors that tend to make larger fields within a play be found earlier do not make the larger plays be developed first. On the contrary, plays tend to be developed in order of ease of exploration and development—often those with shallow reservoirs or easily detectable structural traps are developed first. Some large plays may not be developed until technologic improvements can make them viable.

The Michigan basin shows a multi-cycle exploration history. Hubbert (1959) and LaHerrère (1999), both known for their work with single-cycle trends, recognized that multi-cycle histories existed. Even a rough division of the Michigan basin discoveries into four plays greatly improves the ability to interpret (and draw inference from) the discovery history.

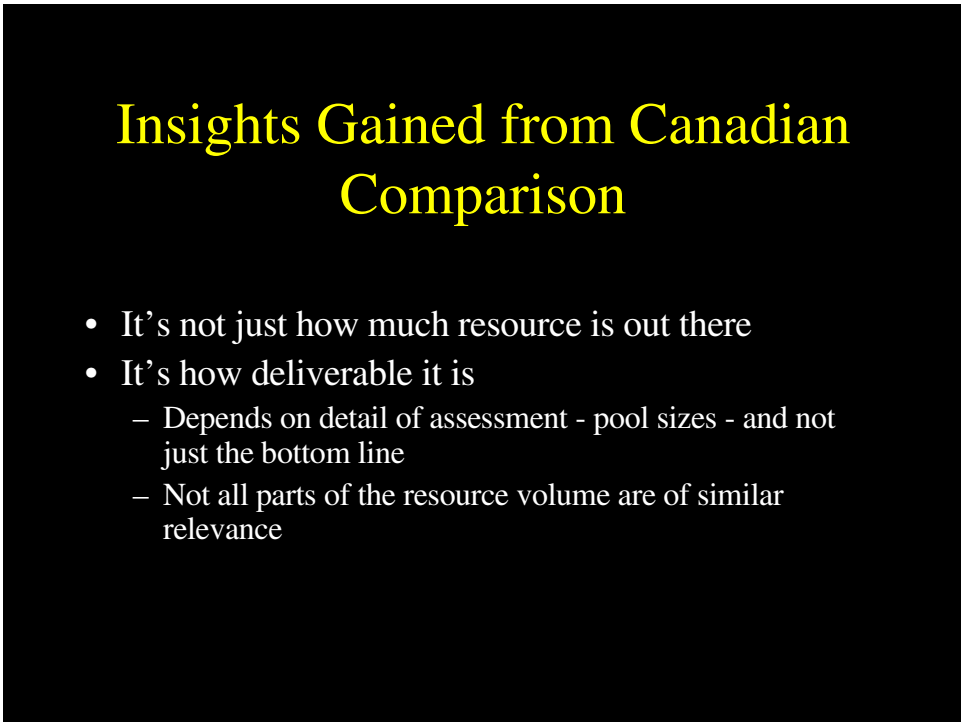


Assessing the resource potential for the Michigan basin requires answers to two major questions. First, is there more potential in the previously explored plays? Second, are there new undeveloped (or barely developed) plays? Trendology can perhaps answer part of the first question, but can provide little information for the second. Although discovery rates for previously explored plays can be extrapolated statistically, trendology alone cannot evaluate what restrictions to exploration have affected these trends. This is important in the Michigan basin because some of the play areas extend into undrilled offshore parts of the basin. The potential for new plays cannot be evaluated by statistics alone, but requires more detailed geologic evaluation, which requires considerably more effort. New plays, if they exist, may or may not be of large size. This cannot be evaluated from the basin's exploration history because, as the previous figure shows, the plays were not developed in order of size. It is important when evaluating the quality of assessments, to ask if the assessors have invested the required effort needed to address these questions.

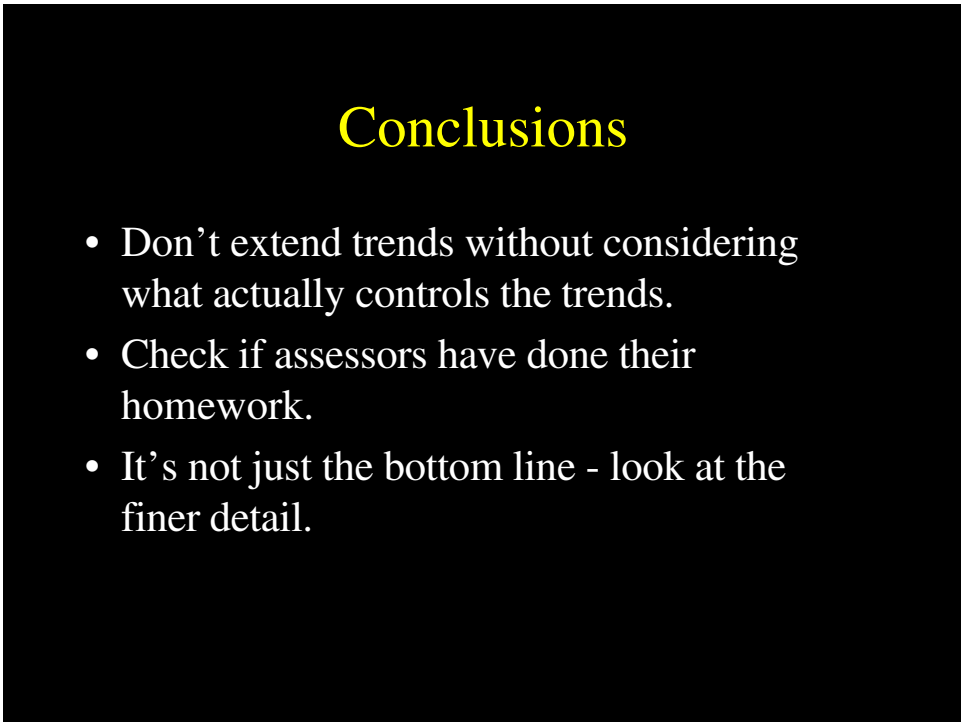


Some of the recent assessments of conventional natural gas potential in the Western Canada Sedimentary Basin range over an order of magnitude. This prompted a study of the reasons for such differences (Henry and Charpentier, 2001).

Most of the differences came from differences in the definition of what was actually assessed—the minimum pool size assessed, the definition of conventional, and whether pool growth was included or not. Methodological differences also seem to have had an effect.



The insight gained from the comparison of Western Canada Sedimentary Basin assessments emphasized that resource volumes alone (the "bottom line") do not give sufficient information to draw conclusions of societal relevance. For assessments to be useful they need appropriate detail, such as pool size, to allow understanding of how relevant various parts of those volumes may be to actual supply and on what time scales. This appropriate detail cannot be gained by merely extrapolating trends.



In conclusion, the debate between petroleum resource optimists and pessimists obscures a more fundamental difference in assessment between statistical extrapolation versus geological assessment that takes many more relevant factors into account. Assessors need to seriously consider the controls on those trends they extrapolate and whether other factors have serious effect on their results. Users of assessments need to keep the assessors honest by insisting that the assessors pay sufficient attention to such factors and document them. Finally, both assessors and users of assessments need to have a better appreciation that the utility comes from the fine detail of the assessments. It's not just the bottom line.

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