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Recent Estimates of U.S. Oil and Gas Resource Potential

by

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Recent Estimates of U.S. Oil and Gas Resources Potential

Recent estimates of oil and gas resource potential are, as you well know, many and varied. As you probably also are well aware, it is not enough just to know numbers, one must also have confidence in their derivation and know how to interpret them. I propose, therefore, to show you some of the many number sets that have been generated, to suggest to you that a reliable and credible consensus of U.S. resource potential on which to base certain elements of policy has evolved, to suggest ways of interpreting the assessments, and finally, to indicate new directions in resource estimation that seem appropriate. Because I want to emphasize more the principles of understanding and interpreting resource estimates, I shall focus my remarks on conventional oil. It so happens that the dimension of our gas resources is sufficiently similar to oil relative to a comparison with annual consumption, production, and rates of reserve addition that what I have to say about recent estimates of oil resource potential applies equally to gas.

Figure 1 shows a representative number of the modern and recent estimates of oil potential. One could choose more to examine; the point would be the same--that there is a general consensus centering around a mean assessment of 60-100 billion barrels of oil as yet undiscovered and awaiting the drill bit. These numbers, when compared to the fact that additions to reserves have been only at a rate of less than 2 billion barrels per year over the past 7 years, are reasonable indications that the present perception of the resource base is not limiting with respect to petroleum availability for at least the next 3-5 decades; rather the limiting factor is our rate of reserves additions.

Now let's explore in somewhat more depth the strength and significance of that statement. Taken by themselves, resource estimates are significant only if they are very low or very high. The former would call for some immediate remedial action; the latter would suggest that there may be more important problems to be concerned with. Numbers in the middle, however, which is the case in point, cannot be responded to just of themselves. One now needs to know the component parts of the assessment and the accessibility of the resource which calls for analyses using related data sets, such as rates of discovery, rates of production, production to reserve ratios, field-size distribution, and so forth.

But first, before comparing the assessment with related data sets, how is confidence established in an assessment? A resource assessment cannot divine truth; it can only, at best, express a systematic aggregation of the conventional wisdom. For it to be useful as an input to policy, it must be both reliable and credible. Without credibility it doesn't matter how reliable it is, because action will not be predicated on assessments that lack credibility. The reliability depends on 1) the estimator's ability to adequately organize and express the conventional wisdom and 2) the former assuming that, indeed, the conventional wisdom does reflect the factors that control petroleum occurrence. Its credibility depends on 1) the critics' perception as to the adequacy of the systematics of data manipulation in the assessment process and 2) the confidence in the data set. Through time, credibility will also be judged by accuracy of results or lack thereof, but the test of time may be a number of years in coming.

The reliability of the present estimates is perhaps best reflected in the consensus that has been achieved by the broad spectrum of people and groups that have attempted independently to synthesize the conventional wisdom. They include respected individuals and groups, both in and out of Government and in varied capacities within the private sector. To perceive reliability in their judgments, one assumes that the data set involved in this widespread activity is collectively as broad as it can be, and a preponderance of the conventional wisdom is thereby captured. As to the second factor, one can, of course, never be sure that he is basing his judgment on the right kinds of data; but there is some confidence now in defining the geologic fence that circumscribes petroleum occurrence, and there is enough regional geologic understanding to apply those constraints to most all basins. Geologic exploration has by and large been successful the world over. The odds are assessors know pretty well what they're looking for, and those data have been aggregated for the assessments.

Of course, there are still surprises in store; ever there will be, but even in the least explored basins we know enough to begin to make reliable judgments on the possible occurrence of giant fields which contain the bulk of all resources, and in the intensely explored areas, the data offer the additional potential to assess the smaller and deeper occurrences. We must accept that any resource assessment is likely wrong. The essence of its reliabilitv, however, should not be viewed as being just in the number; rather it is, as well, in the geologic synthesis of the conventional wisdom that permitted the number generation in the first place. Such a synthesis provides a norm of significant petroleum occurrence parameters that permits recognition of evidence of concurrence with or deviation from that norm at an early stage, which in turn permits timely incremental updates of resource assessments.

Herein I am trying to expand the concept of reliability to include not only the number assessment but as well the geologic synthesis; I am trying to emphasize that even though there is always an unknown, one can, nonetheless, make certain kinds of judgments with a relatively high degree of probability that are important to the assessment process. Let me give you some concrete examples. Prior to the drilling over the past couple of years in the Gulf of Alaska, it was possible to conclude that there was the potential for giant fields on some very large structures if good reservoir rock, which could not be predicted, were in fact encountered; however, the resource assessment of the area had to be downgraded based on data relative to the occurrence of reservoir rock that existed prior to drilling. Subsequent drilling in the area produced 10 dry holes sustaining the conservative assessment, but perhaps equally importantly the geologic synthesis may have been sustained. Much of the data in this area are still proprietary; but if, in fact, the tops of most of the good structures have been tested dry and the concerns relative to the porosity of the possible reservoir rock were confirmed, then the few exploratory holes drilled may be sufficient to be indicative of limited potential in the area (Oil and Gas Journal, Aug. 22, 1977). In another example in the northern Rocky Mountains province, we estimated, at the time of preparation of the 1975 USGS assessment (USGS Circular 725) the potential for 5-11 billion barrels of oil--a substantial number for a single province. Since that estimate, the overthrust belt, included within the province, has become the hottest exploration area in the United States. The fact that we had estimated a substantial amount of oil yet to be found in that province does not mean we predicted the apparent richness of the overthrust belt play. In fact we probably did not, but its discovery lends credibility to our overall assessment for the province. More importantly, however, we had a geologic synthesis of the area that permitted us to recognize, with minimal drilling, the significance of the discovery achievment and the potential for additional discovery. The policy value of this geologic understanding, of course, lies in the advisory role we play in the Executive Branch. The overall value of the assessment in the northern Rocky Mountains provides a broad land-use planning/exploration target. Its aggregation with numbers from other areas produces a number describing an aspect of the overall resource well-being of the Nation.

A resource assessment then should not be viewed just as a number, rather it is a base for understanding, and, as such, for maximum benefit, it must be monitored through time for concurrence with or deviations from the established norm; any program of resource assessment must be dynamic to be fully effective, and such programs are now in place and operational in both industry and Government.

The credibility of the present assessments can be judged by the range of methodologies utilized to arrive at what appears to be a consensus. Clearly, we cannot know the unknown, but confidence in a consensus is enhanced if the general agreement, as is demonstrated on this slide, is achieved by use of a variety of different methodologies. The published discussions and our own understanding of the methodologies used by others would indicate that this is so. The second element of credibility that I mentioned is confidence in the data set. This can only be achieved through publicly available data with attendant verification procedures. Not all assessments, of course, are accompanied by public data, and their crediblity and utility are thereby weakened. Owing to the industry origin of some of the estimates, these are limitations we must accept, but the limitations are at least in part mitigated by the stature of the estimators or the organizations they represent, both of which are substantial.

In spite of the fact that I say we are striving for, and indeed attaining, reliability and credibility in resource estimates, there are gnawing questions about the process and the numbers that appear in the various publication media: What is the effect of new technology? What is the effect of new land to explore? What is the effect of deeper drilling, which clearly provides an increment of new volume and exposes a new stratigraphy not previously explored? Finally, haven't people always underestimated undiscovered resources? All of the questions are valid. What must be understood, however, is that the exploration process is ongoing, and, on the part of the assessors, there are built-in expectations of evolutionary change. In other words, estimates anticipate a steady influx of new technology, new lands being supplied to the process, and deeper horizons being explored. What is anticipated, however, is continued evolution; most assessments do not anticipate revolution. As to the question of traditional under-estimates, one can only acknowledge that it is true when considered over the full history of the oil business. It is also true, however, that a lot more is known about oil occurrence and basin geology than was known in years past. Certainly, there will be suprises, but that is not a good basis for discounting present reasoned judgment.

Given a reliable and credible assessment with full recognition of all its frailities, how is it presented for maximum utility to the public policy maker and how might he interpret the numbers presented? A number of different systems obtain, and one must recognize the reason for his assessment if he is to present it for maximum utility. Clearly, a single classification cannot satisfy all needs. There are certain principles of classification, however, that we believe are significant and have endeavored to systematize our assessments along these lines. If we could just get everybody to agree with these principles, it would be a simpler world in which to live, but everyone must accept inconsistencies and, for purposes of comparison, normalize to some standard the existing estimates as best as possible. I can only urge you all to beware of resource assessment comparisons and to look carefully at their specific parameters--they are not all predicated on the same boundary conditions nor are they all prepared for the same purpose.

The existing Department of the Interior classification shown here (figure 2) shows on the vertical axis degrees of economic certainty and on the horizontal axis degrees of geologic assurance (USGS Circular 725). Both, of course, reflect elements of resource availability, but note that the assessments discussed earlier refer only to the undiscovered recoverable portion of this diagram. Though the numbers shown are dated, we have no reason to believe that we would introduce significant changes at this stage. An assessment process is underway, however, to update these results within the coming year, and the results will be published, similarly, in a Geological Survey Circular.

Now let's look at some of the numbers critically. The numbers in the upper left-hand corner refer to the proved reserve in 1974; the presently available proved reserves are approximately 30 BBO. The diagram should be read with an understanding that national annual production is about 3 BBO/yr. Given that, on the average, a production to reserve ratio greater than 1:10 is not likely, production is at a reasonable maximum today. This means that the Nation does not have the capability to produce all of its demand (that is 6 BBO/yr) for 5 years; rather these data indicate a capability of supplying approximately one-half of our demand, that is 3 BBO/yr, but just at this point in time.

To maintain that level of production, we must maintain a reserve level equal to 10 times the production, which calls for an annual addition to reserves equal to the rate of production, or 3 BBO/yr. To accomplish this there are two sources of new reserves--the one reflected on the horizontal axis of the classification and the other reflected on the vertical axis. Additions to reserves from the former involve the discovery process either in terms of field extensions (the inferred) or new discoveries (the undiscovered). Additions to reserves from the latter involve improvements in the recovery process from already discovered reservoirs. How well we are doing gives a dimension of meaning to the resource assessment and is reported annually by the American Petroleum Institute (and the American Gas Association) as "additions and revisions to reserves." The fact of the matter is, we are doing only barely well enough--barely well enough, that is, to sustain an annual production of 3 BBO. (This, let me repeat again, is only 1/2 our annual consumption.) Considering an average over the past 10 years, we have added to our reserves at the necessary rate of about 3 BBO/yr (reserve data from API annual blue book), but that period includes the Prudhoe Bay discovery. Discounting Prudhoe Bay, however--a unique and seldom equalled event--and considering only the past 7 years from 1971 to 1977, the rate of reserves addition has been only about 1-3/4 BBO/yr. This means that to maintain the present rate of annual production, considering the record of the past 7 years, we must increase the rate of reserves addition by more than 50 percent.

To actually increase production, and thereby have the potential to reduce imports, is even more difficult by an order of magnitude. Every barrel of increased production requires 10 barrels of reserves additions because of the physical constraints of reservoirs that limit production to approximately a 1:10 production to reserve ratio. The essence of this realization is that an increase in annual production by as much as 1 BBO (i.e., from 3 BBO/yr to 4 BBO/yr) over a period of say 10 years would require a doubling of the present rate of reserves additions. Considering the already high level of activity of industry, there is little likelihood that such a doubling is possible--the 50 percent increase necessary to stay even will be a prodigious task.

Whatever the future is to hold, a strategy must be designed to attempt to achieve the desired results, and these resource numbers record some aspects of the target. The quick oil is likely to be found in incremental additions to the already existing reserves (that is, the Inferred), but we cannot live off the past forever. The big oil and the oil to sustain our appetites must come from the discovery of giant fields (that is, fields greater than 100 MBO in ultimate recovery); some of the potential for these is included but not specifically identified in the assessment of Undiscovered Resources. Another source of oil lies in improved recovery technology but it will be an expensive option. An NPC report (Haynes, 1976) has suggested the possibility of recovering as much as 25 BBO at $25/bbl. The target is big. Further, it represents a quantity of oil over and above the 60-100 BBO cited in the consensus assessment of the undiscovered resources and, in that sense, is a hedge against the possibility that undiscovered resources were overestimated. Certainly, through the years our national well-being has prospered from, and we have come to expect, solutions from innovative technology.

The point of this discussion is to express to you some ways of analyzing and utilizing the consensus resource estimates that have been developed by the petroleum community, both private and public. Being so presented, as on this diagram, one can even gain concepts of the length of time necessary to effect change deriving from a given policy direction. For example, one can know that the leadtime for expanding existing reserves (i.e., the Inferred Reserve) is relatively short--say, less than 2 years, whereas the leadtime for discovering and producing remote-area giant fields or improving overall recoverability will be relatively long--say 5 to 20 years. Resource assessments are not designed for precision, rather they are designed to offer guidance--to provide targets. From these, it might be desirable to design a strategy to encourage the discovery of big oil; it would differ from one designed to improve recovery potential. Both add to reserves, but in so doing they produce products that contribute uniquely to the overall resource assessment and to interpretations from it. Remember also that I have focused my remarks only on conventional oil. The issues are far more complex and the options greater when one considers the alternative sources of supply potential found in unconventional sources of petroleum, such as heavy oil, tar sands, tight gas sands, shale gas, or geopressured methane. The options are many--they are all, however, fraught with uncertainty, and to date, in spite of all the pretenders, clearly, no front-running saviour has emerged.

The status of energy is, and will remain, literally fluid for the foreseeable future. Throughout this period of fluidity in resource understanding and policy evolution, it is vital for those involved in resource work to keep a full spectrum of reliable and credible numbers, with their attendant related data sets, and geological and engineering possibilities in front of the decisionmakers, be they industry or Government. This is so because it is important to base policy not only on present production capacity but, as well, on reasoned judgments as to the capability to sustain whatever rates of production.

The realization that resources in their various geologic forms make unique contributions to the Nation's resource well-being, calls for new dimensions in resource assessment and presentation that have not, as yet, been addressed fully. Two such dimensions involve the delineation of the potential for giant fields and the identification of large low-grade, or remote or difficult-to-extract, resources. Giant fields account for 80 percent of the reserves and 60 percent of the annual production. The potential for their discovery is obviously important to an understanding of undiscovered resources, and a substantial effort must be so directed. In accepting this kind of role, the resource estimator

must expand his intellectual horizons to the maximum. He must think in terms of principles of oil occurrence and apply them to the geology of each basin. He cannot just extrapolate from the conventional wisdom. Having encouraged an expansion of intellectual horizons, I find in our own system a built-in classification limit of 5 percent probability on the high side of the assessment, which certainly does not accommodate the "outrageous hypothesis" which may include one or more of the elusive giants. As I said earlier, however, classifications are designed for different purposes. In this case, we were trying to express a reasonable range of probabilities of the occurrence of undiscovered recoverable oil, i.e., 95 percent to 5 percent, for purposes of national policy development. By noting the 5 percent probability limitation, we imply the existence of lower probability resources.

If that lower probability does, in fact, represent the probability of occurrence of some potential giant fields, then we must determine rational means for their recognition and a suitable display of their potential for special aspects of policy guidance. Programs to meet these needs include, among others, the pioneering and ongoing work of scientists in world-basin classification and its relation to giant-field accumulation (Halbouty, 1970). And, in the data acquisition sense, a significant potential program development envisions the use of the Glomar Explorer to develop giant-field resource understanding of our deep-water continental margins. I'm not trying to sell program, I'm only suggesting kinds of activities ongoing and being considered in the search for giants.

The low-grade or difficult-to-extract resources present a special problem in that what one actually wants to know about a resource number is its significance relative to rate-of-productivity. By definition, a resource must be potentially economically extractable. Such an understanding requires a concept of rate, but for so-called unconventionals nobody knows what that rate is. One of the assessment problems lies in determining how best to compare and combine, in a resource sense, heavy oils that may have a production to reserve ratio of 1:50 with a conventional oil field at a ratio of 1:10. Resource estimators clearly must expand their involvement with engineers to help assess the potential rates of recovery of all resources. For the time being, most assessors, including the Geological Survey, treat conventional and unconventional oil separately, relying on the analyst not to ignore the existence of the latter and to apply his own concepts of rates of discovery to whatever unconventional assessment. You all are familiar with the very high assessments that have been published for tight gas sands, or for geopressured methane, or for enhanced oil recovery. In analyzing their potential, one must consider not only the probability of occurrence but as well consider the probable greatly lowered production to reserve ratio.

In summary, I suggest that recent reliable and credible estimates of U.S. oil and gas resource potential have steadied at a level indicating that resource potential is not a limiting factor in sustaining the present rate of production over the next 3-5 decades; the rate of reserves additions, however, may be. Further, it seems unlikely that annual rates of reserves addition will achieve a level sufficient to significantly increase our present rate of production; we will be fortunate indeed to maintain that rate of production. In presenting this analysis, I have also suggested to you that for maximum utility a resource assessment should be viewed from many perspectives. Some components of the resource are suitable for providing short-term productivity, other parts for sustained long-term production. The latter includes the giant fields which we must learn to delineate in our assessment and to discover if we expect to sustain our present productivity. And, finally, I caution that so-called unconventionals must be viewed differently from conventionals because of their possible vastly different production to reserve ratios. In essence, resource estimates suggest that there are many options, but in the selection of options, clearly there are many difficult problems, the solution of which will require the wisdom of Solomon both in the market place and in the political arena.

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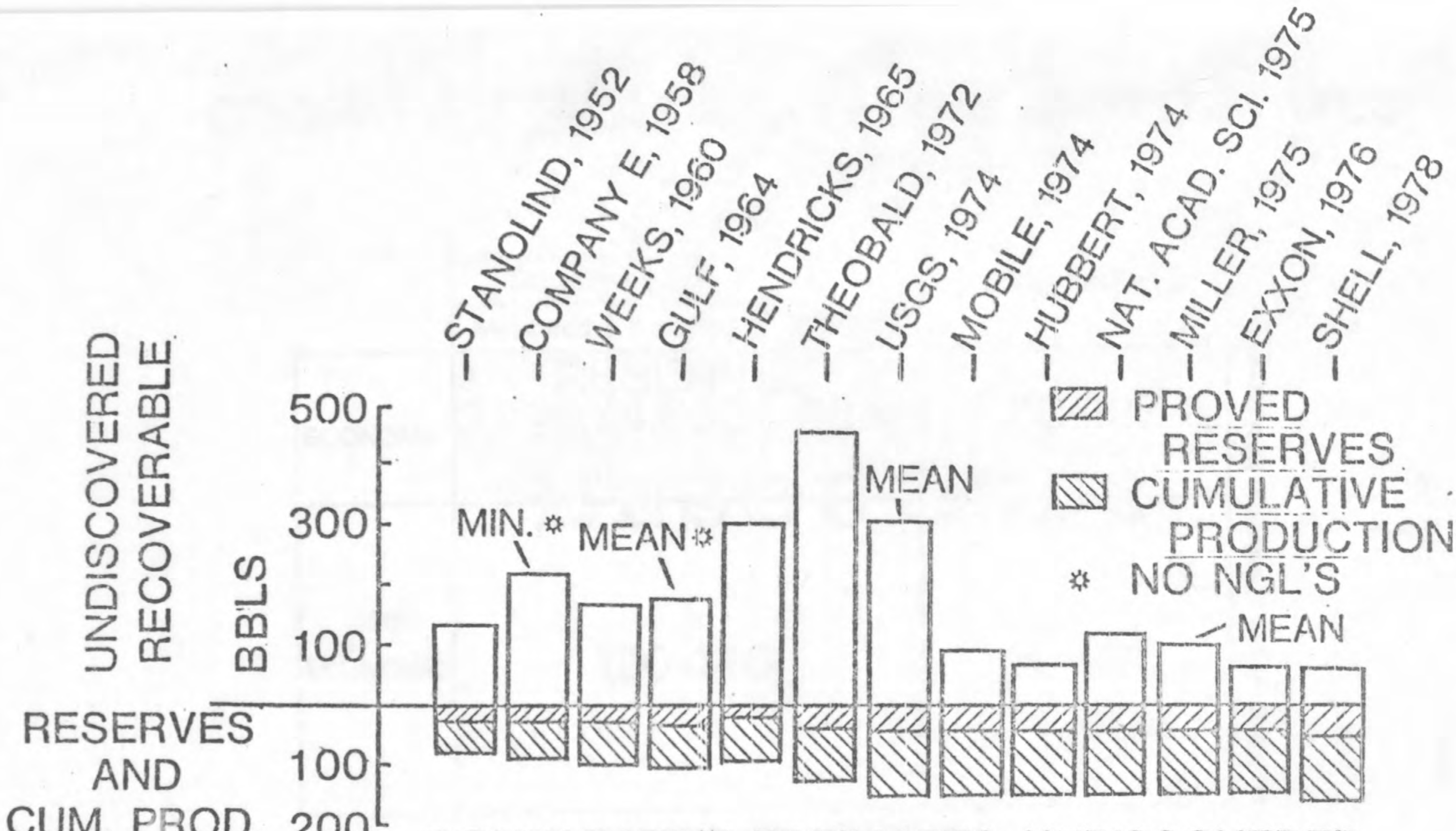
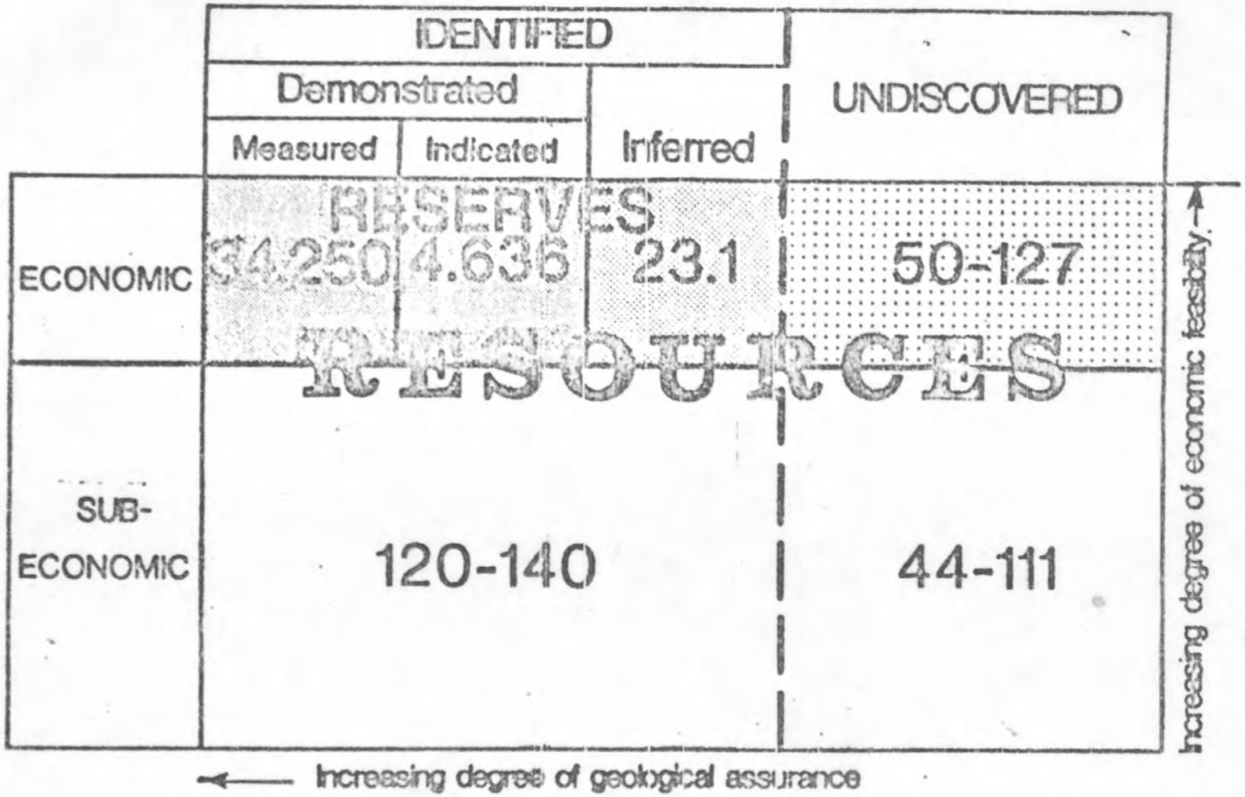


COMPARATIVE ESTIMATES, UNDISCOVERED RECOVERABLE RESOURCES OF CRUDE OIL AND NGL's AS OF DATE OF ESTIMATE

Fig. I

CRUDE OIL RESOURCES OF THE UNITED STATES
(BILLION BARRELS)



Total U.S. Cumulative Oil Production 106 Billion Barrels
12/31/74

Fig. 2