of the individual actions that supposedly had occurred in the responsiveness project. While I did not believe that anything inappropriate had actually occurred, I felt that the exaggerated tone of the report . . . could cause someone not familiar with the general staff practice of exaggerated writing to think that inappropriate activities were being carried on.

Malek by that time had moved out of the White House to work with the campaign directly, but his successor, Dan Kingsley, had Herringer's files on the responsiveness program collected. "It appears that all responsiveness documents collected by Kingsley were burned or otherwise destroyed because of their politically sensitive nature," concludes the report.

It was not the Watergate committee's job to try cases of alleged criminal activity or to charge anyone with such crimes. Hence the draft report does not pass judgment on whether any of the responsiveness activities were in fact illegal. But the report's conclusion comes down hard on the program.

It notes that the conspiratorial, secret nature of all the "eyes only" memos and injunctions not to write things down could constitute a conspiracy to defraud the United States which is punishable under Title 18 of the U.S. Code. As for the meetings with "friendlies" and government officials and talk of possible appointments, grants, or contracts, these could violate another part of Title 18 which bars a government employee from using "his official authority for the purpose of interfering with, or affecting, the nomination or election of any candidate for the office of President. . . ." Still other parts of Title 18 are cited, and the draft Watergate report concludes, "The conduct planned and engaged in . . . not only contravenes the fundamental notions that our nation's citizens are entitled to equal treatment under the laws and that federal awards supported by taxpayers funds should be allotted solely on the basis of merit and need, but also appears to violate numerous federal civil and criminal laws."

—DEBORAH SHAPLEY

Oil and Gas Resources: Did USGS Gush Too High?

If the U.S. Geological Survey is right, the United States is at least a decade away from seriously depleting its domestic oil and gas resources. But if several distinguished disbelievers of the Geological Survey are right, the United States is running out of oil and gas right now.

In a dispute that a committee of the National Academy of Sciences is trying to mediate, the Survey is striving to defend its oil and gas estimates and protect its century-old reputation as the nation's most authoritative mapper and measurer of natural resources. A lot more than the reputation of a government agency hangs in the balance, though. If the critics—who include top exploration authorities in two major oil companies and one of the Survey's own resource experts—are right, the outlook for increased domestic oil production based on new discoveries is dim, and President Nixon's Project Independence could be in deep trouble.

The controversy does not involve "proved reserves"—the amounts of oil and gas the industry knows it has found and can produce at current prices. At issue instead are estimates of the "unknowns"—the undiscovered oil and gas that may eventually be found and produced.

Both sides in the controversy think there is still a great deal of oil and gas left in the ground. The question is whether these resources are plentiful enough for the economists' rule of price-supply elasticity to operate—for prices to drive up production significantly—or whether the United States is already bumping up against the physical limits of rapidly diminishing fossil fuel resources.

Among those challenging the Survey's resource estimates is John D. Moody, the Mobil Oil Corporation's senior vice president for exploration and producing. Moody says that Mobil researchers have calculated national oil and gas resources by three different methods, all of which lead to the conclusion that the Geological Survey's estimates are far too high. On the strength of Mobil's research, Moody contends that the United States has already dug so deeply into its petroleum and gas resources that the industry will be lucky to maintain oil production at its present level of 8.9 million barrels a day. This is 375,000 barrels a day behind the U.S. output at the same time last year.

As for the possibility of increasing production enough to reduce reliance on foreign oil, Moody says, "There's just no way. . . . We're going to have to conserve wherever we can, and make the necessary political accommodations with the producing countries."

If his attitude seems uncharacteristically pessimistic for an oilman, Moody says it's simply realism. Moreover, in a day-long meeting organized on 5 June by the Academy's Committee on Mineral Resources and Environment (of which Moody is a member), two other well-respected researchers presented the results of their own independent studies that appear to corroborate Mobil's conclusions.

The two researchers were Richard Jodry, a senior scientist with the Sun Oil Company, and M. King Hubbert, a former president of the Geological Society of America and a research geophysicist with the Geological Survey. For more than a decade, Hubbert has maintained that the Survey's oil and gas estimates were erroneously high, and he now appears to have gained influential support.

In addition, Hubbert believes that he has found a crucial error in the Survey's method of estimation that could account for the differences currently in contention; Moody and Jodry think Hubbert is right.

The Survey, for its part, is standing by its numbers, but is leaving open the possibility that it might revise them later this year. In an interview, Vincent E. McKelvey, the USGS director, said that from what he understands of Mobil's method of analysis, its results may not fully account for many small reservoirs of oil and gas. As for the error alleged by Hubbert, McKelvey says he's "mulling it over."

Table 1.

Location	Undiscovered recoverable oil and natural gas liquids (billions of barrels)			Undiscovered recoverable natural gas (trillions of cubic feet)		
	Mobil expected value	USGS		Mobil expected value	USGS	
		Low	High		Low	High
		Onshore				
Alaska	21	25	50	104	105	210
Lower 48 states	13	110	220	65	500	1000
Subtotal onshore	34	135	270	169	605	1210
		Offshore				
Atlantic	6	10	20	31	55	110
Alaska	20	30	60	105	170	340
Gulf of Mexico	14	20	40	69	160	320
Pacific Coast	14	5	10	69	10	20
Subtotal offshore	54	64	130	274	395	790
Total United States	88	200	400	443	1000	2000

Mobil estimates include water depths to 6000 feet, whereas USGS now stops at 660 feet. Mobil's numbers represent the median value of a probability distribution. For instance, there is a 90 percent that total U.S. oil is greater than 50 billion barrels and less than 150 billion; the expected value is 88 billion.

Estimates of ultimate resources have always been inherently vague and subject to argument, especially when they involved areas like the continental shelves where very little drilling has been done. The vagueness, moreover, has been compounded by a tangle of terminology and conflicting assumptions that make comparisons among estimates a bookkeeper's nightmare.

One indisputable feature of oil and gas figures, however, is that, for the past 10 years, the Geological Survey's have been head and shoulders higher than almost everyone else's.

According to the Survey's latest estimates, published on 26 March, somewhere between 200 billion and 400 billion barrels of oil and between 1000 trillion and 2000 trillion cubic feet of natural gas remain to be found and recovered in Alaska and the lower 48 states and along continental shelves. (By comparison, the United States has produced about 115 billion barrels of oil and 437 trillion cubic feet of gas since the 1860's.)

The new oil figures represent a substantial drop from the Survey's 1972 prediction that about 477 billion barrels would eventually be found and recovered; much of the difference resulted from a nearly 50 percent reduction in estimates of offshore oil.

Still, Survey officials are convinced that, with record prices driving an exploration boom, these vast resources should permit a rise in domestic production that will take the nation a substantial stride toward self-sufficiency in energy—unless the oil and gas left in the ground is not so vastly plentiful as the Survey thinks it is.

In a 29 March letter to McKelvey, Moody said his company's best estimate was that about 88 billion barrels of oil and 443 trillion cubic feet of natural gas remained to be produced from the whole of the United States, onshore and offshore to a water depth of 6000 feet. Oddly enough, the greatest discrepancies occurred where they might have been least expected: onshore in the lower 48 states. More than 2 million wells have been drilled in the conterminous states in the past 100 years, making this region one of the most thoroughly explored on earth. Yet here, Mobil predicted less than a tenth of the oil and gas that the Survey estimated to exist. Moody said the higher figures were "inconceivable."

How to account for such huge disparities? The answer must lie in the methods used. Either some are right and some are wrong, or not everyone is measuring the same thing. The Survey, for its part, thinks Mobil's method is perfectly natural for an oil company but inappropriate for measuring the entire resource base. And the Survey's critics think its approach uses erroneous assumptions.

Mobil's technique employs an elaborate computer program to combine the geologic and production characteristics of known (and possible) oil and gas reservoirs with the instincts of Mobil's explorationists in the field. The result is a series of "probability profiles" that project the output of known and suspected deposits in each of the nation's 14 oil provinces.

One drawback of the system is that someone, somewhere in the company, must at least conceive of a "play" or prospect of oil before it enters the calculations. But Moody says the technique is "as sophisticated as we know how to make it" and that it covers all U.S. territory, onshore and offshore.

McKelvey and other Survey experts are convinced, however, that Mobil's method must inevitably reflect the major oil companies' tendency to look for giant oil-bearing structures—like the one at Prudhoe Bay on Alaska's North Slope—while giving short shrift to small and scattered deposits that could add up to a lot of oil. Many geologists, McKelvey among them, firmly believe that immense volumes of oil are hidden in small and subtle "stratigraphic traps," sandwiched between otherwise undistinguished layers of impervious rock. "Our best hope," McKelvey says, is that improved seismic detection technology will soon begin finding these elusive traps.

Others in the Survey are less diplomatic about Mobil's method. One resource expert describes it as "computer frosting on subjective judgment. It's the old situation of garbage in and garbage out."

The Geological Survey arrives at its petroleum estimates in a simpler way, requiring nothing more sophisticated than a geologic map of the country and an adding machine.

The technique was first advanced in about 1960 by a Survey researcher named A. D. Zapp. Frustrated by resource estimates that invariably turned out to be ultraconservative (in 1918, for instance, the Survey said the U.S. was on the threshold of running out of oil), Zapp sought a method that broke away from the old practice of extrapolating from proved reserves, the size of which had as much to do with economics as geology.

Zapp's new method led him to the conclusion that, since only 20 percent of the nation's sedimentary rock on and off shore had been thoroughly explored, 80 percent of the recoverable oil resource (or more than 460 billion barrels) remained to be discovered. Except for minor refinements this was the official position of the USGS—and, by implication, the government as a whole—from 1961 to this year.

Zapp's reasoning went like this: Thick sedimentary rock covers 1.86 million square miles of land and nearshore seabed. To explore this area thoroughly, if not completely, would require one well drilled to an average

depth of 6000 feet every 2 square miles, for a total of 5 billion feet of exploratory drilling.

By the late 1950's, cumulative exploratory drilling added up to just under 1 billion feet or 20 percent of the necessary total, leaving 80 percent of the rock to be explored—and the same proportion of oil to be found.

With all that oil, Zapp wrote in 1962, shortly before his death, the size of the resource would not limit domestic production capacity "in the next 10 to 20 years at least, and probably [not] for a much longer time."

It is hard to tell just how this optimistic forecast affected federal energy policy during the 1960's. It may have contributed to Federal Power Commission decisions to hold down the price of natural gas, a contributing factor to the present shortage. A 1968 energy policy report by the Interior Department* noted that if the Survey's oil and gas estimates turned out to be too low "we certainly should know about it in time to decide intelligently among the available alternatives."

The report went on, however, to indicate that the Survey's estimates were probably valid. On the other hand, Harry Perry, a Washington energy analyst with long experience in the Interior Department, say the Survey's predictions were generally taken with a grain of salt. "I don't know anyone who used these estimates for planning public policy," Perry says.

They were, in any case, promptly questioned by Hubbert. Writing in a report on national energy resources produced by the Academy in 1962, Hubbert pointed out that Zapp's approach implied that oil had been, and would continue to be, found at a uniform rate per foot of drilling. In fact, "finding rates" had fallen sharply since the late 1930's as oilmen skimmed the cream off the prospects in Texas, Oklahoma, and California. From a high of 276 barrels per foot of exploratory drilling, discoveries have fallen to about 35 barrels per foot by 1965 and to 30 in 1972.

Not until 1965, however, did the Survey concede Hubbert's point. That year, the USGS noted a "definite decline" in discoveries and postulated now that oil would, on the average, prove to be only half—not equally—as abundant in unexplored rock as in explored rock. Now this number is in contention, with Hubbert claiming that it's at least five times too large for onshore terrain. McKelvey acknowledges that the figure of one-half was largely a "subjective judgment" and another official describes it as "mostly a guess."

Hubbert is a man to be reckoned with. One of the Survey's more venerable researchers, he was among the crews that pioneered seismic technology in the Texas oil fields in the late 1920's. Since the late 1940's Hubbert has been refining his own novel technique for estimating oil and gas resources, and along the way he has acquired a reputation as something of an oracle.

In the long run, Hubbert reasons, the oil industry's growth and inevitable decline must follow a roughly bell-shaped curve dictated by a finite resource—first an exponential rise slowing to a peak, then an exponential decline tailing off to zero. The area under the curve would represent total U.S. oil production. Using past records of discovery, reserve growth, and production, Hubbert says that this total will be about 190 billion barrels (of which 143 billion have already been found).

In 1956 this conclusion led Hubbert to a prediction that was almost universally considered outrageous at the time: U.S. oil production, he said, would reach its peak between 1966 to 1971. Perhaps by coincidence and perhaps not, domestic oil production peaked in November 1970 and has slowly declined ever since. Hubbert has also predicted that natural gas production will peak this year or next.

No one disputes that the petroleum industry must inevitably follow some sort of growth-and-decline curve. Says McKelvey, "Hubbert can't possibly be wrong. In time we will reach a peak and start to decline. The question is when."

Hubbert says it happened 3½ years ago, and the Survey's numbers imply a peak sometime around 1985. The pessimistic view reinforces the oil industry's argument for accelerating offshore leasing. But, as energy policy analyst S. David Freeman notes, it also undercuts industry's case for still higher oil prices.

Whoever is right, the implications for energy policy beyond the mid-1980's are the same. The nation will urgently need dependable replacements for oil and gas. In the shorter term, Harry Perry observes, "The difference is whether the next 10 years will be tough or not."

It's possible, of course, to increase production by improving recovery tech-

* *United States Petroleum Through 1980* (U.S. Department of the Interior, 1968).

NEWS & NOTES

● **PROFS EARN MORE, GROW POORER**: According to a survey carried out by the American Association of University Professors (AAUP), in 1973–1974 for the first time in 16 years college and university professors have lost ground economically. Although the faculty members received compensation increases of slightly less than 6 percent, their real purchasing power eroded by about 1.5 percent. Inflation is said to be the cause of it all. Since the rate of inflation is rising, the economic outlook for faculty members next year is definitely not promising. Copies of "The Annual Report on the Economic Status of the Profession, 1973–74" may be obtained for $2 in early July from Ms. Maryse Eymonerie, AAUP, 1 Dupont Circle, Suite 500, Washington, D.C. 20036.

● **KUDOS FOR ECOLOGISTS**: The first John and Alice Tyler Ecology Award was presented to three scientists this year. The recipients, each receiving an honorarium of $50,000, were G. Evelyn Hutchinson, professor emeritus of zoology at Yale University; Arie Jan Haagen-Smit, professor emeritus of bio-organic chemistry at the California Institute of Technology; and Maurice F. Strong, director of the United Nations Environment Program in Nairobi, Kenya. The award, established by John and Alice Tyler as a result of their avid interest in ecology, will be administered annually by Peperdine University in California. In the future, it is expected that the $150,000 award may be presented to a single recipient.

● **PHYSICAL PHANTASMAGORIA**: Geophysicists in search of new worlds to conquer might do worse than to scan the pages of *Strange Phenomena*, a compilation of unexplained natural events such as the green ray, the Brocken specter, the luminous portents of earthquakes, Barisal guns, and mistpouffers. Apart from brief introductions, the contents consist of original descriptions, many of them drawn from scientific journals such as *Nature*. The compiler, William R. Corliss, is a physicist turned free-lance writer who chose the descriptions on the basis of their strangeness and "their tendency to contradict current scientific hypotheses or stretch them beyond their present bounds." The book is available from Corliss, P.O. Box 107, Glen Arm, Maryland 21057 at $6.95.

niques and by drawing down reserves. Much of the new drilling since last fall, in fact, seems aimed at the latter goal, rather than at extending known fields or finding new ones.

But the United States is down to about a 9-year reserve, whereas the industry has traditionally regarded a 12-year cushion as a rock-bottom minimum. Unless reserves are to be allowed to shrink further, the production rate will have to be keyed to the discovery of new oil, and that means reversing a 19-year slump in discoveries.

The possibility of an undersea Saudi Arabia off the Atlantic Coast, looms large according to the Survey. But almost no drilling has been done along the Atlantic shelf and the little that has occurred has been sorely disappointing. In the past 5 years half a dozen oil companies have spent upward of $200 million to drill 65 holes off the presumably oil-rich coast of Newfoundland. All but three of these were dry, and those contained too little oil to justify building a pipeline to shore.

In the meantime, the Geological Survey is working on a computerized model of fossil fuel resources that will take account of geologic conditions as they vary from one sedimentary basin to the next. But the new model and its more refined estimates probably won't be of much use to the Federal Energy Administration in drawing up its "blueprint" for Project Independence. The FEA's deadline is November.

Almost certainly the blueprint will call for a sharp increase in domestic oil production by 1980. But any expectation that the increase can come from newly discovered oil will be based on only the haziest assurance that the necessary oil really exists. It seems fair to say that a careful review of conflicting resource estimates is long overdue.

— ROBERT GILLETTE

Beagles: Army under Attack for Research at Edgewood

In response to a continuing simmer of public outrage over the military use of beagles for testing toxic substances, the Army has suspended procurement of beagles pending an "intensive review by appropriate offices and agencies of the DOD."

That is the latest development in a controversy that began last summer when Representative Les Aspin (D–Wisc.) revealed that beagles were being used at Wright-Patterson Air Force Base in Ohio to test the toxicity of new fuels and chemicals being used for routine Air Force operations. The fuss was subsequently intensified when Aspin revealed in September that beagles were also being used for research at Edgewood Arsenal in Maryland, the Army's major facility for chemical warfare research.

By the end of last October, the Pentagon had gotten more than 30,000 angry letters—more mail than has been generated by any single issue since President Truman fired General Douglas MacArthur in 1951. Antivivisectionists filed a lawsuit against the DOD (it was dismissed), and conducted nationwide newspaper campaigns against the use of beagles in military research. Little children wrote in pleading that their pets not be carted away to die in agony in government gas chambers.

The furor has mainly been the work of antivivisectionists, the small but exceedingly vocal portion of the animal-loving community that believes no research is justified that causes any pain or discomfort to animals. But the fusion of two touchy subjects—distrust of the military, and people's passionate attachments to their pets—has made this issue a hard one to defuse. It has given an unprecedented boost to the antivivisection movement, and two legislators, Aspin and Senator Hubert H. Humphrey (D–Minn.) have taken advantage of the momentum to introduce measures that would prohibit the military from using dogs in research related to chemical warfare. Antivivisectionists object to research causing injury to animals regardless of whether it is for military or civilian purposes. The two lawmakers are concerned with asserting more legislative control over the military and, in particular, with curbing chemical warfare research. Thus has a bizarre coalition emerged that has stimulated an unusual public uproar, caused considerable annoyance in the Pentagon, and aroused fears among medical researchers that antivivisectionists are getting a foot in the door that will enable them to press passage of "antiscience" measures inhibiting some animal research.

It all started in June 1973 when an Aspin staffer noted that the Army's Aerospace Medical Research Laboratory at Wright-Patterson was seeking 200 "debarked" beagles for use in its Toxicology Research Program. Aspin, who has made a career of picking on the military for any activities that he considers wasteful, useless, destructive, or downright stupid, promptly publicized the matter.

The Air Force became so irritated at the ensuing outcry that it asked the National Academy of Sciences, through a committee of the Advisory Center on Toxicology of the National Research Council, to investigate its $1.2 million program. That report, released on 12 June, concluded that the Wright-Patterson experiments, which involve testing toxicity of new jet fuel, rocket propellants, fire extinguishants, and environmental pollutants, were by and large admirable and necessary. The NAS said beagles were appropriate for the work, that the animals were well-treated, and "there should be no pain" from the experiments.

Since nothing there involves chemical warfare, Aspin has proclaimed himself satisfied by the report. (Humphrey still contends that any research bearing on human health should be done by civilian agencies because "I know the Defense Department and their tricks.") To antivivisectionists, of course, the report is irrelevant.

The academy report poured oil on troubled water, but the Edgewood issue had already begun to come alive again when on 15 May a member of Aspin's staff discovered a notice in *Commerce Business Daily* in which the Army advertised for 450 purebred beagles for use in research at Edgewood.

The Aspin office promptly shot off a press release decrying the use of beagles in war research, and on 31 May Aspin introduced a bill in the House prohibiting the use of dogs for research involving "any biological or chemical warfare agent."

A few days later Humphrey introduced an amendment to the military procurement authorization act that