A Geophysical Outlook—Part 10

How industry/university relations affect exploration

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20-second summary
The current shortage of well-trained explorationists is the largest problem the oil and gas exploration industry has to face in the 1980s. While many scientists are being attracted from related fields, it takes years to educate them in the specific techniques utilized in hydrocarbon exploration. As a result, tremendous competition has been generated for those with the best brains and experience. This article reviews how the industry/university liaison has developed into an entity that can provide both the funding and the tools or techniques necessary for the proper training of new explorationists. It is the last in a series of ten articles on new technologies and advancements in exploration geophysics published in WORLD OIL, which will be adapted for book publication in January 1983 by Gulf Publishing Co.'s Book Sales Department.

THE LEVEL OF scientific training offered by U.S. universities in recent years has fallen far short of its potential for several interrelated reasons: inadequate funding, lack of proper staffing and equipment and a shortage of high-level students entering post-graduate work. However, a close liaison between industry and academia could result in the alleviation of some of the problems, as it has in a few instances across the U.S. already.

Following is a discussion of the current scientific educational problem in this country as it specifically relates to exploration geophysics. Included is a review of ongoing industry-supported projects with a close look at the University of Houston's Allied Geophysical Laboratories. Additional suggestions are offered as to how other educational innovations could further solve this country's scientific training gap.

THE PROBLEM

Numerous university graduate students who historically would have earned PhD degrees for teaching or research are switching to more lucrative careers in business, law, medicine and engineering.[1] Although exploration geophysics has not seen the job market tighten to the same degree that academia and many other professions have, there is still a strong demand for well-trained explorationists. This demand is fueled by the fact that there continues to be a problem in the depth and overall quality of training that exploration scientists are getting in colleges today. By in large, few well-trained explorationists are being graduated.

Quality shortage. The most serious portion of this problem is that the brighter students with a BS degree in geophysics/geology or an advanced degree in a somewhat related field are being "bought" away by industry prior to their obtaining further education. (This is primarily because the recent demand for explorationists is actually a manifestation of the demand for oil.) However, although these students are often very intelligent, it is an exception for them to have obtained as firm a grasp of mathematics, physics, geology, electrical engineering, computer science or geophysics as comes with the exertion required by a good graduate school program. The result is that while the number of explorationists increases, the percentage of well-founded, technically competent scientists is decreasing. Some oil companies obviously meet their short-term manpower needs in this manner, but such brain "buying" is not providing good foundation for continued, high-level exploration research and problem solving.

With the industrial dependence on highly trained professionals, it is important that industry correspondingly recognize the benefits of a long-term approach to personnel needs. This includes recognizing "that a mindless bidding war for these professionals would be destructive for everyone, and that. . . recruiters have an obligation to help universities assure the quality and expand their output of graduates in the sciences and engineering," says Dr. J. B. Slaughter, Director of the National Science Foundation.[2]

Another paradox is that "there are too many PhD candidates and not enough quality," says W. G. Bowen, president of Princeton University.[1] This is a factor that will definitely

Decisions about educational funding today will have a long-term impact on the economic health of this nation.

TABLE 1—Summary of SEG Research Committee survey on universities

Name of University	Departments	Research area	R	$	Source of funds	P	St	Equipment available
U of British Columbia	Geop/Astrop	Time series/ inversion	2	33	NSERC	2	2	Computer, Digital data
U of British Columbia	Geop/Astrop	Seismology/ Tectonophysics	2	60	Industry, NSERC, DEMR	2	3	6-phone dig. marine sys; 2-channel Sonobouy sys, Geo Tech MCR-600, MER-800
U of British Columbia	Geop/Astrop	Instrumentation	1	20	NSERC	1	1	6-element telem. array; A/D conv. sys; FM-tape-rec. seismographs (5)
U of Calgary	Geol/Geop	Seismic stratigraphy	1	–	HBOG	–	1	DFS III, UNIVAC
U of Calgary	Geol/Geop	Radiometrics	1	–	HBOG	–	1	Helicopter-mounted, high-resolution
U of Calgary	Geol/Geop	Electromagnetics	1	–	HBOG	–	1	Gamma-Ray spectrometer, Analog scale model
U of Calgary	Geol/Geop	Gravity	1	–	Chevron	–	1	Worden Gravimeter
Colo. Sch. of Mines	Geophysics	Seismic exploration	6	500	Industry and Gov.	4	40	24-Chan DFSIII, 48-Chan DFS V, P/S vibroseis, TIMAP computer
Colo. Sch. of Mines	Geophysics	Geophysical modeling theor.	4	200	Industry	0	10	CYBER 170/7; DEC LAB-11; TEK 4081, 4025, 4006 and 4016
U of Connecticut	Geol/Geop	Shallow marine seismic	1	8	NRC	1	1	Air gun/recording equipment for work on lakes and inlets
Dalhousie U	Geology	Marine seismology	1	8	NSERC	1	1	Basic profiling
Dalhousie U	Geology	Nearshore marine surveys	1	15	NSERC/EMR	–	–	EG&G sparker system, Varian magnotometer, ORE 3.5 KHz system
U of Iowa	Geology	Exploration geophysics	1	–	SEG		4	–
U of Delaware	Geology	Seismic studies, Continental margins	1	31	NSF, Lamont-Doherty	1	1	Bolt airguns, Hydrophones, Raytheon PGR, 6-Chan. camera recorder
U of Delaware	Geology	Seismic reflection, Baltimore Canyon	1	–	Delaware Geological Survey	1	0	Bolt hydrophones, airguns; Raytheon PGR, 6-Chan. camera recorder
U of Georgia	Geology	Economic geology	5	–	NSF, Industry	–	15	–
U of Georgia	Geology	Marine geology	3	–	NSF	–	5	–
U of Santa Cruz	Geology	Economic geology	1	170	NSF, Amoco, Mobil, Shell	1	7	Single, multichannel reflectors, Union + multibeam bathymetric source
U of Kansas	Geol/Geop	Seismic detection of underground voids	1	12	Kansas Geological Survey	1	1	12 Channel I/O Mini-Sosie DHR 1632
U of Kansas	Geol/Geop	Shallow seismic exploration	2	25	Kansas Geological Survey	1	1	12 Channel, 2 Wackers, recording van, cable truck
U of Kentucky	Geology	Applied seismology/gravity	1	158	NFS, Dept of Transportation, Amoco, U of K	Y	6	Worden, 3 seismographs, 5-station seismic array, Talos digitizer

with active research projects in exploration geophysics, 1980

Name of University	Departments	Research area	R	$	Source of funds	P	St	Equipment available
Louisiana Tech U	Geosciences	Petroleum geology/gravity	1	–	Private Companies	–	–	–
McGill U	Mining	Seismic interpretation	2	10	Canadian Gov.	0	2	Computer facilities
Michigan State U	Geology	Seismology	1	15	NSF	0	4	Gulf 49-to-21 trace recording system
Michigan Tech U	Geology	Seismotectonics-Seismicity	1	142	NRC	1	6	3 seismic systems, 3 portarecorder systems, 3 telemetry systems
Montana Tech U	Geophysics	Seismic	1	–	–	–	2	DFS III
U of Southwestern LA	Geology	Geophysical/ Geothermal	1	124	DOE	2	2	Magnetometer, seismic data
U of New Brunswick	Geology	Develop vibrator source	1	4	EMR	1	–	Electronic equip to drive and monitor vibrators
U of New Brunswick	Geology	Interpretation of NB seismic data	–	–	–	–	1	Over 100 line miles of data on magnetic tape
State U of N.Y.	Geoscience	Field geophysics	1	75	DOE	3	3	Temperature log, Gravimeter
State U of N.Y.	Geoscience	Marine geophysics	1	75	NSF	–	–	–
U of Oklahoma	Geol/Geop	Engineering seismology	1	–	Gulf R&D	–	3	SIE RS-4AC, Soiltest R-60 and associated hardware and software
U of Pittsburgh	Geology	Geophysical studies of the Blue Ridge	1	–	–	1	0	Geometrics GS-816
U of Pittsburgh	Geology	Theoretical models of seismic atten.	1	–	–	1	0	Pittsburgh
Portland State Univ	Earth Sci.	Stratigraphy of Columbia River basalts	1	–	Dept of Geol. & Mining Industries, State of Oregon	1	4	Gamma Counter System
Portland State Univ	Earth Sci.	Stratigraphy	1	25	Petro Co	1	3	Field equipment, sediment analysis equipment
Stanford U	Geophysics	Seismic data processing	2	400	Industry and Government	2	10	Minicomputer
Stanford U	Geophysics	Rock physics	1	200	Industry and Government	2	5	Ultrasonic & sonic velocity, attenuation and hydraulic permeability
Texas A & M	Geophysics	Exploration seismology	1	50	Wes, NSF, Oil Co	1	2	DDS 630 with field Summer, DDS 620, SIE RS-4
Texas A & M	Geophysics	Seismic attenuation	1	120	Consortium of Oil Co.	1	3	seismic-wave lab (Rockwell Intl.) data analysis facilities
Wright State U	Geology	Seismic mapping of buried river valleys	3	5	Exxon	2	1	Digital data system, seismic rig and Mobile B-34 drill, Exxon processing
Wright State U	Geology	Seismic reflection and coal	1	30	Amoco, SSC	2	8	Amoco field equipment and processing center, SSC processing center
Wright State U	Geology	Seismic reflection and coal	2	25	US B of Mines	1	0	Denver office of U.S. Bureau of Mines Equipment

R = No. of researchers
$ = Thousands of dollars in financial support
P = No. of professional employees
St = No. of students

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affect future energy exploration research and development. As Bowen points out, "over the long-term we may face the possibility that the quality of teaching and research will diminish and entire fields of knowledge may be weakened."

The decline in the number of superior students attending graduate school has been dramatic. This slump cuts across the spectrum of academic fields, including those areas that have traditionally provided energy explorationists. Lewis Solomon of the Higher Education Research Institute of UCLA has documented this from surveys.[1] He points out that in 1964 about 75% of top-quarter college graduates who continued their education chose studies in the arts and sciences, while only 20% went into law, medical or business school. In contrast, in 1979 more than half of the top graduates chose professional schools and only a third chose the arts and sciences.

As a specific example, comparing 1964 to 1981, Harvard University went from 77.2% to 30.8% of the seniors who graduated with highest honors going on to graduate school in the arts and sciences.[1] And the reason for this drop is obvious. There is so much difference between the starting salaries in industry and in academe in many of the engineering and scientific disciplines, that the lifetime yield of a person with a doctoral degree and a tenured position on a university faculty can never financially catch up with the financial yield of one who went into industry after an undergraduate degree.[2]

It is important that industry do its part to recognize and reverse this trend. Dr. Slaughter has pointed out that basic research was 14% of total U.S. research and development in 1980, the highest level in 15 years. This suggests that industry *does* recognize that long-term economic health depends substantially on the generation of new knowledge.[2] However, this new knowledge comes with the quality, and not the quantity of researchers working on a problem.

Along this line, it is interesting that the total number of graduate students has not decreased significantly, even though the better students are not continuing their studies. The National Research Council in Washington reports that the total number of students earning doctorates has only declined to 31,319 in 1981 from a high point of 33,756 in 1973.[1]

Needed: innovative industrial management, flexible university administrators and farsighted graduate students.

One major shift in U.S. educational systems is the number of international students being educated here today. The University of Houston, which serves a very culturally mixed community, has an enrollment which is 10% international students. This trend is not really that uncommon for universities across the United States, and perhaps it will have a positive impact on those universities that will be affected by the demographically projected 23% decrease in potential undergraduate students from 1978 to 1997. In fact, while the enrollment of U.S. students may decrease, the number of international students trained at U.S. universities will probably continue to rise.

Professor shortage. One possible reason that this large number of graduate students is not meeting industry needs, is that there are so many experienced professors leaving academia to go into industry. A survey by the American Council on Education found that about 10% of the faculty positions in U.S. engineering schools were vacant in 1980, and computer science departments had openings as high as 16%.[1] Part of this is due to increased student loads in engineering and science. Professors are left with overtaxed teaching loads and laboratories with outdated equipment and instruments. This situation is so bad, in fact, that it has prompted John A. McDonald of the University of Houston's Allied Geophysical Laboratories to repeatedly point out to industry sponsors that the biggest challenge faced by universities is not to raise money for research, or to attract qualified graduate students, but to compete with industry for *qualified* professors and support staff.

It is hard to attract and keep quality personnel in university positions under the fiscal constraints that go with these jobs. Largely because of this, many university positions have been filled on a temporary basis by graduate students, and this is unsatisfactory from many points of view. One problem is the amount of teaching time taken away from professors for the training and retraining of students for simple staff responsibilities.

FUNDING RESEARCH/EDUCATION

U.S. universities are currently entering an era of change in regard to program funding, as the current U.S. government administration is reviewing traditional federal funding of education as part of its overall effort to trim federal spending. The Reagan administration, in fact, is calling for more private sector funding of education, and the bottom line is that higher education will lose $6.5 billion between 1981 and 1984 due to federal spending reductions.[3]

It must be remembered, however, as decisions are being made about educational funding that the current problems faced by universities are closely allied to the problems facing U.S. industry today. These problems include: inadequate transfer of research results into practice, aging physical plants and equipment, inefficient energy usage, shortages of highly trained technical personnel, insufficient investment in long-term research and the diversion of resources to satisfy regulatory requirements.[2] This being the case, it appears that decisions affecting higher education will have an impact on industry and vice versa. In short, decisions about educational funding today will have a long-term impact on the economic health of this nation. Stating this idea another way, George Keyworth, director of the Office of Science and Technology Policy and the President's science advisor, has pointed out that science

Steps have already been taken within the exploration world to bring about better scientific research and development through the joint efforts of academia and private enterprise.

policy is not made in a vacuum. Science policy, he says, "is an exercise in priority setting and decision making that must be carried out in the context of other national policies such as those concerning national security, international relations, energy, social services and the economy. For example, science policy, without considering economic policy, is irrelevant."[4]

Budget specifics. In comparison with other budgets proposed for the 1983 fiscal year, basic scientific research fares well. The amount of $5.8-billon is a 12% increase over the actual 1981 fiscal year budget. However, it is 5.5% lower than the real dollar value of the 1980 fiscal year budget.[4]

One of the basic beliefs of the present administration is that applied research is a private sector responsibility. The Council for Financial Aid to Education recently reported that voluntary support for higher education rose by an estimated 11.3% in 1980-81 to a total of $4.2-billion.[5] Much of the pure research that the National Science Foundation (NSF) has been funding will continue, and at close to the same rate. However, real dollar values are down and industry does need to make more substantial investments in long-term research and education.

Exploration funding. The status of university research and education funding sources as they are tied to exploration geophysics is best summarized by abstracting a survey of North American universities conducted by the Society of Exploration Geophysicists Research Committee in 1980 (Table 1). Despite some serious problems with the survey, it contains some very interesting information. Because of the intensive manpower effort required to keep the survey updated it is already incomplete. Other serious problems have resulted in the fact that the data will probably never be officially published. For example, none of the three universities that the author has been closely associated with returned their surveys. The University of Utah, Southern Methodist University and the University of Houston all have well-known exploration programs in their own spheres, but none are included in the survey in question.

Table 1 is taken from the last item on this survey, which requested a list of areas of research interest. This question included a breakdown of the number of researchers, amount of financial support, sources of financial support, number of professional employees, number of students and available equipment. The table reproduced here only lists those areas of research that are either directly related to exploration geophysics or are listed as being supported by an oil exploration company. The $2.5 million reported by 25 different universities doing work in exploration geophysics averages out to about $250,000 per school per year. After salaries, indirect costs and fringe benefits (insurance, etc.) this does not leave an adequate balance for teaching and research in the cost-intensive world of seismic crews,[6] seismic processing[7] and interactive computer graphics.[8] The research income reported on this survey can be further broken down into government-only sources (20%), industry-only sources (18%), and combination industry/government projects (62%).

The Industrial Associates Program at several universities is one of the longer running procedures for attracting money from industry to aid education. There are several universities that have this type of program including Oregon State University, Scripps Institute of Oceanography, The University of Texas Marine Science Institute and Woods Hole. For the most part, sponsors of these projects provide no direction in the research, but support each of the projects with about $15,000 to $50,000 per year.

One of the major reasons for industry supporting these programs is to be able to evaluate the marine sparker and seismic data as soon as it becomes available. The author visited the Scripps program in 1975 for the specific purpose of evaluating the sparker and single channel data that had been collected by the Scripps vessels in the Andaman Sea. In new prospect areas where there has not been a regional or detailed survey, this data is often the only key to subsurface geology.

Although there is not usually direct contact with the students by sponsors, sponsorship also provides the benefit of having a direct liaison with the professors who supervise the work. Often pure research, as opposed to applied research, is being carried out under this type of a grant. This type of support can be viewed as an example of how industry is fulfilling a responsibility to society. However, more often pure research is funded through government agencies like the NSF. An example is the NSF funding of $4.5 million per year for COCORP, the **Cornell Cooperative Reflection Program.**

Research consortia provide a vehicle that industry can use to more easily direct applied university research. Normally this type of organization will have a very detailed charter to study something of specific interest to the oil companies. With the rapid expansion of exploration, there are often not enough in-house scientists in research and development (R&D) to evaluate all of the new technologies that are influencing industry. However, this does not mean that companies will join every outside project that is proposed. W. G. Clement, Director of Research at Cities Service, Co., points out that there must be limits. Although industry should support outside R&D as part of corporate responsibilty to society, there will not be support of a project if there is not an industry scientist to monitor the project.[9] There will be, of course, more support for projects that are attacking applied research problems of inter-

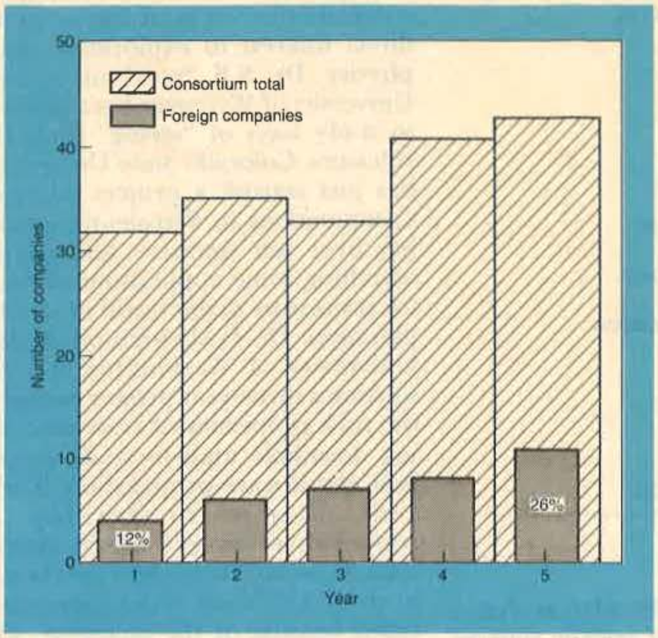

Fig. 1—Membership breakdown of the University of Houston's Seismic Acoustics Laboratory as of May 1982 according to U.S. and international affiliation.

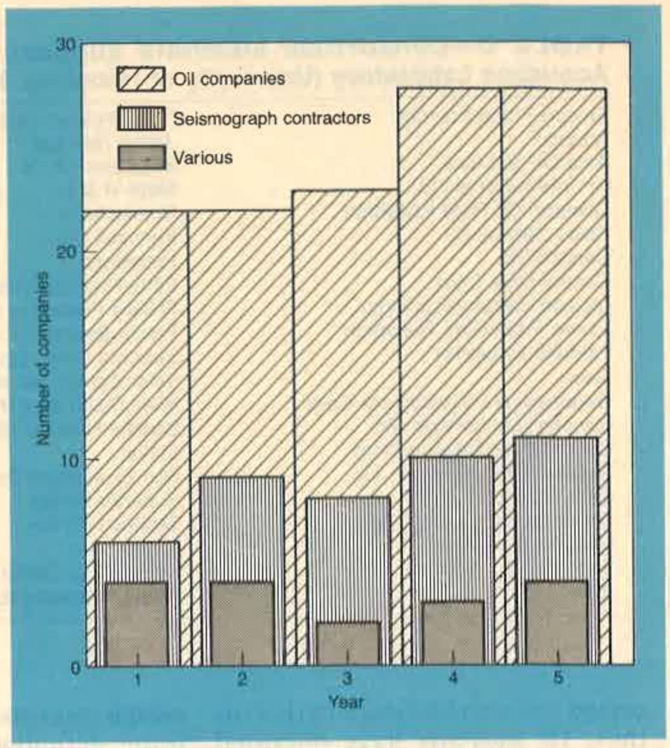

Fig. 2—Membership breakdown of the University of Houston's Seismic Acoustics Laboratory as of May 1982 according to the designated industry sectors. The "various" category includes equipment manufacturers and vendors.

est to sponsors. This support comes not only in the form of money, but also by means of visiting scientists, discussions with visiting sponsors, field data sets, access to company facilities, etc.

There are many different industry-sponsored research consortia around the United States. The first industrial consortia was formed by Dr. Jon Claerbout at Stanford University, in 1973, just before the oil embargo. This project is known as the SEP, which stands for the **Stanford Exploration Project**. There is no permanent university staff associated with this project. It is carried out under the direction of Dr. Claerbout, about a dozen graduate students and visiting scientists. Some of the scientists that have spent a year or so working at the SEP on leave from industry include: F. Muir, Chevron Oilfield Research Co.; L. Rocca, professor at Politecnico Electronica in Milan, Italy, and R.H. Stolt, Conoco Exploration Resources Group.[10] Research has emphasized a seismic migration technique based on the finite difference approach.

The next, best-known research consortium is at the University of Houston. The activities of the **Seismic Acoustics Laboratory**[11] (SAL) have been discussed in detail in this series of articles. Table 2 is a list of sponsors of the SAL as of May 1982. Fig. 1 breaks down the membership as of May 1982 according to U.S. and international sponsors. Fig. 2 illustrates the relationship between oil companies, seismic contractors or another membership category labeled "various," which refers to companies such as computer vendors.

The SAL is one of five research laboratories within the University of Houston's **Allied Geophysical Laboratories** (AGL). The research emphasis in SAL is theoretical and numerical modeling of field reflection seismology. The major research emphasis in the AGL is to study three-dimensional(3-D) seismic techniques from field acquisition through processing and interpretation.

One of AGL's five labs, the **Keck Research Computation Laboratory** (RCL) provides service to other laboratories on a VAX 11/780 computer with a seismic processing package on it. The RCL is also doing research in vector programming on a CDC Cyber-205 vector computer. Income comes from services and grants.

Another AGL member, the **Cullen Image Processing Laboratory** (IPL) is studying display techniques for placing seismic data on computer graphics terminals, interactive interpretation techniques and display and manipulation techniques for work with 3D volumes of seismic data. Funding is from a consortium of oil and computer graphics companies. The IPL has several pieces of advanced display hardware that are available to each of the labs in the AGL. This includes an Adage 4145 vector refresh graphics system with the raster segment generator[12] and the Genisco SpaceGraph, a computer-controlled, true 3D display device.[13]

The **Field Research Laboratory** (FRL) of the AGL, will investigate new ways to acquire seismic data in the field. Income for this project is from grants.

The fifth laboratory, the **Well Logging Laboratory** (WLL), is wholly within the University of Houston's Department of Electrical Engineering; whereas, the others are multidisciplinary, under equal direction of the College of Engineering and the College of Natural Sciences. The WLL is investigating improvements in well logging instrumentation. Its income is derived from a consortium of 16 oil companies.

What now constitutes the AGL has grown from one lab to five intercon-

TABLE 2—Consortium members supporting the Seismic Acoustics Laboratory (University of Houston), May 1982

Amoco Production Co.	ICI Petroleum Services Ltd.
Aramco	Japan National
Arco Oil and Gas	Marathon Oil Co.
BP International Ltd.	Mobil R & D
Chevron Oil Field Research	Norsk Hydro
Cities Service Co.	Pennzoil Co.
Conoco Inc.	Petrobras
Control Data Corp.	Petty-Ray Geophysical
Digicon Geophysical Corp.	Phillips Petroleum Co.
Exxon Production Research	Prakla-Seismos G.m.b.H.
Fairfield Industries	Seiscom Delta, Inc.
Geco	Seismograph Service Corp.
Geophysical Development Corp.	Shell Development Co.
Geophysical Service, Inc.	Societe National Elf Aquitaine
Geophysical Systems Corp.	Statoil
Geoquest International, Inc.	Sun Exploration Co.
Getty Oil Co.	Superior Oil Co.
Gulf Research & Dev. Co.	Tenneco Oil Co.
Horizon Exploration	Texaco, Inc.
Hunt Oil Co.	Union Oil of California
IBM	Western Geophysical Co.

nected research labs since 1976. Further, 15 students have obtained graduate degrees with AGL support and all are working in energy-related industries.[14]

Another project that is sponsored by a consortium of most of the major oil companies and geophysical contractors is the **MIDAS** project at Columbia University. Midas is an inverted acronym, meaning Scattering And Diffraction, Inversion Migration. This project was originally started to evaluate and improve seismic evaluation techniques by using P & S waves (compressional and shear waves) simultaneously. There is an emphasis on using a modeling technique known as the finite element method. The facilities were originally built with NSF funding, and the NSF is still supporting the project. There is a 3D physical modeling experimental facility that can use elastic media for looking at shear waves. Work in inversion has included the slant stack Tau-P method with amplitude as well as arrival time.[15]

The Colorado School of Mines (CSM) has a different approach. They have formed what is known as the **Exploration Research Laboratory** (ERL). The ERL is a contract research organization emphasizing field data acquisition, principally seismic. They are also doing time domain electromagnetic surveys tied to specific areas. One of the major projects was the Source Signature Study. This was a 1½-year project to evaluate the signature of various seismic sources. The idea is that a better definition of seismic sources will provide a basis for setting field parameters and processing parameters like signature deconvolution.[16] There are twenty two masters and three PhD students involved with the ERL who are graduating in 1982.

The ERL also does site specific projects. For example, there is a fire-flood project to map shallow tar sand continuity and a high-resolution coal study near Vernal, Utah, as well as geothermal studies in the Snake River Plains and the Imperial Valley. The financial objective of these projects is to cover the costs. Sometimes they are cheaper than industry projects, especially if all of the processing steps are taken into account. The computer facilities at CSM consist of a CDC Cyber-720 computer that came as part of a $5.2-million grant to the geophysics department from the Keck Foundation. There is also a TIMAP computer for preprocessing. There has not been much of a cut in government contracts to the CSM, but the general economy is reducing support from several sponsors. This affects research and also academics at the school, because of the expensive overhead on the Cyber computer. One solution that is being applied to this problem is to sell excess computer time non-competitively to the Denver seismic community.[16] This can create a problem, however, if the university computer, supported by some state money, is selling computer time at a much lower price that is standard commercially.

There are several other research consortia that are studying areas of direct interest to exploration geophysics. Dr. S.B. Smithson at the University of Wyoming has a project to study ways of "seeing" through volcanics. Colorado State University has just started a project entitled Computations in Petroleum, which has over ten sponsors and is researching some applications of vector processors in the world of oil exploration. Dr. D.M. Johnson at the University of Washington is just starting a three-year project to study the rock properties of fractures using downhole tools to study cross-hole elastic wave propagation. A recent attempt to develop a cooperative project which innovatively would have used two boats to study U.S. Gulf Coast sediments failed because of the recession. All such projects obviously do not succeed.

Several schools that the author is aware of have recently purchased advanced seismic processing systems. These schools include Virginia Polytechnical Institute, the University of Wyoming, The University of Texas, the University of Houston and the University of Bahia in Brazil. Golden Geophysical, a group separate and yet close to and available to Colorado School of Mines students, has obtained a couple of VAX-based minicomputer seismic processing systems. There have also been other donations that are expected to have an impact on educating explorationists. For instance, Evans and Sutherland has donated some thirty-five PS-300 units, advanced line drawing or vector refresh graphics systems, to several universities. This includes two specifically for geophysical work—one to the University of Houston and one to The University of Texas at Austin.

One of the most ambitious university expansions currently taking place is at the University of Oklahoma in Norman, Okla. Effective this year there is a new Geoscience College with schools of geology, geophysics, meteorology, and a Department of Geography. The new energy center is from a gift of $30 million from Bill Saxton, an independent oilman. The university is increasing support and 27 fully-funded, tenured track faculty positions are planned for by 1985, up from 15. The goal is excellence, and there will be an emphasis in the energy area.[18]

NEEDED INNOVATIONS

It was top news across the nation early in 1982 when the presidents of Harvard, MIT, Stanford, the University of California and Caltech held a private conference with their peers at a dozen high-tech firms.[18] The purpose of the meeting, held at Pajaro Dunes, was to contemplate the ramifications of academia's new-found interest in collaborating with industry, particularly in biotechnology. Harvard University President Derek Bok called the conference "reassuring in that it readily established a consensus, shared by business, about the importance of maintaining academic values while acknowledging the possibility of creating sound relationships."[19] This has direct application to industry/academia relations in the area of oil exploration.

The type of policy that needs to be kept in mind in evaluating oil industry's relationship with academia is expressed in the following portion of the Pajaro Dunes conference statement: "Agreements should be constructed, for example, in ways that do not promote a secrecy that will harm the progress of science, impair the education of students, interfere with the choice by faculty members of the scientific questions or lines of inquiry they pursue, or divert the energies of faculty members from their primary obligations to teaching and research."[20] With these ideas in mind it is reasonable to see other companies follow the example of Exxon Educational Foundation's $15-million program to support doctoral students and junior faculty in engineering.[2]

There are several examples of how industry is establishing major, long-term joint projects with academia. The Massachusetts General Hospital (MGH) has a contractual agreement with Hoechst AG, a German pharmaceutical firm, for nearly $70 million over the next 10 years.[21] MGH has agreed to grant Hoechst exclusive worldwide licenses to any patentable developments that emerge from company-sponsored research. Exxon Research and Engineering has established a ten-year, $7-million project with MIT to investigate combustion, and Monsanto has established a twelve-year, $23-million venture with Harvard to study the biological evolution of organs. Most recently, Mallinkrodt announced it will fund almost $4 million of research on hybridoma technology at Washington University in St. Louis.[2] There needs to be the same kinds of commitments by the oil industry to develop even newer and better technologies to solve the complicated problems of exploration geophysics.

Several meritable proposals that have application in industry support of research and education in exploration have been listed by Dr. J.B. Slaughter of NASA.[2] These include: (1) building a $50-million industrial initiative directed towards sustaining the nation's creative engineering base, (2) having industry lobby state legislators for increases in faculty positions and salaries in a specific discipline in the state school system, (3) channeling direct support to schools that are willing to increase their capacity for engineering education, (4) increasing support for company employees to pursue advanced degrees under cooperative programs with a university, and (5) loaning industry scientists to universities to serve as adjunct and visiting professors or researchers. It also seems reasonable that a company could define what is proprietary and then set up a free exchange of remaining ideas and equipment with a university to aid in training students and accomplishing industry tasks.

At the same time, universities need to take positive steps. This could include reducing the quantity of graduate students, while at the same time encouraging those of the highest quality. There also should be ways to reduce the economic pressures of a six-year graduate study program. It would be hard to justify paying a geophysical graduate student twice or three times what a graduate student in another area can receive; however, the economic pressures of present industry needs make it foolish to continue in graduate school on a standard stipend.

SUMMARY

As related here, industry growth and educational excellence have closely tied destinies. Steps have already been taken within the exploration world to bring about better scientific research and development through the joint efforts of academia and private enterprise. However, with the federal government's push to make R&D more of a private sector concern, such academia/industry liaison must continue to expand if the exploration industry is going to have the well-trained professionals that it needs in the years to come.

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