Talking Points:

Geoscience Careers

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Updated 04/16/2008

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With all of the recruiters visiting campus and ads running for geoscientists major professional journals, we are experiencing the first major surge in geoscience employment in more than 20 years. Along with this are emerging concerns about the recent peak in the price of oil and the global decline in major new oil discoveries. You may be tempted to ask, as some of us once did – is there a long term career for me in the Petroleum Industry? Geoscience grads have many choices

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There are rewarding jobs in mineral exploration and development, although most of these are overseas. The oil industry is hot right now, and we'll take a peek at the future of this sector today. The major employers of geoscientists in the US in the past decade, however, have been environmental, hydrology, and engineering geology, and this trend is now spreading globally. Whatever path you choose.

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There is a productivity gap, the lag between starting technical education and becoming fully productive. As noted by John Kaldi in an IPA lecture, it typically takes at least 8 years (5-7 or more years in college, 2+ years on the job).

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Four or more years are needed to achieve a Bachelors degrees, two to three more for a Masters degrees, followed by at least 2 years of training and work experience in a company.

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So what is in the pipeline?
We find that has changed over the years, and probably continues to change

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- Traditionalists – my father…
- I am a baby boomer, …
- following the boomers came a "lost generation" of those entering the job market in the bust of the mid 80s. This group grew up with MS DOS and Super Mario, Brothers, it eventually became known as Generation X and learned early about M&A,

layoffs, and "headcount." Concepts of job security and company loyalty that were hallmarks of the industry for the preceding 50 years disappeared, perhaps for good.
- a more recent change emerged over the past several years. Graduates now are technologically superior, but more respectful of tradition and less oriented towards immediate gratification. Considerations for dual careers, with a spouse or significant other, have grown insignificance. Diversity in nationality and ethnicity is up on campus and in the industry. Globalization is not just coming, in many respects it is already here.

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While technical degrees in the US have been relatively stable over the past 20 years, enrollment of Asians has increased sharply. And enrollment in Asian universities has skyrocketed. And where do these relatively few US Grads go to work?

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The last AAPG study in 2003 showed that over half of all geoscience grads in the US and Canada went to work in envrionmental fields, with the rest split nearly evenly between oil and gas, teaching, and government jobs. European statistics show a similar lack of interest in joining our profession. This may result partly from development of rewarding careers in environmental geoscience, but another cause has been steady, longstanding attrition in petroleum industry jobs.

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Overall, jobs in the petroleum industry declined 68% from the peak in 1981. More than 2 out of every 3 jobs in the industry are now gone.

Two factors combined to force this demise:
- The price of oil cratered to less than $10/bbl in the mid 1980s, and it slumped again to less than $13/bbl in the late 1990s. Workforces were cut to keep companies afloat, and many went under. Pervasive mergers produced greater economies of scale, with the drive to reduce overhead and increase efficiency further reducing staff.
- Major breakthroughs in workstation technology and 3D seismic brought better and much faster imaging of the subsurface with smaller staffs. Exploration success increased with fewer wells being drilled with better exploration technology. Still, less oil was being found, and "cut to the bone" staffing levels provided no cushion for a rebound when prices finally increased.

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Little new blood has come into the industry, as witnessed by the median age of the technical professionals. In 1990 this was 39 and 37 years for the American Association of Petroleum Geologists, and the Society of Petroleum Engineers respectively. In 2000, the median age was 49 and 46 respectively. The workforce has ageing with the calendar, without significant renewal.

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(next)
The industry clearly needs to add staff now, before the experienced supervisors and mentors retire.

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Due to instability in the past, the oil and industry is now long on jobs and short on qualified people to fill them. We can't just send lawyers to the wellsite. But is there a future for college grads just entering the job market?

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Oil doubled in price in the fall of 2005, due to the disasterous impact of mega-hurricanes Katrina and Rita. The price of oil is important, because it is the dominant factor in the price of gasoline at the pump.

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As shown by AAPG Past President Pete Rose in the Explorer, oil prices surged from $12 in 1998 to a peak over $67 in Sept 2005, up 500% in 7 years. Dr. Rose is a recognized industry expert in exploration risk and economic return, and he assembled this graph to put the recent upswing into perspective. Actual prices are shown in blue, and inflation adjusted prices are in red. Dr. Rose's statistical analysis of these data shows an average price of $34/bbl and a P50 (50% probability) of $30/bbl. But the past is not always a reliable guide for the future, so we will next look at some estimates of remaining world resources and the balance between supply and demand. But first…

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These are some sobering statistics about exploration activity and success. Let's take a look at what oil has been found and produced, and what supplies may remain for you and me to discover.

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Here is the history of the oil age, from the onset of significant discoveries in the early 1900s to the decline that started in the 1970s. These data were compiled from public sources, and arranged them to show volumes of conventional oil, heavy oil, and gas compiled by discovery year, and annual production shown by the heavy yellow line. Note that the world is currently replacing only about 50% of current production.

- Discovery of heavy oil peaked in the mid 1930s, with major resources in Canada and Venezuela.
- Conventional oil discoveries peaked in the mid 1960s, followed by
- Gas discoveries, which peaked in the mid 1970s.
- Note that discoveries of both oil and gas then declined through the late 1970s and early 1980s, before the disastrous price crash in the mid-1980s. The industry was running flat out with record rates of rig activity and still finding less oil and gas.
- By the end of the 1970's, some drilling had been completed in some 1100 basins, covering almost all prospective areas of the world at that time other than deep water.
- There have been exceptions over the last 10 years, with significant discoveries in deepwater areas, the Middle East, and the North Caspian, but even these have not reversed the trend
- These new finds demonstrate the need to be flexible and vigilant in exploration, but they also show that we are approaching global limits for major new discoveries

Let's look next at what may remain to be discovered.

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These figures are from Dr. Peter McCabe with the USGS; studies by others show variation in absolute numbers but a similar direction. We are getting a handle on world oil resources, discovered and yet to be found. McCabe's study indicates that about 1/3rd of total oil reserves have been produced, with nearly that much discovered and waiting to be produced. The remainder consists of future discoveries and a similar (and growing) amount of reserve growth in existing fields.

Another study by Brian Maxted..

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Brian Maxted estimated a slightly lower total resource of 2.5 tbo vs. McCabe's 3.1 tbo and shows that 90% of future volumes will be discovered outside of North America. As we have seen, the discovery rate peaked worldwide in the 1960s – before most of us entered the industry – and that strat traps, always difficult to image, are up to 40% of recent discoveries from only 10% back in the 1950s.

Discoveries are down, most of the remaining oil is outside of N Amer, and what is left is hard to image. Where in the world are these remaining hydrocarbon resources located?

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On this slide, produced oil and gas are in gray, discovered resources are red, and volumes yet to be found are in cyan. Heavy oil is gold.

- Canada and Venezuela hold 70 % of the worlds heavy oil
- The remained is spread among numerous other countries. The FSU has about 10% of the heavy oil resource and the Middle East only about 1%.

Excluding heavy oil, the bulk of the world's remaining resources – discovered and yet to be found - lie in the Middle East and the former Soviet Union.
Although the Middle East has the largest resource, international oil companies have been largely unable to economically gain access here since the 1970's.

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Clearly, national oil companies (NOCs, e.g. Petrobras, Pemex, Pertamina, PDVSA, Nigerian Nat'l Petroleum Co., Petronas, etc.) control most of the worlds discovered (as well undiscovered) reserves.

- Thus western companies must continue to find ways to partner with them, and this may be critical to future growth.
- Russian Oil Companies are the next largest holder of reserves behind NOCs, and several majors have been working on joint ventures there

Exploration has been slow for the last 20 years, major petroleum supplies are located distant from consuming nations, and resources are largely controlled by national oil companies. It is therefore not surprising…

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The world has been flirting with net oil shortages for the last few years. Indonesia, a founding member of OPEC and a major oil producer for more than 100 years became a new oil importer in 2004. Note that supply increased steadily over the period shown here – the problem is increasing demand. Two related factors fuel an irregular but persistent increase in demand.

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World population growth alone accounts for some increases in demand. Western countries, led by the US, are profligate energy consumers, but these economies have slow to negative population growth and steady improvement in fuel efficiency. The problem is that developing economies account for most of the population growth, and those countries want cars, jet travel, and air conditioning just like the west. As a result

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Overall world fuel consumption from all sources has increased progressively. Coal, hydro, and nuclear contributed incremental increases up until the early 1990s, but most of

the world's rivers have now been dammed and environmental concerns have largely halted expansion of coal and nuclear energy.
Oil usage has been relatively flat, but notice the steady increase in natural gas. Let's examine that in the US Gulf of Mexico.

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Oil production is approaching plateau even in the relatively new deepwater Gulf of Mexico trend
But note that new plays for deep gas – and deepwater gas – are continuing to increase largely offsetting declines in the very mature shallow water fields.

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The US experienced a major shift in exploration starting in the mid 90's, when there were about the same number of rigs drilling for oil and gas. Rigs drilling for gas increased over the next 10 years while rigs drilling for oil declined, changing the ratio dramatically to a recent figure of 86% drilling for gas.

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In summary:
While production rates have exceeded discovery rates for the last 20 years,

- Large volumes of discovered oil remain undeveloped,
- in challenging areas that will require the best in technology and creativity for us to access

There will be exciting new discoveries in different areas of the world,

- but the decline in overall exploration success is expected to continue

The biggest prizes await those who are globally mobile,

- in areas like the Middle East and Former Soviet Union, and
- those able to work effectively with the cultures and bureaucracy of National Oil Companies

Challenging and rewarding careers are available now

- in both exploration and production
- where success will reward those with creativity and technical acumen.

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Oil and gas are not distributed uniformly, but they are distributed widely. Oil is indeed where you find it, and that now covers much of the globe. This slide has been updated several times since initially published by John Armentrout in 2000. For those interested in working – and living – abroad..

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Some preparation can make an overseas assignment a much more positive and enjoyable experience.

- Culture shock is very real, manifested in frustrations of not being able to communicate or find the things you need, absence of familiar food, and feelings of insecurity and intense isolation even when surrounded by people.
- Medical services may be much different or even lacking, and precautions may be needed to maintain your health and that of your family
- Personal security has become a global issue, but concerns and precautions vary widely by location. Security checkpoints, searches, and alerts can escalate personal and family stress levels while living abroad.
- Other concerns best addressed in advance include:
    - Keeping in touch with family and friends
    - Access to quality education and child care
    - Work permits and visas, which may be difficult and time consuming to arrange
    - And be prepared to make adjustments in many aspects of your life

A lot of geoscientists find these sacrifices small in comparison to the advantages of international assignments

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Advantages of living and working abroad include

- learning a new and perhaps very different culture
- Working on projects that may be breathtaking in size, scope, and technical challenge
- Higher levels of individual responsibility, where you not only need to know how to do everything, you are expected to transfer these skills to a national employee
- One of the greatest advantages of living far away was easy access to most of the rest of the world
- Many find the expatriate lifestyle attractive, which may include household staff and a driver in some locations
- Compensation is last on the list, but still an advantage. International postings generally have an uplift in salary which may vary from 5-40%. Do not expect to get wealthy on a typical 3-5 year assignment, however. Be aware that you will have increased travel and vacation costs, and it may cost more to maintain your lifestyle far from home.

At home or abroad, what careers are available to a petroleum geologist or geophysicist?

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(modified from Armentrout 2000)

In most cases, the petroleum geologist will be dealing with relatively small amounts of data and must learn how to interpolate and extrapolate from that limited data set to achieve success. This challenge is met by using all the tools and data available, evaluating the economic potential based on the interpretation of the data, and recommending a plan of action to management. Where else but in an oil company is a geoscientist going to find the resources to test geologic predictions with a well that costs millions of dollars?

One aspect of petroleum geoscience familiar to most students is fieldwork

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(from Armentrout, 2000)
Hard data from the field are needed at an early stage of many exploration projects, mapping surface geology, collecting data and rock and fluid samples. These are used to calibrate models and to project observations from outcrops into the subsurface. Seismic, gravity, and other geophysical data may also be acquired.
Key observations from surface geology include stratigraphy…

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(modified from Armentrout, 2000)
Stratigraphy is the study of the sequence, nature and distribution of rock units.

Stratigraphic applications in the petroleum industry include definition of porous and permeable units that serve as hydrocarbon reservoirs, those impermeable units that seal the traps, and organic-rich strata that source oil and gas accumulations. Many stratigraphic studies focus on characterizing the distribution and petrophysical parameters for

- reservoirs in existing fields, and
- predicting reservoir presence and quality for exploration prospects.

For Clastic systems, sandstones and conglomerates plus new plays for low permeability reservoirs in siltstone and even shale
Sequence Stratigraphy and both deep water and deltaic depositional settings must be understood in relationship to each other, not in isolation.
Forward modeling and rock physics modeling help reduce the risk of unknown alternatives and improve interpretation understanding.
Core, log and seismic data to refine existing predictive models. Also, compiling reservoir parameters for debris flows versus turbidities utilizing flume experiments.
Carbonates present special problems in relating modern environments to ancient deposits. Carbonates may form in situ, not linked by not linked by sediment dispersal systems such as rivers, deltas, and submarine fans. In addition, the distribution and characteristics of carbonate platforms have changed through geologic time.
Concepts for reservoir prediction and characterization in carbonates must combine knowledge of modern systems with age-based analogues
Time-specific spatial maps of carbonate reservoir distribution are important as interpretation aids.
Along with Sedimentary Modeling Incorporating both clastic and carbonate processes and geometries.
Forward modeling, using computer programs to simulate depositional processes constrained by local characteristics of the sedimentary basin, can be important to understanding both carbonate and clastic systems

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(modified from Armentrout, 2000)

Structural geology strives to resolve causes and effects of tectonic processes to better image the geometry of rocks at the surface and in the subsurface. It is used to define subsurface traps for hydrocarbons with log, seismic, and other data such as gravity and magnetics.

Physical modeling provides guidelines for interpreting structural features and resolving ambiguities, such as

- this seismic example of extension followed by compression and structural inversion (uplift of a previous low), and
- an oblique slip model to illustrate orientation and timing of complex fault patterns

Kinematic computer modeling, restoration of the geologic forces and movements, is also important to determine in 3D the magnitude and direction of slip on faults.
Geochemistry also plays an important role

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(modified from Armentrout, 2000)
Geochemistry plays an important role in petroleum geoscience
Analyzing organic richness, characteristics, and thermal maturity of potential source beds to predict
volumes
nature (oil vs gas)
and even quality of hydrocarbons available for exploration
geochemical biomarkers in oils act as "fingerprints" that can be matched to specific source strata
Petroleum source rocks vary from terrestrial woody and herbaceous kerogen to algal lacustrine deposits, coal, deltaic, and deep marine algal sources – each with specific characteristics
Geochemistry helps determine petroleum sources, age, and timing of migration – all critical factors in exploration.
Recently, variations in oil geochemistry has been used to define individual reservoir compartments in highly faulted fields
Reservoir geochemistry is one aspect of the broader field of reservoir characterization..

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(modified from Armentrout, 2000)
Reservoir Characterization integrates all available data to define the geometry, distribution of physical parameters, and flow properties of a petroleum reservoir. The goal is to accurately and quantitatively model reservoir architecture, connectivity, and flow properties such as porosity, permeability, and fluid saturations. This may involve expertise in sedimentology to define reservoir lithology and geometry, definition of flow units and boundaries within the reservoir, and computer simulation of fluid movement and changes in reservoir properties during production.
Geologic models help capture reservoir heterogeneities as well as uncertainties resulting from sparse well control, inadequate resolution on geophysical data sets, and problems

with indirect measurement of reservoir parameters from seismic, log, and production data. These models of the reservoir may aid in more accurately estimating the probability distribution of hydrocarbon volumes, assist in geosteering wells to optimum locations, and provide input to reservoir simulation.

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(modified from Armentrout, 2000)
Computer simulation remains important to guide production throughout the life of a reservoir. History matching the computer model with actual data over time for parameters such as oil/water and gas/oil ratios, fluid volumes, and surface and downhole pressures produces a progressively more accurate picture of reservoir performance. This can also indicate irregularities in drainage, unswept compartments, and guide reinterpretation of reservoir geometry to match conditions in the subsurface.
Computer simulation combines production, petrophysical, subsurface, and seismic data to provide the best possible characterization of a petroleum reservoir. This challenging endeavor requires close collaboration of geologists, geophysicists, and petroleum engineers.
The oil and gas industry needs talented and creative geoscientists to fill these and many other challenging roles. What are the expectations of these employers?

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(modified from Armentrout, 2000)
Recruiters will check transcripts to confirm that candidates are well educated, but they look for more. Computer literacy is required, but also some "soft skills," such as ability to excel in a team environment and good communication skills. Perhaps most important is motivation, being a self starter oriented towards achievement. Regarding technical skills…

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Dr. Chris Heath conducted a survey of medium to large oil companies in 2002. Although there were differences, he found all companies to favor an educational background that combined a solid foundation of science with computer competencies and some non-technical background. Geology and geophysics courses are important, including experience in fieldwork and mapping.
The top technical skills required by employers include the basic tools for petroleum geology. While structural geology is not listed, knowledge of structure and tectonics is likely implied in mapping and regional geology.
Regarding Computer Skills..

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Dr. Heath's survey shows that basic PC skills are the foundation for everyday work throughout the industry, from office towers in Houston and Beijing to wellsites in remote rainforests of Sumatra. You must be able to knock out a memo in Word, analyze data in

an Excel spreadsheet, and present results with PowerPoint. Once we figure out how to properly handle email, that will also be added the list.
Workstation skills are a big plus if you can get them. For geologists, these include mapping, well log correlation and cross sections, and log analysis. Geophysicists should try for experience in 2D and 3D seismic interpretation. It is not necessary to work on a Unix box; some PC systems perform as a geoscience workstations.
What about non-technical or "soft" skills?

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Dr. Heath's survey emphasized the importance of motivation and interpersonal skills to geoscience employers. Personal traits of initiative, integrity, and enthusiasm top the list, followed by interpersonal skills of teamwork and communication. The ability to perceive and communicate key issues is important to problem solving in everyday work.
These skills are critical to success in today's work environment.

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As illustrated in this slide from Dr. John Kaldi of the Australian School of Petroleum, technical work throughout the petroleum industry is now conducted by multidisciplinary teams in a collaborative environment. Workstations may be located in individual offices or cubicles or in common areas, but the emphasis is on communication and collaboration. A well recommendation may be a joint project involving a geologist, geophysicist, reservoir engineer, and drilling engineer. To facilitate the process, many companies provide "visualization rooms" or "collaboration centers" with projection equipment and access to all geological, geophysical, and engineering data. Teamwork and communication skills are as critical to success as technical expertise in this environment.
We have covered the basic skills that employers seek in new hires. Next, let's look at how you can direct yourself into an exciting and rewarding career in geoscience.

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A key strategy to igniting your geoscience career is to set goals, and do it now –

- Consider what you like and what you are good at, and choose the direction
- This might be stratigraphy to support a career in petroleum exploration and production, or petrophysics to work in reservoir characterization
- Take note of remaining coursework, field or thesis studies, and desired summer jobs or internships and determine your timing

Even with lots of recruiters on campus, expect to compete

- Know your strengths and maintain as much versatility as possible in areas like location and job assignment
- Above all, be persistent and patient

Networking is important,

- among your peers on campus and with professors, recruiters on campus,
- and other professionals you may meet in society or campus events

Now and throughout your career,

- it is important to keep growing in technical knowledge and professional competency
- Find someone more senior as a mentor – a professor, someone in industry, or even a student some years ahead of you
- And always be alert to developing new skills

Professional societies like AAPG can help, now and throughout your career.

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Societies like AAPG bring you into contact with experienced professionals, so you can learn first hand what lies ahead

- Events like luncheon talks, short courses, field trips, and conferences expand your knowledge in both technical and practical areas
- and expose you to leading scientific experts and captains of industry

What you get out of professional societies depends on what you put into them, and

- participation on committees and volunteering for events
- expands your skills in working with people and organizations

Active participation provides important networking opportunities
and support that helps you throughout all stages of your geoscience career
AAPG also has direct benefits for students…

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AAPG membership brings top geoscience publications to you each month

- AAPG Bulletin, one of the world's most highly read and respected geoscience journals
- the AAPG Explorer, a "must read" magazine covering both domestic and internal arenas with the latest in geoscience news, events, and commentary

Discounts on AAPG books are available to student members, and

- Student Chapters receive an extra $500 in AAPG books that they select every 3 years
- in addition, the AAPG Publication Pipeline has provided tons of technical books as needed reference materials for universities in developing countries

The Grants in Aid program is an AAPG benefit available for all graduate students

- providing direct financial aid to support for masters and PhD research

Another important financial benefit from AAPG is the Weeks Grant
provided annually to Student Chapters that meet basic requirements

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For AAPG Student Chapters that meet basic membership and reporting requirements
A bequest from L.G. Weeks provides major cash awards
These may vary slightly from year to year but are in the range of about

- $500 to the Student Chapter.
- and another $500 to a student selected by the Student Chapter

The Weeks Grant award to the Student Chapter can provide a major boost for activities

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Reports from AAPG Student Chapters describe some great activities that would appeal to just about all of us. These include

- Distinguished Lecturers and Visiting Geoscientists, experienced (and sometimes world renown) professionals who visit campus to share their knowledge and experience with students and faculty.
- Informative short courses, many times arranged with support of industry to show practical applications of geoscience
- Exciting and educational field trips, such as this excursion into the rain forest of South Sumatra to explore for ancient Hindu artificats from the 7th century using modern geophysical methods.
- Students participate in conferences such as domestic and international AAPG meetings, which now include presentations in both oral and poster sessions, and
- Many other events arranged to benefit the student members. These vary from outreach trips to encourage geoscience among high school students to regional leadership conferences and participation in events like "Earth Day."

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What happens after you graduate? How does AAPG fufill it's self described mission of becoming essential throughout your geoscience career?

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The AAPG Value Pyramid lists specific programs to answer needs of professional geoscientists throughout their careers

- These begin with a solid technical foundation, provide leading journals to members in both hard copy and electronic format.
- Next in line on the pyramid are professional programs like Distinguished Lecturrs and Visiting Geoscients plus outreach programs, including Grants-in-Aid, membership benefits, and assistance for students and student chapters. Above these are
- Professional events and activities, such as meetings and conferences, certification and professional affairs, short courses and e-Learning, field trips, and digital and hard copy books
- For more senior members, AAPG supports mid-career training centers and access to health care and retirement benefits
- Professionalism caps the pyramid, with ethics presentations and training, support of geoscience in education and the new AAPG office to provide accurate scientific information to the government, and networking throughout the global community of AAPG professionals.

AAPG is an important advocate of professionalism in geoscience

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Ways in which AAPG supports professional standing include

- Maintaining a firm code of ethics, clearly communicated to members via presentations and publications
- Professional qualifications, requiring a degree in geoscience and 3 years experience (or an advanced degree plus 2 years experience)
- The AAPG Division of Public Affairs takes this even higher, with certification of petroleum geologists or petroleum geophysicists, and coal geologists. Certification requires more professional experience (8 yrs, less with advanced degrees), a sustained record of the highest professional and ethical standards, and sponsorship by 3 certified geoscientists.
- AAPG meetings, field trips, talks and receptions provide networking opportunities with a broad cross section of the global geoscience community
- You are encouraged to present your work at dinner meetings and conventions, which provides excellent experience in communication skills, discussion, and feedback from peers
- With regional meetings, annual conventions, and international meetings
- AAPG also presents prestigious awards to its members for outstanding accomplishments and service, which are recognized as high honors in the geoscience community

Thank you.

End of notes.