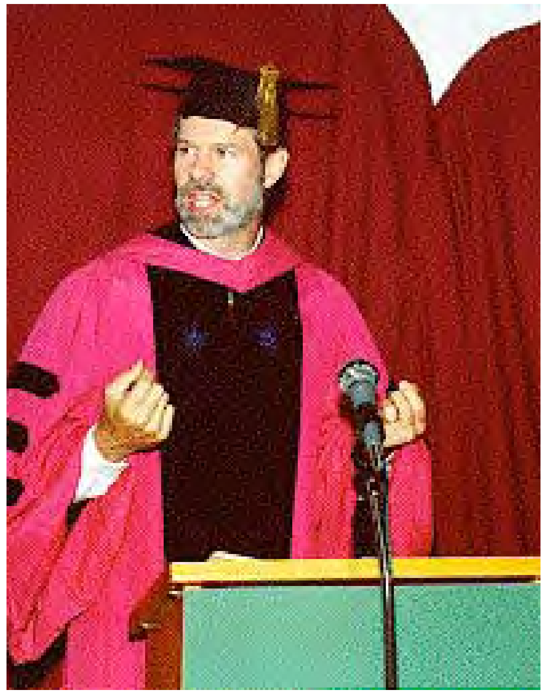
Spring 1998 Commencement Address

Dr. Robert M. Hazen

May 9, 1998

Dr. Robert Hazen, Professor of Earth Science at George Mason University and Staff Scientist at the Geophysical Laboratory of the Carnegie Institution of Washington, gave the spring 1998 commencement address below. Dr. Hazen studies the relationships between crystal structure and physical properties, for high-pressure phases in particular. He has more recently shifted part of his focus to organic systems at high pressure.



Prof. Çoruh, distinguished faculty, students, parents, friends, and most especially honored graduates:

Congratulations! You did it! Sit back, relax, and savor the moment. Today I have the pleasant responsibility to deliver a charge to you. So, as you enjoy what you have accomplished, I ask you to think for a moment about what lies ahead.

As of today, when someone asks what you do, you can answer honestly and with pride, "I'm a scientist." My experience has been that such a response generally leads to one of three reactions.

Most commonly it'll be a kind of, "Oh, really?", followed by an awkward pause. On the other hand, if the questioner is another scientist, a technical conversation will usually follow, with a healthy dose of specialized jargon to establish competency and, perhaps, a pecking order. Now watch out: theoretical physicists always think they're at the top, but you can deflate them pretty quickly by describing your last arduous and harrowing field trip -- be sure to throw in a story about a bear, even if it isn't true.) Then there's the person who, upon hearing of your scientific pedigree, has a million and one questions -- about genetic engineering, black holes, and this really neat rock they picked up at the beach last summer. Now this can be a drag -- unless, of course, you find the questioner particularly attractive.

So many people have questions for us. You see, a myth has arisen in our time that scientists have all the answers. That's not true. But what may, perhaps, be true, is that we are more acutely and joyously aware of how much we don't know, and we are relentlessly driven to seek explanations for what we don't understand. It is in vogue in some academic circles to debate the nature of reality and what it means "to know." Historians and philosophers of science these days ask if scientific truth is absolute, and they argue about whether the pursuit of scientific knowledge is progressive or rational.

Most working scientists find the questions posed by philosophers of science mildly intriguing, occasionally annoying, and largely irrelevant to their day-to-day efforts. We believe that the only practical way to understand how the universe works is to ask questions that can be answered by making observations, performing experiments, and devising models that are independently reproducible and verifiable. We believe, perhaps with naive optimism, that many attributes of the physical universe can be known with certainty, and that the scientific process of observation and experiment is quite simply the best way to discover these traits.

Given that premise, which I daresay is shared by the vast majority of people who do research for a living, we can recognize three broad categories of factual knowledge. The first category of knowledge encompasses facts that we know to be true based on reproducible observations. We know the Earth is round (sort of); we know that younger sediments are laid down on older ones; we know that living things on Earth are formed from carbon-based molecules, and that this life has changed over billions of years of geological history.

Our cumulative scientific knowledge is vast -- much greater than any individual could grasp. Your degrees, conferred today, are a symbol that you have mastered a small fraction of that knowledge -- just enough, in fact, that you'll be able to go on and learn much more, if you chose to do so.

A second category of knowledge includes everything that we know we don't know -- and I'm not just talking here about the questions you missed on that last final exam. To be sure, much of this unknown information is trivial and uninteresting. It's doubtful that anyone has bothered to determine the electrical conductivity of peanut butter or the effects of AM radio waves on amoebas, although the measurements could be made easily enough if we wanted to.

But much of what we know we don't know is profoundly exciting and important to obtain. Finding an environmentally safe repository for nuclear waste, discovering a cure for AIDS, or discovering an unusual new life form will change our world and influence our lives. Discovering things we know we don't know, furthermore, often opens new doors to scientific inquiry. The discovery of the structure of DNA four decades ago, for example, was one of the most widely recognized and passionately pursued problems in science. While few scientists could have anticipated the revolution caused by molecular genetics, many knew that any deep understanding of life had to wait for the breakthrough discovery of what we now know as the double helix.

In earth science today there are numerous, compelling unanswered questions that will continue to drive research (and, by extension, also provide jobs for earth science professionals). Here are just a few of them:

- The history of earth's climate, and especially the mechanisms of climate change. This question is critical in discussions today of global warming.
- The distribution of earth's resources, and the most benign methods of exploiting those resources. Many of you will find challenging jobs in that economic sector.
- The influence of humans on earth's environment, and the search for effective and economically feasible ways to mediate any negative impact. As human population grows, this question becomes more important.
- The history of life on earth -- its origins and evolution; and the exciting possibility of life elsewhere in the universe.

- The mystery of the earth's deep interior -- the dynamic region that drives plate tectonics. This is the realm of geophysics and the seismologists, as well as mineral physics -- a field to which Virginia Tech's distinguished Prof. Gerald Gibbs has made such an important and lasting contribution.

These and dozens of other fascinating, important, and world-altering questions await the researcher in earth sciences. A life can be well spent seeking answers to those things we know we don't know.

Finally, there exists a vast store of knowledge that we don't know we don't know. Think for a moment about things that you don't know you don't know.

You can't do it. One of the most exciting aspects of science is the discovery of completely unexpected new objects and phenomena that no one could have imagined. X-rays, viruses, lasers, polymers, superconductors, dark matter, distant galaxies -- the list of amazing discoveries in the last century alone is astonishing. In earth sciences 100 years ago no one had thought of black smokers, mantle convection, ozone holes, 3-billion year old fossil microbes, mid-ocean ridges, or most of the dozens of sophisticated analytical machines and computer techniques that we use in seeking answers. How many more extraordinary discoveries await scientists and science watchers? We have no way to predict the nature or impact of such discoveries.

And, so, I want to leave you with three pieces of advice to take with you -- to help you cope, no matter what you chose to do with your degrees in earth science. First, never stop learning. What you learned in the science classroom yesterday is subject to revision and amplification tomorrow. When I entered MIT as a freshman, every textbook proclaimed that the Earth's major features -- the oceans and continents -- were fixed and immoveable.

Now, it turns out, they're all moving. What was once stable crust is now being formed and swallowed up at an alarming rate -- geologically speaking. All ideas in science are subject to change, as we learn more and refine our theories. This is a good thing, but it means you have to stay on your toes.

Second, expand your horizons. You have degrees in "earth science," but nature knows no such arbitrary boundary. Many of the most critical problems facing our society -- concerns about resources, health, and environment -- are broadly interdisciplinary. Take nuclear waste disposal -- a key problem that some of you may help to solve. The earth sciences must play a key role, but if you are going to make significant headway you also have to become an expert on the physics of radioactivity, the chemistry of isotopes, and the biological effects of radiation. And the problem will never be solved without a healthy dose of economics and politics, to boot.

So pay attention to the exciting advances in other disciplines. And, finally, never stop asking questions. Our schooling sometimes makes us feel that science is about memorizing answers. But nothing could be farther from the truth. Science is the art of asking questions that can be answered by reproducible observations and experiments. Every great discovery in science starts with a well-crafted question. And the formulation of a new question is often more significant than the discovery of its answer.

We almost certainly have yet to recognize and ask many of the most profound questions about the universe. As William Harvey observed in the dedication to his great 1628 treatise on the circulation of blood, "All that we know is still infinitely less than all that remains unknown." The true measure of scientific progress is thus not so much a catalog of those questions we can answer, as it is the list of the questions we have learned to ask. And for as far ahead as anyone can foresee, there will be no end to the questioning. That is the adventure that a life in science offers.

You are now part of that greatest of human adventures. So I say to you congratulations! Well done! And, let the party begin!

Fall 1998 Commencement Address

Dr. James R. Craig

The Real World

December 19, 1998

James. R. Craig has been at Virginia Tech since 1970, and a full professor since 1978. He was Department Chairman 1990-1994, and has been on the Academy of Teaching Excellence since he won the Spron Award in 1976. He has served on the Virginia Waste Management Board, among other state offices. He has published numerous articles and books on his research fields, which encompass ore mineralogy, ore deposits, geochemistry phase equilibria, resource analysis, ore microscopy in corrosion, and materials applications.

Thank you Dr. Torgersen:

Dr. Torgersen, colleagues, graduates, and guests

I am honored to be the speaker today - especially since the choice was that of the students.

You have given to me what every professor dreams of - time for an extra lecture - to say those things I forgot, never got to, or that I wanted to reemphasize. Actually, rather than a formal lecture I want to emphasize that you are about to take another major step in your education. You just thought you were done! Nothing could be farther from the truth! You have been, to a large degree, sheltered, pampered, and lovingly supported to give you time to mature, to select careers, and to develop a knowledge base so that you can pursue those careers. But now it is time for you to face the "real world". These past four years have been practice - now comes the real thing.

In teaching, I always show quotes at the beginning of each class - small statements that express my view of the world. The one I generally use on the first day of each semester is by Oliver Wendell Holmes, the great Supreme Court Justice: " A man's mind, once stretched by a new idea, can never return to its original dimension". Here, at the University, our primary job has been to do just that - stretch your minds. We hope that they are now much different, much wider, and much deeper, than they were when you arrived. Not only that, we hope that they have a lot of flexibility still left in them and I can assure you that the "real world" is going to stretch you - sometimes in ways you would not have chosen.

You are living in a world that is changing more rapidly than at any time in history, and that rate of change only promises to increase. In your short lives, world population has increased 50 percent (from 4 billion to 6 billion); in the remainder of your lives, it will increase another 50 percent (from 6 billion to over 9 billion). The world consumption of just about everything is at an all time high and no doubt will go higher as each is driven by the enormous growth in population and advances in technology.

With this brief scenario, let me give you three points that I hope you keep in mind as you enter the " real world". Although these are from my arena of interest and activity, they are equally important to all of us. These points are:

- You are, and will remain, dependent upon the Earth for you resources and energy needs.
- There is no "free lunch" - every demand you make upon the earth has complex interconnections to other things and often there are effects you did not intend.
- We are more and more interdependent - and we cannot, as individuals, or as nations, be isolationist

Let me examine each of these briefly:

1. Despite John Glenn, the lunar rover, the Martian lander, the Hubble telescope, and the new space station, we shall not, in my lifetime, and probably not in yours, derive a single usable resource from any body other than the earth. This most beautiful and productive of the planets is unique to our solar system, and perhaps to the Universe - and it is the only home we have. Unfortunately, this magnificent sphere, with just the right temperature, atmosphere, light, water, and vegetation for us to live, is showing quite a bit of wear and tear. Our foot prints are more numerous, more frequent, and more intense than they have ever been and we have begun to erode nature's fabric.

2. The concept of "no free lunch" is certainly not a new one, but it is one of which we all need to be frequently reminded. You cannot have a glass of water without there having been expended energy to drill the well, or run the pump, or make the pipe - or even melt the sand to make the glass. You cannot have that gallon of gasoline with out there being a well, a pipeline or tanker, a refinery , a distribution system. Each of these activities requires that some form of energy to expended - and every form of energy has impacts in the holes left, the heat generated, and the emissions released. The extraction of almost anything from almost anywhere leaves an impact - we rarely complain about having the resource available, but we complain about the eyesores of the holes left and spills made.

Our world is increasingly technology-rich and technology-dependent. That trend will continue to develop over the next 40 years of your working lives, and will require large and dependable quantities of electricity. That demand permits the quick consideration of the complex relationships of which I spoke. Our primary means of generating electricity (and no doubt the primary means for the next 25 years at least) is by burning coal. The process is simple in concept - burn coal, generate heat, use that heat to convert water into steam, use that steam to turn a turbine and generate electricity. But there are a host of other impacts that are completely invisible to the user of the high tech computer or laser or other device. Every step, from the mine, to the combustion, to the disposal has an impact, many of which we do not like. There can be problems of dust, acid runoff, acid rain, carbon dioxide release, surface subsidence, gas explosions, and ground water loss. These are the negative effects resulting from a perfectly positive generation of the electricity that we need. They are predictable if we shall but think ahead; there are many effects that we cannot totally prevent but we can mitigate and plan for - we can weigh the positive effects relative to the negative effects, but we cannot just ignore them. It takes citizens who have some vision and who are willing to think ahead. You are those citizens.

The generation of the carbon dioxide has become a particularly important issue - not only for us, but globally. We now recognize the carbon dioxide is a heat absorbing gas and there is the strong likelihood that it is a major contributor to "Global warming". But there is no way to burn the coal without generating the carbon dioxide and there is no realistic alternative to the burning of coal for electricity generation in the U.S. for the next several decades. We have entered into the Kyoto Protocol, an agreement of some 150 countries, to limit and actually reduce carbon dioxide emissions into the atmosphere. Now, the problem is how do we do this while burning more coal to make more electricity? We cannot prevent carbon dioxide generation, but we could try to capture much of the carbon dioxide and then try to store it - schemes range from pumping it into the deep ocean, to stuffing it into deep aquifers, to pumping it into exhausted oil field reservoir rocks. All of these are very expensive propositions and some have completely unknown environmental effects. We must cut the emissions, but we also must think ahead as to the consequences of the method we select and whether or not we are willing to pay the price. When we look back on our decision 50 or 100 years from now, will we be satisfied that we made the right decision? Such considerations are not always easy, but they are necessary.

In contrast to such future consequences, sometimes there are consequences from the past. About three years ago, Interstate 70 in Ohio collapsed into an old coal mine some 50 years after the mining - the mine's presence was unknown to the Interstate highway builders. The Interstate remained closed for several months when they discovered that the old coal mine lay under about 1/3 of a mile of the road. In another similar incident, the main street of Silver City, Nevada collapsed into a mine shaft that had been dug more than one hundred years ago.

This leads to a very important consideration - many of the effects of actions are:

- - invisible
- - far removed
- - much delayed in time

We do not see the build up of carbon dioxide - it is happening but it has no visible presence
We do not see the down wind, or down slope, effects of the emissions or runoff we create
And often, because we see not an immediate effect, we assume that there is no effect - in fact it may be 50 or 100 years delayed

The point is that we - you and I - need to remember to try to see some things that are not immediately obvious: we must learn to see around corners, look under the carpet, and we must take a longer term point of view. That is, we must anticipate consequences that might result 1 year, 5 years, or more ahead. This does not mean that we do not use resources or that we do not develop any thing, but it does mean that we need to think far beyond the present if we are to preserve a livable planet.

Some thirty years ago, a decision was made to channelize the Kissimmee River in central Florida to reduce some flooding. The flooding was minor and mostly it was a political pork-barrel operation. Nevertheless, 102 miles of the meandering river was reduced to a 58 mile channel through which water could flow more quickly and hence not back up as a flood. To make a long story short, it was discovered that water quality fell, Lake Okeechobee became polluted, 90 percent of the birds disappeared, and the Everglades began to dry out. These consequences were all predictable; unfortunately, no one was thinking ahead to the 2nd and 3rd effects. Now, the state and federal government are undoing the work and returning the Kissimmee to its original condition in order to undo the damage. The problem is that what cost $29 million to do is going to cost $7.5 billion to undo!! In other words, what we had for free, we shall pay $7.5 billion to get back.

3. The third point is that we are ever more dependent on each other as individuals and as countries. The U.S. Geological Survey's "import reliance" diagram for 1997 demonstrates that we are dependent upon 43 other countries as the principal suppliers for 50 major mineral resource materials. If you also consider oil, that list rapidly exceeds 50 countries. I suspect that a thorough listing of those resources would reveal that there is hardly a country on the face of the globe from which we do not import some mineral material.

In the past three days, we have heard again of military action in the Middle East - against Iraq. There was a time when we did not much care what happened in that part of the world. But today we know that the Persian Gulf region contains more than two-thirds of the world's known liquid petroleum reserves and that OPEC, dominated by Persian Gulf members, controls more than three-quarters of the world's liquid petroleum reserves. Should we be concerned about what happens in the Middle East - you bet we should! You may be buying gasoline today at historically low prices, but that situation could change overnight if OPEC were again to operate in a coordinated manner - regardless of the reason. We are now more dependent on foreign sources for our oil both in terms of quantity and percentage than we were when we were severely hampered by the OPEC embargo in 1973. You say this is ancient history - perhaps, but you are part of a generation with a love affair with Sport Utility Vehicles, trucks, and high-powered cars. Historians have noted "those who do not remember history are bound to relive it". Trust me, you do not want to see the embargo. Can we stop all bad things from happening? Certainly not, but next best thing to preventing some problems is at least anticipating them and being ready if they occur.

Most things are more complex than are apparent on the surface. I do not suggest that you be paranoid about looking for problems that do not exist, but rather that you remain diligent . In the mining industry, they use the term "due diligence". It means to check something out before investing in it. In the past three years we witnessed the promotion of what was billed as the largest gold discovery made in the past 100 years. It was a gigantic deposit in Indonesia called Busang and it had as much as 200 million ounces of gold. News of it swept the financial world and the stock rose from $0.08 to $210 per share - millionaires were popping up all over - one entire town in Alberta, Canada had nearly every person invested - using their homes, theirs inheritance, their retirement funds, etc. Since the company that discovered it was too small to develop the mine, they prepared to sell out to a much larger world-scale company for several billion dollars. However, the larger company, before putting any money on the table, conducted its "due diligence" - that is they redrilled holes and reanalyzed samples. When the word came out that they found no gold, they withdrew their offer, and the stock of the first company fell like a rock. More than 2 billion dollars of real people's real money evaporated in less than 30 minutes and a lot of people were left with nothing! The world is indeed complex - not only that, there are many who would capitalize on your failure to do your "due diligence".

The world has never offered more opportunities - but also it has never been so complex - and never has it been so necessary for you to look around that corner, under that carpet, and to think ahead. We have tried to stretch your minds as much as we could - I just hope that you never stop that stretching process.

I congratulate you on your graduation and wish you the very best in the future.

Spring 1999 Commencement Address

Dr. Frank Press

Earth Sciences: Contributions to Science and Society

May 15, 1999

I appreciate your invitation to participate in your graduation festivities, particularly because it is in my own field of Earth sciences, because Virginia Tech has such a fine reputation, and because as a former college teacher I know what commencement means to students and their families and to their teachers.

Bob Hope was once asked to talk to a graduating class about to go out into the world. An expectant audience awaited his advice. And advice he gave them. He said: "Don't go".

Well, I'll say more than two words; but, like Bob Hope, I won't do too much advice giving. I suspect that by now, with the completion of your studies, you're a bit overdosed on suggestions on what to do with the rest of your life.

Rather, I'd like to paint for you the sort of world you're now entering. It's no secret that you are entering a changed world, with "changed" a euphemism. Upheaval is more like it. We've seen enormous changes, and a new instability in global geography and politics. We are seeing changes in the enormous success of how the economy of the United States operates. On the other hand, Japan, the paradigm for economic success in the 1980's, is now in deep recession, as is France and Italy. Germany is still struggling with reunification. Russia could collapse into chaos any day now. These are today's realities. They cannot be wished away. Yet, I will argue, briefly, that we may be looking at the hole instead of the doughnut, that all of you face a world which is richer in promise and in challenges than the world your counterparts faced a few decades ago. A pollyannish outlook is an occupational hazard of commencement speakers. I certainly know that we face difficult social problems in our country, and social and economic problems throughout the world.

I would like to make the argument of a world of new opportunities that are being generated by the scientific, technical, and knowledge revolutions underway. I would like to sketch a new world of opportunity, made possible by science, but not only for scientists and engineers; it is a world of opportunity for the social scientist, the business person, the humanist, the artist -- all of the newly minted graduates, seeking a rewarding life and fruitful careers. One reason I believe that unprecedented opportunities are before us is because we are now in a golden age of science. That wealth of discovery will be part of your lives. The pace of discoveries is incredible. Whether it is the history of galaxies or the structure of atomic matter or the nature of genes and their control, or the new understanding of Earth derived from plate tectonics, we see a richness of discovery that marks a golden age. We are seeing new fields being created around us, others coming together to exploit new insights. In turn, we will see these discoveries transforming technologies, so that new industries are created and old ones given the musculature to create wealth for more people in a global economy. New knowledge and its use are becoming the coin of the realm. In fact the extraordinary success of the American economy in this decade, in the creation of jobs, and the growth of new wealth for everyone, can be attributed to technological innovation and productivity increases made possible by advances in science and technology and by a new generation of managers who know how to use these advances.

This is especially so with core technologies transforming our economy, which grew out of science. A partial list of these core technologies includes:

- electronics, such as the ubiquity of chips in everything from sewing machines to carburetors;
- communications and information processing;
- specialty materials, in which we now design materials to suit the need. These include new ceramics, used increasingly in electronics, eventually will make such things as more fuel efficient automobile engines.
- artificial intelligence and robotics;
- airframes and avionics;
- computer aided design and manufacturing;
- advanced manufacturing technologies;
- natural resource exploration and development in environmentally sensitive ways; and,
- biotechnology.

Some of the technologies altering our economy aren't as easy to capsulize. But they are just as important. Here are a few examples drawn from the Earth sciences. The first deals with resources. The minerals fuels industries are being transformed, driven by some underlying science, most notably the ideas of plate tectonics. These ideas help explain the face of the Earth -- the shapes and sites of its continents and seas, mountains and valleys. And they give us better ideas on where to look for oil and ore deposits.

That underlying science has been joined by a suite of new technologies such as ground technologies such as 3-D and 4-D seismic exploration, and seismic tomography for profiling the interior of the Earth; satellite technologies for looking for tell-tale clues on where to find mineral and petroleum resources, and deep sea robotic vehicles for finding mineral deposits associated with hot springs on the sea floor at ocean spreading centers.

Here are three other examples of the economic and social contributions that are being made by Earth scientists. The United States probably would not have negotiated a nuclear test ban treaty when it did, if university based earth scientists had not developed methods using sophisticated signal processing to detect tiny clandestine underground nuclear explosions and to tell them apart from tiny earthquakes. With this technology a potential treaty violator would not even try to hide the test of a nuclear weapon.

A terrible legacy of the cold war is the contamination of the subsurface vadose and groundwater zones by nuclear wastes and toxic organic chemicals. At some 10 contaminated sites across our country, clean up or the stabilization of these wastes to halt the contamination of aquifers and rivers, will take many decades and will cost the taxpayers hundreds of billions of dollars. Earth scientists are playing a key role in finding innovative, lower cost and accelerated solutions to this serious national problem.

Subsurface contamination is an example of a new frontier for geologic research -- the uppermost few kilometer of the Earth. These are the layers on which our structures are built, where destructive earthquake waves are magnified, in which our underground water supplies need to be conserved and protected, in which sites can be found for the safe containment of nuclear wastes.

I would like to draw an example from my own career as an Earth scientist that illustrates how the golden age of science and technology combined with global cooperation can improve the human condition. In 1984 I made a proposal to organize the International Decade for Natural Disaster Reduction (IDNDR). The idea was to disseminate and use the remarkable progress in Earth sciences, structural engineering and related fields in a world program to reduce the tragic losses from earthquakes, volcanic eruptions, severe storms, floods and other natural disasters. The proposal received the enthusiastic support of thousands of scientists and engineers.

The potential for the IDNDR to reduce the tragedy of disasters can be appreciated by citing a few statistics and a case history. During the past twenty years earthquakes, floods, storms, volcanic eruptions and other natural disasters have killed about 3 million people worldwide. More than eight hundred million people have been adversely affected. They have suffered homelessness, ill health, severe economic losses, and personal tragedies. The impact of these hazards is growing worse by the year despite our increased understanding of them because of the movement of population to urban centers and the coasts. Economic development is set back as scarce resources are diverted to emergency and recovery efforts.

The IDNDR was launched in 1990 as a program of the United Nations involving some 149 participating countries. It is now drawing to a close. More than 100 countries have organized projects, most for the first time, to assess their nation's risk and to explore the use of modern technology and new scientific understanding to reduce their country's vulnerability to natural disasters. A tenet of IDNDR is that the less developed countries where most disaster casualties occur would be aided by the more advanced nations. This is now beginning to happen, with success stories beginning to emerge, of disasters mitigated and thousands of lives saved. The community of scientist can be proud of this global humanitarian contribution.

As always, context is important. We need to see that all of the technologies I have mentioned, and the era they symbolize, mark a historical watershed. Modern industrial society has been transformed by four technological revolutions. The first revolution was that of steam, to drive engines. The second was that of electricity and of fossil fuels. That revolution changed everything -- the scale and style of our buildings and cities, our clothing, medicine, transportation.

Now we're witness to the third revolution that you are part of. This is the information revolution -- the joining of computers and communications, to create wholly new industries, to organize services electronically, to transform how we communicate and use information. Some political scientists credit the changes in eastern Europe and the growth of democracy to the transistor and the information revolution it spawned.

And we are at the edges of a fourth revolution in which the biological sciences and the earth sciences will be among the major drivers. This is the exploitation of our understanding of how cells are built, work, and copy themselves. This is the use of Earth sciences to safely and cleanly draw material resources from the earth. That fourth technological revolution has created new industries, new ways to detect and treat terrible diseases, and to make old products in new and often better ways. You have learned as Earth science majors that humans have become a more important agent for changing Earth=s surface than geologic processes. The fourth technological revolution will also show us how to conserve Earth=s resources, to recycle them or find substitutes. If we must draw them from Earth, we will learn to do so efficiently and without despoiling our environment.

Where is science in this? Look at the revolutions that transformed our world. That of steam was done without science; thermodynamics came after the steam engine. The revolution of electricity and fossil fuels was partly edisonian (Edison was a brilliant tinkerer rather than a scientist). It was also partly science -- the creative use of fossil fuels owing, for example, to the special genius of chemistry and geology.

These revolutions were all created by science. The transistor came out of solid state physics. Recombinant DNA and other biological technologies came out of molecular biology. Progress in understanding global climate change, protecting the ozone layer, mitigating natural disasters, new ways of finding oil and gas fields all came out of the Earth Sciences.

What's happening, of course, holds great meaning for you. Wayne Gretzky, who retired a few weeks ago, perhaps was the greatest hockey player ever, was once asked why he was so good. He answered that he "skates to where the puck is going to be, not where it's been."

The point is universal. And it applies to you. You have spent years immersed in your studies. I'd argue that what you've been taught has less to do with getting ready for a specific career, and more with "skating to where you want to be." I say that knowing the fine reputation of this fine school.

Why would I praise the fact that your education probably had little to do with getting ready for a specific career? Because, as Gertrude Stein once put it, *there may be no there, there. Any job you tried to train for may be gone by the time you get there.* Again, that is a universal truth. The economic change is happening so fast, that what matters is knowledge and the will and ability to use it and to continually acquire it. You'll bring those abilities to our nation's economy. In doing that, you'll, as the Chinese say, live in interesting times.

You'll be swept up by deep changes in the world economy --from national to global markets, from Western Europe to North America and East Asia, from markets that are defined by information and computer links and no longer by a place. Markets that once seemed secure can quickly disappear; assumptions that seemed sensible can fall apart.

How do you manage in a world where within a few years a single product, a microprocessor chip, can transform how we live? Pretty good answers come from a philosopher, sort of. The philosopher is Damon Runyon, unknown to many of you, but maybe not to your parents. Runyon pointed out that "the race is not always to the swift and the strong. But, that's the way to bet." I will bet that you will manage well owing to your ability to acquire and use new knowledge, a skill that you take away with your degree.

And so despite the reality of today's headlines I want to leave you with a message of opportunity. In the century to come, in which you will spend most of your lives, the golden age I have described will be an engine of peaceful and sustainable growth. It will create new wealth that will enable you to live prosperous and contributing lives. And as Earth scientists you really have the advantage of what amounts to a degree in general science because our field is built on a foundation of all of the basic sciences. But with earth sciences as your background you know and have the obligation to explain that *man manages nature not by force but by understanding.*

Jacob Bronowski

And whether you end up as geologists, environmental professionals, lawyers, teachers, physicians, in business or in public service, you will bring to bear your training in science, and the values that are basic to science:

honesty, generosity, a respect for evidence, openness to all ideas and opinions...

Bruce Alberts, *Science and the World's Future*, 136th annual meeting of the National Academy of Sciences, 1999.

You're going to have a lively time. And you're going to help our country and all nations meet the momentous challenges ahead.

Congratulations, and God speed.

Spring 2000 Commencement Address

[Warren W. Wood Ph.D.]

The Challenge of Geoscience Commencement Address

May 13, 2000

Being selected to present a commencement address is a great honor. Presumably the faculty selects a commencement speaker on the basis of a belief that he or she has the insight and wisdom to convey knowledge that will both benefit and inspire the graduates and their families. From my perspective, however, it is a little like that old joke about being Elizabeth Taylor's seventh husband on their wedding night --I know what is expected, but I am not sure if I can make it interesting. When I learned of my selection, I called a good friend of mine who is now a university president and asked for advice as he had sat through many of these exercises. His comment was very succinct --keep it short and humorous. While I think I have a great sense of humor, no one would ever say that Wood can regale an audience with funny stories. That being said, the best I can promise you is that I'll follow half his advice!

Commencement exercises and addresses provide formal closure for parents and students who have made substantial commitments of time and financial resources. For parents, it is a feel-good-time of pride that they have given their issue the best possible start in life. Most students, however, are generally less interested in these formal exercises, and many avoid the event unless parents or department rules insist on attendance. Students who do attend under their own volition are usually seeking some insight into the future. Unfortunately for you, I am unable to make any reliable societal prediction. I do not want to embarrass myself by predicting that you will have robots in your house, jetpacks for your commute, nuclear powered airplanes, or personal helicopters. Nor am I going to whisper "Plastics" in your ear, as was done to Dustin Hoffman in the 1960's film, "The Graduate." Thus, what am I going to say that will justify my taking your time? I would like to offer you some thoughts on what I see as both the excitement and responsibility of being a geoscientist. Hence, the title of this message --"The Challenge of Geoscience."

The excitement is the easiest part. I will give you a personal perspective to put excitement in context. I attended Michigan State University back in the Middle Holocene and was majoring in chemistry. At that time, there were no opportunities for elective courses until you finished your first two years. My family had a summer cottage in northern Ontario, and I had seen all the folded, crumpled, and intruded rock in the road cuts that exist in the area, and I wanted to learn something about geology. So in the fall term of my junior year, I enrolled in geology 101 then taught by Dr. James Fisher. Dr. Fisher changed my life like no one before or since. Within two weeks, I changed my major to geology and went from being a below average student to an A student on the dean's list for scholarship, not disciplinary action!

What caused this epiphanic moment? It was the realization that geoscientists strive to find fundamental truths like: What is the age of the earth? What is the origin of life on earth? How have the continents and oceans evolved? How has the earth's atmosphere evolved? How has the climate changed over geologic time? How has man affected the environment and the environment affected man? I was interested in these questions in a broad sense, but formal philosophy courses seemed sort of vague, nothing I could sink my teeth into! It seemed to me that geology offered the best hope of addressing some of these questions! Your parents think you studied the geosciences so you can become gainfully employed and stop the devastating drain of tuition, room and board. But you and I know that's only a superficial reason. The real reason that most of us have chosen to follow a career in geoscience is the quest for, and the sharing of, knowledge. The work is done for the excitement of the answer, not an application.

The challenge I would like to address this morning is, I believe, more difficult than fundamental science for which you have been well trained during your years at Virginia Tech. This challenge, or responsibility, is one of bringing the scientific method to bear on important questions -- to make a difference in society! Not in an academic environment for which you are familiar and well trained, but in a societal context as diverse as a local zoning committee or the board of directors of a corporation -- that is, in a context that is foreign to a geoscientist's approaches and methods.

It is the contention of my message this morning that as a result of your education you have this additional obligation, or challenge, to utilize the scientific method in the discussion and solution of a range of societal problems. These problems vary from the disposal of toxic waste, global warming, desertification, urban zoning, water supply, geologic hazards, science education and other like topics. You will learn quickly, however, that many important decisions are made on the basis of what I call value systems or consensus, not facts or the use of the scientific approach. Why is this, he asks rhetorically? Part of the answer is misperception about geoscientists and their approach. Thus, before you can influence decisions, you must understand the opposition. Much like a football coach evaluates the strengths and weakness of an opposing team.

Politicians thinking about societal problems are always seeking a consensus; they are not interested in the truth. Judges and lawyers think of a decision in terms of whether it is legal or illegal from the standpoint the Constitution, Magna Carta or other document. Religious leaders think in moral terms of right or wrong in reference to a holy book or document. Business people tend to think in terms of profit or loss referenced to the Dollar, Euro, or Yen. So the community thought structure and fundamental assumptions are very heterogeneous and you will find that their perceptions of geoscience are extremely varied and often inaccurate and might better be referred to as misperceptions. This seems like an appropriate time to look at some of these perceptions or misperceptions because of the way they may impact both your scientific career and your ability to influence societally important decisions.

The first and most obvious misperception is between geoscience and the application of geoscience, which is in reality geotechnology. Geotechnology is a consequence of geoscience and the societal application of knowledge of how the earth responds to different stresses. The application of seismic prospecting to find oil, or the development of a ground-water model to predict contaminate transport, are examples of geotechnology. When a geoscientist is told that he or she must be more responsible for their effects on the environment, say, for example, the impact of a new gold mine, it is the applications of geoscience that people are referring to --the mining -- not the understanding of the process of why the gold is at a particular location.

A second misperception is about thoroughness of science. It is interesting to me that this thoroughness is often misunderstood. To geoscientists it means that we have investigated and carefully measured all the factors that can affect our answer. However, when people say something has been done scientifically, often all he or she means is that it has been done thoroughly. I recently heard a television newscaster talk about the "scientific extermination" of the Hutus in Rwanda. There was nothing scientific about it; it was only thorough.

A third misperception deals with uncertainty. People confuse uncertainty with a lack of fundamental understanding. That is, I can say with some degree of confidence that the half-life of uranium is 4.5 billion years plus or minus 0.1 billion years. This lack of exactness does not invalidate the use of uranium in dating of the age of the earth; it simply means that there will be a range of values for our estimate. That is, we can be certain only to a limit that is dependent upon our measuring instruments and the heterogeneity of natural systems. Saying we have uncertainty in measuring parameters in science is normal, and this uncertainty is generally quantified by some measure such as a standard deviation or equivalent expression. We in geoscience recognize this uncertainty, and it is an integral part of the way we report and interpret information. Many people, however, interpret this uncertainty to mean that we do not understand the fundamental physics, chemistry, or biology, of an issue or problem, which is incorrect. One must be careful that individuals with an agenda other than truth may distort this uncertainty for his or her personal gain. A number of individuals have turned causes into businesses and thus, have a vested interest in that business, with little if any concern or interest in the truth.

The fourth misperception involves the scientific method. This method is based on the principle that observation is the judge of whether something is true or not. It involves clever experiments, careful measurements, learning to ask the right questions, and the application of a string of logical arguments. It is this approach in which observation is the arbiter that distinguishes the scientific method from all other approaches in addressing the mysteries of nature. A geoscientific observation will be the same for any observer. For example, ground water flows from areas of high potential to areas of low potential regardless of race, religion, creed, form of government, economic model, or geographic location of the observer. These observations are indisputable and there is no compromise.

The principle that observation is the final arbiter imposes limitation to the kind of question that can be answered. For example, I can ask what will happen if I inject radioactive waste into an aquifer? But speaking as a scientist I cannot answer the question "should I inject radioactive waste into an aquifer ". This is a value judgement that can not be addressed by the scientific method. This does not mean that value judgements are not important to society or to an individual; they may, in fact, be the most important questions to be asked. They are not, however, questions that the scientific method can address. These are ethical and moral questions, and it is vitally important that you not try to address these questions under the guise of science. Now, you may be able to state a question differently so that it CAN be addressed. For example, if the question is asked, "Should we build a new school on a banks of the James River?" — It cannot be answered by a geoscientist. If the question can be reworded to ask "What is the likelihood that a school building constructed on the banks of the James River will be inundated by floods within the next 5 years?" --then that is a perfectly good question that we can address in terms of flood probability.

In our observational philosophy, we as geoscientists implicitly use the principle of Ockham's Razor named after a 14^{th} century English scholar. The principle states the simplest explanation for an observed phenomenon is the correct explanation. Or in his words "multiplicity ought not to be posited without necessity". This may or may not be true but it is one of the fundamental implied assumptions of geoscience. Because it is seldom explicitly stated, one must be aware that non-scientists may not necessarily be aware of or necessarily accept this assumption.

The fifth misperception deals with the meaning of a scientific theory. The concept is well understood among the scientific community; however, there is some confusion in society at large or deliberate obfuscation by some with an agenda. A theory is built from observations that are consistent with all the physical, chemical, or biological data generated by scientific investigation; it is not just an idea. Yet, some wish to say that any idea is a theory and should receive equal weight. This is absolute nonsense. In this context, I could state that all the rivers in the Northern Hemisphere flow to the south: it is an idea, but it is not supported by experiment or observation and thus should not be treated as a scientific theory.

This leads me into an area in which some of you might not feel comfortable, and that is the relation between science and religion. The general rule that one should not discuss religion and politics is probably correct. It is a topic, however, that must be addressed because certain misconceptions or a lack of understanding threaten scientific support from the community at large. As a geoscientist, you will be at the forefront of this controversy, and it is extremely important to be clear in your thinking about this. The conflict between science and religion is as old as Galileo. Most of the conflict occurs because many religions of the world have an explicit or implicit version of the origin of the earth and the evolution of human life that is not consistent with scientific observation. From my point of view, this need not be a conflict. To me, the role of a religion in the human experience is to provide a guideline for moral and ethical behavior, not an explanation for the physical world. The 10 Commandments, "The five Articles of Faith, the "Turning Wheel of Doctrine" or other guides provide good models by which to live in society. Having a different understanding of the nature of the physical world should in no way be perceived as undermining the great moral and ethical contribution of religion. As a geoscientist, your mind must be clear about this issue.

While all these misperceptions are indeed discouraging to a geoscientist — it is one reason that many of us in geoscience shy away from entering the social/political arena - therein lies the challenge. Because of the misperceptions I have just discussed, you will find that some people outside the scientific community will perceive your views and approach as arrogant, hostile, or inflexible. We must encourage the public to become advocates for science and the scientific approach by helping citizens state important questions in scientific terms and sharing our understandings of societal problems in language they can understand. The challenge is to convey this message to a society that has a different mindset from you own.

In summary you have received an outstanding education at one of the top geoscience departments in North America. As you enter graduate school or start to work, remember the dual challenges of both resolving the fundamental truths for which you have been trained and the responsibility of dispelling the misconceptions so that you can bring the scientific method into societal decision-making. Never forget that you have both the opportunity and the obligation to change the world.

Thank you.

Spring 2001 Commencement Address

Margaret S. Leinen, Ph.D.

Discovery for a Challenged World

May 12, 2001

It is a real thrill for me to be back at a University commencement ceremony. I spent a decade as a dean having the privilege of celebrating this wonderful day with graduates and it never stops making me excited and inspired by the graduates. A few words, first, to those of you who are here to congratulate a son or daughter, a brother or sister, a grandchild or grandparent, a parent, a friend or relative. I know that this university experience took much of the time and energy of your graduate for the past few years. I also know that there were many times that you wished that they were available to spend time with you instead of time studying or working at their internship or working to earn money to study. You have had to sacrifice your time with these graduates and many of you have made financial sacrifices to make this day of commencement possible for your graduate. It was worth it. You have given the person in the black robe and mortarboard a passport to a better future for them. But even more important, you have given all of us a contribution toward a better environment and society. Graduates, please join me in thanking those friends and family who have made your degree possible!!

The most fundamental component of this contribution toward a better environment and society comes from discovery. The faculties who taught you — or taught the student you are here to congratulate — embody this dedication to discovery. They have made fundamental basic research discoveries — whether like me they have had the opportunity to dive 13,000 feet to the bottom of the ocean in a research submarine to study that fertile cradle of life, or whether they have, like Professor Hochella, balanced microbes on the sensitive balance of a biological force microscope to discover their powers of attraction and repulsion. You as students have been a part of this excitement. Many of you have had an internship or independent study that has been built of the strong research foundation of the college.

This research and training is your tool. You will be the first generation to shape the 21st century and the next millennium. And scientific discovery is a critical and exciting part of that century.

I'm constantly amazed that the public believes we know most things about the world. Most people view science as simply addressing sticky problems that we've gotten ourselves into and that the tool is the application of discoveries made in the 19th century. Yes, people still believe that we could make discoveries if we went to other planets, but in here on Earth? Not much new. Nothing could be further from the truth. While I knew that discovery was alive and well before I went to the National Science Foundation, since I went to the foundation a year and a half ago, I have been amazed by the pace and scope of discovery. Each week as I read the compiled NSF news clippings I see the richness of geoscience discovery unfold.

For example, during this year geosciences discovered living microbes over 250 million years old. Yes, microbes alive during the time of the dinosaurs. They were encased in salt deposits in the Southwest US. They weren't growing. But they were living. Living fossils that will give us living DNA over 250 MY old. There have been science fiction novels written about discoveries like this.

A second example is the discovery of a whole new class of hydrothermal vents that are not at sea floor spreading centers. A group of scientists using the three person submersible, ALVIN, to study great fault zones in the Atlantic Ocean were stunned when they came upon huge towering mineral pinnacles out of which was flowing hot water. Unlike the hydrothermal vents that you have all seen in television documentaries and magazines that are covered in a veritable zoo of giant clams and worms, schools of blind shrimp, or large white crabs, these vents had no organisms. They were stark black and white features–like a black and white movie-- that look like they are from another planet.

During this past year we discovered the most abundant organism in the ocean. Yes, the most abundant organism in the ocean. You can well imagine that it is a microbe. But we only found it because we have been doing monthly measurements and sampling at a station in the middle of the Pacific Ocean near Hawaii. This time series station showed unusual patterns of the distribution of nutrient chemicals with time. Something that we didn't understand was at work changing the nitrogen concentration of the ocean in subtle but important ways. A new instrument capable of imagining and separating tiny cells in seawater showed the culprit. And once we knew what to look for, we found it everywhere, playing a critical role in the cycling of nutrients around the ocean and to other organisms. The most abundant organism in the ocean, undiscovered until the year 2000.

I wanted to tell you about these remarkable discoveries to give you a feeling for the excitement and potential for discovery that is waiting for you. I don't remember a time when so many scientists of my generation have said "I wish I were a young scientist again, there is so much excitement and potential that I would love to have my career in front of me rather than mostly behind me". For the public these are wonderful times as well. Have you noticed how scientific discovery captures the imagination of a jaded and cynical world? The excitement over the potential of bacteria on Mars, or an ocean beneath the ice on a moon of Jupiter, or a 250 MY old microbe cuts through our fatigue with our daily schedules, our frustrations, and our cynicism. It reminds us how little we know about the world around us and reminds us of our most exceptional trait — the desire to explore and discover.

And it has never been as important for us to know about the world. You graduates will be the first generation to shape the 21st century and the next millennium. Human activity related to the environment during the past millennium can be summed up as our attempt to learn enough to dominate the environment. The last century can be characterized as the one in which we tried to exert that domination. We have modified almost every aspect of our globe. The composition of our atmosphere is different due to our use of fossil fuels and manufacturing chemicals. Few areas do not bear the stamp of man's agriculture and forestry. We have altered the seacoasts. In small ways, we have even made our mark on the oceans. The small amounts of radioactive gas released to the atmosphere during nuclear testing exchanged with the ocean and we use the so-called "bomb tritium" as a tracer of the circulation of the ocean.

We of your parent’s generation have been busy changing the planet. Most of these massive changes to our planet are not reversible on the scale of our lifetimes. Here at the threshold of the next century and millennium, we know that this approach is fraught with great dangers and that our next century and millennium must be characterized by attempt to learn to live in harmony with the ecosystem. Understanding the impacts of these changes will be one of the most important things that geoscientists can do in this century. And you will all play your role. You will live in a society where every action dealing with life and the environment will be scrutinized for its consequences to the local, the regional or the planetary ecosystem. Your work will constrain business, engineering. Your work will inform health sciences, the humanities and other sciences. You will place the central role in the next century.

Some of you will have the opportunity to add your own amazing discoveries to our knowledge of the Earth. Others of you will lead the way in understanding how to use geoscience to understand the changes that we have made. This is such important work. Whether you work in state and federal agencies or environmental firms, you will be at the forefront of the efforts to deal with this massive change. Others of you will join industries trying to reshape their processes to have a smaller environmental "footprint". Natural resources remain a critical need for our economy, but the ways in which we recover those resources can be harmful or benign. Some of you will become educators, helping new generations of students to understand the Earth and her complexity. Finally, some of you will go into other fields. You’re very important to us as well because you bring with you a geoscience perspective that can inform and educate whatever you do.

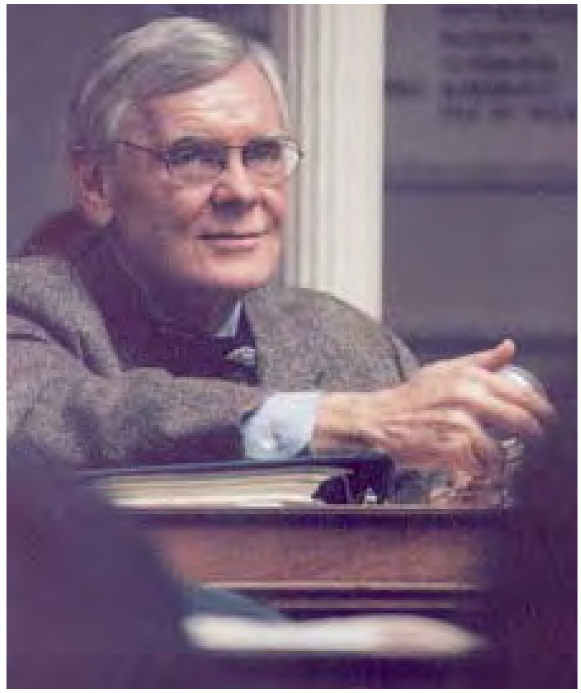
We’ve left you a lot of work to do. But talking to the faculty here at Virginia Tech and getting a sense of your accomplishments already, I know that you’re up to the task. We trust in you because of the education that you have. We at the National Science Foundation look forward to working with you and hearing from you in the future. And we congratulate you on your achievement, your new beginning, and your promise for the future.

Spring 2002 Commencement Address

W. Tayloe Murphy, Jr.

Environmental Protection: Policy And Principles

May 11, 2002



Thank you, Dr. Coruh, Dr. Robinson, Dr. Bodnar, members of the faculty, alumni, parents and family of the graduates, and last, but by no means, least, the 2002 graduates of Virginia Tech's Department of Geological Sciences.

It is a pleasure for me to speak to you on this occasion marking a significant milestone for those who are receiving degrees, and also for those who have nurtured your growth and development and those who have taught and guided you as you have pursued the goal which you achieve here today. It is an honor for me to have been selected to address you, and I am most grateful for the invitation to be a part of your graduation exercises.

You have already heard from my new "boss," Governor Mark Warner, who spoke to you earlier today. Therefore, I am not here to express his regrets at not being able to attend these exercises. It is appropriate, however, that I take this opportunity to express my appreciation to him for choosing me to serve in his administration as secretary of natural resources. My appointment enables me to pursue my longstanding commitment to the conservation of Virginia's natural resources and to the preservation of its historic resources.

The invitation you extended to me to participate in your graduation prompted me to pause and reflect on my own graduations, first from college and later from law school. Educational choices made by my generation of Virginians and your generation are markedly different.

I grew up in a time when young people were, more often than not, expected to follow career paths chosen for them by their parents. We strived to be like our parents and the members of their generation. We dressed like them, we cut our hair like them, we partied like them, and we usually ended up living our lives according to what they thought was best for us. This observation should not be construed as an indictment of our mothers and fathers. They were sincere in their belief that our futures would be more secure and happier if we pursued the educational goals and objectives that they set for us. In many cases, these goals and objectives had not been available to them, and they wanted to provide us with opportunities they had not had.

So in my case, I went to law school, not because I had a consuming desire to be a lawyer — but as a result of what I thought my parents wanted me to do. After practicing law for twenty years, I decided to embark on other pursuits that interested me and were of my own choosing. I successfully ran for the House of Delegates and spent 18 years in the General

Assembly pursuing my strong commitment to land conservation, water quality and other environmental goals. At my age, I should be a retiree rather than a member of the governor's cabinet, but I am doing what I have chosen to do given the opportunities that have been made available to me.

If I were to hazard a guess, I would say that, unlike my generation of students, almost all of you, if not all, have chosen your field of study here at Virginia Tech because geological science is a discipline in which you have a keen interest and which holds opportunities for a rewarding and meaningful career.

I suspect that most of you will take jobs that will involve working with our natural resources at some level. What you do professionally will undoubtedly impact the environment of the Commonwealth; however, when in the course of one's employment, he focuses on a narrow issue it is sometimes difficult to relate that issue to the broader policy that we call "environmental protection" or "natural resource conservation". Therefore, it is important that you look at your day-to-day activities in a larger context — see it more broadly as part of an environmental philosophy and how it contributes to the realization of recognized environmental policy.

This great university, of which all Virginians are very proud, has trained you and prepared you to solve individual problems as they arise within your discipline.

Today I will take leave from the technical aspects of your studies and present to you for your consideration some fundamental principles that I believe should guide your work in order to achieve national and state environmental protection policies. It is the combined effect of the work of thousands of environmental professionals devoted to natural resource conservation that will result in the realization of our goals and objectives.

Before reviewing these principles, I would suggest that from time to time we remind ourselves that the 1971 Virginia constitution itself sets forth the Commonwealth's policy for environmental protection. As you may already know, Article XI reads as follows:

"To the end that the people have clean air, pure water, and the use and enjoyment for recreation of adequate public lands, waters, and other natural resources, it shall be the policy of the Commonwealth to conserve, develop, and utilize its natural resources, its public lands, and its historical sites and buildings. Further, it shall be the Commonwealth's policy to protect its atmosphere, lands and waters from pollution, impairment, or destruction, for the benefit, enjoyment, and general welfare of the people of the Commonwealth."

Unfortunately, we have yet to meet fully the mandate of these constitutional goals. Under Virginia law, it is up to the executive and legislative branches of government to implement the policy so clearly stated in the constitution. The governor and I take very seriously our duties and responsibilities to fulfill this constitutional charge. We hope that you will, also.

Assessments of our success in implementing stated environmental policies are mixtures of good news and bad — of optimism and pessimism. Perhaps this phenomenon is for the best. If the assessments were too rosy, we would all go home and neglect the work that remains to be done. If they were too bleak, we would throw up our hands in despair and abandon the effort altogether.

Notwithstanding these mixed assessments, there is a widespread awareness and commitment to the protection of Virginia’s environment that has already begun to pay dividends. In most campaigns, however, the easy victories come early and may fade as quickly as they came. It is the details that bring most glorious causes to a sputtering, ignominious halt. But those who have the resolve and the ability to stick around after the opening fanfare, and tackle the details, will see the fruits of victory.

We are well into the details stage of environmental protection, and if our efforts at natural resource conservation are to succeed, we must keep in mind those fundamental principles to which I have already referred. I believe that these principles apply in any situation where human activity affects the natural environment, and in my judgment they cannot be avoided.

The first and most fundamental of these principles can be summed up in the phrase: "there is no free lunch." Surprisingly, it was not until the decade of the 1970s that this proposition became sufficiently self-evident to affect national environmental policy. All of our major environmental laws rest on this principle, although their implementation may not honor it in every case.

What it means is simply this: everything we do that adversely affects the environment imposes a cost, and that cost must be paid by somebody — if not by me or you, then by someone else.

For years, however, we cheerfully operated under the assumption that where the environment and natural resources were concerned, we could operate outside the laws of nature and economics. Thus, in what are sometimes referred to as "the good old days", cities disposed of their sewage for "free". Factories poured industrial wastes in the air and into our streams, at little or no cost — to them. Unfortunately, even though the cost of such activities did not show up on any ledger book, they were being "paid for" with heavy interest. The commercial waterman facing condemned oyster grounds, or dwindling populations of crabs and finfish, the seafood packer forced to look further and further afield for products to market, the tourist business whose customers were driven away — all of them picked up the tab for this "free" activity. The vast sums necessary to restore our degraded natural resources are nothing more than the accumulated sum of many supposedly "free" lunches.

Another principle that we must keep in mind as we grapple with the details, or hard issues, is that of the "commons". Simply stated, "the law of the commons" decrees that if each user of a finite resource follows his natural tendency to maximize his benefit from that resource, the combined effect of these individual, and seemingly rational, actions will destroy the resource.

Thus, we agree to restraints on our freedom of action in the form of laws and regulations, so that we can continue to enjoy the benefits of our natural resources. This principle is inexorable, and our failure to heed it will lead — sooner or later — to the destruction of the "commons".

As we attempt to deal positively with what Garrett Hardin termed "the tragedy of the commons", I hope that we will also heed the message contained in a 17th century British proverb which says:

"The law punishes the thief who steals the goose from the commons, but the greater thief

the law lets loose who steals the commons from the goose."

A third, and related principle, is that where the natural environment is concerned, we can never do "just one thing". Every action will have consequences that radiate from it like a ripple on a still pond. Some of these are easily foreseeable — some are not. Most activities that affect the environment are of little apparent consequence in themselves, but as they are added together they have the effect of an avalanche that starts with a few pebbles rolling down a hillside.

There are simply too many of us engaged in activities that degrade the quality of our environment to continue with the notion that our individual actions make no difference.

All of these principles that I have mentioned work together — whether we like them or not. The most insidious thing about them is that they are not always obvious to the individuals making day-to-day decisions. As you embark upon separate careers, I urge you to keep these principles in mind as you go about making your day-to-day decisions in a society that relies on regulations and financial incentives to protect our environment, and not just on appeals to good will to accomplish the job.

After all, if the protection of our air, water and land resources were that simple, it is not likely that we would be taking the time to worry about it.

Too often we tend to think of conservation as something that someone else will take care of, or that we can accomplish by recycling our newspapers and beer cans, or by contributing a few dollars to a conservation organization. Not that those things do not help, but they do not discharge our responsibilities under article xi of the constitution of Virginia, either.

As one individual has noted: "In our attempts to make conservation easy, we have made it trivial."

The conservation of our natural resources is not an easy challenge. Environmental protection is fraught with difficulties that must be overcome; yet, it has universal appeal. Therefore, we are all in this effort together.

Speeches, on the other hand, are easy to make. It takes no effort to profess one’s love for the natural world around us, and not much more to attend a conference where voices of concern for the state of the environment are raised in unison.

But these activities alone will not get the job done. The task ahead of those of us who are engaged in the management of our natural resources will take dedication and hard work.

You have already shown your commitment to these characteristics by completing the degree requirements that entitle you to the diploma you will receive today.

Now it is time for you to put your knowledge and training to work for the improvement of the environment. You will have that opportunity whether you pursue a career in one of the agencies within my secretariat, or at the federal level in the Environmental Protection Agency, the National Academy of Sciences, or the Geological Survey, or, perhaps in the private sector at an engineering or consulting firm.

Whether your chosen path leads you to archaeology, soil science, geographic information systems, ecology, conservation, mineral exploration, or some other field involving natural resource management, you will have a role to play in environmental protection.

But as you deal with the individual issues with which you will be confronted on a day-to-day basis – remember to keep in your mind the principles I have outlined for you this morning.

And remember, as well, that it is the combined effect of all of the good works that all of you accomplish that will spell success in reaching our environmental goals and objectives.

In closing, I would also add another request of you. Be a visionary. Do not lose sight of the big picture. Look at your work in the context of what it contributes to the fulfillment of our constitutional mandate to protect the Commonwealth's "atmosphere, lands and waters . . . for the benefit, enjoyment, and general welfare" of the people.

Helen Keller once said: "It would be better to be blind than to have sight and no vision."

The task ahead of us will be in your hands very shortly. To shoulder the task will take hard work, creativity and sound judgment on your part. But above all, it demands that you have a vision for the future you want to leave to the generation that will follow you.

Those of us who are nearing the end of our careers are counting on you to meet the challenges that lie ahead. We know that our confidence in you is not misplaced; nevertheless, we wish you the best of luck.

And finally, I extend to each of you my hearty congratulations and every good wish for your future accomplishments.

Thank you.

Spring 2003 Commencement Address

John R. Lawson, II

Dream, Then Execute!

May 10, 2003

Thank you. Chairman Çoruh, distinguished faculty, honored graduates, families and friends. I am honored to join you here today for an acknowledgment of hard work and dedication, but also to celebrate and prepare for the next chapter in your life.

One beautiful day in June 1975, I was also attending graduation ceremonies for the Department of Geological Sciences. As a new Geophysics graduate during an energy crisis, I was certain that the world was at my disposal and that all that was good in life was soon going to be mine. Wow! I sure was wrong. Actually, I ended up with some of the most meaningful things in life. The irony was that I had the wrong initial priorities and objectives, and it took me longer than I had planned to get there.

Looking back over 30 years of family, friends and career, there are some common thoughts and philosophies I have seen that can allow you to reach almost any goal or objective.

First, to make the journey possible, comes the most important element, YOU! The quality of your life cannot be measured or improved without first learning to love and respect yourself. Although successful early childhood development is the best and most effective way to learn self-respect, there are ways to increase and improve this basic building block. Let's call it "The Winning Attitude." People with a "Winning Attitude" value confidence, concentration, appearance, and a competitive spirit. I truly believe that these traits are the result of having basic philosophies in your life that require action, and do not always happen naturally. To find true happiness and reach your lifetime goals, start with a "Winning Attitude" and use it to "Dream, and then Execute."

The best place to start would seem to be with those who have actually been there. A survey of a broad range of successful people over 50 years of age revealed, several common laments:

- I didn't use all my talents.
- I had a vague personal mission statement.
- My life goals were shallow.
- My career was my identity.
- My life was spent on a treadmill.

Are you tired of people "preaching" about how life should be? Are you willing to do what it takes? Can you handle it once you have what you now seek?

Let’s focus on the “Winning Attitude.” Do you love to win? If you don’t you never will. You can fire up your competitive spirit and also gain confidence and improve concentration by giving yourself an advantage. Not necessarily an advantage over the competition but an advantage over negativity – yours.

We live in a country of endless opportunity and resources. Why, then do we always seem to focus on what’s wrong in our lives, and not what is right? Think about it. We are always trying to work on our problems, in the misguided attempt to cure all ills. If we spend the majority of our time on the things that are broken or don’t work, what happens to those things in our life that do work? They get worse, or at least they don’t get better. Wouldn’t we be more effective if we tried to emphasize the positive? If we put the majority of our time and talents working to improve the things that are already good? Wouldn’t our upside potential be greater?

In business, I’m sure you have heard of the 80/20 rule. That’s where 80% of your profits come from 20% of your customers. Yet many business people make the same mistake of trying to salvage the relationship of the customers that are not profitable instead of improving the business of the customer that is already very profitable.

When I was fresh out of Tech and learning the business world, my Dad’s partner told me one day that sometimes the very best decisions start and end with a single word. NO! You see, you can emphasize the positive by refusing to accept people or situations that are negative.

Successful golf pros constantly visualize the next successful shot. Those that can’t make the cut are always preoccupied with what went wrong with the last bad shot, and how they can make corrections. This happens in business and personal relationships too! Maybe you have heard about the recent email sent from the boss at one misguided company. WARNING TO ALL PERSONNEL: Firings will continue until morale improves.

The winning attitude requires a competitive spirit, but you are more competitive when you have confidence. Confidence can be increased by concentration. Concentration can be increased by focusing on those things that you already do well. Your poise will improve, your decisions will be crisp and you will start to develop a “Winning Attitude.”

Winners are usually leaders. Ever study and observe a real leader? Leaders always talk about what works and how to improve what already works, not what is broken. Leaders ask the right questions. Virtually all the answers exist. The key is to ask the right questions. A question is a valuable tool. Leaders use a question to say, “I value your opinion,” and to get a desired response. A carefully phrased question can make the responding person feel confident and valued.

There is no more satisfying experience than to realize a dream. Throughout history, dreamers have created the best contributions to our lifestyle. However, most failed dreams also include a failure to execute. Rare, is the decisive dreamer. Dreamers have a “big picture” outlook on life. They are conceptual thinkers that know that a great concept is difficult to ruin and a bad concept is nearly impossible to fix. The most successful people and leaders combine a conceptual mind with an ability to execute — quickly, decisively, and without remorse. The one-way road through life contains many forks. Each turn takes us in a different, irreversible direction. Those people who possess a “Winning Attitude,” see the big picture, and execute, will be the winners.

Your experience in this great university has provided you with the tools to put yourself in a position to win. You have spent your entire life in preparation for this moment. It is now up to you. The difference between success and failure is so very small. A poor attitude, taking the wrong fork in the road, not being decisive, and not allowing yourself to see the future through your dreams can all contribute to failure. The choice is yours.

Will you look back at your life in 30 years and wish you had the “Winning Attitude”? Will your dreams go unfulfilled by a failure to execute?

In my life, the final most effective way to tie my goals and objectives to real, meaningful results is through giving. Giving of your time and resources. Giving through your heart and soul. People with an effective “Winning Attitude” always have a kind and generous heart. You always reap more than you sow. Remembering back to the survey of those over fifty, and their common laments:

- I didn’t use all my talents.
- I had a vague personal mission statement.
- My life goals were shallow.
- My career was my identity.
- My life was spent on a treadmill.

Doesn’t a life that includes volunteer efforts and charitable giving help solve all these concerns?

I wish you well in your journey through life, and I hope you will develop a “Winning Attitude.” Just remember that you will never be a true leader or complete person without also sharing your talents with others.

Thank you.

Spring 2004 Commencement Address

Leonard P. Harris

To Congratulate, To Counsel, To Challenge

May 15, 2004

Dear Cahit, Members of the Faculty, Parents, Families, Friends, Distinguished Guests, and above all — Graduates of the class of 2004. It is indeed an honor for me to be addressing you this morning. I was a member of the Class of 1957, and here I stand this morning speaking to you — Miracles Happen — the American Dream is alive and well!Edward Bennett Williams once observed that a commencement address is a 15 minute interruption that is impeding the progress of a happy crowd of young people on their way to a great party. So trust me — I'll try to keep my comments brief.Graduates — I stand before you today to do three things:

- To Congratulate you,
- To Counsel you, and
- To Challenge you.

First — **Congratulations!** Just think of it. Starting tomorrow you can finally start paying off your student loans.A degree from Virginia Tech is always hard earned. The best teachers I ever had were those who forced me to do my best — who would not accept merely the acceptable, teachers who required the maximum effort. I understand there are still a few teachers here at Virginia Tech like that.Let's congratulate your teachers and your families too. This is their day as much as your own. Parents, the two biggest raises I ever got were when our two children graduated from college.Graduates, don't forget what your professors and you families did for you — so — please rise, turn to them and give them a round of applause.And now my **Counsel** — First let me give you some truths that were presented in a Commencement address at Hood College in 2002 by Ambassador Acersba:

- It is certain that the United States is still the Beacon of Freedom, Hope, and Democracy. A country where great opportunities exist for everyone — regardless of race, religion, nationality and capabilities.
- You are tomorrow's leaders — act locally but think globally.
- Tolerance is required — Tolerance of people who look, think, act and feel different than you. Tolerance is a real test of civilization.
- Life is not fair — get used to it. If you thought the professors here were tough, wait until you get a boss. Bill Gates said, "Life is not divided into semesters. You won't get Spring Break anymore."
- Great economic opportunities exist for you. Reach for the stars. If you do, then you'll

never come down with a handful of mud.
- It is certain if you don't know where you're going, you're already there. So always have a vision, a goal, and pursue it like there is no tomorrow. And when you feel like there's no tomorrow, remember, it's already tomorrow in New Zealand.

I have been involved with oil wells in Kazakhstan, with computers as early as the late 50s with the Rand Corporation, founded and grew a corporation, and I am here to tell you technology, culture, and times have changed. I urge all of you to learn to be a part of a team. The team will be made up of professionals from a number of disciplines. Geophysics needs Computer Sciences; Biology and Chemistry are becoming more interconnected. As you grow, lawyers, accountants, government regulators, and international treaty considerations all become a part of any project. So you need to grow — in knowledge from across professional boundaries. Those of you who have the ability to learn from other professionals have a greater probability of developing the innovations needed to solve the complex problems of the world. You are graduates of the College of Science and so it's you to whom we will look to innovate. Innovation is what enables us to have a rising standard of living. Innovation is the ability to get people to do things in a new way. Innovation is using new methods to obtain results.Sometimes it takes a long time to take a cluster of knowledge and combine it in an innovative way. For instance:

- The binary theorem was developed in the 17th century
- The calculating machine in the 19th century
- The vacuum tube in the early 20th century

By 1918, all of the knowledge to develop the computer was known. However, it took 30 years — until 1946 — for someone to figure out how to use the knowledge to develop the computer.Look at the Bioinfomatics Institute — the research on Nanotechnology — the discovery of oil. So I urge you to become innovators across the frontiers of the professional world by recognizing the value of working as an interdisciplinary team.Now for the **Challenge**, and I know that all Virginia Tech graduates are up to challenges. I know as you grow, you will do well in your careers, but will you use that hard earned degree to also benefit society? I challenge you to give something back. Virginia Tech was here for you in the past — it will be here for you in the future. Use it and its resources — but give something back. Your talent helps — your time helps — and part of your treasure helps.I challenge you to do good. Believe me when I say that if you are good — have high morals, integrity, and give of your time to society — then happiness and success will pursue you.The **Final Challenge** is to get you to recognize each of you is a dwarf — Yes, I said DWARF. Virginia Tech has given you a prescription — they have given you your rehabilitation routine — they have given you the directions that go with the prescription. If you follow the knowledge and advice they have provided, each of you will grow and some of you will actually become giants. Now I want to close by asking each of you to go and take your medicine and grow. **THANK YOU**

Spring 2005 Commencement Address

Phillip E. Barnard, Jr.

Finding Your Path In This *New Age of Discovery*

May 15, 2005

Good Morning! Thank you Chairman Rimstidt, Dr. Hochella, Members of the Faculty, Parents and Families and, most of all, the graduates of the Class of 2005. It is an honor for me to speak with you today on such a special occasion for all of you.

First, let me say that I am proud to have my parents and family here today. My father is a loyal graduate of this university from the Class of 1960. My wife is from the Class of 1980. My daughter represents the future Class of 2016! I recall a high school conversation I had with my dad. I had just received all of my college acceptance letters.

He said to me,
"So, what are your options?"
I said,
"Dad I've been accepted to UVA for Pre-Law and to Virginia Tech for Geology."
He asked,
"What is Geology?"
I said
"Geology is rocks, dad."
He said,
"Ok. Let me get this straight. With UVA, you have pre-law and with Virginia Tech, you have rocks?"
He thought for a second about my choices and then said,
"So, tell me more about the rocks!"
And here I am.

I am also proud to have in attendance my faculty advisor and mentor from my undergraduate days here, Dr. Wallace Lowry. I credit Dr. Lowry with teaching me the most important concepts that any geoscientist in the field must understand. The ability to see the importance of what you recover. To visualize the earth history represented by your surroundings. To see the big picture beyond what you are holding in your hands. I have to admit, though, when he first took me out in the field to teach me this, I did not make a great first impression. We arrived somewhere near the top of this mountain in a couple of blue vans. I was so excited about what we were there to find. My new rock hammer did not have a mark on it. When I saw this stream bed below us, I was sure it was going to be a fossil locality. Just as we stepped out of the vans, this pickup truck full of garbage ran right past us on this single lane road up to the top of this peak. It left us all in a terrible fog. We managed to stumble down to the outcrops he wanted us to see, only to hear him explain that we were there to see a significant unconformity in the Appalachian system. I couldn't believe it. All this just to see something that was actually missing. Then, Dr. Lowry asked us all to close our eyes and picture an environment where rock strata would actually be eroded away.

After a moment, he looks at me and says,
"Phillip, what do you see?"
I opened my eyes and said,
"Dr. Lowry, the only thing I can see is that garbage truck is heading right back for us!"
Everybody started running!

Anyway, I could not begin to talk to you about the challenge of finding your path in this world without showing you how important it is to recognize your foundation. Your rock! I am talking about your family and your professors! No matter what you do or where you go, never forget those who helped you to start your journey through life. They will always be your greatest source of strength. Let's take a moment and give them a round of applause for all they have done for us.

Only 22 short years ago, I was sitting in your chair. This means that I am not old enough to have forgotten the kind of celebrating your thinking about doing right now! I am here to celebrate with you. I am also here to express my excitement for each and every one of you. For you now have earned a degree from one of the very best Earth Science programs anywhere at a time when Mankind has a renewed passion for exploration like never before.

My friends, we are living today in a *New Age of Discovery*; a period of time that started some twenty years ago when advances in new technology began to inspire the common man everywhere to explore for and recover almost anything that Mother Earth or Mankind has ever hidden underground or underwater. In that twenty-year period, our world has seen the opening of many new frontiers of exploration and experienced a monumental "Quest for Knowledge." Each of you is the product of this New Age and now each of you is positioned to take full advantage of it.

Let us think, for a moment, about the Ages of Discovery from our past. We would have to start with the original period of world exploration begun by Columbus in 1492. The Spanish Conquest initiated by Cortes in 1519. The California Gold Rush in 1848. The first rush for crude oil in western Pennsylvania beginning in 1859. Each of these periods was defined by men with no previous exploration experience suddenly re-directing their lives in pursuit of a better life. The economies of entire populations were changed. The fortunes and balance of power among countries were altered forever. In each of these Ages of Discovery, a state of mind existed in the average person that allowed them to see opportunities that never existed for them before. Today, it is no different. But, we have something today that did not exist in any of these previous Ages of Discovery. We have the Earth Scientist!

I stand before you today, as someone who has immersed himself in this *New Age of Discovery* from its very first days, and I am here to tell you that having a background in Earth Science will give you a distinct advantage, no matter which path you should ultimately choose for yourself. I am not here to suggest which path is best for you. My goal today is to provide a measure of assistance to you as you endeavor to begin the complicated task of finding your path in this *New Age of Discovery*.

So what are these new frontiers of exploration that have emerged over the last 20 years and what opportunities do they offer for you?

How about entirely new localities for some our most valuable natural resources; some on dry land, some now in the deep ocean. Add to this never before seen efforts to extract the world's greatest mineral and fossil specimens. Or, you could participate in the recovery of approximately 90% of all that Mankind has buried underground; 95% of all that Mankind has lost in shallow water; and 99% of all that Mankind has lost in deep water. In all four of these major areas of exploration and recovery, geoscientists today have an endless supply of opportunities in which to apply their training. Let me illustrate these opportunities for you by describing two very different perspectives on the value of what you could recover.

To illustrate tangible value, I need to ask you one question. How do you like your gold! You could be a part of new lode mining operation and see the results of your work poured out in 12.5 kilo gold bars at around $430 an ounce. Or, if your preference is for a larger bar, we have 75 kilo gold bars, thousands of which remain buried in the Philippines since World War II. If $430.00 an ounce sounds too low for you, you could add some historical value to your gold by recovering it from time capsules waiting on the sea floor. Finger bars from 17 th Century Spanish shipwrecks have sold for over $5000.00 an ounce. Assay bars from gold rush period shipwrecks have sold for up to $27,000.00 an ounce. Sound amazing? It gets better. A single 24-sided Trapezohedron crystal of gold recovered in a placer operation in Venezuela is being sold for $255,000.00 an ounce. That's almost 600 times the market value of its gold content! In this New Age, if you can attach historical and scientific value to any basic material, the price will soar.

To illustrate intangible value, I have another question for you. How do you like your knowledge? For many, like me, what you value most isn't something that you can hold in your hands. The most valuable thing you can discover for Mankind is knowledge. When Mankind is suddenly motivated to search every square inch of the earth's surface, the human race as a whole has an opportunity for an unprecedented increase in knowledge and we must protect this precious commodity. Need I remind you that you are all part of the first *Discovery Channel* generation! That company also began twenty years ago. Now look at what the average person can learn today through their cable television. In this New Age, we have, for the first time ever, a true financial market for a project aimed at discovering nothing more than knowledge.

Want to combine your love for science and history? Imagine helping a country like Mexico discover if the shipwrecks in their waters hold precious reminders of their decimated population of 500 years ago. Imagine helping a country salvage the memory of their ancestors who died during World War II. Maybe you could help re-write the early history of a lost civilization. Or, perhaps you could play a role in discovering the true origin of all life on earth; all over again.

Let's face it. Twenty-five years ago, when a group of geologists studying deep ocean hydrothermal vents accidentally discovered plants and animals living in a purely chemical environment combined with major mineral concentrations, it was like Mother Earth looked at Mankind and said, “It's about time you showed up here!” And, “If it's precious metals you like, well here, like Mother always said, get it while it's hot!” And we are. The very first government permit for deep sea mining was issued just last year. Man has finally accepted the challenge of harvesting all that our deep sea earth surface has to offer.

The exploration and recovery business today is experiencing the same transition that the oil and gas industry saw in the early 20 th century. This stems from two very important factors which I learned early in my career:

1. From the oil and gas business, I learned that a discovery site all by itself does not insure success as a recovery project. You need to have the right technology for the site; a pipeline allowing safe passage of the recovered material to the market; a vibrant, energetic market to establish price levels; local government support to provide established guidelines for both ownership and operations; and finally, you need adequate funding.

2. From my first experience with an international underwater recovery project, I saw that exploration in this New Age was going to involve a set of rules and principles that never existed in any previous Age of Discovery. Explorers were going to have to respect the environment and the value of the information found at their project site.

The wildcatting “smash and grab” days in this *New Age of Discovery* are over. All of the governments worldwide have now recognized the value of every type of resource under their control, and that includes their underwater cultural heritage. They have all established strict guidelines for controlling environmental issues, archeological value, cultural value and sharing monetary value. Projects need scientists, like you, because, today, they must run a very scientific recovery operation. This is exactly why you, as an earth scientist, have an advantage today. The amateurs are moving out. The professionals are moving in. We have a saying the recovery business. “Nothing makes a wildcatter madder than a bunch of scientific chatter.” Take it from me. This is true.

When you decided to major in geosciences, you did so either because you were drawn to the science of the earth, the history of the earth or, the exploration of the earth. As an earth scientist, you are, together, a scientist, a historian and an explorer. You just need to discover what kind of explorer you are. Will your exploration take place in a laboratory, a corporate environment, in the field or on a research vessel?

Ask yourself these questions. Do you like to find things you don't think anyone has ever found before? Do you like to go places you don't think anyone has ever been before? Do you have a relentless drive to journey forth in search of something? Do you continue to think clearly when facing your worst fears?

Was there a problem with that last question? You earned a degree from this department. Facing your worst fears should present no difficulty! But seriously, any type of exploration you choose to undertake in life involves risks. The greater the exploration, the greater the risks. Progress always involves risk. Once you are prepared to face the fear you associate with the risks you are taking, you will be one giant step closer to reaching your goals.

Now, I need to ask each of you three tough questions:

1. Do you remember why you originally chose to become a geoscientist?

2. Do you remember what inspired you to choose geosciences as your career path?

3. Do you remember what your dreams were before you arrived at this university?

You may have the same answer to each of these questions or, you may not. Don't be afraid to be honest with yourself. The only wrong answer to these questions is to have no answer at all.

I remember my answers to these questions. I wanted to be an "oil man"! I dreamed of standing in front of my own hand made derrick, singing and dancing, with crude oil raining down all over my head! It took only a few years, after I graduated from this program, for me to realize that it wasn't the oil business that I was dreaming about. It was the singing and dancing. The thrill of discovery! That realization set me on my own path. It helped me to focus my goals and build the business plan for my companies.

How will you find your path in this *New Age of Discovery*? First, you need to find out who you are. What separates you from the person sitting next to you? Do you understand your own strengths and weaknesses?

In 1928, a noted Psychologist, William Moulton Marston published, *Emotions of Normal People*, in which he described the DISC theory we still use today in behavioral research. Marston described four categories of human response. *Dominance* , the drive to overcome opposing forces you perceive to be inferior to yourself; *Influence* , the attempt to ally forces to yourself through persuasive means; *Submission* , the acquiescence of yourself to an allied force you perceive to be superior; and *Compliance* , the subordination of yourself to a hostile force you perceive to be of superior strength.

Personally, I like Dominance and Influence. But who wouldn't? The truth is, as each of you will have to do, I had to determine my own strengths and weaknesses in responding to each of these four situations. How you respond to each of these situations will absolutely determine which path you choose in pursuing your own interests.

How far you go on that path will require you to have something else entirely; *Vision* . Do you have vision today? If not, that's ok. Vision is very individual. Keep your mind open and it will come to you. It is the ability to see from where you are standing at any given time, all the way to where you want to go. Step by step. All the way up your own mountain to your own goals at the top. The higher your goals, the higher your mountain and the more critical it is that your vision be clear. Your vision is your power. Do not allow anyone to take it from you. Vision will pull you out of the tough times and keep you on your chosen path. Refining your own vision along the way is normal, and it shows that you are taking a leadership role in reaching your own goals. Once you do that, you can lead others. Real leaders, after all, are just ordinary people with extraordinary determination.

Being a leader also means giving back to your younger generation. Wouldn't our world be a better place today if we started teaching our children to understand the earth at an earlier age? I have a suggestion that each of you is qualified to do tomorrow. I've done this. It's priceless. Offer to visit an elementary school class. Have the children bring to class that day a favorite rock or mineral specimen that they discovered. Teach them the local geological history using their own specimens to tell the story. When you ask each of those children to stand while you attach importance to something they found, you will see the face of a child who has discovered what it means to explore the earth.

So, I leave you with these words which come straight from my soul. Never lose focus on your dreams, your goals, your path, and your vision. The greater they are, the more you need to keep them glued to your forehead. Leave room in your mind to explore and room in your life to grow. Leave room in your mind to grow and room in your life to explore. And in the words of Mr. Marston:

“Realize what you really, really want. It stops you from chasing butterflies and puts you to work digging gold!”
Thank you. Now, let's celebrate!

Spring 2006 Commencement Address

L. Preston Bryant, Jr.

Virginia's Natural Resources: A Case for Stewardship

May 13, 2006

Professor Tracy, Faculty, Staff, Graduates, Families, and Friends:

It is with joy and no small amount of pride that I am here this morning to address you. I was honored to have received the invitation, the very first commencement invitation I have received in my new role as Secretary of Natural Resources.

And, besides, it is not every day that a liberal arts graduate is asked to address geosciences graduates. After all, my primary academic interests are late-18th century poetry and prose as well as modern British literature, and I dabble a bit in Beowulf, Chaucer, and Shakespeare. So far be it from me to presume to offer advice, whether practical or theoretical, to bright scientific minds on this early Saturday morning.

I am, to be sure, a believer in a liberal arts education. Our world is increasingly complex; our societies are increasingly cross-cultural; and our collective need to be increasingly collective in thought in so many areas of life is, well, increasing. It is incumbent upon us to contemplate, plan, and be able to measure the impact of technological advances on the human condition. We need to know how emerging science and technology will change the way we understand ourselves and others.

Personally, I am fortunate to have spent time in – and to, in many respects, to have been defined by – the arts, sciences, and social sciences. Most every summer, I teach a five-week literature course at the local community college – often medieval and middle English, occasionally Romantic and modern; for more than a decade, I have been a partner in an engineering (civil, geotechnical, and environmental), surveying, and planning firm; and I also have had the distinct privilege of serving in state government, for a decade in the Virginia House of Delegates and now in the Executive Branch, where higher education policy and environmental policy have been primary concentrations. So, yes, the arts, sciences, and social sciences are all a part of me.

This is a life-mixture that not everyone can experience. I realize that. And I am grateful that I have been fulfilled in this way.

When Wordsworth sat a few miles above Tintern Abbey in the Wye River Valley, looking out over a landscape that I also have admired and hiked, he was moved to write what is perhaps the most pantheistic poem in Romantic-era literature. In all parts of nature, Wordsworth saw great good.

When Joseph Conrad wrote *Almayer's Folly, Victory, Lord Jim, Heart of Darkness,* and other novels and stories, he often relied on the landscape and natural world around his characters to reflect and accentuate for the reader their human condition. To Conrad, travelers' trips down rivers through jungles were searches for souls in unsettled colonial worlds.

And when the modern James Michener wrote *Chesapeake*, he did so with such description and power that he brought to life a most historic landscape of Virginia (and Maryland), allowing the reader to clearly see that the water and land and indigenous wildlife were as important to our Commonwealth's – and nation's – founding as ships and guns and tools. (If you're a Virginian and you have not read Michener's *Chesapeake*, then let that be your first post-graduate homework assignment.)

Ours is a Commonwealth whose natural resources are, in my opinion, more historic than those of any other state. Looking eastward, we see our 12,000-year-old Chesapeake Bay, one of the world's most wondrous estuaries. Its tidal flows connect ocean species to today's landlubbers; certainly, those flows helped that first fish with toes come ashore. And, of course, we all know about its 35 million-year-old cataclysmic crater. On our westward spine, there are our Blue Ridge Mountains, renowned in film and song, but historic for their pre-Revolutionary War wagon road, which Englishmen, Scots, German Protestants, Mennonites, and Moravians traveled to settle much of the eastern United States. And connecting that wondrous estuary to those renowned mountains are the most historic rivers in our nation – the Potomac, Rappahannock, and James – which led the very earliest settlers into a new frontier.

And then, of course, there are such relatively unknown but highly treasured resources as the small quarry in Pittsylvania County, which is the only place on the planet where entire Triassic insect fossils are being collected. We can be proud that researchers from this very department are involved in that work.

Yes, Virginia has the most historic natural resources in the nation. Put another way, we have a lot to lose if we are not careful. It is our responsibility to preserve and promote them – and that is one of the impressions I hope to make upon you this morning.

If we are indeed to preserve and promote them, however, we must do so by first acknowledging the stresses our resources are under.

Let's look at three areas to make this point – population growth, transportation demands, and energy consumption.

Our natural resources will forever be under stress as Virginia continues to grow. Such is not new, really, and it only states the obvious. Virginia has for many decades worked to protect our heritage resources against the demands of a growing population and an increasingly sophisticated economy. We are kindly "victimized," in a way, for living in an economically well-positioned mid-Atlantic state, whose proximity to the nation's capital, moderate climate, diverse landscape, and generally high quality of life are more than so many can refuse. That said, such growth, in many ways, beats the alternative. Living in a growing, healthy state, while bringing on certain challenges, is a good thing.

Reviewing the past half-century, though, we can see that our state's population has doubled. In 1960, Virginia was home to four million people. Today, we have seven-and-a-half million. And by the end of this decade, we will be home to eight million people. That's twice as many people in 50 years, with the rate of increase in just the past decade especially hyped.

The result, in part, is that our spatial gaps are being filled. Our once rural areas – especially those between Northern Virginia and Richmond, along our historic Northern Neck and Middle Peninsula, in our upper Shenandoah Valley, and in our southeastern peanut-and-pine flats along the North Carolina border – are becoming increasingly suburbanized.

Over the past decade alone, Virginia has lost to development an average of 60,000 acres each year, and much of what is lost is from working farmland. Broken down, we lose to development nearly 200 acres every day – that's nearly a hundred acres lost before lunch time each day, and another hundred acres lost before dinner.

In transportation, we see an unsurprisingly similar trend. Over the past 20 years, the vehicle miles traveled in Virginia has increased by more than 70%, while over the same period the number of new lane miles constructed has only been 8%. This equates to the congestion levels that we know so painfully well, the increased time we spend in our cars, and growing amounts of energy we routinely expend (or waste).

And energy is something we know to be more and more precious. (I actually got excited yesterday when I saw that gas was down to $2.75 per gallon.) Our in-state energy trends are no different than our national ones – they track an obviously similar upward path. Virginians consume nearly two-and-a-half quadrillion BTUs annually. We import more than 50% of our total energy needs, with petroleum accounting for two-thirds of it. Coal is our only energy export – and that's being depleted.

A couple of hours southwest of here, we have about 250 million tons of coal reserves remaining. Steady growth in Virginia's coal production began in about 1890 and lasted for a century. However, our state production peaked in 1990. Since then, there has been a steady decline in coal extraction. Indeed, projections suggest that over the next decade, Virginia coal extraction from the quarter-billion tons we have will fall to about 20 million tons per year and then to half that over the ensuing years. A steady decline in the balance will come over the next century. It is safe to say that in the mid- to late-21st century, Virginia coal will peter out to negligible annual yields. And economics being what it is, those negligible yields will likely give way to the no-longer-worth-it costs of production.

Oil is in equally challenging supply. Virginia is not a great oil-refining state. We never have been. Though we do have one major oil refinery in Hampton Roads.

There is an estimated two trillion barrels of oil beneath the earth. One trillion has been extracted, and we are now down to the second trillion. Globally, we are extracting about a thousand barrels every second. We are now burning 31 barrels for every 4.5 barrels discovered. Production is on the decline in 54 of the 65 oil-producing countries.

These are trends – facts – that should ring certain alarm bells.

We know the need for alternative sources of energy. Such is the challenge facing the new graduates from this Department of Geosciences.

But let's bring the case for stewardship back closer to home. Let's return to James Michener's Chesapeake Bay.

It's one thing to cite a mineral that's disappearing; it's another to cite a historic Virginia species and food source. The plight of our native Chesapeake Bay oyster, the *C. virginica*, is a delicious stewardship point to make. Indeed, its sad decline is precisely what happens when the demands of growth outstrips our natural resources – or at least our smart management of those resources.

When Captain John Smith arrived in the Chesapeake Bay and our tidal rivers nearly 400 years ago, he found mounds – mountains – of oyster shells so numerous and near one another that they were navigational hazards. Oyster shells were elongated and measured a foot in length.

In the early 1900s, however, we Virginians began significantly over-harvesting our Bay's oysters. We took the oysters but did not replenish their shell habitat. Instead, we used their shells for road-building. And we continued this over-harvesting through the 1950s, when our post-war population began booming and development in the Chesapeake Bay watershed dramatically increased, causing greater urban and suburban runoff pollution (phosphorus and nitrogen), a dramatic increase in the loss of open-space lands, and a predictable result in water-quality degradation. Our native oysters, then, with their environment so damaged and changed, became vulnerable. Disease set in more than a half-century ago, and the population has never amassed the numbers or strength to recover. Our oyster harvest today, relatively speaking, is measured in teaspoons rather than buckets. The last 10 years' harvest has been disastrous.

We most certainly will never see the kind of rebound we would like in our native *C. virginica* oyster. For more than five years we have been conducting research on the introduction of an Asian oyster, *C. ariakensis*, into our Bay. And a several-year environmental impact statement is also now being conducted.

Yes, these are the challenges that face new graduates from this Department of Geosciences.

Virginia without oysters is like a flower without petals. It is historically upsetting and significant.

Leaving Virginia Tech and this Department is the first step of your professional careers – careers that will take time to develop and then unfold.

Your personal lives and professional careers will need a proper balance to prevent undue wearing on any given side. Personally, you should continue sharpening your scientific minds by feeding, in no small part, off of other non-science foods – art, literature, and history.

If you need a patron saint, look to Bertrand Russell, the British philosopher, logician, essayist, and social critic. He was a prolific writer in both the sciences and humanities. While not everyone would call Russell "balanced" in every sense of that word – he was more eccentric than anything – he did cut a colorful swath in life.

It is incumbent upon you, though, to work for a personal balance much the way we Virginia policy-makers are forever working to balance our natural-resource protection against the growth trends we know so well and with our long-standing, historic commitment to economic development.

And when you are professionally working for "progress," consider the many ways progress can be defined and what the impact of that progress might be in a social and cultural sense. Think of our *C. virginica* oyster. Will your work – or the next generation of product that your work today may lead to – change the way we understand ourselves and others? If so, how?

I will say again that I do not presume to impart great wisdom. I can only testify to the joys I have had from engaging in the part-time teaching of Beowulf and Chaucer and Wordsworth and Conrad while being a full-time partner in a civil engineering firm while still working in the public policy of our Commonwealth – social, economic, educational, and environmental.

I hope the personal and professional balance you achieve brings the same level of joy as you step away from these beautiful mountains.

Thank you for allowing me to be a part of this special weekend.

Spring 2007 Commencement Address

William A. Thomas

The Geosciences at Virginia Tech: One Hundred Years and Counting

May 12, 2007

I am highly honored and greatly pleased to be invited to address the 2007 graduating class of the Department of Geosciences at Virginia Tech on the occasion of the 100th anniversary of the awarding of the first geoscience degree from what was then VPI. It was 1907 when Joel Hill Watkins received that first degree. I, too, am a graduate of this department. I came to Virginia Tech in 1957, which, if you do a little arithmetic, turns out to be 50 years ago, on the 50^{th} anniversary. In my memory, at least, that milestone went unremarked. Nevertheless, it is humbling and inspiring to realize that I have been associated with this department for half of its history. I do want to acknowledge someone here who has had an even longer and much more direct association with the department, Dr. Wally Lowry.

I finished my Ph.D. dissertation in the fall of 1959 and participated in commencement in 1960. At that commencement, the department awarded three Ph.D. degrees; these were the 2^{nd}, 3^{rd}, and 4^{th} Ph.D.s granted by the department. Looking around us today, it is clear that the department has grown and prospered, along with the university, during the past 50 years.

I hope you will indulge me a bit of reflection on the department of 1957. Graphics software was tracing paper and ink; graphics hardware was a pen and a Leroy lettering device. Word processing was done on a typewriter, and the final dissertation required an original and five carbon copies. The department had a faculty of seven, and it shared Holden Hall with Mining Engineering and Metallurgical Engineering. We worked with the theory and technology of the day. We students learned to evaluate data and to derive conclusions by pursuing the scientific method. Most importantly, we learned to question established theory, to ask critical questions, and (in today's vernacular) to think outside the box. What did we get from our geoscience education at Virginia Tech? That background has enabled us to adapt through the years as new ideas and technology have evolved. For example, the research of my recent students spans quantitatively balanced structural cross sections, foreland subsidence modeling, U-Pb ages of zircons, Sr isotopes, and interpretation of seismic reflection profiles. My work on construction of balanced structural cross sections uses no paper or pencil, only a computer program that I have adapted. The 1950s grads of Virginia Tech were prepared to adapt and grow, and the seeds of the present department were being sown 50 years ago through the leadership and vision of Byron Cooper and Wally Lowry.

So we come to today, recognizing the achievements of the 100th crop of Hokie geoscientists. This group of students has had access to a large and diverse faculty, to modern technology, and to a Virginia Tech tradition of research that involves thinking outside the box. This is now one of the premier departments of geosciences, and it is growing. To the class of 2007, I extend my congratulations. You are well prepared to take on the next 50 years.

Having taken a look back, I would now like to look ahead. During the time I was President of The Geological Society of America, we launched a series of strategic discussions of "The future of the geosciences." What are the geosciences? What unites us as geoscientists? The growth of new lines of inquiry and diversity of specialties, as well as interdisciplinary studies, expands our horizons and strengthens our science. We do need to maintain our common ties to avoid a public and political perception that we are simply a disconnected collection of small groups of specialists rather than a large integrated force with common goals. Unity and a common voice are essential if geoscientists are to achieve the strength of numbers necessary to gain greater public and political recognition and support. We are in this together. We would all like to see a greater use of geoscience data and advice in decision making at all levels. Of course, we know that the oil companies use geoscience data intensively; we would hope to see the same intensity in venues from city planners, to regional water boards, to the federal government, to international agencies. We can begin with greater emphasis on geoscience education at all levels, including the generally weak K-12 programs around the country. Improvement of geoscience literacy throughout the population is necessary to greater acceptance of our role in the solution of societal challenges.

Our recent discussions have turned to some specific questions, and I'll address those questions to you. Think for a minute. What are and will be the major issues facing the national and world population over the next 15 to 20 years? I'm sure that we here could quickly agree on an imposing list: water quality and quantity; energy resources; food supplies; global climate; sources of industrial raw materials; natural hazards—earthquakes, volcanoes, landslides, storms, bolides; population density; government stability and distribution of wealth; religious extremism. Now, the next question is, which of those issues has a geoscience component and/or a geoscience solution? Perhaps partly because we are geoscientists, our list of issues is dominated by geoscience issues. Food supply, for example, encompasses the geoscience issues of soil, water, and mineral fertilizer. Distribution of wealth is related to distribution of natural resources and to the development of those resources. Clearly, many of the global issues of the next two decades have roots in the geosciences. Having recognized that, the challenge to us is, what will we as geoscientists do about it? We can strive to improve geoscience education, including continuing education, to have an informed public involved in decision making; and perhaps we can improve comprehension of the geosciences by better public relations. Nevertheless, the most direct challenge is to have our research provide the actual solutions for the big problems. If our research clearly is having an impact on improving global living conditions, a public awareness and demand for improved geoscience education and understanding will follow. The challenge is to ourselves: what are the big issues? And how does our research address those issues? I'll personalize the question, and address it to each of you individually, how does your work address those issues? While this question may seem as advocacy for short-term, goal-oriented, directly applied research, it is more. The future of our understanding of the processes that drive both challenges and solutions depends on fundamental, curiosity-driven research; indeed, many of our issues are complex, long-term, and multi-context. We are challenged both to resolve current problems and to provide the theoretical basis for future applications. To the class of 2007, you face grand challenges that offer you grand opportunities. The future of the geosciences is in your hands; indeed, considering the issues we have just listed, the future of the world is in your hands. Standing here with you in this room today, I have a sense of comfort, because I am confident that you will meet those challenges.

Ordinarily, I would stop here. I would repeat my congratulations to the class of 2007 and wish you well. I do most sincerely congratulate you and wish you well. However, we all remember that this graduating class has gone through an unimaginably horrifying experience. We will always remember. Your graduation today stands as a reaffirmation that order will prevail, as well as a reaffirmation of our free and open system of higher education, of a positive sense of purpose, and of dedication to a meaningful goal. I am sure that all of you were, as I was, touched and inspired by the words of Professor Nikki Giovanni, and I will close with a quote.

"*We will prevail.*

We will prevail.

We will prevail.

We are Virginia Tech."

Spring 2008 Commencement Address

Barbara Tewksbury

Insights from Apollo for Teaching and Learning Geosciences in the 21st Century

May 10, 2007

The PowerPoint presentation accompanying this text is available as a PDF.

Apollo science (1)

I think you could argue that the Apollo missions to the Moon were the ultimate field trips – who in this room of geologists doesn't envy Jack Schmitt, trucking around the lunar surface, dirty up to his thighs with Moon dust? But more than that, I think you could argue that the Apollo EVAs were the single most important 80 hours of field work in history. They constrained not only our understanding of the origin and evolution of the Moon and Early Earth but also established the importance of impact cratering in the histories of planets and provided radiometric calibration for planetary surfaces across the solar system. But no matter whether you figure the cost by the hour or the kilo of rock collected, it was hands down the most expensive field work in history and involved a truly staggering number of people both in training and in the missions themselves.

Apollo science (2)

With one exception, none of the Apollo astronauts were geologists. They were pilots trained in engineering or aeronautics. Despite this, they did good geology on the Moon. I have just come back from a meeting in Houston where about a dozen of us met to begin planning the geologic training for the next group of NASA astronauts, the ones who will return to the Moon. It was a fascinating and stimulating meeting that began with a day of presentations by Apollo astronauts and the geologists who trained them. I learned a lot. They had a lot to say about what worked and didn't work in Apollo geologic training.

Apollo Geo training

Bob Tracy asked me to talk to you today about geoscience education. I thought I would do it in the context of how the Apollo astronauts were trained to do good geology. We'll look at what worked and what didn't. And we'll see that the training was, in many ways, very much ahead of its time. We'll look at what they accomplished and how they did it and think a little bit about how it validates current trends in geoscience education.

So many rocks, so little time

What challenges did the Apollo astronauts face? Everyone wanted them to do more than just trot around a grab as may rocks as they could. They needed to know enough about geology and the science objectives of the mission to decide which of literally hundreds of rocks they would actually pick up and document. For example, by the time Apollo 15 rolled around, geologists had seen plenty of mare basalts and impact breccias, but a sample of the Highlands and a sample of old crust was still the Holy Grail at the time of Apollo 15. Random rock grabbing was not likely to change that.

No hand lens, no bending

What other challenges were there? Imagine doing field work in a suit where you can't use a hand lens and you can't bend over at the waist. And where there is literally nothing to see in the shadows because there is no atmosphere on the Moon to diffuse light into the shadows. Imagine the time constraints imposed on you – the last three missions to the Moon had rovers and had the most time dedicated to work on the lunar surface, but each of these had only three 7-hour EVAs each. And imagine doing field work where you can't take notes and you are describing everything you see out loud to the geologists in the "back room" at Mission Control back on Earth. Not only do you have to know enough geology and geological language to do this, but you also need to be able to do it systematically and efficiently.

You can't take it with you

And last, the astronauts couldn't bring home everything they saw so that some geologist could look at it. The astronauts needed to be good observers and good describers. In short, they needed to be field geologists. Problem was, at the time Apollo geology training started in 1964, none of the 29 astronauts had had even an intro geology course. So, NASA started from scratch training the Apollo astronauts in geology. Things looked up when Harvard Geology PhD Jack Schmitt became an astronaut in 1965, and he played a significant role in astronaut geology training, but it wasn't until the very last mission to the Moon that a geologist saw the rocks first hand. Every other Apollo astronaut needed significant training in field geology.

How did they train?

The most successful and crucial element of training were the field trips – nearly one a month for each crew. Astronauts had shirt sleeve training, training with backpacks to simulate the life support units, and full-up in-suit training in the field in settings designed to be as Moon-like as possible. Each mission prime crew and back-up crew spent more than 150 hours in the field. To put that into perspective, the average one-semester geology course with lab has at most 75 hours in classroom and lab. And, in addition to field trips, the astronauts had classroom, lab, and personal study time in geology.

What did they do?

Many of the field trips at the outset were pretty much show and tell. But, because they were boring for the astronauts and not successful in teaching them anything, they quickly evolved into a model that had brief show and tell for context followed by a long working traverse. Each team of 2-3 astronauts worked the traverse and then debriefed with geologists on the way back. The astronauts were the ones doing the work, and they received almost immediate feedback on what they had done well and what they had missed, which is an ideal situation for learning.

What were the aims? The training was designed to: develop an astronaut's ability to see, and not just look, and to describe what they saw; make them fluent in the geologic language to communicate with the "back room"; give them practice in organizing their thoughts and approaching geologic problems in the field; and give them experience in context - with rocks and settings that were as close to what they might see on the Moon as possible.

Did they succeed? (1)

As I mentioned before, one of the elusive targets at the time of Apollo 15 was crystalline rock, anorthosites in particular. When Irwin and Scott almost simultaneously saw a nearly white rock along one of their traverses, they were completely beside themselves. Here's an excerpt from the Apollo 15 transcripts:

> "Oh, man! Oh, boy! Look at that. Look at the glint! Almost see twinning in there! Guess what we just found. (they are by now laughing with pleasure) Guess what we just found! I think we found what we came for. Look at the plage in there! Almost all plage. Oh, boy! I think we might have ourselves something close to anorthosite. What a beaut."

Does this sound more like a pilot or a geologist?!?

In a post-mission debrief, Dave Scott was asked about the discovery. Here's an excerpt from the transcript. "It's crystalline, and nobody'd ever found any crystalline rock before (except small pieces in the soil samples). That was the whole idea of the traverse because the craters were expected to have excavated some of the pre-mare highlands material, which people contemplated was crystalline, plagioclase, anorthosite. So we had spent a fair amount of time discussing that, obviously tuned to looking for it. When you look across the surface, the rocks are all covered with dust, so you're not going to see this clear demonstration of the twining in plagioclase for the crystalline rock. You have to pick it up and you have to look at it to be able to see it. It was probably more definitive than any plagioclase we had seen, except the real pure stuff they had in the lab. "

These were clearly not just pilots running around grabbing samples on the Moon. They were good observers, and the transcripts show that they were outstanding at describing and thinking in the field. And they were clearly invested in the process.

Did they succeed? (2)

Let’s look at another example, this time from Apollo 16. John Young and Charlie Duke trained extensively for what geologists were sure would be volcanic rocks in the Cayley Plains. John and Charlie were well enough trained to recognize once they got there that they weren’t, in fact, looking at volcanic rocks but, instead, more impact breccias, and they described exactly what they saw and what they thought it was. They didn’t even allow themselves to be bullied by the geologists in the “back room”, who didn’t believe them. As John Young said, “We got to see anorthosites in the Duluth Gabbro and we saw them in the San Gabriel Mountains. The ones at the Duluth Gabbro had a remarkable resemblance to the ones out there that we found at 16. ”

Fast forward 40 years

Over the past 25 years, cognitive scientists have learned a lot from studying how people learn. What cog sci research tells us is that people learn when they are actively engaged, when they have a purpose, when they apply and solve problems, and when they have a context for new experiences

Apollo Geo training in retrospect

If we look at Apollo geo training in retrospect, we can see that the training overall was very much ahead of its time and completely consistent with what has been documented about how people learn. Initially, the geology training was heavy on classroom lectures and outside experts as talking heads. The astronauts were bored and not learning much. After the first field trip, the astronauts’ reaction was “We’ve listened to you for two weeks in class and not understood much. We couldn’t see the importance of any of it. On the first field trip, though, it all made sense”. And you have to give a lot of credit to those planning the geo training. They had a clear goal of making the astronauts good at lunar field geology, and, when they initially saw what worked and what didn’t, they modified what they were doing in the classroom and field until, quite frankly, it had the hallmarks of what we think of today as the best kind of geoscience education:

- It de-emphasized talking heads and show-and-tell and, instead, focused on having the astronauts learning by doing.
- And they were doing more than learning facts.
- Their training was focused on observing and describing – on seeing instead of just looking.
- Their training was also problem-based and in context of what they would be doing on the Moon.

Implications for teaching geoscience

Whether it's in the field or the classroom, astronauts and students learn better if they are doing geology, speaking geology, applying what they know to solve problems, organizing their own thoughts and approaches to geologic problems that are in context, and arguing and defending their ideas.

Last slide

The Apollo astronauts look back on their geological training and speak with great enthusiasm about the truly extraordinary teachers they had (and you will recognize their names) – Lee Silver, Farouk El-Baz, Bill Muelberger, Gene Shoemaker. These teachers had an enormous challenge and responsibility, and their instincts about how to train pilot-geologists were spot on. The average geology classroom in this country isn't yet where these teachers were 40 years ago in terms of really effective teaching. Hopefully we will get there before the next humans set foot on the Moon.

Spring 2011 Commencement Address

Dr. Carol Simpson

May 14, 2011

“When Is It All Going to Stop?”

When I thought about what I would say today, coming back to the Department of Geological Sciences to address the graduating class of 2011, I remembered my first ever Commencement exercises - right here at Virginia Tech.

As Dr. Eriksson mentioned, I didn't study at Tech as a student - and unfortunately I never went to any of my graduation ceremonies. I had always moved on to the next position already. So the first one I ever participated in was right here at Tech, as a brand new assistant professor faculty member.

It was all a bit of a mystery to me, to be honest - it seemed odd that a ceremony meant to celebrate the end of years of study and the completion of a degree program was called “Commencement.”   It seemed backwards.

But I soon realized that Commencement really ***is*** about new beginnings - the start of the next phase of your lives.

My next thought was about the faculty and staff who have been your teachers and mentors, how for them, for any of us who have careers in education, this Commencement ceremony is all part of the annual cycle of academia - just like the cycles of plate tectonics - the academic cycle never actually stops…

Students move through the programs - sometimes at rates that seem geologically slow to you (and to your parents,) and then, quite suddenly, you have reached the end and you are moving on to something new. Again, it's a bit like plate movements - always moving, even if quite slowly at times, but then you suddenly realize that almost without you noticing it, the world has changed.

Your worlds and the faculty's worlds have changed this week as dramatically as after a shift in the tectonic plates.

So my title “When is it all going to stop?" relates in part to this continuum of academic teaching and learning and research. Because although your studies for the degree that you've just earned have stopped, learning doesn't ever stop.

Next week, next month, most of the faculty here will be working away with their graduate students on their research projects - and many, if not all of you will be learning new skills in one new position or another.

I’ll bet many of you graduates were delighted that the last exam, or your thesis, or your dissertation defense, was finally done? No more studying and reading up on a subject. The hard work will finally stop...."

I'm sorry to tell you, but....
Now that you have all shown that you ***can*** do the hard work, that you ***can*** study and do the research and be successful, your future employers are going to say:

"Great! Keep on doing that, please, and show us you can do even more!" Even if you start your own company, the testing of your skills and ability to adapt never really stops. And here at Tech, in the Fall there will be new students for the faculty and staff to get to know. The cycle continues.

There is a second reason for my title of “When is it all going to Stop?” It goes back to a time in 1994 when a significant earthquake rocked Los Angeles and much of southern California. Some of you may have learned about it in your courses – the Northridge Earthquake.

January 17, 1994, at 04:31 Pacific Standard Time. The quake lasted for about 10–20 seconds and caused an estimated $20 billion in structural damage.

The earthquake had Moment Magnitude 6.7, nothing like the M 8.9 of Japan recently, but the ground acceleration caused significant structural damage.

At the time of Northridge, I was working on the faculty at Johns Hopkins University and took a phone call later that day from someone called Larry King who wanted to interview me about the earthquake on his TV and radio shows.

So off I went to meet Larry King, having no idea who he was (I never watched late night TV or listened to his show). I rather naively fielded questions from him and from the listeners who called in, who had questions such as “Should I move to Oregon?” and comments such as:

"My cats always know when there is going to be an earthquake." Hmmmm.

And the final call in listener of the evening was an angry-sounding gentleman who demanded to know: “When is it all going to stop?!! That's what I want to know!”

Well I cheerfully told him that plate motion wasn't going to stop - at least not anytime soon. And that unfortunately, we really are still a long way from predicting when and where the next fault will slip.

And that’s why we need to continue the research. But there is more to it than just the geoscience research. Human behavior and politics and economics each play a huge role.

Those terrible disasters in Haiti and Sumatra and most recently in Japan - these are human catastrophes that can only be “mitigated” by understanding the underlying causes But in addition, we also may need to take extraordinary measures at great expense, such as:
Very expensive earthquake/civil engineering structures;
Or moving whole populations away from danger zones such as fault zones or the coast (where land is cheap and the views are often spectacular);
or, investing billions of dollars in systematic monitoring of every known fault zone.

OR by some entirely new invention or measurement technique that is still to be invented. Perhaps by one of you!!

The bad news is that earthquakes and tsunamis (and other major disasters) will not stop, but the good news is that neither will the effort to find new practical solutions to help mitigate their effects.   There is still much work to do. One of you here today could easily be the one to come up with the answer to one or all of these problems. And that is something that your Virginia Tech education has taught you to do.

I’ll admit that most of us are happy enough doing a good job without necessarily trying to change the world. But each of us ***does*** change the world, whether we like it or not or whether we mean to or not.

The final reason for my title is that I am sure some of you have noticed the doomsday prophecies that are flying around at the moment. One is that the Mayans predicted the End of the World will be in 2012. Another is that the beginning of the end will start on May 21, 2011....that would be next Saturday...., and end on October 21, 2011.

Realistically, neither prediction is based on scientific data nor at all likely to occur. ***But***, if we do not take action ***now***, to preserve our world, its water, animal and plant species, clean air.... Then the world as we know it, with all its natural beauty and diversity, really will stop. Not this year, or next, but in your children's or grandchildren's lifetime.

So Class of 2011, I ask that you be thoughtful and purposeful about using the geoscience and other information you have learned and help those who do not understand issues like climate change to see what the long term effects will be if we do not take some serious action now.

It isn’t a question of challenging people’s belief systems – the data are real enough. The oceans ***are*** warming. Ever so slowly. And sea level ***is*** rising. Ever so slowly, yes. But it isn’t going to stop. At least not in your lifetime.

We can't actually stop or reverse global warming and sea level rise overnight, but we can look at alternative energy sources that will not worsen the effect and that do not pollute our oceans and fresh water supply, or poison our agricultural land.

You will each go on to do great things in your lives. Things large and small, but all are important. Whether you go to work for an energy company or the water/waste industry, or help build wind farms, or advise elected officials, or become an elected official, or raise a family, or go into education…. These are not all mutually exclusive, by the way.

What you are going to do with your lives ***will*** make an impact on others.

So:

Show the world what a Virginia Tech geosciences education has done for you.
Use that education and the skills you have learned to change the world, a little bit at a time, in positive ways. Your contribution to the world as a whole is just starting… and it isn't going to stop!

Congratulations, Class of 2011!

Biographical Notes

Robert M. Hazen

Robert M. Hazen, research scientist at the Carnegie Institution of Washington's Geophysical Laboratory and Clarence Robinson Professor of Earth Science at George Mason University, received the B.S. and S.M. in geology at the Massachusetts Institute of Technology (1971), and the Ph.D. at Harvard University in earth science (1975). After studies as NATO Postdoctoral Fellow at Cambridge University in England, he joined the Carnegie Institution's research effort.

Hazen is author of more than 300 articles and 19 books on science, history, and music. A Fellow of the American Association for the Advancement of Science, he has received the Mineralogical Society of America Award (1982), the American Chemical Society Ipatieff Prize (1986), the ASCAP Deems Taylor Award (1989), the Educational Press Association Award (1992), and the Elizabeth Wood Science Writing Award (1998). He has served as President and Distinguished Lecturer for the Mineralogical Society of America. Hazen's recent research focuses on the role of minerals in the origin of life, including such processes as mineral-catalyzed organic synthesis and the selective adsorption of organic molecules on mineral surfaces.

Hazen's books have received widespread critical praise. The Music Men, Wealth Inexhaustible, and Keepers of the Flame, all coauthored with his wife, Margaret Hindle Hazen, explore ties between technology and culture. The Breakthrough, The New Alchemists, Why Aren't Black Holes Black, The Diamond Makers, and Genesis: The Scientific Quest for Life's Origins describe the forefront of scientific research. He has also written widely for popular audiences, including articles in Newsweek, Scientific American, New Scientist, Smithsonian Magazine, and The New York Times Magazine. His writings have been selected for inclusion in several science writing anthologies, including The Best Science Writing of 2001.

Prof. Hazen is active in presenting science to a general audience. At George Mason University he has developed courses and companion texts on scientific literacy. His books with coauthor James Trefil include the best selling Science Matters: Achieving Scientific Literacy and The Sciences: An Integrated Approach, now in its fourth edition. Hazen also served on the team of writers for the National Science Education Standards. He teaches courses on symmetry in art and science, on images of the scientist in popular culture, and on scientific ethics. Hazen serves on the Committee on Public Understanding of Science of the American Association for the Advancement of Science, and on Advisory Boards for NOVA (WGBH Boston), Earth & Sky, Encyclopedia Americana, and the Carnegie Council. He appears frequently on radio and television programs on science, and he developed two popular video courses: The Joy of Science and The Origins of Life, both produced by The Teaching Company.

In addition to his scientific activities, Robert Hazen is a professional trumpeter. He has performed with numerous ensembles including the Metropolitan, New York City, Boston, and Washington Operas, the Royal, Bolshoi, Jeoffrey, and Kirov Ballets, the Boston Symphony, the National Symphony, and the Orchestre de Paris. He is presently a member of the National Philharmonic and the National Gallery Orchestra.

Robert and Margaret Hazen live in Glen Echo, Maryland.

Dr. Frank Press

Dr. Frank Press was President of the U.S. National Academy of Sciences and Chairman of the National Research Council from 1981 to 1993 and Science Advisor to the President of the United States and Director, Office of Science and Technology Policy from 1977 to 1980. Prior to that, he was Professor of Geophysics at Massachusetts Institute of Technology and Chairman of the Department of Earth and Planetary Sciences. Previously, Dr. Press was Professor of Geophysics at California Institute of Technology and Director of the Caltech Seismological Laboratory. He is a Life Member of the Corporation of MIT and a board member of the Woods Hole Oceanographic Institution, the Marine Biological Laboratory, and the Monterey Bay Research Institute. He was the Cecil and Ida Green Senior Fellow at the Carnegie Institution of Washington from 1993-1997.

Dr. Press was elected to Fellowship in the American Academy of Arts and Sciences, the Royal Astronomical Society, the Royal Society (London), the Russian Academy of Sciences, and the Academie des Sciences of France. He is the recipient of 30 honorary degrees. Among his awards are the U.S. national Medal of Sciences, the Vannevar Bush Award, and the Pupin Medal from Columbia University. Dr. Press received the Japan Prize from the the japan Emperor in 1993.

Recently, he has undertaken numerous projects involving R&D strategic planning, and creating management and research scenarios for new research undertakings, including research partnerships, in industry and academia. His extensive experience in international science has been utilized in helping client corporations to develop new international research opportunities.

Dr. Press earned a B.S. degree from the City College of New York in 1944, and M.A. and Ph.D. degrees from Columbia University in 1946 and 1949, respectively.

Warren W. Wood Ph.D.

Dr. Warren W. Wood is a Research Hydrologist with the U. S. Geological Survey in Reston, VA. His research interests include diffusion and solute geochemistry of crystalline rocks, geochemical modeling of evaporite deposits, and geochemistry of artificial recharge. Dr. Wood's scientific contributions are published in over 75 papers.

Dr. Wood received many awards and honors. Some of them are:

- Visiting University Fellow at Oxford University, UK;
- Distinguished Service in Hydrogeology, Birdsall Distinguished Lecturer, and Fellow, in the Geological Society of America;
- Elected Board of Directors, in the American Ground Water Trust;
- Elected Life Membership of the National Ground Water Association;
- Keith Anderson Award from the Association of Ground Water Scientists and Engineers;
- Meritorious Service Award, from the Department of Interior;
- Phoebe Hearst Distinguished Lecturer at the University of California, Berkeley;
- Distinguished Lecturer for the National Water Well Association;
- Certificate of Excellence in Hydrology from the National Water Well Association;
- Honorable Mention Best Paper by the Society of Agricultural Engineering.

Dr. Wood's professional society services include:

- Editorial Board member of Geotimes;
- Associate Editor of Water Resources Research;
- American Geophysical Union Symposium Chairman;
- Association of Ground Water Scientists and Engineers Board of Directors;
- Chairman Darcy Search Committee NGWA;
- Editor-in-Chief of Ground Water;
- Chair of the Fellowship, Awards, and Distinguished Lecturer Selection Committees and Chair of the Association of Ground Water Scientists and Engineers Program;
- Chair of the Hydrogeology Division, National Program, and Birdsall;
- Distinguished Lecturer Selection Committee of Hydrogeology Division of the Geological Society of America.

Dr. Wood's university contributions include:

- Lectures at 58 North American universities during the last 10 years;
- Lectures at universities in Abu Dhabi, Australia, Botswana, England, Israel, Japan, Jordan, N. Ireland, Oman, Spain, and S. Africa;
- Advisory Committee member for the Department of Geosciences at the Michigan State University;
- Chairman of Scientific Review Committee, for the Center of Excellence, at University of Waterloo;
- Associate Professorship in the Department of Geosciences at Texas Tech University.

Dr. Wood received his BS, MS, Ph.D. degrees in Geology, Geology/Geophysics, and Geology/Hydrology, respectively, all from the Michigan State University.

Dr. Margaret S. Leinen

Assistant Director for Geosciences National Science Foundation

Dr. Margaret S. Leinen was appointed Assistant Director for Geosciences at the National Science Foundation effective January 10, 2000. In addition to her responsibilities as the Assistant Director, Dr. Leinen is responsible for coordinating environmental science, engineering and education programs within the National Science Foundation (NSF), and for environmental cooperation and collaborations between NSF and other Federal agencies.

Prior to coming to NSF, Dr. Leinen was Dean, Graduate School of Oceanography and Vice Provost for Marine and Environmental Programs at the University of Rhode Island. She was also Interim Dean, College of the Environment and Life Sciences. Dr. Leinen spent her entire academic career at the University of Rhode Island, considered one of the country's top institutions for marine studies. During her tenure, she spearheaded the University's efforts to build a cohesive interdisciplinary marine and environmental focus. Dr. Leinen is a well-known researcher in paleo-oceanography and paleoclimatology. Her work focuses on the history of biogenic sedimentation in the oceans and its relationship to global biogeochemical cycles, and the history of eolian sedimentation in the oceans and its relationship to climate.

Dr. Leinen received her B.S. degree (1969) in Geology from the University of Illinois; M.S. (1975) in Geological Oceanography from Oregon State University; and Ph.D. (1980) in Geological Oceanography from the University of Rhode Island.

She is past president of The Oceanography Society. She served on the Board of Governors of the Joint Oceanographic Institutions, Inc., and the Ocean Research Advisory Council. Dr. Leinen also served as the Vice Chair of the International Geosphere-Biosphere Programme and on the Board on Global Change of the National Research Council/National Academy of Sciences.

W. Tayloe Murphy, Jr.

Secretary of Natural Resources
State of Virginia

Prior to being appointed Virginia’s secretary of natural resources by Gov. Mark Warner, Tayloe Murphy served in the Virginia House of Delegates from 1982 to 2000. During his tenure in the General Assembly, Murphy served as Chairman of the Chesapeake Bay Commission. He was also chairman of the Joint Legislative Audit and Review Commission during its two-year review of the Virginia Department of Environmental Quality.

Throughout his tenure in the General Assembly, Delegate Murphy was noted for his commitment to environmental conservation and stewardship and protection of Virginia's natural resources. He was an instrumental leader behind the General Assembly's passage of both the Chesapeake Bay Preservation Act and the Virginia Water Quality Improvement Act.

Murphy served as co-chairman of the House Labor and Commerce committee, and held a seat on the committee on Corporations, Insurance and Banking, where he won respect for a reasoned and responsible approach to the intersections between industry and the environment.

Secretary Murphy holds a law degree from the University of Virginia, and an undergraduate degree from Hampden-Sydney College.

John R. Lawson, II

President and CEO W. M. Jordan Company, Inc.

Mr. Lawson began his career with the W. M. Jordan Company as a Field Engineer in 1975 after graduating from Ferguson High School and Virginia Tech with a BS in Geophysics. He is a 1989 graduate of the Advanced Management Program of the Associated General Contractors of America. Under his leadership, W. M. Jordan Company has become the largest general contractor in Virginia, with annual revenues exceeding $275 million dollars and a ranking in *Engineering News Record's* Top 400 Contractors in the United States for the past 25 years.

John is actively involved with the Associated General Contractors of Virginia, and is a past State President. He was recently appointed by Governor Warner to the Virginia Tech Board of Visitors. Other organizations include the World Presidents Organization, President of Greater Peninsula NOW, Advisory Board of the School of Building Construction for Virginia Tech and Stadium Expansion Committee for Virginia Tech. He also serves on the Board of the Peninsula Alliance for Economic Development, Virginia Foundation for Architecture, Hampton Roads Partnership, Children's Hospital of the King's Daughters, and the Mary Immaculate Hospital Foundation. He is Past-Chairman of the Virginia Peninsula Economic Development Council, serves on the Board of the Future of Hampton Roads, is a Board Member of Harbor Bank, Chairman of the Peninsula Light Rail Steering Committee, and Campaign Chairman of the Mary Immaculate Foundation Capital Campaign. Mr. Lawson is on the Building Committee of the Virginia Living Museum, and is newly elected to the Board of the Mariners' Museum.

He is married to the former Paige Zemany of Virginia Beach and resides in Newport News with his 8 year old son, Taylor, 7 year old daughter, Tess, and 3 year old son, Jack. In his leisure time, he enjoys boating, golfing, skiing, and history.

William A. Thomas

Chair of Earth and Environmental Sciences, University of Kentucky

Introductory Remarks by Bob Tracy, Geosciences Department Chair

My next, and most important, task here today is to introduce to you our commencement speaker for 2007, Professor William A. Thomas, Chair of the Department of Earth and Environmental Sciences at the University of Kentucky. Bill has been invited to be our speaker before, but has not been able to accept due to other commitments. This in fact has worked out very well in this particular year, since not only is he one of our own graduates, but he and his wife Rachel arrived on campus in Blacksburg as students in the fall of 1957, 50 years ago. The math is inevitable: Bill Thomas has experienced exactly one-half of our 100-year history of geology at Virginia Tech. He is therefore an admirable witness to share his perceptions of the past and future of this department, and its place in the greater geosciences community.

I have known Bill Thomas for fully thirty years. As a graduate student and post-doc in the 1970s, I was very much aware of his pioneering work on the tectonics of the Appalachians, and on global tectonics in general, and I had some great learning experiences hearing his presentations at meetings and talking with him on field trips. Bill graduated from the University of Kentucky in 1956 with a BS in geology. The next information will either shock or inspire the students in this room (or both!): he then obtained his MS from UK in 1957 and finished his PhD at Virginia Tech in 1959. His official degree date is the 1960 spring commencement, but he tells me he left Blacksburg for a job with the California Company (now Chevron) in fall of 1959. So - somewhere between three and four years from BS to PhD, doing a field-based sedimentology-stratigraphy-tectonics thesis for his PhD with the renowned hardnosed task-master Professor Byron Cooper. Truly remarkable, as his subsequent career has also been remarkable.

After his Chevron days, he moved into academia and has since been in five departments. He was in the department of Geology at the University of Alabama for an extended period, and has been at the University of Kentucky since 1991, where he is currently both the Hudnall Professor of Geology and Chair of his department. He has spent 47 years as a professional geologist, 43 of them in academia. He has published more than 160 articles in geological journals, and has most recently served as President of the Geological Society of America from 2004 to 2006. It is truly both a great pleasure and honor for me to present to you our own alumnus Professor William A. Thomas who will share with you and our graduates his thoughts on "The Geosciences at Virginia Tech: 100 Years and Counting."

Leonard P. Harris

Chief Executive Officer Southeastern Computer Consultants, Inc.

Virginia Tech Class of 1957

Mr. Leonard P. (Leo) Harris is a member of the Virginia Tech Class of 1957 with a degree in Geology.

He started his career as a Geodesist with the Aeronautical Chart and Information Center in 1958. In 1959, he moved to the Rand System Development Corporation as a System Engineer and later became Department Manager. In 1977, Leo formed Southeastern Computer Consultants, Inc. The Corporation now has offices in eight locations and he remains Chairman of the Board.

Mr. Harris also started a network corporation called Uninet, Inc. in 1990 and sold the company in 2003. In 1994, Mr. Harris formed Double Eagle Energy Company, Inc. to re-work two oil fields in Kazakstan. The company was sold back to the Kazakstan Government in 2000.

Mr. Harris has given generously in support of Virginia Tech. He is a member of the *Ut Prosim* Society, is a member of the Board of Virginia Tech's Institute for Critical Technology and Applied Science (ICTAS), and is a member of the Dean's Roundtable for the College of Arts and Sciences and now the College of Science.

Mr. Harris is a wonderful role model for our students. He has been successful in starting, building and leading corporations, he has been actively involved in an advisory capacity at the College and University level, and he contributes to our students' success by providing scholarship support.

Ladies and gentlemen, members of the class of 2004, it is a great pleasure to welcome Mr. Leo Harris as our Commencement Speaker. Mr. Harris!

Phillip E. Barnard, Jr.

Chairman & CEO Barnard Discovery Companies

Virginia Tech Class of 1983

Mr. Barnard received his Bachelor of Science degree in Geology from Virginia Tech in 1983. His undergraduate studies also included programs for the study of Field Geology in Switzerland and Invertebrate Paleontology at the University of Tubingen, in Germany. Upon receiving his undergraduate degree, Mr. Barnard had the honor of being accepted directly into a Doctoral Program at the City University of New York, where he was also the recipient of the program's highest fellowship grant and full tuition waiver. His doctoral research there began in the area of Stratigraphic Palynology and eventually turned to "Oil Potential in Back Arc Basins," a major new focus area for worldwide oil and gas exploration at that time.

Prior to the completion of his doctoral research, his growing interest in the business side of exploration led him to start his career as the Assistant to the Chairman of Owens & Company, Inc., an oil and gas industry corporate consulting firm in Arlington, Virginia. In this position, he gained first-hand experience in servicing management needs in the areas of mergers and acquisitions, corporate development, strategic analysis and project financing at the highest level.

In 1986, the oil and gas industry experienced a major downturn and suddenly new exploration projects for oil and gas became financially unattractive. This led Mr. Barnard to resign his position and form Barnard Associates, Inc. as a consultancy, offering similar corporate services for the local commercial real estate market. His focus on the business of exploration was quickly restored when he began to receive requests for similar services from start-up mining companies. The turning point of his professional career, however, came in late 1986, when his services were requested by one of the first international exploration projects in underwater shipwreck recovery. This project convinced him that a *"New Age of Discovery"* was beginning to appear worldwide.

In 1991, he formed Barnard Discovery Corporation, the first in a series of Companies with one prime mission — "To capitalize on emerging opportunities in an era where recent developments in new technologies would allow even the common man to open new frontiers in all four major fields of exploration and recovery: earth's Natural Resources and Natural Specimens, and man's Buried Treasure and Sunken Treasure." His services began to focus on areas of business vital to the success of these "new age" exploration projects. This served to unite his vocational interests in the business of exploration with his avocational interests in historical research and antiquity.

Today, after nearly 20 years in servicing the needs of new age exploration efforts all over the world, Mr. Barnard has played a valuable role in projects and transactions in every major field of exploration and recovery. Through the Barnard Discovery Companies, project management clientele receive a selection of trade and investment services, which is unique in the world of new age exploration. His private practice and strictly confidential delivery of services attracts a global clientele that currently includes foreign governments, numerous private exploration companies and some of the world's richest private investors. In 2005, the proven asset value of the projects and transactions requesting his services will exceed One Billion USD.

He is married to the former Diane Hofmeister, who is herself a 1980 graduate of Virginia Tech with a Bachelor of Science degree in Education. They reside in Northern Virginia with their 11 year old daughter, Marlana. Mr. Barnard is a certified wine sommelier and is a retired tennis teaching professional with top certification from the United States Professional Tennis Association for the past 22 years. He has served as a member of the Dean's Roundtable for the former College of Arts and Sciences, and has recently agreed to serve on the Alumni Advisory Board for the Department of Geosciences.

L. Preston Bryant, Jr.

Secretary Natural Resources State of Virginia

L. Preston Bryant, Jr., serves as Secretary of Natural Resources in the cabinet of Virginia Governor Timothy M. Kaine.

Prior to joining Governor Kaine's cabinet, Secretary Bryant served in the Virginia House of Delegates for 10 years, where he sponsored landmark legislation to help preserve more than one million acres of nontidal wetlands, streamline the state's stormwater management programs, and create a nutrient credit trading program to advance upgrades to more than a hundred wastewater treatment facilities that discharge into Virginia waters.

Secretary Bryant also was a partner in a Virginia-based engineering, surveying, and planning firm that specialized in the design of large-scale residential, commercial and industrial developments as well as transportation facilities.

Secretary Bryant was born in Lynchburg, Virginia. He received his B.A. in English from Randolph-Macon College, a master's degree in the humanities from the University of Richmond, and an M.A. in modern British literature from the University of London. He and his wife, Liz, live in Richmond.

Barbara Tewksbury

Professor of Geology, Hamilton College and past president of the American Geological Institute

Introductory Remarks by Bob Tracy, Geosciences Department Chair

My next, and most important, task here today is to introduce to you our commencement speaker for 2008, Professor Barbara Tewksbury, Professor of Geosciences at Hamilton College in Clinton, New York. She is a distinguished geosciences educator and is both a renowned theorist in geosciences education and an innovator in educational practice. She has held both the Kenan and Kirner Chairs at Hamilton College. She received a B.S. in Geology from St. Lawrence University and a Ph.D. from the University of Colorado. Her geologic research mainly focuses on structural geology and tectonics, and she is currently actively working on deformation of Precambrian rocks of the Grenville Province in the northern Adirondacks.

She has spoken and published widely on Geoscience education issues and has played a leadership role in the national geosciences education community for many years. She is a past president of the American Geological Institute, past President of the National Association of Geoscience Teachers and has served as President of the Geology Division of the Council on Undergraduate Research for three years. She is a Fellow of the Geological Society of America and has served as an elected member of the National Science Foundation National Visiting Committee for the Massachusetts Collaborative for Excellence in Teacher Preparation. She was named New York State Professor of the Year in 1997 by the Carnegie Foundation for the Advancement of Teaching, and was the 2004 recipient of the National Association of Geoscience Teachers Neil Miner Award for exceptional contributions to the stimulation of interest in the Earth Sciences. In 2006 she received an honorary Doctor of Science degree from her alma mater St. Lawrence University in recognition of her work in geoscience education.

Her presentation to us today is titled "Insights from the Apollo Program for Teaching and Learning Geoscience in the 21st Century." The presentation is a first for us at commencements as a Powerpoint-aided talk. It is an honor to have her here to address us, so please join me in welcoming Professor Barbara Tewksbury.

Carol Simpson

Provost and Vice President for Academic Affairs at Old Dominion University

Introductory Remarks by Kenneth Eriksson, Geosciences Department Chair

It is now my pleasure to introduce our commencement speaker Dr Carol Simpson, Provost and Vice President for Academic Affairs at Old Dominion University.

Carol Simpson became Old Dominion University's Provost and Vice President for Academic Affairs in January 2008.

Prior to her appointment at Old Dominion, Simpson served as Vice President and Provost at Worcester Polytechnic Institute in Worcester, Mass. (2005-2007), and served as Associate Provost for research and graduate education at Boston University (1999-2005). She also has more than four years' experience as a program officer with the National Science Foundation in addition to service on numerous federal, professional, and academic review panels and editorial boards.

As a faculty member, Simpson served as Professor and Chair of the Earth Sciences Department at Boston University, Associate Professor at both Johns Hopkins University and Virginia Tech, and visiting assistant professor at Oklahoma State University and Brown University.

An expert in structural geology and tectonics, she has authored more than 50 refereed publications and more than 80 professional conference papers and has received external grants of almost $1.4 million for her research. Simpson's honors include a Best Paper Award from the Geological Society of America (GSA), selection as a member of the AURA U.S. National Solar Observatory oversight panel, and election as a fellow and councilor of the GSA.

She received a bachelor's degree in Geology from the University of Wales, a master's in geology from the University of Witwatersrand in South Africa, and a doctorate in structural geology from ETH Zurich in Switzerland.

The title of Dr Simpson's address today is: "When is it all going to stop?" Carol, we are delighted to welcome you back to Blacksburg.