

CSM SENATE DISTINGUISHED LECTURE – DECEMBER 1999
125 YEARS OF EARTH SCIENCE PROGRAMS AT CSM: LESSONS FOR THE
FUTURE
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INTRODUCTION

The needs of society are fulfilled by the availability of natural, agricultural and human resources. Without adequate food, water, energy, shelter, materials and environment, much of the world's population as it currently exists would be doomed to a premature death.

By educating students for professional careers and conducting research in the discovery, production and beneficence of natural resources for 125 years, CSM has provided two of the resources essential to mankind. And by its dedication of purpose and the success of graduates and faculty, Mines has earned an international reputation as a premier natural resources college. In the last 35 years, degree offerings have been broadened to include other fields of engineering and economics, but the core programs in mineral engineering remain viable and continue their historical contributions to society.

Inasmuch as geology has been taught throughout the entire 125-year history of Mines, the staff and students of earth science programs have played an important role in the CSM success story. The purpose of this paper is to present a short historical account of the people and programs in geology, geophysics and geochemistry, which have been in lock step with, and supported by, all other academic programs as they contribute to Mines' mission. To fulfill the slogan "world's foremost school of mineral engineering" all students for many years were required to take four courses in geology in the core engineering curriculum; about one-half of the students would take as many as six or seven courses. Thus, the Geology Department grew because of a large service load in addition to its degree granting activities, at both the undergraduate and graduate levels.

SETTING FOR A SCHOOL OF MINES

The discovery of gold in 1859 brought prospectors, farmers, laborers, and businessmen to Colorado in large numbers—a 25,000 population when the Colorado Territory was created February 3, 1861, and over 100,000 by 1870. Land was claimed legally by individuals because of Acts by the U.S. Congress: Preemption Act of 1831, Homestead Act of 1862, Mining Act of 1872 and Railroad Acts of the 1860's.

Colorado was the subject of early geological and geographical surveys funded by the federal government. Early surveys that were given specific missions were: Pike Expedition (1806-07); Long Expedition (1820); Fremont Expeditions (1842-45), and the Pacific Railroad Surveys (1853-55). Because of the demand for gold and other

minerals, post-civil war surveys (1867-79) were chartered to explore and map geology and resources to aid in development. These were the King Survey of the Fortieth Parallel; Wheeler Survey west of the 100th Meridian, Powell Surveys of the Grand Canyon; and, the Hayden Survey of Colorado (1873-77). Hayden published the first geologic map of Colorado in 1877. The work and publication of these pioneer scientists made Colorado residents keenly aware of the value of geology and natural resources to their future.

Furthermore, many U.S. territories had a pattern of creating educational units to fulfill development needs--a university, an agricultural and mechanical school, a school of mines and a normal school to train teachers. Colorado was no exception so by 1870 the stage was set to establish a school of mines in Colorado primarily through the efforts of residents of the mining districts. As the Territorial Capital from 1862-1867, Golden was a center of frontier activity, and had many influential citizens in territorial politics. W. A. H. Loveland, E. L. Berthoud, George Welsh, N. P. Hill, George West, Levi Harsh and F. V. Hayden are all credited with promoting Golden as the site for the School of Mines.¹

EARLY HISTORY OF CSM: 1874-1906

Buildings and Places

The School of Mines, a unit of a private school in 1871, was changed to a territorial school in 1874, and then to a state school in 1876.¹ These events, related to a humble and sparse beginning one mile south of today's campus, are well known.^{2, 2a, 3, 4} The following is a brief summary with comments on the Geology programs.

George Randall, an Episcopal Bishop from Boston, built Jarvis Hall College in 1870, which among other subjects offered mining courses. Mathews Hall was added in 1871, and a School of Mines building in 1873 was constructed with financial support (\$3872.00) from the Territorial Government. An Act in 1874 transferred the Mines building and five acres from the church to the Territory, appropriated \$5,000.00. for operation, and provided for a Board of Trustees. The first faculty numbered six: E. J. Mallett, Jr., Professor in Charge (Chemistry); E. L. Berthoud (Geology and Civil Engineering); Arthur Lakes (Freehand and Mechanical Drawing); Richard Pearce (Metallurgy); Julius Pohle (preparation of ores) and Francis Schmidt (Mathematics, German, Spanish). The Board of Trustees consisted of W. A. H. Loveland (President), E. L. Berthoud (Sec.), N. P. Hill, W. W. Ware, and A. Wright. The student enrollment is unknown but probably numbered between 10 and 15. Bishop Randall's death in Denver, October 12, 1873 had a significant impact on the operation and future plans for Jarvis Hall. Randall was replaced by Bishop Spaulding.

Lakes and Berthoud taught geology and other subjects at Jarvis Hall and both moved to the new Territorial School of Mines. Berthoud was in charge of geology courses from 1874-80 and Lakes from 1880-93, followed by Horace Patton (1893-1917). Berthoud was on the Board of Trustees for 15 years. Lakes started a Geology

Museum at Jarvis Hall, and through time it moved along with the department. Mineral displays promoted the School of Mines at the 1876 Centennial Exposition, the 1893 Chicago Exhibition and the 1903 World's Fair. The naming of Berthoud Hall and the Lakes Library honors the pioneering leadership of these professors in geology and engineering education at CSM, and research on Colorado's natural resources. Born in Geneva, Switzerland, Edward L. Berthoud came to New York at age two in 1830 and graduated from Union College in 1849. He came to Golden in 1860 and was an active civic leader for 40 years. Arthur Lakes was born in Cornwall, England in 1844, and, after graduating from Oxford University with majors in Theology and Geology, he came to North America, first to Canada and then to teach at Jarvis Hall. Horace Bushnell Patton graduated from Amherst and studied at Leipzig for two years before receiving a PhD degree from the University of Heidelberg, Germany. He taught at Rutgers for two years before coming to CSM in 1893.

Jarvis and Mathews Halls burned to the ground in April, 1878 leaving the School of Mines building standing alone. Instead of rebuilding, Jarvis Hall College was moved to Denver and a decision was made to give Mines "a second chance" by moving the school to the Loveland Building in Golden for the 1878-79 term, the same building that housed the territorial legislature from 1862-67. The original Mines building was transferred to the State for use as an Industrial School.

The legislature appropriated \$7500.00 to construct a new building in 1880 on the present campus at the site of Hill Hall. A Colorado mill levy tax on mineral production was passed to provide financial support of the school, and to accommodate a growing enrollment. Additions to the building were funded in 1882 and 1889.

The Geology Department and museum were located in the 1880 building (old Chemistry Hall) from 1880 to 1906, and then moved to the newly constructed Guggenheim Hall in 1906. Geology, Geophysics (after 1926) and the museum occupied the first floor. With an expanding program, Geophysics moved to a house where the Field House now stands on the corner of 13th Street and Maple. They had laboratories and classrooms there before moving to Berthoud Hall. With the construction of Berthoud Hall in 1939, financed by the State and the federal Public Works Administration, both departments and the museum occupied the new space. The east and west wings of Berthoud Hall were added in 1940 and provided additional space for the Geophysics Department and Museum. Geophysics moved again in 1972 to the Green Center. Each of the moves reflected increasing enrollments that required more educational space and faculty.

CURRICULUM, ENROLLMENT, FACULTY, AND PRESIDENTS: 1880-1919

International Recognition

Students are attracted to schools because of curriculum, faculty and location. The move of the campus to near the center of Golden, a new four-year curriculum leading to degrees in Mining and Metallurgy, and the openings of courses to special students all

contributed to increased enrollments. Although diplomas were offered at the first location as early as 1876, the first two graduates in the new curriculum were in 1883: William B. Middleton of New York, and Walter H. Wylie of Los Angeles. Enrollments in the 1880's were 20 to 50, that increased in the 1890's to an average of 160.

Albert C. Hale, the last Professor in Charge and the First President, served from 1880-83. A popular drawing course by Arthur Lakes, geology professor, attracted 13 women in 1881 and 33 women in 1882.

Regis Chauvenet, President from 1883-1903, is credited with developing the curriculum "which earned for the institution a world-wide reputation for scope and scholastic soundness in the field of applied science."³ Arthur Lakes, as one of eight professors, taught geology until 1893 when Horace Patton replaced Lakes as department head.⁵ Dr. Patton was acting President during the summer of 1903 until Victor Alderson was selected as the fourth President. Student and faculty unrest resulted in Alderson's dismissal in 1913 and further contributed to instability during three short-term Presidents from 1913-17. Alderson was rehired as President in 1917 and Patton resigned in protest. Dr. Patton's academic and research contributions seem to be largely forgotten in historical accounts of the school, in as much as his 24-year tenure was sandwiched between popular figures of Berthoud and Lakes (20 years) and Van Tuyl (33 years). The first geology option under the Engineer of Mines degree was initiated by Patton and Alderson in 1910.⁶ Previously, geology majors received the Engineer of Mines (EM) Degree, with their course work focused on Mining Geology. A new course entitled "Geology of Coal, Oil and Gas" was noted in the 1914-16 catalog, and was taught by Jenner A. Pynch. Petroleum Geology was later expanded and taught by F. M. Van Tuyl for over 30 years.

Victor Ziegler (AB, Univ. Iowa; AM, Columbia Univ.), a young geology professor at CSM hired in 1914, was made Department Head and Dr. F. M. Van Tuyl (AB, MS, Univ. Iowa; PhD, Columbia Univ.) was hired to replace Patton. Alderson fired Ziegler in 1919 for reported involvement in a shady oil deal in Kansas, and Van Tuyl was promoted to Department Head in 1920, a position he held for 33 years.^{6a} Ziegler may have had the last laugh because he discovered the 40-million barrel Bonanza oil field in Wyoming in 1950 and became a millionaire overnight.⁷

With a steady student enrollment in the period of 1900-1919, averaging 250 to 300, the faculty increased to 15 with two or three teachers in geology. New buildings to accommodate the school growth were two additions to the 1880 building (old Chemistry Building), Engineering Hall (1894--oldest building on present campus); President's residence (1889), Assay Building (1900), Stratton Hall (1903), Guggenheim Hall and Powerhouse (1906) and Gymnasium (1907).

ENGINEERING CURRICULUM: 1917-1945

Post-World War I enrollments increased steadily over 20 years from 400 to 800 students with a corresponding increase in faculty. Although minor changes occurred in

degrees being offered after 1880, the first major curriculum change was in 1922 during Alderson's second term. The Engineer of Mines degree expanded with options in Metal Mining, Coal Mining, Metallurgy and Mining Geology, and new engineering degrees were offered in Geological, Petroleum, Metallurgical, Mechanical, Electrical and Civil.⁶ A core two-year course sequence was instituted.

With the dismissal of Alderson a second time in 1925 and the promotion of M. F. Coolbaugh, a chemistry professor to President, the degrees in Chemical, Mechanical, Electrical and Civil Engineering were abolished, with four engineering degrees remaining in Mining, Metallurgy, Petroleum and Geology. Geological Engineering, the first such degree in the U.S.,⁶ was expanded in 1926 to include a Geophysics option with Dr. Carl Heiland (DSc, Univ. Hamburg) hired as Head of a Geophysics Department.^{8, 9} This action made the Geophysics Department one of the oldest in the United States. New courses in Geophysics particularly as applied to oil exploration, attracted students from many parts of the world. A separate Geophysical Engineering Degree was not authorized until 1948. By 1929, there were six full time teachers in Geology and two in Geophysics. With the four degrees in mineral engineering, the stage was set by President Coolbaugh for 20 years of stability underpinned by growth in the petroleum, mining and materials industries.¹⁰ The four mineral engineering degrees were first accredited by the Engineering Council for Professional Development (ECPD) in 1937. Student enrollment reached 828 in 1938 and, after assessing space needs, Coolbaugh worked with the federal and state governments for funding to construct Berthoud Hall occupied in 1939. The geophysics and museums wings were finished in 1940.

Graduate education was directed by a Committee organized in 1922 and chaired by Clark Carpenter of Metallurgy for 31 years with Van Tuyl and others as members.³ The first Masters thesis in Geology was by Thomas T. Gow in 1922; and, the first Doctorate thesis by William Manuel in 1928.

Two courses in the Engineering curriculum had significant impact in the professional careers of students. One was required ROTC that led many graduates to serve with distinction as Officers in the Corps of Engineers and other units during World War II. The other, which provided summer and permanent employment during the depression years and later, was a summer surveying field course required between the freshman and sophomore years.

AN ERA OF CHANGE: 1946-1970

The 25 years after the World War II brought unprecedented changes in all aspects of CSM—larger enrollments (fueled initially by GI Bill veterans), many new buildings, student and faculty enhancements, new undergraduate degrees, expansion of the graduate programs, new CSM Foundation initiatives and the CSM Alumni Association move back to the campus after an absence of 40 years.

In Geology and Geophysics, the School-wide changes were accompanied by more faculty for teaching and research in response to societal needs brought about by expansion in the petroleum and mining industries in the post-World War II era.

The three Presidents following World War II were earth scientists. Ben H. Parker (1946-50), the first and only graduate of CSM to be President, EM 1924, MS 1932 and DSc 1934; John W Vanderwilt (1950-63), AB 1922, U. Michigan, PhD 1927 Harvard; and, Orlo E. Childs (1963-70) BS 1935, MS 1937, U. Utah, PhD 1945, U. Michigan. In addition, Vanderwilt was on the Board of Trustees (BOT) from 1947-50 before switching places with Parker who then served on the Board from 1950-69. Parker was President of the BOT for 12 years until his death July 31, 1969. After his death, the Board, with T. P. Stockmar now President, voted at its first meeting to memorialize Parker's many contributions to Mines by naming the Ben H. Parker Student Center for him.¹¹ Continuity in policy and planning during the post-war years was given to the BOT by T. S. Harrison, EM 1908 (1939-56), T. P. Stockmar, PE 1943 (1948-82), and L. C. Thomas, EM 1912 (1945-54).

Buildings

When I came to Mines in 1957, I thought the most obvious change from earlier impressions was the new building program to accommodate ballooning enrollments of over 1000 students and about 100 faculty. Funded by a state tax dedicated to capital improvements on campuses, Mines constructed a new Powerhouse ('48), Chauvenet Hall ('51), Coolbaugh Hall ('53), Alderson Hall ('53), Bradford Hall ('53), Library ('54), Randall Hall ('57), the Volk Gym ('59), Hill Hall ('63), Meyer Hall ('63), Parker Student Center ('64), Morgan and Thomas Halls ('67), remodeled Guggenheim ('70) and planned for the Green Center ('69; occupied '71). The new space relieved pressure on the campus-wide use of Berthoud Hall, home of Earth Sciences, and students and faculty benefited by the expanded facilities. The Cecil H. Green Geophysical Observatory near Bergen Park was completed in 1967 with a private donation from Cecil H. Green.⁸

Each building has a history of its own and the Green Center has a special history in relation to Earth Science. It represented a return to philanthropic giving for buildings on Mines campus after a long hiatus. The concept of a Graduate and Professional Center to be used by the public and Mines community was planned and implemented by four years of unusual dedication and perseverance of Orlo Childs, A. G. Pegis, Vice-President for Development and others in the administration.¹¹ Efforts to raise money included a private contributor for preliminary design and drawings, state appropriations for site purchase and preparation (\$600,000.), gifts from five foundations and many individuals (\$1,800,000), and a large gift from Cecil and Ida Green (\$1,700,000), for whom the building is named.

Cecil Green, a long time and loyal friend of Mines, is a renowned geophysicist and philanthropist. Cecil was one of the founders of Geophysical Services Inc. (GSI), a highly successful seismic contractor in the expanding world of oil exploration. Many

Mines graduates were employees of GSI, and Green considered their ability, loyalty and devotion to be an important part of his business success. A smaller geophysics building, planned with John Hollister, was his initial interest in a gift to Mines, but Childs converted this interest to support of the Green Center with a portion of the large building to be the home of the Geophysics Department. In addition, an auditorium, large lecture rooms, offices and laboratories, Computer Center, Mineral Economics Department and geoscience laboratories (in the lower level) were all housed in the new building. It was occupied in 1971 after Dr. Childs left the University. Childs' contributions to this campus center and, through its use, the strengthening of ties with the community, are an important part of CSM history.

Faculty and Student Enhancement:

Policy decisions were made to improve and expand the faculty, enlarge graduate enrollments accompanied by funded research, and provide for more student aid. To implement these changes "The Horizon Plan" was created in 1954 as an overall plan for future growth and development. A formal Committee on Development was formed and the CSM Foundation (originally formed in 1928) was revitalized. A seven-point support plan was initiated to acquire finances for faculty improvement in the areas of salaries, teaching loads, physical facilities, improved teaching, support staff, professional development and academic leaves.¹² Successful efforts in fund raising through the Horizon Plan also supported research, graduate education and laid the groundwork for later fund drives. A problem in acquiring philanthropic gifts for CSM was mitigated when the Colorado legislature in 1975 enacted a bill that stated that private donations would not be offset by a reduction in state appropriations (Sec. 24-75-104, amended CRS 1973). This action set the stage for successful fund campaigns that have resulted in the later successful fund drives that have resulted in the current endowment of \$130 million.

I was hired in 1957 as a part of the faculty improvement and expansion program in geology administered by Department Head L. W. LeRoy and Dean of the Faculty Truman Kuhn. The Horizon Plan was explained to me in some detail, and this favorably influenced my decision to teach at Mines. For the Geology Department, the plan called for hiring PhD's from other institutions, elimination of the program of having doctorate candidates serve on the staff as instructors, time and incentives for start-up research projects with funded graduate research assistants, and funds for travel to professional and scientific meetings. Statements of the School's personnel and promotion policies were spelled out in a Faculty Handbook. The new faculty hiring blended people with interests in both basic and applied research, an essential ingredient to Mines success.

In explaining the Horizon Plan, President Vanderwilt said "...the faculty is the heart and soul of an educational institution. What makes a better faculty makes for a better institution. Through its faculty improvement program, the Colorado School of Mines is planning and working now to build for itself an even greater and more useful future." In the same vein, Dr. Philip Dubois, President, University of Wyoming, recently said, "much as we administrators might like to believe otherwise, there are absolutely no

distinguished universities which have outstanding administrators but mediocre faculty.” (Installation Address, Laramie, WY, October 4, 1997).

Curriculum Changes: New Degrees

Curriculum changes in universities are necessary to incorporate scientific and technological advances to forge progressive improvements in education. If done slowly and continuously, as in changing course content, the response is hardly noticeable. But if done rapidly by changing required courses and credit hours for degrees, the results can be difficult for many faculty, especially if they don't believe in the creation of new departments.

After about 30 years of minor curriculum changes (1925-55), major revisions occurred in the late 50's through the 60's brought about by accreditation pressures by the Engineering Council for Professional Development (ECPD), Colorado Commission of Higher Education (CCHE), Goals in Engineering Education by the American Society of Engineering Education (ASEE); and, forward-looking administration, Faculty, Board of Trustees and Alumni.¹³ The time was ripe for change and it was largely implemented under the Vanderwilt and Childs administrations with strong support from the faculty.

Academic leadership for change was under Dr. Truman H. Kuhn, Dean of Faculty and Vice-President from 1956-74. A graduate from Cal Tech with a PhD from University of Arizona, Kuhn taught in the Geology Department from 1942-53 and was the first full-time graduate dean from 1954-56. Dr. A. Raymond Jordan, Physicist, University of Colorado, PhD 1940, was hired to expand graduate education, research, develop a graduate faculty and new organizational structure. He served as Graduate School Dean from 1957-72. I was Head of Geology (1964-69) and John Hollister was Head of Geophysics (1948-79).

In the mid-50's, the number of hours required for undergraduate degrees changed from about 212 to 175. This revisionary process continued in the late 60's with a further reduction from from 175 to 145 hours, about the same that most departments now require for graduation. Non-degree-granting departments were authorized to offer Mineral Engineer degrees in Chemistry, Physics and Mathematics by the Board of Trustees in 1962, and the first graduate in these degrees was in 1964. The new degrees attracted more Colorado High School Graduates to Mines and the enrollments increased from a plateau of about 1000 in 1963 to 1400 in 1967. The percentage ratios of resident to non-resident students in the student body changed from 40/60 to 60/40; the faculty increased from 100 to 125.

The most controversial change, with the reduction of hours for graduation to 145, was the designation of the four-year first degree as a Bachelor of Science in Engineering.¹⁴ Previously this degree was called a Professional Engineer (PE) Degree, which took the majority of students five years to finish. Many alumni, but not all, were incensed; the claim was that their degree had been cheapened, a charge not

substantiated. A compromise was to move the PE degree to a five-year program in the undergraduate school.

The new Geological Engineering curriculum required senior year students to complete at least two of four applied geology courses, selected from petroleum, ground water, mining or engineering. Students in these applied fields, at both the undergraduate and graduate levels, could take complementary courses in the Departments of Petroleum, Mining and Basic Engineering.

The revisions and reduction of required hours affected all departments who offered courses in the common two-year program, but especially Basic Engineering. Although a non-degree-granting Department, it offered the 3rd and 4th year engineering courses essential for accreditation of degrees by the ECPD (now ABET). Efforts to initiate degrees in the Department were not successful until 1975 when a BS in Mineral Engineering and a Professional Engineer Degree were approved. The ground work was laid for students to have specialties in Civil, Mechanical and Electrical Engineering in 1981 and these fields now have the largest undergraduate enrollments at CSM.

New Graduate Degrees

For Earth Science students, new course offerings and degrees in Geochemistry, Environmental Science and Mineral Economics provided opportunity to develop broader interests and knowledge while pursuing scientific and technical backgrounds for professional careers.

Geochemistry

Geochemistry is an important component of the Earth Sciences but a formal stand-alone program in the field was slow in development at CSM. Chemistry was among the first courses taught at CSM and has been a vital part of the curriculum since 1874. Six of the first eight presidents had chemistry backgrounds but, despite this influence, a degree in the Chemistry Department was not offered until 1964.

Along with the undergraduate degree, Mineral Engineer-Chemistry, graduate degrees were initiated as interdisciplinary programs with other departments. The first Geology and Chemistry Degree was a PhD in 1965 earned by Charles Chapin. The word "Geochemistry" was added to the degree title in 1969. Staff members with interdisciplinary backgrounds were added to support and direct the expansion of the programs. Masters Degrees for the Departments of Chemistry, Mathematics and Physics were also granted in 1969.

The Department's name was changed to Chemistry and Geochemistry in 1978 and a doctorate in Applied Chemistry was first offered in 1988. Department Heads during the above changes were Walter Dumke, Raymond E. Bisque, George H. Kennedy and Stephen R. Daniel.

For many decades, Geochemistry was taught in the Geology Department as a part of petrology, mining geology and mineralogy courses. An Exploration Geochemistry course was first offered in the mid-1950's by Harold Bloom, and this and other geochemistry offerings are now coordinated among staff of the Geology and Geological Engineering and Chemistry and Geochemistry departments.

Mineral Economics

Mineral Economics is an indispensable component of the natural resource industries, and all mineral engineers need either formal or informal training in the subject. Risk assessment, capital formulation and use, resource availability, predicting marketplace prices and trends, the impact of technology changes--all play vital roles in resource companies.

After years of having undergraduate courses in Economics, CSM applied for and received approval to offer a Masters Degree in Mineral Economics,¹⁵ the program was later expanded to include a PhD (an undergraduate degree in Economics was first offered in 1996). Dr. Jean P. Mather was hired as Department Head, and a highly visible staff and courses were implemented. The first MSc Degree was awarded in 1971 and the first PhD in 1976. The Department rapidly became one of the largest graduate degree programs on campus.

Environmental Sciences

The blooming of U.S. environmental laws and regulations from 1954 to 1980 (20 new Acts) required that engineers be knowledgeable about natural systems and that they practice good stewardship of the earth. The natural resource professional must find, extract, and process earth materials to sustain human life in a global-expanding population. The impact of this vital service to mankind can be mitigated by careful planning and restoration. To advance these objectives CSM decided to complement course material offered in individual departments by forming a new focused program in 1977.

The Environmental Science and Engineering Department has been closely allied to Chemistry and Geochemistry Department although for many years environmental-related subject material was offered in hydrogeology and engineering geology courses.. Dr. Elizabeth Willard was the only Professor and Director when the new environmental program was started in 1977. and her planning led to an environmental science elective offered in 1979. Minors in environmental science were available to students in all options under the Environmental Science and Engineering Ecology Department, which was formalized in 1982. Rapid expansion of the staff and courses have occurred in the last decade since the first Masters degree was awarded in 1991.

CONTINUED GROWTH: 1971-2000

CSM has continued to sustain progress on all fronts over the past 30 years under the leadership of Presidents G. T. McBride, Jr., (1971-1984)¹⁶ G. S. Ansell, (1984-1998)¹⁷ and T. A. Bickart (1998-2000).¹⁸ Earth Science programs have followed the

pattern of most other departments by adjusting curriculum, broadening course offerings, and increasing research activities, all achieved with about the same size teaching staff. New institutes and centers have enlarged the number of research and adjunct staff members and reflect emphasis on obtaining research funding. Most importantly, endowed chairs have been funded to provide long-term stability in applied science and engineering subjects. The combined teaching and research staff of 60 people in Earth Sciences is one of the largest in the world.

Enrollments in Earth Sciences have responded to cyclic business trends in the natural resource industries. Numbers of graduate students have generally increased whereas undergraduate engineering student numbers have fluctuated but remain viable. The total enrollment in the six degree-granting departments in 1957 was 1000; a comparable figure for 1998 was 1300. The expansion in overall enrollment to present 3200 has come from expanded undergraduate engineering programs initiated in 1964 and 1975, and from larger graduate enrollments in all departments. Enrollments had previously peaked in 1983 at 3250 before dropping to 2300 in 1989 and then returning to over 3000 in 1993.

Financial support for earth science education has increased in several ways: endowed chairs, state-supported remodeling of Berthoud and Coolbaugh Halls; increased research and educational equipment; industry-based consortia; and financial aid to students.

Leadership changes may provide the opportunity for more flexibility and new directions in academic programs. Although CSM has permanent appointments as Department Heads, the tenure of the position has changed over the past 30 years. In Geology, Robert J. Weimer, Harry C. Kent, Joseph J. Finney, Samuel S. Adams and Roger M. Slatt served from five to eight years each. John R. Hayes and Gregory S. Holden served as Acting Head for one year terms. Geophysics has had six heads since 1970, John C. Hollister, Ralph C. Holmer, George V. Keller, Phillip R. Romig, Thomas L. Davis (Acting Head), and Terence K. Young. Two professors have been appointed Dean of Graduate Studies; Samuel B. Romberger (1983-88) from Geology and Geological Engineering; and, Phillip R. Romig (1998-p) from Geophysics. (Earlier administrative appointments were James Boyd, a professor in the Geology Department, Dean of the Faculty from 1947 to 1948 before moving to Washington, D.C. as Director of the U.S. Bureau of Mines; Dean Truman H. Kuhn was acting president in 1971).

Some highlights of activities from the last 30 years that relate to the Earth Science programs are as follows:

- ?? Change of BOT members in 1975 from five to seven appointed by the Governor, and a student member elected by the student body. For 24 of the last 30 years, an earth science graduate has been on the BOT.
- ?? Remodeling of Berthoud Hall in 1988 at a cost of \$4.2 million; completion of the Green Center (1971) and then remodeling of a portion for a Center

for Exploration Geoscience Computing (1990); remodeling of Coolbaugh Hall with new wing for Environmental Sciences completed in 1995 for a cost of \$13.5 million; enlargement of Lakes Library, 1979; construction of U.S. Geological Survey Building (1977) and, Brown Hall (1980).

- ?? Support of fund-raising drives: The Resource Fund 1976-85, a \$63 million, 10 year campaign under President McBride; and, Resources: The Campaign for CSM, a five-year \$60 million effort started in 1991 under President Ansell. Both drives exceeded the stated goals and led to the current endowment of \$130 million.
- ?? Increased research funding and graduate enrollments.
- ?? Continuing education, technology transfer, and outreach programs to industry and government in the U.S. and abroad; courses offered in the 1960's, and later, contributed to the start and continuity of the CSM Special Programs and Continuing Education (SPACE).
- ?? Replacement of earth science staff while maintaining the traditional balance among basic and applied research and teaching.
- ?? Name changes for departments: from Geology to Geology and Geological Engineering (1987); from Chemistry to Chemistry and Geochemistry (1977); PE Degree (1990) in Hydrogeology.

The stature of the CSM Earth Science programs in the U.S. and abroad is at an all-time high. The 125-year dedication to the exploration, production and beneficence of natural resources and unparalleled success in educational programs demonstrate that CSM made the right decisions at the right time to initiate new programs to fulfill resource needs of the people of Colorado, the U.S., and other parts of the world. The Earth Science activities had a world-wide reach long before globalization and international studies at CSM were formalized.

The new staff in the 1950's and 60's has now been succeeded by another generation of faculty. From all appearances you are as talented and dedicated as the faculty that preceded you. The future of Mines rests with you and the students you attract and then shape for professional careers. I wish you well.

Much credit for Mines' reputation must go to the exceptional performance of graduates in the workplace, wherever it might be. They are Mines' ambassadors, and, through the CSM Alumni Association, have given financial assistance, career placements, and fostered the "Mines Spirit" that makes CSM graduates a world-wide fraternity. Their formal education, of course, was provided by the faculty and curriculum, which in turn resulted from policies established by the BOT and implemented by the administration, support staff and made possible by a secure financial base from the State of Colorado and the private sector. The student quality,

numbers, and responsiveness to excellence in education is where it all starts. Mines has been fortunate in attracting dedicated and talented people to support all aspects of the education, research and service components of the College.

LESSONS FOR THE FUTURE

CSM programs in engineering, science and technology have a bright future. As in the past, natural resources will be in demand to sustain the earth's expanding population. CSM will play an important role in providing resources needed by society: energy, water, minerals and materials as in the past, but in new fields of human endeavor as well. The following comments reflect lessons from the past to guide the future.

- ?? The 125-year history has given CSM and Earth Science programs a culture of their own. The organizations have the knowledge and resilience to combat complacency and overcome adversity in order to change to assure future success.
- ?? To educate future leaders, CSM must stay abreast of and respond to rapidly moving technology demands of industry, government, and society in general. This commitment will require continuation of faculty development, particularly in departments with expanding enrollments. Recruitment of top students in engineering and science and providing financial aid remain top priorities.
- ?? When a described four-year program takes a full-time student five or more years to complete, then the faculty, administration and BOT must make adjustments in reducing curriculum and in designing new programs, while at the same time being mindful of maintaining excellence in traditional internationally recognized fields.
- ?? Growth at CSM will come from programs other than natural resources, although they may be closely allied.
- ?? The Earth Science programs will remain stable as they expand into non-traditional fields that will also offer excellent career opportunities for graduates.
- ?? Departments and staff should be more involved in public policy forums and in public education about the vital role that natural resources and technology play in society. They should also be more actively supportive in fund-raising to attract and support students and programs, efforts that should be better coordinated with other traditional activities.
- ?? CSM has a continuing commitment, as a state-supported institution, to underpin and support, through education and research, the \$2 billion per

year natural resource industry in Colorado, as well as to fulfill other technology needs.

?? The “electronic era” will challenge the format of traditional educational institutions (like CSM) and necessary adjustments to change must be continually a part of the developing culture.

I am grateful to have had the opportunity to be part of the CSM scene for 43 years and would like to be a part of the exciting future. Please accept my sincere appreciation for the honor of being selected as the last Senate Distinguished Lecturer of the century on the occasion of CSM's 125th Anniversary.

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