MINING AND METALLURGY

IN SOME OF THEIR RELATIONS TO THE

PROGRESS OF CIVILIZATION

ESPECIALLY TO THE

PROGRESS OF MINING IN THE UNITED STATES.

An Address Delivered by Invitation at the Commencement

Exercises of the Missouri School of Mines

BY

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ERRATA.

Page 3. Sixth line from the bottom of page, for Carriterides, *read* Cassiterides.

Page 4. For adventerous marines, *read* adventurous miners.

Page 5. Second line, for spoils obtaine, *read* spoils to be obtained.

Page 6. Sixth line, for prompted, *read* promoted.

Page 6. Twenty-fourth line, for little regions, *read* little known.

Page 7. In foot note, for American Journal Sciences, *read* American Journal of Science, Second Series, XXV, p. 227.

Page 8. Line seventeen, for miner, *read* mines.

Page 9. In the foot note, for Schwab, *read* Swank.

MINING AND METALLURGY IN SOME OF THEIR RELATIONS TO THE PROGRESS OF CIVILIZATION.

An Address Delivered by Invitation Before the School of Mines and Metallurgy of the University of Missouri, at Rolla, May 30th, 1902.

This is a vein of thought which may be followed to advantage upon this occasion in an institution devoted to education in mining.

EARLY FABLES AND RECORDS.

Mining, as an art, antedates human history. No other occupation of man has, however, left more enduring monuments of his work. Temples and habitations decay and disappear, but excavations in solid rock remain to tell us of the search for the hidden treasures of the earth. Relics of the stone age, preceding the eras of bronze or iron, tell us of the search for stones of the proper hardness, grain and strength out of which to fashion arrow and spear-heads for the chase and for defense, or implements with which to till the earth in the dawn of agriculture.

In the glittering gold from the beds of rivers the most ancient and forgotten races found a malleable and enduring metal with which to decorate their bodies in life and enshroud them after death.

From the earliest ages miners and metallurgists have been the pioneers of progress. They have ever been the promoters of exploration of unknown regions; of the subjugation of the wilderness and of the birth and growth of the exact sciences.

The outcroppings of records of mining as one of the leading occupations of man may be found in the earliest pages of history. The Hebrew Scriptures abound in refer-

ences to the precious metals, especially as used for the decoration of religious objects, such as the ark of the covenant and the golden candlesticks. Even the quality of gold is noted, as for example:

"The gold of that land (Havilah) is good."*

We are told of "Tubal Cain, the instructor of every artificer in brass and iron,"† and should recognize him as the most ancient professor of metallurgy of whom we have any record.

The ancient poets, especially Homer, have perhaps unconsciously given us valuable "indications" of the abundance and use of gold and silver. The admirable workmanship of the shield of Achilles is described, but little or nothing is recorded of the source of the metals.

The fantastic fables of the ancients regarding the occurrence and sources of gold show a desire to exalt the popular estimation of the value of the metal by exaggerating the difficulties and dangers attending its production. Its sources were not revealed. Gold and other treasures were said to be guarded by the griffins, those fierce beasts, half lion and half eagle, from whose custody gold was wrested by the Arimaspi. These were the one-eyed men of the North, the legendary Cyclops, living in caverns in the mountains and occasionally coming out to the light of day with one flaming eye in the middle of the forehead. In these imaginary terrible monsters we can readily recognize honest toiling miners emerging from tunnels with their candles in their hats. By way of contrast with the Cyclops we have the Carthagenian story of gold mining by beautiful young girls who drew gold-dust out of the mud of a lake by means of feathers smeared with pitch and tied to long poles.‡

The Persians had a tradition of people who went forth into the sandy deserts on camels to steal the gold-dust reported as raised from the earth by "ants as big as foxes."§

*Genesis, 2d chapter, 12th verse.

†Gen. 4, 22.

‡Herodotus, 4, 95.

§Pliny, 33, 15.

The tendency to exaggerate in mining matters, you may observe, is not of modern growth.

Pliny tells us of Saulaces, King of Colchis, who gathered in immense quantities of placer gold from the soil of his kingdom, famous for the golden fleece. In this curious legend of the fleece, we may recognize a foundation in the fact that sheep-skins are used to collect gold in washing operations. Skins so used and sheeted with gold would attract attention and arouse cupidity. There is thus less wonder that expeditions were organized for the recovery of the fleece. Jason and the Argonauts had substantial objects in view.

Thus, out of legendary fables we may be able to "pan out" a few golden grains of truth, and show that the love of gold early had a dominating influence upon explorations.

There is little doubt that the sands of the Pactolus furnished a great part of the riches of Crœsus, and the gifts sent by him to Delphi.*

But the mining operations of the ancients were not confined to gold alone. The silver, lead and zinc mines of Laurium worked as early as the Trojan wars, about 1200 years before Christ, were deserted at the beginning of the Christian era, but remain to this day as fine examples of extensive and comparatively well-designed mining operations upon an extended scale.

PHOENICIAN EXPLORATIONS.

It was the desire for gold and other metals which led the Phoenicians beyond the Pillars of Hercules along the coast of Spain and Gaul to Britain. (B. C. 450.) Their trade for tin took them to the Carriterides, and paved the way for the invasion of Gaul and Britain by Cæsar. Thus the tin-bearing lodes of Cornwall were the cause of the injection of Roman civilization in the heart of England. Tin became the basis of an overland trade by pack-trains from the coast through Gaul to Rome and the Mediterranean,

*Herodotus, 5, 41.

giving knowledge of the geography, people, and resources of that region to the Romans.

The commercial supremacy of the Phœnicians is ascribed to their extensive trading expeditions in and beyond the Mediterranean, and especially with Tarshish, where they had not alone profitable fisheries, but rich mines of silver and other metals. They had also drawn tin from the mines in the north of Spain, as well as from Cornwall. *

From the days of the Golden Fleece till now, the desire for gold has been the great incentive to expeditions of investigation and discovery, and the usual result has been that by finding gold the means have been secured for further and greater efforts, and for the rapid advance in civilization and wealth.

There are, it is true, some most notable exceptions to the statement that the search for gold, or other mineral products or material benefits, has been the dominating impulse of exploration, but such exceptions, if any, are usually the fruit of success and of the wealth based upon the riches drawn primarily from the earth. ‡

DISCOVERY OF AMERICA.

It was the desire for gold and the wealth of the Indies which turned the attention of adventerous marines to the possibility of reaching India by the western ocean. We owe the discovery of America to this spirit. It was not the pure love of knowledge, for its own sake, which induced Columbus and his band to sail from the little port of Palos in 1492. The expectation of gain was shown conclusively

*Ency. Brit.—Art Phoenicia.

†Jastrow while admitting the tradition that Phoenician ships passed through the Straits of Gibraltar and reached the English coast, questions whether they actually brought back tin from the mines of Cornwall. Vide Johnson's Cyclopedia, Art Phoenicia.

‡Amongst some of the more notable exceptions, we may cite the Challenger Expedition, United States Exploring Expedition, the Austrian Expedition around the world, the various Polar Expeditions, Perry's voyage to Japan, (having however, trade and commerce in view), and lately the Harrimann Expedition to Alaska.

by the stipulations of Columbus, regarding the division of the spoils obtained by conquest, or by trade.

After the return of Columbus from his first voyage he represented to the Court of Spain that Santo Domingo was a country abounding with gold, offering an inexhaustible source of wealth to the Crown and Kingdom. The only really valuable objects he was able to display to the sovereigns were the ornaments of gold. It was the yellow metal which produced the greatest impression and which induced the Council of Castile to determine to take possession of the newly discovered countries inhabited by practically defenseless savages.* There was a pretense of anxiety to convert these poor Indians to Christianity; this seemed to gloss over and sanctify the rank injustice of the project, but the hope of securing treasures of gold and precious stones was the real underlying motive.

Columbus, with an instinct worthy of a modern mine promoter, proposed that half of all the gold and silver that should be found should belong to the Crown. This met the approval of the Council, but in the course of a few years it was found impossible to pay so heavy a tax, which was soon reduced to a third, then to a fifth; to a tenth, and finally to one-twentieth part of the gross produce of the gold mines. In this we have indicated to us the origin of what for so many generations was known in Spain and Mexico as the "King's fifth," and which still survives to us in the form of the bullion or export tax.

Adam Smith says it was the sacred thirst for gold that carried Oieda Nicuessa and Vasco Nugnes de Balboa to the Isthmus of Darien; that carried Cortez to Mexico, and Almagro and Pozzaro to Chile and Peru. When these adventurers arrived upon any unknown coast their first enquiry was whether there was any gold to be found there.† Every Spaniard who sailed to America expected to find an Eldorado.

The increase in the revenues of Spain from the influx

*Adam Smith's Wealth of Nations; 2, cap. 7, 353.

†Wealth of Nations, 2, 7, 354.

of the gold and silver from the New World did not fail to attract the attention of other European nations and to stimulate them to explore, and to found colonies upon the shores of America. Visions of golden wealth dazzled the imaginations of the adventurous spirits of England, and greatly prompted the early settlement of the New World.

The first settlers of America from England offered a fifth of all the gold and silver which should be found there to the King as an inducement to the Crown to make grants and issue patents and privileges to the colonists.

In the patents to Sir Walter Raleigh; to the London and Plymouth Companies, and to the Council of Plymouth this fifth was reserved to the Crown.*

The successive expeditions planned by Raleigh to the shores of America were inspired by the desire for gold, and the belief in the existence of the fabled Eldorado, in search of which he went in person in 1595 to the Orinoco.†

SPANISH COLONIAL EXPLORATIONS.

The Spanish colonists were no sooner well established in Mexico than their attention was directed northwards to Sonora and beyond, into the region now know as New Mexico and Arizona.

Several successive expeditions were fitted out in Mexico to traverse these little regions. There was much enthusiasm amongst the gay Spanish cavaliers, The adventurers more than once traversed the table-land of Mexico, through Sonora to the confines of Arizona, where, finding the sources of the Santa Cruz, they followed this valley and stream, which then formed a long line of verdure in the deserts leading to the Gila and the great Colorado of the West. They discovered many silver-bearing veins on their way. The great masses of native silver known as the *planchas de la plata*, dug from the soil near our present

*Wealth of Nations, 2, 7, 357.

†Raleigh's charter of colonization was obtained in 1584. He sent Amadas and Barlow to examine the country, which he named Virginia.

boundary line, verified their wildest dreams of mineral wealth. They founded missions, and the pueblos of Tubac, Tucson and Santa Fe as early as the settlement of New England.

These early explorers were stimulated to undertake these hazardous expeditions by the extravagant stories of not only the abundance of the precious metals, but of precious stones, foremost amongst these being the turquoise, the gem known to the aboriginal people as chalchuite, and more highly prized by them than gold. This beautiful gem was in general use and high estimation for ornamental purposes, and was extensively mined not only in New Mexico near Santa Fe,* but at several places in Arizona, as proved by the abundance of mining implements, made of stone, found in pre-historic workings upon veins of chalchuite. And we have abundant evidence that the pre-historic tribes not only of New Mexico and Arizona, but of the Mississippi valley and the great lakes were familiar with some of the more important mineral deposits of the country.

Lead ores were extracted and were used for ornament and were, perhaps, smelted long before the advent of the whites.

In the copper regions of Lake Superior the native copper was mined from the upper portion of the Cliff Mine Lode, and no doubt from other croppings as shown by ancient trenches, at the bottom of which quantities of stone mauls have been found. The aborigines were thus not content with a bit of drift copper, found here and there, but had recourse to the veins as well. The finding of copper ornaments and implements in some of the aboriginal mounds in the Mississippi valley indicates to us a very considerable trade or communication between the ancient tribes of the Northwest and the Ohio valley.

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*See papers upon the Chalchuite of the Mexicans and its identity with turquoise. American Journal Sciences.

THE LOUISIANA PURCHASE.

Let us now consider the influence of mineral riches and of mining upon the early settlement and occupation of the region about us.

In the year 1712, Louis XIV, of France, issued a patent for the discovery and operation of mines in the then Territory of Louisiana. This patent was transferred to the "Company of the West," of which John Law was the promoter,* in 1717. In 1719, Renault was made general director of the mines of the company, and left France with two hundred miners and artisans† and was accompanied by La-Motte, who afterwards worked the deposits now bearing his name. Renault's expedition is credited with the introduction of slavery in this region, for he stopped on the way at Santo Domingo, W. I., and brought five hundred slaves from there to work in the mines.

You are already so familiar with the history of lead and zinc mining in Missouri, and the importance of the miner of these metals to the state, that I need not do more than to remind you of their influence upon its development. So, also, of the lead deposits of southern Wisconsin and of Iowa, and of their influence upon the early trade of the Mississippi.

IRON AND STEEL.

Time does not permit us to attempt even a rapid survey of the beginning and progress of the mining and metallurgy of the more common and useful metals, but we must not omit mention of some of the more important advances in metallurgy by American engineers, and especially of the industry of Iron and Steel, so important in its relations to

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*This Company of the West was also known as the "Mississippi Company." A bank was established and later failed with over $200,000,000 in circulation in worthless notes. The charter reverted to the Crown in 1731. Mo. Geol. Survey, 6, p. 269.

†Schoolcraft, 203, p. 19. Cited by Winslow.

the progress of humanity in all the arts and amenities of life.*

The consumption of iron and steel in any community has come to be regarded as a sort of industrial barometer indicating the extent of productive and constructive energy, much as the quantity of soap used per capita has been regarded as evidence of godliness in a community. The distinguished Dr. Torrey used to say we could judge of the intelligence of a people by the amount of sulphuric acid consumed.

The chronological record of the beginning and progress of the iron and steel industries in the United States exhibits a most remarkable evenness and regularity of growth and a still more remarkable breadth of geographical distribution and rapidity of expansion in the last quarter of the 19th century.†

As early as 1619, the Virginia Company sent to Virginia a number of persons to set up three iron works in the Colony. In 1622 the works were destroyed and all the workmen were massacred by Indians.

In 1642, eleven English gentlemen, with a capital of £1,000, organized an iron company and built a foundry at Lynn, Massachusetts, and in 1658 a blast furnace and a refinery forge were in operation at New Haven, Conn., and before the end of the century iron-works had been established in Vermont, Rhode Island, Connecticut, New York, New Jersey and Pennsylvania. The limonite ores of Salisbury, Conn., were early worked, and bar iron was produced there before the Revolutionary war. A bloomary forge was

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*Abram S. Hewitt has ably presented this subject in his report entitled, "Iron and Steel in their Economic and Social Relations." Paris Exposition of 1867.

†A chronological record of the leading events in the development of the iron and steel industries of the United States down to the close of the 19th century is given by James M. Schwab, general manager of the American Iron & Steel Association, in his Annual Statistical Report, Nov. 25, 1901: reprinted from the 12th Annual Rept. U. S. Geol. Sur., Div. of Mining and Mineral Resources. See also "Iron in All Ages,"

erected at Lime Rock in 1734.

At the beginning of the 19th century the iron ore beds of the Adirondack, N. Y. region were developed, and iron was made there in Catalan forges. The Iron Mountain and Pilot Knob districts, in Missouri, were developed in 1815-1816.

Coke was first successfully used in the blast furnaces in the United States by Firmstone in 1825. Anthracite coal was first used for the production of pig iron in the blast furnace in 1839, but the credit of the first completely successful effort, in 1840, to use anthracite in smelting iron is given to David Thomas, who is called the father of our pig-iron industry.*

The discovery of the iron ores of the Lake Superior region by white men was made in 1844, and the first shipment of about ten tons was made in 1850. Its first use in a blast furnace was in Pennsylvania in 1853.

Connecticut was probably the first of the Colonies to make steel, and as early as 1728. (p 13)

In February, 1865, Alex. L. Holley produced Bessemer steel at Troy, in works constructed there in 1864. Some Bessemer steel was also produced at Wyandotte, Mich., in 1864, at the experimental works of the Kelly Pneumatic Process Co.

Natural gas was first used as a fuel in the manufacture of iron in the year 1874.

In 1890 the United States, for the first time, made more pig-iron than Great Britain.

The production of pig-iron in 1900 was 13,789,242 tons, and in this year the United States for the first time made more open-hearth steel than Great Britain. We produced of Bessemer steel, 6,684,770 tons in 1900, and adding other kinds of steel, the aggregate exceeded 10,000,000 tons.

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*Anthracite was first mined 1793: shipment began 1820: used for generation of steam 1825, and not until 1839, as an exclusive fuel in manufacture of pig iron.

ZINC, NICKEL, CARBORUNDUM, ETC.

Zinc does not permit more than a brief mention of some of the more important advances made by American metallurgists.

In the industry of zinc we may take great pride. We have not only produced a superior grade of commercial spelter, but have cheapened and increased the production of zinc-white by the bag process for its collection, the invention of S. T. Jones, of New York, about 1850. This method, now generally adopted abroad, is known as the *American Bag Process*. It is well supplemented by the Wetherill Furnace, the most economical and effective. Since the year 1850 the great zinc ore deposits of Sussex County, New Jersey, at Stirling and Franklin, have been actively worked. LaSalle, Illinois, and Joplin, Mo., have since become prominent as centers of the industry of zinc. The poet-geologist Percival early directed the attention of metallurgists to the value of the "dry bone" usually thrown over the dump by the miners of Wisconsin.

In the preparation and manufacture of pure metallic nickel, Joseph Wharton, of Philadelphia, surprised the metallurgists in 1876, and again at Paris in 1878, by the number and excellence of objects made from nickel extracted from the low grade sulphide ores of Lancaster Gap, surpassing anything produced abroad.

Wetherill has astonished electricians by the power and effectiveness of his electro-magnetic concentrators.

Carborundum—the silicide of carbon—has been added to the list of abrasives by American ingenuity and the utilization of the electric current.

PETROLEUM.

The utilization of rock oil or petroleum, and the boring of the first well by Drake in 1859, were events of the utmost importance in the history of mining, and to the march

of civilization.*

The oozing of mineral oil from the ground, and its diffusion upon the waters of the creek had long before been observed. It was collected in small quantities for years and sold as a medicine. The water was either skimmed, or the oil was absorbed by blankets spread upon pools of water in tanks or trenches, or in salt wells. As early as the year 1845 the crude oil from Tarentum had been used as a lubricant in the Hope Cotton Factory. Attempts were soon after made to refine the oil for illuminating purposes. The younger Silliman at Yale was called upon to make an analysis and to advise respecting its treatment. The world was sadly in need of light. Experiments upon volatile oils distilled from coals had been numerous. An oil which could be used to replace the vile-smelling greasy whale oil in hand lamps was the great desideratum. Its use as an illuminant had been suggested as early as 1828.

The experiments promised success. A clarified distillate was obtained. Burners and chimneys of glass were devised. Perfect combustion and a brilliant light was secured. The next question was as to quantity. This was answered by the drill of Drake. The industry of petroleum was born. It has been said that "the discovery of Drake not only opened the door to material wealth, but to new avenues of human activity, mental and manual."

Oil in quantities in the remote forests of Pennsylvania required new methods, new machinery, new methods of storing and of transportation. Compare for a moment the movement of oil in barrels, on wagons, and in flat boats down the creeks to the river, with the magnificent pipe-line transportation of to-day from the wells to the sea-board. Compare the original price of $20 per barrel for Drake's crude oil with the price of one dollar at the end of the century. Compare the cost of refined oil in 1860 at from 70 to

*Work at the first well began about the 20th of May, 1859, and the general impression is that oil was struck in flowing quantities August 27, 1859. The boring had reached a depth of 69½ feet from the surface, and the yield was about twenty barrels a day.

75 cents per gallon, with its present price of about 10 cents per gallon.

One oil-producing district after another has been added to our sources of petroleum, and of its accompaniment, natural gas. Both have been utilized as fuel and in metallurgy. The industry of iron and steel has been modified, almost revolutionized, by their use. Better products have resulted.

Oil is being substituted for coal upon some of our railways, and at our mills for reducing ores. It is destined to play a most important part in the smelting of ores.

GOLD IN CALIFORNIA.

The discovery of gold in California was an event of the utmost significance and world-wide importance. Every industry, every calling in life, was stimulated to greater activity. The spirit of adventure and exploration was aroused throughout the world. The comparatively unknown vast region of the west lay between the people of the Atlantic states and the new Eldorado.

Expeditions were rapidly organized. Companies of enterprising energetic men went over the broad plains by way of the Platte and South Pass, following the trails of Fremont, some by the Gila River route, some by Nicaragua, and others by Panama, or around Cape Horn.

Argonauts from every land crowded the Golden Gate of the Pacific, each one eager to secure a golden fleece. A new era—the golden era—had dawned upon the world! Civilization had spanned a continent at one bound.

In placer mining great and rapid progress was made. The pan and cradle were succeeded by the sluice and the hydraulic method, said by some to have been the invention of a New York fireman.

Attention was soon turned to the veins, and then arose a demand for crushing and stamping machinery. One or two mills had been imported from Cornwall, crude affairs with stamps of timber shod with iron, but they were quick-

ly superseded by stamps of improved construction. The California stamp mill was evolved, and became the standard mill of the mining world.

Foundries and machine shops were established in San Francisco, and were sustained chiefly by the demand for mining and milling machinery.

The first rock-breaker replaced hand spalling of rock in 1861, at the Merced mill, in Mariposa county.

The discovery of the Comstock Lode, and its rapid development, made renewed and greater demands for both hoisting, pumping and milling machinery of the most advanced and approved types, rivaling the superb machinery from the establishments of Belgium, France or Germany. The foundations were thus laid for the great works at which such cruisers and battleships as the Charleston, the San Francisco and the Oregon have since been produced.

RAILWAYS.

With this wonderful development of mines in California and Nevada, and the outflow of gold and silver, the need of rapid overland communication with our new territories on the Pacific became more and more urgent. The toiling teams of oxen in their three months of travel had given way, in part, to staging by relays of horses and to the Pony Express. The possibility of a railway was much discussed. Though much information regarding our vast interior region had been gained by the expeditions of Fremont, Stansbery, Sitgreaves and Emory, and from the hurried emigrant, the U. S. Congress in 1853 authorized the series of explorations under the direction of the War Department "to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean," which resulted in giving to the nation and to the world the series of reports in 12 quarto volumes upon the topography, geography, mineral and other resources of that vast interior, far surpassing in extent and value any similar work in the history of the world. The construction

of the first transcontinental line soon followed, and today there are no less than seven trunk lines connecting the Mississippi with the Pacific,—great links in the march of civilization westward, promoted and hastened, and largely, if not chiefly supported, by the development of mining. And to the same development we owe the construction and maintenance of the Panama railway.

GOLD IN AUSTRALIA AND NEW ZEALAND.

Following close upon the development of the gold deposits of California came the discovery ot the golden riches of Australia and New Zealand leading to the occupation of those remote insular continents by the English speaking race.

AFRICAN MINES.

The gold and diamonds of Africa, the deep and promising mines of the Rand have profoundly shaped the destinies of Africa, and have left a scar upon the civilization of England. The great war in which England is engaged was not undertaken for the benefit of the Boers, but for the more complete control and ownership of the mines. It is impossible to foresee the far-reaching effects of this contest, now happily ended, or of the tide of wealth poured into the channels of trade and world development.

It is interesting to note that in the working and administration of some of the vast properties in Africa, American talent has been employed in the persons of Williams and of Hammond, educated mining engineers of world-wide celebrity, who grew up under the influences of mining in California.

ALASKA.

The belief in the abundance of gold in Alaska, in addition to the great value of the region for timber and fisheries, had no small influence in the negotiation for its pur-

chase. Time has verified the correctness of this belief, and today we find the country redeemed from its former desolation of snow and ice, and occupied by advancing civilization, drawing to it men and capital from all parts of the world, supporting lines of steamships and projecting lines of railway. Alaska gives us, also, one of the most interesting and instructive examples of gold mining and milling on a large scale upon ores of extremely low average contents of the precious metal.

The influence of the golden tide flowing from that ice-bound land is felt not alone in the markets of the world by the creation of a wider demand for all forms of the products of furnaces, farms and factories, but in the halls of education and science. Already the geographers and geologists of Washington have penetrated the interior, and are giving the results of their explorations to the world. But still more extended surveys and varied routes of travel are projected for this summer (1902).* Railways are promised, and copper mines as well as gold deposits are attracting attention.

GOLD AND PLATINUM OF THE URALS.

We no doubt owe to the desire to know more about the gold fields of the Urals the splendid results of the geological reconnaissance by Sir Roderick J. Murchison, Von Keyserling and de Verneuil.†

The earlier discovery of a strange white metal in the auriferous sands of the Ural mountains, which in 1823 was recognized as platinum, was the cause of the scientific expedition to the Urals by Humboldt, G. Rose and Ehrenberg in 1829.‡

In regard to the explorations of Humboldt in New

*Vide: Proposed Surveys in Alaska in 1902, by Alfred H. Brooks, U. S. Geological Survey, Nat. Geographic Magazine, XIII, No. 4, p. 133.

†Russia in Europe and the Urals.

‡Treatise on Chemistry, Roscoe and Schorlemmer, Vol. II, Part 2, p. 289.

Spain, who can say that the means were not provided largely with the expectation of deriving some practical money results in the form of a better knowledge of the productive capacity of the region in gold and silver?

It is certain, however, that the expedition of Ward in 1825, was for the purpose of gaining better knowledge of the great silver mines of Mexico.

There is one exploration—a Missouri expedition—I must not omit to mention. The first expedition from this State to the Rocky Mountains for silver. Upon the reports of silver in those mountains by James Cockrell in 1827 Benjamin Majors with 24 men set out for the reported mines. They crossed the plains in the saddle, reached the Raton Mountains, and after much searching found some dirty looking rock with white metallic specks in it, which they were not sure was silver. They were greatly disappointed not to be able to chop off chunks of pure silver with the hatchets they took with them for the purpose. They expected to load their horses with the metal and to walk back. They, however, had the opportunity of walking, for at the crossing of the Arkansas the Indians stole their hortes. The fruits of this expedition were surely a much better knowledge of the great plains, of the Indian tribes, and of the range of the Buffalo which then covered the plains in countless hordes.*

INFLUENCE UPON EDUCATION AND SCIENCE.

The search for precious mineral property has thus been the great promoter of exploration and the development of distant lands. And the discovery of valuable gold fields has always exerted an almost electrical impulse upon all forms of industry. Villages, towns, cities spring up as by magic, roads are made, railways built, all forms of transportation are brought into requisition, a wilderness is re-

*For a full notice of the Cockrell-Majors Expedition see Seventy Years on the Frontier, by Majors, p. 34, Rand, McNally & Co., 1893.

deemed from desolation and made to bloom. There is labor and reward for all. New wants are created, new industries are required. Wealth abounds, and in its wake the luxuries and comforts of life follow. The mind of man is expanded, his horizon enlarged, and his capacity for knowledge is increased. Then come the demands for knowledge —systematized knowledge—science. Buckle has said: "Wealth must accumulate before knowledge can begin," and that great ignorance is the fruit of great poverty.

Mining and Metallurgy as arts have exerted, and continue to exert a most potent influence upon the origin and progress of physical science.

Whewell wrote: "In all cases the arts are prior to the related sciences. Art is the parent not the progeny of science."*

Alchemy, and the desire to transmute metals into gold, preceded the science of chemistry. So, also, the search for the elixir of life, and for remedial agents, gave us rich stores of knowledge ready to be systematized.

With the discovery of copper at Lake Superior, and of gold in California, a demand arose for some knowledge of mineralogy, geology and mining. Assayers were wanted in California and elsewhere. Parties outfitting for the long overland journey required some one with them who could read the rocks and tell the difference between gold and brass.

There were no mining schools in the United States at that time. Chemistry and mineralogy were taught at Yale and at Harvard in recently established schools of science; that at Harvard endowed by Lawrence, that at Yale without endowment till some years later, when Sheffield realizing its value, left a large part of his fortune for its maintenance. That school in 1852 graduated five students. It now has over 600 students upon its rolls.

From only two or three centers of instruction in science in the United States in the middle of the century the demand for knowledge has spread until every state and ter-

*History of the Inductive Sciences, Vol. 1, p 240.

ritory now can boast the presence of schools devoted to the increase of knowledge of nature's powers and laws, and the practical utilization of such laws and forces. We cannot estimate in dollars the value of such schools to the nation. Nor can we omit to name with gratitude the far-seeing wise statesman, Senator Morrill, the author and promoter of the beneficent legislation which permits of your existence as a department of the University of Missouri here today.

There are now some sixty-five or more land grant colleges, receiving in the year 1901 $1,200,000 from the United States, with over 2200 instructors and 1800 students. There are also nearly 500 institutions for higher education.

We may here acknowledge with gratitude the magnificent educational endowments and institutions founded by those who have drawn their riches from the treasuries of the earth. The names of Hearst—known and beloved by Pacific Coast miners as "Uncle George"—of Rockefeller, of Carnegie, and we may add of Stanford. These men have given practical eloquent evidence of their appreciation of the value of education.

MINING AND GEOLOGY.

The facts developed by the work of miners in their subterranean operations have been in all places valuable to the science of geology. The phenomena of the rocks are closely observed by intelligent miners and demand explanation. It is necessary to success that miners should observe closely. Mining, more than agriculture, tends to intellectual growth. Environment and occupation are great factors in education.

The influence of the geological structure of a country upon the inhabitants has been discussed by De la Beche. He contrasted the condition of the laborers on the poor sands of the carboniferous series of northwestern Devon and the miners of Cornwall, both considered in the mass:

"While the former are thinly distributed over the country full of prejudices against improvement, and still oftener

firm believers in witchcraft, ghosts, etc., the miners of Cornwall, thickly congregated together in the neighborhood of the working lodes, abound with intelligence, and from the constant exercise of their judgment are able to take correct and enlarged views of many other subjects than those immediately connected with their ordinary occupations."*

M. Fournet has well remarked that "metals having become objects of the first necessity to man, he would during all times and in all places attach great importance to their receptacles, and that it is to their mode of occurrence, their connection with adjoining substances, and their relation to the phenomena obtainable in the neighboring country that geology owes its birth."† This view was accepted by no less an authority than Sir Henry De la Beche.‡

And we may say that the desire to learn more of the extent and distribution of our mineral wealth in the several states has induced the appropriation of money for geological and mineralogical surveys. The money value of, and probable money returns from such surveys have been generally the leading argument with legislatures of those seeking for appropriations, and in general also in proportion to the neglect of pledges to work for economical results the surveys have come to grief. "Science for science sake," though beautiful in theory, has rarely, especially in the earlier stages of our mining and industrial development, been a successful sentiment in the appeal for appropriations. But in the faithful endeavors to really prove and solve the mysteries of the deposits of mineral wealth, rich harvests of science have been gathered in, and results achieved equally valuable to industry and to science.

MINING SOCIETIES AND ORGANIZATIONS.

Amongst the more important agencies of the increase and diffusion of knowledge of mining and metallurgy we place the many technical and scientific societies and organizations, not forgetting the immense service of the printing

press in technical papers and journals. The multiplication of periodical publications devoted to mining is surprising, especially to those who can remember when no such journal was published in the United States. Each great center of the mining industry may now be said to have its special mining journal of wide circulation amongst the mills and mining camps of the mountains. And the great daily papers are incomplete and unsatisfactory without reports from the mines.

The great international exhibitions since that of 1851 in the Crystal Palace at Sydenham have also been a great factor in education generally, and especially in metallurgy and the industrial arts. Amongst the educational agencies by which mine engineering has been rapidly promoted in the United States, we cannot fail to recognize the American Institute of Mining Engineers as one of the foremost. Organized in 1871 with perhaps a dozen members, there are now more than 3,000 names upon the roll. One or two large volumes of transactions are published annually, the series comprises not less than thirty volumes, and these are crowded with technical papers of the highest value to the arts of mining and metallurgy. These volumes have been ably edited and issued under the untiring care and devotion of the Secretary, Prof. R. W. Raymond.

Another important organization is found in the American Iron and Steel Association, formerly the American Iron Association, organized as such at Philadelphia in 1855. The present name was adopted in 1864. Under the general management of James M. Swank it has been an important agent and factor in the promotion of the iron and steel industries of the United States. It has been a bureau of information for the American iron trade, publishing annually a series of statistical reports.

We should also, at least, mention the Iron and Steel Association of Great Britain, and the several engineering societies abroad which are devoted to the advancement of engineering in its varied phases and applications in construction and manufacturing.

VALUE OF MINERAL PRODUCTS IN THE UNITED STATES.

The aggregate value of the mineral production in the United States at the end of the century—year 1900—was over a billion of dollars, divided between metallic and non-metallic products, as follows:

Metallic	$549,934,370
Non-metallic	516,671,217
Not specified	1,000,000
Total	$1,067,605,587

In the order of greatest total value we find in round numbers of millions:

	MILLIONS.
Coal	$321
Pig Iron	238
Copper	100
Iron Ore	79
Gold	78
Petroleum	75
Silver	37

When we consider the magnitude of these figures and the national importance of the mining industry, and the fact that in the states of the Pacific coast the greater portion of the product is drawn from the national domain, we cannot but feel that mining, equally with agriculture, should enjoy the fostering care of the national congress, and that mining colleges should be as liberally endowed as the national schools of agriculture. This becomes the more vividly important when we consider the imperative demand for well educated eugineers, and the desire for knowledge which such a demand stimulates and sustains. An education in mining has money value. Young men crowd our mining schools because they wish to learn. They are not sent, but they come as earnest seekers after knowledge. Mining is a noble profession, requiring varied attainments. A mining engineer, worthy of the name, is a liberally educated man, equipped to deal with the forces of

nature, and to use them for the good of humanity, and the advancement of civilization. Such an education, I am fain to believe, induces general culture. It is ethical in tendency. It gives respect for truth and right living. Instruments of precision and the balances of the chemist are great mentors. The history of life on the earth shows us our place in nature and our responsibility. Yet in the limited range of our knowledge we stand aghast at our insignificance and our dependence on the unseen. We are taught humility and reverence. Humility is the proper attitude for learners. Learners, young and old, we must ever be. Let us be grateful for the heritage of knowledge left us by those who have gone before and strive to contribute our proportion according to the advantages we enjoy.

*Dela Beche, Cornwall and Devon, page 462.

†Etudes sur les Depots Metalliferes, D'Aubuissen's Traite de Geognosie, 2d Ed., tom iii, p. 383.

‡Report on the Geology of Cornwall, Devon and West Somerset, London, 1839, p. 349.