**Government School of Mines and of Science Applied to the Arts, Museum of Practical Geology : 2nd session, 1852-52.**

# GOVERNMENT SCHOOL OF MINES

AND OF

# SCIENCE APPLIED TO THE ARTS.

## MUSEUM OF PRACTICAL GEOLOGY.

## 2nd Session. 1852–53.

THE importance of the mineral wealth of the United Kingdom far exceeds that of any other European State, and furnishes four ninths of the raw mineral produce derived from all Europe. Although the annual value of the mineral produce of this Kingdom amounts to 24,000,000*l*., and the capital and labour employed in its extraction and application represent a much larger sum, no school having for its especial object the instruction of persons engaged in mining operations had, until last year, been established in the United Kingdom.

Mining Schools have long existed in France, Russia, Prussia, Saxony, Austria, Spain, Sweden, and other countries even less connected with mining; and their practical value is recognized by the fact, that the respective Governments of these States have found it necessary to develope still further the educational resources of such institutions. The want of similar establishments in this country has long been felt in mining districts, and has been expressed both in Parliament and in memorials addressed to the Government. In the Report of the Committee

of the House of Lords (1849), the Committee observe that "among those best qualified to speak upon this point, a want appears to be felt of facilities for acquiring mining education, such as are provided by the mining schools and colleges established in the principal mining districts of the Continent, apparently with the most beneficial effects." Memorials have been presented from the principal mining districts of the Kingdom, urging this want, and indicating the Museum of Practical Geology as the proper institution to be converted into a Mining School. In consequence of these representations, and of the enlargement of the Museum, the Government have applied the resources of the institution to public instruction in Mining, and in the applications of Science to the Arts.

Although the intention always was entertained, as shown by the name of the school, to include instruction in the applications of Science to the Arts, various circumstances have occurred which have induced the Professors to give prominence to this kind of instruction, as well as to the mining education so much required by this country. A strong feeling on the part of the public has been manifested for the establishment of schools professing instruction in the Arts. This feeling has found expression in memorials to the Commissioners of the Exhibition from Birmingham, Bristol, Hull, Nottingham, Sheffield, and other towns; and the Educational Council of this school have thought it expedient to enlarge the character of the instruction, so as to include the more important applications of the Sciences professed by the Lecturers to the Arts and useful purposes of life. The Museum has in consequence been enriched with illustrative collections of the progressive stages of mineral manufactures, its foundation at present not enabling it to include the organic manufactures, which are, however, illustrated by the lecture collections of the individual Professors.

The Laboratories and working rooms of the several departments are so arranged and organized, that systematic studies in Chemistry, Metallurgy, Geology, Palæontology, Physics, Mineralogy, and Mining, may be entered upon with great

advantage under the direction of the officers of the respective departments. The Museum itself is of an essentially practical character, and was primarily intended to bring Science to bear on Geology in its application to the useful purposes of life; its officers were selected with a view to carry out the educational character of the institution, recognized shortly after its formation by an official letter of the Chief Commissioner of Her Majesty's Woods, and sanctioned by the Lords of the Treasury.

The following is a list of the officers entrusted with the courses of instruction:

PRESIDENT.—Sir HENRY T. DE LA BECHE, C.B., F.R.S.

| | |
|---|---|
| CHEMISTRY, applied to the Arts and Agriculture - | *Lyon Playfair*, Ph. D., F.R.S. |
| NATURAL HISTORY, applied to Geology and the Arts - - - - - - - - | *Edward Forbes*, F.R.S. |
| MECHANICAL SCIENCE, with its application to Mining - - - - - - - - | *Robert Hunt*, Keeper of Mining Records. |
| METALLURGY, with its special applications - - | *John Percy*, M.D., F.R.S. |
| GEOLOGY, and its practical applications - - - | *A. C. Ramsay*, F.R.S. |
| MINING and MINERALOGY - - - | *Warington W. Smyth*, M.A., F.G.S. |

The education contemplated in this School differs essentially from that given in colleges, where general education is the primary object. Although it is intended to give general instruction in Science, to those who may require elementary knowledge, still, the chief object of the Institution (to which everything else is made subsidiary) is to give a practical direction to the course of study, so as to enable the student to enter with advantage upon the actual practice of Mining, or of the Arts which he may be called upon to conduct. The students forming the different classes are subjected to regular and frequent examinations, both written and oral, in addition to those which are required for the Duke of Cornwall's Exhibition. As an example of these examinations a few of the papers are appended. It may therefore be desirable to call attention to the peculiar features of the Institution, and to the Courses of Lectures to be given by the respective Professors.

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## The Museum.

The Geological Survey of the United Kingdom being carried on in connexion with the Museum, has afforded great facilities for making complete collections illustrative of the applications of Geology to the useful purposes of life. These collections contain an extensive series of rocks stratigraphically arranged, with reference to their mode of accumulation, and the subsequent action of various causes upon them; of fossils classed in the order of geological time; of specimens illustrative of the ores of the useful metals, of their mode of occurrence, and of the methods of preparing them for smelting; of mineral substances used for constructing public works and buildings, and of those employed for ornamental purposes, or for the useful arts in connexion with chemical or metallurgical manufactures. The processes of converting these raw materials into industrial products are carefully exhibited, and illustrations of the finished products are also displayed. The various arts connected with the mineral resources of the country are illustrated by specimens showing varieties or peculiar excellences of manufacture.

Models of mines, mining tools, and working models of mining machinery, are collected, with the view of exhibiting the various modes of working carried on in different districts. The Museum is open to the Public for the first three days of the week, the remaining days being reserved for study.

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## Geological Surveys.

The Geological Surveys of the United Kingdom are carried on under the general direction of Sir H. T. De la Beche, and their central office is at the Museum. In this office the maps and sections are prepared and deposited. The field surveys are carried on in the localities under examination for the time being, and it is contemplated to communicate instruction in the field in the various departments of Geological Surveying, under the Mining, the Geological, and the Palæontological Professors.

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## Office of Mining Records.

This office, superintended by Mr. Robert Hunt, is established for the preservation of Mining Records. The absence of these needful documents was found to be the cause of much waste, in attempts to work in localities where there was little prospect of success, or where from a want of proper knowledge of the old workings much useless expenditure was incurred. A large collection of plans and sections of mines, and many important statistical mining details, are deposited in this Office, and are made available for the instruction of students.

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## Laboratories.

Two Laboratories, one for General, Practical, and Analytical Chemistry, under Dr. Lyon Playfair, the other for Metallurgy and Assaying, under Dr. Percy, are established in the Museum. Students will, under certain regulations, be admitted into the Laboratories for the purpose of receiving instruction in the analysis of minerals and ores, and of the methods used in applying them to useful purposes in the Arts.

Unless the student has already become acquainted with Practical Chemistry, it will be requisite to pass through the Chemical Laboratory before entering that for Metallurgy, as the latter requires previous chemical knowledge before its study can be usefully entered upon.

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## Palæontological Department.

As the relative age and sequence of geological formations are, to a great extent, determined by the fossils they contain, it has been found necessary, in the prosecution of the Geological Survey, to attach a department of Natural History, under the direction of Professor E. Forbes, where the organic remains contained in the sedimentary rocks of the British islands may be examined and preserved. Extensive collections of these fossils are arranged, and used for the instruction of students.

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The following Courses of Lectures will be given during the Session :—

## Chemistry.

The instruction in Chemistry is given both by Lectures and in the Laboratory. The lectures explain the general laws of chemical affinity and combination, the physical forces connected with chemical phenomena, and their application to useful purposes. The elementary bodies and their compounds are discussed, and especial importance is given to the practical appliances of the different substances described. The processes used in the chemical arts, and the manufactures chiefly depending on the application of chemical principles, are treated of in detail. The chemical facts of importance in their applications to mining and engineering, in the treatment of soils, and the conversion of mining products into substances useful in the Arts, are fully discussed. Organic Chemistry is so far entered upon, as is sufficient to enable the student to study more fully this important branch of the science; and its applications to the Arts and to Agriculture receive especial attention. In the Laboratory the students are taught the processes of qualitative and quantitative analyses.

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## Natural History applied to Geology.

The subjects of this Course include the principles of Natural History, considered especially in their bearing on geological evidence; the organization of extinct creatures compared with and illustrated by that of existing animals and plants; the history of the successive aspects of animal and vegetable life during the different geological epochs; the examination and description of organic remains, and the application of them to the determination of strata. The practical bearings of Natural History on the Arts will be illustrated in a separate Course.

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## Mechanical Science.

This Course will embrace a full consideration of the mechanical powers and the laws of motion, with illustrations taken from such sources as appear to furnish the largest amount of practical information. The laws by which the motive powers applied to machinery are regulated, will receive close attention and ample illustration.

The phenomena of Heat and Light, and the application of our knowledge of these physical forces to purposes of utility, together with Electricity in all its modifications of condition, and particularly Magnetism under the new and important aspects which recent discoveries have given it, will form the subject of examination. The explanations of natural phenomena afforded by Physical Science are necessarily included in this Course.

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## Geology.

This Course includes the proofs of the origin of stratified and igneous rocks, with an account of the more important substances entering into their composition, and an explanation of geological terms. The terrestrial actions now in progress are also described, including the degradation and denudation of land, earthquakes, volcanoes, areas of elevation and depression, &c. &c. Also, a descriptive account of the whole series of geological formations, showing their stratigraphical order and manner of formation, the laws by which these are determinable, and their general economic applications. Especial attention is given to geological surveying and its economical bearings.

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## Metallurgy.

The course of instruction in Metallurgy consists of Lectures and practical demonstrations in the Laboratory. The Lectures embrace the following subjects:—a description of the metals

and such of their compounds as are of metallurgic importance; ores; modes of extracting the metals from their ores; furnaces, crucibles, &c., and the materials used in their construction; fuel; fluxes; slags; methods of assaying; alloys. The smelting of iron, copper, and lead, and the manufacture of steel, are discussed at considerable length; as also is the treatment of silver ores by the "wet" and "dry" ways, and the refining and "parting" of the precious metals. The important branch of Electro-metallurgy is treated of in detail. The principles involved in metallurgic processes are expounded with special reference to practical application.

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## Mineralogy.

The Course embraces Crystallography and the physical properties of Minerals, treated principally with a view to the practical discrimination of the substances considered by this science; the elements of the Chemistry of Mineralogy, with the use of the blowpipe, and such simple tests as fall within the province of the field mineralogist, and the Physiography, or systematic description of Minerals, with particular reference to their mode of occurrence, and the uses to which they are applied.

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## Mining

Involves general considerations on the principles and management of subterraneous workings, the Practice of Mining in this and other countries being taught under the following heads:—Boring, and preliminary researches; Tools, employed in mining; shafts and sinking; levels and driving; the methods of securing excavations by masonry, timbering, and tubbing; "exploitation," or the working away of veins and strata; transport and winding, with the machinery and apparatus required; pumps and pumping engines; ventilation; and the mechanical preparation or dressing of ores.

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## H.R.H. The Duke of Cornwall's Exhibition.

H.R.H. the Prince of Wales, as Duke of Cornwall, has granted annually two Exhibitions of thirty pounds each. One becomes vacant every year, and will be competed for by Matriculated Students only, at the end of the first Session. It is held by the successful competitor for two years.

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## Working Men's Lectures.

Lectures intended for Working Men, and explanatory of the collections of the Museum, are delivered occasionally during the year, and to these Lectures the Students are admitted.

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## Regulations as to Admission.

PERSONS desirous of entering as MATRICULATED STUDENTS, with a view of eventually obtaining the diploma of the Institution, must be at least 16 years of age, and will be required to bring certificates or other evidence of their having received a sufficient preliminary education. They shall pay *thirty pounds* in one sum on entrance, or two annual payments of *twenty pounds* each, for admission to all the Courses of Lectures extending over two years, and field instructions, according to the regulations of the Institution; and shall have the privilege of studying in the Museum and in the Library.

The charge for instruction in the Laboratories (which is not included in the above) is *thirty pounds* for the Session of ten months, or *fifteen pounds* for the Term of five months. The Laboratories are open to Occasional as well as Matriculated Students.

OCCASIONAL STUDENTS will be admitted to the Lectures on payment of *four pounds* for each Course of above 30 Lectures, and *three pounds* for the Course of 30 and under.

Acting Mine-Agents and Managers of Mines are admitted to the Lectures at half the above charges.

Officers of the Army and Navy, in the Queen's or the Honorable East India Company's Service, are admitted on similar terms.

Field instruction in Geology, Mineralogy, and Palæontology will be given to a limited number of OCCASIONAL STUDENTS, at a charge of *five pounds* per month.

The Session will commence on Wednesday the 3d of November, at Three o'clock, with an Introductory Address by Dr. Playfair.

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Particulars respecting the times of Lectures, and all other information, may be obtained by application to Mr. TRENHAM REEKS, Curator of the Museum of Practical Geology, Jermyn-street, London.

# APPENDIX.

The following papers are given as an example of the written examinations.

## SESSION 1851–52.

### CHEMICAL EXAMINATION.

*12th May* 1852.

1. What is the absolute evaporating power of a Coal of the following composition?—

| | |
|---|---|
| Carbon | 84·72 |
| Hydrogen | 6·43 |
| Nitrogen | 1·21 |
| Sulphur | 0·84 |
| Oxygen | 4·80 |
| Ashes | 2·00 |
| | 100·00 |

2. If 100 grains of the above Coal be burned in air, what bulk of air is required for the combustion? What products result from it? What is the weight of each product, and what the bulk of Carbonic Acid produced?

3. Explain the Dutch and French methods for making White Lead, the theory of the processes, and the formulæ of the products.

4. In what respect do air limes and hydraulic limes differ? Explain the manner in which each respectively acts.

5. The following substances being mixed together in powder, how would you distinguish both Acids and Bases?—

Arseniate of Baryta,
Selenide of Silver,
Chromate of Lead,
Silicate of Lithia,
Stannate of Soda,
Tartrate of Antimony.

6. Describe the relation between specific heat and atomic weight.

7. The following observations are made in analysing a gas :—

| Observations. | Volume. | Temp. | Barometer. | Col. of Mercury above that in trough. | Corrected vol. at 0° C and 1 Metre Pressure. |
|---|---|---|---|---|---|
| Gas used (moist) - - | 114·0 | 16·0 | 761·4 | 72·1 | 72·8 |
| After absorption of Carbonic acid (dry) | 111·4 | 15·8 | 760·6 | 74·7 | 72·2 |
| After absorption of O (dry) - - | 97·5 | 15·5 | 749·9 | 89·8 | 60·0 |
| Gas used (moist) - - | 78·6 | 15·4 | 750·6 | 226·1 | 38·1 |
| Oxygen admitted (moist) | 156·3 | 15·3 | 751·0 | 148·1 | 87·3 |
| After Combustion (moist) | 130·0 | 15·5 | 751·0 | 174·7 | 69·3 |
| C $O^2$ being absorbed (dry) - - | 113·9 | 15·3 | 751·2 | 191·0 | 60·4 |
| Hydrogen admitted (dry) | 273·2 | 14·6 | 752·3 | 32·2 | — |
| After Combustion (moist) | 163·8 | 14·4 | 752·3 | 140·7 | — |

Correct the two last observed volumes for temperature, pressure, and tension of aqueous vapour, giving the corrected volumes at 0°C and 1 metre pressure. Calculate from the numbers in the last column, the composition of the mixed gases in 100 parts.

8. A salt containing potash, lime, sulphuric acid, and water, being analysed gave the following results :—

10·05 grs. of the salt gave 3·05 grs. carbonate of lime, and 14·85 grs. chloride of platinum and potassium.

9·28 grs. of the salt gave 0·51 grs. water, and 13·22 grs. sulphate of barytes.

What is the composition of the salt in 100 parts, and what is its probable formula ?

LYON PLAYFAIR.

## EXAMINATION IN NATURAL HISTORY APPLIED TO GEOLOGY.

13*th May* 1852.

1. Explain the terms *Species* and *Genus.*

2. What do we mean by *Provinces in Time* and *Provinces in Space ?*

3. Enumerate the *principal groups* of organized beings according to their relative value with respect to Geological evidence.

4. What *portions of the bodies* of Vertebrata, Articulata, Mollusca, and Echinodermata are likely to be preserved in the fossil state ?

5. Enumerate and define the *orders* of Corals, according to the classification of Milne Edwards, and Haime ; state their geological distribution, and the amount and nature of the evidence they severally afford respecting the climates of past epochs.

6. State the distinguishing characters of the *orders* of Mollusca.

7. Enumerate and define the *extinct genera* of Echinidæ ; and state the geological distribution of each.

8. Enumerate and define the *tribes* and *genera* of Brachiopoda, of which species occur in a fossil state ; and give the geological range of each.

9. Enumerate and define the *genera* of Tetrabranchiate Cephalopoda. State the characters and geological range of the sub-divisions (according to Von Buch) of the genus Ammonites.

10. Explain the structure of a Trilobite, and enumerate and define the leading *tribes* of Trilobites.

11. What are the *genera* of Invertebrate animals that usually occur in a stratum of fresh water origin ?

12. What *genera* of Radiata and Mollusca are exclusively Palæozoic ?

13. What *genera* of Radiata and Mollusca are exclusively Mesozoic?

14. Describe minutely the specimen placed before you.

EDWARD FORBES.

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## EXAMINATION IN MECHANICAL SCIENCE.

14*th May* 1852.

1. Give an example of simple and of compound Motion, and explain the parallelogram of Forces.

2. Define the laws of Gravitation, and examples of each law.

3. A Stone is liberated at the height of 26,000 feet above the level of the sea; neglecting the resistance of the air, in how many seconds will it fall to the ground, and what will be its final velocity?

4. A body is projected vertically from the earth with an initial velocity of 240. Define its velocity during each second of ascent. At the end of how many seconds will it begin to fall?

5. Describe the different phenomena produced by superficial attraction, or the adhesion of, and to surfaces.

6. Give the laws regulating the motion of a pendulum under different conditions of length.

7. Define the laws of the pressure of slightly elastic fluids, and describe their application in the Hydraulic Press.

8. Upon what does the action of the Hydraulic Ram depend?

9. In a vessel kept constantly full of water, there are orifices at the depths respectively of 3, 5, and 9 feet. Give the ratio of the velocity of efflux from each.

10. Give the laws of atmospheric density and elasticity, and the relation of volume to the compressing force.

11. Upon what principle depends the application of the Barometer in measuring the heights of mountains?

12. Describe the operation of Steam in an Engine working "expansively"; and the differences between a single acting and a double acting Steam Engine.

13. Give some examples illustrating the conditions of sensible and latent heat.

14. Define the spaces occupied in the prismatic spectrum by the luminous, calorific, and chemical forces.

15. Define the terms Chromatic Aberration and the aberration of Sphericity, and the principle of the construction of achromatic lenses.

16. What are the conditions of a charged Leyden Jar, and point out some analogous conditions in natural phenomena?

17. Define the expressions, *quantity*, and *intensity* as applied to Voltaic Electricity; and describe the Voltaic arrangements necessary to produce these conditions.

18. Give the law of electro-chemical decomposition.

19. What is the relation between the mechanical power of an electro-magnet and the chemical action in a voltaic battery?

ROBERT HUNT

# EXAMINATION IN MINERALOGY.

15*th May* 1852.

1. What portions of the Inorganic Kingdom are considered by modern authors as belonging to the province of Mineralogy?

2. Give the derivation and meaning of the word *crystal*, and the reason for crystals being looked upon as the *individuals* of the inorganic world.

3. Define a *rhomb*, a *pyramid*, a *tetrahedron*, and an *octohedron*.

4. Describe the method of projection applied to the drawing of crystals, and draw a cube on this principle.

5. How are the axes placed in the *oblique system* of crystallisation? and by what names do you distinguish the two axes which are not vertical, and the horizontal prisms which are produced by modification in those directions?

6. Enumerate some of the irregularities of the surfaces of the faces of crystals.

7. Describe the principle of the *contact* and of the *reflecting Goniometer*.

8. What is meant by *simple* and by *double refraction*, and state what relation appears to exist between these phenomena and crystalline form?

9. Mention some instances of *Isomorphism* in mineral substances, and of the difficulties arising hence, in carrying out a strict scientific arrangement.

10. What are the leading principles of the arrangement adopted by Werner, by Mohs, and by Berzelius?

11. Describe the chief characteristics and localities of the *Diamond*, of *Graphite*, and *Anthracite*.

12. What is the crystalline system, and what the ordinary form of *Quartz?* and enumerate the varieties generally known under other names.

13. Describe the external and chemical characters of *Hornblende* and of *Augite*, pointing out wherein they differ importantly, and with what classes of rock they are associated.

14. What is the generally occurring form and the chemical constitution of the gems termed *Emerald, Garnet, Amethyst, Topaz*, and *Zircon* or *Hyacinth?*

15. What are the chief characteristics of the ores of Manganese called *Pyrolusite, Manganite, Braunite, Hausmannite*, and *Psilomelane?*

16. Describe four of the most important species containing Lead. Draw a crystalline form from the Cubical System, showing a combination of faces of the Cube and Octohedron; and from the Rhombohedral System, showing the combination of faces of the pyramid, prism, and terminal plane; distinguish the faces by their proper symbols, and state which of the species described assume such forms.

17. What are the minerals most valued as ores of Copper? In what systems do they crystallize, and what are their chief constituents? By what methods is the presence of this metal in its ores readily detected?

18. Which of the precious metals occur in a native state, and under what circumstances?

19. Mention the Crystalline System and form of the models of crystals placed on the table.

20. Give the name and chief characteristics of the minerals lettered A, B, C, D, E, F, G, H, I, K.

WARINGTON W. SMYTH.

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LONDON:
Printed by GEORGE E. EYRE and WILLIAM SPOTTISWOODE,
Printers to to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.