PREFACE

Interestingly enough the Government Museum, Madras was founded in 1851 with a small collection of minerals gifted by the Madras Literary Society as a nucleus. Through the years however, while independent sections were set up for Archaeology, Anthropology, Numismatics, Zoology, Botany, etc., Geology could come into its own with a separate section only in 1961. Meanwhile however the collections of geological materials were augmented constantly and were also displayed. In recent times the Geology Galleries have been considerably reorganised on modern lines. Thiru E. George Jesudossan who has been incharge of the section since it was formed in 1961 has written a carefully compiled guide to the Geological Galleries. To anyone interested in Geology, this should prove to be a useful handbook.

N. HARINARAYANA,
Director of Museums

ACKNOWLEDGEMENTS

I express my deep sense of gratitude to Dr. S. T. Satyamurti, Director of Museums (Retired), Madras for having encouraged me to write this book and to Dr. N. Leelananda Rao, Professor of Applied Geology, University of Madras, for helping me in various ways, particularly in re-organising the Petrology Section and in going through the entire manuscript of this guide book. My thanks are also due to Thiru V. Jeyaraj, Curator, Chemical Conservation Section and Thiru M. Mohan, Assistant Curator, Botany Section for assisting me in correcting the proofs.

I also thank Thiruvalargal G. Srinivasan, A. Moses Watts and A. Devarajan for preparing the photographic illustrations.

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I. INTRODUCTION

Geology is the science of the earth. It aims at understanding diverse aspects of the earth. It is concerned with the anatomy of the earth in order to trace its geological history. It endeavours to explain its enshrouded mystery by unearthing the sermons which are locked up in the rocks. It is indeed the most fascinating natural science which finds a fitting place in the Madras Government Museum which is acclaimed as one of the best Museums of our country.

II. HISTORY OF THE GEOLOGY SECTION

The history of the Geology Section in the Madras Government Museum is indeed quite interesting for it is only with geological materials that the Museum started its life. In the year 1828, the Madras Literary Society, a branch of the Asiatic Society of London, desired to have a Museum of Economic Geology at Madras and began collecting geological specimens. But lacking funds and space for an effective Museum, the Society addressed the Madras Government to take the initiative in the formation of the Museum. In 1843, Major-General W. Cullen suggested to the Government the starting of a local Museum not only for helping interest in minerals but also for the encouragement of agriculture and improvement of processes. On the basis of the letters of General Cullen and the Secretary, Madras Literary Society, the Court of Directors of the East India Company agreed, in 1846, to the formation of a Central Museum at Madras. In 1850, Assistant Surgeon Edward Green Balfour, Medical Officer of the Governor's Bodyguard and Assay Master offered his services as Officer-in-charge of the proposed Museum and his offer was

accepted in January 1851. The Central Museum thus began its life in the upper storey of the College of Fort St. George with the geological collections. Due to overcrowding of the rooms and more so owing to damage to the upper storey of the College by the weight of the cases, the Museum was removed to the Pantheon, in 1854, which was then occupied by the Cutcherry of the Collector of Madras.

Thus beginning as a Museum of practical geology its scope was later expanded to cover other fields such as Archaeology, Ethnology, Pre-history, Botany and Zoology. It may be of interest to note that though the other branches were added later, each of them had independent Curators to maintain them, whereas the geological galleries with which the Museum began had no independent Curator till 1961. The geological galleries were, therefore, maintained by the Curators of Botany Section. With the appointment of an independent Curator for Geology in May 1961, the geological galleries were bifurcated from the Botany section. Since then the geological galleries have been considerably improved, re-arranged and modernised.

III. GEOLOGICAL GALLERIES

The geological galleries of the Madras Government Museum are accommodated in two floors. The main section is situated in a large hall at the northern end of the skeletal gallery wherein the skeleton of the whale and other skeletal structures are exhibited. Another section of the geological gallery is situated on the mezzanine floor above the main gallery.

The exhibits are displayed under five main headings, namely, General Geology, Petrology, Mineralogy, Palaeontology and Economic Geology.

In the main hall General Geology and Petrology are located on the left side of the hall and the Mineralogy and Palaeontology are exhibited along the right side. Economic Geology is centrally located in the main hall.

In the mezzanine floor the exhibits are mostly pertaining to Economic Geology with the emphasis on industrial application of economic minerals.

IV. GENERAL GEOLOGY

The General Geological display is mainly composed of pictorial exhibits which explain the work of dynamic agents like wind, rivers, glaciers, seas and oceans. Volcanoes and effects of earthquakes are also illustrated. The architectural splendour of the rocks also find a place in this section. Besides pictorial representation there are also models of the earth showing its general constitution (Fig. 1) and the topographic model of Madras and Chingleput districts. The volcanic lava of Vesuvius, Italy, the calcareous spring deposit travertine containing a leaf impression

FIG. 1 MODEL OF THE EARTH SHOWING ITS GENERAL CONSTITUTION.

Fig. 2. TRAVERTINE WITH LEAF IMPRESSION.

(Fig. 2), the coraline rock, ripple marks displayed by sandstone and a folded quartzite are some of the actual notable exhibits of this section.

A small collection of meteorites is also on display in a table case near the beginning of the General Geology gallery (Fig. 3).

FIG. 3. METEORITES

Meteorites are bodies of extraterrestrial origin which fall on the earth from interplanetary space. They are generally fused fragments, more or less angular in shape and are usually covered with a thin, uniform, black shell called fusion crust. Well defined characteristic pits called regmaglypts are almost always present in them. All meteorites possess magnetic properties.

Based on the proportion of iron and stony components present in them, meteorites have been broadly divided into three groups, namely, iron meteorites, stony meteorites and stony-iron meteorites.

Iron meteorites are entirely made up of nickeliferous iron. The nickel content in them varies from 5 to 30 per cent. Meteorites with less than 4 per cent nickel content has not been encountered. Therefore, this fact enables us to distinguish iron meteorites from native iron of terrestrial origin as the nickel content in the latter does not exceed 2 to 3 per cent.

Stony meteorites are made up of stony masses, chiefly ferromagnesian silicates. Their inner portions are usually ash grey in colour. They cannot be recognised by laymen as they resemble terrestrial rocks. The magnetic properties of stony meteorites enables us to distinguish them from several terrestrial rocks.

Stony-iron meteorites are composed of approximately equal amounts of nickeliferous iron and ferromagnesian silicates.

The specimens displayed in the gallery are those of iron meteorites and stony meteorites obtained from South India. A plaster-cast-model of the stony meteorite which fell at Valudavur in South Arcot district in Tamil Nadu in the year 1944 is also on display. The original specimen was destroyed during analysis by the Geological Survey of India.

At the far end of the hall there are two large paintings displayed on the wall, one depicting the fall of a comet and the other the lunar landscape. In the lunar landscape it may be noticed that the surface of the moon is not smooth but with mountain-like structures, volcanic craters and crevices. Neither animal nor plant life are present in it.

V. PETROLOGY

Petrology deals with rocks. A rock is an aggregate of minerals and it may be mono-mineralic, bi-mineralic or poly-mineralic in composition. Following the normal convention, the rocks are displayed under three divisions, namely, igneous, sedimentary and metamorphic sections.

(i) Igneous Section

Igneous rocks have been sub-divided into three main groups, namely, plutonic, hypabyssal and volcanic rocks.

a. Plutonic

Plutonic rocks are those that are formed under deep seated conditions owing to the consolidation of the molten rocky material called magma. These rocks are equigranular and show variation in grain size from medium to coarse types. They range in composition from acid to ultrabasic types and their silica content decreases from acid to ultrabasic ones.

Several components of the plutonic group are exhibited in the gallery and their essential characteristics are listed hereunder, for proper understanding and appreciation of these rock types.

Granites—Granites are equigranular, fine—to coarse-grained, leucocratic rocks which are essentially comprised of alkali-feldspar and quartz. They may contain minor amounts of mafic minerals like micas, amphiboles and pyroxenes. These rocks occur in nature either as batholiths, stocks, boses, dykes and sills. Their specific gravity is about 2.67. They may carry accessories which can be deciphered under the microscope as apatite, zircon, sphene, magnetite, etc.

Several varietal types of granites adore the petrological gallery of this Museum and they are listed below with their localities in parenthesis:

P 1. *Granite* (*Pamban*):—It is a coarse-grained, equigranular rock made up of pink feldspars and colourless quartz with accessory amounts of dark glistening hornblende and pale green epidote. It is an acid rock which is oversaturated with silica.

P 2. *Granite* (*Madura district*):—It is a medium-grained, pale pink, equigranular rock comprised of laths and grains of pale pink feldspars and colourless quartz. Hornblende is rare. It is an acid rock which is oversaturated with silica.

P 3. *Grey granite* (*Thippasandra, Bangalore district, Mysore State*) :—It is a medium-grained, equigranular rock comprised of pale grey feldspars, colourless quartz and glistening flakes of biotite. Pistachio-green epidote occurs as a lenticular stringer amidst the feldspars. It is an acid rock which is oversaturated with silica.

P 4. *Granite* (*South Arcot district*):—It is a coarse-grained equigranular rock comprised of pale pink vitreous microcline-perthite, colourless vitreous adularia and colourless greasy quartz with radiating spangles and laths of ruby mica. It is an acid rock which is oversaturated with silica.

P 5. *Unakite* (*Cuddappah district*):—The rock is pistachio-green in colour with patches of pink feldspar. The pistachio-green matrix is comprised of green granular epidote admixed with colourless greasy quartz. The pale pink feldspar is microcline and it displays vitreous lustre and two sets of cleavages. It is a highly epidotised granite and hence it is called unakite. It is an acid rock which is oversaturated with silica.

P 6. *Coarse-grained charnockite* (*Hills near Pallavaram, Madras*):—It is a coarse-grained, greyish rock comprised of grey vitreous microcline, grey greasy quartz and disseminated lumps of hypersthene. It displays a coarsely granular texture. It is an acid rock which is oversaturated with silica.

Charnockite was discovered by Sir Thomas Holland in 1893 at St. Thomas Mount and Pallavaram 26½ KM south of Madras in Tamil Nadu. As it was found that the tomb stone of Sir Job Charnock, the founder of Calcutta, was made out of this rock, Holland designated it as charnockite. Since then St. Thomas Mount and Pallavaram have become the type area of charnockite series and has attracted the attention of geologists all the world over.

P 7. *Charnockite (Pallavaram)*:—It is a greyish, medium-to fine-grained, granular rock comprised of yellowish grey feldspars, pale bluish grey quartz and dark glistening grains of hypersthene. It is an acid rock which is oversaturated with silica.

P 8. *Epidotised-mylonitised-charnockite (Viralimalai)*:—It is a dark grey, highly crushed rock which has been replaced, in places, by pistachio-green granular epidote. The dark grey component is essentially characterised by dark grey microcline and grey greasy quartz with lenticular streaks of hypersthene. The minerals occur as highly elongated lenticles owing to shearing. The dark grey component therefore appears to be charnockite. The pistachio-green, granular epidote displays saccharoidal texture and occurs in portions of the rock. Owing to shearing the hydrothermal solutions might have replaced some portions of the rock with granular epidote. Hence the rock is designated epidotised-mylonitised-charnockite. It is an acid rock which is oversaturated with silica.

P 9 *Graphic-granite (Yedali)* (*Fig.* 4).—It is a pale pink, medium-grained rock that displays graphic texture owing to intergrowth of quartz and feldspars. As the intergrowth resembles the hebrew or arabic script, its texture has been designated graphic. It is a bimineralic rock essentially comprised of pale pink glistening microcline-perthite and colourless quartz. It is an acid rock and represents the final stages in the formation of granite.

P 10. *Graphic-granite (Madurai district)*:—This is similar to P 9. On one face the hieroglyphic character of the intergrowth of quartz and feldspars is clearly seen, but along the other faces the irregular intergrowth of quartz and feldspars occur.

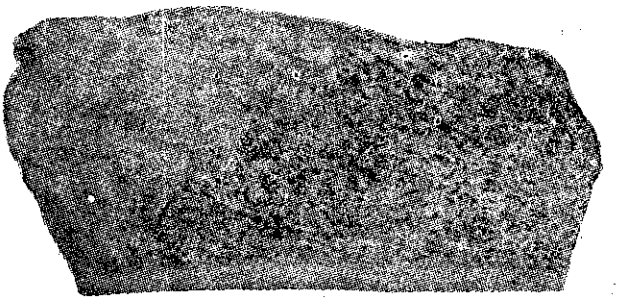


FIG. 4 GRAPHIC GRANITE.

P 11. *Schorl rock (Thuvarangoorichi)*:—It is a pale yellowish white rock peppered with dark glistening grains of tourmaline. The pale yellowish white mass is represented by quartz which shows greasy lustre. As it is comprised of quartz and tourmaline it is designated as schorl rock. It is an acid rock which is oversaturated with silica.

P 12. *Luxullianite (Nagar)*:—It is a medium-grained, pinkish-grey rock comprised of pale pink feldspar, greyish quartz and glistening laths and prisms of tourmaline. It is an acid rock which is oversaturated with silica.

P 13. *Granite-pegmatite (Mysore)*:—It is a coarse-grained rock comprised of coarse pink microcline, white vitreous oligoclase, colourless quartz and books and flakes of biotite. It is a late phase of granite. It is an acid rock which is oversaturated with silica.

P 14. *Granite-pegmatite (South Canara district)*:—It is a coarse-grained glassy-looking rock comprised of coarse crystals of adularia and colourless greasy quartz with books of silvery white muscovite. It constitutes a low temperature pegmatite. It is an acid rock oversaturated with silica.

Syenites.—Syenites are essentially comprised of alkali feldspars. They are usually leucocratic and display variation in grain size from fine to coarse. Quartz may be present in very subordinate amounts or it may be entirely absent. Minor amounts of mafic minerals like biotite, amphiboles, pyroxenes and olivine may be present. In highly alkaline syenites usually alkaline minerals like nepheline, sodalite and cancrenite are present. The accessory minerals that can be made out under the microscope are apatite, zircon, sphene, magnetite, etc. They usually occur as dykes and sometimes as sills. Their specific gravity is about 2.685.

A few syenites are displayed and their essential characteristics are listed below with their localities in paranthesis:

P 15. *Syenite* (*Talupula*):—It is a pinkish brown, coarse-grained rock comprised of pinkish brown microcline and grey glistening pyroxenes. It belongs to the saturated division of plutonic igneous rocks.

P 16. *Syenite* (*Madura*):—This is similar to P-15 but it contains pinkish microcline occuring as laths in between the granular grey glistening pyroxene and granular pink microcline and this displays poikilitic texture. It belongs to the saturated division of plutonic igneous rocks.

P 17. *Pyroxene syenite* (*Kottampatti*):—It is a medium-grained, pale grey, dense rock characterised by patches of dark glistening pyroxenes. The pale grey portions are characterised by medium-grained , pale yellowish grey feldspars, dark grey granular pyroxenes and pink vitreous granular grains of garnet. It belongs to the saturated division of plutonic igneous rocks.

P 18. *Nepheline syenite* (*Sivamalai*):—It is a crudely banded, pale bluish grey rock. It is comprised of pale bluish grey vitreous laths of feldspars which are embedded in a fine-grained, bluish grey groundmass characterised by bluish grey granular microcline, pale grey greasy nepheline and spangles of biotite. It differs from normal syenites in being undersaturated with silica.

P 19. *Nepheline syenite (Mandorai village, 4 KM N.E. of Keshengarh, Rajasthan)*:—It is a finely foliated banded rock with alternating white and dark layers. The white layers are essentially comprised of fine, granular feldspars and pale grey greasy nepheline. Dark layers are enriched with spangles of biotite. It differs from the normal syenites in being undersaturated with silica.

Diorites.—Diorites are pale grey to dark grey coloured rocks. They are equigranular and may be coarse to fine in grain size. Their average specific gravity is about 2.87. They are essentially comprised of basic oligoclase to basic andesine and mafic minerals like biotite, amphiboles and pyroxenes. Quartz and alkali feldspars may be present in very subordinate amounts. Under the microscope they are seen to carry accessories like apatite, zircon, sphene and quartz.

The dioritic members displayed in the petrological gallery are listed below with their localities in paranthesis:

P 20. Diorite *(Near Sholinghur)*:—It is a dark grey, dense, medium-grained rock comprised of dark glistening laths of pyroxenes and pale yellowish green feldspars. The rock is sheared and is traversed by thin pegmatitic veins. It is an intermediate plutonic igneous rock.

P 21. *Diorite (Madura district)*:—It is a dark, fine-grained, equigranular rock comprised of fine glistening grains of hornblende and pale yellowish grey feldspars. It is similar to P 20 but differs in grain size. It is an intermediate plutonic igneous rock.

Gabbros.—Gabbros are basic igneous rocks. They are dark in colour and show variation in grain size from coarse to fine. Their specific gravity varies from 2.9 to 3.2. They are essentially comprised of basic plagioclase feldspars and pyroxenes. Olivine, hornblende and biotite are sometimes conspicuous. Apatite and opaque quartz are the common accessories seen under the microscope. Quartz is rare in some variants. Some varietal types are alkaline in character.

The components of the basic members of gabbroic composition displayed in the Museum are described below with their localities in paranthesis:

P. 22. *Norite (from the centre of a dyke 4½ metres wide, Fraserpet, Coorg)*:—It is a dark grey, fine-grained, granular rock comprised of dark glistening grains of pyroxenes and pale yellow feldspars. It is different from the normal norite in possessing a granulitic texture. It was regarded by Holland as the basic member of the charnockite series. Whatever be its original origin its field characteristics suggest its polymetamorphic state.

P 23. *Augite norite (Watekolli, Coorg)*:—It is a pale yellowish grey, medium-grained, equigranular rock comprised of dark grey glistening hypersthene displaying, in places, its characteristic schiller. Pale yellowish grey labradorite is abundant. It is a basic rock which occurs as distinct bands.

P 24. *Gabbro (near Duggunta, Nellore district)*:—It is a medium-grained, equigranular, greyish rock with dark glistening laths and grains of pyroxenes and pale grey labradorite. It is a basic rock.

P 25. *Gabbro*:—It is similar to P 24.

P 26. *Anorthosite (Kadavur Zamindari, Tiruchirappalli district)*:—It is a greyish, medium-grained, equigranular rock comprised essentially of labradorite. Granular garnet is present as accessory and glistening grains of pyroxene are rare. It is mostly comprised of labradorite and hence it is monomineralic. It is a basic rock.

Ultrabasic Members.—The ultrabasic members of the plutonic igneous rocks are essentially comprised of mafic minerals like pyroxenes, olivine and some amphiboles. They are dark coloured and equigranular rocks. They usually display variation in grain size from coarse to medium. Their specific gravity is about 3.2 to 3.4.

The components displayed are described hereunder with their localities in paranthesis:

P 27. *Pyroxenite (Korati, Tirupathur, North Arcot district)*:—It is a dark grey, dense, compact rock characterised by medium-grained, dark glistening pyroxenes embedded in a fine-grained deep green matrix much enriched with hornblende. It is an ultrabasic rock.

P 28. *Dunite (Chalk Hills, Salem)*:—It is a pale yellowish green, fine-grained, granular rock that displays saccharoidal texture. It is essentially comprised of yellowish green vitreous olivine. It is a monomineralic rock. It belongs to the ultrabasic family of plutonic igneous rocks.

P 29. *Pyroxene peridotite (3 K.M. N.N.E. of Somwarpet, Coorg)*:—It is a dark grey, dense, medium-grained, equigranular rock comprised of glistening greyish laths and grains of pyroxene and dark green granular olivine. It is an ultrabasic plutonic igneous rock which occurs usually as lenticular bands in the basic norites.

P 30. *Peridotite*:—This is similar to P-29 but shows poikilitic texture owing to the presence of large, dark grey plates and laths of pyroxene enclosing dark green granular olivine and dark glistening grains of pyroxene.

b. Hypabyssal

Hypabyssal rocks usually occur in the form of dykes and sills and they result owing to the consolidation of magma at intermediate depths. They commonly display a porphyritic texture owing to the presence of a few phenocrysts embedded in a fine-grained groundmass. They also display fine-grained, equigranular texture and in the central portions of the dykes they are sometimes medium-grained. They display variation in mineralogical composition from acid to basic types. They are represented by granite porphyry, syenite porphyry, diorite porphyry, dolerite porphyry

and dolerites. The characteristic property of the dolerite is the ophitic texture under the microscope where laths of basic plagioclase are seen enclosed in pyroxene.

The components of the hypabyssal rocks displayed in the gallery are described below with their localities in paranthesis:

H 1. *Granite porphyry (Mysore Province)*:—It is a pinkish porphyritic rock comprised of laths of pink microcline embedded in a fine-grained groundmass of pale pink feldspars, colourless quartz and glistening flakes of biotite. It is a porphyritic phase of Arcot granites.

H 2. *Syenite porphyry (Kurnool district)*:—It is a porphyritic rock comprised of laths of pale pink microcline occuring in a fine-grained matrix of pale pink feldspar and dark glistening grains of hornblende.

H 3. *Syenite porphyry (Madura district)*:—It is a porphyritic rock with coarse laths of pink microcline embedded in a fine-grained groundmass composed of finely granular pink microcline and dark green granular epidote. It differs from H 2 in being sheared and the shear plane is characterised by quartz vein.

H 4. *Hornblende-syenite porphyry (Kotampatti)*:—It is a pale brownish grey, inequigranular, porphyritic rock. Coarse crystals of microcline perthite of brownish grey colour and vitreous lustre are embedded in a medium to fine-grained matrix essentially comprised of pale brownish grey feldspars and dark glistening grains of hornblende.

H 5. *Hornblende-biotite-syenite porphyry (Seringapatnam, Mysore)*:—It is a flesh coloured, inequigranular, porphyritic rock. Flesh coloured microcline displaying vitreous lustre and characterised by two sets of cleavages occur as phenocrysts varying in size from 1 cm. × 1 cm. to 0.1 cm. × 0.1 cm. The phenocrysts of microcline are set in a fine-grained, flesh coloured matrix predominantly comprised of finely granular microcline. Dark glistening hornblende with random orientation occur in the fine-grained matrix. Spangles of glistening biotite are associated, in places, with hornblende.

H 6. *Diorite porphyry* (*Near Rapur, Nellore district*) :—It is a greenish grey prophyritic rock comprised of pale green, coarse plates of plagioclase embedded in a fine-grained groundmass of feldspars and hornblende. It is a dyke rock.

H 7. *Dolerite* (*Goribidnur*):—It is a fine-grained, dense, dark grey rock comprised of dark glistening granular pyroxenes and pale grey feldspars. It is a basic rock.

H 8. *Dolerite* (*North Arcot district*) :—It is similar to H 7.

H 9. *Dolerite* :—It is a medium-grained, dark grey, dense, compact rock characterised by laths of pale grey plagioclase and dark glistening grains of pyroxenes embedded in a fine-grained, dark grey groundmass. It is a basic rock.

H 10. *Dolerite* (*Chingleput*):—It is a pale greyish brown medium-grained rock. It displays laths of pale grey plagioclase and dark glistening grains of pyroxenes embedded in a fine-grained groundmass. Hornblende also occurs associated with pyroxenes. It is a basic rock.

H 11. *Dolerite*:—It is a medium-grained rock comprised of laths of grey vitreous plagioclase and needles and laths of pyroxenes embedded in a fine-grained groundmass. It is a basic rock.

H 12. *Crushed dolerite* (*Salem district*). It is a dense, dark, medium-grained rock comprised of glistening grains of pyroxenes and pale yellowish grey feldspars. The rock displays crushing owing to its occurrence in the shear zone. It is a basic rock.

H 13. *Olivine dolerite* (*4 metres S. of Bhagmandal, Coorg*):—It is a medium-grained, dark grey, dense, compact rock with pale grey laths of plagioclase and fine prisms of pyroxenes embedded in a finely granular groundmass. Olivine rarely occurs as dark green, granular mineral. It is a basic rock.

H 14. *Olivine dolerite* (*Near Rapur, Nellore district*) :—It is similar to H 13.

FIG. 5 DOLERITE PORPHYRY

H 15. *Dolerite porphyry* (*Secunderabad*) (*Fig.* 5):—It is a dense, dark grey, porphyritic rock comprised of large laths of pale yellowish white feldspars embedded in a fine grained matrix of dark grey pyroxenes and pale grey feldspars. It is a basic rock.

H 16. *Dolerite porphyry* (*Cuddappah district*):—It is a dark grey, porphyritic, dense, compact rock. It is characterised by phenocrysts of pale yellowish plagioclase embedded in a dark grey, fine-grained groundmass comprised of plexus of plagioclase and finely granular pyroxene. It is a basic rock.

H 17. *Dolerite porphyry* (*Seringapatam*) :—It is a dark grey, porphyritic rock comprised of phenocrysts of pale greyish white feldspars embedded in a fine-grained groundmass characterised by glistening grains of pyroxenes and pale greyish feldspars. It is a basic rock.

C. VOLCANIC

The rocks comprising this division result owing to the eruption of the magma on to the surface of the earth. The erupted magma is designated lava and owing to its rapid consolidation the volcanic rocks result. They are extremely fine-grained and display vesicular and amygdaloidal structures. Owing to rapid cooling of the lava they carry glassy materials along with the crystalline ones. In places, they carry drusy minerals and geodes. Some of them are characterised by porphyritic texture. They display variation in mineralogical composition from acid to basic types. In places, they are fragmental in texture owing to explosive activity during eruption. On the basis of silica content they may be grouped under three divisions, namely, oversaturated, saturated and undersaturated lavas. The undersaturated ones are highly alkaline in character.

The varietal types of volcanic rocks displayed in the petrological gallery are described hereunder with their localities in paranthesis:

V 1. *Felsite* (*Karodivadi, Bombay*).—It is a cream coloured, fine-grained rock comprised essentially of fine laths of cream coloured feldspars and finely granular colourless quartz. It is an acid rock.

V 2. *Felsite* (*Srirangapattam, Mandya district, Mysore State*):—It is a pale grey, fine-grained rock with fine laths of feldspars embedded in a groundmass comprised of very finely granular grey quartz and feldspars. It is an acid rock.

V 3. *Rhyolite* (*Karodivadi, Bombay*):—It is a cream coloured, fine-grained rock carrying minute vitreous laths of sanidine embedded in a fine-grained groundmass characterised by pale cream potash feldspars and colourless quartz. It displays faintly flow banding. It is an acid rock.

V 4. *Rhyolite* (*Karodivadi, Bombay*):—It is similar to V 3.

V 5. *Malani rhyolite* (*Bikaner State, Rajaputana*):—It is a light brownish red, fine-grained rock comprised of vitreous feldspars and quartz. It is an acid rock.

V 6. *Obsidian* (*Delta, Utah*) :—It is a black, vitreous, glassy rock with typical conchoidal fractures and translucent edges which display flow lines. It is essentially comprised of quartz. It is an acid rock oversaturated in silica.

V 7. *Pumice*:—It is a light, dirty white, fine-grained, highly vesicular rock characterised by spongy appearance. The rock is essentially comprised of vitreous quartz. It is an acid rock oversaturated in silica.

V 8. *Pitchstone* (*Berhait, Santhal Pragans district, Bihar*) :—It is a dense, dark blackish grey, fine-grained rock with a pitchy lustre. It is essentially comprised of vitreous quartz. It is an acid rock oversaturated in silica.

V 9. *Trachyte*:—It is a fine-grained, yellowish, dense rock characterised by conchoidal fracture and a rough feel. It is finely vesicular. Needles and fine phenocrysts of glistening feldspar occur in a very fine-grained yellowish matrix. It belongs to the saturated division of volcanic igneous rocks.

V 10. *Basalt*:—It is a dark grey, dense, fine-grained, equigranular rock comprised of dark glistening laths and grains of pyroxenes and grey feldspars. It is a basic rock.

V 11. *Basalt* (*Mysore Province*):—It is a fine-grained, dense, dark grey rock comprised of glistening grey granular pyroxenes and grey feldspars. It is a basic rock.

V 12. *Olivine basalt* (*Hyderabad*):—It is a fine-grained, dense, dark grey rock comprised of glistening grey granular pyroxenes, pale grey feldspars and large vitreous yellowish green grains of olivine. It is a basic rock.

V 13. *Grey porphyritic acid trap* (*Karodivadi, Bombay*) :—It is a greyish, fine-grained, volcanic rock displaying flow texture. It carries minute laths of pale pink feldspars embedded in a fine-grained greyish groundmass. It displays trachytic affinities.

V 14. *Trap*:—The rock is dark grey in colour and displays minutely porphyritic texture owing to the presence of laths of pale grey feldspars and dark glistening grains of pyroxenes embedded in a fine-grained groundmass. It is a medium-grained variant of Deccan basalt.

V 15. *Vesicular basalt* (*Nizam's Dominions*):—It is a greyish brown, dense, highly vesicular rock. Its dark grey colour, vesicular structure and fine-grained texture suggest it to be a basalt. The vesicles are filled, in places, with opal. Drusy quartz also occurs in some of the vesicles. It is a basic rock.

V 16. *Vesicular basalt (Secunderabad)* :—It is a greenish grey, dense, fine-grained, vesicular rock comprised of glistening grey granular pyroxenes and pale grey feldspars. White vitreous calcite and white waxy chalcedony occur in the cavities. It is a basic rock.

V 17. *Vesicular basalt (Secunderabad)* :—It is a pinkish brown, vesicular, fine-grained rock carrying secondary minerals in the vesicles. Its colour, vesicular structure and fine-grained texture suggest it to be a basalt. It carries geode which is characterised by agate and green jasper. The vesicles and the geode together suggest that the volatile constituents escaping from the basaltic lava have played an active part in the formation of this rock. It is a basic rock.

V 18. *Vesicular and amygdaloidal basalt*.—It is a pale pinkish, compact, dense and massive rock characterised by vesicles and amygdules. The amygdules are filled with drusy quartz and opal. Bluish green glassy material sometimes occurs in the vesicles. It is a basic rock.

V 19. *Vesicular and amygdaloidal basalt*:—It is a pale pinkish grey, compact and dense rock characterised by vesicles and amygdules. The amygdules are filled with opal and, in places, stained blue owing to copper encrustations. In places, the vesicles are fairly big in size. It is a basic rock.

(ii) SEDIMENTARY SECTION.

Sedimentary rocks are secondary rocks. They are derived from the pre-existing rocks by the action of the dynamic agents of the atmosphere and hydrosphere. They result owing to the transportation and accumulation of disintegrated and decomposed materials in the basins of sedimentation. After their compaction they are lifted up to form conspicuous sedimentary outcrops on the surface. The most characteristic feature of the sedimentary rocks is the stratification and, in places, the strata are enriched with fossils.

The sedimentary rocks are grouped on the basis of their origin into four broad types, namely, residual, clastic, chemical and organic deposits.

The residual deposits are those that are left as residues after the removal of soluble materials. The outstanding example of residual deposit is laterite.

The clastic sediments, on the other hand, result owing to the deposition of materials carried in suspension by the dynamic agents. Conglomerates, sandstones and shales are a few examples of this type.

Chemical deposits, on the other hand, result owing to the precipitation of the constituents carried in solution by the rivers, ground water, melt water of glaciers and dissolved constituents in the seas and oceans. Flint, limestones, etc., are examples of rocks formed in this fashion.

Organic deposits result mainly owing to the accumulation of the hard parts of organisms in seas and oceans and owing to the accumulation of vegetal matter and the hard parts of organisms in the sedimentary basins. Coal, shell limestone, etc., are examples of organic deposits.

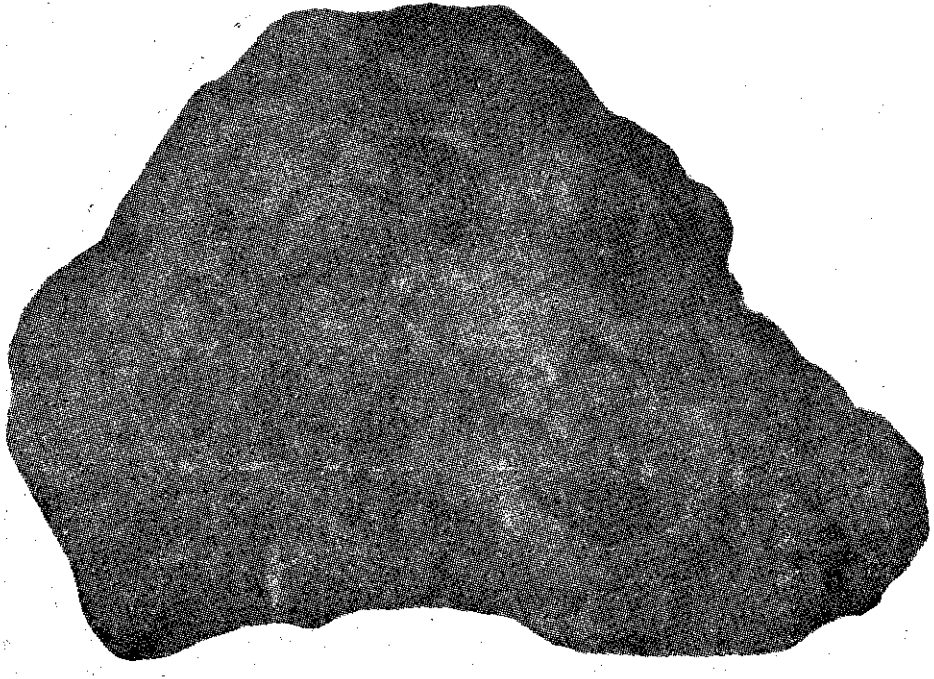


FIG. 6 CONGLOMERATE.

The sedimentary rocks adoring the gallery are described hereunder with their localities in paranthesis:

S 1. *Laterite* (*Near Madras*).—It is a yellowish brown pisolitic rock which is essentially comprised of ferruginous quartz cemented by fine-grained clayey material much enriched with powdery hematitic and limonitic material.

S 2. *Conglomerate* (*South Canara district*) (*Fig.* 6):—It is comprised of coarse, rounded, irregular pebbles of varying size cemented by fine ferruginous and arenaceous materials. It is highly rough to feel.

S 3. *Conglomerate*:—It is mainly comprised of more or less uniformly rounded grains of quartz cemented by ferruginous and arenaceous materials.

S 4. *Conglomerate* (*Dawleswaram*):—It is comprised of more or less uniform, irregular pebbles of quartz cemented by ferruginous and arenaceous materials.

S 5. *Quartzite conglomerate* (*Rayalcheru*):—It is a pinkish rock comprised of rounded, irregular, pale pink quartzite cemented by ferruginous and arenaceous materials.

S 6. *Quartzite conglomerate*:—It is comprised of small, irregular pebbles of quartzite cemented together with ferruginous and arenaceous materials.

S 7. *Kaolin conglomerate* (*Tiruchirappalli district*) :—It is a white rock mottled with pink. The pebbles of quartz are pinkish in colour owing to staining by solutions. The finer argillaceous cementing material has been kaolinised to white earthy material.

S 8. *Puddingstone conglomerate* (*Kurnool district*) :—It is comprised of large pebbles of quartz cemented by finer ferruginous and agillaceous materials. It is highly smooth to feel owing to being much rolled in water.

S 9. *Breccia*:—It is a pinkish brown mottled rock. Pale grey quartz occurs as angular and irregular pebbles. It is cemented by finely ferruginous and sandy materials.

S 10. *Breccia* (*Fig.* 7):—It is characterised by angular pebbles of pinkish greasy quartz cemented by pale pink ferruginous and arenaceous materials.

FIG. 7 BRECCIA.

S 11. *Coarse sandstone*:—It is coarse sandstone which is pale pink in colour. It displays crude banding and carries, in places, patches of limonitic and hematitic material.

S 12. *Coarse ferruginous sandstone* (*Dawleswaram*):—It is pinkish brown, coarse-grained sandstone which is highly rough to feel. It slightly displays graded bedding, the lower bands being coarser than the layers at the top. Its colour may be due to the presence of ferruginous cementing material.

S 13. *Sandstone* (*Nellore*):—It is pale yellow in colour and is comprised of fine sand grains cemented by argillaceous material. In places, it shows pinkish patches owing to the play of iron-bearing solutions.

S 14. *Banded sandstone* (*Mysore*):—It is a fine banded sandstone comprised of pale yellowish grey and dark grey layers. The pale yellowish grey layers are mainly comprised of fine sandy material. The dark grey layers are essentially comprised of ferruginous material. The dark grey layers occur as thinner laminae than the pale yellowish grey sandy ones.

S 15. *Red ocherous sandstone* (*Cochin*):—It is a compact rock which is reddish in colour and rough to feel. It is predominantly comprised of fine sand grains which are stained red owing to the presence of red ocherous material.

S 16. *Flexible sandstone* (*Dandot, Rajasthan*):—It is a pale pink, fine-grained, granular rock chiefly comprised of vitreous quartz grains. The rock is slightly flexible owing to the removal of interlocking feldspar grains. It is locally called '*Zind*' in Rajasthan.

S 17. *Dendritic pink sandstone* (*Near Panna, Vindhya Pradesh*) (*Fig.* 8) :—It is a pale pink, compact rock characterised by fine sandy grains cemented by ferruginous material. It displays on its surface a dendritic pattern owing to the deposition of manganese dioxide by circulating soultions.

S 18. *Argillaceous grit* (*Cape Comorin*):—It is a coarse-grained rock mottled with pink, yellow and pale yellowish white patches. It is principally made up of coarse grains of sand cemented with argillaceous material. It is coarse to feel.

S 19. *Calcareous grit* (*Cape Comorin*) :—It is a pale pink, very coarse-grained rock. It is highly rough to feel and is principally made up of coarse grains of sand cemented with calcareous material. It readily effervesces with acid.

S 20. *Clay* (*From a boring* 92 *metres below the surface, Near Arkonam*):—It is a brown clay characterised by sun cracks. It is somewhat rough to feel owing to the presence of sand along with clay.

S 21. *Clay*:—It is a compact, crudely laminated, greyish white rock stained, in places, by limonite. It gives an earthy smell when breathed upon.

S 22. *Banded clay* (*Vemagiri Hills*):—It is a banded clay which displays dendritic pattern on its surface. It is soft to feel and easily scratched with the finger nail. The dendrites are pale pink in colur and have been deposited by circulating solutions.

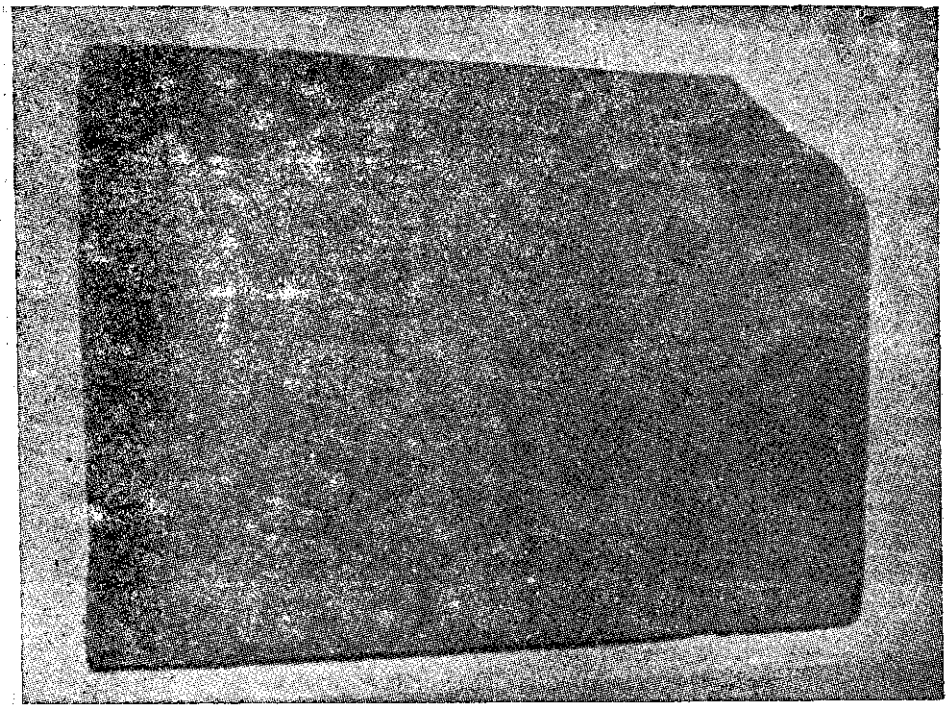


FIG. 8 DENDRITIC PINK SANDSTONE

S 23. *Kaolin* (*Bellary*) :—It is a white, massive, earthy rock comprised solely of argillaceous material. It shows flatly conchoidal fracture and gives an earthy smell when breathed upon.

S 24. *Red ochre* (*Gudalur*) :—It is a massive, earthy material comprised of ocherous cement. It is deep pink in colour and is traversed by veins of calcite. The marginal portions carry limonite. It has a flat conchoidal fracture.

S 25. *Clay shale* (*Kurnool district*):—It is a compact yellowish grey shale which does not display fine laminae. It gives an earthy smell when breathed upon.

S 26. *Shale* (*Near Mundalore*):—It is a banded shale displaying alternate pale yellowish grey and pink bands. It is characterised by fine laminae and gives an earthy smell when breathed upon.

S 27. *Banded shale* (*Sriperumbathur*) (*Fig.* 9) :—It is characterised by alternating pale yellowish brown and white layers. It gives an earthy smell when breathed upon.

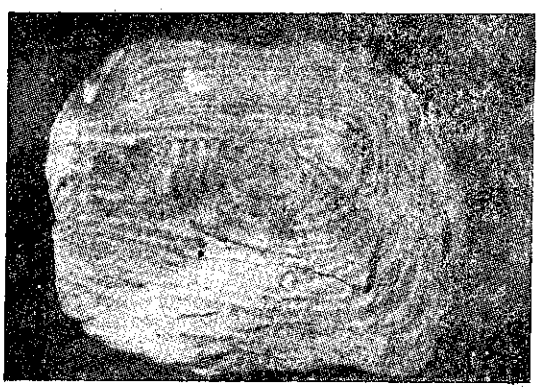


FIG. 9 BANDED SHALE

S 28. *Carbonaceous shale* (*Near Ootacamund*) :—It is a dark grey, compact rock which shows fine laminae. It has a smooth feel and, in portions, it carries yellowish stains of limonite.

S 29. *Micaceous shale* (*Red Hills*).—It is a pale pinkish grey, finely laminated shale carrying glistening specks of silvery mica.

S 30. *Arenaceous shale*.—It is pink, finely laminated shale which is rough to feel owing to the presence of fine siliceous material. A vein of yellowish white calcium carbonate cuts across the laminae. When breathed upon, it gives an earthy odour characteristic of shaly material. Therefore it is also called, argillite

S 31. *Marl* (*Hill near Chingleput*):—It is a finely laminated, dirty white rock comprised of argillaceous and calcareous matter. It effervesces with acid.

S 32. *Calc tufa*:—It is a pale yellowish rock characterised by tubular and nodular calcium carbonate which is tuffaceous in places. It readily effervesces with acid.

S 33. *Limestone* (*Dachepalli*):—It is a pale yellow, compact rock which displays fine laminae. It is characterised by conchoidal fracture and effervesces with acid.

S 34. *Limestone* (*Masulipatam*):—It is a massive, pale grey rock characterised by finely crystalline calcium carbonate. It displays conchoidal fracture and readily effervesces with acid.

S 35. *Limestone* (*Gottimukkala*):—It is a massive, compact rock which is black in colour. It is characterised by conchoidal fracture and sharp edges. It effervesces with acid.

S 36. *Laminated limestone* (*Vellatur*):—It is a greyish black rock which displays fine laminae. The fracture is irregular and it effervesces with acid.

S 37. *Concretionary limestone* (*Duggirala*):—It is an irregular, compact, concretionary rock characterised by calcium carbonate and fine arenaceous material. It effervesces with acid.

S 38. *Crystalline limestone* (*Madurai district*):—It is a massive rock which is pale cream in colour. It is essentially characterised by granular calcite. It effervesces with acid.

S 39. *Banded serpentinous limestone* (*Zorapore*) :—It is a banded rock. Serpentine occurs as pale yellowish green bands. Dolomite occurs as pale yellow bands adjacent to serpentinous layers. In places, the serpentinous layer is characterised by layers of dark grey asbestos. It displays conchoidal fracture.

S 40. *Flint* (*From the bed of Kistna river*):—It is a highly compact rock which is greyish black in colour. It is characterised by conchoidal fracture and sharp-cutting edges.

(iii) METAMORPHIC SECTION.

The word metamorphic means a change and the pre-existing rocks which have undergone a change owing to the play of heat or pressure or owing to the action of chemical agents give rise to metamorphic rocks. Depending upon the role of the active agents in bringing about metamorphism, different kinds of metamorphic rocks are produced. If heat alone is the dominating agent in metamorphosing the rocks, thermally metamorphosed rocks result. If on the other hand, both heat and directed pressure are important agents in bringing about metamorphism, they are designated, dynamothermally metamorphosed rocks. Owing to the play of heat and hydrostatic pressure, plutonic metamorphosed rocks result. If the chemical agents are responsible in bringing about metamorphism, they are grouped as pneumatolitically metamorphosed rocks. The mineralogical assemblages in the metamorphosed rocks act as indicators of the metamorphic stamp of the metamorphic rocks. Thus it is possible to decipher the role of the agents in their metamorphic evolution.

The petrological section in the Geology Gallery housed in the main hall includes a few metamorphic rocks. The characteristics of the metamorphic rocks displayed in the Museum are described hereunder with their localities in paranthesis:

M 1. *Slate*:—It is a dark grey, compact rock displaying fine slaty cleavage. It has a conchoidal fracture and gives an earthy odour on breathing upon it. Owing to the presence of fine streaks of calcium carbonate along the slaty cleavages it effervesces with the acid. On fresh surfaces, however, it is purely comprised of argillaceous material.

M 2. *Phyllitic slate* (*Cuddappah district*) (*Fig.* 10).—It is pale silvery pink in colour. It displays banding owing to compositional difference. It is characterised by an undulating slaty cleavage owing to deformation.

Fig 10. PHYLLITIC SLATE

M 3. *Phyllite* (*near Udayagiri, Nellore district*) :—It is a silvery grey, finely schistose rock comprised of layers of silvery scales of mica. The layers are thrown into crinkles. It has a fine silvery sheen.

M 4. *Phyllite* (*Jaggayapet*) :—It is greyish black in colour with a silvery sheen. It is characterised by fine slaty cleavage.

M 5. *Phyllite* (*Yedadri hill*) :—It is yellowish grey in colour. It has a micaceous sheen and is characterised by slaty cleavage. The peculiarity of this specimen is the presence of cleavages across the bedding and it is of tectonic significance.

M 6. *Banded Phyllite* (*Yedadri hill*) :—It is comprised of alternating silvery grey and pale pinkish grey layers. It displays coarse banding owing to the compositional difference during deposition. The silvery grey layers are much thinner than the

pale pinkish grey ones. In this specimen the development of cleavage perpendicular to the bedding plane is clearly seen along the side portions of the specimen.

M 7. *Banded phyllite* (*Yedadri hill*).—It is a banded rock comprised of alternating layers of shaly and phyllitic materials. The phyllitic layers are present as narrow thin bands amidst the broader bands of shale. The phyllitic layers display micaceous sheen, whereas the shaly layers are pale yellowish grey in colour and possess a dull lustre.

M 8. *Banded phyllite* (*Yedadri hill*):—It is a banded rock displaying alternating grey and silvery grey layers. It displays micaceous sheen under reflected light. It is characterised by slaty cleavage.

M 9. *Limonitic phyllite* (*Yadaki*):—It is a greyish rock with a silvery sheen and characterised by slaty cleavage. Along the cleavages it carries limonitic material.

M 10. *Chlorite schist* (*South Canara district*):—It is a light green schistose rock comprised of green soapy flakes of chlorite.

M 11. *Chlorite schist*:—It is a green, fine-grained, schistose rock essentially comprised of green glistening flakes of chlorite.

M 12. *Contorted chlorite schist* (*near Maddiri Taluk*):—It is a dark greyish green schistose rock essentially comprised of flaky chlorite. The layers of chlorite are thrown into minor folds owing to shearing.

M. 13. *Chlorite talc schist* (*near Salem*):—It is a silvery grey schistose rock comprised of thin leaves of deep green chlorite and silvery grey talc. The talc is soapy to feel.

M 14. *Chlorite talc schist* (*Doorgum district*).—It is a pale green schistose rock comprised of thin layers of flaky chlorite which, in places, is associated with pale green soapy talc.

M 15. *Biotite schist* (*Coimbatore district*):—It is a dark schistose rock essentially comprised of glistening dark flakes of biotite with minor amounts of vitreous quartz and occassional grains of feldspars.

M 16. *Mica schist* (*Sunnapurallagutta*):—It is a schistose rock chiefly comprised of thin layers of white glistening flakes of muscovite alternating with highly siliceous layers.

M 17. *Mica schist* (*Yelanir Ghat*) :—It is a schistose rock comprised of white silvery flakes of muscovite with pimples of pink garnet.

M 18. *Ferruginous mica schist* (*Wynaad*):—It is comprised of finely granular colourless quartz and pearly scales of muscovite. It carries oval and irregular and lenticular patches of hematite which is, in places, coated with yellowish patches of limonite.

M 19. *Quartz mica schist* (*Sathyamangalam, Coimbatore district*) :—It is a crudely banded rock in which finely granular colourless quartz layers alternate with finely granular quartz enriched with fuchsite and spangles of muscovite. It displays schistosity owing to the presence of streaks of quartz.

M 20. *Hornblende schist* (*Vinukondu Taluk*) :—It is a dark coloured schistose rock essentially comprised of dark green needles of hornblende.

M 21.*Hornblende schist* (*Near Tatipalli, Nellore district*) :—It is a dark grey schistose rock essentially comprised of fine needles of dark glistening hornblende. Feldspar and quartz occur as fine granular leaves alternating with hornblende.

M 22. *Banded hornblende schist* (*Kundre Mukh*):—It is a banded rock with white layers alternating with dark grey ones. The white layers are comprised of pale pink feldspars and colourless quartz. The dark grey layers are finely schistose and comprised of needles of hornblende.

M 23. *Hornblende schist with porphyroblasts of feldspar* (*Kundre Mukh*) :—It is a dark grey, finely schistose rock comprised essentially of dark glistening needles of hornblende. Pale pink feldspar occurs as streaks and fine porphyroblasts. Pale pink garnet occurs as pimples in the hornblendic layers.

M 24. *Weathered hornblende schist* (*Yeshwantpur*):—It is a plae green schistose rock comprised of pale green needles of hornblende and pale yellowish feldspars.

M 25. *Garnetiferous hornblende schist* (*South Canara district*):—It is a dark grey, finely schistose rock comprised of dark grey needles of hornblende and pimples of pink garnet.

M 26. *Garnetiferous kyanite schist* (8 *K.M. South of Mercara, Coorg*):—It is a dark grey schistose rock comprised of grey needles of kyanite, pale pink feldspars, granular colourless quartz and lenticular patches of granular garnet. Grey, greasy graphite occurs in some places.

M 27. *Muscovite kyanite schist* (*Thanjavur district*) :—It is a pink rock which displays a schistose texture. It is essentially comprised of silvery flakes of muscovite and needles of kyanite. Owing to weathering it has the pinkish appearance.

M 28. *Ferruginous quartzite* (*Palnad*):—It is a pinkish brown rock dabbed with grey. It is finely granular and is essentially characterised by granular quartz. It displays conchoidal fracture and sharp-cutting edges. Its colour is due to ferruginous impurities.

M 29. *Fuchsite quartzite (Hills near Nemakallu, Bellary)*:—It is a pale bluish green, fine-grained, greasy rock predominantly comprised of finely granular quartz. Its colour is due to the presence of fine silvery spangles of fuchsite mica. It displays, in places, conchoidal fracture and sharp-cutting edges.

M 30. *Fuchsite quartzite (Belwadi, Chikmagalur district, Mysore State)*:—It is a bright, deep emerald green, greasy looking, finely granular rock essentially made up of finely granular quartz and glistening silvery spangles of fuchsite. It displays conchoidal fracture and has sharp-cutting edges.

M 31. *Amphibolite*.—It is a deep green, dense, coars-grained rock predominantly comprised of dark glistening grains of hornblende and laths of deep green actinolite. In places, it is characterised by pale yellowish grains of plagioclase mixed with medium-grained, dark, granular hornblende. It is a basic rock.

M 32. *Amphibolite (East of Nadigodda, Talchir district, Orissa)* :—It is a dark grey medium-grained, equigranular rock essentially comprised of dark grey glistening grains of hornblende and pale yellowish grey feldspars. It is a basic rock.

M 33. *Amphibolite (Cuddappah district)* :—The rock carries dark grey to greyish brown fibrous laths of anthophyllite associated with cummingtonite and grunerite. It occurs as a xenolith in the granite. Porphyroblasts of amphiboles occur and impart to the rock a porphyroblastic texture. It is a basic rock.

M 34. *Amphibolite*:—It displays tight minor folds. It is a dark grey, medium-grained, granular rock with granular, pale yellowish green plagioclase and dark, glistening grains of hornblende. It is a basic rock.

M 35. *Lenticular gneiss (Gonikopal, Coorg) Fig.* 11):—It is a medium-grained, grey, gneissose rock with alternating white and dark layers. The white layers are chiefly comprised of feldspars and vitreous quartz and the dark layers are essentially made up of dark glistening flakes of biotite. In places the white bands are drawn out as thin lenticles and hence the rock is named as lenticular gneiss. It is also designated as augen gneiss.

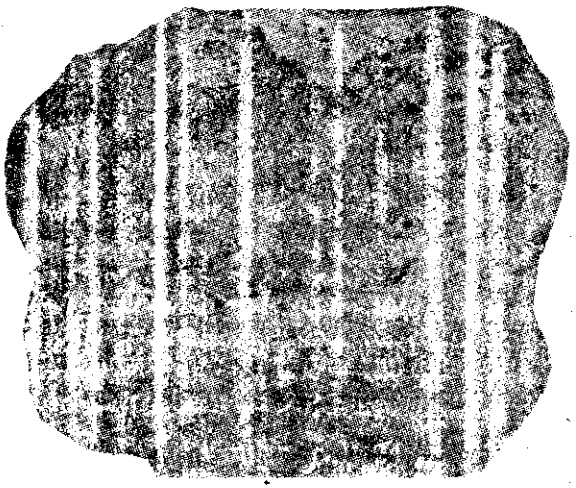


Fig 11. LENTICULAR GNEISS

M 36. *Sheared gneiss (Tiruchirappalli)*:—It is a pale grey rock which displays mylonitic texture owing to the presence of shooting stringers of mylonite. In places, the layers are thrown into tight folds. It is essentially comprised of pale pink feldspars, colourless quartz and dark glistening flakes of biotite.

M 37. *Leuco-gneiss (Coimbatore)*.—It is a pale cream, finely banded rock which displays banding owing to the presence of drawn-out stringers and thin leaves of quartz. It is essentially comprised of finely granular colourless quartz and pale cream feldspars. It is a felspathic gneiss called leuco-gneiss.

M 38. *Mica gneiss (Mysore State)* :—It is a dirty white foliated rock comprised of layers of silvery white muscovite and dark glistening flakes of biotite alternating with layers of white granular vitreous feldspars and colourless quartz.

M 39. *Sericite quartz gneiss (Pasumalai)* :—It is a pale yellowish grey gneissose rock. Grey greasy quartz occurs as elongate plates and grains. Sericite occurs as spangles and is pale yellowish in colour. Owing to the presence of drawn-out lenticles of quartz it displays a perfect gneissose texture. Bands enriched with sericite and quartz are sandwiched between highly siliceous grey bands.

M 40. *Gneiss with porphyroblasts of feldspars (Bellary)*:—It is a pale greyish white rock essentially comprised of pale grey greasy quartz, greyish white vitreous feldspars and spangles of dark glistening biotite. It is a massive type of gneiss in which the porphyroblasts of feldspars vary in size from 2.5 cms x 1.3 cms to 0.6 cms. x 0.2 cms. It is a coarse-grained gneiss with porphyroblasts of feldspars.

M 41. *Pink gneiss (Poobakhanda Taluk)*:—It is a pale pink rock which feebly displays gneissic banding. Quartz occurs as drawn-out leaves and grey granular grains. Feldspar is pale pink in colour and biotite occurs as dark glistening spangles.

M 42. *Coarse-grained granite gneiss (Pallavaram)* :—It is a coarse-grained granite gneiss with porphyroblasts of pale pink feldspars, pale grey granular quartz and spangles of biotite.

M 43. *Granodiorite gneiss (Nizam's Dominions)* :—It is a finely banded rock comprised of dark glistening bands enriched with biotite alternating with pale grey bands enriched with finely granular pale greyish white feldspars and colourless granular quartz. The feldspars are represented mainly by plagioclase with minor amounts of microcline. Therefore, this rock has been designated, granodiorite gneiss.

M 44. *Hornblende gneiss* (*Sittampatti*) :—The rock displays gneissic texture owing to the presence of drawn-out stringers of dark glistening hornblende. Pale yellow feldspars and colourless quartz are much admixed in the felsic layer.

M 45. *Hornblende gneiss* (*Coimbatore district*):—It is a banded gneissic rock. Dark bands comprised mostly of hornblende sometimes occur as drawn-out stringers. The light coloured bands are mainly comprised of pale pink microcline and pale grey greasy quartz.

M 46. *Hornblende gneiss* (*Madura district*):—It is a medium-grained, finely banded, gneissose rock with alternating light and dark layers. The dark layers are essentially comprised of glistening prisms of hornblende and the light layers are characterised by feldspars and quartz.

M 47. *Hornblende gneiss* (*Madura district*):—It is a grey, medium-grained, crudely banded, gneissose rock comprised of dark granular hornblende, vitreous quartz and feldspars. The dark layers are enriched in hornblende and the white layers are comprised of quartz and feldspars.

M 48. *Hornblende gneiss* (*Bogoria hills*):—It is a well banded rock comprised of alternating pink and dark grey layers. The pale pink layers are comprised of fine granular feldspar and quartz. The dark layers are enriched with needles and slender prisms of hornblende. It is a banded hornblende gneiss. The individual bands range from 3 mm. to less than 1 mm. in width.

M 49. *Hornblende gneiss* (*Sirumalai*):—It is a pale green rock characterised by crude banding. Thin lenticular layers of feldspars admixed with hornblende alternate with dark hornblendic layers.

M 50. *Hornblende gneiss* (*Kurnool district*):—It is a finely foliated hornblende gneiss carrying fine streaks of granular feldspars and quartz and needles of hornblende. In places, the felspathic layers display tight minor folds.

M 51. *Garnet gneiss (Nizam's Dominions).*—It is a coarse grained garnetiferous gneiss which is pale grey to pale cream in colour. It carries stringers of pale pink granular garnet embedded in a granular feldspar and quartz matrix. It displays crude banding on weathered surfaces owing to the presence of drawn-out stringers of granular garnet. In places, pimples of garnet occur immersed in pale cream layers.

M 52. *Garnetiferous gneiss (Navgam):*—It is a pale pink, crudely banded rock comprised of pale cream layers enriched with feldspars and quartz alternating with dark pink layers enriched with stringers of garnet.

M 53. *Garnetiferous biotite gneiss (Bezwada Hill):*—It is a crudely foliated pale pink, gneissose rock carrying pale pink, granular, greasy garnet mixed with pale yellow, granular quartz, pale yellow feldspars and spangles of dark glistening biotite. In places, sodaclase occurs as white lenticular porphyroblasts.

M 54. *Coarse-grained leptynite (Hills near Pallavaram, Madras):*—It is a crudely banded, coarse-grained, cream coloured rock with grey greasy quartz, pimples of pink garnet and pale cream coloured perthite. In places, quartz occurs as drawn-out lenticles.

M 55. *Garnetiferous leptynite (Coonoor, Nilgiris):*—It is a pale pink rock which shows gneissose texture owing to the presence of drawn-out streaks and stringers of pale pink granular garnet in a finely granular groundmass comprised of pale grey quartz and pale pink feldspars.

M 56. *Garnetiferous sillimanite gneiss (8 K.M. SW. of Mercara, Coorg)*:—It is a greyish white crudely banded rock which carries patches and stringers of pale pink garnet. Sillimanite occurs as colourless prisms associated with pale yellow feldspars and pale grey quartz. Grey greasy graphite occurs in some places.

M 57. *Khondalite (Vizagapatam):*—It is coarsely banded, pinkish grey rock characterised by pale pink layers enriched with quartz and feldspars alternating with pink layers studded with garnet. Sillimanite occurs as silvery needles.

M 58. *Siliceous tremolite gneiss (Madura district)*:—The rock is pale yellowish grey in colour and displays a gneissose texture owing to the presence of oriented needles of pale grey colourless tremolite embedded in a finely granular, highly siliceous, pale yellowish grey matrix.

M 59. *Diopside calc-granulite (Chorboli, Nagpur district)*:—It is a pale grey, finely granular rock. Finely granular grey calcite occurs intimately mixed with dark glistening granular diopside.

M 60. *Marble (Mudinamallai)*:—It is a white saccharoidal rock comprised of finely granular calcium carbonate. It effervesces with acid.

(iv) Uses

The different types of rocks described above are used mainly in construction. The rocks that are characterised by smooth surfaces owing to the presence of conjenial joints and capable of taking high polish are employed as decorative stones.

The other rock types are mainly employed as construction materials for miscellaneous purposes. Granites, gneisses and charnockites are extensively employed for the construction of roads in South India. Basalts are profusely used in Western India where it extensively occurs. Clays are employed for brick making. Limestones are used as building materials where rocks like granites, gneisses and basalts are rare. Similar is the case with sandstones.

Besides their extensive use as construction materials they also serve as repositories of economic mineral deposits.

VI. MINERALOGY.

(i) Introduction

Mineralogy is that branch of geologic science which deals with the study of minerals. A mineral is usually a natural inorganic substance having a definite chemical composition and a characteristic atomic structure. When it crystallises under favourable conditions it assumes certain geometrical shapes. These shapes help a great deal in identifying the mineral. Some crystals are so perfectly shaped by natural growth that they appear to have been artificially cut and polished. Though the term mineral is applied only to natural inorganic substances, under exceptional cases, coal and copalite are included under minerals even though they are of organic origin. Except for mercury and water, minerals are solid substances. Two or more crystals may intergrow with each other producing twin crystals.

(ii) Megascopic Properties of Minerals

Minerals are identified by their physical, optical and chemical properties. Since optical and chemical properties are highly technical, only some of the most important physical properties are described here.

Crystal form :—Most of the minerals are crystalline and the form in which they have crystallised provides a clue in identifying them. Minerals crystallise according to six basic systems. They are :—

1. Cubic system (e.g.) Galena.
2. Tetragonal system (e.g.) Zircon.
3. Hexagonal system (e.g.) Beryl.
4. Orthorhombic system (e.g.) Sulphur
5. Monoclinic system (e.g.) Orthoclase.
6. Triclinic system (e.g.) Rhodonite.

Some minerals are amorphous.

Structure is the shape and form of minerals. The most important types of structures exhibited by minerals are as follows:

1. *Columnar;* when made up of slender columns of imperfect crystals.
2. *Bladed;* when the individual crystals are flat like a blade (e.g.) Kyanite.
3. *Fibrous;* when made up of fibres which may or may not be separable (e.g.) Asbestos and satinspar.
4. *Radiated;* when the crystals radiate from the centre.
5. *Lamellar;* when platy (e.g.) Talc.
6. *Foliated;* when the plates are thin and easily separable (e.g.) Mica.
7. *Granular* ; when made up of grains (e.g.) Dolomite.
8. *Oolitic;* when made up of small spheres.
9. *Pisolitic*; (Fig. 13) when made up of large spheres (e.g.) Bauxite.
10. *Botryoidal ;* (Fig. 12) when grouped like bunches of grapes (e.g.) Manganese ore.

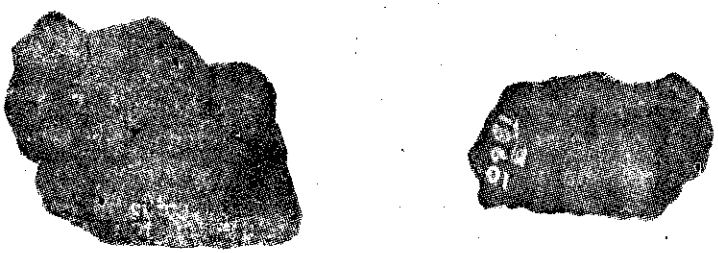


FIG. 12 MANGANESE ORE (BOTRYOIDAL.)

11. *Mammillary;* when the prominences are large (e.g.) Chalcedony.

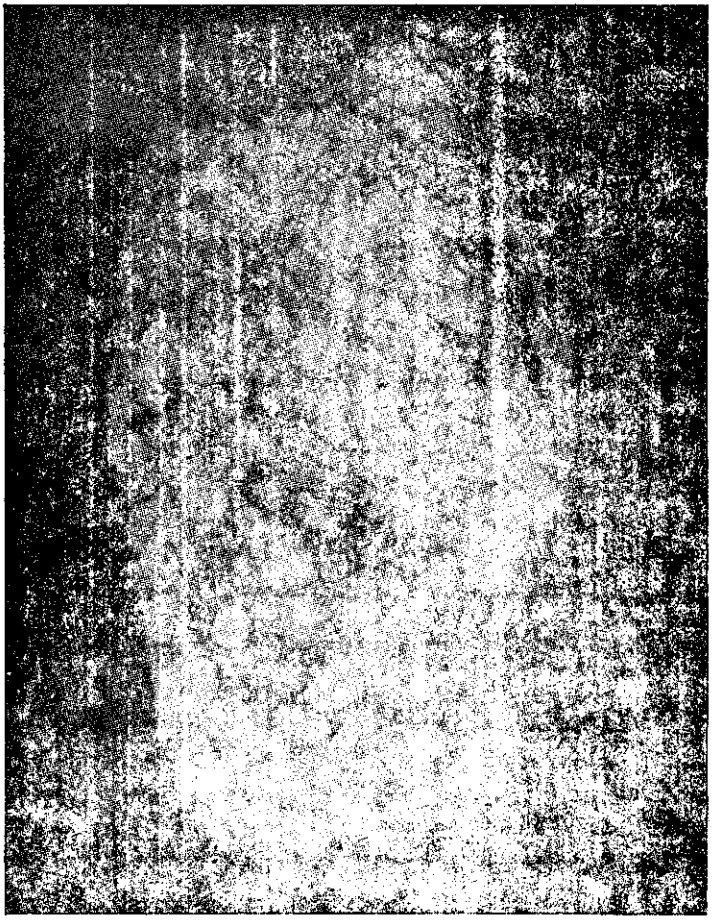


FIG. 13 BAUXITE (PISOLITIC).

12. *Nodular;* when made up of irregular prominences.

13. *Accicular;* (*Fig.* 14) when needle-like (e.g.) Manganite

14. *Drusy;* when closely covered with minute crystals (e.g.) Quartz.

15. *Earthy;* when made up of very minute particles (e.g.) Clay.

Pseudomorphs :—When minerals crystallise they assume a definite and characteristic form. Occasionally some minerals resemble some other species in crystal form but differ from them entirely in chemical and optical properties. They have no regular cleavage and internally they are made up of some earlier mineral. Such forms are known as pseudomorphs. (e.g.) Limonite after pyrite.

Minerals are said to be transparent if objects can be seen through them, translucent if only light passes through them without the objects being visible, and opaque if light does not pass through them.

Some minerals glow under ultra violet rays. This property is called fluorescence (e.g.) Fluorite.

A few minerals continue to glow even after the removal of the source of excitement. This property is called phosphorescence.

A few minerals like labradorite and precious opal exhibit play of colours (i.e.) several prismatic colours appear on the surface of the mineral when it is tilted in daylight.

Colour of the mineral is also an important property which aids in the identification of minerals.

Streak is the colour of the powder which is obtained by scratching the mineral on an unglazed porcelain plate. The streak of non-metallic minerals is either colourless or very light, whereas that of metallic minerals is often dark.

FIG. 14 MANGANITE (ACCICULAR)

Lustre is the appearance of the surface of a mineral in reflected light. There are two principal types of lustre, metallic and non-metallic. Metallic lustre is that of metals and minerals of metallic appearance.

Non-metallic lustre are many and they are described as follows:—

1. *Adamantine;* when the lustre is like that of diamond.
2. *Vitreous;* when it is like quartz.
3. *Resinous;* when like a resin.
4. *Greasy;* (e.g.) Nepheline.
5. *Pearly;* (e.g.) Talc.
6. *Silky;* (e.g.) Fibrous gypsum.
7. *Earthy;* when it is like mud.

Cleavage is the tendency of many crystallised minerals to split in certain definite directions yielding more or less smooth surfaces. It is described as perfect or imperfect according to the ease with which it splits. Calcite, mica and galena exhibit perfect cleavage.

Fracture is the nature of the face obtained when the mineral is broken in a direction other than that of cleavage in the case of cleavable minerals and in any direction in the case of massive minerals.

Fracture is described as:—

(*a*) *Conchoidal;* when the mineral breaks with smooth, curved, concave surfaces. Flint and opal exhibit this fracture.

(*b*) *Uneven;* when the surface is irregular and rough throughout. This is the most common type in minerals.

(*c*) *Even;* when the surface is approximately plane even though there are elevations and depressions.

(*d*) *Hackly;* when the elevations are sharp.

Hardness is the resistance which a mineral offers to abrasion and is of utmost importance in identifying minerals. Moh's scale of hardness is the standard scale used to determine the hardness of minerals. It consists of ten minerals arranged according to their degree of hardness as shown below ranging from one of the softest mineral talc to the hardest mineral diamond.

Mineral.		*Hardness.*
Talc	...	1
Gypsum	...	2
Calcite	...	3
Fluorite	...	4
Apatite	...	5
Orthoclase	...	6
Quartz	...	7
Topaz	...	8
Corundum	...	9
Diamond	...	10

While testing the hardness of a mineral care should be taken that its surface is fresh, i.e., its surface should not be weathered, splintery or powdery.

If the hardness of an unknown mineral is to be determined, it is first taken and scratched over the minerals listed above starting from talc. If the mineral, for example, say, scratches fluorite (hardness 4) but not apatite (hardness 5), then apatite is taken and scratched over the mineral. If apatite scartches it then the hardness of the mineral is between 4 and 5, i.e., 4.5. If apatite does not scratch the mineral then the hardness of the mineral is equal to that of apatite, namely 5.

Moh's scale of hardness is exhibited at the far end near the Mineralogy gallery.

Specific gravity is the ratio of the weight of a mineral to an equal volume of water.

Some minerals are attracted by a magnet, i.e., they are magnetic (e.g.) Magnetite.

Many minerals become electrically charged when rubbed. The gems are, in general, negatively charged in the raw state. They become positively charged only when they are polished. The diamond always exhibits positive charge whether polished or not.

Many minerals also become electrically charged when heated (e.g.) Tourmaline.

Few minerals like pitchblende, which contain radioactive elements, give out invisible radiations which can be detected with a Geiger counter. Such minerals are said to be radioactive.

These properties facilitate in identifying the minerals megascopically.

The minerals in the geology galleries are classified and arranged according to their chemical composition. They are displayed in the cases situated along the wall on the right side at the far end of the gallery.

The gallery begins with oxides and ends with native elements. As it is not possible to describe all the displayed minerals in this book only the important ones among them are described.

(iii) Oxides

Quartz is the commonest mineral widely distributed in all kinds of rocks. It is an oxide of silicon occurring as masses and as hexagonal crystals. Crystals are characterised by the horizontal striations on the prism faces. The colour of quartz varies

its streak is white when pure. It breaks with a conchoidal to sub-conchoidal fracture and has a vitreous, greasy or waxy lustre. The hardness of quartz is 7 and its specific gravity is 2.6.

Quartz is used in the manufacture of glass, porcelain, refractory, abrasive, paint, lenses and optical instruments. It is also used in metallurgical and chemical industries. Quartz sand is used in mortar and concrete.

Rock crystal is a colourless, transparent variety of quartz. It is used as a semi-precious stone and in the manufacture of lenses, optical instruments and quartz crystal oscillators. A hexagonal crystal of rock crystal, 9 inches long, is exhibited in the gallery.

Smoky quartz is a smoky brown variety of quartz. Its colour is probably due to some organic compound. It is used as a semi-precious stone. A cluster of well crystallised hexagonal crystals of smoky quartz is exhibited in the gallery (Fig. 15).

Amethyst is a purple or violet variety of quartz. Its colour is probably due to manganese dioxide. It is used as a semi-precious stone. Amethyst crystals are usually found lining the inside of hollow cavities.

Rose quartz is a pink variety of quartz and it is used as a semi-precious stone. It is less common in occurrence compared to the other varieties.

Sagenetic quartz is a variety of quartz containing accicular inclusions of other minerals. Sagenetic quartz containing tourmaline inclusions is exhibited in the gallery.

Chalcedony is a crypto-crystalline variety of quartz having a waxy lustre. Its surface is smooth and it breaks with a typical conchoidal fracture. It occurs in a variety of colours and is

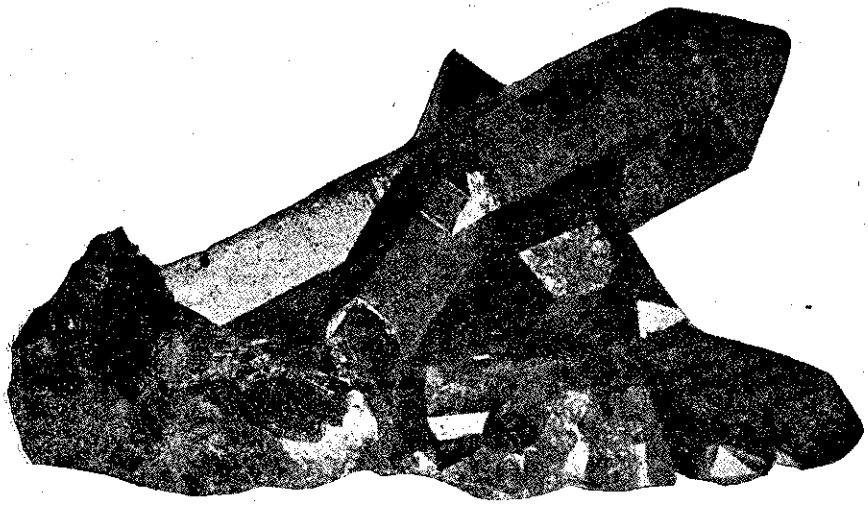


FIG. 15 SMOKY QUARTZ CRYSTALS

either translucent or transparent. It usually exhibits mammillary, botryoidal and stalactitic structures. Chalcedony is used as an ornamental stone.

Carnelian is a red to reddish brown variety of chalcedony Its colour is due to the presence of iron. It is a semi-precious stone. The Taj at Agra is studded with this type of stone.

Chrysophrase is an apple green variety of chalcedony. Its colour is due to nickel oxide or nickel silicate. It is used as a semi-precious stone.

Prase is a translucent, dull, light green variety of chalcedony. Its colour is due to a large number of hair-like needles of actinolite. It is used as an ornamental stone.

Plasma is a dark to light green variety of chalcedony and is sub-translucent or slightly translucent. Its colour is due to the presence of chlorite. It is used as an ornamental stone.

Heliotrope or Bloodstone is plasma with tiny spots of red jasper. It is used as an ornamental stone.

Agate (Fig. 16) is a banded variety of chalcedony. The bands may be straight or zigzag. The colour of the bands are usually grey and white and they can be artificially coloured. It is used in the manufacture of knife-edges in scientific balances and in the manufacture of agate mortars and pestles. When artificially coloured, it is used as an ornamental stone.

Flint is somewhat similar to chalcedony but different from it in being opaque, rough and dull. It is grey, brown or black in colour and breaks with a typical conchoidal fracture producing sharp-cutting edges. It is usually found embedded as nodule in chalk or lime deposits. Hence its outer surface is whitish. Flint is chiefly used in the manufacture of abrasives. Pre-historic people used it for making tools and for producing fire.

Chert or hornstone is an impure form of flint and is usually brittle.

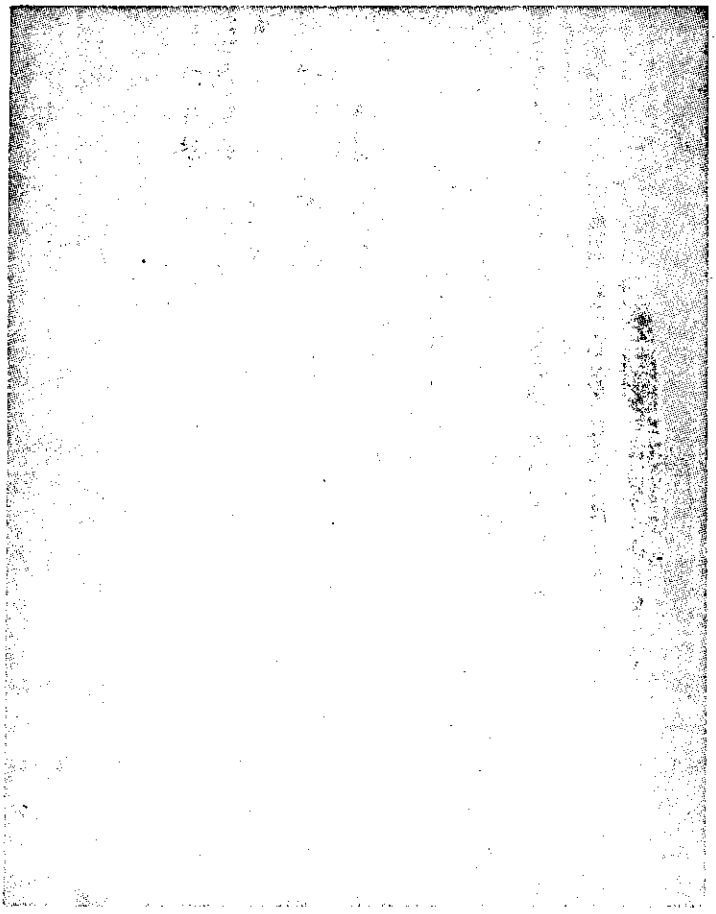


FIG. 16 AGATE

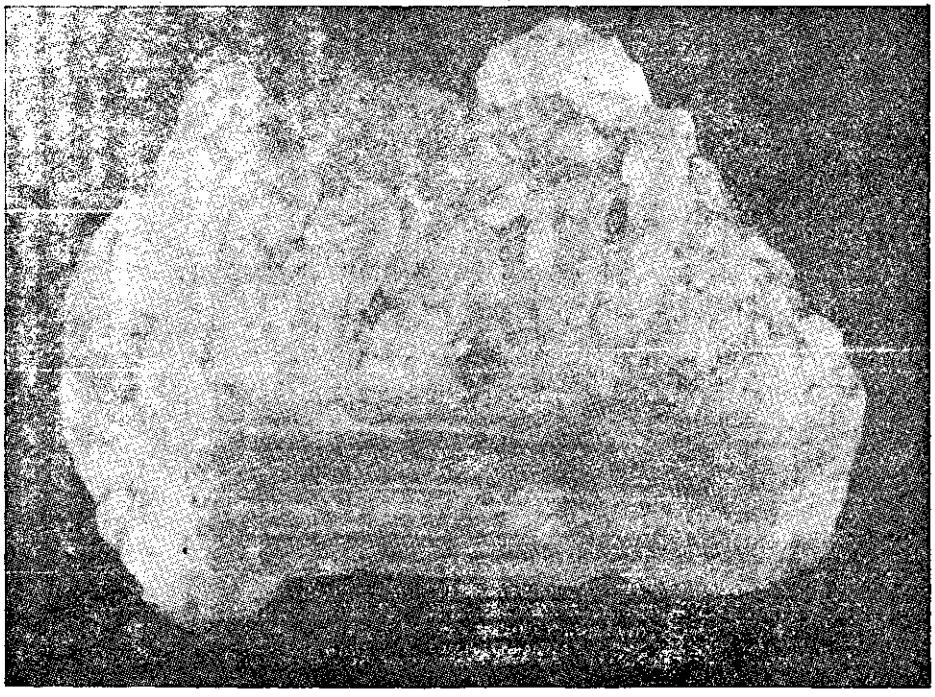


FIG. 17 AGATE WITH QUARTZ CRYSTALS

Jasper is an opaque variety of quartz usually red, brown or yellow in colour. It is sometimes banded and is then termed as striped or riband jasper. Jasper is used as an ornamental stone.

Opal is an amorphous (non-crystalline) variety of quartz with varying amounts of water. It occurs in a variety of colours and gives a white streak. Its lustre is vitreous, resinous or pearly. Its hardness varies from 5.5 to 6.5 and its specific gravity ranges from 1.9 to 2.2. It breaks with a marked conchoidal fracture. Some exhibit play of colours and they are used as semi-precious stone.

Wood opal is wood petrified by opal.

Corundum is an oxide of aluminium. It occurs as massive bodies and as hexagonal crystals. The characteristic property of this mineral is its hardness which is 9. Its specific gravity ranges from 3.9 to 4.1. Its fracture is uneven to conchoidal and its lustre varies from adamantine to vitreous. It occurs in a variety of colours and its streak is uncoloured.

Ruby is the red, transparent to translucent variety of corundum.

Sapphire is the blue, transparent to translucent variety. The term sapphire is also used for the other colours of corundum, except red, which are transparent to translucent.

Corundum is chiefly used as an abrasive. The transparent varieties are used as a gem.

Corundum is usually found to occur in syenite, crystalline limestones, dolomite, slate, mica schist and gneiss.

In Tamil Nadu, corundum occurs at Sitampundi, Papparappatti and Palakad in Salem district and in the Sivamalai area near Kangayam in Coimbatore district.

Hematite, also known as red iron ore or red oxide, is a sesquioxide of iron and is the most important ore of iron. It contains about 70 per cent iron. It is steel-grey or black in colour

when compact and red when earthy and produces a reddish brown streak. Its hardness varies from 5.5 to 6.5 and the specific gravity ranges from 4.9 to 5.3.

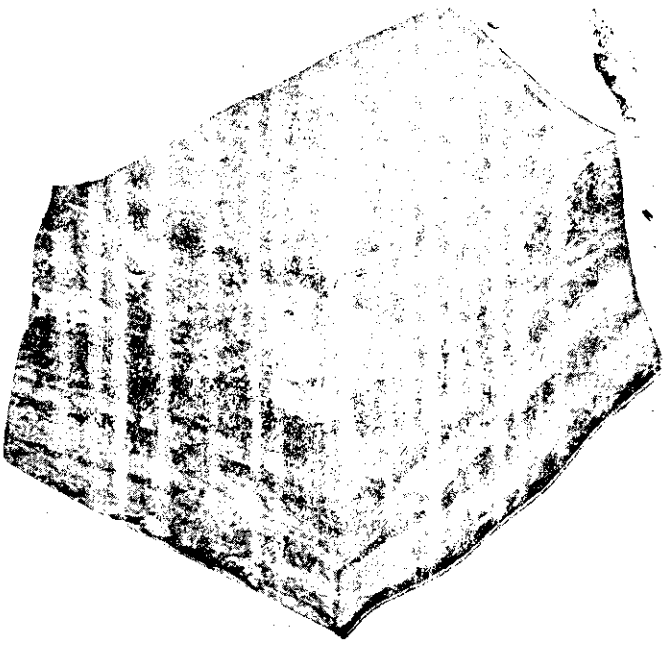


FIG. 18 BANDED HEMATITE JASPER

India is rich in hematite deposits. One of the world's largest deposit is situated in Bihar State.

Ilmenite is an oxide of iron and titanium and is the chief ore of titanium. It is iron-black in colour and produces a black to brownish red streak. Its hardness varies from 5 to 6 and the specific gravity ranges from 4.5 to 5. It breaks with a conchoidal fracture and its lustre is sub-metallic. It occurs as compact masses and as loose grains. Ilmenite occurs in basic igneous rocks. In Malabar and Travancore in Kerala State ilmenite occurs as sand along the coast mixed with monazite, zircon, garnet, magnetite and rutile grains.

Spinel is a magnesium aluminate crystallising in the cubic system. Its hardness is 8 and its specific gravity ranges from 3.5 to 4.1. It breaks with a conchoidal fracture. Its lustre is commonly vitreous but it may vary from splendent to dull. It occurs in a variety of colours and produces a white streak. If spinel is transparent or translucent it is used as a semi-precious stone. Spinel usually occurs associated with corundum in the gem gravels.

In the Mogok district of Burma the mineral occurs in the alluvial deposits and in streams and in the crystalline limestone rocks. In Ceylon, it occurs in the gem gravels as water-worn pebbles.

Pink, transparent to translucent spinel is exhibited in the gallery.

Chromite is a chromium sesquioxide and is the chief ore of chromium. It is black or brownish black in colour and produces a brownish streak by which it is distinguished from magnetite and ilmenite. Its fracture is uneven, lustre sub-metallic to metallic, hardness 5.5 and the specific gravity ranges from 4.1 to 4.9

Chromite generally occurs in highly basic igneous rocks such as peridotites, pyroxenites, dunites and serpentinites.

Magnetite, also known as magnetic iron ore, is a sesquioxide and protoxide of iron and is an important ore of iron. It contains about 72 per cent of iron. It crystallises in the cubic system usually as octahedrons and dodecahedrons. It is strongly attracted by a magnet. Its colour and streak are black. Its fracture is sub-conchoidal to uneven and the lustre varies from metallic to dull. Its hardness ranges from 5.5 to 6.5 and the specific gravity is 5.1.

Magnetite occurs in basic igneous rocks and metamorphosed sedimentary rocks.

In Tamil Nadu magnetite deposits occur in Salem and Tiruchirappalli district.

Lodestone is a variety of magnetite which exhibits polarity. A specimen of lodestone with iron filings adhering to it is exhibited in the gallery. This specimen is from Magnet Cove, Arkansas, U.S.A.

Limonite is a hydrous sesquioxide of iron formed by the alteration of iron bearing minerals. It is widespread in its occurrence. It does not crystallise. It usually occurs in botryoidal, mammillary and stalactitic forms. It occurs in various shades of brown and its streak is yellowish brown. Its hardness varies from 5 to 5.5 and the specific gravity ranges from 3.6 to 4. It is used as an iron ore. When earthy it is used as a yellow pigment.

Geothite is a hydrous sesquioxide of iron crystallising in the orthorhombic system. It exhibits reniform, stalactitic and fibrous structures. It is yellowish brown or red in colour and produces a brownish yellow streak. It has a perfect cleavage and an uneven fracture. Its hardness ranges from 5 to 5.5 and the specific gravity is 4.3.

Goethite is usually found associated with limonite. It is used as an iron ore.

Rutile is an oxide of titanium and it crystallises in the tetragonal system. Crystals are accicular. It also occurs in massive form. Commonly it is black and its streak is light brown. Its hardness ranges from 6 to 6.5 and the specific gravity is 4.2. It breaks with a sub-conchoidal to uneven fracture and has a metallic to adamantine lustre.

In South India, rutile is found in small quantities in the beach sands of Travancore.

Manganite is the hydrous sesquioxide of manganese crystallising in the orthorhombic system. It also occurs as columnar and stalactitic forms. It is black in colour and its streak is reddish brown. Its hardness is 4 and the specific gravity is 4.4. It breaks with an uneven fracture and has a sub-metallic lustre. It is usually found associated with other manganese oxides. Manganite is used as an ore of manganese.

Pyrolusite is a dioxide of manganese and is the chief ore of manganese. It commonly occurs in massive, botryoidal, columnar and reniform forms. It has a hardness of 2 to 2.5 and often soils the fingers. Its specific gravity ranges from 4.7 to 4.9. It is steel grey to black in colour and its streak is black. It has a metallic lustre.

In India, pyrolusite occurs in Madhya Pradesh and in Andhra Pradesh.

Psilomelane is a hydrous oxide of manganese containing varying amounts of barium, potassium and sodium oxides. It does not crystallise but occurs in massive, botryoidal, reniform and stalactitic forms. It is steel grey to black in colour and its streak is black. It is harder than pyrolusite having a hardness which ranges from 5 to 7. Its specific gravity varies from 3.3 to 4.7 and its lustre is sub-metallic or dull.

Wad is a soft impure variety of psilomelane with a dull black colour.

Psilomelane is used as an ore of manganese. In India, it occurs in Andhra Pradesh and Madhya Pradesh.

Bauxite is a hydrous oxide of aluminium and is the only ore from which aluminium is extracted. It occurs as an amorphous mass and in concretionary grains. It is earthy in appearance. When pure it is white in colour. Commonly it is yellow, brown or red or a mixture of these colours. Its hardness is variable and the specific gravity is 2.5.

Bauxite is formed by prolonged weathering of aluminium bearing rocks under tropical climatic conditions.

In Tamil Nadu, bauxite occurs at Yercaud in Salem district and at Berijam in Kodaikanal.

Bauxite with pisolitic structure is also exhibited in the gallery.

(iv) Carbonates.

Calcite is a carbonate of calcium and it crystallises in the rhombohedral class of the hexagonal system. An interesting feature of this mineral is that the crystals exhibit a great variety of forms. It also occurs in fibrous, stalactitic, nodular, granular, compact and earthy forms. It has a perfect rhombohedral cleavage. Its hardness is 3 and the specific gravity is 2.7. Its lustre varies from vitreous to earthy. It occurs in a variety of colours and its streak is white to grey. Some calcites exhibit fluorescence and some exhibit phosphorescence on heating. Calcite effervesces immediately with cold dilute hydrochloric acid.

Calcite is wide spread in occurrence commonly occuring in sedimentary rocks and in the cavities of lavas.

Iceland spar is a pure transparent variety of calcite having high double refraction.

Among the calcite specimens exhibited are hexagonal prisms of calcite and nodular calcite.

Calcite is chiefly used in the manufacture of cement. Iceland spar is used in the maufacture of optical instruments.

In Tamil Nadu, calcite occurs in Salem, Tirunelveli and Ramanathapuram districts.

Aragonite is a carbonate of calcium having the same chemical composition of calcite, but it crystallises in the orthorhombic system. It also occurs in columnar, globular and stalactitic forms. It is slightly harder and heavier than calcite having a hardness of 3.5 to 4 and a specific gravity of 2.93 to 2.95. Its cleavage is not so distinct as calcite and it breaks with a sub-conchoidal fracture. It has a vitreous lustre. With cold dilute hydrochloric acid it readily effervesces. Aragonite is less common in its occurrence.

Dolomite is a carbonate of calcium and magnesium crystallising in the hexagonal system. The faces of the crystal are often curved. It also occurs in massive and granular forms. It is harder than calcite and its hardness ranges from 3.5 to 4. Its specific gravity varies from 2.8 to 2.9. The colour of dolomite varies, its fracture is sub-conchoidal and its lustre is vitreous. Some show pearly lustre. With cold dilute hydrochloric acid dolomite slowly effervesces.

Dolomite commonly occurs in sedimentary rocks. It is used in the manufacture of refractory bricks and in certain type of cements.

Magnesite is a carbonate of magnesium. It usually occurs in massive and granular forms having an earthy appearance. Crystals are rare. It is white, light grey, yellow or buff in colour and breaks with a flat conchoidal fracture. Its hardness ranges from 3.5 to 4.5 and the specific gravity varies from 2.8 to 3. It effervesces with hot acids.

Magnesite is generally found to occur associated with serpentines derived from ultra-basic igneous rocks such as dunite and peridotite.

Magnesite is chiefly used in the manufacture of refractory bricks and crucibles.

In Tamil Nadu, high grade magnesite occurs at Chalk Hills, Salem district. In Mysore State, it occurs in the districts of Hassan and Mysore.

Malachite is a hydrated basic carbonate of copper. It commonly occurs in massive form with a smooth mammillary or botryoidal surface. It is commonly banded with different shades of green. Crystals are rare. It is bright green in colour and its streak is pale green. Its hardness varies from 3.5 to 4 and the specific gravity is 4. It effervesces with acids. The lustre of malachite varies from adamantine to vitreous in crystals and from dull to earthy in massive forms.

Malachite is an altered product of the ores of copper. Hence it is usually found associated with such ores in the oxidized zone and below this usually the sulphide zone of copper occurs.

Malachite is used as an ore of copper and as an ornamental stone.

Azurite is a hydrated basic carbonate of copper. It commonly occurs in massive form having a deep azure blue colour. Its streak is light blue. In massive forms the lustre is dull to earthy whereas in crystals it is vitreous to adamantine. The hardness of azurite ranges from 3.5 to 4 and the specific gravity varies from 3.7 to 3.9. It effervesces with nitric acid.

Azurite usually occurs associated with malachite and other ores of copper in the oxidized zone.

Azurite is used as an ore of copper.

Smithsonite is a zinc carbonate. It rarely occurs as crystals and usually exhibits reniform, botryoidal and stalactitic forms. Its colour varies, but is usually green. It has a vitreous to pearly lustre and breaks with an imperfect fracture. The hardness of smithsonite is 5.5 and the specific gravity ranges from 4.3 to 4.45. It effervesces with acids.

Smithsonite usually occurs in calcareous rocks. It is used as an ore of zinc.

(v) Anhydrous Silicates.

Feldspars form a large group of minerals which are found in all types of rocks. All the minerals included in this group crystallise in the monoclinic or triclinic systems. Their prismatic angles slightly vary from 60° and 120°. They have perfect cleavage in two directions whose angle is 90° or nearly 90°. The hardness of feldspars varies between 6 and 6.5 and the specific gravity is between 2.5 and 2.9. They are usually light coloured.

Based on the chemical composition, the feldspars are divided into two groups (1) Potash feldspars and (2) Plagioclase feldspars.

Orthoclase and microcline belong to potash feldspars and albite, oligoclase, andesine, labradorite, bytownite and anorthite belong to plagioclase feldspars.

Orthoclase is a silicate of aluminium and potassium crystallising in the monoclinic system. It is usually white, grey, pale yellow or flesh-red in colour and its streak is uncoloured. Its specific gravity is between 2.57 and 2.58. Orthoclase is a common mineral. It is found in igneous rocks, pegmatite veins and in metamorphic rocks. It alters to kaolin or china clay.

Orthoclase is used in the manufacture of porcelain.

Adularia is a transparent to sub-transparent variety of orthoclase often with a pearly opalescent reflection or a bluish reflected scheen. This is commonly known as *moonstone* and is used as a semi-precious stone.

Microcline has the chemical composition similar to orthoclase but it crystallises in the triclinic system. It is usually white, grey, pink, or green in colour. Its specific gravity is between 2.54 and 2.57.

Like orthoclase, microcline is also used in the manufacture of porcelain.

Amazonstone is the bright or pale green variety of microcline. It is used as a semi-precious stone.

Labradorite is a plagioclase feldspar. It is grey in colour. Some exhibit play of colours. Then they are used as a semi-precious stone.

Labradorite exhibiting play of colours is exhibited in the gallery.

Rhodonite is a manganese metasilicate. It belongs to the pyroxene group and crystallises in the triclinic system. It is pink, flesh-red or brown in colour having a hardness ranging from 5.5 to 6.5. Its specific gravity varies from 3.4 to 3.68. It has distinct cleavages and it breaks with a conchoidal to uneven fracture. It occurs in various manganese ores.

Rhodonite is used as an ornamental stone.

Beryl is a silicate of aluminium and beryllium crystallising in the hexagonal system. Crystals are common. Its hardness varies from 7.5 to 8 and the specific gravity ranges from 2.63 to 2.8. The colour of beryl is usually green, blue, white or pink. Its streak is white. Lustre varies from vitreous to resinous and the fracture is conchoidal to uneven. Though it looks like apatite in appearance it is easily differentiated from it by its hardness which is greater than apatite. The common occurrence of beryl is in pegmatite veins.

Emerald is a bright emerald green variety of beryl. It is used as a precious stone when clear and transparent.

Aquamarine is a pale blue or greenish blue variety of beryl. When clear and transparent it is used as a semi-precious stone.

Beryl is used as an ore of beryllium. When transparent it is used as a gem stone.

A green hexagonal crystal of beryl from Nellore, Andhra Pradesh is exhibited in the gallery. Pale blue aquamarine is exhibited under Gem stones.

Lapis Lazuli or Lazurite is a silicate of sodium and aluminium with sodium sulphide and it crystallises in the cubic system. It commonly occurs in masses. Its hardness varies from 5 to 5.5 and the specific gravity ranges from 2.38 to 2.45. Fracture is uneven. It is azure-blue, violet-blue or greenish-blue in colour. Lustre is vitreous.

Lapis Lazuli occurs in limestones which are in contact with granitic rocks.

Lapis Lazuli is used as an ornamental stone.

Garnets form a group of complex silicate minerals, all of which crystallise in the cubic system. Dodecahedron and trapezohedron are the common forms in which they crystallise. Their hardness varies from 6.5 to 7.5 and their specific gravity ranges from 3.15 to 4.3. They occur in a variety of colours and produce a white streak. The lustre varies from vitreous to resinous and the fracture is sub-conchoidal or uneven.

Garnets commonly occur in igneous and metamorphic rocks.

The minerals included in this group are grossularite, pyrope, almandite, spessartite, andradite and uvarovite.

Pyrope is a magnesium aluminium garnet having a specific gravity of 3.5. It is dark red in colour. A specimen of pyrope is exhibited in the gallery.

Dodecahedral forms of garnet crystals are also on display.

When transparent, garnets are used as gem stones. They are used as an abrasive when non-transparent.

Kyanite is a silicate of aluminium crystallising in the triclinic system. Crystals are usually long and bladed. It also occurs in columnar and semi-fibrous forms. Kyanite has an unusual hardness. Parallel to the crystal axis its hardness varies from 4 to 5. Perpendicular to the crystal axis its hardness is 7. Specific gravity of kyanite varies from 3.56 to 3.67. Its colour is blue, green or grey and the streak is uncoloured. It has a vitreous to pearly lustre.

Kyanite is a metamorphic mineral occuring chiefly in gneisses and schists. It is often associated with garnet, staurolite and corundum.

Kyanite is principally used in the manufacture of refractory bricks. It is sometimes used as a semi-precious stone when transparent.

In India, large deposits of high grade, non-transparent massive kyanite occurs in Lapsa Buru, Bihar. Coarse bladed kyanite occurs in the Nellore district of Andhra Pradesh and in the Hassan district of Mysore State.

Staurolite is an iron aluminium silicate crystallising in the orthorhombic system. Crystals are commonly flat and prismatic. Twinned crystals are common. Twinning may be at 60° or at 90°. When at 90° the twin crystals form a perfect cross. Hardness of staurolite varies from 7 to 7.5 and its specific gravity ranges from 3.65 to 3.77. It is brown to black in colour and its streak is grey. The lustre varies from vitreous to resinous and the fracture is conchoidal to sub-conchoidal.

Staurolite usually occurs in schists often associated with garnet and kyanite.

When transparent it is sometimes used as a gem stone. Twinned crystals which form a perfect cross are sold as charms or souvenirs.

A perfect twinned crystal in the form of a cross is on display. (Fig. 19).

Tourmaline is a complex silicate of boron with aluminium and several other metals. It usually occurs in well-developed hexagonal crystals. Prismatic faces are strongly striated vertically. Hardness of tourmaline varies from 7 to 7.5 and the specific gravity ranges from 2.9 to 3.2. It is usually black in colour and its streak is uncoloured. The lustre of tourmaline varies from vitreous to resinous and the fracture is sub-conchodial or uneven. When tourmaline crystals are heated, opposite charges are developed at opposite ends of the crystals.

Tourmaline occurs in pegmatites and in metamorphic rocks such as schists and gneisses.

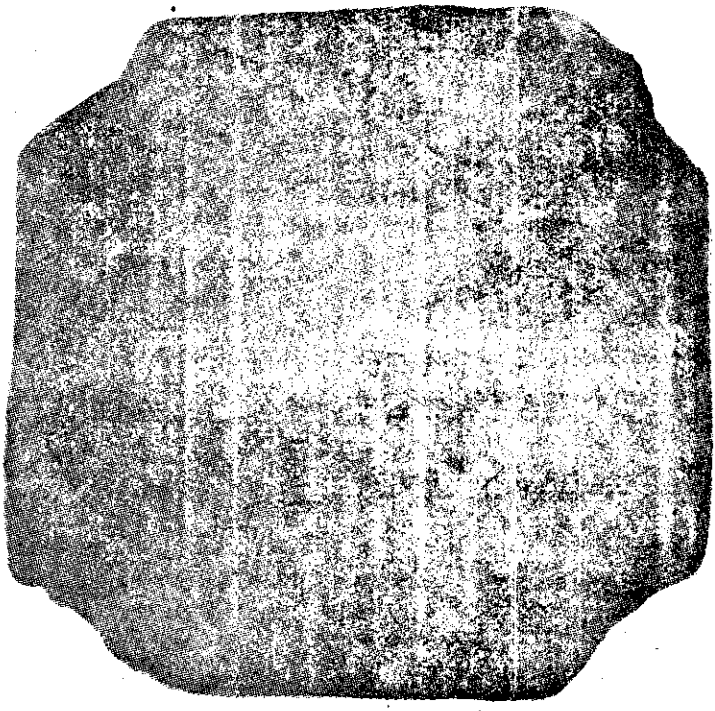


FIG. 19 TWIN CRYSTAL OF STAUROLITE

Attractively coloured and transparent tourmalines are used as gem stones.

Light green tourmaline of non-gem grade is reported to occur near Kiranur in Tiruchirappalli district and in the Rajulacheruvu Mica Mine in Nellore district.

Specimens of black tourmaline are exhibited in the gallery of which the one associated with quartz is of interest.

Micas are a peculiar group of minerals having certain physical and chemical characteristics in common. They all have a perfect basal cleavage yielding extremely thin, tough, flexible sheets.

Chemically they are all silicates of aluminium with other metals, singly or in combination. All micas, when heated, yield water. When a blunt instrument is placed on a sheet of mica and lightly struck, a six-rayed star called percussion-figure is produced.

Muscovite, ruby mica, biotite, phlogopite, lepidolite and vermiculite are some of the types of mica which are on display.

Muscovite or potash mica is the most common mica. In thick blocks it is grey in colour and almost colourless in thin flakes. Its hardness varies from 2 to 2.2 and the specific gravity ranges from 2.8 to 3.

Muscovite commonly occurs in granites, pegmatites and in metamorphic rocks such as schists, phyllites and gneisses. Economic quantities are, however, obtained from pegmatites, A pegmatite rock containing books of muscovite mica is exhibited in the Economic Geology gallery.

Muscovite is chiefly used as an insulator in the manufacture of electrical equipments.

India has rich deposits of muscovite occuring in Andhra Pradesh, Bihar and Rajasthan. In all the three places muscovite occurs in pegmatite.

Biotite is a dark coloured mica black to green in colour. In thin flakes it is green or brown. Its hardness varies from 2.5 to 3 and the specific gravity ranges from 2.7 to 3.

Biotite occurs in igneous and metamorphic rocks.

Phlogopite is an yellowish brown to brownish red mica. Its hardness varies from 2.5 to 3 and the specific gravity ranges from 2.7 to 2.9.

Phlogopite occurs in crystalline limestone and dolomite.

In India, phlogopite occurs near Neyyoor and Punalur in Kerala State.

Phlogopite is used in electrical industry.

Lepidolite or lithia mica is pink, grey or white in colour. Its hardness varies from 2.5 to 4 and the specific gravity ranges from 2.8 to 3.3.

Lepidolite usually occurs in pegmatite.

It is used as an ore of lithium.

Vermiculite is a hydrous mica formed by the alteration of phlogopite or biotite mica. It is yellow to brown in colour and swells considerably upon heating. It also becomes light golden yellow in colour after it has been heated.

Vermiculite occurs in basic igneous rocks such as pyroxenites and dunites.

Vermiculite is a good insulator against heat, cold and sound It is used for insulation and lightweight concrete and plasters It also finds use in horticulture.

In Tamil Nadu, vermiculite occurs in Tirupathur taluk of North Arcot district.

(vi) Hydrous Magnesium Silicates

Serpentine is a hydrous magnesium silicate and may contain iron or nickel or both. It usually occurs in masses. Cystals are rare. Fibrous serpentine is the chrysotile asbestos. Colour of serpentine varies from white to black through various shades of green. Its streak is white. Hardness varies from 2.5 to 4 and the specific gravity ranges from 2.5 to 2.7. Its lustre is greasy or waxy.

Serpentine is a secondary mineral formed by the alteration of magnesian rocks and minerals.

Serpentine is used as an ornamental stone. Fibrous serpentine, chrysotile asbestos, is chiefly used in insulation and as a fire proofing material

Serpentine with various hues is found near Pulivendla in Cuddappah district.

Serpentine containing veins of chrysotile asbestos is also on display (Fig. 20).

Talc is a hydrous magnesium silicate. It usually occurs in, foliated and compact masses. Crystals are rare. It is a soft mineral, white, grey or green in colour with a pearly to greasy lustre. It is soapy to the touch. Its hardness varies from 1 to 1.5 and the specific gravity is 2.7.

Talc is a secondary mineral usually associated with serpentine, chlorite schist and dolomite. Talc obtained from dolomitic rocks is often pure white, cream or apple green in colour and translucent in thin plates while that derived from serpentine and chlorite schist is often greenish grey or buff.

Talc has a variety of uses. It is used in the manufacture of paints, rubber, ceramics, insecticide, toilet powder, etc.

Foliated talc is exhibited in the gallery.

Steatite is a high grade massive talc. Steatite which is free from cracks and inclusions is used in the manufacture of high frequency insulators in the radio industry and in the manufacture of radar and electronic equipments. It is also used in the manufacture of oil and gas burner tips. The most important use of steatite is in the manufacture of special porcelain and refractories.

Soapstone is a massive rock chiefly made up of talc. The other minerals present in it may be chlorite, tremolite, magnetite, quartz, etc. It is greyish green or brownish grey in colour having a soapy feel and can be cut with ease. It is resistant to heat, electricity and acids.

Soapstone is used for making pots, fire-bricks, sinks, electrical switch boards, stoves, etc

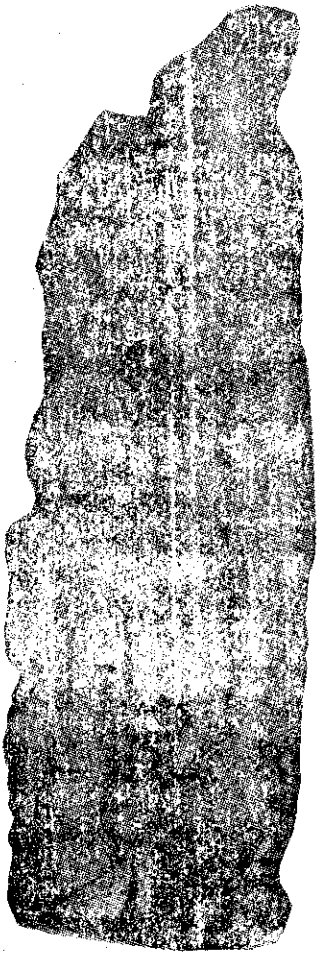


FIG. 20 SERPENTINE WITH VEINS OF CHRYSOTILE ASBESTOS

Powdered soapstone is used in paints, papers, toilet powders, etc.

(vii) SULPHATES.

Barite is a barium sulphate commonly known as barytes or heavy spar. It crystallises in the orthorhombic system. It is heavy having a specific gravity of 4.3 to 4.5 and a hardness which varies from 2.5 to 3.5. It is colourless or white, grey, blue, yellow, brown or black in colour. Its streak is white. Lustre is vitreous to resinous and fracture uneven.

Barite is used in oil—well drilling, paint, paper, glass, rubber, linoleum, ceramics, etc.

It is commonly associated with ores of lead, zinc and copper.

In South India, barite occurs in Ananthapur, Cuddappah and Kurnool districts of Andhra Pradesh.

Gypsum is hydrous calcium sulphate crystallising in the monoclinic system. Crystals are common. Twin crystals are also common. Its hardness is 2 and the specific gravity is 2.3. Its lustre is either pearly, vitreous, silky or earthy. It is colourless or white, grey, pink, brown or black in colour. It produces a white streak. The mineral dissolves readily in hot hydrochloric acid.

Gypsum occurs in sedimentary rocks. Large deposits have been formed by the evaporation of sea water.

Varieties—

(1) Selenite is a colourless, transparent gypsum.

(2) Satinspar is fibrous variety with silky lustre.

(3) Alabaster is a massive, fine-grained variety.

Gypsum is used in the manufacture of cement and plaster of Paris. In agriculture it is used as a fertilizer.

In Tamil Nadu, gypsum occurs in Tiruchirappalli, Tirunelveli, Coimbatore and Chingleput districts.

A perfect crystal of gypsum is on display along with the other varieties. (Fig. 21).

FIG. 21 GYPSUM CRYSTAL

(viii) SULPHIDES

Galena, commonly known as lead glance, is a sulphide of lead crystallising in the cubic system. Cubic crystals are common. It is a heavy mineral having a specific gravity of 7.5. Its hardness varies from 2.5 to 2.8. Galena has a perfect cubic cleavage. Its colour and streak are lead grey and the lustre is metallic.

Galena usually occurs associated with ores of zinc, silver and copper.

Galena is the chief ore of lead. It usually contains some amount of silver which is recovered during the extraction of lead.

The most important source of galena in India is from Zawar, in Udaipur, Rajasthan. In Tamil Nadu, galena occurs associated with ores of zinc and copper in the Mamandur area of South Arcot district.

Argentite or silver glance is a sulphide of silver crystallising in the cubic system. It commonly occurs in massive form. Its hardness ranges from 2 to 2.5 and its specific gravity varies from 7.2 to 7.3. Its colour and streak are dark lead-grey and its lustre is metallic.

Argentite usually occurs associated with galena and other sulphide ores.

Argentite is used as an ore of silver.

Pyrite or iron pyrites is a disulphide of iron. It is also called fool's gold. It crystallises in the cubic system, the common forms being cubes and pyritohedrons. Crystals are common. The faces of the crystals are often striated. It also occurs in masses and grains. Pyrite is pale brassy yellow in colour. Its streak is greenish black or brownish black. The hardness of pyrite varies from 6 to 6.5 and the specific gravity ranges from 4.9 to 5.1. It has a metallic lustre.

Pyrite commonly occurs in sedimentary and metamorphic rocks.

It is used to obtain sulphur.

Marcasite or white iron pyrites has a chemical composition similar to pyrite but it crystallises in the orthorhombic system. It commonly occurs in massive and fibrous forms.

Marcasite is very pale bronze yellow in colour and its streak is greyish or brownish black. It has a metallic lustre. Its hardness varies from 6 to 6.5 and the specific gravity is 4.8.

Marcasite is commonly found associated with galena, sphalerite, calcite, etc. It also occurs in sedimentary rocks.

A cluster of marcasite crystals is exhibited in the gallery.

Chalcopyrite or copper pyrites is a sulphide of copper and iron crystallising in the tetragonal system. It commonly occurs in massive form . Its hardness varies from 3.5 to 4 and the specific gravity varies from 4.1 to 4.3. It is brass yellow in colour and its streak is greenish black. Chalcopyrite is distinguished from pyrite by its low hardness and brass yellow colour which is somewhat darker than pyrite.

Chalcopyrite is the chief ore from which copper is extracted.

It occurs in igneous and metamorphic rocks.

In India, chalcopyrite is being mined in the Singhbhum district of Bihar.

Orpiment is a trisulphide of arsenic. Crystals are rare. Hardness varies from 1.5 to 2 and the specific gravity is 3.5. The colour of orpiment is of various shades of yellow and its streak is paler than its colour. Its lustre is resinous.

Orpiment usually occurs associated with realgar.

Orpiment is used as a pigment.

Molybdenite is a disulphide of molybdenum crystallising in the hexagonal system. Crystals are either tabular or prismatic. It commonly occurs in massive and flaky forms. Molybdenite is a lead-grey mineral. Its streak is bluish-grey. It is soft and heavy having a hardness of 1.5 and a specific gravity of 4.8. Its lustre is metallic.

Molybdenite occurs in granites, pegmatites and metamorphic rocks.

Molybdenite is a chief ore of molybdenum which is used as an alloy in iron and steel to increase their strength.

(ix) Haloids

Fluor spar or fluorite is a fluoride of calcium crystallising in the cubic system. Crystals are common. The mineral is mostly fluorescent under ultra violet light.

Fluorite has a perfect octahedral cleavage. Its hardness is 4 and the specific gravity varies from 3 to 3.2. The colour varies, but the streak is white. Its lustre is vitreous. The mineral is transparent to translucent.

Fluorite usually occurs as veins in sedimentary and igneous rocks. Cubic crystals of fluorite occur in the crystalline limestones of Sirimadevi in Tirunelveli district.

It is used as a flux in the manufacture of steel and glass. It is also used in the making of hydrofluoric acid.

(x) Phosphates

Apatite is a phosphate of calcium with fluorine or chlorine. It crystallises in the hexagonal system. Crystals are common. It is commonly sea-green or bluish-green in colour and produces a white streak. Its hardness is 5 and the specific gravity is 3.2. Its fracture is conchoidal to uneven and the lustre is vitreous to sub-resinous.

Though it resembles beryl it is easily distinguished from it by its hardness.

Apatite occurs in crystalline limestones and in igneous and metamorphic rocks.

Apatite is used as a fertilizer.

(xi) NIOBATES, TANTALATES AND TUNGSTATES

Columbite-tantalite is a niobate and tantalate of iron and manganese. When the mineral is rich in niobium it is called Columbite; when rich in tantalum it is called Tantalite.

Columbite-tantalite is deep brown or black in colour having a hardness of 6 and a specific gravity varying from 5.3 to 7.5. Its streak is deep red to black and the lustre is sub-metallic to resinous.

It is a rare mineral usually occuring in pegmatite veins.

In India, columbite-tantalite occurs in the mica-bearing pegmatites in Bihar and Andhra Pradesh, near Palni in Madurai district and near Kadavur in the Tiruchirappalli district of Tamil Nadu.

Columbite-tantalite is used in the manufacture of steel.

Samarskite is a velvety black mineral producing a dark reddish brown streak. Its hardness varies from 5 to 6 and its specific gravity ranges from 5.6 to 5.8. It has an adamantine to pitchy lustre.

Samarskite is a rare mineral. It occurs as masses in the pegmatite veins of Nellore district.

Samarskite is a radioactive mineral and is used in atomic energy.

Wolframite is a tungstate of iron and manganese crystallising in the monoclinic system. Crystals are commonly tabular or prismatic. It is a heavy mineral with a specific gravity of 7 to 7.5 and a hardness of 5 to 5.5. It is dark brown or black in colour. Its streak is black and its lustre is sub-metallic.

Wolframite commonly occurs in granites and pegmatites.

It is used as an ore of tungsten.

Scheelite is a tungstate of calcium crystallising in the tetragonal system. It commonly occurs as masses and in grains. Its hardness varies from 4.5 to 5 and the specific gravity ranges from 5.9 to 6.1. The colour of scheelite varies. Its streak is white and the lustre is vitreous.

Scheelite commonly occurs in pegmatite veins.

It is used as an ore of tungsten.

(xii) Native elements

Graphite is carbon. It is also known as black lead or plumbago. It is a very soft, black to steel-grey mineral having a greasy feel. It usually occurs as foliated, flaky, scaly, granular or earthy masses. Crystals are uncommon. Its hardness is between 1 and 2 and the specific gravity varies from 2 to 2.3. The lustre of graphite varies from metallic to earthy and its streak is black. Though it resembles molybdenite it is distinguished from it by its black streak.

Graphite occurs in igneous and metamorphic rocks.

In South India, graphite occurs near Vizagapatnam in Andhra Pradesh and in Travancore in Kerala State.

Graphite is used in the manufacture of pencils, refractory crucibles, paints, etc.

VII. PALAEONTOLOGY.

Palaeontology is a science which deals with the study of fossils. Fossils are the remains of animals and plants which inhabited the earth in the past ages and which have been preserved in the rocks.

The study of fossils is of primary importance for it is only through that the geologist is enable to determine (*a*) the chronological succession of the materials of which the crust is composed of, (*b*) the age of the deposits in which they occur, (*c*) the climate of the period in which they lived and the changes which have taken place on the earth in past ages, (*d*) the conditions under which the formations were deposited, and (*e*) the race history or phylogeny of plants and animals.

An animal or plant may become a fossil only when it has hard parts and is covered by some deposit. Since the conditions for fossilisation are much more favourable in water than on land, the majority of fossils are found in sedimentary rocks. Igneous rocks, in general, are devoid of fossils.

The fossils in the palaeontology gallery are arranged accord ing to the different periods to which they belong. The gallery begins with a coloured chart of the geological time scale in which the various geological periods, their duration and the important animals and plants which lived during those periods are explained. In addition to this chart, which is rather a small one, there is a huge four-sided show case about 10 feet tall near the beginning of the mineralogy gallery containing four multicoloured panels illustrating the geological time scale, the evolution of animal and plant life and the major earth movements and phases of igneous activity which occured during the various geological periods. The palaeontological collections are mainly comprised of invertebrate fossils and the cretaceous fossils are mainly from Tiruchirappalli cretaceous formations.

Among the exhibits in this gallery, the most interesting, to mention a few, are the plaster model of Brontosaurus sp; photographs of Trachodon, Triceratops, Stegosaurus; the gigantic fossil ammonite specimen *Pachydiscus peramplus* from Tiruchirappalli district and the fossil elephant skull from Rameswaram.

During the Mesozoic era (i.e.) Triassic, Jurassic and Cretaceous Periods, giant reptiles known as Dinosaurs or the terrible lizards dominated the earth and became extinct at the close of that era. To this group belongs the Brontosaurus sp., Triceratops, Trachodon and Stegosaurus.

Brontosaurus sp. (Fig. 22) is an extinct reptile which lived during the Jurassic Period (i.e.) about 150 million years ago. It had a bulky body, a long neck and a tail and stumpy legs. The front pair of legs were shorter than the hind ones. It was a voraceous eater living on the vegetation which flourished during that period. The specimen exhibited in the gallery is a plaster model 1/25 the size of the original reconstruction in America.

Trachodon (Fig. 23) is a duck-billed dinosaur which lived during the Jurassic Period. It was 15 feet high and walked on its hind legs in an upright position. The skull was flat and broad.

Stegosaurus (Fig. 24) also lived during the Jurassic Period. The chief characteristic feature of this reptile is the double row of pointed plates along its back. The largest of these plates measures about 2 feet across. The animal was 20 feet in length and 11 feet high near the hip. It walked on all the four pillar-like legs. The hind limbs were longer than the fore-limbs. On the tail there were four long, curved, horny spikes. Its head was small.

Triceratops (Fig. 25) is a horned dinosaur which lived during the Cretaceous period (i.e.) about 110 million years ago. It was about 20 to 25 feet long and possessed three long horns on its head and an armour of bony plates all over its back.

FIG. 22 BRONTOSAURUS SP.

The fossil specimens exhibited under Cretaceous Period are exclusively from Tiruchirappalli district in Tamil Nadu. The huge, attractive ammonite specimen *Pachydiscus peramplus* (Fig. 26) exhibited near the ultra-violet unit, is also from Tiruchirappalli district.

The huge fossil skull of an elephant, exhibited next to the big ammonite specimen, is from Rameswaram.

Among the plant fossils, the Gondwana specimens and the specimens from Britain are of interest. The former are exhibited under Gondwana Period and the latter are exhibited in a table case adjacent to the huge ammonite specimen.

FIG. 23 TRAGHODON

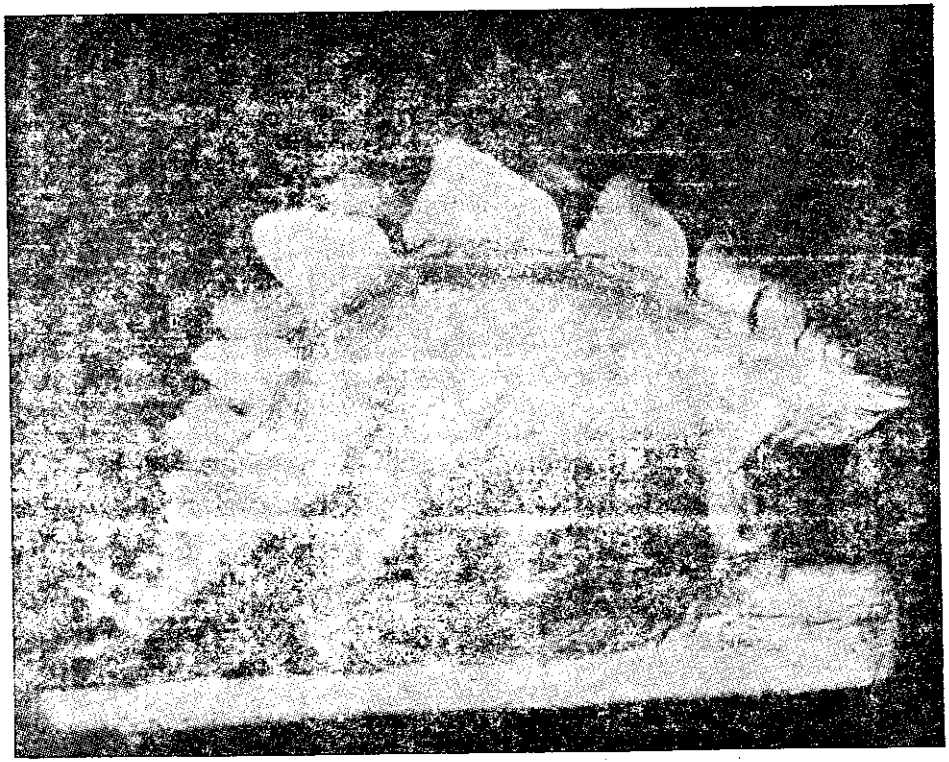
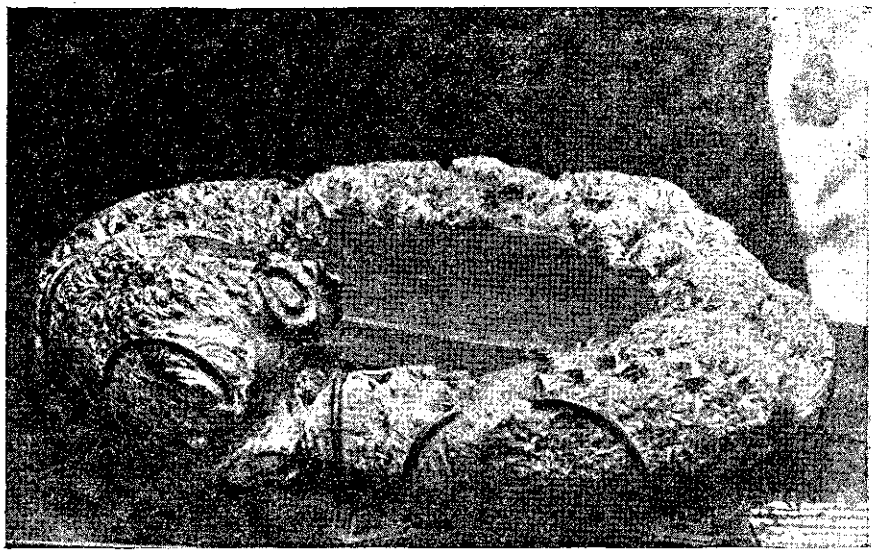


FIG. 24 STEGOSAURUS

FIG. 25 TRICERATOPS



IG. 26_ AMMONITE (Pachydiscus peramplus)

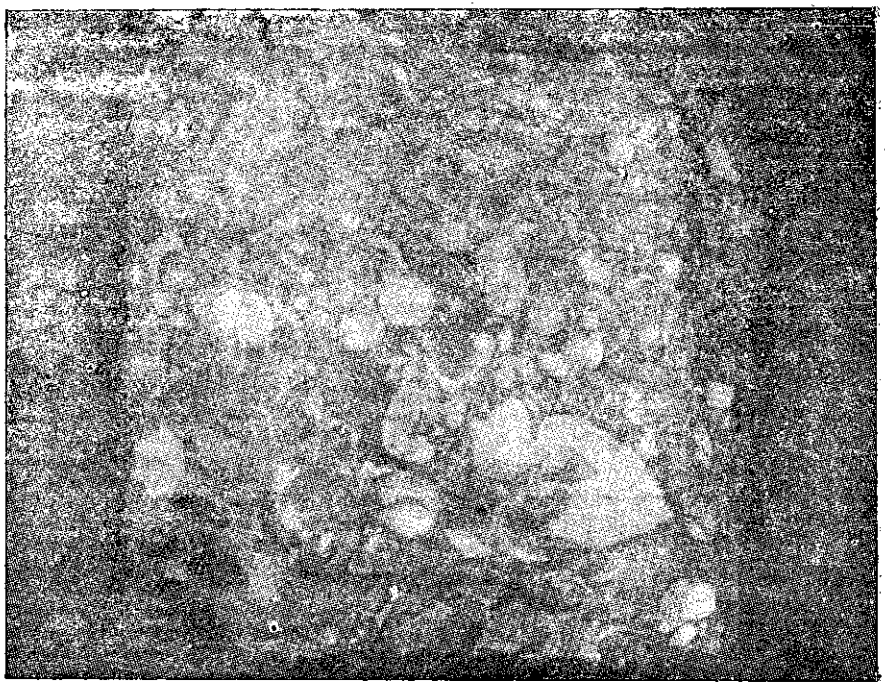


FIG. 27 SHELLS EMBEDDED IN LIMESTONE

VIII. ECONOMIC GEOLOGY

Economic Geology deals with the economic aspects which is the core of geology. As this branch of geology is highly important, both for the public and the scholar, the cases in the central portion of the hall and on the left wing of the mezzanine floor above are entirely devoted to it so that the public in particular may get to know the various raw-materials which are employed in industries. In certain cases products derived from the raw-materials are also on display.

In the modernised built-in show-cases situated at the central portion of the geology hall which consists of 21 cases, exhibits pertaining to gold, silver, various ores, refractories and their products, mica, gem stones, building stones, coal, radioactive minerals, abrasives, pigments, pencil manufacture and ceramics have been exhibited. Each case is provided with bilingual captions and the exhibits in each are described below.

(i) *Earth's Treasures.*—This is the front modernised show-case which the visitor will see on entering the Geology Gallery. Representative specimens from the remaining 20 modernised show-cases have been selected and displayed in this case so as to introduce the visitors as to what they would find in the other cases. In short it is an introductory case. Interesting specimens such as mica, asbestos, calcite, gypsum, coal, rock crystal, agate, varieties of clay, ores of iron, copper, lead, aluminium, chromium, etc., have been displayed and the uses of each specimen are indicated on their label. A few of the specimens in this case are models made from plaster of Paris. For want of those specimens such models have been displayed and they would be re-placed as and when such specimens are obtained.

(ii) *Gold and Silver.*—Gold is neither the rarest nor the most valuable metal. It is generally found in quartz veins. Occassionally it occurs in sediments where it has been re-deposited. It may also occur in metamorphic rocks.

Gold occuring separately in blue quartz and white quartz have been exhibited. There is also a specimen of blue quartz with gold from South Africa. Among the specimens exhibited, special attention may be drawn to the auriferous quartz specimen (gold bearing quartz specimen) containing abundant gold. This quartz is of the blue variety. A descriptive label and a flow sheet explain the process of extracting gold.

The chief ore minerals of silver are native silver, argentite, cerargyrite, polybasite, proustite and pyrargyrite. Silver is most commonly associated with ores of lead, zinc and copper. A specimen of native silver is on display.

It is needless to explain the various uses of gold and silver as they are too well known.

(iii) *Ores of rare metals.*—In this case various ores containing rare metals have been displayed.

(iv) *Ores of common metals.*—Ores of common metals have been displayed in two cases. The first case contains ores of aluminium, copper, lead and tin. The second case contains ores of manganese, chromium, mercury and antimony.

Aluminium.—Bauxite is the only ore from which aluminium is obtained commercially. Various types of bauxite are on display. Among them specimens from Yercaud, Salem and Berijam, Kodaikanal have been displayed. The uses of aluminium are very well known. Its chief uses are in the manufacture of household products, aeroplanes, steamlined trains, automobile parts and electrical goods.

Copper.—The chief economic ores of copper are native copper, chalcopyrite, bornite, chalcocite, covellite, enargite, tetrahedrite, tennantite, cuprite, tenorite, malachite, azurite, chrysocolla, antlerite, brochantite and atacamite. Very few varities of copper ores are on display among which the specimens of chalcopyrite are the most interesting ones.

Copper ores generally occur as replacements or cavity fillings formed by hydrothermal solutions.

Copper is chiefly employed in electrical industry and in the manufacture of alloys such as brass and bronze. It is also a very essential metal for military purposes.

Lead.—The economic ores of lead are galena, cerussite and anglesite. They are almost always found associated with zinc ores and they are rarely free from contained silver. Specimens of galena are on display.

Lead ores generally occur as cavity fillings and replacements formed by low temperature hydrothermal solutions.

The chief uses of lead are in the manufacture of pipes, sheets, pigments, alloys, ammunitions, solders, collapsible tubes, sheathing for electric cable and radioactive protection equipments.

Tin.—The principal tin ore of commerce is cassiterite or tinstone as it is commonly called. The other tin ores of minor importance are stannite and teallite. Tin ores commonly occur as placer deposits, stockworks and as fissure veins.

Cassiterite is a dioxide of tin crystallising in the tetragonal system. It commonly occurs in massive form with reniform shape and as pebbles and grains. It is commonly brown or black in colour and its streak is white, brownish or greyish. It is a heavy mineral with a specific gravity varying from 6.8 to 7.1. The hardness varies from 6 to 7. The fracture is sub-conchoidal to uneven and its lustre is glassy to adamantine.

Wood tin is a variety of cassiterite.

Both cassiterite and wood tin are on display.

Tin is chiefly used for coating tin cans inorder to protect the iron of the can from rusting and also in the manufacture of alloys.

Manganese.—The important ores of manganese are pyrolusite, psilomelane, manganite, hausmanite, rhodonite and rhodochrosite. Except for hausmanite and rhodochrosite, the rest of the ores are on display.

Manganese ores generally occur in sedimentary, metamorphosed and hydrothermal deposits and as residual concentrations. The major portion of the world's supply is obtained from sedimentary and residual deposits.

Manganese ores are chiefly used in the manufacture of steel, dry batteries, paints and varnishes, pigments, dyes, glass, ceramics, chemicals and fertilizers. Manganese metal is used in the manufacture of many kinds of alloys.

Chromium.—Chromite is the only ore from which chromium is obtained. The specimens exhibited include both fine and medium-grained varieties.

Chromite ore is used in the manufacture of refractories. The metal, chromium, is mainly used in the manufacture of stainless steels, various alloys and chemicals. Chromium alloys are tough, hard and strong. They are not easily oxidised, abraded or attacked by chemicals.

Mercury.—The economic ores of mercury are cinnabar, metacinnabarite and calomel. Of these cinnabar is on display.

Cinnabar is a sulphide of mercury usually occuring in massive form. It is bright red to brownish red in colour and its streak is scarlet. Cinnabar is a heavy ore with a specific gravity of 8 to 8.2 and a hardness of 2 to 2.5. Its fracture is subconchoidal to uneven and the lustre is adamantine to dull.

Mercury ores are formed from hydrothermal solutions and are typically found near volcanic rocks.

Mercury is the only metal which is liquid under ordinary temperatures. It is used in the manufacture of thermometers, scientific instruments, electrical instruments, vapour lamps, dry cell

batteries, explosives, chemicals, insecticides and fungicides and in medicine. It is also used for recovering gold and silver by amalgamation.

Antimony.—The most important ore of antimony is stibnite or antimony glance. Lead ores also contain large percentage of antimony.

Stibnite is a trisulphide of antimony commonly occuring as veins associated with quartz. The veins usually occur in granitic rocks. The other minerals associated with it besides quartz are other antimony compounds, galena, sphalerite, silver ores, pyrite, etc. The colour and streak of stibnite is lead-grey to steel-grey. Its hardness is 2 and the specific gravity varies from 4.52 to 4.62. The fracture of stibnite is sub-conchoidal and the lustre is metallic to splendent.

Antimony is used in the manufacture of hard lead, type metal, various alloys, antimony salts and compounds.

One of the most important use for metallic antimony is for hardening lead.

Hard lead is used for storage battery plates, cable coverings, chemical lead pipes, acid chambers, siphon taps and stop cocks for sulphuric acid bottles.

As an important ammunition material hard lead is used in the manufacture of sharpnels and shells, in lead filled bullets and in shotgun ammunition.

Antimony compounds are used for flame-proofing, pigments, enamels, safety matches, glass, vulcanizing and medicine.

(v) *Iron ores.*—The economic iron ore minerals are magnetite, hematite, limonite and siderite. All the four types of ores are displayed in this case. The banded hematite with red jasper bands, specular hematite from Kurnool, limonite from Salur Taluk

and the crystalline siderite from Masulipatam are some of the interesting specimens. Magnetite—quartzite from Kanjamalai, Salem district is also on display.

(vi) *Iron.*—This case contains mainly photographs pertaining to iron manufacture.

(vii) *Refractories.*—Refractories are materials which can withstand high temperatures without fusing. They are very essential to industries like the metallurgical and ceramic industries wherein high temperature operations are involved.

Refractory minerals in general should have a very high melting point (above 1500° C) and should neither expand nor shrink upon heating. Neither should they crack or spall when heated and cooled suddenly or slowly. They should be fairly light and sufficiently hard and tough to withstand the weight and wear of molten metals and slag. They should be inert to chemicals and should be capable of being made into any standard shape.

The most important refractory minerals are andalusite, bauxite, beryl, chromite, diaspore, dolomite, fire-clay, graphite, kyanite, magnesite, mica schist, monazite, olivine, pinnite, sericite, sillimanite, soapstone, spinel, talc, topaz, tripoli, zircon, quartz, sand, sandstone and quartzite.

Many of the specimens listed above are on display.

(viii) *Refractory products.*—Two cases are set apart for refractory products. The exhibits in them include products made from fire clay and magnesite.

(ix) *Mica* (Fig. 28).—The different types of mica described under minerals have been very attractively displayed in this case. Photographs of the muscovite mica mines at Nellore district in Andhra Pradesh are also exhibited. The pegmatite rock with books of muscovite mica is a noteworthy specimen.

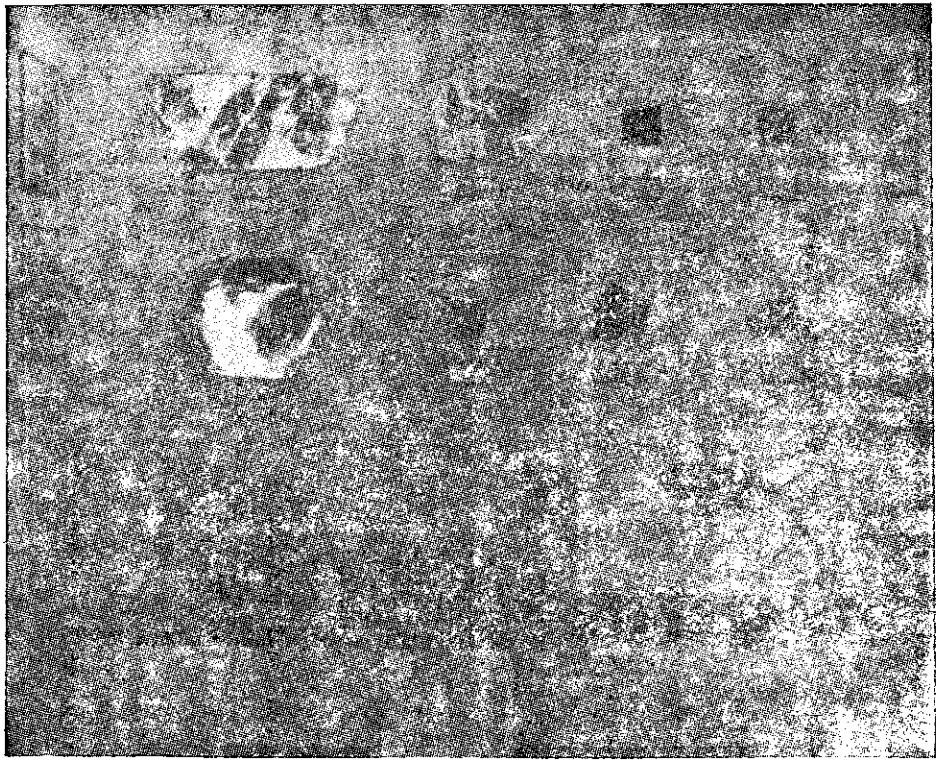


FIG. 28 VARIETIES OF MICA DISPLAYED IN THE MODERNISED SHOWCASE

(x) *Gem stones.*—Gem stones are used for personal adornment and ornamental purposes. A perfect gem stone should be transparent, beautiful' to look at in colour, durable, rare, costly and possess good lustre and high refractive index. Such stones are called precious stones. Those which are common and cheap and those lacking any of the above said qualities are treated as semi-precious stones.

Diamond, emerald, ruby, sapphire and precious opal are the important precious stones.

The important semi-precious stones are topaz, aquamarine, spinel, garnet, tourmaline, peridot, zircon, chrysoberyl, quartz, turquoise, feldspar, jade, lapis-lazuli, agate and carnelian.

Various semi-precious stones are displayed in this case.

(xi) *Building stones.*—The various types of rocks used in the construction of buildings, dams, roads, etc., and for ornamental paving and roofing purposes are termed as building stones.

Building stones in general should be strong, durable, compact, dense and free from pores, cracks and joints. Flint or cherty concretions, mica segregations, pyrite in appreciable quantities and tremolite should not be present in them as these minerals cause injury to the stone.

Rocks containing cherty concretions tend to split along the lines of concretions. Further as flint and chert are harder than the surrounding rock they are more resistant to weathering due to which they stand in knotty relief on weathered surface giving an ugly appearance.

Mica is not harmful when it is scattered in the rock. It is injurious only when it is segregated forming patches. Such segregations give an ugly appearance to the rock and when present along the bedding planes, the rock tends to split on continued exposure to frost.

Pyrite, too, is not harmful when it occurs in minor amounts and well distributed in the rock. It is injurious only when it occurs in appreciable quantities. Pyrite when exposed to weather decomposes and changes into limonite. Due to this pits are developed in the stone. Further, when limonite is washed down, reddish brown stains are produced on the surface of the rock thereby giving a very ugly appearance. Sulphuric acid is also produced when pyrite decomposes. This acid will attack the carbonates if present in the rock.

Tremolite on exposure to weather changes into clay which is easily washed away thereby producing pits on the surface of the stone.

Igneous, sedimentary and metamorphic rocks are used as building stones. Some igneous and metamorphic rocks such as granite and gneiss are amongst the strongest with a very high degree of crushing strength. Medium-grained and compact rocks are stronger than the coarse ones.

The various rocks which are used as building stones are granite, charnockite (blue granite), diorite, syenite, gabbro, dolerite, trachyte, rhyolite, andesite, sandstone, quartzite, limestone, marble, serpentine, slate, gneiss and laterite. Many of these are exhibited in this case.

Polished rock specimens used in the construction of the Maharajah's Palace at Mysore are also displayed in another case. Elsewhere in the gallery, both in the ground floor and on the mezzanine floor, polished cubical stones of various rocks are exhibited. Polished slabs of marbles of various colours from Madukarai, Coimbatore district and that of the serpentinous stones are embedded in the wall at the far end in the ground floor.

Stones used for ornamental purposes should have a pleasing colour. Light coloured stones are, therefore, preferred to dark coloured ones.

(xii) *Neyveli Lignite.*—Lignite from Neyveli, South Arcot district, Tamil Nadu, has been exhibited in this case.

Lignite occuring at Neyveli is of drift origin, i.e., vegetation which grew at some place was drifted and deposited at the present place where they got converted into lignite. Lignite seams occur at a depth of 180 feet from the surface. Nowhere does it outcrop on the surface. The seams are lenticular and wavy in character. The thickness of the seams vary from 13 feet to 80 feet. Below the lignite seam there are artesian aquifers under high pressure. Kaolin, refractory clay and pottery clay occur in the over-burden above the seam.

Reserves are estimated to be about 2,000 million tons over a total area of 100 square miles. It has a very high moisture content and a very low ash content. Due to the high moisture content and the property of spontaneous combustion it cannot be stored or transported over long distances. In order to facilitate this they are made into the form of briquettes. On carbonising the briquettes various by-products such as char fines, middle oil, tar, phenol, etc., are obtained.

Interesting specimens of lignite are on display. One specimen contains semi-decomposed leaves, another contains semi-decomposed leaves and barks, yet another contains semi-decomposed barks and wood and finally we have the specimen with semi-decomposed wood alone. Briquettes made in foreign countries such as Switzerland and Germany from Neyveli lignite are also on display. The carbonised briquette and the briquette made with the combination of magnetite and lignite are of interest. The iron ore, magnetite, used for making the latter briquette is from Salem district. Among the charts on display special attention may be drawn to the coloured chart showing the section of strata at pit No. 3 at Neyveli.

(xiii) *Coal.*—Coal is a very important fuel. It has been formed by the accumulation of large quantities of vegetation in shallow waters in the geological past which were subsequently covered by beds of mud, sand and other sediments. Due to the heat and

pressure produced by the deposition of sediments the vegetable matter was gradually carbonised. Depending upon the nature of the vegetable matter, degree of carbonisation and nature of sediments above the accumulated vegetation, various types of coal were formed. Peat, lignite or brown coal, bituminous coal and anthracite are the important varieties of coal.

Peat is the first stage in the formation of coal. It contains partly decomposed vegetable matter which can be easily seen. It is soft, light in weight and brown in colour. It burns with little heat and produces a great deal of smoke.

Lignite is also known as brown coal. It represents the intermediate stage between peat and true coal. It is dark brown in colour and burns with great amount of smoke. It is composed mostly of woody matter.

Bituminous coal represents true coal. Vegetable matter is not ordinarily visible. There are two varieties in this coal—coking coal and non-coking coal or free-burning coal.

Coking coal is used for making coke. It is black in colour and has a shining appearance. When heated it swells and forms into a soft, spongy mass called coke.

Non-coking coal or free-burning coal burns with great heat and little smoke and does not coke. It is black and not so bright as the coking variety. It breaks into cubical or prismatic blocks.

Anthracite is the last stage in the formation of coal. It is jet-black in colour, extremely hard with a brilliant black lustre and does not soil the fingers. It is difficult to ignite this coal. When ignited it burns with a blue flame and does not produce smoke. The heat produced is very great.

The above mentioned varieties of coal except anthracite are displayed in this case. Photographs of coal mines at Kargali and Jharia and a chart illustrating the important organic

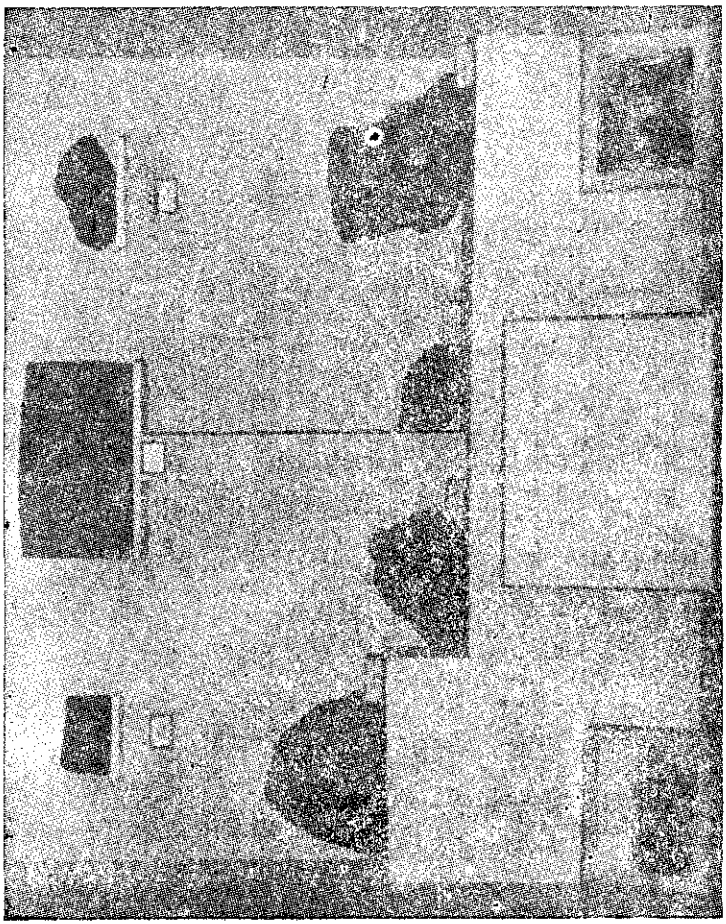


FIG. 29 VARIETIES OF COAL DISPLAYED IN THE MODERNISED SHOW-CASE

products obtained from coal are also on display. (Fig. 29) Anthracite is exhibited under Mineralogy. On the mezzanine floor there is a huge specimen of coal showing horizontal banding.

(xiv) *Radioactive Minerals.*—Minerals containing uranium and thorium elements have been displayed in this case.

The important uranium bearing minerals are uraninite, pitchblende, carnotite, torbernite, autunite and uranophane. Uranium bearing minerals are classified as primary and secondary minerals. Primary minerals are those minerals which were deposited during the original period or periods of metallization. Secondary minerals are those minerals formed by the alteration of primary minerals. Primary minerals are dark in colour whereas secondary minerals are brightly coloured, the common colours being yellow, orange or green. Among the uranium minerals listed above uraninite and pitchblende are primary minerals. The remaining minerals are secondary minerals.

Primary minerals commonly occur in veins and pegmatites. Secondary minerals are usually found in irregular flat-lying deposits of sedimentary rocks.

The important thorium bearing minerals are monazite, thorianite and thorite.

Uranium and thorium minerals are used in the manufacture of atomic weapons, in nuclear energy projects, in medicine, in agriculture, in photography, in industries, etc.

The exhibits displayed in this case are uraninite with allanite, carnotite, torbernite, autunite, euxenite, monazite, thorianite and samarskite. A plaster model of pitchblende is also on display. There is also a disintegration chart showing the various stages in which uranium disintegrates. The final product of its disintegration is lead. Photographs of geiger counter and scintilating counter, the two types of instruments used for dedecting radioactive minerals, are also exhibited

Uraninite is a dioxide of uranium with thorium, lead, helium, argon, etc. It crystallises in the cubic system. It is velvety black to grey in colour and its streak is black to dark olive green. The fracture of uraninite is irregular to conchoidal and its lustre is sub-metallic, greasy, pitch-like or dull. The hardness varies from 5 to 6.5 and the specific gravity is high ranging from 8 to 10.5.

Pitchblende is a massive variety of uraninite and is lighter than uraninite.

Uraninite and pitchblende occur in primary vein deposits in igneous and metamorphic rocks and in sedimentary rocks. They are commonly associated with the primary ores of iron, copper, cobalt, lead, silver and bismuth. If they occur in weathered zones they are commonly accompanied by secondary uranium minerals.

Carnotite is a vanadate of potassium and uranium. Most commonly it occurs as soft, powdery aggregates or in thin films or stains on rocks. It is the most important secondary uranium ore mineral. It is lemon yellow in colour and its streak is yellow. The mineral is not very hard and can be easily scratched with the finger nail. Its specific gravity is about 4 and the lustre is earthy. Carnotite does not exhibit fluorescence under ultra-violet light.

Torbernite is a hydrated phosphate of copper and uranium crystallising in the orthorhombic system. Crystals are usually tabular. It also occurs in micaceous and foliated forms. The mineral is emerald green or grassy green in colour and its streak is paler than its colour. The lustre of torbernite is pearly on cleavage planes and sub-adamantine elsewhere. Its hardness varies from 2 to 2.5 and the specific gravity is about 3.5. It is fluorescent under ultra-violet light.

Torbernite is the most common secondary uranium mineral and is found associated with primary uranium minerals.

Autunite is a hydrated phosphate of calcium and uranium crystallising in the orthorhombic system. It commonly occurs as small, flat, translucent crystals which may be square, rectangular or octagonal in shape or as thin coatings or stains on the surfaces of rocks and minerals. It is lemon yellow or apple green in colour and its streak is pale yellow or green. The hardness of autunite varies from 2 to 2.5 and its specific gravity is about 3.1. Under ultra-violet light it fluoresces with a brilliant yellow to greenish yellow colour.

Autunite is commonly found associated with torbernite and is a secondary product of the primary uranium minerals. It is commonly found in pegmatites.

Monazite is a phosphate of cerium and other rare earths, Thorium and uranium are also present in it, the percentage of the former varying from 1 to 15 per cent. It is yellow, yellowish brown, red brown, or greenish in colour and its streak is colourless, yellow or pale brown. The hardness of monazite varies from 4.9 to 5.3. Its fracture is conchoidal to uneven and the lusture is resinous.

It is commonly found as small grains concentrated in sands and gravels along rivers and beaches. It is also found in large masses in granitic and syenitic pegmatites.

Thorianite is chiefly an oxide of thorium and uranium crystallising in the cubic system. It is a black, greyish or brownish mineral with a grey or greenish streak. Its hardness varies from 5 to 7 and the specific gravity is high which is about 9.3. The lustre of thorianite is sub-metallic to greasy.

Among the thorium bearing minerals thorianite is the richest thorium mineral and it may contain upto 33 per cent U_3O_8 Thorianite containing 15 per cent or more U_3O_8 is called uranothorianite.

Thorianite occurs in pegmatites, granites and gneisses.

Euxenite is a niobate and titanate of yttrium, erbium, cerium and uranium crystallising in the orthorhombic system. It commonly occurs in massive form. Its colour is black and its streak is brown to yellow. Hardness of euxenite varies from 5.5 to 6.5 and the specific gravity ranges from 4.5 to 5.9. Fracture is sub-conchoidal and the lustre is vitreous to earthy.

Euxenite occurs in pegmatite veins.

(xv) *Pigments.*—Some of the naturally occurring minerals and rocks are used as pigments in the manufacture of paints, plasters, stucco, cement, mortar, rubber, plastic, colour washes, linoleum, etc. Some of them are directly used as pigments and some others after burning or subliming them. Some mineral pigments are manufactured from ore minerals such as ilmenite, galena, etc.

White pigment is obtained from white clay, chalk, marble, limestone, talc, tremolite, gypsum, barite, ilmenite, galena and sphalerite.

Black pigment is obtained from graphite, magnetite, black slate or shale and coal.

Red pigment is obtained from red ochre, hematite and red slate or shale.

Yellow pigment is obtained from yellow ochre.

Brown pigment is obtained from brown ochre, umber.

Yellowish brown pigment is obtained from limonite.

Green pigment is obtained from green earth and chromite.

Many of the minerals and rocks listed above are represented in this case.

(xvi) *Abrasives.*—Abrasives are those materials which are generally employed in industries for grinding, sharpening and polishing purposes. They are broadly divided into natural abrasives and artificial abrasives.

Natural abrasives include various minerals and rocks. They are divided into three groups namely the high grade abrasives, siliceous abrasives and miscellaneous abrasives. Diamond, corundum, emery and garnet are high grade abrasives. Siliceous abrasives include quartz, quartzite, novaculite, sandstone, flint, chert, sand, tripoli, pumice, diatomite and quartz mica schist, Miscellaneous abrasives are calcite, dolomite, feldspar, fuller's earth, kaolin, magnesite, bauxite and talc.

Most of the above mentioned minerals and rocks are displayed in this case.

Natural abrasives may be used either in the natural state, e.g., sand or after shaping, e.g., millstone or after being ground and made into wheels or paper.

Many of the natural abrasives have been replaced by artificially prepared ones. Artificial abrasives are silicon carbide, fused alumina, boron carbide and metallic abrasives.

Silicon carbide.—This is more popularly known as Carborundum. It is made by fusing coke and silica sand in an electric furnace.

Fused alumina.—This is made by fusing bauxite, coke and iron in an electric furnace. In trade it is commonly known as Alundum, Aloxite, etc.

Boron carbide.—This is made from coke and dehydrated boric acid in an electric furnace.

Metallic abrasives.—Steel shots, crushed steel and steel wool are the metallic abrasives. They are made from special irons and steels.

Abrasives are largely used in industries. The automobile industry is said to be the largest consumer of abrasives.

(xvii) *Pencil*.—In this case the various stages in the manufacture of ordinary pencils starting from the raw material graphite have been exhibited. Woods used in pencil manufacture are also on display.

In the manufacture of ordinary pencil graphite is crushed to powder and then refined and sieved. The sieved powder is mixed with fine clay in water and ground into a mixture. Moisture in the substance is then squeezed out by subjecting the latter to hydraulic pressure. The plastic mass so obtained is drawn through an apperture of the chosen size and form. The string-like bits that come out from the apperture are dried to form the lead. The bits of lead are then baked out of contact with air in kilns.

In the case of copying pencils anilin dye is blended with graphite before the latter is shaped in to lead.

In the case of coloured pencils, kaolin, some gums and waxes and the colouring material are ground together and drawn into leads and the use of graphite and the process of baking are dispensed with.

Any light wood that can be easily cut with a knife can be used in making pencils. But in this respect the cedar wood, however, commands a certain amount of preference. Whatever be the wood that is chosen, it is first cut into small slats which are then planed and grooved. Next, sandwiches are formed by gluing two slats together by their grooved faces keeping the baked bits of lead in the resultant tube-like, central, blank spaces. Machines divide the sandwiches and shape the bits into single pencils.

(xviii) *Ceramics*.—The photographs in this case show the various stages in the manufacture of ceramic objects, beginning with the important raw materials and ending with glazed, finished products. Specimens of the important raw materials used in the manufacture of ceramics and some ceramic products are also on display. The descriptive label and the flow-chart explain the process of manufacturing ceramic objects.

IX. MEZZANINE FLOOR.

On the left wing of the mezzanine floor above the geology hall, Economic Geology exhibits pertaining to glass, lenses, clays, saltpetre, sulphuric acid, cement, fertilizers, lithographic stones, core samples containing coal from Kattavakkam, Chingleput district and some miscellaneous specimens are displayed in sloping cases and table cases. Products too are exhibited in some cases.

(i) *Glass.*—Exhibits pertaining to glass are displayed in six sloping cases. The first case contains quartz sand, sieves used in sieving the sand and the various coloured glasses obtained from quartz sand. A chart explains the various materials to be added to the sand for obtaining different colours. If quartz sand is not available, quartz can be crushed and used. In the manufacture of glass, the sand used should be free from iron or may contain only traces of it. The raw sand is first passed through sieves of 30, 40 or 80 mesh per square inch. The quality of the product depends on fineness of the sand. The sievings are washed and mixed with soda, borax, lime and arsenic in certain definite proportions. A predominance of soda results in what is called soda glass which is of inferior quality. The pyrex glass in which borax predominates is very hard and heat-resistant. In the manufacture of coloured glass, a colouring agent is also added. The whole mixture is then fused in a tank furnace in making colourless glass. For coloured glass, a pot-like furnace (called by virtue of its pot-like compartments) is used.

The fused mixture is directly utilized for making miscellaneous glass wares in general or collected in cylindrical moulds and cast as cylinders. These cylinders are broken into small pieces, called block glass and transported to other factories as raw materials for making glass bangles and beads.

The second case contains exhibits pertaining to glass beads. In the manufacture of glass beads, pieces of block glass of the same colour are fused together into a single lump; and when the lump is still hot and plastic it is pressed into a slab which is

later melted and cast into rods. One end of the rod is strongly heated over a flame and the hot molten drops from the same are collected as gatherings on a brass wire with a coating of china clay. The gatherings are shaped by turning them in hot iron moulds, into spherical or oval beads or by pressing them between hinged moulds into beads with square faces. The beads are gathered and strung together to form necklaces.

The tiny black glass beads from Pappayanaidupet, Andhra Pradesh is of special interest as they have been very skillfully made by hand by the natives of that place. The beads are just as tiny as a mustard, each having a hole and they have been strung to a thread.

The third case exhibits bangles. In the manufacture of bangles, pieces of block glass of the same colour are fused together into a single lump, and when the lump is still hot and plastic, it is pressed into a slab.

What are known as Belan bangles, are manufactured by strongly heating the slab in a pot furnace and pulling and drawing it out as a thin rod. While this rod is hot and flexible, it is wound on an advancing and rotating cylinder. It is allowed to cool and form a spiral. Each coil of the glass spiral thus formed is cut-up into an open ring. Both the ends of each such ring are then fused over a flame and that completes making of a Belan bangle.

What are known as Tarapore bangles, are manufactured by sandwiching and fusing glass rods of different colours between two of the block glass slabs. Keeping the whole combination plastic in a pot furnace, one end of the sandwich is little pulled, twisted, turned back and again twisted and drawn out as a long, thin, twisted glass rod. The different colours used, thus get spirally arranged in the rod. It is cut into smaller rods which are made into crude bangles by heating, bending and fusing the two ends together. The crude bangles are perfected by heating and pressing them hard on clay cones.

In the fourth and fifth cases, some more glass products such as glass sheets, chimneys, tubes, bottles, scientific instruments; fibreglass wool, thread and cloth; etc., are displayed.

For making glass sheets, the molten glass from a tank furnace is sent, when it is still hot and plastic, between a pair of closely-adjusted and hot rollers with absolutely smooth surfaces. In consequence, the material comes out as a glass sheet from between the rollers.

For making chimneys, tubes, bottles, etc., one end of a hot iron pipe is dipped into a sufficiently hot, molten glass in a tank furnace. The pipe is taken out and air is blown into it from the other end, thus developing a bubble of glass. The bubble is placed in a hot iron mould to the form required (chimneys, tubes, etc.). At the same time the pipe is kept slowly turned and air is also blown in. After cooling, the glassware in its full-blown form is taken out of the mould. Scientific apparatuses are also manufactured by heating and combining glass tubes in various ways. The tube can be constricted at a given point, by turning that point over a flame; or it can be bulged out by heating it at the given part and at the same time, by blowing air through one end and keeping the other end closed; or it can be bent at will by heating and bending it at the given part. Products prepared by blowing glass are annealed (or heated a second time in separate kilns), which process gives uniform thickness to the glass.

Fibreglass is used as an insulation material. Fibreglass reinforced plastics are stronger than steel and lighter than aluminium.

The sixth case contains photographs pertaining to glass manufacture.

(ii) *Lenses.*—In ancient days spectacle lenses were made from rock crystal. Specimens of rock crystal and lenses made from it are displayed in this section. A photograph shows how rock crystal pebbles were cut and ground at Tanjore for making spectacle lenses.

(iii) *Clays.*—Adjacent to lenses in the same case are the exhibits pertaining to clays which are exhibited in two sloping cases. Various types of clays together with some products made from them are on display.

(iv) *Saltpeter, Sulphuric acid and Cement.*—Exhibits pertaining to saltpeter, manufacture of sulphuric acid and cement are displayed in one sloping case.

Saltpeter, also known as nitre, is a potassium nitrate used for fire works and in the manufacture of explosives, fertilizers, soaps and matches and in glass and ceramic industries. It is colourless, white or grey in colour and occurs as thin granular crusts or masses, or as minute needle-like crystals and as a thin coating on soils and rocks. It deflagrates violently on heating, dissolves readily in water and has a saline taste.

Crude saltpeter, refined saltpeter, nitrous earth containing saltpeter and educed earth obtained after refining saltpeter are on display.

The chief mineral required for the manufacture of sulphuric acid is sulphur. Pyrite or iron pyrites as it is commonly called is also used in the manufacture of sulphuric acid in place of sulphur. Both these minerals are on display. Pyrite crystals are shown occuring in a slab of calcareous shale from Nandyal, Kurnool district, Andhra Pradesh.

The chief raw materials required for manufacturing cement are limestone, clay or shale and gypsum. Limestone should not contain more than 10 per cent magnesium oxide and it should be free from pyrite and free silica. Oyster shells and marl can also be used in place of limestone. The clay or shale should contain 20 per cent SiO_2, Al_2O_3 and Fe_2O_3 and 5 per cent magnesia, alkalies, etc. The purpose of gypsum is to prevent too rapid setting.

The exhibits displayed include photographs of a cement factory at Madukarai, Coimbatore district, Tamil Nadu.

(v) *Fertilizers.*—Fertilizers are materials which are used to enrich the soil for the proper growth of plants. Their functions are many.

The chief mineral fertilizers are potash minerals, sodium nitrate, phosphate rock, phosphatic marl, phosphatic limestone, sulphur, gypsum, greensand, magnesite, borax and epsomite.

The specimens exhibited in the gallery are apatite, phosphorite, phosphatic nodule, gypsum, magnesite, feldspar and halite.

(vi) *Lithographic stone.*—Limestones and dolomites used by lithographers, for engraving designs on them in order to print them on paper, are called lithographic stones. They are used in the form of rectangular slabs. Such stones are extremely fine-grained, compact and homogeneous. They are generally grey, blue or yellow in colour and break with a sub-conchoidal fracture.

According to Merill, a good stone must be sufficiently porous to absorb the greasy compound which holds the ink and soft enough to work readily under the engraver's tool, yet not too soft. It must be uniform in texture throughout and be free from all veins and inequalities of any kind inorder that the various reagents used may act upon all exposed parts alike. It is evident therefore that stability of this stone for practical purposes depends more upon its physical than its chemical qualities. An actual test of the material by a practical lithographer is the only test of real value.

Specimens of limestone, dolomite and rectangular slabs used by printers are displayed in this section.

(vii) *Core samples.*—Core samples of Kattavakkam, Chingleput district, have been recently acquired from the Geological Survey of India containing coal in certain of the samples and they are displayed in the sloping show-case adjacent to the one containing lithographic stones.

(viii) *Miscellaneous.*—Some miscellaneous exhibits have been exhibited at the far end. Among them, the cubical rock salt specimens, the large coal containing banding and the cubical soapstones (from Salem, North Arcot and South Canara) are of special interest.

A special feature to be noted in coal is that of the clear horizontal bandings.

Common salt obtained from sedimentary rocks is called rock salt. It usually occurs as very extensive deposits either as single beds of salt or interbedded with gypsum, anhydrite, clay, dolomite, etc. Single beds of salt several hundreds of feet thick are common.

In India, massive beds of rock salt occur in the salt range. The salt is pink to white in colour. Some of them are translucent or transparent.

Two translucent cubical specimens of pink and white rock salt are on display.