Understanding the Natural World through the Use of the Earth Science Kit

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Abstract

School Science is an agglomeration of the three basic disciplines of science viz., physics, chemistry and biological sciences. Little attempt has been made so far in the curriculum, specifically to understand the dynamic processes of the Earth to comprehend and appreciate the wonder and awe of nature, observations of which have led to conceptualisation of the intricacies of science itself in human history. The inclusion of Earth Science in science curriculum can be a strong option to understand science holistically. The National Curriculum Framework 2005 highly recommended the use of the science kit for effective learning, through hands-on, minds-on learning approaches. In this regard, an attempt has been made to facilitate an understanding of the earth and its various processes of dynamism by developing an Earth Science Kit. This Earth Science Kit helps in understanding the many facets of nature and phenomenon of Earth. Different activities related to the Earth's behaviour have been compiled in the kit to quench the thirst of insatiable minds.

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Introduction

Humans have always been curious about the world around them. The inquiring and imaginative human mind has responded to the wonder and awe of nature in different ways. One kind of response from the earliest times has been to observe the physical and biological environment carefully, look for any meaningful patterns and relations, make and use new tools to interact with nature, and build conceptual models to understand the world. This human endeavour has been conceptualised as Science, (*NCERT Position Paper on Teaching of Science* 2005, p. 1). Yet, school science is basically an agglomeration of three basic disciplines of science viz., physics, chemistry and biology. Very little attempt has been made so far to understand the dynamic processes of the Earth and the universe to understand science holistically at the school level. A closer look for example, at one of the basic disciplines of science, say physics, reveals that its foundation revolves around the general analysis of nature. Physics is a branch of fundamental science because the subject of study of all branches of natural science like chemistry, astronomy, geology and biology are constrained by the laws of physics.

Geology or Earth Science as a subject, however has been neglected over the years as a part of the school curriculum, although many concepts of science have evolved from observation of the Earth and Nature itself. It is felt that a better understanding of the Earth, universe and its processes even at the school level would do wonders in helping students conceptualise science.

It will always be better if a student knows and comprehends certain geological or natural aspects. For example, while the universe evolved around 16 billion years ago, our Earth was born 4,600 million years ago. Our Earth also took a long time in terms of millions of years, to generate the lithosphere, the hydrosphere, the atmosphere and finally, the biosphere. As soon as life sprouted on Earth, biological evolution was also triggered. Our Earth is still dynamic, both internally as well as externally. As a consequence of internal dynamism, we experience earthquakes, plate movements, volcanism, while climatic variations for example, are manifestations of external dynamism. When a common man enjoys the beauty and awe of nature, seldom does he/she realise how much time and pain it took for the Earth to evolve and shape its splendour. It is felt that if this effort of nature is realised by the students, our future generations will act reasonably and the goals of sustainable development will definitely be attained.

In this backdrop, the designing and development of an Earth Science Kit was conceptualised at the North East Regional Institute of Education, NCERT with the help of a few Earth scientists of the region.

Science Curriculum

Science is a dynamic, expanding body of knowledge, covering ever new domains of experience. The curriculum should engage the learner in acquiring the methods and processes that lead to the generation and validation of scientific knowledge, and nurture the natural curiosity and creativity of the child in science. To ensure holistic understanding of the physical world, the integrated curriculum of science should highlight the dynamic processes of the Earth under a different unit of science as earth science or geology and thus, portray the unified nature of science. The curriculum, in the process will provide opportunities to the learners to attain some basic levels of scientific literacy on Earth Science.

Development of the Earth Science Kit

To ensure that science plays an emancipative role in the world, students should be engaged in learning science as a composite discipline at the secondary stage. Compared to the upper-primary stage, more advanced technological modules need to be designed so that learning can be joyful, and achieved by engaging the mind, hands and tools. Science education in India is still far from achieving the goal of equity, enshrined in our Constitution. The development of science corners and providing access to science experimentation kits and laboratories, in rural areas are also important ways of equitably provisioning for science learning (NCF 2005). No reform, however well motivated and well planned, can succeed, unless a majority of teachers feel empowered to put it in practice. To empower the teachers to handle Earth Science effectively, an Earth Science Kit was developed at the North East Regional Institute of Education, NCERT.

Special Features of the Earth Science Kit

Keeping in mind the standard of readers, a total of 37 activities (Table 1) are incorporated in the Earth Science Kit.

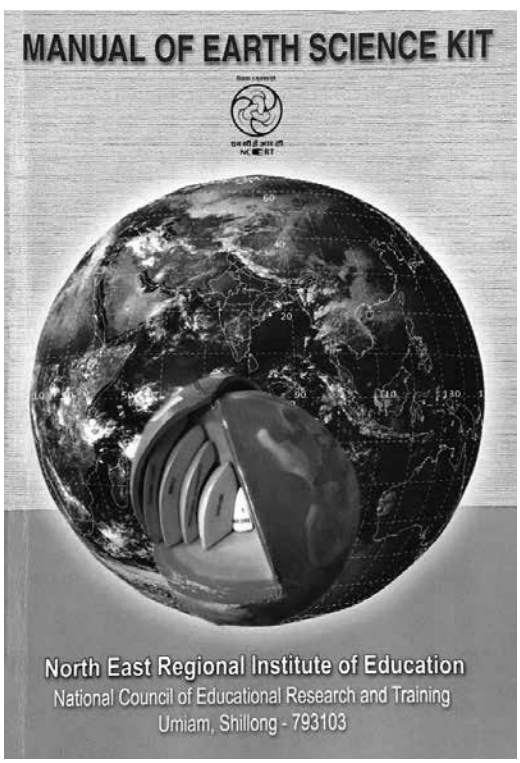

Figure 1. Manual of Earth Science Kit developed at NERIE

Table 1

List of Activities Incorporated in the Earth Science Kit

S.No.	Activity
1.	Appreciating the beauty of our Earth from space
2.	Looking at Earth from different elevations
3.	Viewing various natural Earth features from space
4.	3-D view from stereophotographs
5.	Understanding the Earth and its interior
6.	Earth as a magnet
7.	Did the continents drift?
8.	Plate tectonics theory
9.	Knowing about earthquakes
10.	Volcanoes—windows to the interior of Earth
11.	Locating a point on the Earth's surface
12.	Determine the geographical north-south direction and locate yourself
13.	Sketch, map and directions
14.	Scale of maps
15.	Overlapping maps
16.	Understanding time
17.	Understanding natural crystalline and amorphous substances
18.	Understanding common rock forming and ore forming minerals
19.	Understanding the types of rock: igneous, sedimentary and metamorphic
20.	Identifying sandstone, limestone and shale
21.	Understanding rock structures
22.	Geological time scale
23.	Let us make fossils
24.	Let us play with fossils
25.	Understanding fossils
26.	Petrified wood—what is that?
27.	Understanding drainage pattern
28.	Understanding watershed
29.	Deserts: the abode of sands
30.	Climate zones of the world
31.	Climatic regions of India
32.	Soils of India

33.	To determine pH of the soil and level of acidity in soil
34.	To determine the 'available nitrogen' status of the soil
35.	To determine the 'available phosphorus' status
36.	To determine the 'available potassium' status
37.	Knowing crude oil and its by-products

Activities are drawn from the space and the Earth's external as well as internal dynamism and related phenomenon. This Earth Science Kit helps in understanding the Earth's three layers that is, below the surface, on the surface and above the surface. A manual (Figure 1) has also been developed to carry out the different activities with the equipments in the kit.

The activities in the manual are structured in such a manner that the students can question, explore and finally, discover the concepts involved. The manual is based on an approach, wherein attempts are made to inculcate scientific enquiry and understanding of the subject matter among the students. In the process of doing the activities using the Earth Science Kit, not only will the students feel the excitement, but it will also give them the opportunities to comprehend subject matters which may not be achievable by a reading of the textbooks alone. The success and usefulness of the kit with the manual will depend on how best the teachers can motivate the students to use the items, rather than a mere demonstration by them. Of course, this requires time and keen interest on the part of the teachers as well as the students, to know the unknown and the science behind the natural phenomenon. It is hoped that the teachers would also enjoy making use of the kit and the manual.

Enlisted herewith are a few activities to reflect the attributes and objectives of the manual. Shown

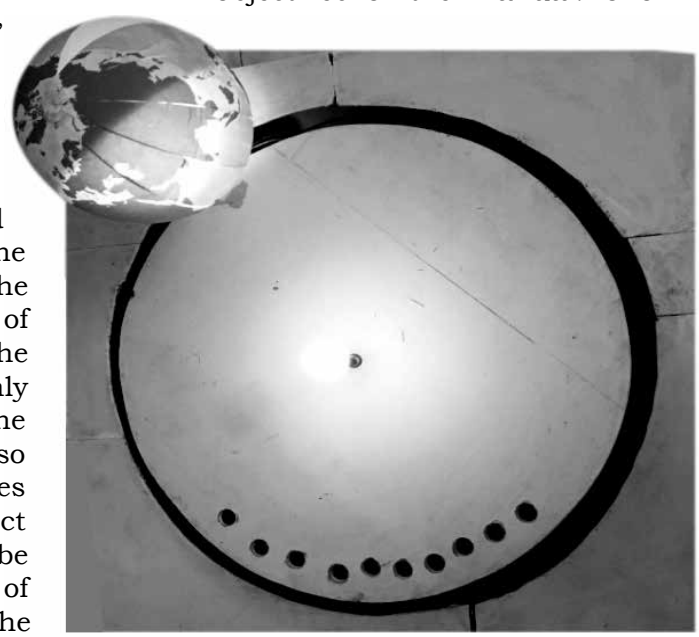

Figure 2. A mechanised model to explain the Earth's rotation and revolution

below for example, in Figure 2 is a model to explain the rotation and revolution of the Earth around the Sun in a slightly elliptical orbit. When the model is switched on, the Sun at the centre remains stagnant and the Earth rotates as well as revolves around it. The tilt of the Earth's axis is also shown. This model explains the variations in solar insolation on the Earth's surface. The Sun is shown as a small body here as it is 150 million kilometres or 0.000016 light years away from the Earth. The concept of time variations across Earth can also be worked out from this model.

Above the Surface

Under this, the activities have been prepared in such a manner that the students would identify how the topography of the Earth looks like from the space or atmosphere, and why it looks so.

Activity—3-D View from Stereophotographs

Objectives of the activity

- To visualise the 3-D view of an area using a stereoscope
- To understand the depth perception which is visualised through the stereoscopes

What is required to perform this activity?

- A lens stereoscope and a stereo pair
- Preliminary knowledge of what a lens stereoscope and a stereo pair are

How will we proceed?

- Let us check the lens stereoscope given in the box along with the stereo pairs. We then try to describe the lens stereoscope and stereo pairs (stereophotographs).
- Let us fix the given stereo pair in a flat surface (on a table).
- We open and place the stands of the stereoscope on the stereo pair.
- Let us look into the stereo pair through the stereoscope and adjust the eye piece according to your eye base (distance between both the eyes).
- Then we look into the stereo pair for sometime till we get the 3-D view of the terrain.
- Once we get the 3-D view, we can describe the features with regard to the area and slopes.

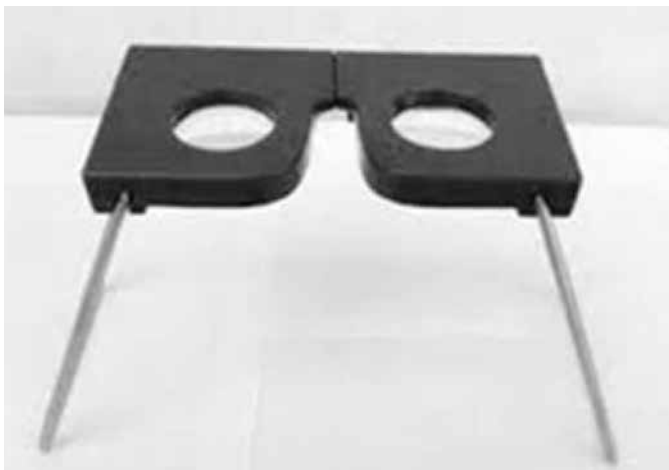

Figure 3. A simple lens stereoscope

What have we learnt?

- When we look at two photographs of the same area taken from two different points using a stereoscope, a three-dimensional model of the area can be viewed.
- The same principle is applied when we view the 3-D film in a cinema hall by wearing 3-D glasses.
- The depth perception which is visualised through the stereoscopes can be explained by the principles of parallax.

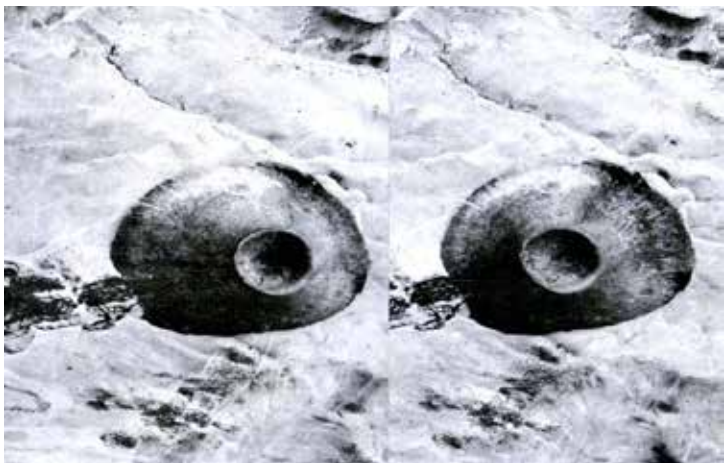

Figure 3(a). Stereophotograph of a volcanic cone
(Source: Miller and Miller 1961)

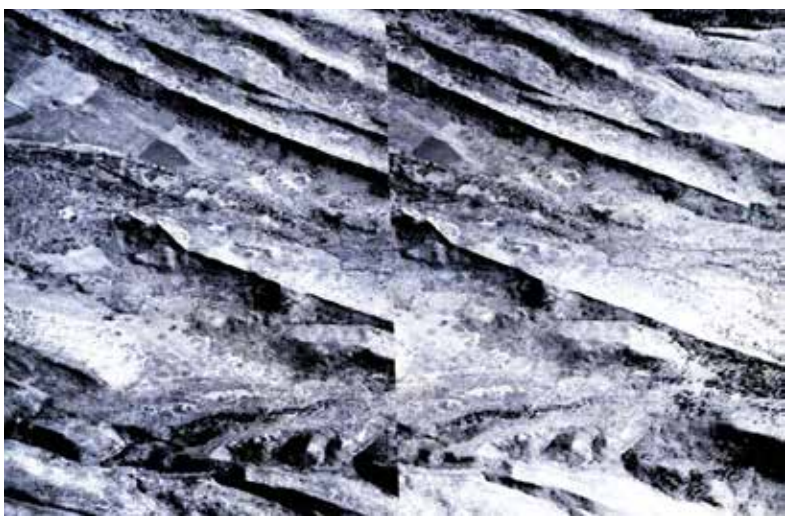

Figure 3(b). Stereophotograph of an area having ridges and valleys
(Source: Miller and Miller 1961)

Below the Surface

Under this, activities have been prepared in such a manner that the students would identify some attributes of the Earth's interior.

Activity—The Earth as a Magnet

Objectives of the activity

- To identify that the interior of our Earth comprises three big units—crust, mantle and core
- To understand that the rotation of Earth at a very high speed produces a magnetic field
- To identify that the magnetic field of the Earth trends north-south

What is required to perform this activity?

- We need to have a magnetic 3-D globe model. A magnetic 3-D globe has been developed and given in the kit.

How will we proceed?

- We need to know that our Earth has three major layers—crust, mantle and core. The core has a lot of iron and nickel and its outer part is liquid. We know that our Earth revolves around the Sun as well as rotates around its axis at a very high speed. Do you know the speed of rotation of our Earth?
- You must have seen a bicycle fitted with a head lamp. Have you noticed how the lamp glows? The more you speed up your bicycle, the more will the light glow brilliantly. Try to understand the mechanism with your science (physics) teacher's help. Have you heard about the Oersted experiment? Observe the figure given below. In figure 4(a), the magnet is aligned parallel to the Earth's magnetic field when the circuit is not switched on. As soon as the current flows, the magnet gets deflected. Now observe figure 4(b). This means that when an electric field is generated, a magnetic field is also triggered at right angles. Let us now relate this with our Earth. Our Earth rotates at a very high speed similar to a generator producing electricity. As such a magnetic field is also generated within the Earth, which is very important.

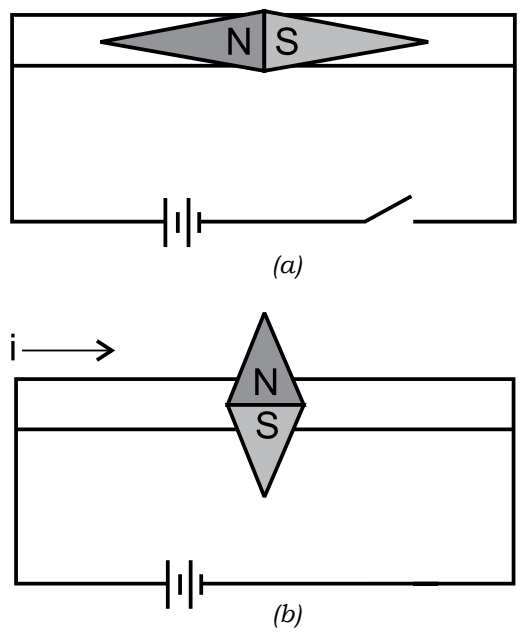

Figure 4(a–b). Electromagnetic framework to carry out Oersted experiment

- You will find it interesting to know that our Earth has two poles—the geographic north-south and the magnetic north-south. Both the poles do not overlap with each other in the sense that the magnetic pole is a little deviated from the geographic pole. When you place a small compass on your palm, it points to the magnetic north.

- You may do another small activity. Bring two bar magnets close to each other. What do you observe? Both the magnets may be parallel to each other but they are aligned opposite to each other, isn't it? This is because, like poles repel. Now, when we place a compass and note the north direction, is it the actual north of the compass? In fact, what the compass needle points to is the geographic north and that end is the south end of the compass.
- Let us take the 3-D globe provided in the kit and hold the metal rod with our right hand. With your left hand, put a small compass on top of the globe very close to it. We observe that the magnet is almost parallel to the north-south trend of the globe. Now let us swing the

Figure 5. Magnetic globe of the kit

globe on a soft surface left and right. We will observe that the magnet also gets deflected. This model has been prepared to help one understand that the Earth is a big magnet which deflects magnetic material.

What have we learnt?

- The interior of our Earth comprises three big units—crust, mantle and core.
- The Earth rotates at a very high speed and like a generator, it produces a magnetic field.
- The magnetic field of the Earth trends almost north-south.

Activity: Let us Play with Fossils

Objectives of the activity

- To understand the fact that fossils of different ages are not seen within a single rock layer
- To understand that fossils and the rock layers within which the fossils are found, are of the same age
- To estimate the age of the rock layers from the embedded fossils and identify the beds chronologically

What is required to perform this activity?

- Pottery clay or plasticine
- Container to make dough
- Water
- Fossils that you had made
- Permanent marker pens or colours of different shades
- Small plastic toys of different creatures, preferably as shown in the geological time scale chart under Activity 22 (see Table 1) may be used.

How will we proceed?

- Use the fossils that you made in the earlier activity.
- Let us make pottery clay dough by mixing requisite quantity of water in the container or plasticine, in good amounts.
- Now let us flatten the dough and make layer(s) as shown (Figure 6(a) and (b). We can add different colours to the clay layers too.
- Let us insert the fossil toys within the clay layers as shown in Figure C. We have to be careful while inserting fossils into the layers.
- Look at the pictures of organisms shown below. Check their names and their age from the geological

Figure 6(a). Layers that can be made out of pottery clay or plasticine.

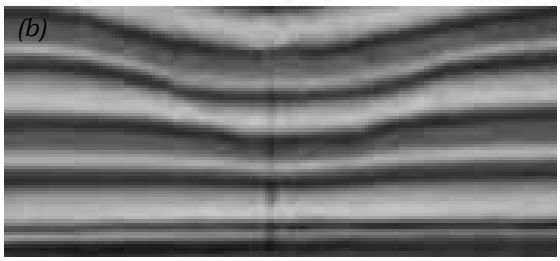

Figure 6(b)

time scale chart. Can we put all these organisms in a single layer?

- Let us try to make fossils of different ages and repeat this game.

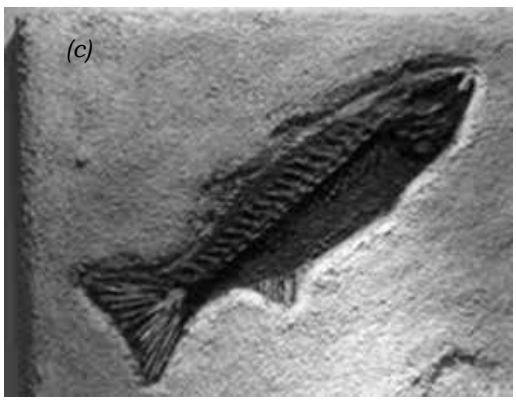

Figure 6(c). Shows how fossils may stay embedded in rock layers.

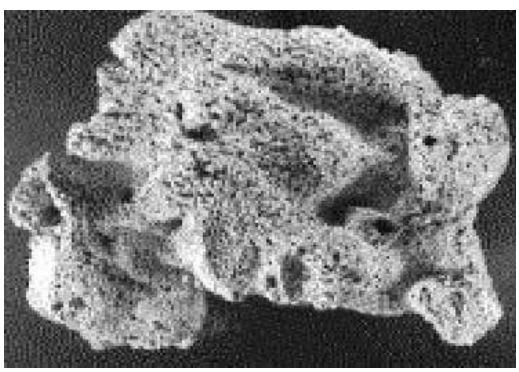

Figure 6(d). Sponge

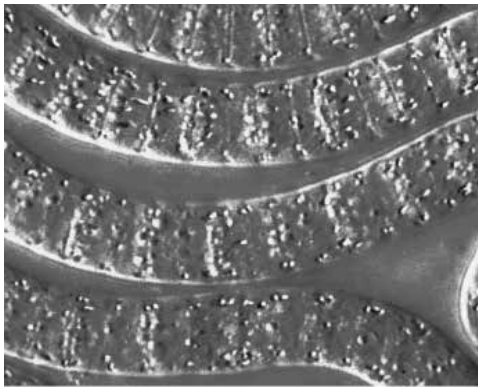

Figure 6(e).Cyanobacteria

Figure 6(a–e). Different fossils which inhabited our Earth in the geologic past

- Can we try to know what is meant by the concept 'superposition of strata'?

What have we learnt?

- Usually, fossils of different ages are not seen within a single rock layer usually
- Fossils, and the layers of rock within which the fossils are found, are of the same age.
- The age of the layers of rock may be known from the embedded fossils.
- In layered sedimentary rocks, the lowermost layer is usually the oldest.

On the Surface

Under this, activities have been prepared in such a manner that the students would identify some attributes of the Earth's exterior.

Activity—Overlapping maps

Objectives of the activity

- To understand that soil is a degraded product of rocks

- To understand that hilly areas (in the present case) are composed of hard rocks while there is soft alluvium near the river.
- To understand that there are different soils in different regions because of differences in the nature of the underlying rocks

What is required to perform this activity?

- We need to know that functionally, maps can be of different types.
- We need to have different functional maps of the same scale, tracing paper, scale and pencil, eraser, etc.

How will you proceed?

- We have with us three maps of Kamrup district of Assam—relief and slope, rocks and minerals, and soil [Figures 7(a), 7(b) and 7(c)].
- Let us trace the soil map on a tracing paper.
- Let us overlap the traced map over the relief map and the rocks' and minerals' map.

What have we learnt?

- The soil is a degraded product of rocks.
- Hilly areas (in the present case) are composed of hard rocks while near the river, there is soft alluvium. Accordingly, the distribution of rocks and minerals vary.
- You find different soils at different regions because of differences in the nature of the underlying rocks.
- *Note for teacher: A student may ask about transported soil.*

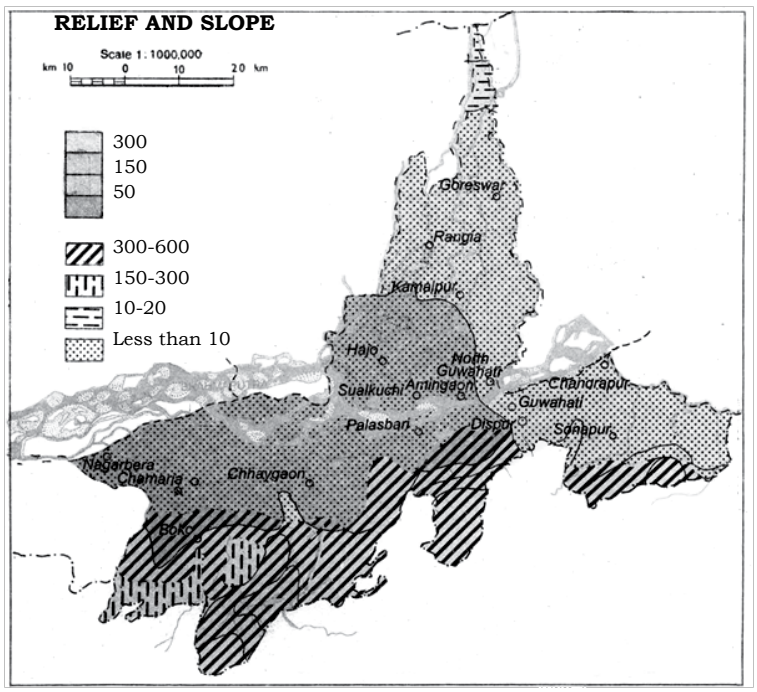

Figure 7(a). Relief and slope map of Kamrup district, Assam
Source: National Atlas and Thematic Mapping Organisation (NATMO), Geological Survey of India and Directorate of Geology and Mining, Assam

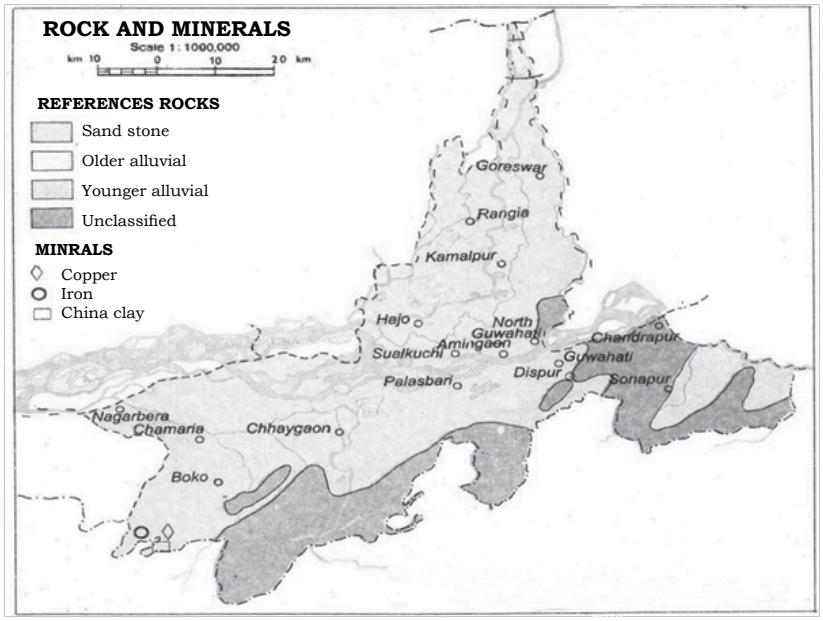

Figure 7(b). Rocks and minerals map of Kamrup district, Assam
(Source: NATMO, Geological Survey of India and Directorate of Geology and Mining, Assam)

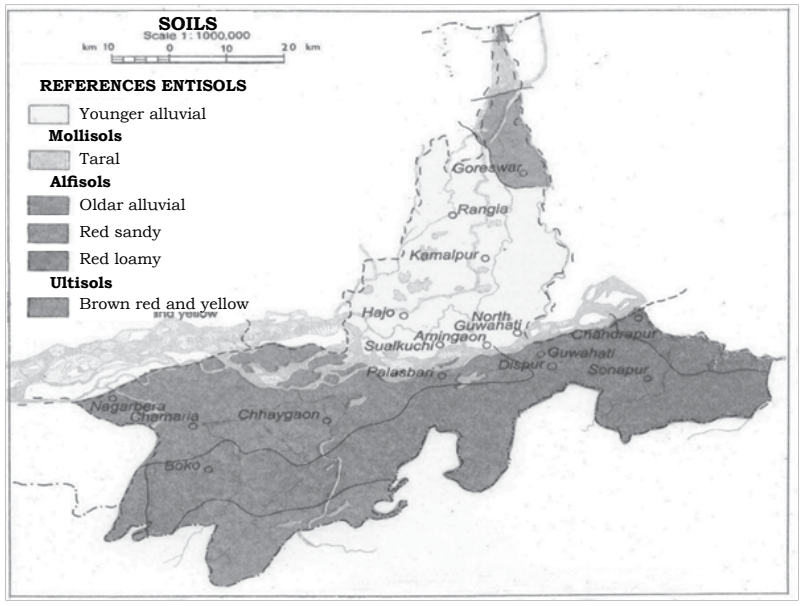

Figure 7(c). Soil map of Kamrup district, Assam
(Source: NATMO, Geological Survey of India and Directorate of Geology and Mining, Assam)

Conclusion

The process of education and attainments thereof, has an impact on all aspects of life. The use of the science kits has been highly recommended in NCF 2005 for effective learning through hands-on, minds-on learning approaches. The focus on improving learning levels would need improvement in classroom processes, child-centric activities in classrooms, larger recruitment of better educated younger teachers and cluster level leadership created among teachers, rather than relying on school administrative support structures and personnel.

The Earth Science Kits will be an essential alternative to the lack of any equipment to comprehend earth science in the schools and will serve as a supplement to the textbooks for introduction of Earth Science as a part of composite science at the secondary level. The kits have the following advantages—

- understand and apply the basic concepts of Earth Science;
- learn scientific enquiry skills of gathering information;
- user-friendly;
- portability from one place to another; and
- low cost and use of easily available resources.

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