LOCALITY, MATERIAL AND METHODS

Locality:

The area under investigation forms a part of the famed richly fossiliferous belt of Neogene-Quaternary Sivalik sediments. It comprises of low hills exposed in the northeast of Chandigarh and falls in the jurisdictions of Punjab, Union Territory of Chandigarh and Haryana (Text Fig. 1). Its location can be marked on the Survey of India topo sheet numbers 53B/9, 53B/13 and 53 B/14. The tract is easily approachable by bus or other vehicles. Many small link roads connect the main roads with villages, around which different fossil localities are situated.

On the whole the area is underdeveloped and local inhabitants of the terrain are poor and less educated. Due
to the lack of water, agriculture is poorly developed. Consequently, people generally engage themselves in labour. Some people also hold lands which yield very little due to the unproductive type of soil, lack of irrigation facilities and the menace of wild animals. The farmers are completely dependent on rains for the irrigation of the crops. The major crops of the tract include maize, wheat, barley, grams and some sugarcane. The common means of transport within this area is camel.

In general, the area is dry and xerophytic conditions prevail. Major part of the tract is covered with thorny bushes, shrubs and wild grasses. In recent years, soil conservation wing of the Forest Department is seriously engaged to aforest the terrain in order to check the exceedingly fast rate of denudation of these hills. Particular attention has been paid to bring the catchment area of Sukhna Lake, which is fed by Sukhna and Kansal *Choes*, under plantation so as to minimise the inflow of silt in the lake. Besides constructing a number of small dams in the gradient of *Nullahs**, large-scale plantation of fast growing plant

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* Choe is a local word meaning seasonal ephemeral streams having intermittent flow and essentially a sandy bed.

**Locally, Nullah means a dry water course, which only temporarily becomes active, immediately after heavy rains.
varieties, e.g., *Eucalyptus*, has been made in the area drained by Sukhna and Kansal Choes. Consequently, a prominent part of this richly fossiliferous area has become difficult for fossil exploration due to thick vegetation. Sharma and Sharma (1966) reported more than 900 plant species from this region. The common plant types observed by the author include *Acacia arabica* (Kikar), *Acacia catechu* (Khair), *Acacia lucopolea* (Safed kikar), *Acacia modesta* (Phulai), *Zizyphus nummularia* (Ber), *Woodfordia fructicosa* (Dhanu), *Azadirachta indica* (Nim), *Dalbergia sissoo* (Sisham), *Mangifera indica* (Aam), *Eucalyptus* (Safeda), *Saccharum bengalense* (Sarkara), *Abrus precatorius* (Ratti), *Phoenix sylvestris* (Jangli khajur), *Phicus bengalensis* (Bur), etc.

The wild fauna in this tract which was once reasonably good is now scanty. Some wild animals, amongst others, encountered by the author are *Herpestes edwardsi* (Mongoose), *Vulpus bengalensis* (Indian fox), *Oryctolagus cuniculus* (Rabbit), *Funambulus pennantii* (Stripped palm squirrel) and *Sus cristatus* (Indian wild boar).

**Material and Methods** :

An area of about 160 square kilometers in the north-east of Chandigarh was explored for the recovery of vertebrate fossils. Various geological aspects were also studied with a view to understanding the past environmental conditions. The data collection for this work involved
Field investigations:

In all about six months of field work, spread over a period of four years, i.e., from 1975 to 1979, was carried out. Lesser vegetation and moderate weather conditions are the two main factors which make the first three months of the year most congenial to field work. During this period sustained efforts were made to collect vertebrate and invertebrate fossils, hand specimens of rocks for micropalaeontological and sedimentological studies, and to gather field information regarding various geological aspects.

A. Fossil collections:

Prior to commencing the actual fossil collection, preliminary traverses in different directions were taken to get acquainted with the area. Subsequently, the terrain was thoroughly combed for faunal and floral remains. The exposed slopes were explored from base to top as well as laterally along their trend, to recover fossil specimens. As a result, more than 500 fossil specimens, most of them in situ finds, have been collected and catalogued from a number of localities of the area (Text Fig. 2). Proper stratigraphic control was observed in case of surface finds. In gullies and very small Nullahs, where the rain-water transports and accumulates fossils, additional care was
taken to compare and match the matrix attached to the fossils in order to ascertain their provenance and, as far as possible, correct stratigraphic occurrence. Some of the partly visible specimens had to be quarried out of the beds. Large blocks of rocks with fossils embedded in them were reduced to the minimum possible size by removing matrix. Care was exercised to avoid fossil collection from main channels which preclude their proper stratigraphic placement. Besides, the specimens occurring in the main channels are often badly rolled thereby hampering their correct identification due to the erosion of significant morphological details. For invertebrate fossils, particular attention was paid to grey beds which yielded a rich crop of them.

The fossils recovered were moved to the field camp where they were tentatively identified and given numbers in the field catalogue. The precise locality, the stratigraphic position and the type of rock in which the fossils occurred, were recorded in the field catalogue. Subsequently, the specimens were wrapped in tissue papers or in other appropriate wrapping material and field catalogue numbers inscribed on them. The pieces of fossils occurring in a fragmented form were properly adhered together with appropriate adhesives. At the end of a field season, the fossil material recovered was transported to the palaeoanthropology laboratory of the Anthropology Department, Panjab University, Chandigarh, for preparation leading to their final identification.
B. Geological investigations:

Study of the rock sections of the area was conducted to gather information regarding the stratigraphy, structures and lithologies of various formations of Upper Sivalik Subgroup. Best sections were observed along the stream and Choe cuttings; some sections also occur along the road cuttings. Representative rock sections were measured with the help of a cloth tape and the details about the lithology and sedimentary structures of individual beds were recorded in the field diary. At places, the attitude of the beds was marked on the base map with the help of a clinometer compass. The location of the fossil localities and the places of rock sampling were also traced on the base map using clinometer compass. Fresh hand specimens, each weighing about 1.5 kg, of unconsolidated sandstones, siltstones and clays were removed from representative rock sections. The hand specimens were given identification numbers and packed in polythene bags. Fresh samples for micropalaeontological investigation were selected after careful examination of the hand specimens with a 10X pocket lens. Grey silty clay beds which exhibited small mollusks on surface yielded a rich harvest of microfossils.

All the measured rock sections and important localities were photographed with a 35 mm Honeywell Pantax camera holding a 50 mm normal lens. Photographs of various
structural features encountered in the field were also taken.

The essential equipment carried to the field by the author for the present study included a base map on 1:50,000 scale (prepared from the Survey of India topo sheet Nos. 53B/9, 53B/13, 53B/14), geological hammer, pick and hammer, ice picks, clinometer compass, camera with films, haversac, pocket lens, chisels of various sizes, polythene bags, field diary with pen and pencil, set squares, cotton rolls, tissue paper rolls, field catalogue book, cloth measuring tape, adhesives of various types, adhesive tapes, etc.

Laboratory investigations:

The material collected in the field was processed and systematically analysed in the laboratory. The laboratory work entailed the preparation of fossils before their ultimate identification, recovery of microfossils from the rock samples, mechanical analysis, roundness determination, and estimation of carbonate and other solubles, etc., of the rock samples.

A. Preparation of fossils:

Not all the fossils collected in the field are clean. Most of them either carry the matrix adhered to their surface or, in some cases occur embedded in a chunk of
competent arenaceous rock. Key to correct identification of fossils is a clean and properly prepared specimen. Small quantities of matrix or other foreign material can hide some finer and highly crucial details, leading to erroneous identifications and faulty interpretations. In view of this and depending upon the type and nature of a fossil and the adhering matrix, different techniques were employed to prepare the fossil specimens.

a. Chemical techniques:

(i) Washing: The fossil material transported to the laboratory was washed with tap water to remove loose matrix and dirt. In some cases, where the matrix was harder, the specimens were soaked in water for over a month so as to soften the attached sediments. Extra attention was paid to prevent any damage to the specimens due to prolonged absorption. In other cases, where the matrix was siliceous, the soaking of fossil specimens in a dilute solution of sodium carbonate proved very effective. At times, the use of acetone and alcohol, particularly in the case of dental material, was very helpful in denuding the surface. Some specimens were subjected to heating and cooling treatment, by immersing the specimens alternately in two beakers containing ice cold and hot water, to loosen the matrix. Appropriate care was exercised to avoid any kind of damage to the specimens.
(ii) Leaching with acids: Matrix with calcareous cementing material was removed by the use of dilute solution of acetic acid (5-10%). Being cheap, the acetic acid was preferred to formic acid. Strong acids, like Hydrochloric acid, were not employed for cleaning purposes which, though would have proved more effective and would have removed the matrix faster, could leach and damage the specimens.

b. Mechanical techniques:

Apart from making use of acids, the adhering rock material of many specimens was also taken away by mechanical methods. Larger specimens covered by a thick layer of sediments were preliminarily prepared by the use of steel chisels of various types and sizes, according to the nature of fossil and the attached matrix. Subsequently, the remaining matrix was removed by grinding, employing a Wolf's flexible shaft grinder and mounted stone points of various sizes and shapes. Small amount of matrix still sticking was eroded by various sizes of hard wire brushes. Finer details of the specimens, especially the teeth, were cleared by diamond bits and tungsten carbide bits mounted on a variable speed flexible shaft dental engine. Ordinary needles, dental scalers and tooth brushes were found to be very useful to remove matrix from such areas as narrow and deep valleys, fissures, etc., which were usually inaccessible to bits, etc.
Highly fragile and badly weathered specimens were repeatedly impregnated with dilute solutions of alcohol soluble impregnators to strengthen the specimens. Before identification, broken specimens were properly glued together with adhesives, such as Fevicol, Araldite, Quickfix, Pattax, etc.

B. Extraction of microfossils:

Bulk of the samples macerated to recover microfossils comprised of siliceous-clay and clay. Bigger lumps of sediments were broken to smaller pieces before heating them in water with one or two table spoons of sodium carbonate. The sediments were frequently stirred to avoid burning of the pot. Prior to boiling, the sediments were dried in oven to remove interstitial water which inhibits easy breakdown of sediments during boiling. The disintegrated sediments were washed with water through a battery of copper sieves, namely, 22, 44, 60, 85, 100 and 120 mesh. After washing, each sieve, along with the sediments, was transferred to electric oven for drying at about 80°C. A major portion of the microfossil assemblage, including ostracodes and charophytes, was extracted from 44, 60 and 85 fractions. The dried sample from each sieve was examined under a binocular stereozoom microscope to hand pick the specimens. The picking was carried out with the tip of a slightly wet '00' sable hair brush and the specimens were glued to
microfossil slides having a thin coating of dilute solution of gum. Majority of the microfossils picked were free from adhering sediments and did not require further cleaning.

C. Mechanical analysis:

About thirty representative friable sandstone samples from Tatrot and Pinjor Formations of the study area were subjected to mechanical analysis. Rock samples weighing 100 gm were soaked in water for about two weeks to disintegrate the sediments. The clay and silt fractions were gradually removed by repeated decantations till no clay or silt remained. Care was taken to prevent the flowing of sand grains during decantations. The sand fraction left in the beaker was dried and passed through a combination of copper sieves of 5, 7, 10, 14, 18, 25, 35, 45, 60, 80, 120, 170 and 230 mesh. The column of sieves was shaken continuously for about half an hour and the sand retained in each sieve was weighed.

D. Estimation of carbonate and other solubles:

Ten grams of representative sandstone samples with calcareous cementing material were digested with dilute hydrochloric acid to estimate the percentage of carbonate and other solubles. After digestion the residue was repeatedly washed and filtered using Whatman's filter paper
No.40. The residue was dried in oven and weighed. The loss of weight gave the weight of carbonate and other solubles.

E. Photography and sketching:

The fossil specimens were photographed in the laboratory under artificial light with 35 mm Asahi Pantax camera, fitted with normal lens. In case of smaller specimens extension tubes were also employed. Some of the fossils, e.g., a few Equus molars, had to be coated with a thin film of magnesium oxide for better results.

Sketches, of all specimens were made by the author himself. The abbreviations of the dental terms used in the sketches of fossil specimens are explained in Appendix-I. Microfossils were sketched, for identification purposes, with the help of camera lucida attached to a microscope.

F. Measurements:

Various measurements were taken on the fossil specimens with the aid of Accumeasures Vernier Caliper and Mitutoyo Vernier Caliper with least counts of 0.02 mm. All the measurements presented in this work are in millimeters. Bulk of the fossils considered here consist of maxillary and mandibular fragments and isolated teeth. Different measurements taken on them depending upon the fossil group,
are as under:

1. Maximum mesio-distal diameter.
4. Length of protocone.
5. Breadth of protocone.
7. Thickness of enamel.
8. Depth of mandibular ramus.

G. Statistics:

Keeping in view the type of mammalian dentition, the above measurements were subjected to the following statistical analysis:

i. Index

\[ \frac{\text{Maximum bucco-lingual diameter}}{\text{Maximum mesio-distal diameter}} \times 100 \]

ii. Height breadth index

\[ \frac{\text{Maximum crown height}}{\text{Maximum bucco-lingual diameter}} \times 100 \]

iii. Protoconal index

\[ \frac{\text{Breadth of protocone}}{\text{Length of protocone}} \times 100 \]