



RECORD OF BOVIDEAN FOSSILS FROM THE PINJOR FORMATION OF THE SIWALIK GROUP, SOLAN DISTRICT, HIMACHAL PRADESH

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ABSTRACT

A large number of mammalian vertebrate fossils including fossils of bovids were recovered from the sandy and silty horizons, especially from the horizontal or low-dipping beds of the Pinjor Formation of the Siwalik Group from a number of places in the Nalagarh area, Solan district, H.P. Recovery of fossils was more in the horizons where calcretised concretions are developed. Our fossil collection includes isolated molars, ramus fragments, horns and limb bones belonging to bovids, equids, cervids, proboscids, hippopotamids, felids, camelids and rhinocerotids. The fossils of bovids are quite abundant, both in number and generic variations mainly belonging to *Bos* sp., *Bubalus* sp., *Boselaphus* sp., *Gazella* sp. and *Sivaceros* sp. The fossil assemblage suggests that the area had grasslands and water bodies to support a rich and diverse bovid population during deposition of the Pinjor Formation.

Keywords: Vertebrate Fossils, Bovidae, Pinjor, Siwalik, Himachal Pradesh

INTRODUCTION

The Siwalik Hills representing the Sub-Himalayan foothill region, are made up of the rocks of the Siwalik Group (Neogene terrestrial sediments). These make the southern flank of the Himalayan ranges bordering the northern limit of the great Indo-Gangetic plain extending from the Indus River in the west to the Brahmaputra River in the east. The Siwalik rocks are rich in mammalian vertebrate fauna and have been used in the classification of the Siwalik rocks. Lydekker (1876, 1878, 1880a, 1880b, 1881, 1882, 1883, 1886) made detailed studies of the Siwalik vertebrate fossils; and divided the Siwalik rocks into Lower and Upper Siwaliks on the basis of faunal assemblage, and assigned a Pliocene age. Pilgrim (1910, 1911, 1926, 1932, 1939) made fossil collections from a much wider area in the Siwalik Group and carried out elaborate studies. Pilgrim correlated the Siwalik fauna with similar European faunas and adhered to the three-fold classification as suggested by Medlicott (1864). Later, a number of workers, Nanda (1973), Verma and Verma (1970), Gupta *et al.* (1981) studied vertebrate fossils of the Siwalik Group. Verma (1972, 1988, 1989) and Srivastava and Patnaik (2002) have made significant contributions in collection and identification of vertebrate fossils and marked many fossil localities in Himachal Pradesh. Verma (1981) has reported fossils of bovids from the Pinjor Formation around the Nalagarh area, Solan district, H.P. The main Siwalik mammalian fauna includes Carnivora, Proboscidea, Perissodactyla, Artiodactyla, etc.

A number of workers have collected and described the different bovidean fossils from the Siwalik Group of rocks of India and Pakistan (Colbert, 1935; Pilgrim, 1939; Bhatti *et al.*, 2006; Khan *et al.*, 2008). Baker (1843) described the fossil Bovidae collected by Falconer, Cautley, Baker and Durand.

The Siwalik rocks are rich in various types of bovids like boselaphines, caprines, reductines, antilopines, bovines, ovines, hipotragines, etc. In the present paper, only the fossils of bovids from the Pinjor Formation of the Upper Siwalik Subgroup from the Nalagarh area, Solan district, Himachal Pradesh are studied.

The present work was carried out in the Upper Siwalik rocks around Nalagarh *tehsil* of Solan District, Himachal

Pradesh (latitude 30° 55'00" – 31° 05'00"N and longitude 76° 32'00" – 76° 45'00"E). The Siwalik Group in the study area is the extension of Upper Siwalik belt exposed near the Pinjor area. The main localities from where the fossils were recovered are Jhiran, Lakhampur, Naharsingh and Mandiarapur in Solan District, H.P. (Fig. 1).

The fossil collection of the present study consists of isolated molars, ramus fragments, tusk fragment, horn core, scute, carapace, plastron, limb bone, coprolites, etc belonging to Testudinidae, Trionychidae, Bovidae, Equidae, Cervidae, Proboscidea, Hippopotamidae, Felidae, Camelidae and Rhinocerotidae. In the present paper, only the bovid fossils from the Pinjor Formation are dealt with. The rock successions were also measured at the major fossil recovery site (Fig. 2). Fossils were excavated from the surface and embedded material (*in situ* fossils) with the help of chisel, hammer, needles, knives, brushes, etc. The recovered fossil specimens were washed, cleaned and prepared in the laboratory with the help of vibrator and chisel. The fossil specimens were compared with the existing collections at Siwalik Fossil Park, Saketi, Sirmour, H.P.; fossil repository of G.S.I., Northern Region, Lucknow; catalogue of the Siwalik vertebrate fossils. The collected vertebrate fossils have been kept in repository of Palaeontology Division, GSI, NR, Lucknow.

GEOLOGY OF THE AREA

In the study areas, the Pinjor and Kalar (Lower Boulder Conglomerate) formations of the Upper Siwalik Subgroup are exposed. The stratigraphy of the area is as follows:

Pinjor Formation

It consists of the alternate sequence of red, pink and yellow clays, sandstone and siltstone. Clays are often concretionary in nature. All the fossils are collected from this formation.

Kalar Formation

The rocks of the Kalar Formation, earlier known as the Lower Boulder Conglomerate (Verma, 1996), are characterized by unconsolidated conglomerate (pebble bed), friable sandstone and siltstone. During the field work, no fossils could be recovered from this formation.

Table 1: Stratigraphy of the Nalagarh area (after Verma *et al.*, 2002).

Group	Subgroup	Formation	Lithology	Age
S	Upper Siwalik	Kalar (Lower Boulder Conglomerate)	Friable sandstone, sandy clay and interbedded conglomerate	Late part of Early Pleistocene (1.0 – 0.6 Ma)
I		Pinjor	Pink and red clay, siltstone, sandstone and very few conglomerate lenses.	Late Villafranchian (1.6 – 1.0 Ma)
W				
A				
L				
I				
K				

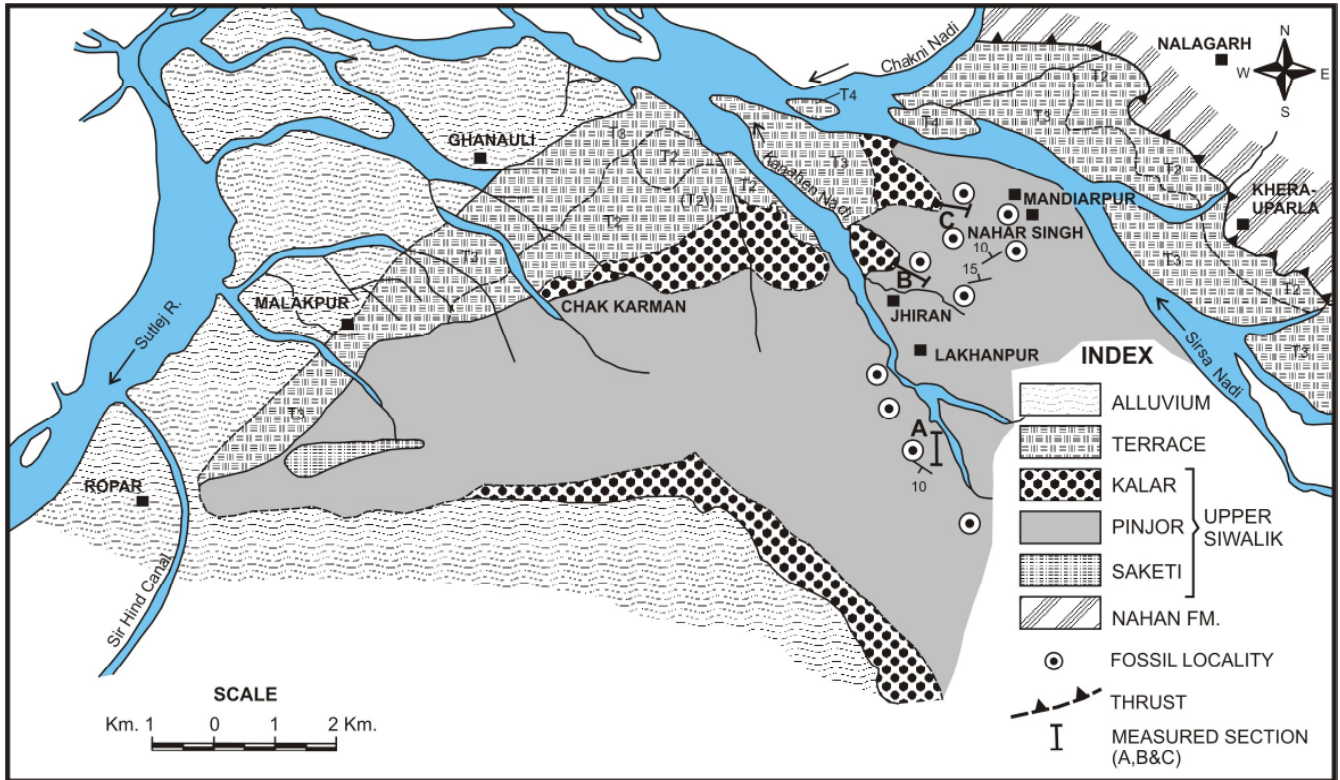


Fig. 1. Geological map of the Nalagarh area, Solan district, H. P. showing fossil localities (after Verma, 1981).

Three major fossil recovery sites, namely Lakhanpur, Jhiran and Mandiarpur (Fig. 2) were identified, and lithocolumns, prepared.

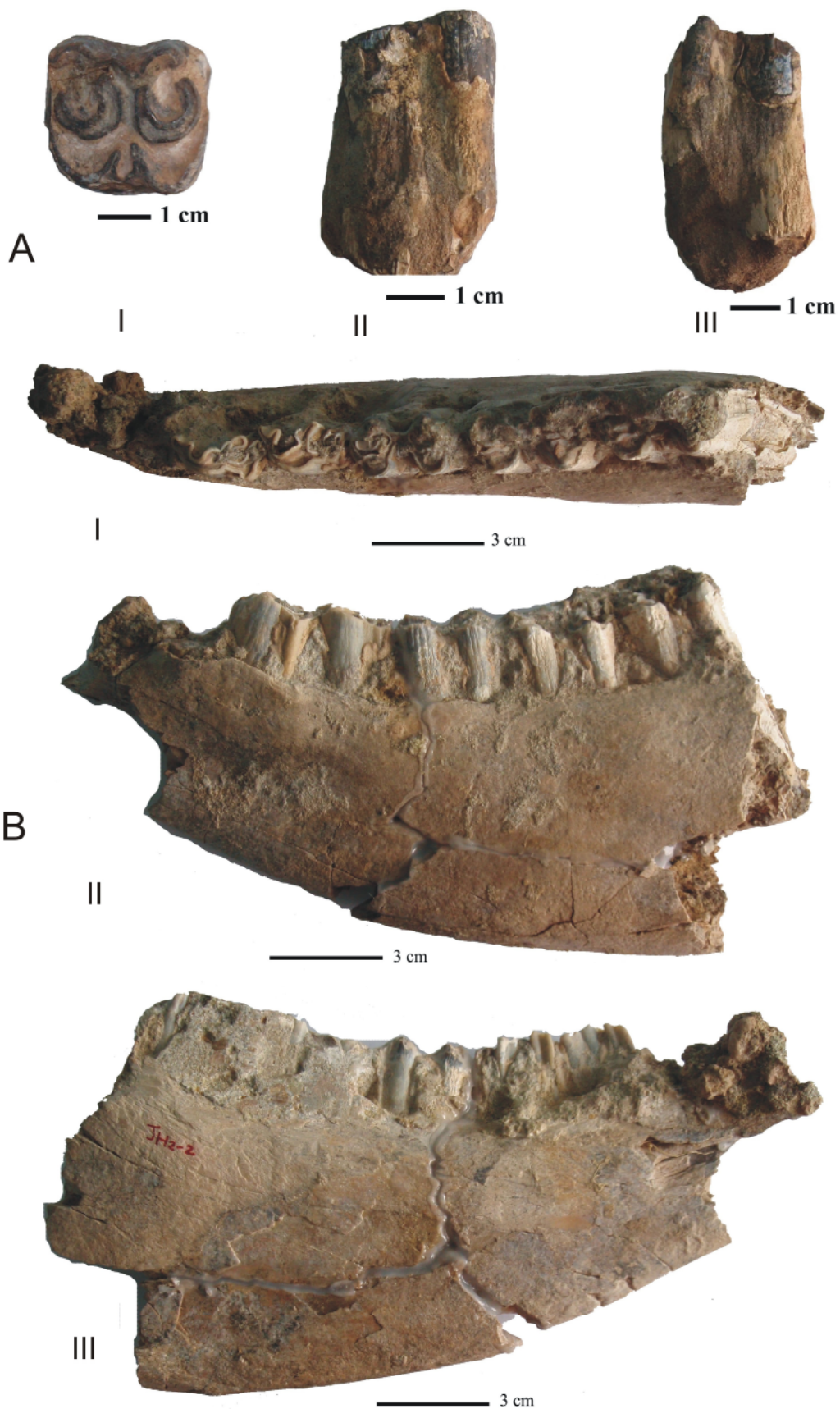
- A. **Lakhanpur Section:** It exposes the Pinjor Formation (+40m) consisting of alternate beds of sandstone and siltstone. Thickness of individual beds varies from 15 cm to 2 m. Large number of vertebrate fossils were recovered from sandstone as well as siltstone. Fossil assemblage includes *Hemibos* sp. (maxillary fragment), *Camelus sivalensis* (limb bone, femur), *Cervus* sp. (maxillary fragment), *Elephas (Archidiscodon) planifrons* (palate with molars), proboscidean tusk, reptilian scute, chelonia (plastron), vertebra and large number of unidentifiable limb bone fragments.
- B. **Jhiran Section:** This section exposes the Pinjor and Kalar formations (+25m). The Pinjor Formation is represented by sandstone and siltstone which is calcretised at number of

places. Large number of vertebrate fossils were recovered from the calcretised siltstone. The Pinjor Formation is overlain by the Kalar Formation, which is represented by pebble beds. Fossils recovered from the Pinjor Formation of this section include *Equus sivalensis* (ramus fragment, molars, incisor, metapodials), *Cervus* sp. (molars) and Bovinae (pelvic girdle, limb bone). The Kalar Formation is devoid of fossils.

- C. **Mandiarpur Section:** The Pinjor and Kalar formations are exposed in this section (+20m). The Pinjor Formation consists of alternate beds of sandstone and siltstone with calcrete. Fossils were recovered are proboscideans (tusk and molar), bovine (isolated molar), suids (ramus), *Bubalus* sp. (molars), *Boselaphus* sp. (molars), antelope (antler fragment and horn core), *Stegodon* sp. (molar fragment), proboscidean tusk, *Camelus sivalensis* (molar and limb-

EXPLANATION OF PLATE I

Bos sp. A. NRV-2/850 right upper isolated molar (M2) and B. NRV-2/909 left mandibular ramus fragment with premolars and molars (pm3 – m3). (For figs. A & B: I – Occlusal view, II – Lingual view, III – Labial view).



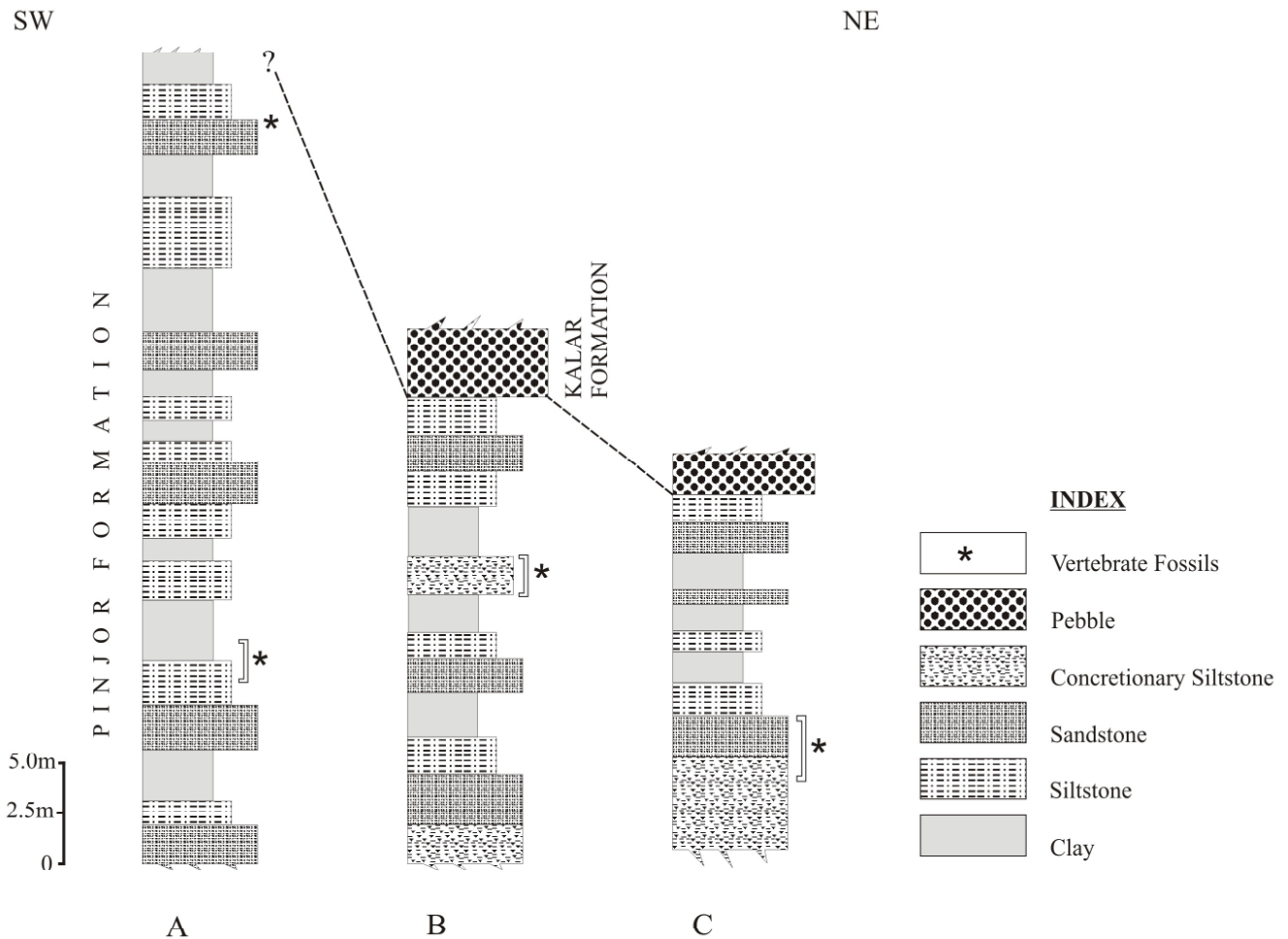


Fig. 2. Lithocolumns of measured sections of Siwalik rocks, exposed at Lakhampur (A), Jhiran (B) and Mandiarpur (C) areas in Nalagarh, Solan district, H. P.

bone fragment), *Equus sivalensis* (molars), *Cervus* sp. (molars and antler fragment), and number of limb-bone fragments, etc. The Kalar Formation has not yielded fossils.

BOVID FOSSILS

In the present study, seventeen bovidian fossils belonging to six genera viz. *Bos* sp., *Bubalus* sp., *Boselaphus* sp., *Gazella* sp. *Hemibos* sp. and *Sivaceros* sp. have been identified and described. The fossil remains are mainly the cranial parts comprising molars, ramus fragments, maxillary fragment and horn core. However, along with these fossils, a large number of post-cranial skeletal remains such as limb-bone fragments, isolated vertebra, astragalus, etc were also found associated.

SYSTEMATIC PALAEOLOGY

Order **Artiodactyla**

Family **Bovidae** Gray 1821

Subfamily **Bovinae** Gill 1872

Genus ***Bos*** Linnaeus 1758

Bos sp.

(Pl. I, figs. A, B)

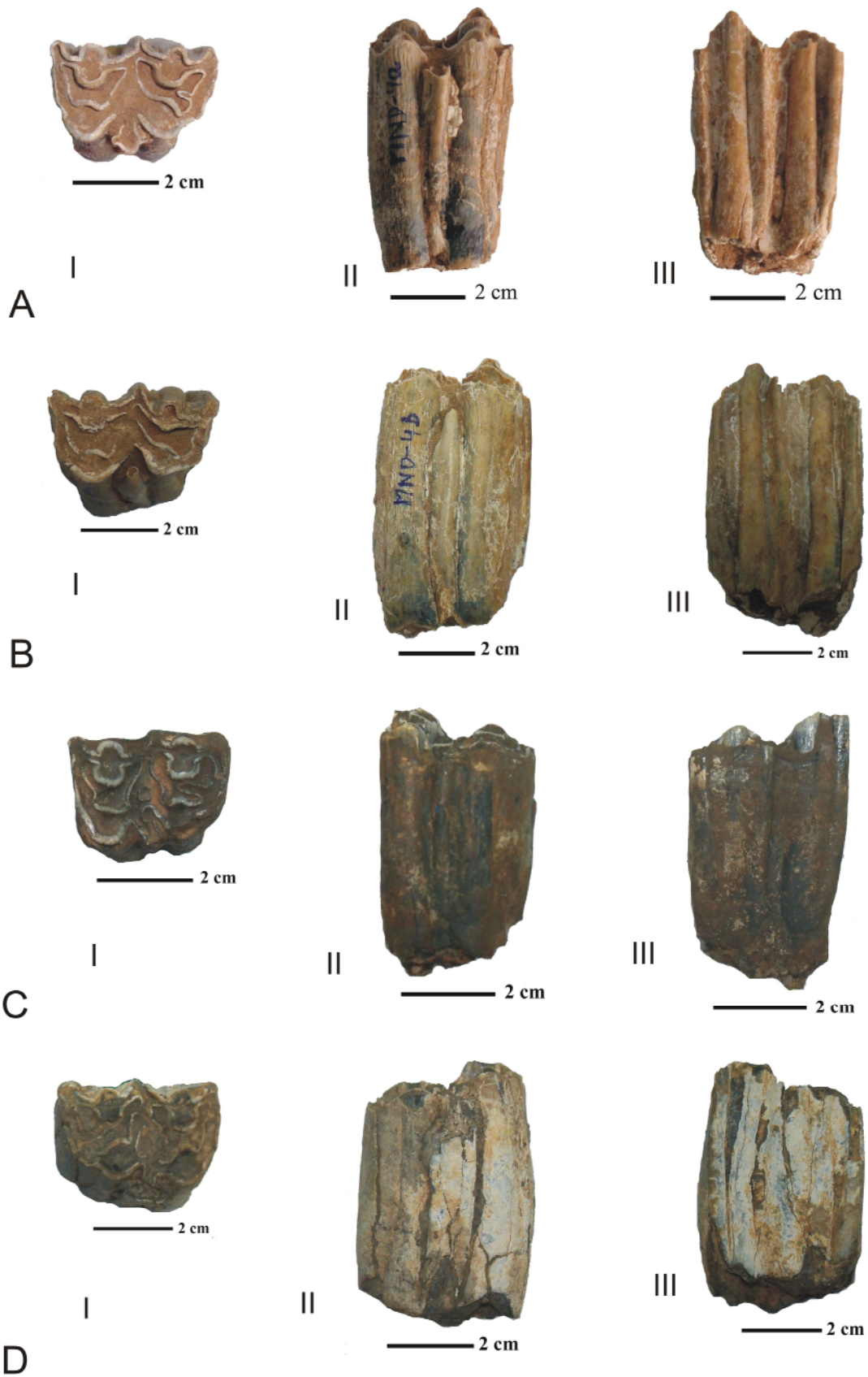
Material: NRV-2/850 Right upper isolated molar (M2) and NRV-2/909 left mandibular ramus fragment with premolars and molars (pm3 – m3).

Remarks: NRV-2/850 (Pl. I, fig. A) is a well preserved right upper second molar (M2). Molar is elongated, square in shape and hypsodont. The specimen is in advance stage of wear in which dentine is exposed and enamel is thick and moderately rugose on the lingual side. Crown surface is almost flat and sloping inward, i.e. towards lingual side. Both lingual and buccal (labial) sides are almost smooth. Paracone is higher than protocone. Protocone is U shaped. Thin parastyle and metastyle are equally developed, forming a sharp ridge. Anterior and posterior lobes are almost equal in size. Inner fossettes are horse-show shaped.

NRV-2/909 (Pl. I, fig. B) is a damaged left mandibular ramus from anterior and posterior side containing third and fourth premolars and all the three molars (pm3 – m3). The ramus is 22.0 cm long anterior-posteriorly, vertically 11.0 cm at m3 and 7.6 cm at p3. Second premolar is broken and only root part is present. Both third and fourth premolars are well preserved and all the features are exposed and in middle stage of wear. Enamel

EXPLANATION OF PLATE II

Bubalus sp. A. NRV-2/811, (Left upper molar, M2), B. NRV-2/812 (Left upper molar, M1), C. NRV-2/815 (Left upper molar, M3) and D. NRV-2/820, (Right upper molar, M3). (For figs. A, B, C & D: I – Occlusal view, II – Lingual view, III – Labial view).



is moderately thick and highly rugose mainly towards lingual side. Both the premolars are having convex outline towards labial side. Anterior valleys in both premolars are wider and almost U shaped. The metaconid is higher than protoconid in p3 and p4.

The crown surface of all the three molars are covered with sediment, therefore features of crown surface are not fully exposed. In general, enamel is thinly developed and show middle stage of wear in the all the molars. Ribs on the labial side are developed. The posterior part of m3 (hypoconulid) is broken and root is exposed. The crown is high. The metastylid and parastylid are thinly developed. Fossettes are small and somewhat crescent shaped. Basal pillars are faintly seen, as it is covered by sediment.

The studied material NRV-2/850 has been compared with the upper molar of *Bos* sp. (NRV-2/663 and 665) described by Verma (1981), though it slightly resembles with these but much details could not be made out. NRV-2/909 has been compared with specimen of *Bos* sp. described in the interactive website of "The Grant Museum".

Locality: NRV-2/850 near Naharsingh (N31.00.560 E76.41.274).

NRV-2/909 East of Jhiran (N31.00.085 E76.40.086).

Horizon: Pinjor Formation.

Order **Artiodactyla**

Family **Bovidae** Gray 1821

Subfamily **Bovinae** Gill 1872

Genus **Bubalus** Smith 1827

Bubalus sp.

(Pl. II, figs. A-D)

Material: NRV-2/811, (Left upper molar, M2), NRV-2/812 (Left upper molar, M1), NRV-2/815 (Left upper molar, M3) and NRV-2/820, (Right upper molar, M3).

Remarks: NRV-2/811 (Pl. II, fig. A) and NRV-2/812 (Pl. II, fig. B) are well preserved, isolated left upper molars M1 and M2 respectively, probably of a same individual as they were recovered close to each other and show similar characteristics. The specimens are in middle stage of wear, columnar, hypsodont having plenty of enamel. Dentine is present. Folds on the buccal side are very strong in the form of ribs. Median ribs are also prominently developed on both anterior and posterior lobes up to the paracone and metacone. The outline of protocone is more convex than the hypocone. They show very prominent basal pillar (column) from base up to crown surface. The basal pillar of NRV-2/811 is less worn whereas in NRV-2/812 is unworn. Parastyle (broken at the tip), metastyle and mesostyle are well developed forming sharp ridge. Inner fossettes in both are wide and deep with folds and is broadly crescent shaped.

NRV-2/815 (Pl. II, fig. C) is last upper of left side (M3). Ribs are developed on the buccal side. Paracone is higher than metacone, protocone is damaged. NRV-2/820 (Pl. II, fig. D) is highly worn and damaged last upper molar (M3) of right side. Ribs along with median rib are developed on buccal side. Paracone is higher than the metacone. Damaged basal pillar is present.

The studied material has been compared with the second upper molar of *Bubalus* sp. (SFP/177) described by Mishra *et*

al. (2013).

Locality: NRV-2/81, NRV-2/812 and NRV-2/815 near Mandiarpur (N31.01.348 : E76.40.916). NRV-2/820 near Mandiarpur (N31.00.941 : E76.41.206).

Horizon: Pinjor Formation.

Order **Artiodactyla**

Family **Bovidae** Gray 1821

Subfamily **Boselaphinae** Simpson 1945

Genus **Boselaphus** Blainville 1816

Boselaphus sp.

(Pl. III, figs. A-D)

Material: NRV- 2/859 (right upper molar), NRV- 2/876 (left upper molar), NRV- 2/874 (right upper molar), NRV- 2/860, NRV- 2/889 (upper molar), NRV- 2/891 (upper molar) and NRV- 2/901 (upper molar).

Remarks: NRV- 2/859 (Pl. III, fig. A) is well preserved right upper molar and shows all the characteristics. The enamel is thick and strongly rugose. Rugosity is more prominent on buccal side as compared to lingual side. Fossettes are seen in all the molars which is moderately wide, deep and crescent shaped. Paracone is higher than the protocone. The molars are selenodont, narrow crowned and in early stage of wear. External folds with ribs are strong. Median rib is prominently developed on both anterior and posterior lobes. Median ribs are well developed upto parastyle and metastyle. Basal pillar (column) is prominent. Basal pillar in NRV-2/876 (Pl. III, fig. B) is in early stage of growth and weakly developed. Other specimens show almost similar features as described above. In NRV-2/874, basal pillar is moderately developed and does not reach upto the crown surface. In NRV-2/901, basal pillar is broken and median rib is covered with sediments.

The studied material has been compared with the extant genus of *Boselaphus* (nilgai).

Locality: NRV- 2/859 and NRV- 2/860 near Naharsingh (N31.00.560: E76.41.274). NRV- 2/874, NRV- 2/876, NRV- 2/889, NRV- 2/891 near Naharsingh (N31.00.500: E76.41.330). NRV- 2/901 near Mandiarpur (N31.00.736 : E76.41.176).

Horizon: Pinjor Formation.

Order **Artiodactyla**

Family **Bovidae** Gray 1821

Subfamily **Gazellinae** Coues 1889

Genus **Gazella** Blainville 1816

Gazella sp. cf. *G. lydekkeri* Pilgrim 1939

(Pl. IV, figs. A, B)

Material: NRV-2/935 (right mandibular ramus fragment with p4-m3) and NRV-2/902 (isolated upper molar).

Remarks: NRV-2/935 (Pl. IV, fig. A) is a well preserved right mandibular ramus containing p4 and m1, m2 and m3. The length of ramus is 9.6 cm which is broken anteriorly. The anterior height is 3.8 cm at p4 and posterior height is 4.3 cm at m3. The specimen belongs to a juvenile individual. The enamel is rugose on the lingual and labial side. p4 is very small, broken and embedded in sediment. p3 is broken and alveoli is observed. The crown of m1 is broken. Metaconid is higher than the paraconid. The paraconid and metaconid of m2 are equal in height and higher than the protoconid. The hypoconid of m3 is broken and root is exposed. The central cavity in m2 and m3 in

EXPLANATION OF PLATE III

Boselaphus sp. A. NRV- 2/859 (right upper molar), B. NRV- 2/876 (left upper molar), C. NRV- 2/874 (right upper molar), and D. NRV- 2/901 (upper molar). (For figs. A, B, C & D: I – Occlusal view, II – Lingual view, III – Labial view).



A I



II 1 cm



III 1 cm



B I



II 1 cm



III 1 cm



C I



II 1 cm



III 1 cm



D I



II 1 cm



III 1 cm

small and is crescent shaped. Ribs on the lingual side are in early stage of development.

NRV-2/902 (Pl. IV, fig. B) is a well preserved highly worn right upper molar (probably M2). The enamel is moderately thick and rugose. The paracone and metacone are almost equal. The protocone and hypocone are fairly U shaped. The prominent and deep central cavity is present. Ribs are developed on the buccal side; anterior rib is stronger than the posterior. Thin median basal pillar is present.

NRV-2/935 has been compared with the right mandibular ramus of *Gazella* sp. cf. *G. lydekkeri* (Plate 1, fig. 6) of Pilgrim (1939) and also with the left mandibular ramus of *Gazella* sp. (GSI Type 20967) of Verma *et al.* (2002). The molars in the studied material are less erupted and may belong to a juvenile individual. NRV-2/902 has been compared with the right maxillary fragment of *Gazella* sp. (Plate 1, fig. 5) of Pilgrim (1939) and also with the right maxillary fragment of *Gazella* sp. (PUPC98/101) described by Khan *et al.* (2009). The studied material is highly worn out molar.

Locality: NRV-2/935 West of Khol Belly (N30.58.486 : E76.42.914).

NRV-2/902 Near Mandiarpur N31.00.736 : E76.41.176

Horizon: Pinjor Formation.

Order **Artiodactyla**

Family **Bovidae** Gray 1821

Subfamily **Bovinae** Gill 1872

Genus *Hemibos* Rutimeyer ex Falconer 1866

Hemibos sp.

(Pl. V, fig. A)

Material: NRV-2/921, right maxillary fragment with well-preserved three molars (M1-M3)

Remarks: NRV-2/921 is a right maxillary fragment with a very small part of palate containing well preserved M1, M2 and M3. The length of the maxillary fragment is 11.0 cm. The anterior height is 5.5 cm at M1 and 6.5 cm at M3. Though it is broken at anterior end as well posterior end but posterior part, i.e. M3 is well preserved. Molars are stout and show sub-hypsodonty, dentine is exposed. The enamel is thick and rugose. Rugosity is more prominent on the buccal side than the lingual side. M1 is in middle stage of wear, however M2 and M3 are highly worn. Folds on the buccal side are present in the form of ribs. In M2 and M3 partly damaged median ribs are present. Protocone is U shaped. Inner fossettes are present, in M1 it is horse shoe shaped. In M2 and M3 worn out basal pillar is present. Paracone and metacone are developed in all the three molars which is higher than protocone. Moderately thin parastyle and metastyle are also developed but damaged at places. Crown surface is sloping inwardly.

The NRV-2/921 has been compared with the left maxillary fragment of *Hemibos* sp. (GSI Type 20993) of Verma *et al.* (2002). The studied material is almost of the same size with all the three molars, whereas in GSI Type 20993 pm4-m2 are preserved.

Locality: Approx. 2 km south of Lakhanpur (N30.58.156 : E76.41.135)

Horizon: Pinjor Formation.

Order **Artiodactyla**

Family **Bovidae** Gray 1821

Subfamily **Caprinae** Simpson 1945

Genus *Sivaceros* Pilgrim 1939

Sivaceros sp. cf. *Sivaceros gradiens* (Pilgrim 1939)

(Pl. V, fig. B)

Material: NRV- 2/868 (Horn core).

Remarks: The horn core is 7.5 cm long and belongs to a medium-sized individual. It is broken from tip and basal part is preserved. The base of the horn is almost symmetric. In cross-section, it is slightly elongated oval in shape and longitudinally symmetrical. Keel is faintly observed. Horn core is slightly curvaceous and striated with fine ribs on the surface.

The studied material has been compared with *Sivaceros gradiens* of Pilgrim (1939). It has also been compared with the material described by Khan *et al.* (2011) and is almost half the size.

Locality: Near Naharsingh (N31.00.560 : E76.41.274)

Horizon: Pinjor Formation.

CONCLUSIONS

A large collection of bovid fossils of the Pinjor Formation has been recovered from the Nalagarh *tehsil* of Solan district, H.P. Only cranial parts such as molars, ramus and maxillary fragments, etc have been described. It was observed that the recovery of fossils is good from those beds, which are nearly horizontal or low dipping. It may be attributed to the fact the fossiliferous horizons of low-dipping beds get more surface exposure and more area for weathering and erosion than the high-dipping beds. Recovery of fossils is more where sandstone and siltstone is calcretised. A variety of fossils is present in the Pinjor Formation; they are rare in the Lower Boulder Conglomerate, now named as the Kalar Formation.

The rich bovid fauna of the Pinjor Formation suggests that the climate was wet and warm which supported the growth of luxuriant vegetation. The bovid fauna of the Pinjor Formation exhibits large-sized cheek teeth indicating abundant food material for grazing. It suggests that during time of deposition of the Pinjor Formation there were well-developed grasslands with plenty of water.

These fossils belong to *Bos* sp., *Bubalus* sp., *Boselaphus* sp., *Gazella* sp., and *Sivaceros* sp. The bovids during the time of deposition of the Pinjor Formation were more diversified as compared to the present day.

The Lower Boulder Conglomerate (Kalar Formation) has not yielded fossils in the study area, despite intensive search. It may be due to change in climate and vegetation which led to extinction/migration of fauna during deposition of the Kalar Formation. It is also likely that preservation conditions for vertebrate fossils in the Kalar Formation were not favourable.

EXPLANATION OF PLATE IV

Gazella sp. cf. *G. lydekkeri*, A. NRV-2/935 (right mandibular ramus fragment with p4-m3) and B. NRV-2/902 (isolated upper molar). (For figs. A & B: I – Occlusal view, II – Lingual view, III – Labial view)



I

2 cm



II

2 cm



A

III

2 cm



B

I

1 cm



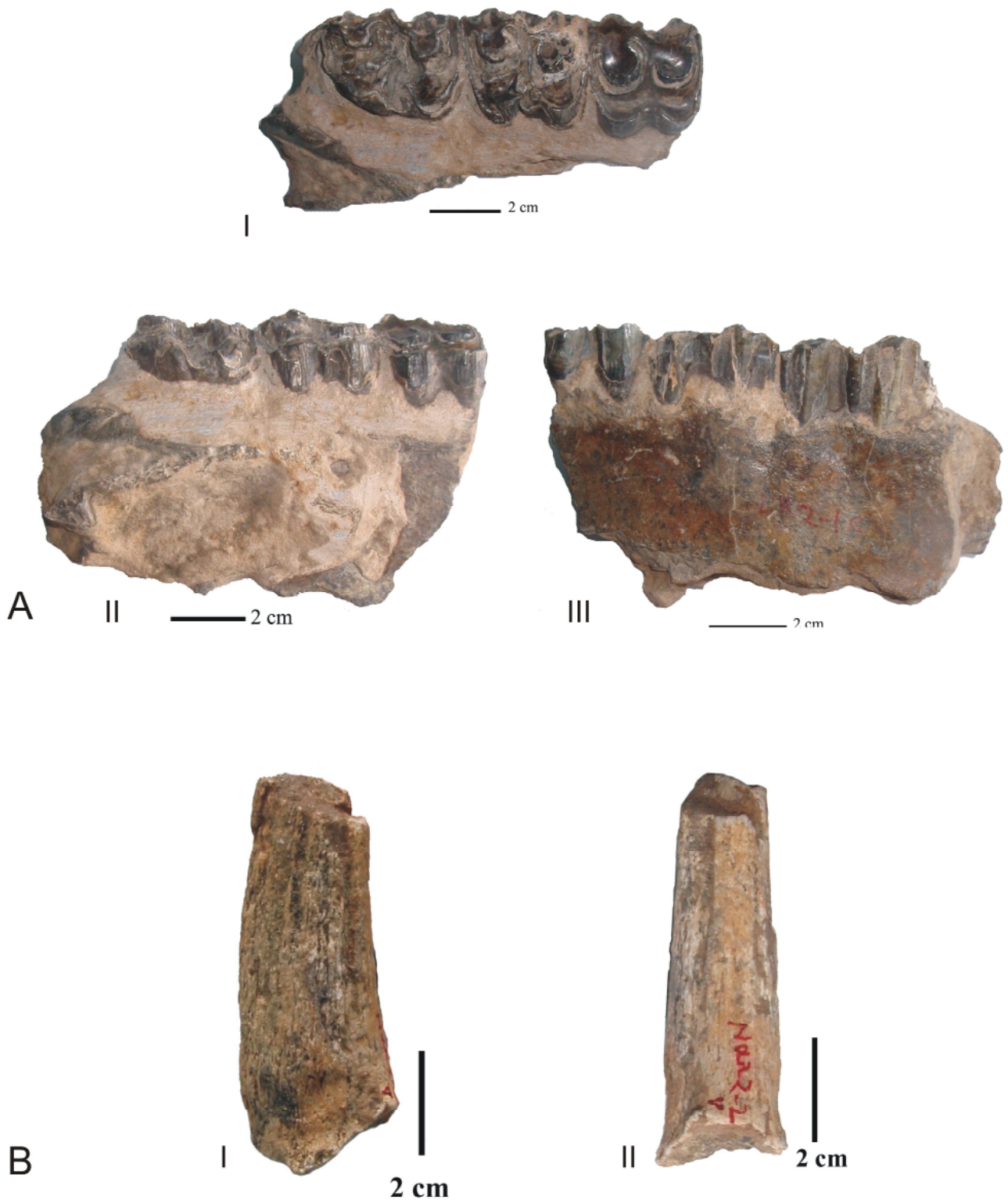
II

1 cm



III

1 cm



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EXPLANATION OF PLATE V

A. *Hemibos* sp., NRV-2/921, right maxillary fragment with well preserved molars (M1-M3) (I – Occlusal view, II – Lingual view, III – Labial view)
B. *Sivaceros* sp. NRV- 2/868 (Horn core) (Two different views).

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