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Geoarchaeology of Cuddapah Basin and Eastern Peneplains in Peninsular India: An Oasis of Prehistoric Cultural Progression

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Abstract: *The Cuddapah Basin Region (CBR) of Andhra Pradesh is unique landscape in peninsular India, typified by different geological formations and subsequent geomorphological processes during the Pleistocene and Holocene Periods. Limestone caves, caverns, rock shelters, riverine deposits and floodplains of the region gained prominence due to the recovery of data related to prehistoric cultures, animal fossils, volcanic ash and sand dunes. These data systems were collected through explorations and excavations and have been subjected to geoarchaeological, palaeoenvironment, rock art and chronometric studies by various researchers of different academic fields and surveys. During the last one and half centuries (1863-2024) prehistoric studies have identified 270 culture bearing sites in the region, characterised as surface stations, caves and rock shelters, yielded the evidences of lithic tools belong to Palaeolithic (Lower, Middle and Upper), Mesolithic, Neolithic and Megalithic cultures and their respective associated cultural and non-cultural objects of evidencs. Some of these sites have preserved animal fossils, particularly in limestone caves, rock art at ceilings and walls of rock shelters, volcanic ash (Youngest Toba Tuff) in riverine and lacustrine substratums and sand dunes as surface deposits. These fossils, ash and sand dunes are of great significance in calibration of absolute chronology and environmental reconstruction of CBR. Scientific methods like Carbon-14, OSL, TL and XRF are deployed and cross-dated to MIS timeframes of Pleistocene and Holocene periods, and delineated typo-technological cultural progression of the region based on archaeological evidences and geographical distribution. Review and compilation of these studies and sites has resulted in deduction of possible paths of prehistoric migration from coast to inland and thereafter into the CB in the context of out of Africa south coastal migration of anatomically advanced hominines. The data are presented in various tabular forms (3) together with appendix, which provide site specific data for further studies.*

Keywords: *Palaeolithic, Limestone caves, Rock shelters, Youngest Toba Tuff, Animal fossils, Palaeoclimate, Palaeoenvironment*

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Introduction

In archaeological studies, particularly the prehistoric investigations necessitated the stratigraphic context of Stone Age artefacts and fossil fauna in quest for antiquity of man. The stratigraphy being the 'time capsule' of deposits of geological processes, associated material culture and bio-fossils resulted in application of geosciences in spatio-temporal studies of prehistoric archaeology. Owing to artefact recoveries from deposits of rivers, coasts, lakes, caves, colluviums and such related landscapes, stratigraphy has been a key method resorting to scientific and systematic inquiry. During the initial stages of archaeological studies earth and biological sciences are entangled to have in depth understandings of man and his works. The geology, petrography, geochemistry, geography, geomorphology, sedimentology and such related sub-disciplines of earth sciences, faunal, floral and palynology branches of biological sciences contributed much to archaeological understandings in building theories and methodologies (Butzer, 1982; Shiffer, 1984; Leach, 1992; Rapp and Hill, 2006; Engel and Buckner, 2014). During the process of systematizing inter disciplinary approaches, the use of archaeology prefixed by geo, zoo, ethno gained prominence as geoarchaeology, zooarchaeology, ethnoarchaeology to take forward archaeology as science. Among these, geoarchaeology gained much prominence, encompasses the study of glacial, riverine, coastal, wind, gravitation, and such related energy systems and morphologies at macro- level, and formation of an archaeological site and thereafter, taphonomy at micro-level, contributed much in reconstruction of early humans, culture and environment specifically during the Pleistocene and Holocene Periods. The geoarchaeological studies are of two types, the area specific and site specific, the former consists of larger area of a given geophysical resource, while the latter composed of temporal substratum embedded with remnants of natural agencies and human endeavour. The geological methods of study and scientific perception of archaeology lead to the plethora of geoarchaeological methods of survey across larger regions. The macro scale methods of geological, geomorphological, topographic, soil, aerial photos, satellite imagery, and such related scientific inputs are deployed in exploration of archaeological sites. The associated geogenic materials like tephra, lineaments and rocks, progradation and degradation, stability of substratum, inundation and denudation processes of rivers and coastal geomorphology are meticulously analysed by the application of geoarchaeological methods and techniques. Of late, the geoarchaeology is defined as the application of geosciences in archaeology and vice versa to understand the interaction between humans and ecosystem over a period of time (von Suchodoletz *et al*, 2020).

In Indian context, the geoarchaeological studies are mostly carried out in riverine deposits, sediments, and brought out Quaternary stratigraphic successions. The contents and sedimentary columns of these deposits, both cultural and biological evidences together with varied geo-materials are analysed for palaeoenvironment reconstruction and chronometric dating by applying scientific methods making use of modern devices. Geoarchaeological studies ever since de Terra and Paterson investigations in Potwar Plateau (de Terra and Paterson, 1939 in Sankalia, 1974), the Thar Desert (Allchin *et al*, 1978) and catchment areas of different river valleys (Wadia *et al*, 1995) brought out the palaeo ecological, palaeo climatic regimes contemporary to the varied cultural manifestations. These studies delineated the 'change' in Pleistocene and Holocene periods and deduced Palaeoclimatic episodes, thereby environment and consequent cultural adaptations together with time lines, which are perceptible in Indian Geoarchaeology.

The Cuddapah Basin (CB)

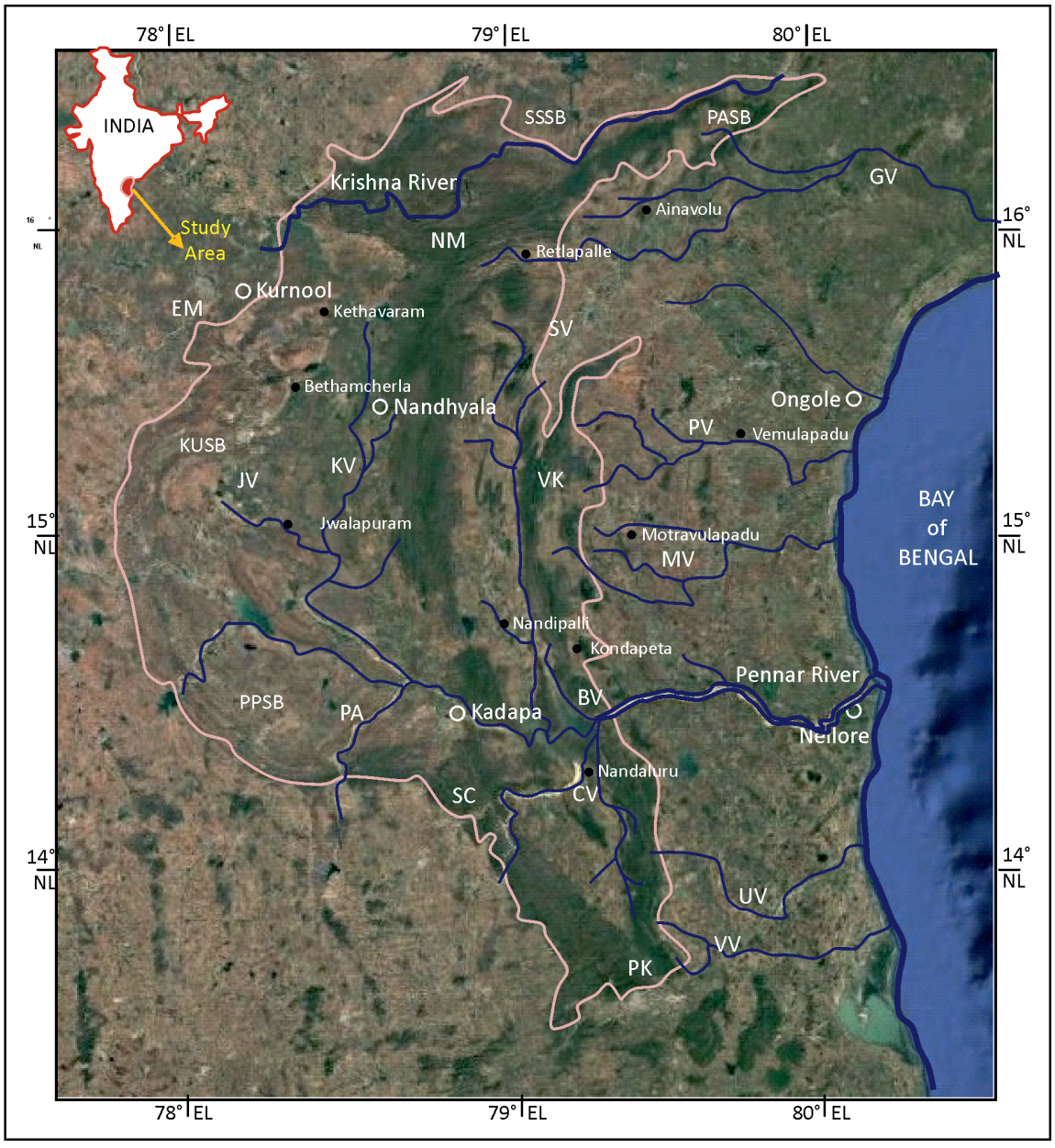
The Cuddapah Basin (CB) in peninsular India is Proterozoic sedimentary geological unit, the second largest *purana* basin after the Great Vindhyan basin. The CB is divided into four sub-basins (Papagni,

Kurnool, Srisailam and Palnad), each with different depositional history, complexity of geophysical environs and drainage systems (King, 1872., Nagaraja Rao *et al*, 1976). Several of these resources are subjected to archaeological studies by considering geo, zoo and ethno archaeological methods ever since the first discovery of Stone Age tools and Pleistocene animal faun from limestone region of Kurnool sub-basin by Bruce Foote way back in 1880s. The CB is a crescent shaped geological formation, western convex and eastern concave, located between latitudes 13˚30'N to 17˚N latitudes and 78˚E to 80˚E longitudes, covers an area of 44,500 sq. km extends for a length of about 450 km along the arcuate eastern margin with a mean width of 150 km. The arcuate eastern margin is marked by a prominent boundary thrust, which is parallel to the Nellore schist belt, Eastern Ghats mobile belt and the East Coast. The basin is composed of four sub-basins, three parallel hill ranges and two river valleys. The Papaghni, Kurnool, Srisailam and Palnad sub-basins are at western half of the basin, the Erramala, Nallamala and Velikonda hill ranges of Eastern Ghats run in north-south culminating at Seshachala and Palakonda hills at southern end. The Papaghni and Kurnool sub-basins are geographically interlinked sites of deposition at different times; both with underlying Cuddapah sediments, between these two sub-basins, the Kurnool sub-basin contain the younger Kurnool sediments. Srisailam sub-basin contains upper Cuddapah sediments, while Palnad sub-basin exposes only the younger Kurnool sequence. The eastern half of the Cuddapah basin is occupied by the Nalamala fold belt consisting of upper Cuddapah sediments. The quartzites, shales, lime stones, and sandstones are the chief rock formations, but the quartzite as strong rock dominates and intermittently intrudes into all other soft formations (Ramam and Murty, 1997).

The Krishna in the north and the Pennar in the south, both flow in west-east direction are the chief river systems of CB with networks of several hill streams. Between these two Pennar catchment area occupies major portion of the basin. Hill streams like Kunderu, Jurreru, Galeru, Sagileru, Boggeru on the left and Chitravati, Papagni, Bahuda, Cheyyeru and Gunjana on the right joins the Pennar river at different confluences, while at northern part tributary rivers like Tungabhadra and Handri joins the Krishna River on its right bank. Geomorphological features of these rivers show variation due to local etroglyphs and structures (Vaidyanathan, 1964, Maheshwararao, *et al*, 2020). The CB presents denudational, fluvial and karst landforms, which are of archaeological significance as some of the morphological units were formed during the Quaternary Period. The fluvial and alluvial deposits, breccia of caves, colluviums (debris and rock shelters) and air fall of ash are of utmost significance as they preserved archaeological, fossil and other related datable materials. The study area is drained by 2 major (Krishna and Pennar) and 3 minor (Gundlakamma, Paleru and Manneru) rivers with their respective tributaries/hill streams (15). The main rivers drain in west-east, while tributary/hill streams traverse in north-south direction between Erramala and Nallamal, Nallamal and Velikonda hill range, while south-north direction between hill tracts of Palakonda and Seshachala to join their respective river courses, finally to debouch into the Bay of Bengal (Map-1). Since these coastal rivers had origin in CB, presenting geo-cultural connectivity and to have inclusive as well as explicit geoarchaeological perspective, the CB and adjoining landscape is considered for this article under the head Cuddapah Basin Region (CBR).

The heterogeneous and uniqueness of the CB attracted attention of geologists and geomorphologists alike, who identified several spatio-temporal lithologies of academic and economic significance. The minerals like barites, limestone, dolomite, steatite, asbestos and fullerene are of immense economic value. The drainage networks of the Krishna River in the north and the Pennar River in the south coupled with monsoonal climatic regime presented divergent geophysical landforms like valleys, valley within valley, piedmonts, lakes, rolling plains, and remnants of conglomerates, gravel and soil

deposits in the basin and also at foot hills. Dry deciduous vegetation together with its respective fauna characterizes semi-arid subtropical climatic regime. The basin receives an average rainfall of 780 mm with a range of 500-900 mm, mostly from southwest monsoon. Divergent landscapes of riverine (alluvial and fluvial) and etroglyphs of limestone, shale and quartzite attracted another group of scientists, the culture historians, archaeologists and geo-archaeologists in recent years, who brought out cultural dimension, the humanization of the basin. Thereby the Cuddapah basin has become an area of investigations to unravel facets of prehistoric cultures and palaeo-environment.



Map I: Google Map of Cuddapah Basin Region (CBR) Presenting Hill Ranges and River Valleys of Southern Eastern Ghats

INDEX (•Important sites)
Sub-Basins: PASB= Palnadu, SSSB= Srisailam, KUSB= Kurnool, PASB= Papaghni
Hill Ranges: EM= Erramala, NM= Nallamala, PK=Palakonda, SC= Seshacahala VK= Velikonda.
River Valleys: BV= Boggeru, CV= Cheyyeru, GV= Gundlakamma, JV= Jurreru, KV= Kunderu, MV= Manneru, PA= Papaghni, PV= Paleru, SV= Sagileru, UV= Upputeru, VV= Venkatagiri.

Curiosity of British Officers on Prehistory of CB

During pre-independent India (prior to 1947) the scientific temper, curiosity and inquisitiveness of British officers on Indian traditions and cultural plurality laid foundations for documentation of archaic as well as living traditions and practices. Geologists in preparation of geological resource maps come across prehistoric cultural relics in varied geographic contexts, particularly in the peninsular part of India. Robert Bruce Foote's report on first Palaeoliths from Pallavaram, Madras (now Chennai) at the coast of Bay of Bengal (1863) and Charles A.E. Oldham's Palaeolithic collections in inland hill terrain at Rayachoti in Cuddapah basin were the pioneering discoveries of prehistoric past (Brown, 1917). Exploratory information of several reports extracted from different Memoirs of the Geological Survey of India volumes such as King (1872), Sewell (1882), Henry Foote (1884), Newbold (1884), Oldham (1893), Moir (1909), Brackenbury (1914) and Cammiade and Burkitt (1930) strengthen the prevalence of prehistoric cultures in India.

Further extensive discoveries of Robert Bruce Foote in and around Cuddapah basin covering erstwhile revenue districts of Ananthapur (1887, 1890), Cuddapah (1891), Kurnool (1865, 1866, 1883, 1884, 1885), Nellore (1867, 1875), Guntur (1876-77) and Krishna (1884) had brought out varied cultural phases of Prehistory of the region. Bruce Foote and Henry Foote (1885), the father-son legacy of explorations and excavations in limestone caverns of Kurnool region enhanced the cultural face of Cuddapah basin, which inculcated interest among culture historians (Chakrabarti, 1979). Cornelius Cardew excavation of Neolithic-Megalithic complex in 1887-88 near Guntakal (west) and W.R. Robinson collections of Palaeoliths (east) of Cuddapah basin from Karkambadi near Renigunta in Chittoor district are significant in spatio-temporal understandings of prehistory of Cuddapah in particular and peninsular India in general (Brown, 1917). These exploratory notes of prehistoric tools/ sites are extracted from Records of the Geological Survey of India.

Indian Culture Historians and Cuddapah Basin

Initiatives of Archaeological Survey of India (ASI) have brought out cultural mosaic of independent India and also academic departments inquiry into prehistoric cultural processes brought out several site and phase specific studies across the nation. Information on most of the prehistoric studies conducted for the award of degrees in the form of P.G, M.Phil and Ph.D by Indian university departments remained dissertations and theses lying in their respective libraries. Initially, revenue divisions were considered for explorations, while excavations are site specific, which in turn brought macro imprints of prehistoric and protohistoric cultural background of India. Similar methods of study (erstwhile districts of Rayalaseema and adjoining coastal districts) contributed to the understanding of prehistoric and protohistoric cultural background of the Cuddapah basin, the present study geographical area.

Studies of Soundararajan (1952) and Isaac in Kurnool district (1960), Murthy in Chittoor district (1966), Reddy in Cuddapah district (1968), Reddy in south western Andhra Pradesh (1968), Sudarsen in Nellore district (1976, 1979), Jayaraj in Tirupathi valley (1985), Madhusudhan Rao (1979, 1987), Aditya Kumari, (1987) and Muralimohan (1990) in Prakasam district, Raju in Gunjana valley of Cuddapah district (1981, 1988), Venkatasubbaiah (1987-88, 2007) in Pennar valley, are noteworthy in typo-technological frame of reference. The Archaeological Survey of India (ASI) reports of Stone Age occupations in Cuddapah basin and its environs by Raghavachari (IAR 1960-61), K.D Benerjee (1963-64), H.N. Singh (1967-68), R.V. Joshi and B.P. Bapardikar (IAR 1973-74), Hanumanth Rao (IAR 1973-74), Raja Rao (IAR 1974-75), I.K. Sharma (IAR 1975-76), Krishna Murthy (IAR 1977-78), Sengar (IAR 1977-78), R.S. Pappu, (IAR 1980-81), Satyanarayana (IAR 1983-84), Reddy *et al* (IAR 1988-89) have provided a vivid prehistoric picture of the basin. These studies have brought

out profound evidence of Prehistoric and Protohistoric cultural evidences belong to Palaeolithic, Mesolithic, Neolithic and Megalithic phases. Times to time prehistoric studies are compiled to generate cultural characteristics. More than 400 sites are enumerated to their cultural characteristics (Ratna Rani, 1991; Reddy, 2001; Settar and Korisettar, 2002; Murty, 2003, Shipton *et al*, 2010., Korisettar, 2021) and presented a vivid picture of prehistoric past of erstwhile Andhra Pradesh.

This article is aimed to compile prehistoric studies carried out during the last one and half centuries in CB and its adjoining coastal landscape with a basic premise that the scientific inferences brought out by geoarchaeologists, palaeontologists, chronologists as well as archaeologists, independently or as a team, made use of geoarchaeological methods, scientific devices and my own experience in the region as culture historian, to consolidate the findings to infer importance of CB in humanization and subsequent cultural processes, and to provide a benchmark comparative report for future studies. The main focus of the study is to understand the significance of a closed geological system of a basin (Cuddapah) and its adjoining open coastal landscape, with a premise that there has been generic connectivity of riverine drainage (rivers and streams) within mountainous geological basin (Cuddapah Basin of Eastern Ghats) and that gush out into open landscape to join the ocean (Bay of Bengal) in west-east or inland-coastal directions. It also aims at to delineate inter connectivity between closed and open geo-environs in cultural progression during prehistoric and protohistoric times. Studies related to these phases and the study area are consulted and reviewed to their drainage, nature of recovery, cultural material and other associated evidences. The study had identified 270 sites named after the nearby village (village location can be accessed through Google search otherwise hamlet or spelling error) spread over four districts (Appendix-I). These sites are sub categorised into different groups (18) based on prehistoric culture characteristics in relation to rivers/streams (26), and different landscapes (4), the data of which are presented in Table I.

The site-wise prehistoric and protohistoric cultural data represented by Palaeolithic, Mesolithic, Neolithic and Megalithic cultural phases of the study area are presented riverine-wise. Eight river/stream courses join two major rivers, while three streams join Gundlakamma, accounting in total 26 riverine courses, which have preserved 271 culture bearing sites. Out of these 271 systematic excavations are conducted only at 9 sites (3.32%), data recovered at 72 sites (26.57%) from stratified sections, while the remaining 190 sites (70.11%) are surface stations. Seven out of nine excavated, and 25 from stratified and 97 surface sites are from CB (Cuddapah-2+16+56=74 and Kurnool-5+9+41=55 districts), while two excavated, 47 stratified and 93 surface are from eastern coastal peneplains (Prakasam-2+45+59=106 and Nellore-0+2+34=36 districts). The sites distribution analysis indicates explorations were conduced extensively but the in situ data recovery was limited to very few sites where they are embedded in substratums of different gravel and soil horizons of riverine and lacustrine systems. Much of the data was collected at different surface stations of water courses and floodplains, which were in disturbed conditions due to natural erosion and anthropogenic pursuits like habitations, agriculture and development (roads, reservoirs and building) operations.

The Palaeolithic cultural remains are further categorised into Lower (LP), Middle (MP) and Upper (UP) characterised by core, flake and blade tool lithic complexes respectively, based on typo-technological variation and progression, while Neolithic (NE) and Megalithic (ME) cultural phases are characterised by pottery and associated material evidences. The division of these cultures is further strengthened by relative chronology of stratigraphy and calibrated by different absolute methods and techniques of dating. The observed variation within each of these phases is attributed to differential adaptations in relation to spatiotemporal distribution of lithic groups of tools. Location of site, substratum, associated remains, recovery of data, surfacial and excavation, seem to be prime characters

influenced variability of cultural remains. The CB has shown caves, rock shelters and surface stations of both at eroded and *in situ* sections of riverine sediments. Cultural materials are recovered from different substratums of graveliferous and siltiferous layers in succession, at times associated with fossils, volcanic ash and pot sherd. These are found at different locales such as foothills, uplands, hilltops, peneplains, along gully and nala cuttings of stream and river courses. Rock shelters are depicted with rock art. The pair of culture-site analysis indicates varied patterns of site occupation. Out of a total of 270 pairs, exclusively of Lower Palaeolithic (72), Middle Palaeolithic (32), and also in combination (54), accounting to 58.52%, indicate independent workstation or habitation space, transition shifts and reoccupation of the same site. Similar trends of shifts are also noticed from LP to UP (7), MP to UP (8) and continuity of occupation during all phases of cultural progression LP, MP and UP (10) during Palaeolithic period, indicate transitions and continuity, may be due to resource fluctuations and potentialities of sites. The evidence of Mesolithic (Mes), as transitionary cultural phase between Palaeolithic and Neolithic, though meagre, appears at sites of LP (1), MP (1), UP (2), LP and MP (2), MP, NE and ME (1) and exclusively (1) indicate its multifaceted contribution to the preceding hunting-foraging and succeeding incipient cultivation.

Lower Palaeolithic evidence characterised by Acheulean tradition is more pronounced in the main river courses of Kunderu (10) and Sagileru (7) and their network of hill streams (7) in CB and Paleru (16) in its adjoining eastern coastal uplands. Among these three rivers, the Kunderu is conspicuous by the presence of exclusive LP and absence of exclusive MP, indicating the valley between the Erramala and Nallamala hill ranges seem to be congenial habitat for the Acheulean to thrive on, while the Sagileru valley between Nallamala and Velikonda hill ranges, and the Velikonda eastern foothills being the catchment area of the Paleru river these valleys are characteristic of LP and MP evidences, initially the Acheulean, the 'core-flake' and transition of typo-technologies on reduction mode into Levalloisian 'flake' and diminishing tool dimensions. The LP-MP their occurrences in differential substratums or sedimentary or depositional environments at 54 (20%) sites strengthen their transitions within and at reduction pace. Along with the main river courses, the smaller and tributary/hill stream headlands and high energy water body environs seem to have played a vital role as indicated by the occurrence of independent as well as successive cultural phases as evidenced in Tungabhadra (9), Boggeru (17), Penneru (15), Gunjana (22) and such alike. The Gundlakamma river valley cultural (19), Toba Ash (15) and animal fossils (2) and also Paleru valley sand dunes (3) scientific analysis and inferences pertaining to spatio-temporal and ecological dimensions are of immense significance in connecting the CB with that of eastern coastal landscape of the region in culture-ecological understandings. The Gunjana valley is an intensive ethnoarchaeological study brought out cultural adaptations in a narrow valley particularly during the UP phase of cultural development (Raju, 1988).

Among 270 archaeological sites, the Jwalapuram in Jurreru valley gained significance due to the presence of YTT intensive and extensive scientific inquiry through international collaboration. Similarly the studies of Geological Survey of India (GSI) on Youngest Toba Tuff and Sand Dunes are of immense significance in chronometric dating. Recent studies in Gundlakamma, Paleru and Manneru River courses by a group of scientists from the Indian Institute of Technology, Gandhinagar (IIT-GN), Gujarat state (Anil *et al*, 2022, 2023, 2024), and excavations at Konadapet, Markapur and archaeometric analysis of lithic tools by Delhi University (Singh, 2014, 2019, Sunep, 2014), and LP/MP sites in Ganjuvaripalli basin are towards a new direction of geoarchaeological, archaeometric and ethno archaeological studies (Subrahmanyam *et al*, 1985; Murali Mohan, 1990). In recent years, the CB and its hinterland is drawing the attention of national and international scholars for their geo-ecological significance in understanding the prehistoric adaptations, mobility and migrations,

particularly in the context of air fall of YTT and out of Africa, the southern coastal migratory route of modern hominin. The limestone cave (10) and granite rock shelter (17) sites, the former in unearthing animal fossils along with cultural relics from the breccia, and rock art of stone shelters mostly animals and human figures are of great significance in reconstruction of fauna of the region and ecological context thereby the palaeoenvironment. Among 17 rock shelter sites, the rock art found at 10 rock shelter sites at Kethavaram near Kurnool (Chandramouli, 1987-88) and Jwalapuram rock shelters near Banaganapalli (Tacon *et al*, 2010) is significant in understanding typology of rock paintings, hand prints and pictographs, both of animals and human. Though a considerable number of Neolithic sites are located in the study area they are not dealt as they are not in association with prehistoric sites (Venkatasubbaiah, 1988 and 2007, Fuller *et al*, 2001).

Rock Shelters and Rock Art

It appears that the physical and chemical weathering processes of underlying soft rocks of shale and sandstone in CB might have resulted in rockslides of superimposed hard quartzite into huge to moderate boulders over the landscape. Such of these are overhanging projections providing shade is called rock shelters and they are in 104 in the region. These rock shelters are in addition to limestone caves (9) of the region. Evidence of rock art in the form of paintings on walls and ceilings of rock shelters is found at about 26 sites in the Kurnool sub-basin (Chandramouli, 1994, 2002, Clarkson *et al*, 2009, Petraglia *et al*, 2009b, Blinkhorn *et al*, 2010). Most of the sites are represented by more than two to as many as 50 rock shelters , and many of them portrayed by rock art (Appendix-I). Systematic study of rock art has resulted in the identification of pictographs and petroglyphs. In the absence of absolute dates, the analysis of the artistic manifestations based on depiction of pictures, drawn lines, colours used and other motifs, temporal scale of Mesolithic, Neolithic and Megalithic cultural phases are adopted. The Mesolithic is characterised by paintings of game animals dominated by deer, human figures in isolation, initially large in size and diminished later, hand prints, use of red, black and yellow colours, red being dominant, were marked particularly at Kethavaram rock shelters. Absence of hunting scenes, bow and arrow, female figures appear to be local variant of Kurnool landscape of caves and caverns of Indian Mesolithic rock art (Prakash, in press). The humped bull both in pictograph and petroglyphs formats in red colour, with or without human figures characterise the Neolithic phase or Mid Holocene (Tacon *et al*, 2013). Symbolic representation of zoo and anthropomorphic figures mostly in petroglyphs, circle with trident are common in Megalithic phase, and they continue into early historic phase.

Climatic dimensions of Fossil Fauna

In Indian sub-continent the palaeoanthropological evidences of Quaternary period, represented by vertebrate fauna have come from the Siwalik Hills and Karewa deposits and Narmada valley in Central India and extensive fluvial deposits in the peninsular region (Badam, 1988; Roberts *et al*, 2014). The vertebrate fossils range from the Middle Miocene to the early Middle Pleistocene in age are from the Siwaliks, while the fossil fauna belong to Middle and Late Pleistocene are discovered from different river systems of peninsular India (Badam, 2002). Though the Godavari and the Krishna are the main rivers of the peninsular India, most of the Pleistocene fossil remains are discovered in the catchment area of the Pennar River, particularly in Kurnool limestone region of Cuddapah basin (Rao *et al*, 1992). The Kurnool sub-basin is one of the four sub-basins of the Cuddapah basin is composed of younger sediments like Banaganapalli conglomerates, Owk shales, Paniam quartzites, Koilkunta limestones and Nandhyala shales, Thadipatri granites in a succession over Cuddapah sequence with unconformity. The differential hardness and superposition of harder over the soft rocks, dissolution

and corrosion of subsurface and surface water above the water table has resulted in erosion/ formation of several caves and rock-shelters (huge boulders). Among many such secondary formations, the caves located between Kurnool and Banganapalle limestone region, are of geoarchaeological significance due to the Palaeolithic artefacts in association with animal fossils of Pleistocene period. Kunderu, a tributary of Pennar River originate in limestone caverns and crevasses between the Erramala and Nallamala hill slopes, drain towards south to meet the Pennar River at Kamalapuram. Several limestone caves, named after local villages such as Billasurgum, Chandrapalli, Chintamanu, Kottalapolimera, Krishnammakona, Muchachatla, Muchachatlaswamy, Peddapavuralabaddi, Sanyasual, Yaganti and Yerrazari. These caves are located in steep hill slopes of limestone escarpment at 21 to 52 m above the hill streams of Kunderu valley floor. The cave floors are characterised by breccia of clays, stalagmites, stalactites and cemented limestone blocks of various dimensions (Prasad, 1996).

The ossiferous nature of caves in Kurnool limestone area were identified by Newbold (1884) and subsequent excavation of several fossil fauna by Lydekker (1886a and 1986b), and association of lithic artefacts by Bruce Foote (1884), Henri Foote (1885) and Cammiade (1926, 1927) made indelible mark on classification and chronological ordering of Stone Ages of Pleistocene Period. Three out of nine excavated caves are implementiferous and fossiliferous. Systematic excavations in some of these caves conducted during 1970s have resulted in unearthing of stone, bone and faunal assemblages and their association with Upper Palaeolithic and Mesolithic phases. The stone and bone tools together with a wide range of fauna brought out by archaeologists (Murty, 1975, Murty and Reddy, 1976, Reddy, 1980, Deshpandey-Mukharjee *et al*, 2005), was scientifically identified and classified at genera and species by palaeontologists (Badam, 1979, Prasad and Yadagiri, 1986, Patnaik *et al*, 2008, Prasad, 1996). The unearthed faunal remains of Kurnool caves are presented in Table-2 to consolidate and delineate the Pleistocene palaeo-ecological context in which prehistoric cultures are associated with.

The palaeontological studies are focused on reconstruction of the then surviving animals, geophysical terrain, resources, climatic conditions, habitats, and also migratory patterns of animals and cultural development. The diverse faunal groups such as Bovins (cattle), Lepus (hares), Sus (boars), Equus (ass) suggest expanses of grass along streams and streamlets (Murty, 1974), while arboreal animals like Presbytis (languor) and Papio (baboon) adapted to terrain of rocks and cliffs with shady groves and water sources nearby (Reddy, 1980). Similarly, the carnivores like Felis (cats), Vivera (mangoose), Ursidae (bears), and flocking animals like Antilope (blackbuck), Gazelle (chinkara), Cervus (sambar), Boselaphus (nilgai) indicate shrub jungle. The faunal data accounts for 31.90 percent grass and leaf eating animals (Artidactyla), while the carnivores, who depend on herbivores accounted for 21.28 percent suggesting a balanced pyramid of food web, and Rodentia (14.88 percent) indicate crevasses and cliff environs. These interpretations suggest the prevalence of thick forest over Erramala and Nallamala hill ranges, landscape of caverns, cliffs, swamps between these hill ranges with vegetative undergrowth around, grassy vegetation along floodplains and peneplains of Kunderu valley during Late Pleistocene (Badam, 1979, Patnaik *et al*, 2008). The evidence of fire place, burnt bones, lithified bones in Upper Palaeolithic horizon indicate coeval of fauna and hominid occupation of caves during late Pleistocene times (Nambi and Murty, 1983), but no significant progressive stages of development of lithic assemblages within the caves (Reddy, 1980). The chronometric ESR analysis of datable materials of occupational levels of Kurnool caves (Gogte *et al*, 1986) and cryptotephra layer in Charnel House cave on comparative method dated to~74 ka BP (Lane *et al*, 2011).

The in situ Kurnool caves fauna, particularly the evidences of Rhinoceros kanuliencis and Cynocephalus (Papio sp.) represent Ethiopian region (Prasad, 1996), and similar hypothetical evolution, distribution, migration, and links between India and Africa have been presented by various

authors (Lydekkar, 1886, Badam, 1979, 1984, Chauhan, 2007, Roberts *et al*, 2014). The fossil record succession of Kurnool caves indicate that the arid phase of Last Glacial Maxima (LGM) seem to be root cause for disintegration of swamp conditions lead the Pleistocene fauna to migrate or perish (Patnaik *et al*, 2008). The fossil fauna discovered from oxidized and calcretized fluvial silts laying above the volcanic ash in Sagileru valley at Venkatasettipalle includes Antelope cervicapra, Bos sp., Cervus sp., and Equus sp. (Shankar *et al*, 2006) interpreted to be Late Pleistocene to Early Holocene as they are associated with Upper Palaeolithic tools. At present the Kurnool sub-basin is a semi-arid dry zone of dry deciduous vegetation. Discovery of ostrich eggshells in association with flake tools of Middle Palaeolithic cultural phase in Paleru River valley at eastern border of the Cuddapah basin towards the seacoast (Press News) is interesting as the region presenting contrasting geo-climatic regimes, the wet and dry. In this context, the cave studies together with geoarchaeological studies of YTT within and outside Cuddapah basin, sand dunes of Paleru are of some significance in understanding spatio-temporal facies of prehistoric cultures. The Geological Survey of India reports in upper Gundlakamma river valley resulted in the discovery of animal fossils and Toba ash along with gravel, sand, silt deposits. These deposits were part of T2, prominently seen at Kothapalem, Gokanakakonda and Vemulakota (Singaraju and Shah, 2001, Reddy and Shah 2004). In addition to animal fossils, Palaeolithic artefacts are discovered at 3 sites in association with the Toba ash at Ainavolu, Timmayyapalem and Kothapalem in upper reaches of Gundlakamma (Reddy and Shah, 1998-99., Anil *et al*, 2019).

Temporal dimensions of Toba and Sand Dunes

Toba Ash: The eject of volcanic ash of Toba caldera in Sumatra, Indonesia occurs extensively as air-fall tephra in varying thicknesses (2-5 m) in the Indian subcontinent, Bay of Bengal and Indian Ocean (Acharyya and Basu, 1993). Among the four eruptive events from the Toba caldera complex over the past 1.2 m.y. the event that took place about 74 ka ago is designated as (YTT) Youngest Toba Tuff (Chesner *et al*, 1991; Westgate *et al*, 1998). Association of Prehistoric and late Pleistocene mammalian fauna in Narmada and Son river valleys of central India, and also in alluvial basins close to east coast of Andhra Pradesh (Singaraju and Shah, 2001), gained much prominence in geoarchaeological studies. The dated tuff has been used as an effective sinchron tool in correlation and dating of late Quaternary geomorphological sequences of Indian rivers (Westgate *et al*, 1998). The YTT occurrences in Cuddapah basin are known from Jurreru, a hill stream of Kunderu (Raman and Murty, 1997, Korisettar, 2014), Sagileru (Blinkhorn *et al*, 2014, Vijayakumari *et al*, 2017) and Jurreru (Blinkhorn *et al*, 2012) of Pennar river catchment area. The discovery of YTT at Jwalapuram (city of fire), a peasants village about 12 km from Banaganapalli, the mandal headquarters, Nandhyala district by Korisettar (2007) gained prominence, which lead to intensive inquiry through international collaboration.

Systematic geoarchaeological excavations into alluvial and lacustrine deposits of Jurreru at Jwalapuram has resulted in discovery of Middle Palaeolithic cultural material above and below the ash, dated to 74±7 ka and 77±6 ka by the team led by Petraglia (2007, 2009a, 2009b, Blinkhorn *et al*, 2012) and the contextual archaeometric analysis and OSL (Optically Stimulated Luminescence) dating in the absence of human remains was meticulously articulated to palaeo ecological conditions and human behaviour (Petraglia *et al*, 2012a, 2012b). These studies did not reveal any conclusive differences among the stone tool assemblages (1628 artefacts) belong to pre and post YTT, such as flakes, scrapers, retouched blades and burins, indicating technological continuity and also decimal impact of Toba on adaptive strategies of prehistoric populations. Similarly, multifaceted inquiry into

biological remains (mega/micro), sediments and phytoliths indicate woodland environment with swamps and grasslands (Hashalam *et al*, 2010a, 2010b and 2011).

The geochemical fingerprinting of glass shards and biotite deposits at Vankamari in Sagileru tephra are very similar in composition of YTT of Jurreru valley (Blinkhorn *et al*, 2014). The Vankamari Palaeolithic industries and stratigraphic compositions separating Lower Palaeolithic from Middle Palaeolithic and Late Palaeolithic is similar to that of Nandipalli in Sagileru valley (Reddy and Sudarsen, 1978) except that the tephra YTT offers an initial indication as isochron. The radiocarbon dating of gastropod shells from a sterile silty clay deposit separate the gravel bearing Middle Palaeolithic and microlithic industry, which was dated to c. 23-25 ka (Reddy and Sudarsen, 1978) indicate younger to 75 ka of Toba eruption (Blinkhorn *et al*, 2014). The OSL dating of the exposed Toba ash are bracketed between the range of 57±5 ka and 22±3 ka below and the above, in spite of primary and secondary nature of YTT of Kunderu and Sagileru (Geetanjali *et al*, 2019).

Sand Dunes: The eastern boarde of CB comprising the rocky knobs, small ridges, and foothills of Nallamala and Velikond hill ranges has been the source area for network of several hill streams of east flowing independent rivers of Gundlakamma, Paleru and Manneru. The headlands of Musi and Paleru rivers have preserved fluvial units of calcretised silty sand, clay unit underlined by sand dunes of etrogl origin, which are spread over 142 sq km area near Kanigiri and Pamuru, Prakasam district. These dunes are assigned to wind deflation phase of Quaternary times of last glacial maxima i.e. 18,000 BP indicating an extreme arid phase. The fluvial deposits below the sand dunes have yielded Palaeolithic cultures at some of the prehistoric sites listed in Appendix-I (Mishra and Singaraju, 2009; Anil *et al*, 2018). Morphological and chronometric analysis indicate two generations of dunes, the older one (A2) comprises dark brown highly oxidized very fine sand overlaid by fluvial unit, while the younger one (A1) consists of pale-yellow fine sand, indicating two phases of aridity during the Quaternary period. TL/OSL dating of dune by NGRI (National Geophysical Research Laboratories) indicates Mid-Pleistocene to Holocene ages (20,000-200 yrs BP). The silica and heavy mineral (quartz and feldspar) and SEM analysis of the sands indicate the source from quartzites of CB, blown by the palaeo-winds in west-east direction (Mishra and Singaraju, 2009). OSL dating of 47 samples yielded seven groups of ages from the present to 90 ka (90, 45-48, 30-33, 21, 11, 4.6, 1.7 ka and 16-200y), suggesting a long aggradation history, reflecting short-lived arid phases in an otherwise semi-humid landscape (Reddy *et al*, 2013).

Comparison of Chronology and Cross Dating

The geoarchaeological investigations in the CBR have resulted in four types of evidences that are used for calibration of temporal scale. These are recovered from fluvial deposits, Aeolian sand dunes, Karst breccia and air-fall Toba ash. Depending upon the evidence different dating methods such as Carbon-14, TL, OSL, SEM, AMS, EMP and XRF are used in conformity with conventional stratigraphic method, lithic artefacts and fossils. The studies are focused towards the diachronic nature of Stone Age cultures, synchronic air-fall of YTT, palaeo-windblown sand dunes, and characteristic fauna of palaeoenvironment to ascertain palaeoclimate and human ecology of the CBR. Collection of published works and compilation of analysed data systems in relation to the evidence, depositional agency, location, dating methods (relative/absolute), cultural phase, and main references of study are presented in Table 3. The consolidated calculated data is compared to the MIS stages to portray the CBR Palaeoclimatic episodes.

1. The Lower Palaeolithic date is contextualised as older than 90 ka based on the OSL calibrated dates of Aeolian sands to 90 ka as the Acheulean artefacts are unearthed below the sand dunes at Hajipuram, Veligandla and Vemulapadu of Paleru valley.

2. The Middle Palaeolithic is assigned to ca. 23-25 ka on Carbon 14 date of associated gastropod shells from a fluvial deposit of Sagileru at Nandipalli.
3. The YTT is an isochron found in different river valleys such as Gundlakamma, Sagileru and Jurreru valleys, the Jwalapuarm (JWP-3) is found in primary and secondary contexts, and in between the occurrence of Middle Palaeolithic is bracketed between 77±6 ky and 74±7 ky .
4. The fossil fauna of Gundlakamma recovered at Vemula together with YTT equated to Late Pleistocene period in comparison with cave deposits of Bethamcherla region.
5. The Upper Palaeolithic evidences together with vertebrate fossil fauna unearthed from a cave at Mutchatlachintamanugavi dated to ~18,000 to ~13,000 (TL dating of 17,390±10 BP).
6. The Upper Palaeolithic and Mesolithic cultural evidences of Billasurgum and Gunjana valley are assigned to Late Pleistocene on relative time scale.
7. The Jwalapuram Rock Shelter Carbon-14 date keeps the Mesolithic at 34 ky to 12 ky BP, the earliest of all the dates of Mesolithic culture in India.

It is evident from the compilation of the chronometric data that the hominin in CBR were present during Middle Pleistocene, and continued into Late Pleistocene during MIS 5 and MIS 3, practiced Palaeolithic cultures during LGM and thereafter into Holocene during MIS 7-5, practiced Mesolithic culture, and subsequent protohistoric cultures (Neolithic and Megalithic).

Topographical profile of CBR

The spatial distribution of different culture bearing sites belong to successive lithic typo-technological phases of development and their association with different deposition substratums, animal fossils, datable materials like YTT and sand dunes in CBR has been an unique context. Compilation of these data systems has resulted in delineation of 'cultural mobility' and transitions across macro habitats and adaptation to microhabitats. The broad riverine valleys, high-energy ravines, caves, rock shelters, either as continued prehistoric habitations or as seasonal camp stations are evidenced by the density and typology of tools and technological transitions and progressions at site level in specific and region in general. In order to understand spatiotemporal patterns of mobility and change, the graphic representations of topographic features of hills, uplands and valleys are drawn from contour patterns across the CBR with a premise that the water courses act as pathways. Five such graphic representations are drawn purposively at west-east directions of the CBR to generate topographic profile to understand probable migratory paths supported by site locations and associated material evidences under discussion (Map-II and Graph-I).

Spatio-temporal dynamics of valleys (young and matured water courses), floodplains (flora and fauna), geological formations (outcrops, caves, rock-falls), and weathered coarse and fine grained rocks into boulders, pebbles and chunks are of critical and integral resources that determine habitation, mobility and migration of prehistoric populations. A cursory look into the typo-technological variation of Palaeolithic cultures of the study area indicates that archaic forms and technique of fabrications are characteristic of coastal landscape than the interior Cuddapah Basin, where technological advancement and continuity of tool production is more prominent. Three zone progressions have been discerned from the graphic analysis. The first zone being the confluence of upstream coastal backwater rivulets of Venkatagiri, Kandleru and Upputeru with that of matured portion of the lower Pennar valley together with Boggeru and Cheyyeru tributaries seems to be congenial corridor-cum-habitat of main river course for Lower Palaeolithic, Lower and Middle Palaeolithic cultural transitions. Similarly, the interface of high-energy river portions of Gundlakamma, Paleru and Manneru of Velikonda foothill

zone and adjoining Sagileru valley lying in between Nalamala and Velikonda hill ranges enhanced the change from Acheulean to Levalloisian traditions, and continue to spread further into Cuddapah Basin (CB) lying between the Erramala and Nallamal hill ranges has been the second zone. The landscape of limestone upland caves and caverns and the Kunderu-Jurreru floodplains together with valley fills and biota of CB continue to support Palaeolithic cultures to flourish, and subsequent pre and protohistoric transitions as evidenced by the Mesolithic, Neolithic and Megalithic culture bearing sites in the CB.

Remarks

1. Limestone Dissolution channels as Caves and Rockslides of quartzite boulders as Rock-shelters

The Kurnool sub-basin is composed of succession of alternate shale and limestone formations capped by quartzite rocks. The limestone being water soluble, surface and subsurface water flows along joints and beds carved out several solution channels formed into caves during the geological past. Location of these caves in relation to terrain and water resource has been critical resources made use of as micro habitats for human inhabitation. Three out of 9 caves in Bethamcherla area were under human habitation during the Late Pleistocene and early Holocene times, as evidenced by Upper Palaeolithic and Mesolithic cultural material and associated fossil fauna. Similarly, differential weathering of underlying soft rocks like shale and limestone, and super positioned harder quartzite resulted in rockslides of huge boulders, strewn over piedmont region, depending upon the size, direction and angle of the boulder contiguous to water bodies, were large enough to provide shade are rock shelters. Several of such rock shelters were under occupation as evidenced by microliths, beads, and associated human and animal remains. In addition, the flat and plain rock surfaces have been used as canvas for aesthetic expressions as evidenced by several pictographs and petroglyphs, possibly drawn by the rock shelter dwellers (Chandramouli (1987-88). Occupation of Jwalapuram Locality 9 rock shelter by Mesolithic folk dated to c. 35,000 BP, and subsequent continuance into recent past as evidenced by Neolithic and Megalithic evidences is game changing landmark of the Indian prehistory (Murty, 1985; Clarkson *et al*, 2009). In a nutshell, the geological structures of CB, such as Owk shale, Narji limestone, Banaganapalli sandstone, Panniyam quartzite, and their differential succession, geophysical, geochemical composition and geomorphological processes resulted in assured micro habitats proximate to water bodies has been the most critical resource to consider the CB as an oasis of early hominine occupation, and even today the habitat of the Chenchu, the only hunting gathering community of mainland India until recent times, now at pre-agricultural stage (Murty, 1985; Prakash, in press).

2. Kunderu-Jurreru Valleys are Classical Prehistoric Habitats

The main drainage system of the Kurnool sub-basin is the Kunderu (215 km) and a network of hill streams. The Jurreru (45 km) is the most important hill stream/river due to its geoarchaeological markers, which were systematically surveyed, excavated and analysed for various culture chronological parameters. Limestone caves (9) are important repositories of Stone Age artefacts together with animal fossils of different kind (45). Other noteworthy evidence is the rock shelters (about 100), some of which are exhibiting prehistoric pictographs and petroglyphs in addition to cultural relics. The rock shelter (JLP 9) is one of the best studied Mesolithic occupation site, and the oldest (34 ky) provided human remains and artistic expressions. In addition, considerable number of protohistoric sites denoting Neolithic and Megalithic cultures are evidenced in alluvial plains, foothills and hilltops of the region. The limestone caves, caverns, boulders, springs, streams, waterholes, swamps and

such geophysical resources together with dry/humid deciduous vegetation, and its typical fauna continued to support the hominines ever since their entry into the basin during Mid Pleistocene times, continued to thrive during Pleistocene-Holocene transition, and subsequent cultivation communities as evidenced by 42 Neolithic sites (Venkatasubbaiah, 1987-88, Fuller *et al*, 2000-2001) and thereafter known by protohistoric (Megalithic) and subsequent early historic sites (details are not dealt here). The geophysical resources and geomorphic processes together with characteristic flora and fauna of the landscape between Erramala and Nallmala hill ranges of Kurnool sub-basin has been the classical habitat of adaptation for early hominines to thrive and progress during climatic fluctuations of MIS 3-5 and MIS 5-7 of arid and humid, as inferred from the geoarchaeological studies.

3. Nallamala-Velikonda Foothill Environs are Congenial Palaeolithic Habitats

The Sagileru River (141 km) is one of the tributary rivers of the Pennar River, while the east flowing independent Gundlakamma (225 km), Paleru (112 km) and Manneru (130 km) rivers had their origins at the foothills of Nallamala and Veliokonda hill ranges at north-eastern portion of CB as indicated by network of hill streams. The headword erosion of several hill streams provide access to landscapes endowed with natural springs, streambeds, pools, flora, fauna, and most importantly fine and coarse grained rocks rubble (shale, sandstone and quartzite) of different sizes (boulders, pebbles), types (broken pieces with sharp edges), shapes (handful size with cortical surfaces), and shades (brown, yellow, green etc.) to the early inhabitants. Evidences of Lower Palaeolithic (Acheulean culture) and Middle Palaeolithic (flake-tool culture) bearing sites at foothill regions and piedmont landscapes are more in number than main river courses, indicating the importance of hill streams region. Most of the sites located in hill stream regions belong to Lower and Middle Palaeolithic phases, while the sites of main river courses mostly of successive cultural phases such as Upper Palaeolithic, Mesolithic and Neolithic. The site specific analysis in relation to landscapes indicate the hill stream dissected foothill-piedmont environs are congenial for LP and successive progression to MP cultures, while floodplains of main rivers are more suitable for wide spread of Mesolithic culture, and a few micro environs for Upper Palaeolithic and Neolithic cultural practices or development.

4. Pennar and Coastal Rivers as Corridors of Cultural Transitions

Catchment area of the Pennar river right from its origin in Nandi Hills of Karnataka passing through the Cuddapah Basin of Andhra Pradesh to join the Bay of Bengal has been lifeline for Pre and Protohistoric cultural development, as envisaged by several geoarchaeological and palaeontological studies. The earliest Palaeolithic cultural evidence of CBR is denoted by Acheulean culture (Late Acheulean) otherwise would have been chopper chopping (pebble tools) and Abbevillian (early stage of Acheulean) or Early Acheulean, which are found in neighbourhood Kandleru and Venkatagiri rivers located south of Lower Pennar valley. But the prehistoric studies conducted in the south and southeast of CBC indicate pebble tools (chopper, chopping tools), Abbevillian (crude hand axes) and Acheulean hand axes in the stream beds and banks of Kandleru (69 km) and Venkatagiri (< 40 km), which join Upputeru, a backwater streamlet traverses through coastal laterites to join Bay of Bengal (Sudarsen, 1979). The pebble tool element is categorically seen (92 out of 539 finished tools accounting for 17.07 %) and three technological stages of hand axes (deep, deep and shallow, small and steep flaking) among 272 hand axes indicating Abbevillian/Early and Late Acheulean stages of hand axe development. During my fieldwork as part fulfilment of MA course, experimented to produce pebble tools on water worn quartzite pebbles in pebbly bed of Kandleru stream (Prakash, 1976). Further south in Tamil Nadu, the 'Madrasian Industry' characterised by hand axes and cleavers found

at Attirampakkam, a prehistoric site gained academic prominence and excellence due to its scientific precision of data collection, analysis and date, much earlier ~1.7 to ~1.07 my than believed to be about one lakh years (Pappu and Akhilesh, 2019). The differential occurrence and distribution of archaic and advanced traditions of Acheulean evidences in independent river valleys of Coromandel Coast (coastal landscape between the Krishna and the Kaveri Rivers), covering coastal districts of Prakasam and Nellore districts of Andhra Pradesh and Tiruvallur district of Tamil Nadu, and inland Cuddapah Basin, the Pennar river course flowing west-east direction from Nandi Hills of Karnataka state till debouch into Bay of Bengal might be viewed as corridor of trespass for varied essential geo-biological resources by the early Hominine. The geo-cultural connectivity of CB presumed to be from coastal east and southeast (coastal lateritic area and backwater streamlets) than the inland Deccan. The north connect of Krishna-Godavari and Kolleru wetlands is not possible as they were of Holocene origin (Prakash, 2025).

5. *Rich in Heritage-Poor in Conservation*

The CBR is known for several hundreds of Prehistoric sites with thousands of lithic artefacts and associated fossils and datable material evidences. These sites are brought to light by the government departments (Geological and Archaeological Surveys of India, State Departments of Archaeology and Museums), and various academic departments of Universities. Explorations are carried out as administrative responsibility by the government departments; publish as reports and some in academic journals, while the academic institutions as part of field training and for the award of research degrees. Most of the data is collected from surface sites; a few excavated, analysed and published. In case of protohistoric sites, most of cultural vestiges are left at site, which were destroyed or vandalised. Geomorphic landmarks like sand dunes and volcanic ash are quarried for pernicious purposes. It is heartening to state that the land (CBR) endowed with plurality natural and cultural heritage brought out by several geoarchaeological studies is not properly conserved for posterity, which entangles pride and prestige of the land and people (caves are concretised, while rocks, ash, earth, sand are indiscriminately quarried).

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Table 1: Distribution of Archaeological sites against the Rivers, Caves, Foothills, Hilltops, associated with Fossils, YTT and Rock Art in Cuddapah Basin, and adjoining Upland Coastal Landscape [Data compiled from different sources of studies (See References)]

S. No	*Rivers / Landscapes*	*Tributary Rivers that join the main river course/ Landscapes*	*Hill Streams (HS) that join the tributary river*	*Pre historic and Protohistoric Cultures / Lithic Cultures*													*Other Evidences*				***Total***
				LP	*MP*	*UP*	*LP, MP*	*LP, MP, UP*	*LP, UP*	*MP, UP*	*LP, Mes*	*UP, Mes*	*LP, MP, Mes*	*MP, Mes*	*Mes*	*NE, ME*	*MP, Mes, NE, ME*	*Foss*	*YTT*	*Foss/ YTT*	*RS/ RA*	
A	Krishna River	Tungabhadra (AP 58 km)	Tungabhadra (MRC)	1	5	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9
B	Pennar (Left side) Kurnool Sub-Basin	Kunderu (215 km)	Kunderu (MRC)	10	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	12
			Galeru	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
			Jurreru	-	2(2)	-	-	-	-	-	-	-	-	-	-	2	1(1)	-	(1)	-	(1)	**5 (3)**
			Bhavanasi	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	**1**
		Sagileru (141 km)	Sagileru (MRC)	7	4(2)	4	6	2	1	2	-	-	-	-	-	-	-	1	4(2)	-	-	**30 (2)**
			Badvel	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
			Bokkineru	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	**2**
			Mulavanka	1	-	-	1(1)		-	-	-	-	-	-	-	-	-	-	(1)	-	-	**2 (1)**
			Rallavagu	4	1	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	**9**
			Teegaleru	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	**2**
		Boggeru (<50 km)	Boggeru (MRC)	4	2	-	10	-	1	-	-	-	-	-	-	-	-	-	-	-	-	**17**
			Penneru	1	3	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**5**
	Pennar [597 (AP 536 km)]		Pennar (MRC)	4	4	1	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**15**
	Pennar (Right side) Papagni Sub-Basin	Papagni (< 50 km in Cuddapah Basin)	Papagni (MRC)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
			Bahuda	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
		Gundleru (<50 km)	Gundleru (MRC)	1	-	-	2	-	-	1	-	-	-	-	-	-	-	-	-	-	-	**4**
		Buggavanka (< 50 km)	Buggavanka	-	-	-	2	-	-	1	-	-	-	-	-	-	-	-	-	-	-	**3**
		Cheyyeru (87 km)	Cheyyeru (MRC)	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**3**
			Gunjana	6	1	12	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	22
C	Independent Rivers origin at eastern border of Cuddapah Basin and join Bay of Bengal	Gundlakamma (225 km)	Gundlakamma (MRC)	3(1)	2(1)	5	2	2(1)	1	3(1)	-	-	-	1(1)	-	-	-	-	15(4)	2(1)	-	**36 (5)**
			Chilakaleru	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	**1**
			Pasupuleru	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	**1**
			Pulivagu	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**
		Paleru (112 km)	Paleru (MRC)	16(1)	4	1	15	1	1(1)	-	1	-	2(1)	-	1	-	-	-	-	1+3*	-	**42 (3)**
		Manneru (130 km)	Manneru (MRC)	7	1(1)	1	1	-	-	-	-	-	-	-	-	-	-	-	1(1)	-	-	11 (1)
D	Other Type of Landscapes	Kurnool Sub-Basin	Caves	-	-	2(2)	-	-	-	-	-	1(1)	-	-	-	-	-	7(9)	(1)	-	-	10 (3)
		Kunderu Valley	Rock-Shelters	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	17**	**17**
		Erra/Nallamala Hills	Foothills	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	**2**
		Srisailam Sub-Basin	Plateau/Hilltops	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	**2**
		Total		72(2)	32(6)	28(2)	54(1)	10(1)	7(1)	8(1)	1	2(1)	2(1)	1(1)	1	2	1(1)	8(9)	22(10)	3	17	271(18)

MRC: Main River Course, LP: Lower Palaeolithic, M.P: Middle Palaeolithic, UP: Upper Palaeolithic, Mes: Mesolithic, NE: Neolithic, ME: Megalithic, Foss: Fossils, YTT: Youngest Toba Tuff, Figures in the parenthesis indicate Prehistoric sites associated with YTT (13), Fossils (4), and in substratum (22), Some sites may have different Localities. YTT associated with Pot Sherds (2),Fossils & Pot Sherds (1, Sand Dunes (2). Rock Shelter sites** (17) are found away from the rivers/stream courses and are distributed at higher elevations. In total there are 104 Rock Shelters, and many of them present Rock Art.

Table 2: Comparative list of Fossil Fauna unearthed from the Caves of Kunool Limestone Region and Jwalapuram, Cuddabaph Basin, Andhra Pradesh

S. No	*Order/Class*	*Billasurgum (Family / Species)*			*Muchatla-chintamanu*	*Chandrapalle*	*Jwalapuram JWP 9*	*Common Name*
		Lydekkar, 1886	*Prasad and Yadagiri, 1986*	*Reddy, 1980*	*Murty, 1974,*	*Prasad, 1996*	*Petraglia et al*	
1	Primates-2 (4.26%)	Semnopithecus priamud, Blyth.	Presbytis entellus	Presbytis sp.	-	Presbitis emtellus	Presbytis entellus	Langur
2		Cynocephalus (cf. annibus, F. Cuv.)	Papio sp.	-	-	-	-	Baboon
3	Carnivora-10 (21.28%)	Felis tigris (or? Leo), Linn	Panthera tigris	Felis sp.	Viverra sp.	-	-	Tiger / Lion
4		Felis? Paradus, Linn	Felis rubiginosa	-	Felis sp.	Felis sp.	-	Leopard
5		Felis chaus, F. Cuv.	-	-	Hystrix sp.	-	Felis chaus	Jungle cat
6		Felis rubiginosa, Geoffr	-	-	-	-	-	Rusty spotted cat
7		Hyaena crocuta (Erxl.)	-	Hyaenid sp.	-	-	-	Spotted hyanea
8		Viverra karnuliensis, n.sp.	Viverra karnuliensis	Viverra	-	Viverra karnuliensis	-	Indian grey mangoose
9		Herpestes smithi, Gray	Herpestes sp.	-	-	-	Herpestes edwardsi	Indian brown mangoose
10		Ursus, sp.	Melursus sp.	Ursidae	-	Ursus footei*	-	Sloth bear
11		-	Canis sp.	Canis sp.	-	-	Canis sp.	Jackal/Wolf
12		-	Crocuta sp.	-	-	-	-	Hyena
13	Insectivora-1 (2.13%)	Sorex (cf. caerulescens, Shaw).	Sorex sp.	-	-	-	-	Shrew
14	Chiroptera-2 (4.26%)	Tophozous saccolaemus, Temm.	Tophozous saccolaemus	-	-	-	-	Pouch bearing bat
15		Phyllorhina diadema (Geoffr).	-	-	-	-	-	Large Malaya leafnosed bat
16	Rodentia-7 (14.88%)	Scirrus macrurus, Harda.	Sciurus sp.	-	Equus sp.	-	-	Squirrel
17		-	Bandicota indica	-	-	-	-	Porcupine
18		Golunda ellioti	-	-	-	-	-	Indian bush rat
19		Mus mettardi, Gray	-	-	-	-	-	Soft furred field rat
20		Mus platythrix, Sykes	-	Mustelidae	-	-	-	Indian brown spring mouse
21		Nesokia bandicoota, Rech.	-	-	-	Nesokia bandikota	-	Large bandicoot rat
22		Hystrix crassidens (hirsutirstris)	Hystrix crassidens	-	-	Hystrix crassidens	Hystrix indica	Porcupine
23	Lagomorpha-2 (4.26%)	Lepus (cf. nigricollis, F. Cuv.)	Lepus cf. negricollis	Lepus	-	-	Lepus negricollis	Black-naped hare
24		-	-	Leporidae	-	-	-	Rabbit / Hare
25	Perissodactyla-3 (6.38%)	Equus (? 2 sp.)	Equus asinus	-	-	Equus asinus	Equus sp.	Ass
26		-	-	-	-	Equus sp.	-	Wild Ass
27		Rhinoceros karnuliensis	Rhinoceros karnuliensis	-	-	-	-	Rhinoceros

S. No	Order/Class	Billasurgum (Family / Species)			Muchatla-chintamanu	Chandrapalle	Jwalapuram JWP 9	Common Name
		Lydekkar, 1886	Prasad and Yadagiri, 1986	Reddy, 1980	Murty, 1974,	Prasad, 1996	Petraglia et al	
28	Artiodactyla-15 (31.91%)	Bos or Bubalus	-	-	Babalus sp.	Bos sp.	Bubalus bubalus	Ox / Buffalo
29		Boselaphus tragocamelus (Pall)	-	-	-	-	Boselaphus tragocamelus	Nilgai
30		Bos or Bubalus	Boselaphus tragocamelus	Boselaphus sp.	Boselaphus sp.	Boselaphus tragocamelus	-	Ox / Buffalo
31		Boselaphus tragocamelud (Pall)	-	Bos sp.	Bos sp.	-	-	Nilgai
32		Gazella benneti (Sykes)	Gazella benneti	-	Gazella sp.	-	Gazilla tetracerus	Chinkara
33		Antilope cervicapra (Linn.)	Antelope cervicapra	Antelope sp.	Antilope sp.	Antelope cervicapra	Antilope cervicapra	Blackbuck
34		Tetraceros quadricornis (Blain)	-	Tetracerus sp.	-	-	Tetraceros quadricornis	Four-horned antelope
35		Cervus aristotelis, Cuv.	-	Cervus sp	Cervus sp.	-	Cervus unicolor	Sambar
36		Cervus axis, Erxl.	-	-	-	-	Axis axis	Chital/Spotted Deer
37		Tragulus [cf.meminna (Erxl.)]	-	-	-	-	-	Mouse deer
38		Sus cristatus, Wagner	Sus karnuliensis	Sus sp.	-	Sus cristatus	Sus sp.	Indian wild boar
39		-	-	-	-	-	Erinaceous sp.	Hedgehog/Mullapandi
40		-	-	-	-	-	Muntiacus muntjak	Barking Deer
41		-	-	Oris sp.	-	-	-	Sheep
42		-	-	-	-	-	Capra hircus	Goat
43	Edentata-1 (2.13%)	Manis gigantea, Gray	Manis gigantea	-	Panther	-	Manis gigantia	Pangolin
44	Reptilia-3 (6.38%)	-	Crocodylus sp.	-	-	-	-	Crocodile
45		-	Varanus dracanea	Varanus	-	-	-	Monitor Lizard / Udumu
46		-	Naia tripudians (Merr.)	-	-	-	-	Snake / Cobra
47	Amphibia-1 (2.13%)	-	Bufo melanosticus	-	-	-	-	Frog
	100%	**47**	**26 (55.32%)**	**17 (36.17%)**	**11 (23.4%)**	**12 (25.53%)**	**19 (40.43%)**	**47**

* Collected by Andhra Pradesh State Department of Archaeology, NOTE: In addition to these at Vemula in Gundlakamma valley Elephus, Equus, Bovid and Cervid fossils remains are reported (Reddy and Shah, 2004), and at Ainavolu, Gokanakonda and Khambampadu fossil remains of Bos sp. are recovered (Anil et al, 2019)

Table 3: Comparative Chronometry of Cuddapah Basin and Cuddapah Basin Region

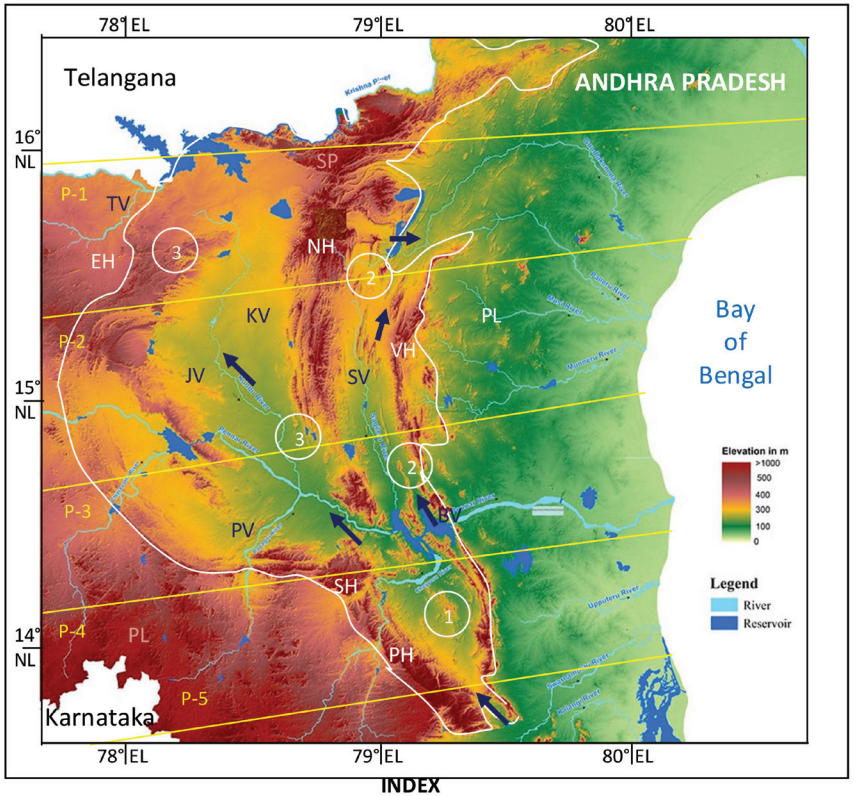
S. No	*Type of Evidence*	*Depositional Agency*	*Location / Site /Area*	*Chronometry*		*Prehistoric Culture*	*Important Reference*
				Relative Dating and (MIS)	*Absolute Dating (OSL, C-14)*		
1	Stratified Deposits	Fluvial Sagileru Valley	Nandipalli	Late Pleistocene	Gastropod shells Ca. 23-25 ka (Carbon-14) PRL	Middle Palaeolithic	Reddy and Sudarsen, 1978
2	Sand Dunes	Paleru Valley Aeolian	Hajipuram Veligandla Vemulapadu	Mid Pleistocene MIS Stages 3- 5	OSL ~90 ka to Recent (7 groups), SEM studies: Aeolian, XRF studies: Local Transport	Lower Palaeolithic	Mishra et al, 2009 Reddy et al, 2013
3	Fossil Fauna	Karst Breccia Caves	Billasurgum &	Late Pleistocene &	Carbon 14 Date 50 kya Ranges between 1487±27 & 3995±32	Upper Palaeolithic & Mesolithic	Murty, 1975, Reddy, 1980, Prasad, 1996 Roberts et al, 2014
			Mutchatla-chintamanu Gavi (MCG)	Holocene, MIS 7-5 LGM ~18,00 to ~13,00	TL Date 17,390±10 BP	Upper Palaeolithic	Nambi and Murty, 1983 Patnaik et al, 2007
			Sanyasulagavi	Late Pleistocene	Carbon 14: 1159±30 BP B5: 3515±25	Mesolithic, Potsherds	Petraglia et al, 2009 Fuller et al, 2007
4	Toba Air Fall Ash (YTT)	Jurreru Valley	Jwalapuram (JWP-3)	MIS 5	OSL 77±6 ky and 74±7 ky	Middle Palaeolithic Pre and Post YTT	Petraglia et al, 2007, 2014
			Jwalapuram Rock-Shelter	MIS 3-5	C14 Dates: 34 kyr to 12 kyr BP	Mesolithic	Petraglia et al, 2009, 2014
		Sagileru Valley	Sagileru Bridge (SB) Singampalli (SGP) Venkatamarri VKM)	EMP studies: similar to that of Jurreru	OSLDates at SB 67±25 ka and 65±3 ka SGP 28±21 ka and 0.3±0.01 ka VKM 48.2±4 ka and 64±7 ka	Middle Palaeolithic Transition	Blinkhort et al, 2014 Geethanjali et al, 2019
		Gundlakamma Valley	Ainavolu (ANV) Retlapalle (RTP) Vemula (VML)	Fossil Fauna indicate Late Pleistocene	OSL at ANV 57±5.01 ka and 22±3 ka Equated to Jurreru based on textural studies	Late Acheulean	Reddy et al, 2004 Geethanjali et al, 2019 Anil et al, 2019, 2023
		Manneru Valley	Motravulapadu (MVP)				Anil et al, 2025

TL= Thermo Luminescence, OSL= Optically Stimulated Luminescence, AMS+ Accelerator Mass Spectrometry, EMP= Electron Microprobe, XRF= X-ray Fluorescence Spectroscopy, MIS= Marine Isotope Stage

Map- II: Location of Cuddapah Basin (CB), adjoining Eastern Peneplains and Coastal Region

Graph-I: Topographic cross profile of Cuddapah Basin Region (CBR)

[Profiles (P-1 to P-5) are drawn purposively between western borders of CB to the East Coast (Bay of Bengal) through hill ranges of Eastern Ghats]



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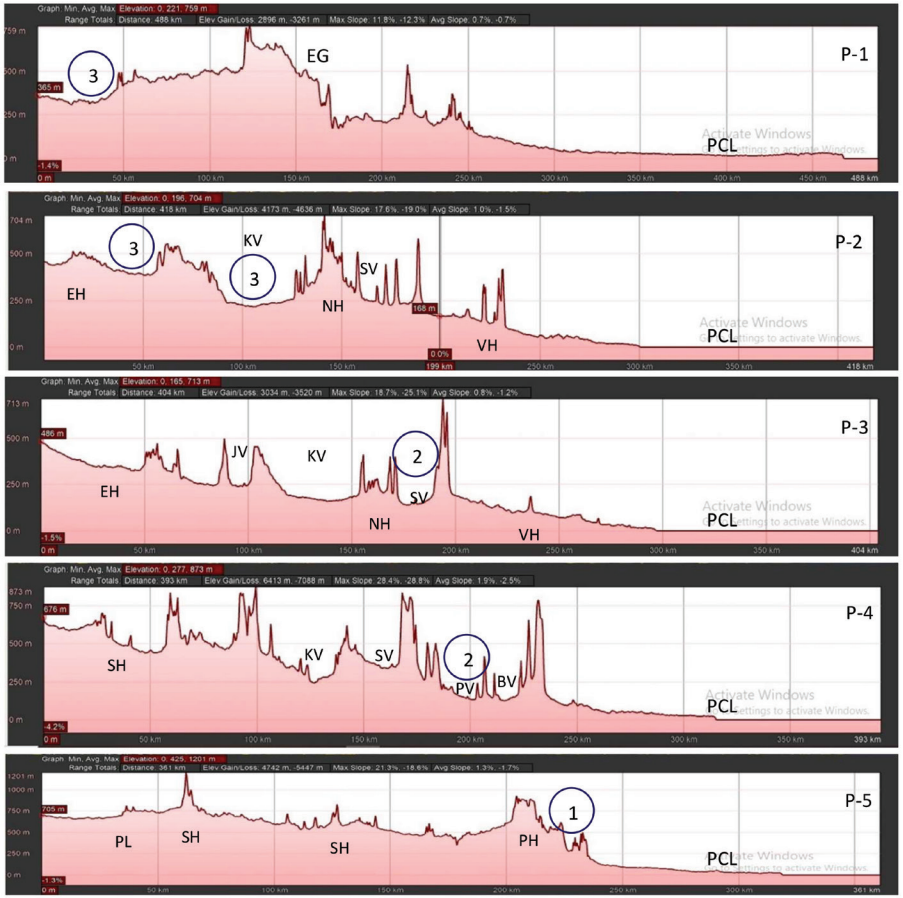
PCL= Peneplains and Coastal Landscape, EG= Eastern Ghats, EH= Erramala Hills, NH= Nallamala Hills, PH= Palakonda Hills, SH= Seshachala Hills, VH= Velikonda Hills BV= Boggeru Valley, GV=Gundlakamma Valley, JV= Jurreru Valley, KV= Kunderu Valley, PV= Pennar Valley, TV= Tungabharda Valley.



Base Map source: Dr. G. Prasada Rao, Andhra Pradesh Space Application Centre (APSAC), Vijayawada, Andhra Pradesh.

Graphs source: Prof. K. Raghu Babu, Dept. of Geology, Yogi Vemana University (YVU), Kadapa, Andhra Pradesh.