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ORIGINAL ARTICLE

Geoarchaeological Heritage of Kachchh Region, Gujarat, Western India: Geotourism Potentials

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Abstract

The evolution and proliferation of human civilization garner great interest, not only from the scientific community but also from the general public. Each year, millions of tourists visit archaeological locations across the globe. Ancient civilizations are often shrouded in mystery due to the limited data available from archaeological structures. Allied sciences like geology have been of tremendous assistance in understanding the relationship between man and the environment. The Kachchh region is home to several sites of the Indus Civilization (also known as the Harappan Civilization). Due to its geological setting, Kachchh also has unique structural, geomorphological, petrological, paleontological and archaeological attributes. Therefore, the region attracts the attention of geologists, archaeologists and tourists alike. The present study describes Harappan sites in Kachchh which have been proposed as potential locations for geoarchaeological tourism. Since UNESCO World Heritage archaeological sites like Dholavira are already popular with tourists, it acts as an impetus for geotourism and geoarchaeological research. Geoarchaeological tourism in Kachchh can serve as a great avenue for boosting the economy of the local communities by utilization of the existing geological and archaeological assets and contributing to the nation's growth.

Keywords Geotourism · Geoarchaeology · Indus Civilization · Kachchh

Introduction

Geological studies have a long history of association with archaeology and are often used in conjunction with modern archaeological research. Geoarchaeology can be termed as a discipline that involves the application of geoscientific methods to solve certain problems in archaeological research (Pollard 1999). Geology and climate have always played a vital role in shaping the cultural and socio-economical aspects of a particular region. Geological settings like rivers, plains, mountains, coastlines, deserts etc. decide the resources a human settlement has at its disposal and the challenges it would face in the particular setting. Climatic fluctuations, like variations in Indian summer monsoon strength in the past, have resulted in serious human crises with economic and ecological implications as a result of severe floods and droughts (Enzel et al. 1999; Shewale and Kumar 2005; Cook et al. 2010; Dixit et al. 2014, 2018; Dutt et al. 2018; Kotlia et al. 2018). The effect is so widespread that it influences the whole region of South Asia which consists of about a quarter of the global human population. Similarly, the fluctuating climate during the Holocene has witnessed the rise and fall of several civilizations. The impact of climate fluctuation on civilizations has been so significant that the ~ 4.2 ka aridification event has been linked with the collapse of civilizations such as Egypt (Old Kingdom), Greece, Crete (Early Bronze Age civilizations) and the Mesopotamia (Akkadian Empire) (Cullen et al. 2000; Marshall et al. 2011; Weiss and Bradley 2001). Recent studies by a few scholars also relate the probability of large-scale deurbanization of (Indus Civilization) to the onset of the Meghalayan age (Staubwasser et al. 2003; Madella and Fuller 2006; Dixit et al. 2014; Sengupta et al. 2020) .

This article is part of the Topical Collection on Indian Geoheritage: From the Precambrian to the Present

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The Kachchh region has been important for several geological findings for a century owing to its unique geology (Bhosale et al. 2021). As such, various sites in the Kachchh region have been proposed as geoheritage sites by previous researchers (Bhosale et al. 2021; Chauhan et al. 2021; Chavan et al. 2022). The term "geoheritage" includes sites at all scales, that are intrinsically or culturally important, which offer information or insights into the formation or evolution of the Earth, or into the history of science, or that can be used for research, teaching, or reference (Brocx and Semeniuk 2007). Along with the unique regional geology, Kachchh is also home to several archaeological sites spanning from the Palaeolithic to the Late Medieval Period (Blinkhorn et al. 2019; Bharucha 1996) . The most popular of these is the presence of archaeological remains of the Indus Civilization (one of the earliest urban civilizations of the ancient world) throughout the region (Khan and Possehl 1992; Weber et al. 2010).

The present work aims to promote geotourism through the lens of geoarchaeological study in Kachchh. Dholavira (the fifth largest city of the Indus region), in the Great Rann of Kachchh, is one of the most famous Harappan sites in India. However, it is just one of the many sites throughout the region. Some of the sites are either recently discovered or not well known to the locals and tourists. These sites carry great potential as tourist attractions as well as immensely valuable for geoarchaeological research. The geoarchaeological research in Kachchh is still in its nascent stage with only a few major sites which have been focused on. Geotoursim along with an archaeological approach incentivizes study on particular topics and raises important questions concerning the proliferation of human civilization. The Kachchh region being climatically harsh, tectonically active and affected by changing sea levels is a fascinating prospect to observe the influence of geology, climate and ecology on ancient human societies. It sheds light on how all these factors have played a role in the adaptation, evolution and decline of these settlements. The paper discusses various Harappan archaeological sites throughout Kachchh in conjunction with the local geological sites which serve as a guide and an archive for potential touristic and research endeavours in the region.

Study Area

Geological Setup of Kachchh Basin

The peri-cratonic rift basin of Kachchh formed as a result of the breakup of the Gondwana mega-continent during Late-Triassic to Early-Jurassic (Biswas 2016a). Presently, the basin is experiencing compressive stress due to the collision of the Indian and the Eurasian plates which have given rise to the present-day complex structures as a result of tectono-sedimentary-igneous origin. The Kachchh region is tectonically active and is categorised as zone-5 on the seismic zonation scale. There are several East–West trending basin bounding faults in the region which were a result of the initiation of rifting (Nagar Parkar Fault, NPF; Island Belt Fault, IBF; Kachchh Mainland Fault, KMF; and North Kathiawar Fault, NKF) (Biswas. 2016b). These primary faults have given rise to the different uplifts in Kachchh (Kachchh Mainland Uplift, MU; Wagad Uplift WU; Island Belt Uplift, IBU; Paccham Uplift, PU; Khadir Uplift, KU; Bela Uplift, BU; Chorar Uplift, CU) (Fig. 1). During the Late-Cretaceous-Early Paleocene, the Indian plate travelled over the Reunion hotspot, which resulted in several intrusive bodies throughout the Kachchh region, known as the Deccan Traps (Biswas and Deshpande 1973). The plugs and igneous intrusion have formed positive relief within the terrain because of their high strength against the weathering activities (Kshirsagar et al. 2011).

The vast salt-encrusted wasteland, known as the Rann of Kachchh, covers a major portion of the region. The Rann is divided into the Great Rann of Kachchh (GRK), which covers the central and northern parts of Kachchh while the Little Rann lies in the southeast region. The geological history of the basin is around 200 million years old starting from the Jurassic Period to the present day. The Kachchh Basin is recognized as one of the most important Jurassic fossil localities in the world, especially for fossil ammonoids. The Mesozoic and Cenozoic formations in Kachchh are abundant in several fossil assemblages which include Molluscs, corals, sponges, crustaceans, sharks, giraffes, elephants, rhinoceros, whales, crocodiles, ichnofossils, plant fossils and microfossils (pollen, spores, foraminifera etc.).

Climatically, the Kachchh region is classified as an arid to semi-arid region with annual precipitation of ~ 310 mm and the average temperature varies from 50°C in the summer to 10°C in winter (Basu et al. 2019). Due to scanty rainfall the, rivers in Kachch are seasonal in nature. The drainage system in Kachchh is largely tectonically controlled.

Archaeological Setup of the Kachchh Basin

Geographically, the Kachchh region lies between Sindh in the southeastern portion of Pakistan and the rest of Gujarat. Geologically, it marks the western limit of the Deccan Traps. The archaeological records from Kachchh show features similar to the adjacent regions, giving the region a transitional quality. The high frequency of Harappan urban phase sites in Kachchh points to the fact that this subregion was an important part of the Indus Civilization (Possehl 1980). Most of the sites in the region are of Urban and Post-Urban Harappan phases with only a few Pre-Urban Harappan. The sites are scattered all over the region from coastal to inland with some of the sites found in the present-day climatically and resourcefully challenging areas like the Rann of Kachchh. Some of the Urban Harappan sites in Kachch are

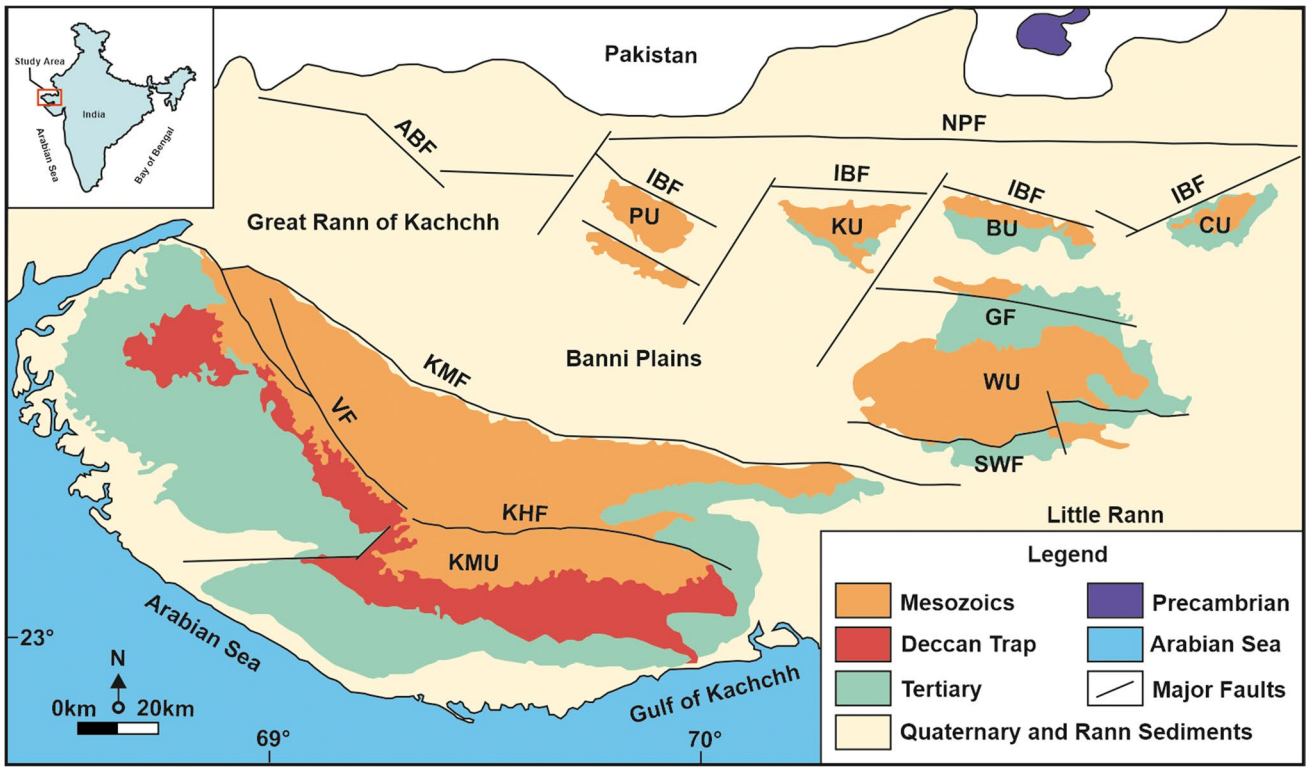

Fig. 1 Geological map of Kachchh showcasing the stratigraphy and major structural features (modified after Biwas 1993). KMU, Kachchh Mainland Uplift; WU, Wagad Uplift; PU, Paccham Uplift; KU, Khadir Uplift; BU, Bela Uplift; CU, Chorar Uplift; KMF, Kachchh Mainland Fault; SWF, South Wagad Fault; IBF, Island Belt Fault; NPF, Nagar Parkar Fault; KHF, Katrol Hill Fault; VF, Vigodi Fault; GF, Gedi Fault; ABF, Allah Bundh Fault

fortified in nature. The goods made at various Harappan sites in Gujarat have been found in sites like Harappa and Mohenjodaro. Archaeological evidence from various sites in the Greater Indus region clearly shows that Kachchh also served as a strategic trade corridor (Possehl and Raval 1989). A few scholars have argued that changes in the Rann of Kachchh over time led to conditions that effectively cut off Gujarat from the rest of the Greater Indus Region (Roy and Merh 1977; Gupta 1977). The locations and descriptions of major sites in Kachchh have been further depicted in the following sections (Fig. 2).

Geoarchaeological Studies from Kachchh

In terms of geoarchaeological studies associated with the Harappan Civilization, a fair amount of work has been done in northern India, especially in areas of Rajasthan, Punjab, Haryana etc. Since the Kachchh region lies in the transitional zone which connects the Sindh to the rest of Gujarat, it is important to understand the changes occurring in the Kachchh region to get a clearer picture of the Harappan Civilization in Gujarat. Significant studies related to Holocene climatic changes have been done in the Kachchh region but only a few of them attempt to explain the human-climate connection. There is often a discrepancy in the geological and archaeological findings which are yet to be resolved. Hence, the need to reach a common consensus related to the Harappan culture in Kachchh and the rest of India is necessary. Significant geoarchaeological studies from the region will be described in this section. Deo et al. (2011) studied the environmental changes in the coastal archaeological sites of Gujarat and Maharashtra. According to the study, Kanmer which is presently situated in an arid-rocky landscape witnessed 2–5 m deep water in the little rann of Kachchh during the mid-Holocene. Pokharia et al. (2011) and Goyal et al. (2013) suggest a shift to drought-resistant crops during the Late Harappan Period at Kanmer as a result of a shift to declining monsoon conditions and a relatively drier climate. Gaur et al. (2013) suggest that the Rann of Kachchh could have served as a navigable water body during the Harappan Period which facilitated overseas trade in the region. Chatterjee and Ray (2017) studied the sedimentation history of the Great Rann of Kachchh and suggest that the drying up of the Ghagra-Hakra-Nara river system may not have been the primary cause for the decline of the civilization. Kothyari et al. (2019) reported structural damage to the Kotada Bhadli Harappan site around 2200 BC as a result of an earthquake and abandonment of the site around 1900 BCE due to increasing aridity. Dumka et al. (2019) studied the archeo-seismological aspects of Dholavira and estimated that the Island belt fault can generate an earthquake of

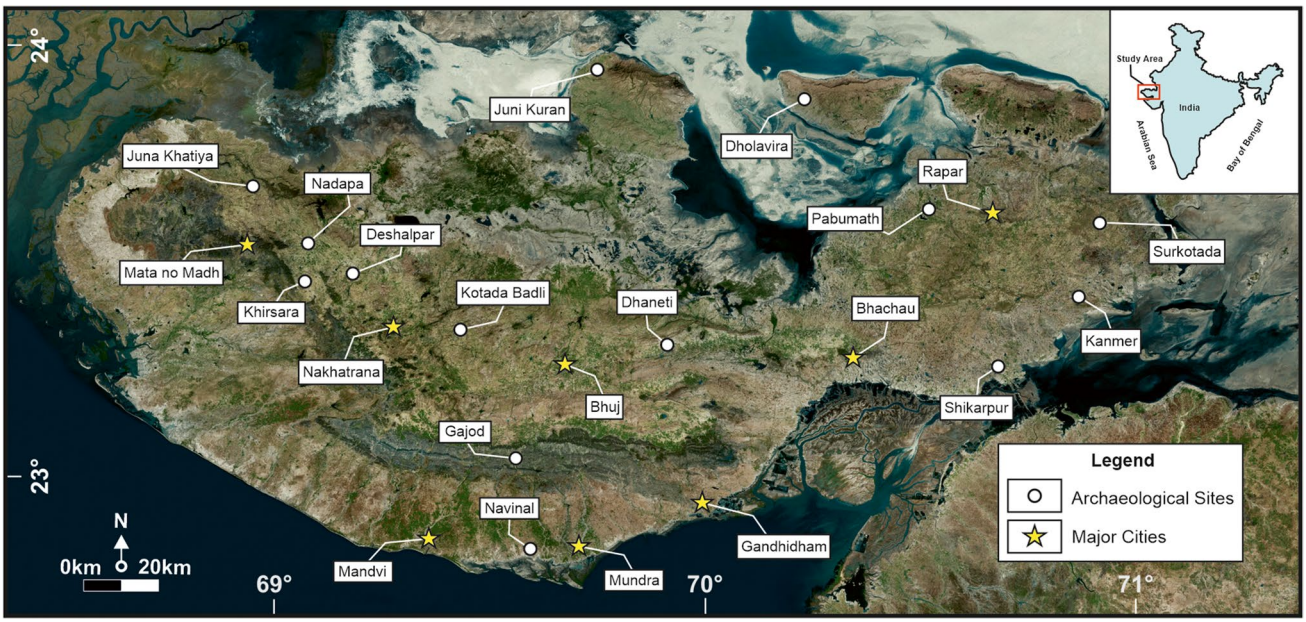

Fig. 2 Location map of the 14 geoarchaeological sites along with the major cities in the region

≈ Mw 6.0. Radiocarbon dating of archaeological carbonates from seven cultural stages at Dholavira suggests the beginning of occupation at ~ 5500 years BP and continuation till ~ 3800 years BP with a possible drought around ~ 4300–4100 years BP which contributed to the collapse of the settlement (Sengupta et al. 2020). Records from the coastal dunes of western Kachchh indicate a lowering of sea level during ~ 4.2 ka; however, the sea-level changes in the area do not seem to have a major impact on the Harappan settlements (Dabhi et al. 2021).

Harappan Sites in Kachchh

The section contains a detailed description of the reported archaeological sites of the Harappan Civilization from the Kachchh region which are proposed as geoarchaeological sites in the current paper. Along with the published archaeological details, the local geology of the site has also been described.

Juna Khatiya

Archaeology

Juna Khatiya (23°41′52″ N; 68°57′23.96″ E) is an Early Harappan cemetery site (Fig. 3) discovered (2016) and excavated by the Department of Archaeology, Kerala University in 2019 and 2020. The site is located on the right bank of the Gandi River near Khatiya village in Lakhpat Taluka of Kachchh district. The surface features have revealed close to five hundred burials and some have been eroded or disturbed by anthropogenic activity. The excavation has revealed various types of burials including primary and secondary burials, cremation and symbolic pot burials. Burial goods recovered from the site include shell bangles, shell beads, stone beads and different types of pottery. A Rohri Chert blade and Pre-Urban Harappan Sindh Type ceramics found from the site indicate interregional interaction between Kachchh and the Sindh in the late fourth millennium BCE. The pottery from the site shows similarities with the pottery from Santhali, Moti Pipli, Nagwada, Dhaneti, Amri, Nal and Kot Diji. The ceramic assemblage is comparable to the Pre-Urban Harappan Sindh Type ceramics recovered from the Datrana which has been radiocarbon dated to the Early Harappan Period (Gadekar et al. 2021).

Geology

The site is around 0.25 sq km in size. Most of the area is covered by Deccan Trap basalts (Ukra Intrusives) and the Mesozoic Bhuj formation. The site is situated on the tributary of a locally known Gandi River near a meander which is presently covered by quaternary sediments. The Gandi River shows meandering and braided nature with sharp turns at several places indicating the reactivation of pre-existing faults. Shales and sandstones are the Mesozoic rocks exposed in the area. The burial walls and the covering slabs have utilized locally sourced sandstone. Some basaltic slabs have also been used to cover the burials. The Quaternary sediment consists of loosely compacted material with the dominance of the river deposits, pebbles, fragments of the basalt, soil derived from the shale and weathered sandstone with some of the reworked miliolite acting as cementing material for the meander deposits. Depositional structures in the Quaternary deposits have been disturbed due to farming

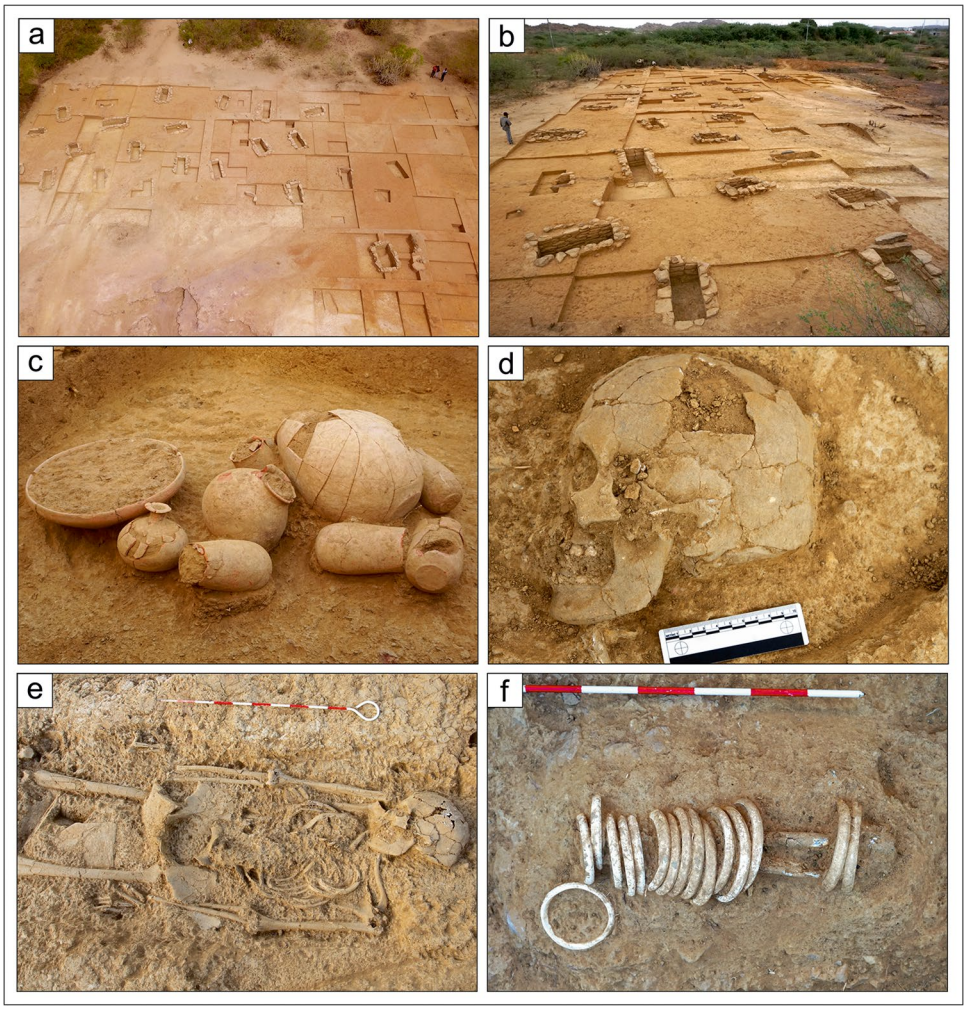

Fig. 3 **a**, **b** Aerial and close-up view of the excavated burials at Juna Khatiya. **c** Different types of pottery recovered inside the burials. **d** Fully intact human skull inside one of the burials. **e** Completely intact 6-ft-tall human skeleton inside the burial. **f** Preserved shell bangles around the hand bones

activity. Presently, several small embankments/ check dams have been constructed for rainwater harvesting in the region (Biswas 1993, 2016a, b; Gadekar et al. 2021).

Khirsara

Archaeology

The archaeological site of Khirsara (23°27′17.34″ N; 69°3′34.54″ E) is named after a small village 2 km west of the site on the Bhuj–Narayan Sarovar State Highway, Nakhatrana Taluka, Kachchh District (Fig. 4a, b, c). The site is also locally known as "Gadhvadi." Excavations by ASI from 2009 to 2013 have revealed a cultural deposit of five structural phases. The fortified Urban Harappan settlement of Khirsara measures about 310×270 m and is trapezoidal in shape (IAR 2016). The excavations have revealed several residential structures, factory areas, warehouse, kilns and wells. The Citadel is located in the southern part of the site near the factory and the warehouse. Other significant finds from the site include steatite seals, shell bangles, gold beads, copper objects, stone beads, terracotta toy carts etc. (IAR 2016). The site also shows evidence of damage caused due to floods in successive phases which have led to the raising in height of the structures. The site was an important manufacturing hub in western Kachchh engaged in bead-making, shell crafting and copper working. A circular seal of Mesopotamian origin is indicative of overseas trading activity (Nath 2012; Nath et al. 2012).

Geology

The site is bordered by two seasonal streams on the northern and southern side which drains into the river Khari flowing at a distance of around 400 m away. The streams were likely an important source of freshwater and fish for the settlements during monsoon for the inhabitants. The site lies on the Mesozoic Bhuj sandstone which has also been used as construction blocks for several structures. The site also lies near the Vigodi Fault zone (Kothyari et al. 2022). Deccan Trap intrusives can be found near the site which has intruded through the weaker planes. These Deccan basalts serve as a source of secondary minerals like quartz for the inhabitants of the region (Biswas 1993, 2016a, b).

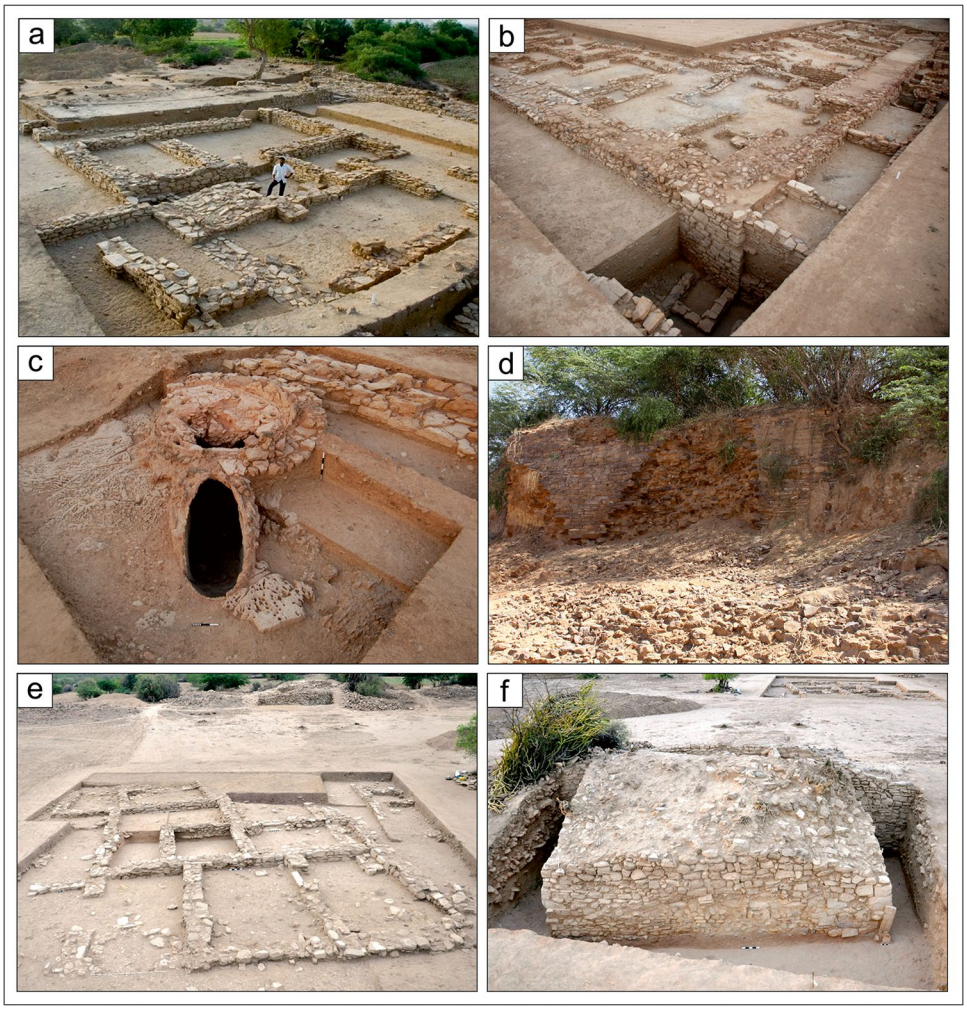

Fig. 4 **a** Residential complex at the archaeological site of Khirsara. **b** Fortified factory area at Khirsara. **c** Furnace structure at Khirsara. **d** Wall structure at Desalpar. **e** Structures of residential complex at Kotada Badli. **f** Middle bastion at Kotada Badli

Desalpar

Archaeology

The ancient Harappan site of Desalpar (23°27′59.29″ N; 69°10′9.67″ E) (Fig. 4d) measures about 130 × 100 m in dimension. It is located on the northern bank of Bamu-Chela, a tributary of river Dhrud. The site exhibits 3 m cultural deposits ranging from Mature and Late Harappan to the early historic period assignable to the Rang-Mahal Complex and Vasai Ware. The site has a massive stone fortification wall with a basal width of 4 m and a height of 2–5 m. The fortification wall is also reinforced with corner towers. Mud bricks have been used for the houses inside the town, some of which were built against the fort wall itself. One of the noteworthy findings was the presence of Reserved Slip Ware. Other significant findings include script-bearing seals. Objects like a copper chisel, knives, rods, terracotta cart frame and animal figurines have also been recovered from the site. (IAR 1967).

Geology

The Harappan Site of Desalpar lies about 11 km away from the Khirsara Site. Hence, it shares similar geology to that of Khirsara. The two sites are separated by Deccan trap intrusives. The site rests on the quaternary fluvial deposits around the river which is underlain by the Mesozoic formation. Location-wise, the site lies close to the edge of Kachchh mainland near the Banni Plains and on the interface of the Bhuj and Jhuran Formation (Biswas 1993, 2016a).

Kotada Bhadli

Archaeology

The archaeological site of Kotada Bhadli (23°20′47.04″ N; 69°25′33.68″ E) (Fig. 4e, f) is located in the Nakhatrana Taluka of Kachchh District and was discovered by J. P. Joshi in 1964 (IAR 1973). This site was subjected to excavation for three seasons, i.e. from 2010–2011 to 2012–2013 by

Deccan College, Post-Graduate and Research Institute and Gujarat State Department of Archaeology, Gandhinagar. The site measures approximately 3.11 acres in size. Unlike other sites, it does not represent a mound but is flat within the fortification walls. Residential structures constructed using dressed sandstones of various sizes are found inside the fortification walls. The ceramic assemblage found at the site includes Red Ware, Pink Ware, Grey ware and Kaolinite Ware. Based on the pottery and the style of construction of the site, it is assumed to be of the Late Mature Harappan and Post-Urban Harappan Phase, (Shirvalkar and Rawat 2012). Craft items like stone weights, beads, terracotta beads, spindle whorls, pottery discs, pottery rings and stone blades have also been unearthed from the site (Rajesh 2018).

Geology

The site is located in a confluence zone of two rivers, one on the western side and one on the eastern side. The site geology consists of plains, hillocks and streams. The fortification walls are built from locally available sandstone and rubble. The location of the site and availability of raw materials served as an impetus for the development of the site in this region. The site is also located on the upthrown block of the Kachchh mainland fault which is the most tectonically active fault in Kachchh. Based on the archeo-seismological evidence, the site seems to have suffered damage due to tectonic activity (Biswas 1993, 2016a; Kothyari et al. 2019).

Juni Kuran

Archaeology

The ancient site of Juni Kuran (23°56′34.64″ N; 69°45′30.62″ E) (Fig. 6a, b) is located in the northeastern corner of Pachchham Island, 3 km north of the present-day village Kuran and about 25 km south of the Indo-Pakistan border. It was first reported by J. P. Joshi in 1968–1969 and excavated by ASI in 2003–2004. The settlement is roughly rectangular in shape and covers an area of 410 × 350 m. The excavation revealed a fortified town with gateways, a citadel and a middle town (?). Mud bricks and stone structures can be observed throughout the site. According to Pramanik (2004), the architecture and construction resemble that of Dholavira. Terracotta animal figurines, balls, hopscotch, blades, shell bangles; copper objects like arrowheads, wires and fish hooks, ceramics and animal bones were also recovered from the site (Pramanik 2004; Rajesh 2018).

Geology

The site lies on Pachchham Island in the northern part of Kachchh at the foot of the Kaladongar hill which constitutes the highest peak in the Kachchh region. Juni Kuran is bounded by two rivers flowing from the Kaladongar hill range. Geologically the rock type is classified into the Mesozoic Kaladongar formation. Rocks of the Kaladongar formation consist of the oldest Mesozoic sequence of the Kachchh basin. The rocks are characterised by varying proportions of mixed siliciclastic-carbonate sediments which are either intercalated by calcareous or argillaceous shale (Biswas 1993). The site is surrounded by the Great Rann which was supposedly navigable during the Harappan times. Since the site is located near Dholavira, it is possible that a waterway was established between the two settlements which facilitated trade and migration.

Gajod

Archaeology

The archaeological site of Gajod (23°03′07″ N; 69°34′14″ E) (Fig. 5) is located 25 km south of Bhuj. The site locally known as 'Kotada Khetar' is situated 2 km north of the Gajod village on the eastern bank of Nagamati River. The site was discovered by Jaypalsinh M. Jadeja, one of the authors of the present paper in 2018. Exploration of the site has revealed cultural remains of the Integration and Localization eras of the Indus Civilization. One major structure exposed due to anthropogenic activity appears to be the northern fortification wall built with locally available basalt. The pottery found at the site comprises of Classical Harappan, Sorath and Late Sorath Harappan, Anarta pottery and varieties of Reserved Slip Ware. Objects like shell bangles and bangle manufacturing wastes, terracotta beads, spindle whorls, hopscotches, terracotta hubbed wheel, lithic flakes, blades, core, quern and muller were found at the site. A noteworthy finding from the site is a copper dagger similar to the Copper Hoard culture from North India. Based on the features of the site, it can be relatively dated between c. 2600 to 1600 BC.

Geology

The site is situated on the banks of the Nagmati River which probably served as a source of water for irrigation and agriculture during the Harappan Period. The site is situated on the Deccan trap basalts with several south-flowing streams flowing from the Katrol Hill range. The basalts form an important source of secondary minerals like quartz which was widely used by the Harappans to make several tools like blades. The basalt is underlain by the Mesozoic Bhuj sandstone. The rivers exhibit a typical dendritic drainage pattern which is characteristic of the basaltic terrain. The site is currently utilized for agricultural activity. The weathering of the basaltic terrain provides access to the fertile soil (Biswas 1993, 2016a).

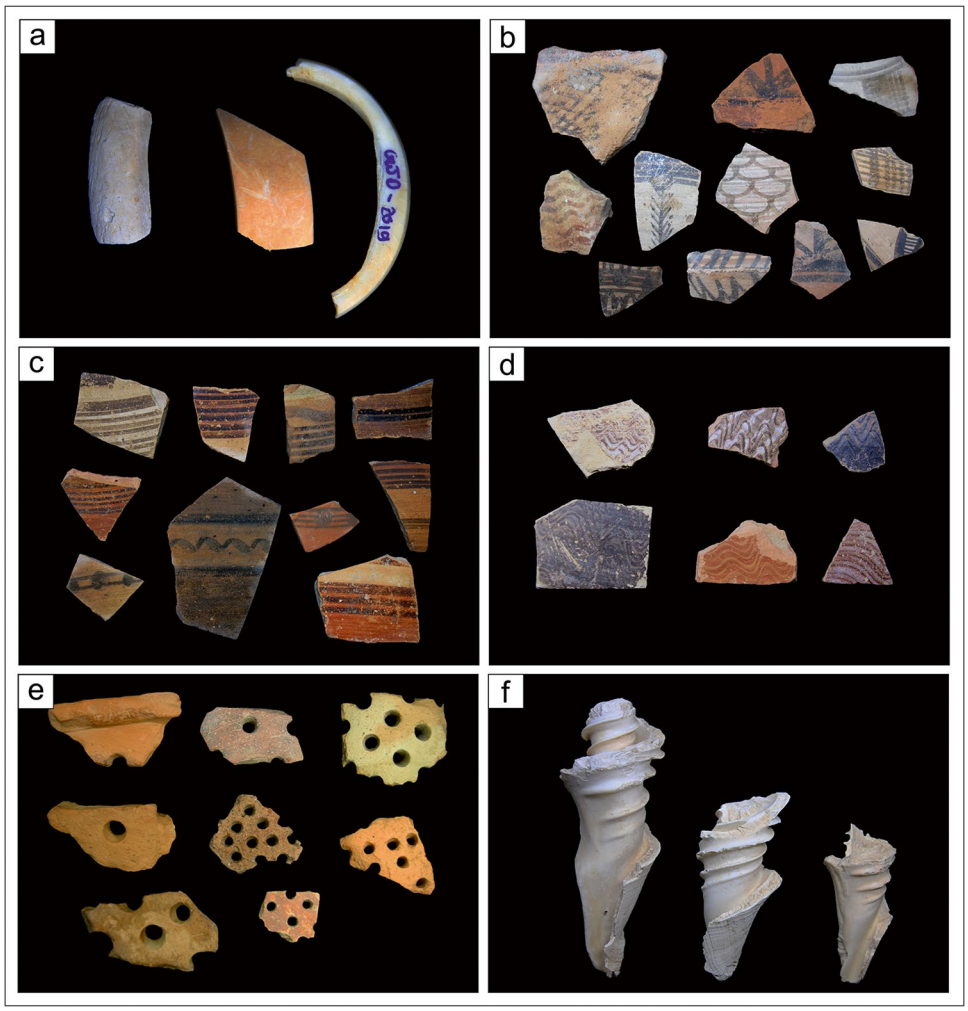

Fig. 5 Different types of pottery, cut shells and shell bangles discovered from the archeaeological site of Gajod

Navinal

Archaeology

The Harappan site of Navinal (22°49′22.84″ N; 69°35′43.41″ E) is situated in the Mundra Taluka of the Kachchh district. The site was discovered by P. P. Pandya in the 1950s and was first reported by S. R. Rao in 1963. The findings from the site include artefacts of Sorath Harappan, Classical Harappan, Anarta Tradition and Late Sorath Harappan. Objects such as spindle whorls, pottery discs, hubbed wheels, toy cart frames, perforated shell discs, bangle fragments, small broken comb/hair band, various types of beads, stone amulet, grinding stones, hammerstones and a large number of copper tools have been reported from the site (Gadekar et al. 2014). Various stone structures at the site are indicators of craft production which include pottery production, stone tool production, copper working and shell working (Rajesh 2018). A variety of fish remains like fish otoliths and skeletons have been recovered from the site and these indicate the utilization of fish resources in large quantities by the Harappan population of the site. Radiocarbon dating of shell samples and otoliths has revealed an age of 2300 to 1920 B.C. (Abhayan et al. 2016).

Geology

Navinal is a coastal Harappan site situated about 10 km west of the present Mundra port. The site lies on the quaternary coastal deposits. Mudflats and dunal sands are some of the peculiar features of the area. The quaternary deposits are underlain by tertiary bedrock. Several south-flowing rivers originating from the Katrol Hill range debouch into the Arabian Sea. The southern part of the site is dominated by mudflats (Tidal Flats) where sediments from river runoff and inflow from tides have resulted in mud and sand deposits (Prizomwala et al. 2010). About 15sq km of mangrove communities are found in the intertidal region. Owing to the ecological and economical importance of the mangroves in Kachchh, they have been categorised as an endangerered ecosystem. The coastal site of Navinal might have played an important role in sea trading during the Harappan Period.

Fig. 6 **a**, **b** Wall structure at archaeological site of Juni Kuran. **c** Excavated burials at Dhaneti. **d** Eastern wall at Kanmer. **e**, **f** Fortification wall structures at Surkotada

Dhaneti

Archaeology

Dhaneti, the Early Harappan Burial site locally known as 'Rojimatano Saran' (23°16′47.00″N; 69°55′8.30″E) (Fig. 6e), is located about 25 km east of Bhuj on the Bhachau-Bhuj Highway. The site was excavated from 2017 to 2019 by Maharaja Sayajirao University of Baroda. The site measures about 4.5 ht in size. Extended inhumation and symbolic pot burials have been unearthed from this site. Laterite blocks have been used for the construction of the burials while huge sandstone blocks serve as capstones. An outcrop in Savara hills, 7 km south of Dhaneti has been suggested as the provenance for the sandstone blocks. The transportation of these huge sandstone blocks which weigh around 200–300 kgs requires the presence of a sound social structure and resource investment involving mass participation. Surprisingly, no comparable habitational sites for the early Harappans have been found in the region. The burial goods include dishes, dish-on stand, storage jars, tall cylindrical beakers, conical flasks, shell bangles and beads. The pottery vessels associated with the burials are similar to those from Early Harappan sites like Amri, Kot Dijji, Nal and Damb Sadaat in Pakistan and Datrana, Santhli and Nagwada in North Gujarat, India. (Ajithprasad 2018) .

Geology

The archaeological site at Dhaneti lies on the southern side of the Kachchh Mainland fault zone. It lies on top of the quaternary sediments underlain by the Bhuj formation. The comparatively older Mesozoic Jhuran formation occurs north of the site. The sandstones used in the burials are that of the Bhuj formation. On the north of the site, we have the Habay dome and Kas hill anticline which form the northernmost part of the Kachchh Mainland Uplift. Due to the vicinity of the site to the KMF, the site probably witnessed several seismic activities (Biswas 1993, 2016a).

Dholavira

Archaeology

Dholavira (23°53′10″ N; 70°13′00″ E) (Fig. 7) is one of the five largest Harappan cities in the subcontinent and it is located in the Bhachau taluka of the Kachchh district. The site was excavated by R. S. Bisht of the ASI from 1989–1990 to 2003–2004. The site is remarkable for its exquisite planning, monumental structures, aesthetic architecture, efficient water harvesting system and funerary architecture. The excavation revealed seven stages of cultural change at the site. The first settlement was raised at the site in stage I and in stage II, a residential area was added to the north of the walled settlement. Stage III was the most creative and important phase for town planning; during this stage, a formidable castle was added and a bailey was added to the west of it. Stage III was elegant for civic amenities like a playground, water reservoirs and outer fortification of the city and the settlement was damaged in this stage by natural catastrophe and its repairs were undertaken and a lower town was added. Stage IV belonged to the Classical Harappan phase and almost all salient features were maintained along with the monumental structures. Stage V is characterised by a general decline. Stage VI is the Post-Urban Harappan phase; in this phase, the residential buildings were different in planning and the city was shrunk. After a break, the residentials of stage VII set on the citadel and nearby areas without any type of Classical Harappan traits like craft items, long-distance trade and monumental structures; they built their houses in a circular form and they had not followed town planning as by their predecessors had followed. The site was never occupied once the people of stage VII left. The cemetery area is located in the west of the city. Hemispherical-shaped two tumulus-type burials are a unique characteristic of this settlement. The site has yielded script letters widely known as the 'Ten letters Sign Board'. Apart from the huge amount of chalcolithic pottery, human and animal figurines, chert blades, stone weights, copper objects, beads of semi-precious stones, seals and sealings and drill beats were unearthed from sites. The dates of the seven stages are between 3500 and 1700 BC (Rajesh 2018; Bisht 1991).

Fig. 7 **a**, **b**, **c**, **d** Strucutral elements at the archeaological site of Dholavira. **e** Museum at Dholavira showcasing the discovered artefacts. **f** Petrified wood at Khadir wood fossil park

Geology

The Harappan settlement of Dholavira is situated on the Khadir island which is surrounded by the Great Rann of Kachchh on all sides. Manhar and Mansar are the two ephemeral streams which originate from the northeastern hills and run around the site. These rivers are mostly dry today and rarely flow during the monsoon (Sengupta et al. 2020). The Khadir uplift is a single large anticline with steep dipping beds in the north and gentle dipping beds in the south. The settlement rests on the Khadir formation which consists of shales, sandstone and conglomerates. It is also one of the oldest formations of Kachchh. Apart from the northern side, the rest of the island is covered with tertiary formations on the fringes (Biswas 1993; Jani et al. 2021). Just 8 km north of Dholavira is the Khadir fossil park. It consists of logs of petrified woods which have been preserved and showcased for display which was later declared the Khadir Wood Fossil Park by the Gujarat government. The geologists of the Department of Earth and Environmental Science (Kachchh University, Bhuj) then restored this natural asset, taking into account its geoheritage importance. The petrified wood fossils are part of the Hadibhandang Shale member of the Khadir Formation. The petrified woods have annular rings, knots and stomps. During the Middle Jurassic Period, this ancient forest of the Indian subcontinent was located around 30 latitudes in the southern hemisphere, in the subtropical zone. These deadwood trunks were carried by ancient fluvial channel systems that ran through the forest and are now preserved in the sandstones.

Kanmer

Archaeology

The fortified Harappan settlement Kanmer (23°25′4.67″ N; 70°51′47.97″ E) (Fig. 6d) locally known as 'Bakar Kot' was located in Rapar taluka in the Kachchh district. The site was jointly excavated by JRN Rajasthan Vidyapeeth, Udaipur, Gujarat State Department of Archaeology and Research Institute for Humanity and Nature, Kyoto, Japan, during 2005–2006 to 2008–2009 and 2013–2014 to 2014–2015. The fortified settlement measuring 115 m × 115 m × 10 m revealed a fivefold cultural sequence namely KMR-I to KMR-V. KMR-I is a pre-fortification level, revealing a 40 cm deposit. The KMR-II Urban Harappan phase is subdivided into IIa and IIb and KMR-III is the Post-Urban Harappan phase. The latter two phases KMR-IV and KMR-V revealed artefacts respectively from the Early Historic to Medieval Period. Varying thickness levels of stratigraphy show growth and decrement of two phases (KMR-II and KMR-III). In these phases, stones and mud bricks were widely used for the construction of residential structures. Habitants of period IV (Early Historic) disturbed the deposit of predecessors and constructed their residence. Artefacts from the site include beads of steatite and semi-precious stones, faience, steatite and terracotta seals, terracotta sealings, terracotta cakes, gamesman, copper, stoneand terracotta weights, bangles of shell and terracotta. Wild animals, plants and fishes formed part of their diet (Abhayan et al. 2020; Rajesh 2018; Kharakwal and Rawat 2012; Kharakwal et al. 2009, 2012).

Geology

Kamner rests on the Wagad sandstone formation which is overlain by the Khari Nadi Formation. The site lies very close to the Eastern segment of the South Wagad Fault, which is often considered an extension of the Kachchh Mainland fault. Unlike other uplifts in the region, the Wagad uplift is north-dipping with the fault on the southern side of the uplift. Many features like domal anticlines, transverse faults and nick points can be observed in the region. The domes near the site include the Kanmer anticline, the Gui dome and the Mardak dome (Biswas 1993; Lakhote et al. 2021). Recent studies indicate the presence of wave-cut cliffs and notches at the Mardak Bet which implies that the eastern segment of the South Wagad Fault zone was marginally uplifted during the Middle to Late Holocene Period. The study also suggests that the eastern margin of the fault zone which was considered to be seismically silent is also capable of generating earthquakes of large magnitude (Lakhote et al. 2021). The unique location of the site is such that it is able to access both the Gulf of Kachchh and the Gulf of Khambat which is significant for trade and migration.

Shikarpur

Archaeology

The site Shikarpur (23°14′17.52″ N; 70°40′38.56″ E) locally known as Valamiyo Timbo located in the Bhachau taluka of the district Kachchh was excavated by the Department of Archaeology, Government of Gujarat during 1987–1990. According to the excavators, the site has evidence of Pre-Urban Harappan and Urban Harappan cultural remains. In this excavation, copper objects, terracotta figurines, shell beads and bangles, chert blades and beads, ceramics and animal bones were unearthed. From 2007–2008 to 2013–2014, the site was re-excavated by Maharaja Sayajirao University of Baroda to establish the cultural sequence. The excavation revealed a habitation deposit of 6.40 m thick divisible into three phases of the Harappan occupation. Phase I was marked by the artefacts of Classical Harappan, phase II by the Sorath Harappan and Classical Harappan and phase III by the Post-Urban Sorath Harappan. Artefacts like terracotta tablets, seals, sealing, steatite pendants, female and male figurines, weights, beads and dril bits, pottery animal bones, fish remains and floral remains were collected from the site. (Rajesh 2018; IAR 1993a, b, 1994; Bhan and Ajithprasad 2013).

Geology

The archeaeological site of Shikarpur lies on the southernmost portion of the Wagad Uplift. The site lies on top of quaternary sediments (Biswas 1993; Lakhote et al. 2021). The location of the site is near the vertex of Kachchh and Saurashtra adjacent to the Gulf of Kachchh. The vicinity to the Gulf of Kachchh provides the inhabitants of the site immediate access to both local trade with the Saurashtra region along with overseas trade.

Pabumath

Archaeology

Pabumath is a Harrapan archaeological site (23°37′0″N, 70°31′0″E) in the vicinity of Suvai village, Rapar Taluka in Kachchh district. The excavation work was carried out from 1977 to 1981 by the Archaeological Survey of India. The excavation revealed the presence of a large building complex. One of the major findings from the site is an inscribed seal bearing a unicorn motif. Other findings from the site include beads, shell bangles, antimony rods in copper and steatite micro beads. Pottery from the site consists of large and medium-sized jars, goblet, beaker, steep sided dish, dish-on stand, perforated jars etc. Fine red pottery from the site often contains black-painted designs such as criss-cross, wavy lines, loops and hatched ferns. Excavation has also revealed the remains of animal bones belonging to cattle, buffalo, goat, sheep, rabbit and fish.

Geology

Pabumath lies on the northern side of the Wagad highland. The area is tectonically less active compared to the sites situated in the southern part of Wagad Uplift (Biswas 1993; Lakhote et al. 2021). The Rann of Kachchh lies to the N-W of the site. The Trambau River flows close to the site and cuts through the Jurassic and Miocene rocks. It debouches in the Rann of Kachchh towards the north. Various species of fossil ammonites, belemnites, gastropods etc. can be found in the area.

Surkotada

Archaeology

The site Surkotada (23°36′40.62″ N; 70°55′2.25″ E) (Fig. 6e, f) was excavated by J. P. Joshi of ASI in 1970–1971 and 1971–1972. Excavation revealed three sub-period of Harappan culture, namely IA, IB and IC. The period IA was the Urban Harappan with some traits of an antecedent culture. During period IB, the Harappan elements continued in decreasing order along with chalcolithic pottery. The occurrence of a thick layer of ash marked the end of Sub-Period IB. Period IC was characterised by white-painted Black-and-Red Ware and Harappan elements continue in a restricted manner. The fortified settlement consisted of a citadel, lower town and cemetery to the southwest. Another important feature of the site is a rectangular barbican with a ramp, steps and guard room in front of the southern gate of the citadel. The noteworthy point about Surkotada is the occurrence of a few horse bones (?) (Rajesh 2018; IAR 1974, 1975). The team of the Department of Archaeology, University of Kerala, found a human skeleton near the boundary wall of the site during their site visit in 2015. Close observation revealed that the skeleton was placed in a crouched position along with vessels near the head and knee inside the pit and the pit was plastered with lime. An anthropological study revealed that the skeleton is an adult male and it has to be different in three ways from other burials that were exposed at the site in excavation. First of all, the burial is not located in the designated cemetery area. The second point is that it shows almost complete skeletal elements (some portion is missing due to recent disturbance) unlike the other burials which are symbolic or with a few cremated bones in pot burials. The third reason is that all the pottery associated with the present burial is different from the so far reported pottery assemblages of Harappan and regional Chalcolithic-cultures in the Greater Indus region. The associated pottery of burial yielded the AMS date based on which the earliest occupants of Surkotada can be dated to the second half of the fourth millennium BC, i.e. Pre-Urban Harappan phase (Mushrif-Tripathy 2018).

Geology

Surkotada is the easternmost Harappan site in the Kachchh region. The site rests upon the Mesozoic Wagad formation. Most of the construction of the site utilizes local sandstone. The site is situated on the Wagad Uplift and is surrounded by the Rann in the northern and the eastern part. Shallow water in the Rann must have provided the inhabitants a safe harbour for navigation to various coastal Harappan sites. The site lies northeast of the South Wagad fault zone and is hence considered to be tectonically less active than the sites on the southern side of the Wagad Uplift in the vicinity of the fault (Biswas 1993; Lakhote et al. 2021).

Nadapa

Archaeology

The Archaeological site of Nadapa (23°33.325′ N; 69°05.131″ E) is located near Gadani Village of Nakhatrana Taluka in the Kachchh district. The site was discovered by

J. P. Joshi of the Archaeological Survey of India and has been described as a low and eroded Harappan mound. One of the unique characteristics of the site is that the general architecture superficially exhibits classical Harappan features but it has characteristics typical of the Sorath Harappan (Rajesh et al. 2020). The walls of fortifications and residential structures do not intersect at the corners which is a feature observed at other Sorath Harappan settlements at Jaidak (Ajithprasad 2008; Sen 2009), Kotada Badli (Shrivalkar and Rawat 2012), Rojdi (Possehl and Raval 1989), Babar Kot (Possehl 1994) and Kuntasi (Dhavalikar 1996). An important feature of the site is the absence of stud-handled bowls and the presence of channel-handled bowls. The site also reveals evidence of small-scale production of stone tools. The site also reveals some regional chalcolithic ceramic traditions like Anarta (Ajithprasad and Sonawane 2011; Rajesh et al. 2013) and Glazed Reserved Slip Ware (Krishnan et al. 2005).

Geology

The site is located in the low-lying area known as the 'Bhuj low' between the Kachchh mainland hill range and the Katrol Hill range (Biswas 1993). Several rivers and their tributaries dissect the area and flow towards the Rann of Kachchh. The site is located on a paleochannel of the Khari river and the present topography is the outcome of all surficial geological processes. The Khari river and its tributaries flow in the SW-NE direction (Thakkar et al. 2001). The lithology present on the site consists of the sandstones and shales of the Bhuj formation. The Bhuj formation is covered by Quaternary sediments with reworked miliolite.

Table 1 List of notable geological attractions in the vicinity of archaeological sites for geotourism

Geosite no	Name of geological site	GPS coordinates	Geological aspects	Geological age
1	Khari Gorge	23°15′3.25″N 69°37′48.88″E	Sedimentology, ichnology, neotectonic and paleoclimate	Early Cretaceous
2	Kodki Fault	23°14′37.57″N 69°34′58.63″E	Structural geology, igneous activity	Early & Late Cretaceous
3	Tapkeshwari Hills	23°10′52.27″N 69°40′0.81″E	Geomorphology, structures, tectonics, stratigraphy, sedimentology, paleontology, hydrogeology	Late Jurassic to Early Cretaceous
4	Habo Hills	23°22′34.44″N 69°50′26.72″E	Stratigraphy sedimentology, paleontology structures igneous activity	Mid-Late Jurassic and Late Cretaceous
5	Kas Hills	23°22′46.18″N 69°54′25.14″E	Tectonic geomorphology, stratigraphy, paleontology, structures, igneous activity	Late Jurassic and Late Cretaceous
6	Vidi Section	23° 4′24.56″N 70° 1′24.96″E	Igneous activity sedimentology stratigraphy, K-T boundary	Late Cretaceous
7	Khari Nadi Section	23°25′45.00″N 68°49′40.00″E	Sedimentology, stratigraphy, paleontology	Miocene
8	Waior Village	23°25′15.70″N 68°41′59.93″E	Stratigraphy, sedimentology, paleontology	Miocene, Oligocene
9	Rakhadi River	23°28′44.77″N 68°40′48.91″E	Stratigraphy, sedimentology, paleontology, fuel geology	Eocene, Oligocene
10	Harudi Cliff	23°31′36.03″N 68°41′8.63″E	Stratigraphy, sedimentology, paleontology, fuel geology	Paleocene, Eocene
11	Koteshwar- Pinjor Pir	23°42′41.32″N 68°33′13.24″E	Sedimentology, geomorphology	Quaternary
12	Panandhro Lignite Field	23°42′24.19″N 68°46′38.84″E	Sedimentology. stratigraphy, economic deposits	Paleocene, Eocene
13	Ghuneri Hills	23°48′9.90″N 68°49′40.70″E	Stratigraphy, sedimentology	Early Cretaceous
14	Matanomadh	23°32′44.25″N 68°57′0.35″E	Stratigraphy, igneous activity, planetary science	Late Cretaceous
15	Jara Hills	23°41′43.19″N 69° 1′0.09″E	Stratigraphy, sedimentology, paleontology, Structural	Late Jurassic to Early Cretaceous
16	Keera Hills	23°35′4.63″N 69°14′34.86″E	Stratigraphy, sedimentology, paleontology, structural geology	Mid- Late Jurassic
17	Dhinodhar Hill	23°27′16.60″N 69°20′31.05″E	Geomorphology, igneous activity	Late Cretaceous
18	Nirona River	23°26′40.32″N 69°29′13.86″E	Geomorphology, stratigraphy, sedimentology, structural	Mid-Late Jurassic
19	Goradongar Hills	23°51′9.57″N 69°46′12.28″E	Geomorphology, structural geology	Mid-Jurassic
20	Kaladongar Hills	23°56′13.73″N 69°48′51.97″E	Stratigraphy, paleontology, geomorphology	Mid-Jurassic
21	Kanthkot-Tramau River	23°29′29.96″N 70°29′42.95″E	Stratigraphy, paleontology	Mid-Late Jurassic

Table 2 Strengths and weaknesses of internal factor evaluation matrix (IFEM)

	Weight	Score	Weighted score
Strengths			
Presence of historically and scientifically important geoarcheological sites (historical and scientific values)	0.2	4	0.8
Inclusion of Dholavira to the list of UNESCO world heritage sites	0.1	3	0.3
Presence of already existing infrastructure like motorable roads, banks, ATMs, means of communication, boarding and lodging etc. in most locations (infrastructural values)	0.1	3	0.3
Presence of unique indigenous culture and wildlife	0.1	3	0.3
Weaknesses			
Lack of awareness about the value of geoarchaeological sites to the locals	0.1	3	0.3
Most sites currently not under the protection of the government or local authorities	0.2	4	0.8
Complete excavation pending at many of the sites	0.1	2	0.2
Harsh climate unsuitable for tourism during extreme summers	0.1	2	0.2
Total	**1**		**3.2**

Discussion

Challenges

The archaeological sites discussed above, along with their geological framework, represent the archive of interaction between man and the environment of the Indus Valley Civilization in the Kachchh region. Archaeology, geology and tourism have an interrelated history aided by the increasing commodification of natural and cultural resources (Gios et al. 2006; Jafari et al. 2000). They share a common origin in the leisure practices of inquisitive elites in exotic locales (Casson 1994; Ryan 2003; Walton 2005). Consequently, archaeological tourism is particularly attractive in developing countries as a device for promoting generalized economic development. (Pacifico and Vogel 2012). However, there are several challenges which need to be overcome to make Kachchh a viable destination for Geoarchaeological tourism. Many of the sites discussed above have undergone only the preliminary phase of the study with a surface collection of pottery and observation of exposed features. As such, excavation and detailed study of such sites are yet to be undertaken by archaeological researchers. Hence, a wealth of information about the true nature of some of the sites is still inaccessible to us. Sites which have been excavated have either been covered with sediments again for protection or do not have adequate provisions for the protection of the exposed features. The protection of large archaeological sites, in particular, requires huge amounts of financial investment to cover the cost of land acquisition, resident and industry relocation and environmental improvement. Many sites that do not contain enticing material are often neglected after salvage excavation. Dholavira, one of the most spectacular of the IVC sites, which has become a popular tourist destination in the region still lacks proper protection and management of the site. The archaeological structures are exposed to wind and rain leading to erosion and deterioration of the site. Simple roof structures constructed over the exposed area would go a long way in protecting the sites from damage due to

Table 3 Opportunities and threats of external factor evaluation matrix (EFEM)

	Weight	Score	Weighted score
Opportunities			
Opportunities for collaborative research to understand the evolution and decline of the Harappan Civilization (scientific value)	0.3	4	1.2
Opportunities for sustainably boosting the economy of the region through tourism	0.2	4	0.8
Showcase and promotion of cultural activities, handicrafts and way of life of the locals in the region	0.1	2	0.2
Potential for establishment of educational programs and workshops for budding geologists and archaeologists	0.2	3	0.6
Threats			
Erosion of archaeological material from the sites	0.1	3	0.3
Undocumented collection of geological and archaeological materials by the locals	0.1	3	0.3
Total	**1**		**3.4**

rain. Furthermore, the undocumented collection of archaeological material by locals and visitors alike due to a lack of management, awareness and governance poses a huge threat to the sites. Local museums need to be constructed near the sites to store and display the collected archaeological artefact for visitors to view. The museum staff also needs proper training in the preservation of conservation of these valuable artefacts. A tour circuit can be created for the tourists which allows visitation of archaeological and geological exhibits throughout the region. The inclusion of prominent local geological features can be implemented in such tour programmes. A list of significant geological sites throughout the region has been discussed in Table 1. Along with tour programmes, there is a need for informed local guides who have adequate knowledge of the archaeological and geological aspects of the sites. Workshops can be conducted by experts from both fields for the training of guides and the spread of awareness among the locals of the region. The creation of 3D models based on the excavation of the sites can aid in visualizing the settlements for children and visitors. Educational programmes regarding the topic of geoarchaeology can be established for individuals who wish to explore the subject in depth. A culmination of geological and archaeological expertise in the form of an advisory committee would be immensely valuable in raising awareness and closing the existing knowledge gaps.

Inclusion of Cultural and Natural Assets in Tourism

Exploration of cultural and natural assets of a particular region has always been an integral part of the touristic experience. The location of the Kachchh Basin has played a major role in the development of its unique cultural and ecological aspects. Events like the Rann Festival perfectly incorporate both these aspects and leverage it for tourism in the region. As such, it provides a great opportunity for tourists to experience the indigenous culture along with its peculiar flora and fauna. The indigenous housing known as "Bhunga" consists of circular huts made out of mud, sticks, wooden beams and a thatched roof. These have unique properties which make them suitable for the location and climate of the region. They act as insulators keeping the inside cool during summers and warm during winters. Due to the circular shape and the central beam structure, the Bhungas are also earthquake-resistant (Gupta and Mazumdar 2016). Construction of these huts at tourist sites like the Rann and Dholavira is being used to attract tourists and provide them with an indigenous lifestyle experience. "Rass", a popular type of folk dance, is often performed for tourists and during festivals. There are several variations of this dance which include Dandiya Raas, Gajiyo Rass, Sword Rass etc. performed by different communities. The music includes the use of instruments like Dhol, Ektaro, Tabla, Manjira etc. which are often accompanied by folk dances to showcase the regional culture to visiting tourists. Kachchh is also home to several unique handicraft practices. Beautiful block-printed cloth which includes Batik print, Ajrakh and Bela prints are worn by several communities throughout the region in the form of Stoles, turbans and Lungis (Edwards 2005). Embroidery work from the region is also quite famous with the use of sequins, motifs and beads which can be seen in traditional attires like the 'chanya choli' worn by women during festivals and cultural performances. The regional fauna includes several animals like the nilgai, Indian wild ass, striped hyena, chinkara, blackbuck, wolf, desert wildcat, caracal etc. The region also hosts several migratory birds and there are around 112 bird species which attract avid bird watchers. Notable bird species include Greater Flamingoes, sarus crane, houbara bustard, Indian peafowl, Indian long-billed vulture and white-backed vulture (Ghalib et al. 2013). The Rann of Kachchh has also been designated as a Kachchh biosphere reserve to protect several endangered species of birds and animals (Fig. 8).

SWOT Analysis

Qualitative analysis of the 13 sites throughout the Kachchh region has been performed by adopting the methodology from Reynard et al. (2016). Table 2 and Table 3 showcase the qualitative assessment of the sites. For the quantitative analysis, the strength, weakness, opportunity and threat (SWOT) profiling is performed to understand the geotouristic aspect and cultural values of the proposed geoheritage sites. SWOT analysis is commonly used in the tourism sector to help develop plans for upcoming tourist locations (Narayan 2000; Reihanian et al. 2012; Zhang 2012). It is also being used to develop geosites as potential tourist destinations (Bhosale et al. 2021; Chavan et al. 2022; Antić and Tomić 2017; Kalantari et al. 2011). In this paper, a combined SWOT assessment of all the 12 geoarchaeological sites was performed. The analysis lists the strengths and weaknesses while also stating opportunities to exploit the strengths and the imminent threats due to weaknesses, aiding in understanding the viability and challenges in developing tourist locations. The strengths and weaknesses fall under the internal factor evaluation matrix (IFEM) and the opportunities and threats belong to the external factor evaluation matrix (EFEM). Both categories need to have a total weighted score (TWS) greater than 2.5, indicating that strengths exceed weaknesses and opportunities outweigh the threats. To calculate the TWS, the stakeholder's weight is used, which ranges from 0 (least significant) to 1 (very significant). A score is also allotted ranging from 1 to 4 (1—poor; 2—average; 3—good; 4—excellent). The stakeholder's weight is multiplied by the score resulting in the weighted score. The weighted score, when summed up for each matrix, results in the TWS. The TWS for both the matrix is then graphically represented (Fig. 9) to review the viability of the sites as potential tourist destinations.

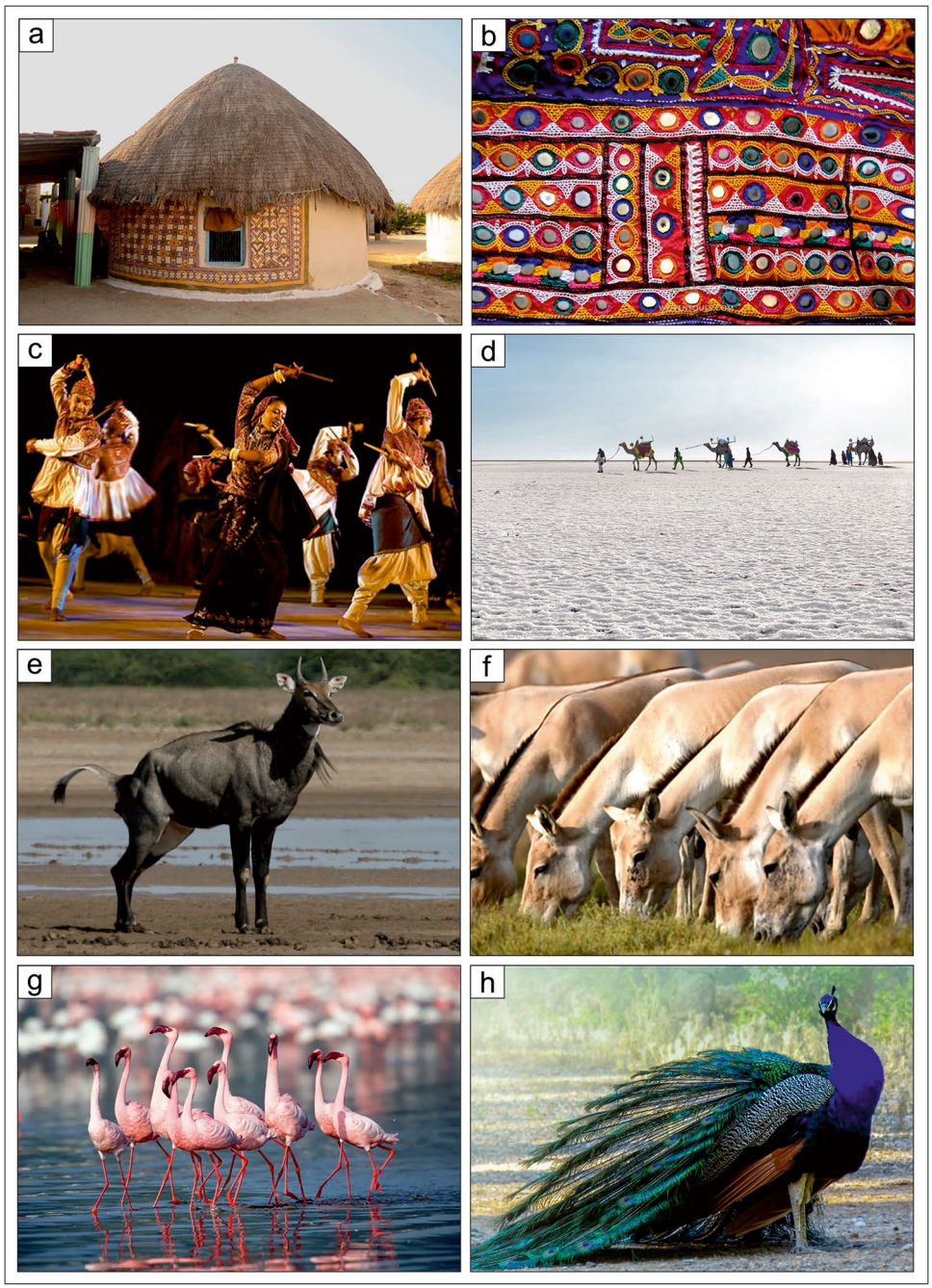

Fig. 8 Cultural and ecological elements. **a** Circular Bhunga huts. **b** Kachchhi Embroidery. **c** Locals performing Dandiya Raas. **d** Rann of Kachchh. **e** Nilgai. **f** Wild ass sanctuary. **g** Saurus cranes in Kachchh. **h** Peafowls spotted in abundance in the region

Conclusion

Geoheritage is linked to the historical, cultural, aesthetic and religious values of humanity (Brocx and Semeniuk 2007). The past few years have seen a significant rise in interest in geoheritage, geoconservation and geotourism studies in India, especially in Kachchh. The amalgamation of geological and archaeological assets for tourism is the essence of geoheritage as it combines the geological significance with the historic and cultural aspects of a particular region. Geotourism has the potential to play a significant role in boosting the economy of a region. The annual Rann festival in the great Rann of Kachchh is a prime example of taking advantage of the natural resources available and utilizing it for economic growth and sustainable development of the region. A large part of Kachchh is barren and cannot be used for agricultural, industrial or residential purposes. Most of the population is concentrated in certain regions of Kachchh while a major portion of the land is underutilized. As such, there is a significant lack of opportunities for the locals to prosper economically. Geotourism provides another avenue for the locals to develop a mode of income to aid in the sustainable development of the community. It also provides a

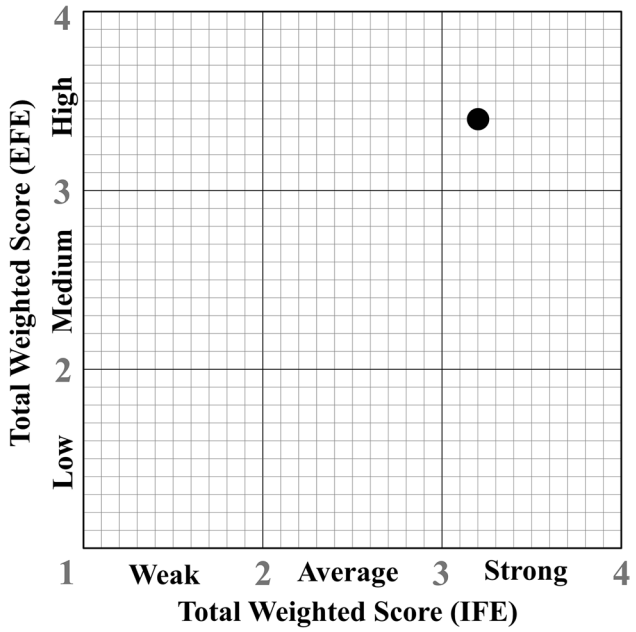

Fig. 9 Graph showing total weighted score of internal and external evaluation matrix indicating the potential of geoarchaeological sites in the Kachchh Basin

platform to showcase the regional culture in the form of local food, music, dances, handicrafts etc. In many aspects, geoheritage is linked strongly to geoconservation, and while geoheritage relates to features of a geological nature, geoconservation is the action that works towards the preservation of sites of geoheritage (Brocx and Semeniuk 2007). Recently, the Harappan City of Dholavira was declared India's 40th UNESCO world heritage site indicating the historical importance of the settlement. However, there are several similar sites in the region which consist of major archaeological and geological evidence that help in understanding the evolution and decline of the Harappan Civilization. The present work attempts to highlight the potential of such sites throughout the Kachchh region which could be also classified as UNESCO geoarchaeological heritage sites. The development of tour plans with the help of local guides to raise awareness of geoconservation and geoeducation would greatly boost interest in locals and visitors alike. It also provides an impetus for future geoarchaeological studies to solve several mysteries and discrepancies as it provides an opportunity for experts from both domains to work towards a common goal.

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Declarations

Competing interests The authors declare no competing interests.

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