CHAPTER-6

LATE QUATERNARY BAJADA SEDIMENTATION IN THE NSF ZONE

BAJADA SEDIMENTATION

The term bajada originated basically from the south-western United States of America and north Mexico and has been used in an informal way by some authors for laterally continuous, sloping alluvial surface formed by alluvial-fan coalescence (Collinson, 1986; Harvey, 1989; Reid & Frostick, 1989; Damanti, 1993). Alluvial fans in general are very sensitive indicators of basin margin tectonism (Heward, 1978a) whereas, the bajada is produced where there are erodible lithologies and the area is undergoing rapid tectonic uplift (Milana et al., 2000). A bajada environment is different from alluvial fan environment in some respects. Grain-size domains in bajadas are laterally extended, parallel to the mountain front, while in fans, they tend to be radial and forms irregular belts limited by the fan radius (Milana et al., 2000). Alluvial fan surface is not equally active because of the presence of a localized active channel which results in irregular radial grain–size belts (Blair and McPherson, 1994). In bajada environment, entire alluvial surface tends to show the same frequency of activity because it is formed by numerous parallel drainage lines. For this reason, bajadas are very homogenous in vertical section. Therefore, significant change in vertical section of bajada sediments may imply external influence (usually climate or tectonics) that modifies slope or transport mechanism influencing grain-size domains. Bajadas are now recognized as dynamic entities, with variable and changing morphology, state of incision or aggradation and extent of basin ward progradation (Leeder and Mack, 2001).

In the Lower Narmada basin, active tectonic uplift along NSF has produced steep mountain front escarpments and abundant north flowing parallel drainages that have provided appropriate physiographic setup for alluvial fan sediments to be deposited. In the present study, bajada sedimentary environment has been recognized and characterized along NSF, in the Lower Narmada Basin.

The extension of bajada sediments is confined by the NW-SE trending Karjan Fault on eastern side and Madhumati Fault on western side. Previous studies in Lower Narmada basin have identified another group of alluvial fans located in segment I around Rajpipla extended between Narmada River and Karjan River (Bhandari et al., 2001). The lithofacies characteristics and facies association indicate debris flows and sheet flood flows as major processes responsible for aggradation of the fans (Bhandari et al., 2001). It has been inferred that the prolonged subsidence along NSF and two other faults along the Narmada River and its tributary Karjan, have provided ideal site for the accumulation of fan deposits during Early Holocene (Bhandari et al 2001). The lithofacies association and types of depositional flows are almost similar in both, Segment I and II; however there is a significant difference in the depth of incision. The rivers crossing fans in Segment I are less incised than the rivers of Segment II.

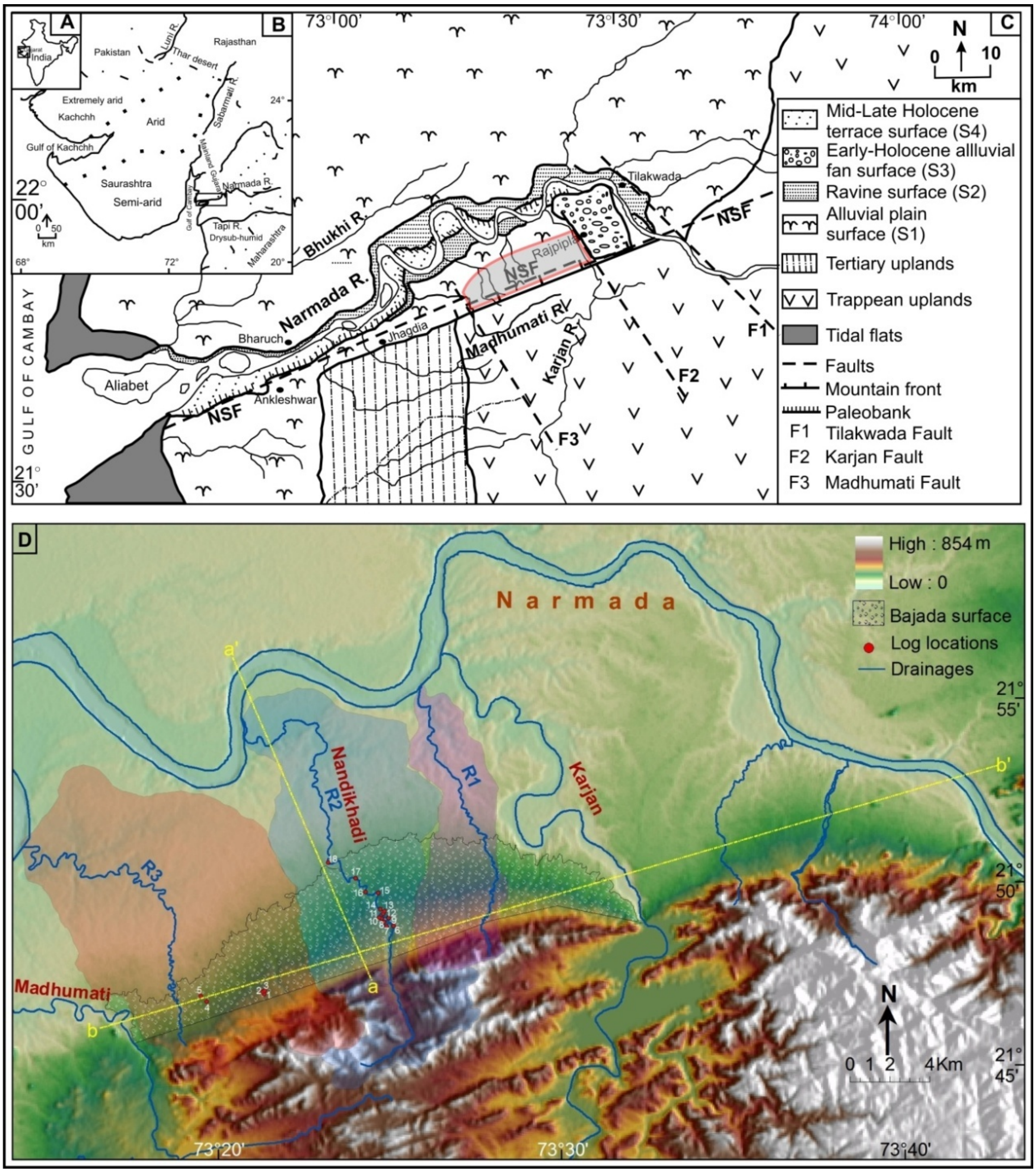

Figure 6.1 (A) Location map of the study area. (B) Map of Gujarat showing climatic zones. (C) Geomorphic map of lower Narmada basin (after Chamyal et al., 2002). Boxed area demarcates the identified bajada surface. (D) DEM of lower Narmada basin showing the physiographic and tectonic setting of bajada surface, and drainage basin of feeder channels. Alignment of the topographic section in Fig. 6.2A and locations of lithologs in Fig. 6.3, 6.4 and 6.5 are also shown.

MORPHOLOGY AND AGE OF THE BAJADA SURFACE

The bajada surface is located between the Karjan River and Madhumati River and shows highest topographic elevation when compared with the alluvial areas exposed to the east of Karjan valley, to the west of Madhumati valley and to the north of Narmda valley (Fig. 6.1D). There are three major parallel feeder drainages forming the group of coalesced fan comprising the modern bajada (Fig. 6.1D). The bajada surface extends over ~24 km in length along the mountain front and has a maximum width of 5.3 km. In longitudinal section, the deposits appear to be of wedge shaped (Fig. 6.2A). The bajada surface displays planoconcave–upward geometry created by the distally decreasing slope. The bajada surface is divided into three sectors using arbitrary boundaries placed at the 100 m, 75 m and 60 m contours (Fig. 6.2A). The most proximal sector has slope of 6-8° and extends 600-800 m from the apex, the medial sector extends ~1000 m with an average slope ~ 3°, and the distal sector has slope of 1-2.6° and length of ~1600 m. The bajada surface encloses an area of 88 sq km, with the proximal sector encompassing 15.8 sq km; the medial sector encompassing 27 sq km and the distal sector 45.2 sq km. The sediments are deeply incised providing an opportunity to examine the sedimentary facies.

The OSL age of 25.1$\pm$1.8 ka BP obtained from the middle part of the bajada succession suggests that the sedimentation occurred during the terminal Pleistocene (Fig. 6.2A). This correlates with the slow synsedimentary subsidence of the basin during the late Pleistocene documented earlier (Chamyal et al., 2002). However, the late Pleistocene sediments exposed along the incised cliffs of Narmada River are finer as they were deposited in alluvial plain environment (Bhandari et al., 2005). The bajada sediments described in the present study are therefore sedimentologically different but stratigraphically comparable with the sediments exposed along the Narmada River. We presume that in the downstream, the bajada sediments may show inter-tonguing relationship with the finer alluvial plain sediments deposited by Narmada river. However, this could not be verified as the thickness of exposed sediments along downstream reach of Nandikhadi River is greatly reduced due to rapid northward decrease in depth of incision mentioned above. Subsurface data is required to support our presumption. The geomorphological setting and inferred morphostratigraphical relationship of the bajada sediments with other alluvial deposits of lower Narmada basin as described by previous workers is summarized in Fig. 6.2A.

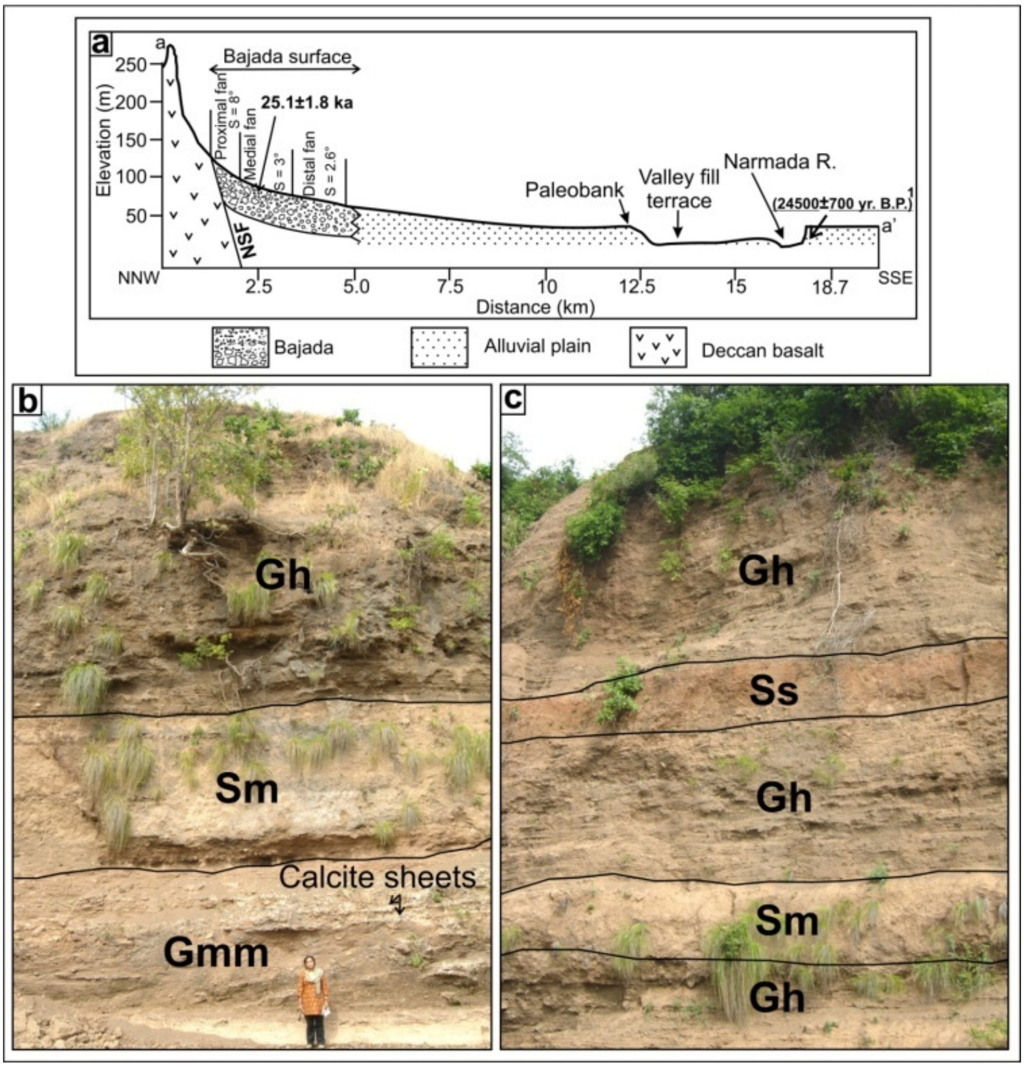

Fig 6.2 (A) Topographic cross profile of the bajada surface drawn from the DEM. Note the wedge shaped coarse gravelly bajada sediments deposited in front of the mountain front. Three sectors of bajada surface and their slopes are also shown. (1- Allchin et al., 1978). (B) View of the cliff section exposing bajada sediments at site 10. Note the parallel horizontal calcite sheets formed in basal matrix supported gravel lithofacies. (C) View of the cliff section at site 11.

SEDIMENTARY FACIES, PROCESSES AND DEPOSITIONAL ENVIRONMENT

Total 13 locations in the Nandikhadi drainage basin and 5 locations from the adjacent small, unnamed but deeply incised drainage basins exposed to the west of Nandikhadi basin were studied in detail. The sediments are characterized on the basis of grain size, fabric, sedimentary structures, bed geometry and sorting (Fig. 6.3, 6.4 and 6.5). These sediments are readily divisible into seven distinct sedimentary facies (Table 6.1) followed after Miall (1996). In approximate order of abundance, the principal facies identified are- matrix supported massive gravel (Gmm), clast supported mas gravel (Gcm), massive silty sand (Sm), soil (P), trough cross-bedded gravel (Gt), horizontally stratified gravels (Gh) and massive brick red sand (Ss) lithofacies.

Table 6.1 Sedimentary facies characteristics of the bajada sequence in the study area (after Miall, 1996).

Facies Code	Facies description	Grain size	Sedimentary structures	Bed geometry	Architecture associa-tion	Environment of deposition
Gmm	Massive poorly sorted, matrix supported gravels	Pebble-cobble	Locally imbricated without direction, poorly sorted	Continuous bed in proximal fan region, 1-2 m thick	GB	High strength debris flow
Gcm	Clast supported massive gravel	Pebble-boulder	Imbricated without direction, moderately sorted	Discontinuo-us bed, 1-2 m thick	GB	Clast rich debris flow
Sm	Massive sand	Fine to coarse grained sand	Poorly sorted	Continuous bed, 1-6 m thick	SB	Sediment gravity flow
P	Fine sand to clay	Very fine clayey to sandy	Colour mottled, blocky structures with root activity and carbonaceous material	Locally, average, 2-6 m thick	FF	Paleosol
Gt	Trough cross bedded sandy gravel	Granule, pebble, coarse sand	Planner tabular and imbricated low angle cross-bedded gravel	Discontinuous bed, 1-1.5 m thick	Minor CH	Cross channel bar, scour fill
Gh	Horizontally stratified gravels	Granule, pebble, rare boulder	Horizontal stratification	Continuous sheets, 1-17 m thick	GB	Longitudinal channel bar,
Ss	Massive sand	very fine sand, minor cobble	Poorly sorted,	Continuous, 0.5 – 1 m thick	FF	Bar top, abandoned channel

Matrix supported gravel (Gmm)

This facies consists of angular to sub angular, poorly sorted, matrix supported gravels that correspond to the Gmm lithofacies of Miall (1996). It is typically wedge shaped and is deposited adjacent to the mountain front. The clasts are of basaltic composition and range in size from granule to boulder. The maximum clast size measured is 30 cm. Minor sand lenses of medium to coarse sand are also present at some places. The clasts are poorly sorted and are supported by poorly sorted calc-rich coarse sandy matrix (Fig. 6.6A). Imbrication is absent but at some places, tabular clasts assume approximate horizontal orientations. The facies have sharp lateral termination and shows upward coarsening in grain size. The beds are visibly compact and massive. These characteristics reflect the formation of this lithofacies by the process of high strength debris flows (Miall, 1996, Garzione et al., 2003; Dorsey and Roering, 2006; Pope et al., 2008). Significant concentration of calcrete nodules and dense calcite horizons as thick as 5 cm is observed. The calcite layers are parallel to the gravel bedding and extend tens of meters laterally (Fig. 6.2B). The nodules are small, soft and elliptical in shape and their concentration is low. The physical properties of nodules indicate that their stage of development resembles to the stage-II development of Gile et al. (1981). This indicates the formation of calcite nodules in arid and semiarid climate (Gile et al., 1981).

Clast supported massive gravel (Gcm)

The clast supported massive gravels correspond to the Gcm facies of Miall, (1996). It consists of subangular to subrounded clasts of Deccan basalt and range in size from pebble to boulder (Fig. 6.6B). This facies is also confined to the proximal sector of the bajada surface. The facies at some places directly overlies the Deccan trap with abrupt contact. There is a general absence of grading and is massive in nature which suggests that the clast supported gravels were deposited by low strength, pseudoplastic debris flows.

Massive silty sand (Sm)

The massive silty sand facies (Sm) overlies the matrix supported gravel lithofacies. The Sm lithofacies is characterized by 0.25 to 4.5 m thick horizons of fine to medium sand and silt (Fig. 6.6C). The facies shows very good lateral continuity. At few localities, calcium carbonate nodules were observed in sediments of Sm facies. The contact with underlying sediments is abrupt and non-erosive. The sand is poorly sorted and do not show any grading. The absence of sedimentary structures, massive texture and poorly sorted framework suggests that the lithofacies was deposited as sheet flood deposits by the process of sediment gravity flows (Miall, 1996; Coltorti et al., 2010).

At some places isolated scour and fill structures are seen at the base of Sm facies (Fig. 6.6D). In this isolated scour-fills, trough cross-bedded sets of coarse sand and gravel are generated when a scour on the bed of a stream is filled. These deposits are rich in rhizocretions, calcite sheets and nodules. The layers of calcite are parallel to the sand and gravel layers whereas rhizocretions are developed perpendicular to the bedding (Fig. 6.6D).

Rhizocretion and stage-II calcite nodules develop in less than 10^3 years and probably no more than 10^2 years (Gile et al., 1981, Mack and Rasmussen, 1984).

Soil (P)

A brownish to reddish soil occurs in the distal fan area (Fig. 6.6E) and corresponds to lithofacies P of Miall (1996). The thickness of the soil varies from 1-6 m. In general, the thickness is found to increase in the downstream direction. The soil is clayey in nature and exhibits abundant pedogenic features like sand filled fractures and vertical fissures. Intense fracturing indicates repeated expansion and shrinking of clays coupled with root activity. The palaeosol provides good evidence of seasonality in climate, with marked wet and dry periods during which the soil underwent expansion and contraction, resulting in churning and de-stratification of parent material. Overall, the presence of palaeosol is interpreted to reflect sub-humid climate or relatively wetter climate. As the parent material of the palaeosol deposit is the mixture of clay, silt and fine sand, we infer that it was possibly deposited as overbank sediments by mixed sediment loaded streams.

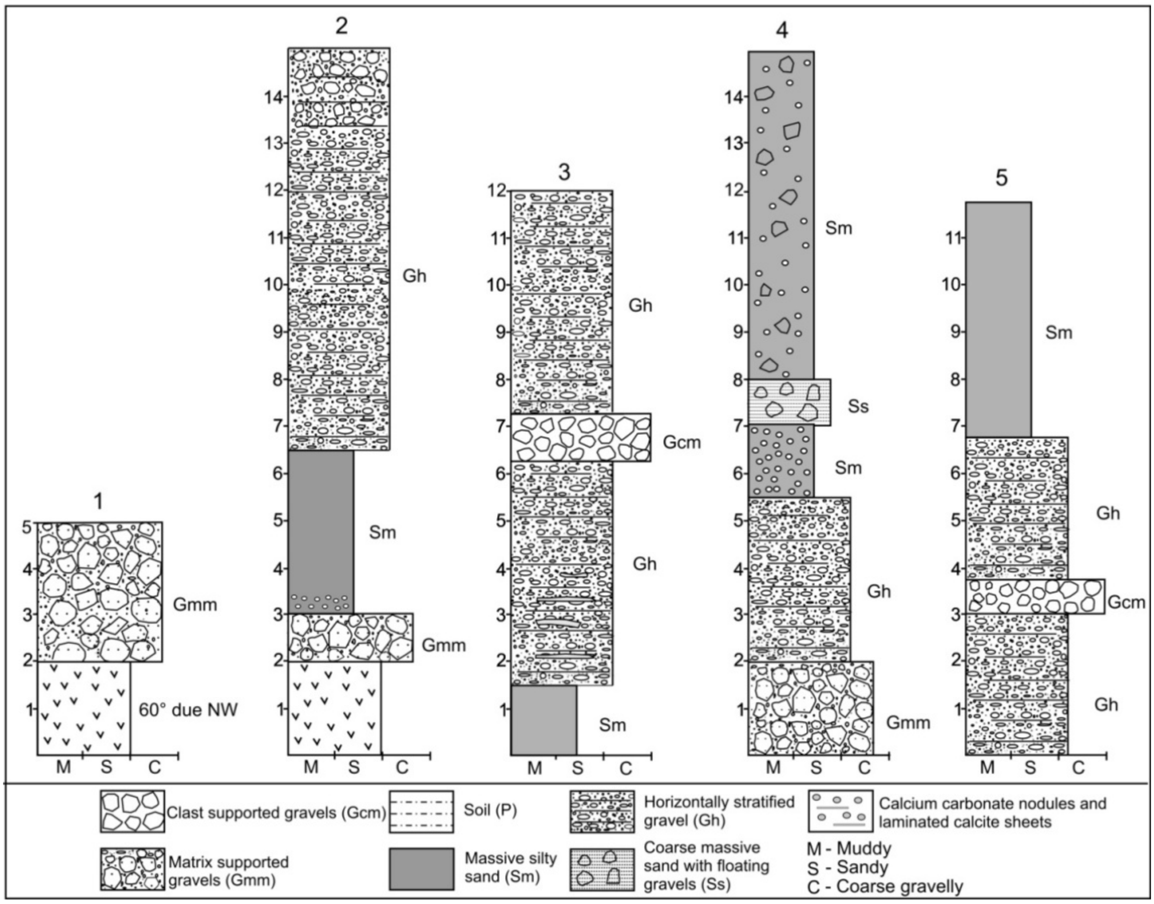

Figure 6.3 Lithologs of bajada sediments exposed in northward flowing unnamed rivers located to the west of Nandikhadi River. Locations are shown in Fig. 6.1D. The vertical scale is in meters.

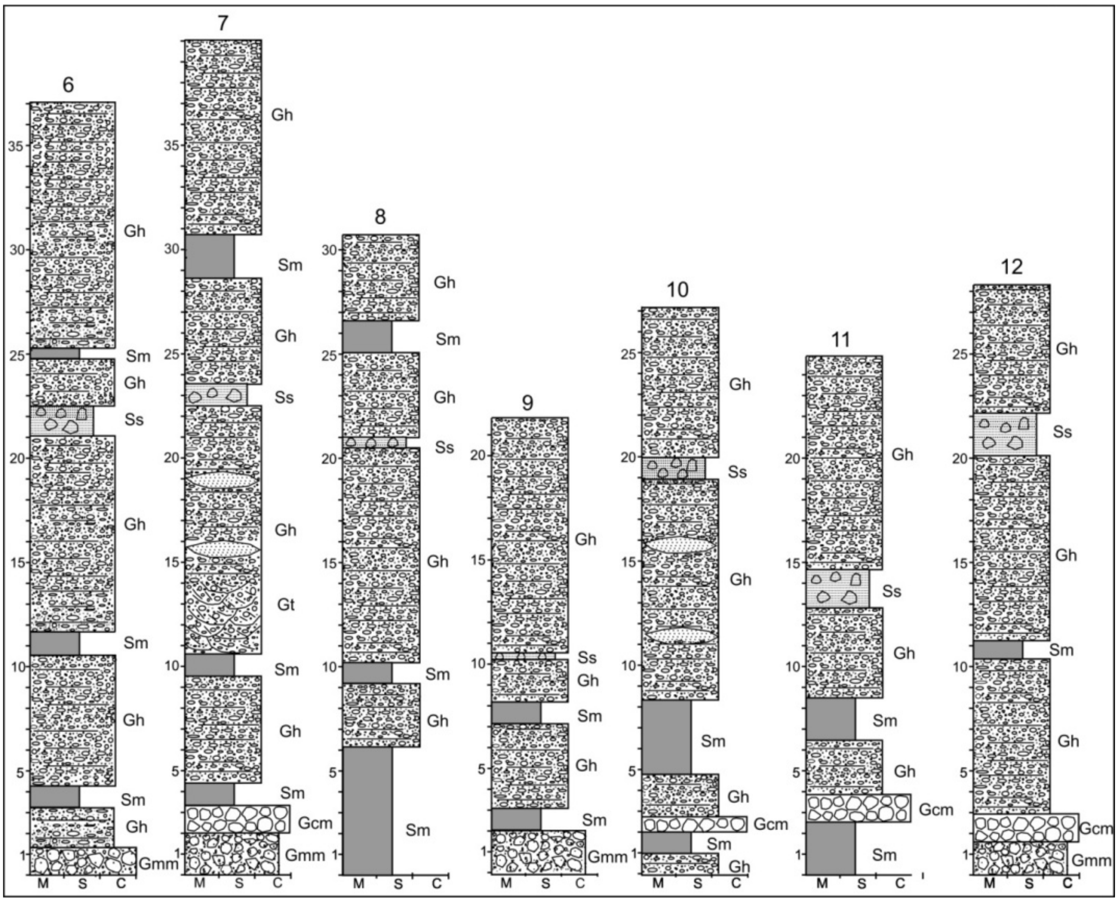

Figure 6.4 Lithologs of bajada sediments exposed in the Nandikhadi River. Locations are shown in Fig. 6.1D. The vertical scale is in meters.

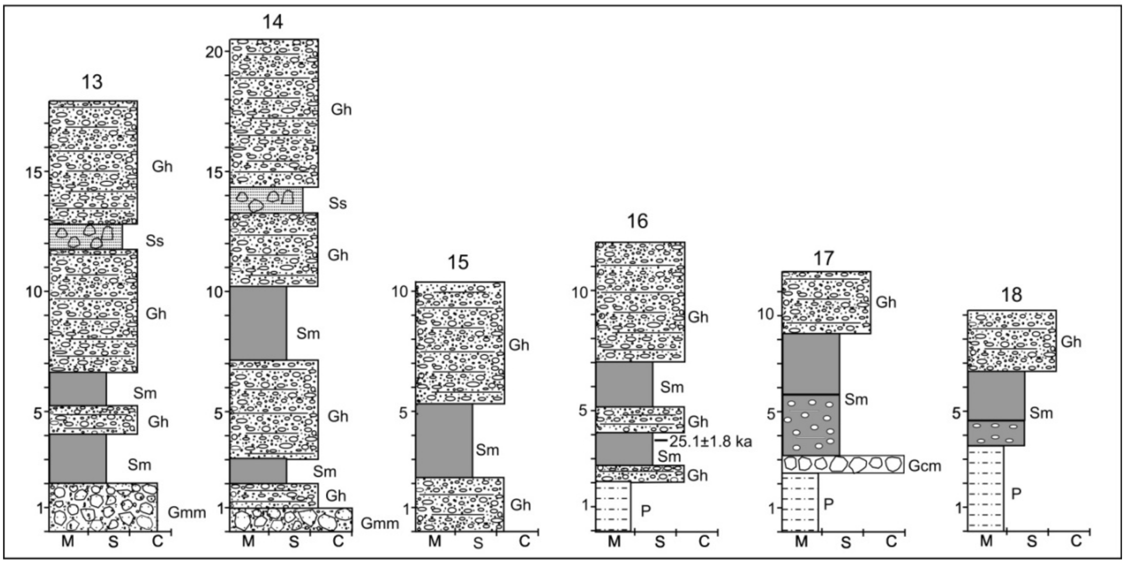

Figure 6.5 Lithologs of bajada sediments exposed in the Nandikhadi River. Locations are shown in Fig. 6.1D. The vertical scale is in meters.

Trough-cross-bedded sandy gravel (Gt)

This facies occurs as fine to very coarse to pebbly sand corresponding to the Gt lithofacies of Miall (1996). The facies is characterized by the presence of broad, shallow scoop shaped bodies 1 m deep and 1.5-2 m wide. Grouped troughs developed in poorly sorted coarse pebbly sand are commonly observable on bedding planes. These units cut into each other both laterally and vertically. The trough cross-beds were formed as dune bed from migrating channel during intermittent high water conditions (Allen, 1963; Williams, 1968). Typically, such trough cross-stratified gravels are deposited by gravel bed-load streams as minor channel fills (Miall, 1996; Crews and Ethridge, 1993).

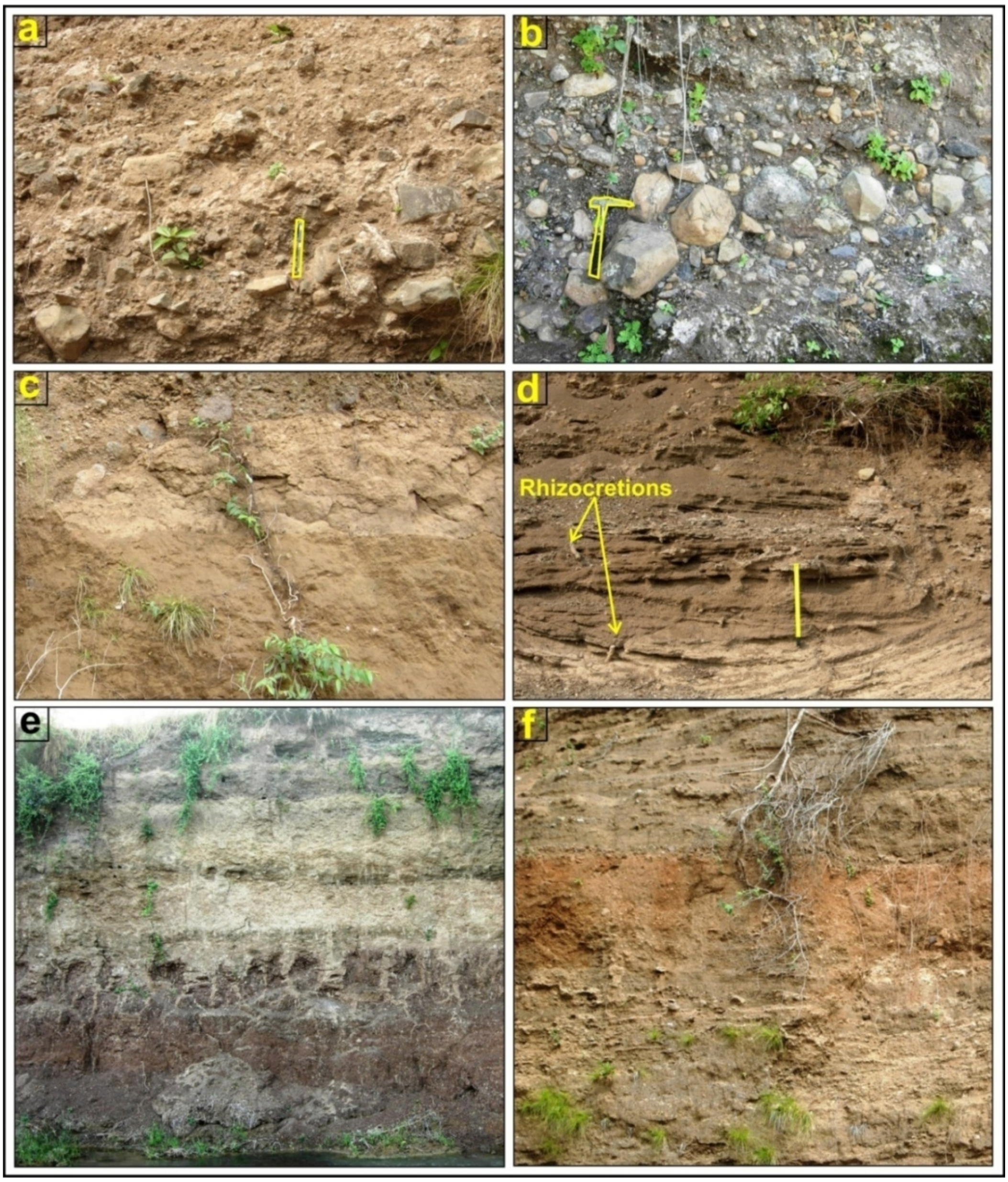

Figure 6.6 Close view of various depositional lithofacies exposed in river cliff sections. (A) Gmm lithofacies. Note the angular granule to boulder size clast embedded in the coarse sandy matrix. (B) Gcm lithofacies. (C) Sm lithofacies. (D) Isolated scour & fill structures formed at the base of Sm lithofacies. Note the presence of rhizocretions formed perpendicular to the horizontal layers of coarse sand. (E) Soil (P lithofacies) exposed in the distal sector of bajada. Note the clearly visible root structure in the middle part of the soil horizon. (F) Ss lithofacies. Note the prominent red color of the facies.

Horizontally stratified gravel (Gh)

This is the most abundant facies particularly deposited in the proximal and medial sectors of the bajada surface. The thickness of the facies varies from 5 to 17 m. Some of the individual units separated by sand units above and below are about 1 m thick. The highest stratigraphic thickness is found in the proximal fan area near the mountain front scarps. It is equivalent to Gh lithofacies of Miall (1996). The contact with underlying sediments is sharp and erosional. The facies consist of clast supported pebble and cobble gravel with crude horizontal stratification. Most of the deposit has clast framework and abundant coarse sandy matrix. However, the percentage of matrix varies considerably. Individual layers of gravel are typically few decimeters thick, with multistoried units reaching several meters in thickness. In modern sedimentary environments this process is most commonly associated with sheet bars or bar complexes (Church and Jones, 1982) in braided gravel-bed rivers (Smith, 1970; Rust and Koster, 1984) where sediments are deposited as extensive longitudinal bedforms or lag deposits (Hein and Walker, 1977; Miall, 1996). The individual units of this lithofacies are several tens of meters in lateral extent which implies that the streams were relatively large.

Massive brick red sand (Ss)

The sand facies ranges from very fine to very coarse grained sand with minor floating gravels (Fig. 6.6F). It is poorly sorted and contains abundant intraclast material and resembles Ss facies of Miall (1996). The brick red colored Ss facies is partially pedoginized which indicates break in sediment deposition. The red color usually comes from oxidized (ferric) iron in illuviated clays. The facies is laterally extensive and ranges from 0.5 to 1 m in thickness. The Ss facies forms the uppermost part of the coarse grained, horizontally stratified gravel lithofacies. In this case, the partially pedogenized Ss facies originated as the uppermost deposit of the channels that were abandoned as a result of channel migration or avulsion (Crew and Ethridge, 1993).

DEPOSITIONAL MODEL

The alluvial architecture is found to change systematically down-fan. In the proximal regions, channel deposits comprise broadly lenticular, coarse grained, longitudinal bar and bar-platform deposits. Overbank deposits and soils represent a minor but significant portion of the deposits in the gravel-bedload stream facies. Virtually all fine grained deposits show evidence of incipient soil formation and presence of intraclast and pedogenic nodules. Lateral continuity of soil horizons through a variety of deposits suggests there were periods of inactivity or abandonment of a portion of fan.

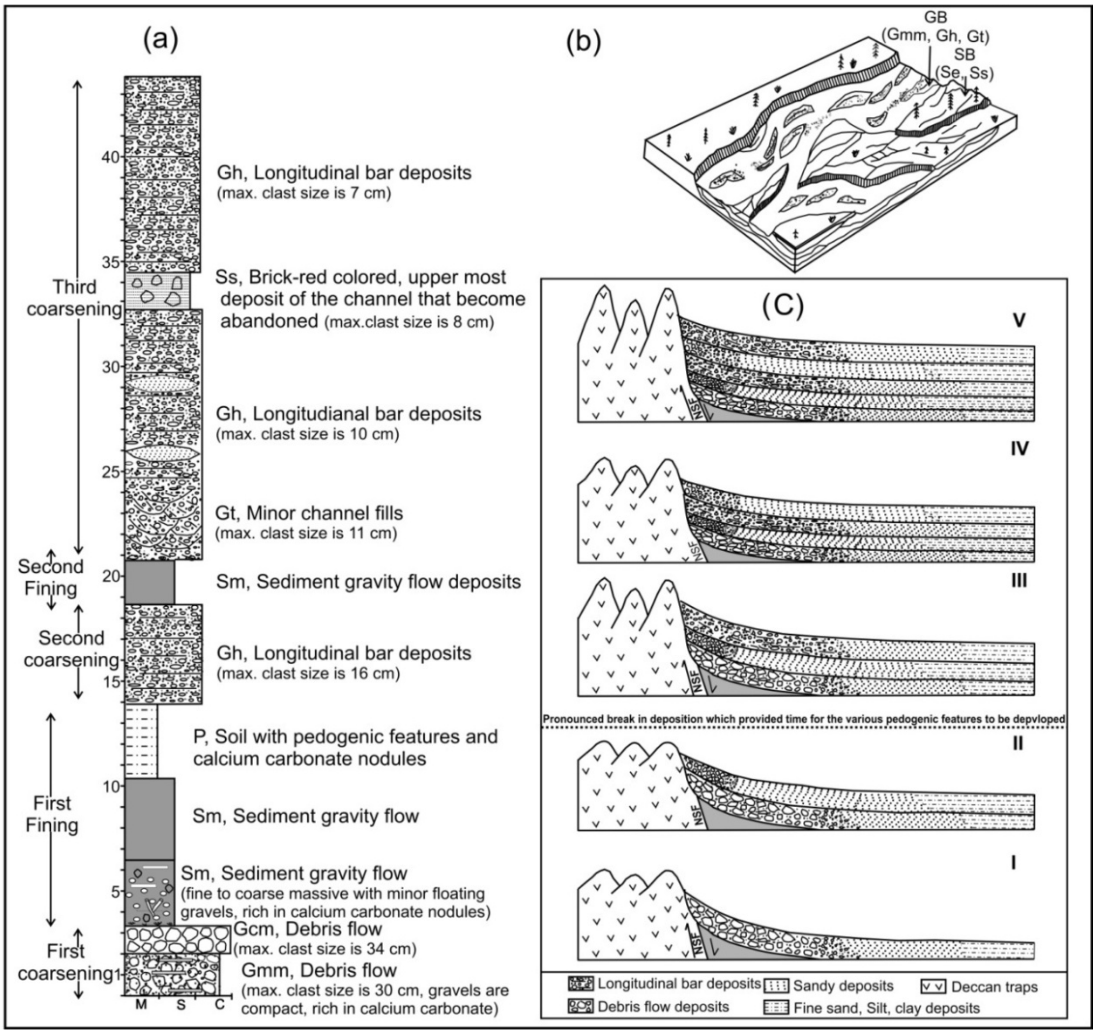

Figure 6.7 (A) Composite litholog showing sequential and topographic development of the bajada with aggradation phases. (B) Depositional model for the deep braided river system based on Miall, (1996) showing the pattern of deposition of different architecture elements and relevant sedimentary lithofacies. (C) Schematic model explaining the deposition of the coarse gravelly sediments in phases that are related to the tectonic uplift along the NSF. Stage I- Initial uplift along the NSF led to the deposition of coarse gravelly debris flow deposits in the semi-arid climate. Stage II- Deposition of fine silty sand deposits during tectonically quiescence period in semi-arid environment. Stage III- The second pulse of uplift provided coarse gravelly material deposited as longitudinal in sub-humid climate. Stage IV- Deposition of fine silty sand sediments during the tectonically quiescence period. Stage V- Third pulse of uplift deposited coarse gravelly sediments as longitudinal bar deposits.

The beginning of the sedimentation started with the deposition of thin wedge of clast and matrix supported gravels (Gc and Gm facies) respectively, that is juxtaposed over the mountain front (Fig. 6.7A). The sedimentation started with matrix supported gravel (Gmm facies) which has overlain Deccan trap rocks. Gravel size ranges from granule to boulder embedded in matrix of coarse sand. The gravels are very compact as they cemented by calcium rich matrix material. Sheets of calcium rich material are also seen at some places.

The presence of coarse granule matrix, poor sorting, absence of grading and imbrications suggest that the matrix supported gravels were deposited by high strength, viscous, plastic debris flows. The top of the Gm?m facies is marked by the deposition of Gcm facies. The clast size of Gcm facies is relatively increased than that of the underlying Gm facies. The coarse gravelly lithofacies is overlain by Sm facies. The deposition of fine grained silty sand over the coarse grained gravels represents the first fining-upward sequence (Fig. 6.7A). The Sm facies comprise of very fine to coarse grained sand and does not show any sedimentary structure. The fine grained sediments are interpreted as local overbank sediments that accumulated along the margins of migrating braided channels (Mack, 1984) and deposited by mixed bedload streams (Miall, 1996; Evans, 1992). The fine grained Sm facies is overlain by the Gh facies, indicating coarsening upward sequence. The Gh facies is the most dominant lithofacies comprises horizontally stratified gravels. The size of gravel clasts range from granule to cobble. Small lenses of sand are present at some places. Most of the deposits have clast framework and abundant coarse sandy matrix. The Gh facies was deposited as a large extensive sheets as it is laterally traceable all along the mountain front which suggest that the deposition took place by gravel bed-load braided streams in the form of large longitudinal bars. The Gh lithofacies comprises ~80% of the total exposed section indicating braided stream deposited as laterally extensive sheets, parallel to the mountain front. Braided stream deposits are characterized by abundant horizontal bedding and trough cross-beds. The grain size ranges from medium sands to granules, with local lenticular bodies of clast supported pebbles and cobbles. Trough cross beds occur in 10 – 30 cm thick sets. Horizontal bedding forms laterally extensive horizons of 1 to 15 m thick successions. The abundant horizontally bedded gravel lithofacies resulted from deposition of longitudinal bars under rapid flow conditions (Williams, 1971). The Gh lithofacies is overlain by brick red colored sand, Ss lithofacies which consists of very fine to coarse grained sand and minor floating gravels. The Ss facies overlies the coarse grained Gh lithofacies forming the uppermost part of fining upward sequence. In this case, the partially pedoginized Ss facies originated as the uppermost deposit of the channels that were abandoned as a result of channel migration or upstream avulsion (e.g. Crew and Ethridge, 1993).

Overall, the sedimentation took place mainly in two major stages. During stage 1, the deposition occurred mainly by debris flows that is represented by Gmm and Gcm sedimentary lithofacies, while stage 2 is dominated by water-laid, braided stream and sheetflood deposits which is represented by Gh, Gt, Sm, Se, and Ss lithofacies. The facies assemblage is related to the GB, SB and FF architectural element (Fig. 6.7B) of Miall, (1996), which suggest that the deposition of coarse gravelly sediments in deep braided rivers.

IMPORTANCE OF OCCURRENCE OF BAJADA SURFACES

The formation and occurrence of bajada surfaces in itself is significant as it is mainly related to active tectonics prevailing in the particular region. In areas of active basin margin faults, tectonic slopes are produced by combination of footwall uplift and hanging wall subsidence (Leeder and Gawthorpe 1987; Prossor, 1993). The footwall slopes are normally steep and typically blanketed by coarse debris in the form of alluvial fans (Miall, 1996). In case of lateral merging and blending of a series of alluvial fans, bajada could be formed and extends from the base of the mountain range out onto the flood plain (Miall, 1996; Milana, 2000). Bajada architecture has been used for the characterization and parameterization of a number of important basin analysis variables including tectonic subsidence rate (Blair and Bilodeau, 1988; Heller et al., 1988; Whiple and Traylor, 1996; Allen and Hovious, 1998), episodes of structural tilting (Hooke, 1972; Leeder and Gawthrope, 1987; Dorsey et al., 1997), fault and fold progradation (Jackson and Leeder, 1994; Gupta, 1997; Leeder et al., 1996; Gawthrope and Leeder, 2000) and climate change (Bull, 1991; Reheis et al., 1996).

Implication for tectonics and topography

Bajada are formed in topographic setting where streams run parallel and are perpendicular to the mountain front (Milana, 2000). In such area, rapid coalescence of fans produced by numerous small drainage basins of similar size, lying beside each other in such a way that lateral spreading of the fan result in the formation of bajada surface. The process results in formation of bajada instead of alluvial fan. Because in fan environment, a relatively major stream emerges from the mountain front forming radial system of sediment distribution, the sediment grain size domain is not parallel to the mountain front. Presence of marginal mountain front escarpment, steep slope of alluvial plain and closely spaced parallel drainages provided suitable topographic setting for the formation of bajada.

In such topographic setting, when uplift rates along basin marginal fault exceed erosion rates sufficiently to produce significant topographic relief, the syntectonic sediments supplied from the uplifted source area tend to be relatively coarse grained and are deposited in a narrow fringe, immediately adjacent to the active mountain front because of the capacity of the rapidly subsiding basin to absorb sediment and thereby decrease depositional slope (Crews, 1993). The reactivation of fault in the marginal fault bounded basin is the possible controlling factor on the initial deposition of coarse grained deposits (Kallmeir, 2000). Initial uplift related to reactivation of NSF provided space for the sediments to get accommodated and also facilitated huge amount of coarse debris that were deposited mainly by debris flows, which is represented by narrow wedge of Gmm and Gcm lithofacies deposited in the proximal part of the bajada.

Three sequences of coarsening and fining upward cycle exist on the scale of few tens of meters thick. The first coarsening upward sequence begins with the deposition of massive, poorly sorted, matrix supported and clast supported gravels (Fig. 6.7C). Clasts are extremely angular and have maximum size of ~ 30 cm. These sediments probably represent short transportation distance indicating the initial stages of uplift. Significant increase in grain size in the first coarsening upward sequence correspond to the appearance of stream flood and debris flow gravels, suggesting sedimentation in proximal fan setting. The first fining upward sequence corresponds to a decrease in grain size from coarse gravels to silty sand. Debris flow and stream flood facies are replaced by laterally continuous stream flood and braided stream facies, which are indicator of midfan deposition. The second coarsening upward sequence, thicker than the first sequence, exhibit a significant decrease in grain size and it is dominated by braided stream and sheet flood facies (Fig. 6.7C). The second fining upward sequence exhibits a decrease in grain size, and it is dominated by overbank deposits resulting from sediment gravity flows. These sediments are brick red in color and partially pedogenised, indicating a gap in sedimentation. The third coarsening upward sequence comprises of inter-bedded sheet flood and braided stream sediments.

The three sequences in the bajada formation are interpreted to be the result of minimum three tectonic pulses. The tectonic uplift led to increase in sediment flux probably accompanied by an increase in drainage basin relief during the period of upliftment (Burbank and Raynold, 1988; DeCellas et al., 1987). Thus, as the source area uplifted along the NSF, coarse proximal alluvial fan facies prograded over more distal facies. The fining-upward part of each sequence resulted from the waning tectonic activity due to gradual decrease in sediment supply and strength as drainage basin relief decreases (Heward, 1978a; Rust and Koster, 1984). The mountains were getting higher and the basin was getting deeper due to the active tectonic uplift along NSF. By the same logic, the fining upward sequences correspond to a post tectonic decline in the rate of supply of sediment to the fan from uplift.

Implication for climate

Favorable climatic conditions are essential for the development of alluvial fan stratigraphy including the distribution of debris flow, sheet flood and channelized fluvial deposits and fan aggradation-dissection intervals (Bull, 1991; Harvey & Wells, 1994; Harvey, 2004). However, it is difficult to infer the palaeoclimatic conditions during fan development stages based only on the sedimentary record of the alluvial fan**.** Bedrock lithology and the drainage basin morphology (particularly the slope) are the factors controlling the kind of alluvial fan processes and sediments (Blair and McPherson, 1994; Sancho et al., 2008). However, tectonics and climate are the primary external processes governing continental erosion, sedimentation and landscape evolution. Tectonic uplift creates elevated terrain and provides increased potential to the agents of erosion such as fluvial system. Tectonic activity generates rubble in mountainous region, thereby increasing the sedimentary inputs into catchment system (Keefer, 1994; Allen and Hovius, 1998; Dadson et al., 2004; Quigley et al., 2007b). Analysis of the exposed cliff sections suggest that they are the sedimentary products of large, extensive braided streams (Gt, Gh, Ss,), flash flood deposits (Sm,Ss) and in minor amount of debris flow deposits (Gmm, Gcm) indicative of humid environment (Miall, 1996; Sancho et al., 2008; Spotl et a., 2010; Koyka et al., 2011). The bajada sediments provide a record of changing depositional facies and fluctuating intervals between sediment accumulation and erosion. Debris flow deposits are interpreted to reflect sedimentation during episodic, high magnitude flooding. The deposition of coarse sedimentary sequence indicates the occurrence of episodic, high discharge flood events capable of transporting coarse material at different time intervals. Conversely, palaeosol development indicates a prolonged period of landscape stability and an absence of large flood events. The cyclic deposition of coarse gravel deposits suggest that coarse material continually accumulate within catchment system and was episodically flushed to alluvial fan system during the stream power threshold discharge events. The fluvial system must transport these coarse material in order to incise the bedrock, and thus, develop the deeply braided streams whose further incision fundamentally depend upon the reoccurrence of large magnitude floods. In general, during the inactive phase the fan is characterized by fan-head incision and by vertically accreting sinuous, single channel (Kesel, 1985). Such condition are found in area, as the bajada sediments incised by north flowing parallel sinuous channels have produced huge cliff sections of up to 40 m height. These sediments have been mapped and studied to analyze the influence of tectonics and climate in producing coarse gravelly bajada sediments. Further the presence of rhizocretions and calcite sheets only within the basal debris flow and sheet flood facies suggesting major climate variation occurred during the bajada formation. Also, wetter than the normal period were represented by well –developed palaeosol consisting of calcite nodules and laminated calcite sheets (William, 1973).