

## Newly Proposed Lithostratigraphy of the Quaternary Succession of Hanna-Spin Karez Area, Quetta, Pakistan

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### Abstract

The “Hanna and Spin-Karez area” in Quetta district lays at the “Quetta Syntaxes”, the intersection between Sulaiman and Kirthar Fold Thrust belts, near the Zarghun Knot, western Balochistan, Pakistan. The Quaternary succession in the area is more than 800 m thick. It had erroneously been mapped as Spin Karez Gravel by the Hunting Survey Corporation (HSC) (Jones, 1961). We remapped the succession on 1:25000 scale and defined the litho-stratigraphy of the succession that allowed us to divide the succession into four different units/formations. The names are proposed for constituting units such as the “Hanna Lake Conglomerate”, “Hanna Red Clays”, “Spin Karez Conglomerate” and “Holocene deposits”.

The “Hanna Lake Conglomerate”, which is the lowermost unit, is 200 meters thick unit. In lower part the boulder conglomerate is poorly sorted and crudely bedded, while in the upper part the conglomerate is cobble to pebble size, well-stratified, however, punctuated with sandstone lenses. The lower contact of the conglomerate is angular unconformity with the underlying “Early Eocene Ghazij Formation”. “The Hanna Red Clays” is more than 500 meters thick red mudstone/claystone succession of with rare interbedded fine-grained sandstone and siltstone. Its lower contact with “Hanna Lake Conglomerate” is transitional and conformable. “The Spin Karez Conglomerate” which is more than 100 meters thick is well bedded and moderately to well sorted cobble to pebble conglomerate with sporadic siltstone/sandstone wedges. The Holocene deposits are topmost 20 m thick unit. They are horizontally lying loose or semi-consolidated sediments composed of gravel interbedded with clay and siltstone. Its lower contact with “Hanna Red Clays” is transitional and conformable. The Holocene deposits are limited to the valley and overlies the “Hanna Red Clays” with angular unconformity.

**Keywords:** Spin karez group, Quetta syntaxes, Subsidence, Quaternary, Lithostratigraphy

### 1. Introduction

The Hanna-Spin Karez area is located close to the confluence of Sulaiman and Kirthar Fold-Thrust belts (Quetta Syntaxes) and southwest of the Zarghun Knot in western Balochistan, Pakistan (Fig. 1) (Sarwar and DeJong, 1979; Bender and Raza, 1995; Kazmi and Jan, 1997). The Quaternary succession of the area was first mapped by the HSC (Jones, 1961) on 1:253,000 scale, however, they indiscriminately mapped this thick succession as recent deposits and named it Spin Karez Gravel. After the HSC, enlarged unpublished map of the area was prepared by Geological Survey of Pakistan (GSP), however, it also failed to recognize the Quaternary succession as distinct lithostratigraphic unit and mapped it as upper part of the Urak Group of Miocene-Pleistocene age (Kazmi and Raza, 1970; Kassi

et al., 1990; Tareen, 2014).

The surrounding area comprises mainly marine sedimentary succession ranging in age from Jurassic to Eocene (Fig. 2; Table 1) (Kassi et al., 2009). During fieldwork we noticed that the thick Quaternary succession of the “Hanna-Spin Karez area” is a distinct lithostratigraphic unit, younger and distinct to the Urak Group, we thus propose Spin Karez Group name to it (Fig. 2; Table 2). This paper presents a new map of the area and describes the lithostratigraphy of the Quaternary succession.

### 2. Lithostratigraphy

Newly identified units (Fig. 2 and 3) are hereby named as the “Hanna Lake Conglomerate”, “Hanna Red Clays”, “Spin Karez Conglomerate” and flat lying “Holocene

deposits” (Table 2) and we name the whole succession as the “Spin Karez Group”. Units of the group, in ascending order, are described below:

### 2.1. Hanna lake conglomerate

The Hanna Lake Conglomerate is the lowermost formation of the Group (Figs. 3, 4 a,b). The formation was named after the scenic Hanna Jeel (Lake), located 8 km north of Quetta metropolitan. The conglomerate mostly outcrops along the northwestern margin of northeast-southwest oriented Hanna valley (Fig. 2). Section exposed near the Atakzai Killi is designated as its reference section. It is composed of boulder and cobble sized clasts in its lower segment and cobble to pebble sized clasts, with sporadic sandstone or siltstone beds in the upper segment (Fig. 4b). In lower conglomerate some beds have clast size up to

1.5 m across. The conglomerate is poorly sorted, subangular to subrounded, crudely-bedded and several tens of meters thick. The upper part of the Hanna Lake Conglomerate is moderately to well sorted cobble to pebble conglomerate. The conglomerate is alternating with very coarse grained to pebbly sandstone and siltstone. Clasts are composed of several types of limestone, sandstone, conglomerate and chert. The formation is more than 200 m thick.

The conglomerate overlies the “Eocene Ghazij Formation” with angular unconformity and underlies the “Hanna Red Clays” with transitional contact. The presence of fragments of the Pliocene till Early Pleistocene Urak Conglomerate (uppermost unit of the Urak Group), Middle Pleistocene age is envisaged for the formation.

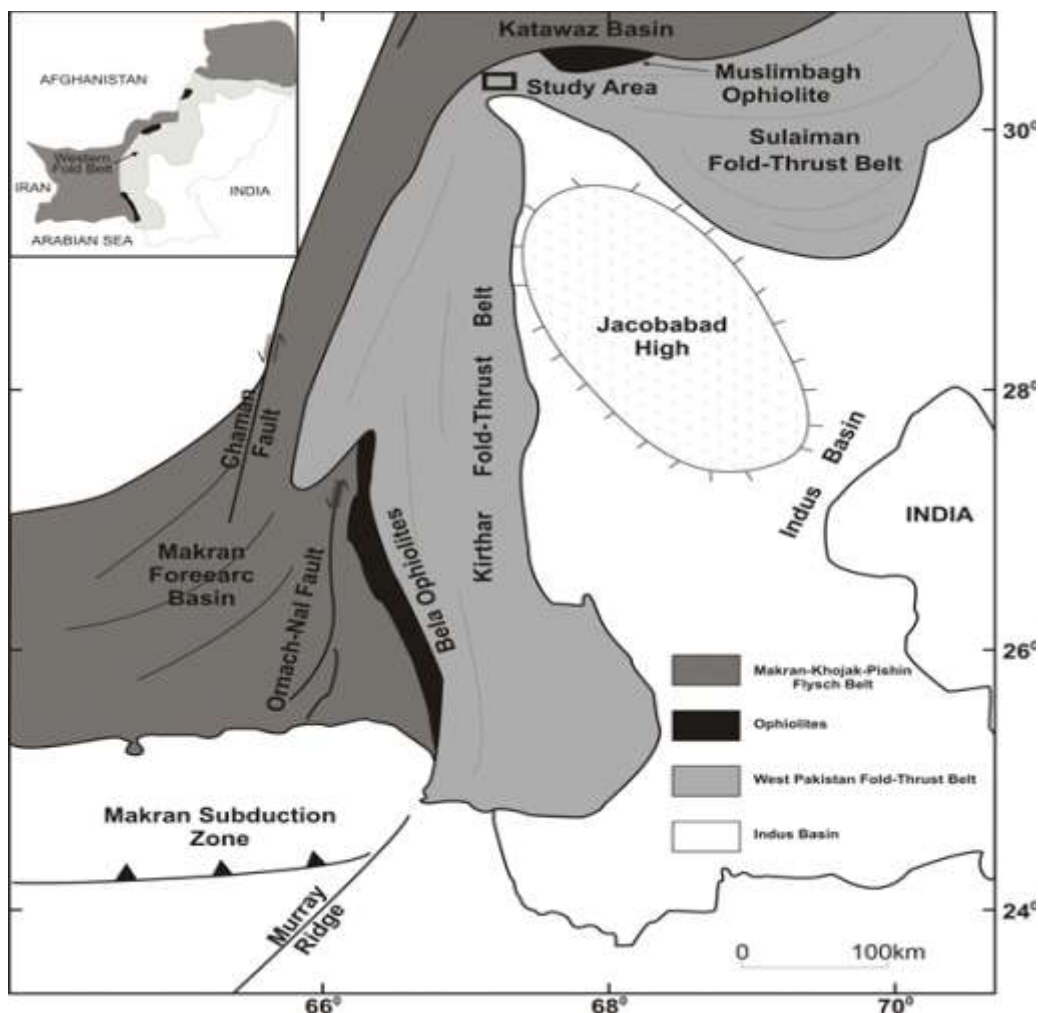


Fig. 1. Generalised geological map of the western Pakistan Fold-Thrust-Belt, showing the location of study area.

Table 1. Stratigraphic succession of the Hanna-Spin Karez and surrounding area.

Age	Formation(s)	Lithology
Holocene	Holocene deposits	Conglomerate, claystone, sandstone
*Quaternary	Hanna Lake Conglomerate, Hanna Red Clays, Spin Karez Conglomerate	Conglomerate, claystone, sandstone.
<b>Angular Unconformity</b>		
Miocene-Pleistocene	Urak Group	Sandstone, claystone and conglomerate.
<b>Disconformity</b>		
Middle-Late Eocene	Spintangi Limestone	Limestone, shale and sandstone.
Early Eocene	Ghazij Formation	Claystone, sandstone, conglomerate, limestone and coal seams.
Palaeocene	Dungan Formation	Limestone and shale.
<b>Disconformity</b>		
Late Cretaceous	Pab formation	White and cream coloured sandstone
Late Cretaceous	Fort Munro Formation	Orbital limestone
<b>Disconformity</b>		
Middle-Late Cretaceous	Hanna Lake limestone	Dull brownish grey, argillaceous limestone.
<b>Disconformity</b>		
Early-Middle Cretaceous	Parh Limestone / Goru Formation / Sembar Formation	Limestone (bio-micritic), marl and shale.
<b>Disconformity</b>		
Jurassic	Chiltan Limestone	Dark grey limestone
<b>Base not exposed</b>		

*\*No direct stratigraphic relationship is observable between the Urak Group and Quaternary succession.*

Table 2. Lithostratigraphy of the Quaternary succession of the Spin Karez Group in the Hanna-Spin Karez area.

Age	Formation	Lithology
Holocene	Holocene deposits	Conglomerate, sandstone and claystone
<b>Angular Unconformity</b>		
Quaternary	Spin Karez Conglomerate	Conglomerate
	Hanna Red Clays	Reddish brown claystone
	Hanna Lake Conglomerate	Conglomerate
<b>Angular Unconformity</b>		
Early Eocene	Ghazij Formation	Claystone, sandstone, conglomerate, limestone and coal seams.

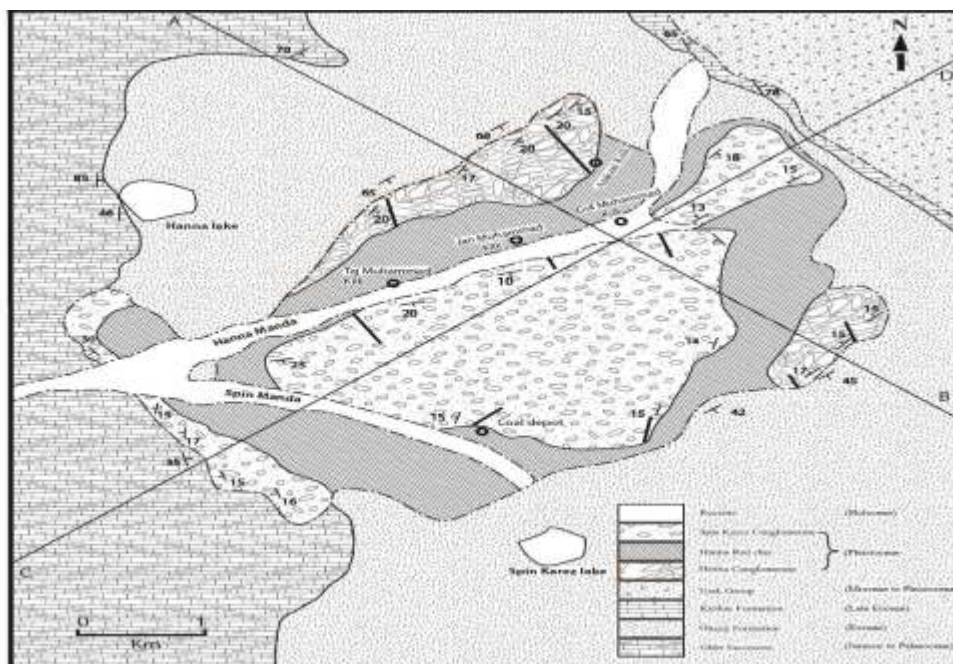


Fig. 2. Geological map of the Hanna-Spin Karez area showing the Quaternary Spin Karez Group and older successions in the surrounding area. Line AB and CD are section lines.

## 2.2. Hanna red clays

The “Hanna Red Clays” takes its name from the Hanna valley, where it is well exposed, it is also exposed in Spin Karez (Spin Lake) area (Figs. 3, 4c and 4d). In the Hanna valley the flat lying sediments of Holocene age mostly conceals it and only exposed in patches. Section exposed east of the Atakzai Killi in the Hanna area is designated as its reference section. The Lower part of the formation is composed of very thick dark to light reddish grey claystone with minor fraction of sandstone and siltstones. The upper claystone dominant part shows alternating strips of light and dark reddish gray and partly bluish gray colour claystones (Figs. 4c and 4d). The formation is about 500 m thick.

The formation has conformable and transitional lower contact with the “Hanna Lake Conglomerate”. The upper contact, exposed east of the Hanna valley (Figs. 5a and 5b), is also conformable and transitional with the “Spin Karez Conglomerate”. Based on stratigraphic position Late Pleistocene age is proposed for the formation.

## 2.3. Spin karez conglomerate

The Spin Karez Conglomerate is named

after the “Spin Karez (Spin Lake)”, located 10 km north-east of Quetta city, on Quetta--Sorange road. It outcrops along the southeastern margin of the “Hanna valley” in the form of vertical cliffs (Figs. 3, 5a and 5b). Section exposed near the Killi Babu Muhammad Jan, in the Hanna valley is designated as its reference section. Lower part of the conglomerate is mostly consist of cobble to pebble clasts with minor proportion of sandstone, siltstone, and claystone. The upper part is composed of very thick compact cobble/pebble conglomerate. The clasts of conglomerate are rounded to well rounded and moderately to well sorted (Figs. 5c and 5d). Clasts up to 25 cm across are present, clasts of several types of limestones, sandstones, cherts and conglomerates make the framework composition. The formation attain over 100 meters thickness in the “Hanna valley”.

The “Spin Karez Conglomerate” represents the youngest Pleistocene succession of the area, it has transitional contact with the “Hanna Red Clays” (Figs. 5a and 5b). Upper contact of the formation is not visible in the area.



## 2.4. Holocene deposits

Holocene deposits are horizontally-lying gravels with interbedded clay and siltstone. They are mainly present in the “Hanna valley” overlying the “Hanna Red Clays”. It is also exposed on top of the Spin Karez Conglomerate tough in small patches. Gravel clasts pebble to cobble size are mostly well rounded, moderately to very well sorted and. The Clay is mostly gray to light reddish gray. The Holocene

deposits make tall terraces on the western margin of the Hanna valley. They are considered as sediments of the older Hanna stream. Their thickness varies from a one meter up to 20 meters.

They represent the youngest deposits, i.e., the Holocene unit of the Quaternary succession. It overlies the “Hanna Red Clays” with angular unconformity.

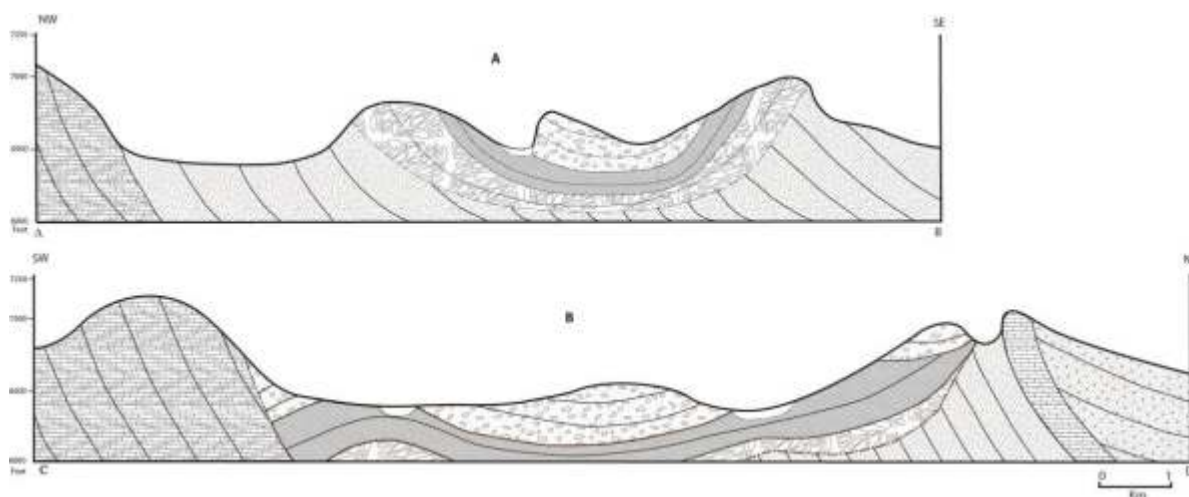


Fig. 3. Cross sections along lines AB and CD of Fig. 2, showing the Spin Karez Group overlying the Eocene Ghazij Formation with angular unconformity.

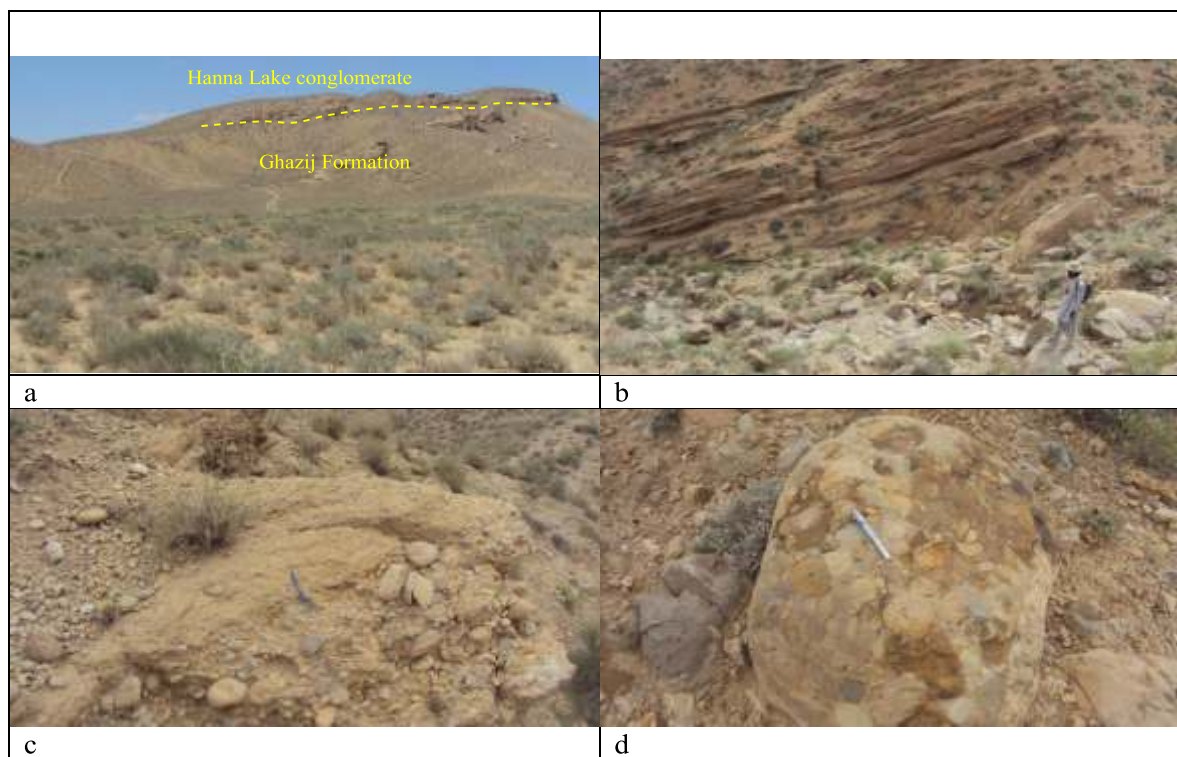


Fig. 4. Field photographs of the study area showing: a) distant view of the Hanna Lake Conglomerate, laying unconformably on top of the Ghazij Formation; b) west dipping thick cycle of boulder conglomerate beds of the Hanna Lake Conglomerate; c) poorly sorted boulder conglomerate of the Hanna Lake Conglomerate; d) a very large conglomerate boulder within the Hanna Lake Conglomerate.

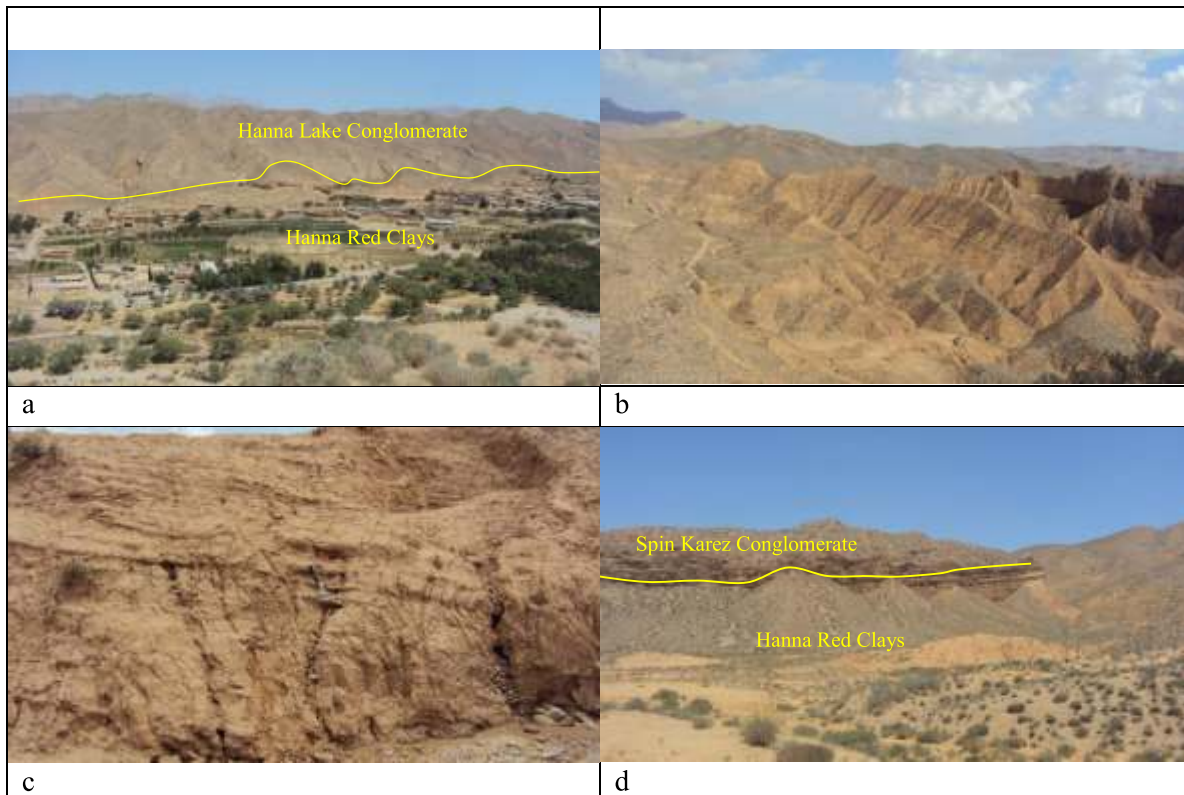


Fig. 5. Field photographs of the Hanna-Spin Karez area showing: a) distant view of the contact between the Hanna Lake Conglomerate and overlying Hanna Red Clays in the Hanna valley; b) a thick well stratified succession of the Hanna Red Clays; c) mudstone interbedded with thin siltstones in the Hanna Red Clays; (d) distant view of the transitional contact between the Hanna Red Clays and overlying Spin Karez Conglomerate.

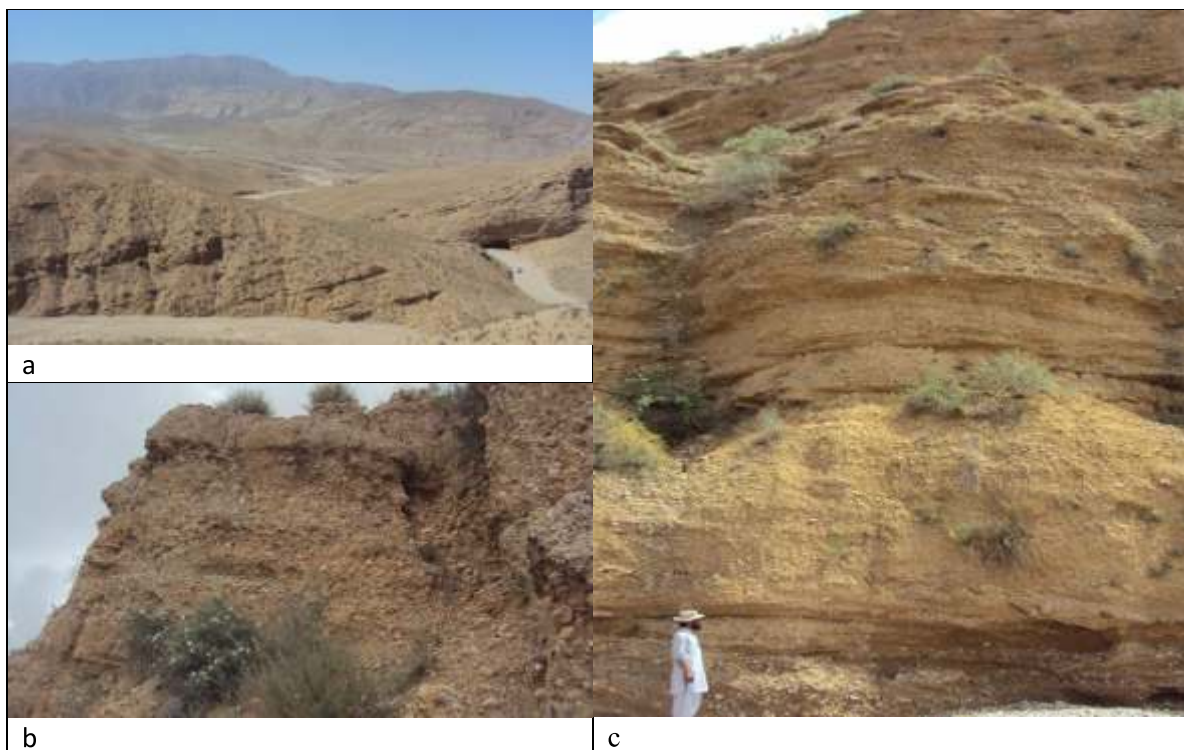


Fig. 6. Field photographs of the Hanna-Spin Karez area showing: a) distant view of the west dipping conglomerate beds of Spin Karez Conglomerate; b) stacked conglomerate channels of Spin Karez Conglomerate; c) pebble to cobble moderately sorted Spin Karez Conglomerate.



### 3. Discussion

Quaternary succession, which covers about 30km<sup>2</sup> area, is exposed along the both edges of the “Hanna valley” and stretches from eastern margin of the “Hanna Lake” to the “Spin Karez” area.

The succession has not been studied before except that the HSC (Jones, 1961) mapped the succession on 1:250000 scale and designated it as “Spin Karez Gravel”, without providing any more description. The present study recommends that the succession can distinctly be divided into four lithostratigraphic units. We mapped, described and named four lithostratigraphic units and hereby propose the “Spin Karez Group” name for the entire succession.

The constituent lithostratigraphic units of the “Spin Karez Group” are thick, have distinct lithological characters and mappable, therefore, deserving the status of formations as per the existing stratigraphic procedures (North American Stratigraphic Codes, 2005). The group makes angular unconformity with the underlying Early Eocene Ghazij Formation.

If the Stratigraphic Codes (Rahman, 1962; North American Stratigraphic Codes, 2005) are applied on the Quaternary succession of the study area, it will clearly be entitled to the status of a “group”. The Codes define the “group” (as per its Article 28, —Group) as the “lithostratigraphic unit next higher in rank to the formation. Groups are defined to express the natural relations of associated formations. They are very useful in small-scale mapping and regional stratigraphic analysis. In some reconnaissance works, the term “group” has been applied to lithostratigraphic units that appear to be divisible into formations, but have not yet been so divided. In such cases, formations may be erected subsequently for one or all of the practical divisions of the group”. Therefore, in view of these Articles (28, 19b, 19g) of the North American Stratigraphic Codes (2005) our proposed “Spin Karez Group” deserves the status of a group. Previous workers, however, did not realize that the successions actually is a mappable lithostratigraphic unit, further divisible into 4

distinct mappable lithostratigraphic units and deserves the status of a “group”.

The constituent lithostratigraphic units of the proposed Spin Karez Group are map-able units, which have not been mentioned and/or properly named nor have been mapped before; therefore, we prepared a geological map of the proposed group and clearly defined and described the constituent formations, as per the Stratigraphic Codes (Rahman, 1962; North American Stratigraphic Codes, 2005). The North American Stratigraphic Codes (2005) defines “lithostratigraphic unit as a body of sedimentary, extrusive igneous, meta-sedimentary, or metavolcanic strata that is distinguished and delimited on the basis of lithic characteristics and stratigraphic position. A lithostratigraphic unit generally conforms to the Law of Superposition and commonly is stratified and tabular in form. The proposal of a new formation must be based on tested mappability, however, thickness is not a determining parameter in dividing a rock succession into formations”. The proposed constituent lithostratigraphic units, i.e. the “Hanna Lake Conglomerate”, “Hanna Red Clays”, “Spin Karez Conglomerate” of our proposed “Spin Karez Group” fulfill the requirements of the Article 24 of the North American Stratigraphic Codes (2005).

We propose that the Quaternary succession was deposited in a basin that evolved within the soft mudstone-dominant Early Eocene Ghazij Formation. The succession outcrops between the present “Hanna Jeel (Hanna Lake) and Spin Karez (Spin Lake)” areas. We believe that the over 800 m thick Quaternary succession of the “Spin Karez Group” developed in response to subsidence of the thick soft mudstone/claystone-dominant Early Eocene Ghazij Formation due to the gradual deposition and overloading of the succession. Trend of the SE-plunging open-type syncline developed within the Spin Karez Group is contrasting to the trend of the older succession (of Jurassic through Pleistocene) age and apparently does not show tectonic relevance. This also supports the phenomenon of the gradual subsidence of the basin.

The older rock succession, which ranges from Jurassic till Pleistocene age is exposed to the south and southwest of the trough, whereas the younger succession of Late Eocene till Pleistocene age is exposed to the north and northeast of the trough. The detritus was provided by those older succession.

Sedimentology and petrology of the Spin Karez Group will provide us with further insight into the tectonic history of the Quaternary period. The thick permeable conglomerate succession is very promising for undertaking the hydrogeological studies.

#### 4. Conclusions

The Quaternary succession exposed in the “Hanna-Spin Karez” area of district Quetta is over 800 m thick. The succession is clearly divisible into four discrete lithostratigraphic units. The Early Eocene Ghazij Formation accommodates the succession with an angular unconformity. The succession was mapped for the first time, the units were identified, measured, described and named the constituent. We propose the name “Spin Karez Group” for the overall succession. We also propose the names “Hanna Lake Conglomerate”, “Hanna Red Clays”, “Spin Karez Conglomerate” and “Holocene deposits” for the constituent units of the Spin Karez Group.

#### Authors' Contribution

*Naseer Ahmed, proposed the main theme, did the field work and wrote the paper. Akhtar Muhammad Kassi, did the field work and assisted in establishing map and lithostratigraphy of the area. Aimal Khan Kasi, did the field work, assisted in logs preparation and submission of the manuscript. Aminullah Kakar did review and proofread of the manuscript.*

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