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Provenance of the Early Eocene Chashmai Formation in South-Western Kohat: Indications of an Uplifted Island Arc

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ABSTRACT

The Chashmai Formation of Early Eocene age is well exposed in the western Kohat basin and is clastic equivalent of carbonate and evaporites in the eastern and central Kohat basin. The formation is a coarsening upward sequence of shale, sandstone and conglomerate. Petrographic and modal compositional studies of the formation at its stratotype show that it is composed mainly of quartz and lithic fragments of sedimentary affiliation. Minor amount of volcanic lithic fragments were probably derived from rhyolites or dacites. Feldspar content is small and most of it has been altered or replaced by calcite cement. Detritus for these sediments was probably derived from cover sequence of an uplifted orogenic belt which was located to the west of the basin of deposition. North Waziristan and Kurram melange zone are the probable source area for these sediments.

INTRODUCTION

The Early Eocene Chashmai Formation in western Kohat (Figure 1) is stratigraphically coeval to the Shekhan Formation in the northern and eastern part and to the Jatta Gypsum in the central part of the Kohat basin (Figure 2). The name Chashmai Formation (Tanoli et al, 1992b) is proposed for the Gurguri Sandstone of (Meissner et al, 1974) and Wells (1984). The type locality is along Chashmai Algad (33° 06' 45"N, 70° 47' E), about 1.5 km north of Chashmai village which is approximately 8 km WNW of Latambar town on the Kohat-Bannu road (Figure 1). The study area in western Kohat is bounded to the west by north Waziristan and Kurram fault. The formation is well developed in the western Kohat measuring 32 metres at stratotype, 40 metres at Lodhi Khel, 22 metres at Mardan Khel, and 14 metres at Gurguri (Figure 3). It conformably overlies the Panoba Formation and underlies the Kuldana Formation.

The Chashmai Formation is a coarsening-up sequence of interbedded shale, sandstone and conglomerate. At stratotype it consists of dominant clay and sub-ordinate sandstone in the lower part, sandstone and clay in the middle part and dominantly sandstone and subordinate conglomerate in its upper part. Sandstone is gray in colour, medium-grained, horizontal to cross-laminated, some of which is bidirectional, and at places bioturbated. Fossiliferous horizons in sandstone beds are also common. Most of the sandstone beds are lenticular and pinch out laterally on outcrop scale. The polymictic conglomerate beds consist of gray and white limestone, chert and quartzite pebbles set in a coarse-grained sandstone matrix. The conglomerate is texturally mature and consists of well-rounded clasts generally less than 10cm in diameter.

This paper is aimed at describing the petrography of sandstone and conglomerate of the Chashmai Formation from its stratotype. A total of 20 thin-sections were studied in detail, of which 10 representative sections were selected for modal compositional studies. Different grain parameters used in the provenance discrimination plot are shown in Table. 1.

A minimum of 350 detrital framework grains were identified and counted per sample. The most common framework grains present are quartz, rock fragments, some feldspar grains and minor amount of heavy minerals (Table 2). According to Folks (1974) classification, the sandstone is sublitharenite to litharenite (Figure 4).

TEXTURE AND FRAMEWORK COMPONENTS: GENERAL DESCRIPTION

Texture

Sandstone of the Chashmai Formation is fine to medium-grained, detrital grains being subangular to subrounded, both matrix and framework supported. Most of samples show bimodal grain distribution with

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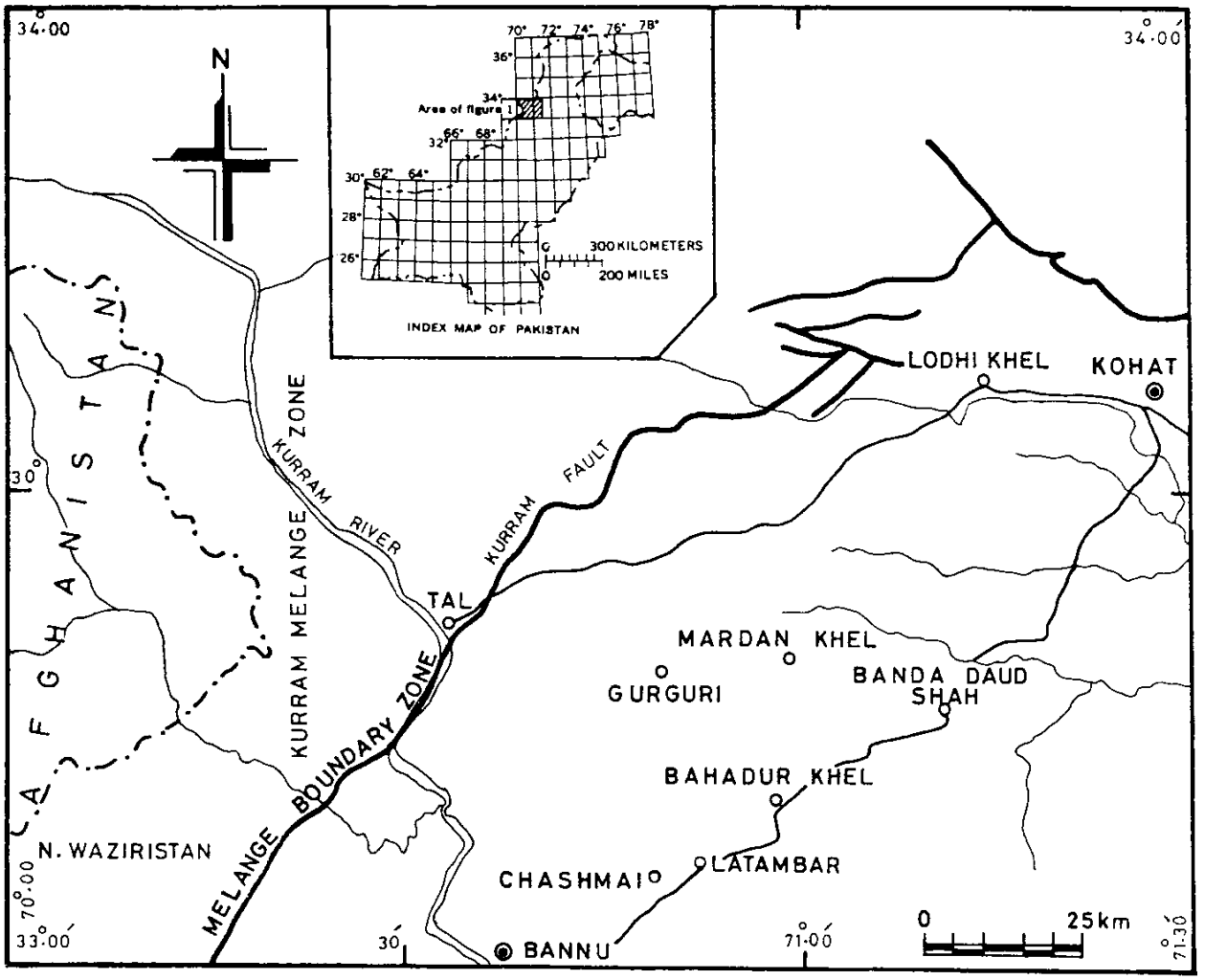

Figure 1– Location map of the Kohat basin (modified from Meissner et al, 1974, 1975 and Beck et al, in prep.).

poor sorting, however, some samples show moderate sorting. Framework supported grains commonly exhibit grain contacts such as triple junctions and concavo-convex boundaries. The sandstone is well cemented and porosity is negligible due to diagenetic calcite growth. Most of detrital grains are corroded at edges by calcite. Poor to moderate sorting, subangular to subrounded grains, and abundant rock fragments indicate that the sandstone is texturally immature. However, mineralogically the sandstone is submature due to abundant quartz and low feldspar content.

Framework Component

The main framework components of the sandstone useful for provenance interpretation are quartz, feldspar and rock fragments. In the Chashmai Formation, quartz and rock fragments are dominant framework components whereas feldspar content is negligible. Minor amount of heavy minerals is also present. General features of these framework components are described below:

Quartz.– Quartz is the most common detrital constituent of the formation, and is found both as (i) monocrystalline grains with undulatory and nonundulatory extinction, and (ii) polycrystalline grains. Amount of quartz ranges from 52% to 93% across the formation with a random distribution but generally increases upsection (Table 2). Nonundulatory monocrystalline quartz is most abundant with minor amount of composite and polycrystalline quartz. Metaquartzite fragments when present were counted as polycrystalline quartz, whereas, chert was counted as rock fragments.

KOHAT BASIN		
NORTHERN	CENTRAL	WESTERN
KOHAT FORMATION	KOHAT FORMATION	KOHAT FORMATION
KULDANA FORMATION	KULDANA FORMATION	KULDANA FORMATION
SHEKHAN FORMATION	JATTA GYPSUM + BAHADUR KHEL SALT	CHASHMAI FORMATION
PANOBA FORMATION	PANOBA FORMATION	PANOBA FORMATION

Figure 2– Eocene stratigraphy of the Kohat basin.

Table 1. Grain-parameters (after Suczek and Ingersoll, 1985)

a) Q = Qm + Qp, where
Q = total quartzose grains
Qm= monocrystalline quartz grains
Qp= polycrystalline quartz grains

b) F = K + P, where
F = total feldspar grains, and calcitized feldspar grains
K = potash feldspar grains
P = plagioclase grains

c) L = Lv + Lm + Ls, where
L = total lithic fragments
Lv= volcanic lithic fragments
Lm= metamorphic lithic fragments
Ls= sedimentary lithic fragments

Table 2. Modal point-count data from The Chashmai Formation.

	Sample No.									
	CaG2	CaG3	CaG5	CaG6	CaG9	CaG13	CaG15	CaG18	CaG19	CaG20
% QFL										
Q	55	75	78	68	72	52	85	91	89	93
F	10	7	4	6	4	-	3	3	-	-
L	35	18	18	26	24	48	12	5	7	7
Other components										
Heavy Minerals										
Zircon	1	tr	1	tr	tr	-	1	tr	tr	tr
Glauconite	2	1	1	1	tr	tr	1	1	tr	tr
Tourmaline	1	1	tr	tr	tr	tr	tr	tr	-	-
Garnet	tr	tr	1	tr	1	tr	tr	-	-	-
Calcite	31	27	28	29	39	35	34	22	38	18
%age of lithic fragments										
Limestone	62	66	30	54	26	17	22	20	28	63
Chert	17	19	30	11	19	17	44	48	50	18
Sandstone	10	-	-	-	-	-	6	4	6	-
Volcanics	tr	6	15	13	30	-	28	20	10	-
Fossil Frag	-	6	24	20	22	66	-	10	4	18

Rock Fragments.–Rock fragments make the second largest framework component of the formation. The amount of lithic fragments range from 7% to 48% with an overall random distribution across the succession. Sedimentary rock fragments are by far the most common followed by minor amount of volcanic rock fragments. Sedimentary lithic assemblage is composed of limestone, chert, sandstone and minor amount of

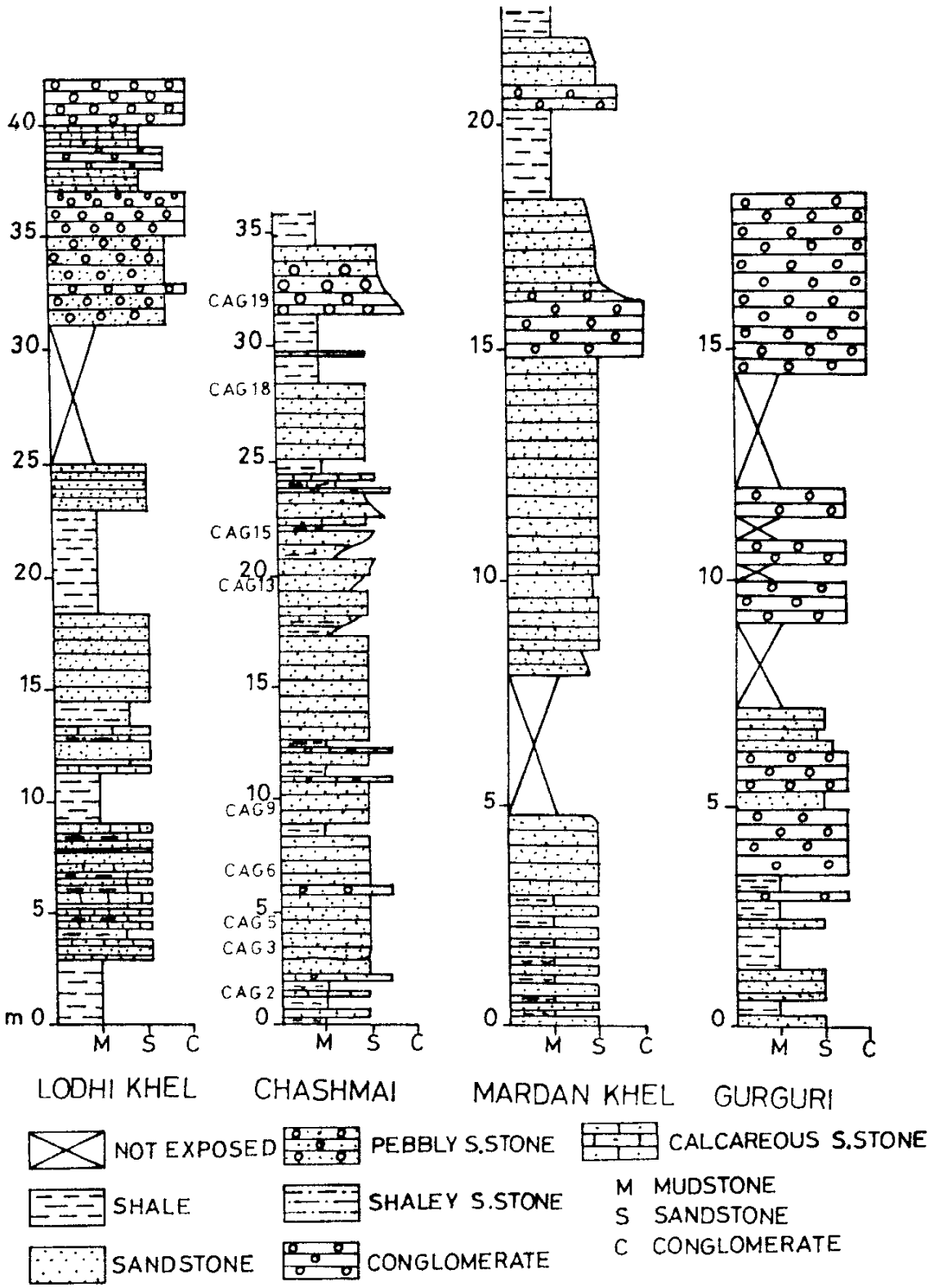

Figure 3– Lithological classification of the Chashmai Formation (after Folk, 1974).

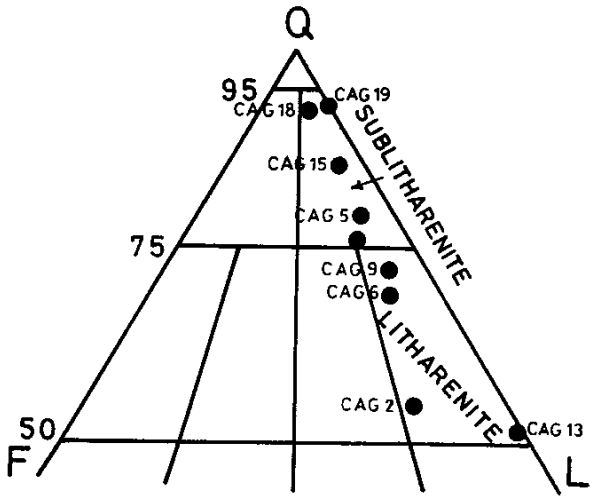

Figure 4– Sandstone classification of the Chashmai Formation (after Folk, 1974).

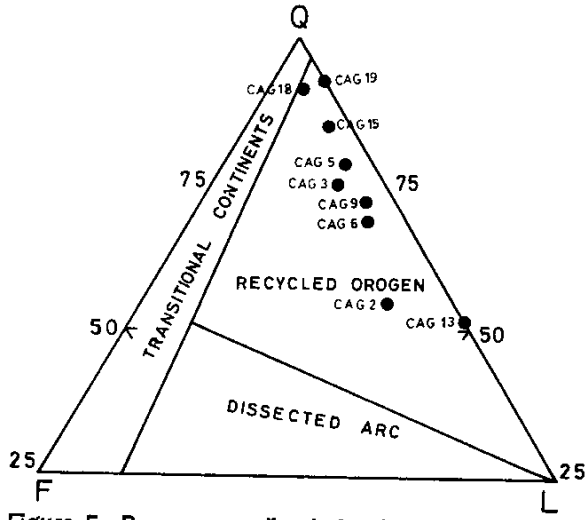

Figure 5– Provenance discrimination diagram of the Chashmai Formation (after Dickenson et al, 1983).

siltstone. Chert fragments are well rounded as compared to the other lithic fragments whereas, sandstone and siltstone fragments are angular. Volcanic rock fragments are acidic in composition and some of them are chloritized. Rounded fragments of chalcedony are also found in a number of samples.

Feldspar.– A minor amount of feldspar averaging about 5% of the framework components is also present. The feldspar is highly altered and has been replaced by calcite. Tiny remnants of feldspar fragments surrounded by oversized calcite patches in most of the samples indicate feldspar replacement due to calcite growth. Feldspar grains under surface conditions are highly susceptible to calcite replacement (McBride, 1987). Where recognizable, these calcite ghosts were counted as detrital feldspar fragments for provenance discrimination (McBride, 1987). It is mainly potassic, with minor amounts of alkali feldspar.

Fossil fragments.– The Chashmai Formation is rich in larger Foraminifera which in order of abundance are *Alveolina, Nummulites, Orbitolites,* and *Discocyclina.* In addition to these, there are a few echinoids, milliolids and Planktonic Foraminifera such as *Morozovella.* Most of these fossils are fragmented and have gone through some degree of transportation.

Heavy minerals.– Heavy minerals fraction is comparatively scarce relative to the other framework components. Important heavy minerals in the formation are glauconite, zircon, blue-green tourmaline, garnet, rutile, and traces of amphibole and epidote. Glauconite is both authigenic and detrital. Minor amount of authigenic chlorite is also present.

Composition of Conglomerate

Interbedded conglomerate horizons are composed of well rounded pebbles of limestone, chert and quartzite. The limestone is white and gray to black in colour, moderately recrystallized and fossiliferous. This limestone has close lithological resemblance with the Mesozoic limestones of the Waziristan area (Tahirkheli, R.A.K. pers. comm). Abundant chert in conglomerates indicates a melange zone affinity. Quartzite pebbles are green to black in colour, rounded and coarser in size than the limestone and chert pebbles.

PROVENANCE AND DISCUSSION

Point count data, is recalculated (Table 2) to produce the grain parameters indicated in Table 1, are plotted on the QFL provenance discrimination diagram (Figure 5) of Dickinson et al (1983). The probable provenance of the formation is interpreted on the basis of provenance discrimination plot and detailed observations made during the field and petrographic studies.

Point count data shows that the sandstone is dominantly composed of quartz and lithic fragments. Quartz is most abundant and is nonundulatory monocrystalline. Among the lithic fragments,

sedimentary rock fragments are more abundant than igneous and metamorphic rocks and are composed of limestone and chert. Volcanic rock fragments are mostly acidic in composition and were probably derived from rhyolite and dacite. The provenance discrimination plots (Figure 5) suggest that detritus for the formation has a recycled orogen provenance, derived from an uplifted foreland basin (Dickinson and Suczek, 1979). This implies that the Chashmai Formation was deposited close to an orogenic belt during early Eocene times, which contributed detritus into the Kohat basin. The orogenic belt was probably located to the west of the Kohat basin and detritus was contributed through an eastward directed paleodrainage system as indicated by the paleocurrent directions.

On the western and southwestern margin of the Kohat basin, a suture zone, "Melange Boundary Zone" (MBZ) delineates the closure of Cretaceous oceanic basin between the Indian shelf sediments and Waziristan Volcanic Arc (Beck et al, in prep). The Melange Boundary Zone (MBZ) separates the Waziristan Arc and Kurram Melange Zone to the west, from the rocks of the Indian Plate to the east. The Cretaceous ocean (a segment of Neo-Tethys) was probably completely closed on its western margin during Maastrechtian time (Late Cretaceous) and its melange zone was thrust over the Indian Shelf during Late Paleocene and Early Eocene (Ahmad and Hamidullah, 1987; Beck et al, in prep). Detritus from this melange zone may have been contributed into the early Eocene Kohat basin. Abundant sedimentary lithics (limestone and chert) in sandstone, and clast type of the conglomerate suggest that the melange zone was characteristically rich in sedimentary rocks particularly limestone and chert. Complete scarcity of basic minerals and basic rock's fragments from the sandstone and conglomerate may be due to the fact that the orogenic belt was not uplifted enough to expose the deep seated lithologies during Early Eocene time. According to Beck et al (in prep) the ophiolite sequence of the Waziristan orogenic belt was not exposed to erosion until Early Miocene times. Minor amounts of volcanic rock fragments show that some eruptive rocks such as rhyolite and dacite were also exposed to erosion. Therefore most of material for the Chashmai Formation was derived mainly from the cover sequence and recycled sediments of the Waziristan orogenic belt.

Uplift along the orogenic belt was episodic since collision. Presence of Middle Eocene carbonate rocks (Khan et al, 1982; Ahmad and Hamidullah, 1987) in north Waziristan area indicates a time of quiescence during which a major sea incursion took place. Due to sea transgression, the limestone of the Kohat Formation (Middle Eocene) was deposited in the north Waziristan and Kohat Plateau. Movement along the orogenic belt probably started again since Late Eocene, and reached its maximum during Miocene times when the ophiolite belt was exposed to denudation (Beck et al, in prep).

The western part of the Kohat basin, particularly Chashmai area, during Early Eocene time was prevailed by a deltaic setting (Tanoli et al, 1992a). The delta was fed by high energy, possibly ephemeral streams draining the cover sequence of Waziristan and Kurram melange zone.

CONCLUSIONS

1) The sandstone of the Chashmai Formation is dominantly composed of quartz and lithic fragments. Minor amount of feldspar is also present. Sedimentary lithic fragments such as limestone and chert constitute the bulk of rock fragments.

2) QFL provenance discrimination plot suggests an uplifted recycled orogen such as an uplifted foreland basin as source terrain for the clastic sediments of the formation.

3) North Waziristan orogenic belt uplifted due to the collision of Indian Plate and Waziristan Island Arc on the western margin of the Kohat basin is proposed as a source terrain.

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