Journal of Himalayan Earth Sciences 40 (2007) 25-31

Newly proposed Cretaceous-Palaeocene lithostratigraphy of the Ispikan-Wakai area, southwestern Makran, Pakistan

Akhtar Muhammad Kassi[1], Abdul Salam Khan[2] and Aimal Khan Kasi[2]
[1]Department of Geology, University of Balochistan, Quetta, Pakistan
[2]Centre of Excellence in Mineralogy, University of Balochistan, Quetta, Pakistan

Abstract

Thrust-bound inliers comprising Cretaceous-Palaeocene succession of varied lithological characters are present around the villages of Ispikan and Wakai of the southwestern Makran, Pakistan and their lithostratigrphy is hereby first time described. We have classified them into two distinct groups named them as the Wakai and Ispikan groups.

The Wakai group, exposed 7-10 km to the southwest of the Wakai village, comprises undifferentiated succession of cream coloured biomicritic limestone interbedded with purple, blue and cream coloured shale and isolated outcrops of basic and ultrabasic rocks. They occur as a few meters to tens of meters thick thrust-bound successions of Cretaceous age cropping out within the domain of the Oligocene-Miocene Panjgur Formation.

The Ispikan group, exposed 3 km to the north east of Ispikan village is divisible into two lithostratigraphic units, the Late Cretaceous Ispikan Formation in lower part and Palaeocene Ispikan Conglomerate in upper part. The Ispikan Formation comprises about 50 m thick succession of cream, purple and varicoloured shale interbedded with very thin bedded fine grained sandstones and siltstones. Its lower contact is thrust with the Oligocene-Miocene Panjgur Formation and upper contact with the overlying Ispikan Conglomerate is transitional and conformable. The Ispikan Conglomerate comprises up to about 250 m thick succession of very coarse grained pebbly sandstone, conglomerate and very minor proportion of medium to fine grained sandstone. Its upper contact is also thrust with the Oligocene-Miocene Panjgur Formation.

It is proposed that these thrust-bound inliers, comprising the Ispikan and Wakai groups, formed in response to the accretion of the oceanic floor of the Gulf of Oman during its northward subduction beneath the southern margin of the Afghan Block of the Eurasian Plate.

1. Introduction

Thrust-bound inliers, comprising Cretaceous-Eocene successions of varied lithological characters are found around the villages of Ispikan and Wakai, southwestern Makran, Pakistan (Fig. 1). They occur as a few meters to tens of meters thick successions within the Oligocene-Miocene Panjgur Formation. Inliers of Eocene Wakai Limestone have been mapped and described (Hunting Survey Corporation, 1960). However, inliers of older successions have not been mentioned, mapped and/or described before. The Hunting Survey Corporation (1960) mapped and briefly described the Palaeocene Ispikan Conglomerate in their reconnaissance report, however, older succession conformably underlying the Ispikan Conglomerate has not been described and their relationship with the Ispikan Conglomerate not mentioned. It's stratigraphic and palaeogeographic relationship with the surrounding Oligocene Panjgur Formation is enigmatic because its upper and lower contacts are thrust (Hunting Survey Corporation, 1960).

These inliers, as well as the surrounding succession of the Oligocene Panjgur Formation, are part of the emergent Makran Accretionary Wedge, which formed in response to the northward subduction of the oceanic crust of the Gulf of Oman under the southern margin of the Afghan Block of the Eurasian Plate (White and Clittgord, 1976; Farhaudi and Karig, 1977; Jacob and Quittmeyer, 1979; White, 1979; Platt et al., 1985; Platt and Leggett, 1986; McCall, 2003; Kassi et al., 2003; Nicholson et al., 2003; Grigsby et al., 2004).

This paper describes the lithostratigraphy of some of the inliers of Cretaceous-Palaeocene age that were found and studied by the authors.

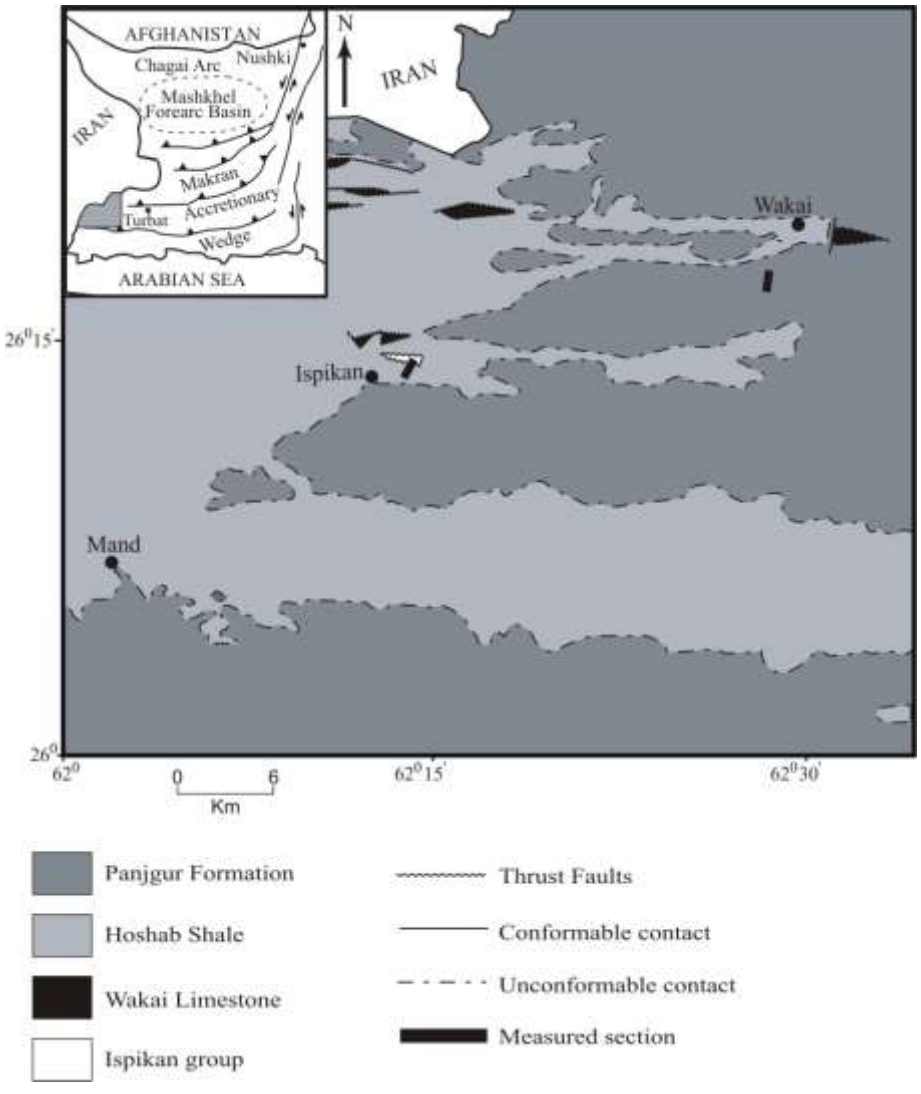

Fig. 1. Location and geological map of the Ispikan-Wakai and surrounding area, showing studied localities.

2. Lithostratigraphy

We hereby propose the names, Wakai and Ispikan groups, for the Cretaceous-Palaeocene successions of the Ispikan-Wakai area of southwestern Makran. Lithostratigraphy of the proposed groups is described below:

2.1. The Wakai group

The Wakai group (Table 1), is named after the Wakai village (26°20'N; 62°29'E) on Ispikan-Wakai road, which is exposed 7-10 km south-southwest of Wakai village. The Wakai group is composed of mafic volcanic rocks, agglomerate and sedimentary succession including purple and pink coloured shale, cream coloured biomicritic limestone (Fig. 2) and bedded cherts, found in three small exposures.

A 3 meter thick agglomerate (Fig. 2a and b) is exposed 7 km south of the Wakai village as a thrust-bound inlier within the Oligocene-Miocene Panjgor Formation. It comprises 35 cm thick shale in its middle part and 5-6 cm very coarse grained volcaniclastic sandstone at its base. The body is lenticular and pinches both ways within a distance of 8 meters. It is composed of poorly sorted, generally angular, up to 40 cm large fragments of mostly mafic volcanic rocks with minor amounts of granite and rhyolite. Rock fragments are highly crushed and weathered. Sandstone is composed mostly of basalt, volcanic glass, volcanic tuff, rhyolite, trachyte and very minor proportions of limestone, calcareous fossils, quartzite, schist and serpentine fragments.

Table 1. Proposed scheme of stratigraphic succession of the southwestern Makran, modified after the Hunting Survey Corporation (1960) and Cheema et al. (1977).

Age	Group	Formation	Lithology
Pleistocene to Holocene	**Makran Group**	Jiwani Formation	Shelly and reefoid limestone, sandstone and conglomerate
		Unconformity	
Late Pliocene		Gawadar Formation	Soft and poorly consolidated mudstone with minor sandstone
		Unconformity	
Early Pliocene		Chatti Formation	Calcareous shale and marl
Late Miocene		Talar Formation	Cyclic succession of sandstone and shale
Early Miocene		Parkini Mudstone	Mudstone with occasional thin sandstone
Oligocene-Early Miocene	**Turbat Group**	Panjgur Formation	Sandstone interbedded with shale
Late Eocene-Early Oligocene		Hoshab Shale	Shale with occasional thin bedded sandstone
Thrust			
Eocene		Wakai Limestone	Highly fossiliferous to reefoid limestone
Thrust			
Palaeocene	**Ispikan Group**	**Ispikan Conglomerate**	Conglomerate interbedded with very coarse pebbly sandstone
Late Cretaceous		**Ispikan Formation**	Interbedded shale, mudstone and thin bedded fine grained sandstone and siltstone
Thrust			
Cretaceous	**Wakai Group**	Undifferentiated	Agglomerate, purple shale, marl, chert, biomicritic limestone and mafic and ultramafic rocks
Thrust			

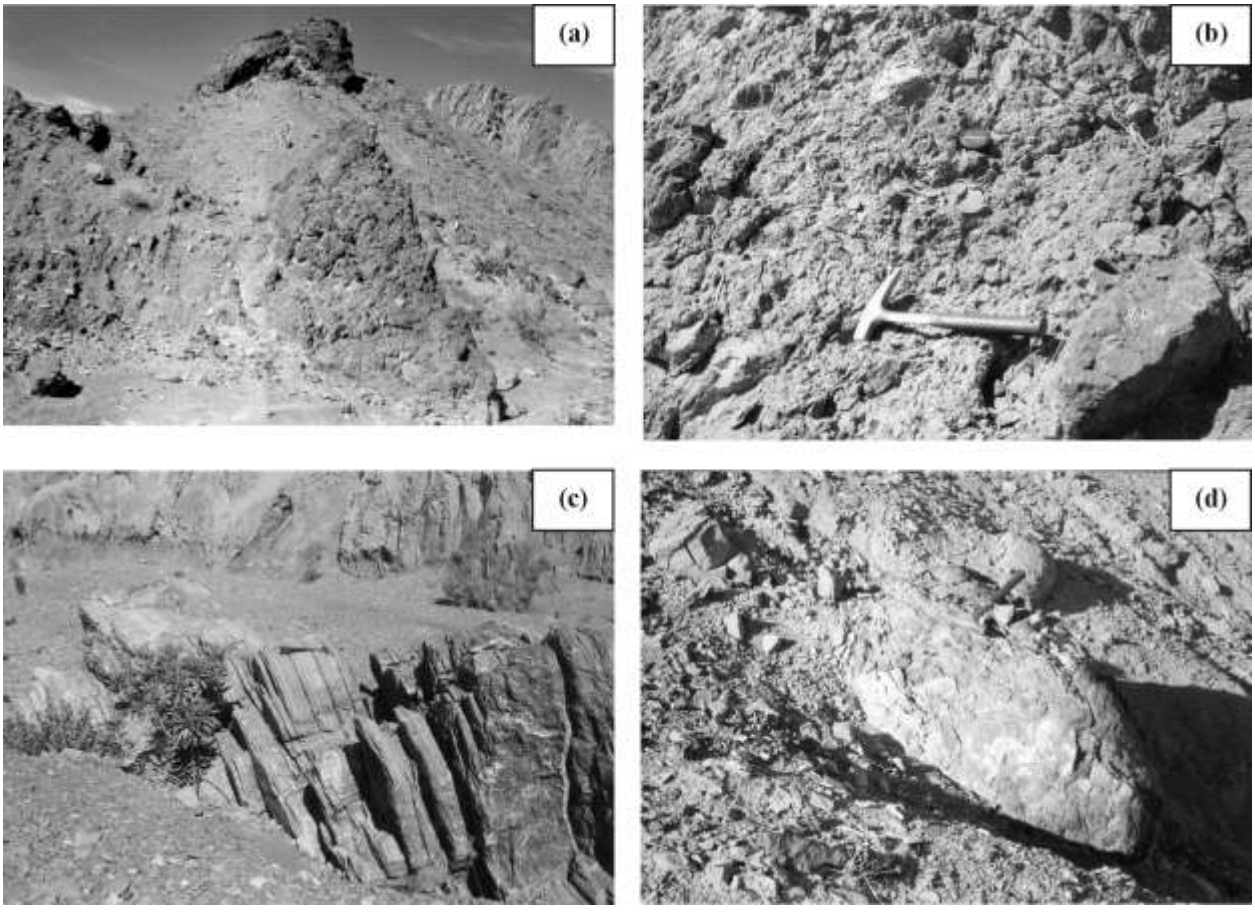

Fig. 2. Field photograph of the Wakai group: (a) Lenticular agglomerate bed cropping out within the Panjgur Formation; (b) Close up view of the agglomerate bed showing angular fragments of mafic volcanic rocks; (c) An outcrop of the micritic limestone and (d) An exposure of the mafic volcanic rock, cropping out within the shale succession of the Oligocene Panjgur Formation.

In the middle part of a shale dominant succession of the Oligocene-Miocene Panjgur Formation, nearly 8 km south of the Wakai village, on Ispikan-Wakai road in a stream-cut section, about 1 m thick lump of highly crushed basaltic igneous rock is exposed (Fig. 2d).

About 10 km south of the Wakai village on the Ispikan-Wakai road, in a stream-cut section, another crushed zone, containing angular fragments of the mafic and ultramafic igneous rocks, is present within the purple-coloured shale matrix. Rocks types include highly deformed and weathered dunite, basalt, serpentinite and chert. Also about 25 m thick succession of purple and pink coloured shale, cream coloured biomicritic limestone (Fig. 2c) and bedded cherts is also exposed in the same locality.

2.2. The Ispikan group

The Ispikan group (Table 1) is hereby classified into the Ispikan Formation in lower part and Ispikan Conglomerate in upper part. They are described below:

2.1.1. Ispikan Formation

The Ispikan Formation, comprises massive to very finely laminated, very thin to very thick bedded and highly bioturbated biogenic mudstone of cream to white colour (Fig. 3a). Shale is massive, highly bioturbated, purple, red, brown and varicoloured, which is very thinly to very thickly bedded with sharp upper and lower contacts and planar geometry. Sandstone is very thin-bedded, very fine grained and occurs in the form of sandstone/siltstone and mudstone couplets. Sandstone and siltstone beds have planar geometry, sharp bases and gradational top surfaces and are planner and cross-stratified.

Thickness of the Ispikan Formation is about 50 m. Its lower contact is thrust with the Oligocene-Miocene Panjgur Formation and upper contact with the Ispikan Conglomerate is transitional and conformable. Based on the report of Hunting Survey Corporation (1960) and study of microfossils (Flugamen R. personal communication) the Formation is assigned Late Cretaceous age.

2.2.2. Ispikan Conglomerate

The Ispikan conglomerate (Fig. 3b, c and d) comprises thick bedded, very coarse pebbly sandstone and conglomerate. Sandstone (Fig. 3c) is very coarse, pebbly, thick to very thick (up to several meters thick) bedded, poorly sorted, matrix-supported and normally graded, with or without the mudstone/siltstone intraclasts of the underlying succession. Clasts are generally pebbly and reach up to several centimeters in length. Beds have sharp erosive bases and generally gradational contacts with overlying facies. Some sandstone beds generally show 30-40 cm thick solitary or composite sets of cross-bedding and planner stratification.

Conglomerate (Fig. 3b and d) is generally moderately to well-sorted, clast supported, rounded to well rounded and having pebble to boulder size clasts. Clasts size varies between 2 and 10 cm with maximum clast sizes between 10 and 20 cm. Beds are generally normally graded, however, inverse grading is also present. Some very thick bedded conglomerate beds are generally very poorly sorted, matrix supported and have subrounded to rounded pebbles. The gravel clast size in very thick conglomerate beds varies between 2 and 40 cm and the maximum clast size reaches up to 110 cm. Beds are irregular to lenticular and their thicknesses range between 200 and 500 cm. Conglomerate is composed of very high proportions of metamorphic and acidic igneous rock fragments and minor proportion of sedimentary rock fragments. Metamorphic rock fragments include quartzite, muscovite-biotite-chlorite schist, gneiss, phyllite and slate, and marble. The igneous fragments include granite, rhyolite, basalt, volcanic glass and trachyte.

Thickness of the Formation is about 250 m. The Hunting Survey Corporation (1960) assigned Palaeocene age to the Ispikan Conglomerate on the basis of its stratigraphic position because its lower part, which in the present paper is named as the Ispikan Formation, is of Late Cretaceous age.

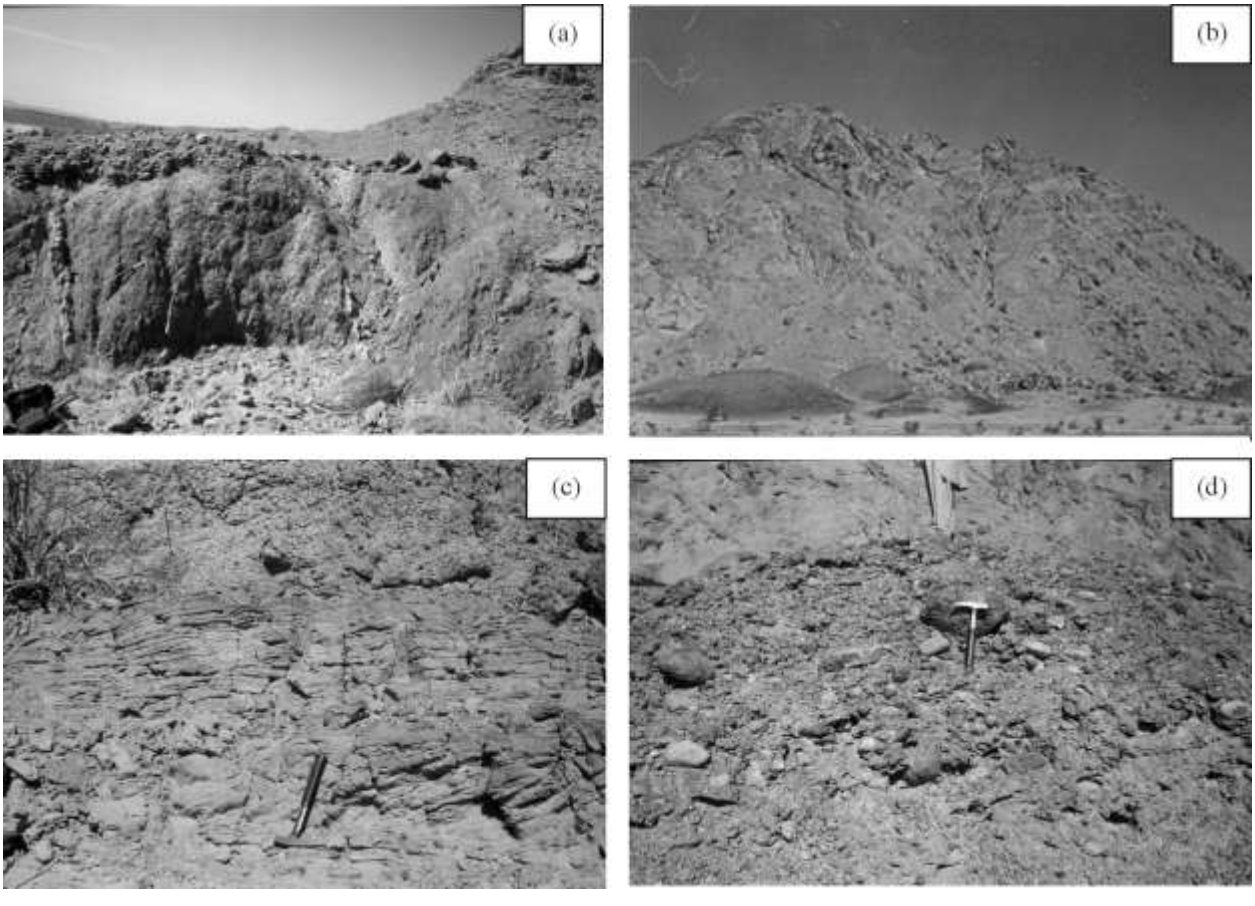

Fig. 3. Field photographs of the Ispikan group: (a) Outcrop of the Ispikan Formation showing purple coloured shales interbedded with thin sandstone beds; (b) Distant view of the Ispikan Conglomerate; (c) Close up view of the parallel laminated and cross-bedded sandstone and (d) Close up view of the conglomerate succession of the Ispikan Conglomerate.

3. Discussion

Thrust-bound inliers of the Cretaceous-Palaeocene age comprise very minor proportion of the vast area of the Makran Accretionary Wedge, which mostly comprises the Turbat Group including the Oligocene-Early Miocene Hoshab Shale and Panjgur Formation and its equivalent formations mapped under different names (Hunting Survey Corporation, 1960) in the north and central Makran (Table 1). Younger succession of the Makran Group of Miocene through Holocene age is exposed in the southern Makran. However, the thrust-bound inliers, which have not been mapped and/or described before, make very important part of the geological history of the Makran area and their study is very important for proper understanding of the geotectonic history of the Makran Accretionary Wedge. Successions in the Ispikan-Wakai area include Cretaceous-Palaeocene rocks of the Wakai and Ispikan groups, the Eocene Wakai Limestone, the Late Eocene-Oligocene Hoshab/Siahan shales and the Oligocene-Early Miocene Panjgur Formation. Rocks of the Cretaceous through Eocene age mostly occur as thrust-bound inliers within the thick successions of the Oligocene-Miocene Panjgur Formation, which are exposed in the area. The area has not been studied since the reconnaissance report of the Hunting Survey Corporation (1960) and particularly the Cretaceous successions, which occur as thrust-bound inliers, have not been pointed out or described before by any worker, except Rehman et al. (2000), who have described the petrology and provenance of the Ispikan Conglomerate.

The Oligocene-Miocene Panjgur Formation has been studied (Critelli et al., 1990; Qayyum et al., 1997a, 1997b; Kassi et al., 2003; Grigsby et al., 2004). These sediments were longitudinally dispersed to the Katawaz remnant ocean to form the "Katawaz-Panjgur delta-submarine fan complex", which has been interpreted as the present day analogue of the Indus Fan (Critelli et al., 1990; Qayyum et al., 1997a, 1997b; Kassi et al., 2003). Facies and facies associations of the Late Cretaceous-Palaeocene Ispikan group also indicate deposition in inner-fan channels and basin-floor, which is presumably part of the earliest submarine fan system of the submarine complex. Despite the age contrast and thrust-bound relationship, the Palaeocene Ispikan Formation and Oligocene-Early Miocene Panjgur Formation share the characteristics of being components of a submarine fan complex that had started to establish during the Early Palaeocene and continued to evolve during Palaeocene through Miocene (Kassi et al., 2003). A Palaeocene age has been proposed for the Ispikan Conglomerate by the Hunting Survey Corporation (1960) on the basis of their stratigraphic position, as they overlie the Late Cretaceous pelagic shales and mudstones, which we now propose to name as the Ispikan Formation. The stratigraphic and palaeogeographic position of the Late Cretaceous-Plaeocene Ispikan group with the surrounding Oligocene-Early Miocene Panjgur Formation, however, is still enigmatic because of their thrust-bound contact relationship. In order to establish their palaeogeographic and stratigraphic relationship we propose that further detailed work, especially on biostratigraphy of both the Wakai and Ispikan groups may be carried out.

Association of varieties of rocks in the Wakai group such as the mafic and ultramafic rocks and agglomerates, biomicritic limestone, purple coloured shale and bedded chert, which occur as thin slivers or crushed material within the major thrust zones, may represent ophiolitic mélanges. It is proposed that they formed in response to the accretion of the oceanic floor of the Gulf of Oman during its northward subduction beneath the southern margin of the Eurasian Plate (Kassi et al., 2003; Grigsby et al., 2004).

Nicholson et al. (2003) studied the geochemistry of the mafic rocks of the Wakai group. They found that igneous rocks of the Wakai group range in composition from basaltic to andesitic and trachytic and are predominately low-K, alkaline to sub-alkaline tholeiites with a few samples showing medium to high-K series affinities (Nicholson et al., 2003). Their tectonic discrimination diagrams suggest an arc or subduction zone origin. Ti/V ratios fall into the overlapping region for calc-alkaline/MORB/Back-arc/Arc fields. Further discrimination shows that lavas have predominately calk-alkaline and tholeiitic affinities (Nicholson et al., 2003). Geochemistry shows an arc or subduction related signature of the lavas and that lavas were generated in an island arc or active continental margin environment (Nicholson et al., 2003).

Secondary minerals, such as chlorite and serpentine, are indicative of a seafloor alteration with temperatures reaching up to 350^{o}C and low pressures. This assemblage may have been formed either during low-temperature hydrothermal seawater alteration or during the tectonic emplacement of the ophiolitic mélange (Nicholson et al., 2003). The occurrence of mafic volcanic rocks of basaltic composition, along with agglomerate, shale and chert, within the major thrust zones also supports this notion.

Based on preliminary findings (Kassi et al., 2003; Nicholson et al., 2003; Grigsby et al., 2004) we propose that the thrust-bound inliers of the Cretaceous-Palaeocene Wakai and Ispikan groups formed in response to the accretion of the oceanic floor of the Gulf of Oman during its northward subduction beneath the southern margin of the Eurasian Plate. This preliminary model accounts for both the sedimentary assemblages and for the geochemical signatures found in the igneous rocks (Kassi et al., 2003; Nicholson et al., 2003; Grigsby et al., 2004).

4. Conclusions

a) Several thrust-bound inliers of the Cretaceous through Eocene age are present in the southwestern part of Makran, near the villages of Ispikan and Wakai. Although large size inliers of the Eocene Wakai Limestone have been mapped and described; the smaller inliers of Cretaceous-Palaeocene have not been studied and described, except the Ispikan Conglomerate.

b) Inliers of the Cretaceous-Palaeocene age are hereby classified as the Wakai and Ispikan groups. The Wakai group comprises undifferentiated basic rocks, agglomerates, biomicritic limestones, shales and cherts. The Ispikan group, however, has been subdivided into the Late Cretaceous Ispikan Formation and Palaeocene Ispikan Conglomerate. The Ispikan Formation comprises mostly shales interbedded with thin bedded sandstones, whereas, the Ispikan Conglomerate comprises mostly very coarse pebbly sandstone and conglomerate.

c) It is proposed that the thrust-bound inliers of the sedimentary and igneous assemblages the Wakai and Ispikan groups formed in response to the accretion of the oceanic floor of the Gulf of Oman during its northward subduction beneath the southern margin of the Afghan Block of the Eurasian Plate.

Acknowledgements

The authors acknowledge the Higher Education Commission of Pakistan for funding the fieldwork programs in the Makran area. J. D. Grigsby and G. Kelling are highly appreciated for their fruitful comments.

References

Cheema, M. R., Raza, S. M., Ahmad, H., 1977. Cenozoic. In: Shah, S. M. I. (Ed.), Stratigraphy of Pakistan. Geological Survey of Pakistan, Quetta, Memoirs, 12, 56-98.

Critelli, S., De Rosa, R., Platt, J.P., 1990. Sandstone detrital modes in Makran accretionary wedge, southwest Pakistan: implications for tectonic setting and long distance turbidite transportation. Sedimentary Geology, 68, 241-260.

Farhaudi, G., Karig, D.C., 1977. Makran of Iran and Pakistan - an active arc system: Geological Society of America Bulletin, 5, 664-668.

Grigsby, J.D., Kassi, A.M., Khan, A.S., 2004. Petrology and geochemistry of the Oligocene-early Miocene Panjgur Formation and upper Cretaceous-Palaeocene Ispikan Formation and Wakai mélange in the Makran Accretionary Belt, southwest Pakistan. Abstract, Geological Society of America, Annual Meeting, Colorado, USA, 9th November 2004 (GSA Abstracts with Programs, 36, (5).

Hunting Survey Corporation, 1960. Reconnaissance Geology of part of West Pakistan. A Colombo Plan Cooperation Project, Toronto, Canada, 550.

Jacob, K.H., Quittmeyer, R.C., 1979. The Makran region of Pakistan and Iran: Trench-arc system with active plate subduction. In: Farah, A., DeJong, K. (Eds.), Geodynamics of Pakistan. Geological Survey of Pakistan, 305-318.

Kassi, A.M., Grigsby, J.D., Khan, A.S., Nicholson, K., 2003. Sandstone petrology of the Oligocene-Early Miocene Panjgoor abyssal plain turbidites in Turbat-Ispikan area of the Makran Accretionary Wedge, southwest Pakistan. Abstract, Geological Society of America, 37th North Central Meeting, Kansas City, Missouri, USA, 23-25, March 2003.

McCall, G.J.H., 2003. A critique of the analogy between Archaean and Phanerozoic tectonics based on regional mapping of the Mesozoic-Cenozoic plate convergent zone in Makran, Iran. Precambrian Research, 127, 5-17.

Nicholson, K., Kassi, A.M., Grigsby, J., Khan, A.S., 2003. Petrology and geochemistry of the mafic-intermediate volcanic Rocks of the Makran Accretionary Wedge, southeast Pakistan: Abstract, Geological Society of America, 37th North Central Meeting, Kansas City, Missouri, USA, March 2003.

Platt, J.P., Leggett, J.K., Young, J., Raza, H., Alam, S., 1985. Stratal extension in thrusts of footwalls, Makran accretionary prism - implications for thrust tectonics. American Association of Petroleum Geologists Bulletin, 70 (2), 191-203.

Platt, J.P., Leggett, J.K., 1986. Large-scale sediment underplating in the Makran accretionary prism, southwest Pakistan. Geology, 13, 507-511.

Qayyum, M., Lawrence, R.D., Niem, A.R., 1997a. Molasse-delta continuum of the Himalayan orogeny and closure of the Palaeogene Katawaz remnant ocean, Pakistan. International Geology Review, 39, 861-875.

Qayyum, M., Lawrence, R.D., Niem, A.R., 1997b. Discovery of the palaeo-Indus delta-fan complex. Geological Society of London, 154, 753-756.

Rehman, K., Farooqui, M. A., Kassi, A.M., 2000. Petrology and provenance of Ispikan Conglomerate, southwest Makran, and its implications on the tectonic evolution of Makran region. Abstract, Acta Mineralogica Pakistanica, 11, 137-38.

White, R.S., 1979. Deformation of the Makran continental margin. In: Farah, A., DeJong, K. (Eds.), Geodynamics of Pakistan. Geological Survey of Pakistan, 295-304.

White, R.S., Klitgord, K., 1976. Sediment deformation and plate tectonics in the Gulf of Oman. Earth Planetary Science Letters, 32, 199-209.