

Cretaceous Environments of Afghanistan: A Synthesis Based on Selected Sections

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Abstract The Cretaceous of Afghanistan is marked by great facies diversity. The evolution of Cretaceous basins is part of a complex accretionary history involving three distinct tectonic units namely the Asian (Russian) Block separated from the Indian plate by a rather well defined transcurrent fault (Chaman-Nuski). The southwestern component is represented by the Iran-Afghanistan plate. The Lower Cretaceous of the Asian Block is represented by the Red-Grit Series which is conformable to the underlying Upper Jurassic sequences. The transition is marked by evaporitic facies dominated by salt, gypsum and marl deposits. In south Afghanistan volcanic rocks occur at Farah, with the emplacement of plutonics in west-central Afghanistan. The Upper Cretaceous of north Afghanistan is marked by richly fossiliferous, limestone-dominated sequences. The Upper Cretaceous of southern Afghanistan is marked by strong ophiolitic magmatism.

Key words Cretaceous, Afghanistan, biostratigraphy, palynology

1 Introduction

The Late Mesozoic sequences of Afghanistan are important in understanding the geodynamic evolution of the northwestern part of South Asia, in particular the transgressive and regressive history of the northwestern part of the Tethys connecting Iran to the west and the northern Indian Subcontinent to the east.

Jurassic to Upper Cretaceous sedimentary sequences were initially studied by Griesbach (1885-1887) and Hayden (1880-1901) through several traverses in northern and southern Afghanistan. These reports form the basis of all known data from that country until the 1960's when there was a resurgence of interest with the works of Kaever (1963), Hinze (1964), Gabert (1964), Weippert (1964) and Lapparent & Lavigne (1965) and the late 1970's with the works of Ashraf (1977, 1979) and Schweitzer *et al.* (1987).

In general, the preliminary geological survey of Afghanistan had already started around 1830 and

1840, with works of Piddington (1835) dealing with the metamorphic rocks near Ghasni and Hay (1840) describing the Upper Cretaceous and Tertiary molluscs from Bajgah. The history of geological investigations of Afghanistan for the next 100-125 years has been comprehensively documented by Kaever (1967-1970), Kastner (1971) and Afzali (1981). Apart from a short period ranging from 1925-1940, which were particularly productive in understanding the fundamental concepts of the geology of Afghanistan, the major advances were initiated after 1959. At this time, the technical help programme of Federal Republic of Germany was initiated with the objective of the geological survey and mapping of central and south Afghanistan. At almost the same time, Russian geologists started mapping the northern part of the country.

The primary focus of geological activities was to establish a stratigraphic base for economically exploitable deposits by providing a base geological map (Fig. 1). The data are fairly complete till 1973, after

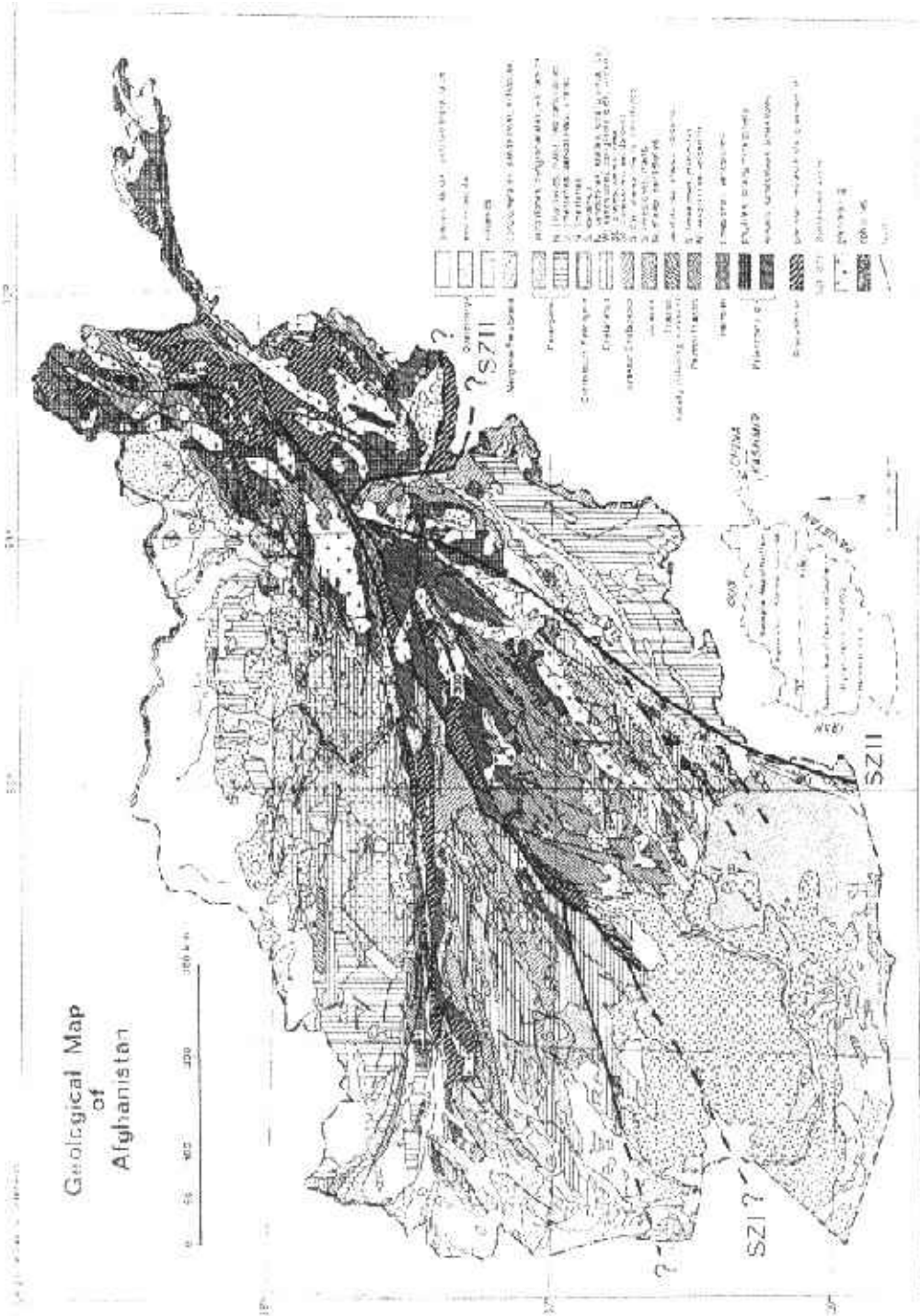


Fig. 1. Geological map of Afghanistan (slightly modified after Weichert, Wittkeud & Wellert, 1970)

which political turmoil prevented regular systematic geological studies. The present information pertains largely to the data collected during the technical help programme of Federal Republic of Germany and through the efforts of the one of the authors (Ashraf, 1977).

The accretionary history of Afghanistan is complex: three distinct tectonic units can be clearly recognized (the palaeogeographic and tectonic development of Afghanistan has been summarised in Figs. 2, 3 and 4): (1) the northernmost tectonic unit comprises the Asian (Russian) plate (Block); (2) to the east lies the Indian plate which is separated by a rather well defined transcurrent fault, namely the Chaman-Nuski-Moqur fault and (3) the southwestern component is represented by the Iran-Afghanistan microplate (Krumtsiek, 1976) which forms a wedge between the other two blocks. As far as is known, the collision history of what is now the Afghanistan landmass is similar to that recently worked out by Treloar *et al.* (1996) for the Kohistan region of Pakistan and further east for the Dras area of India (Thakur, 1995).

The accretion of Iran-Afghanistan microplate, however, needs to be better understood. The geology of Afghanistan is dominated by the existence of a central northeast-southwest trending basement complex (gneisses, greenschist facies, etc.) as well as by Palaeozoic sedimentary and metamorphosed sequences. The Upper Jurassic to Upper Cretaceous sequences have a complex history with a deep sea trench facies occurring towards the north and a more shallow red grit facies with continental sediments existing on the Asiatic Block to the south. The Tethys was an epicontinental sea which also deposited the Pab Sandstone of Pakistan.

2 Upper Jurassic

The Upper Jurassic of Afghanistan is represented by two distinct facies, a continental facies to the

north (Russian plate) and a marine deep water facies at the active continental margin of the Iran-Afghanistan plate (Figs. 3b and 4a, Cross-Section III).

2.1 North Afghanistan

The Jurassic sediments of North Afghanistan, a part of the Asian (Russian) plate, are represented by more or less completely terrestrial sediments as compared to the continuous marine deposits in the southern Afghanistan. The marine portion is limited to the younger sediments. The terrestrial sediments were named by Hayden (1911) as the "Saighan Series" which represent the Jurassic and may also comprise a part of the Rhaetian. The type locality of Saighan Series is located at Saighan (near Doab) where the most complete Jurassic deposits are developed. From here, extending to the northeast, there is an intergradation with marine facies caused by the transgression of the north and northeast sea which deposited the Pamir Limestone.

Kaever (1970) differentiated three areas as follows:

(1) a region "without marine sediments" (Saighan-Ishpushta) (Figs. 2 and 5b, section 22);

(2) a region with "minor marine sediments" (around Koh-i-Firouz) (Figs. 2 and 5b, section 19);

(3) a region with partly marine sedimentation as well as metamorphic-plutonic rocks (Wakhan-Pamir and Badakshan) (Figs. 2 and 5b, section 23).

The Jurassic sedimentation appears to be conformable to that of the Doab Series of Triassic age.

The Saighan sediments consist of sandstones, conglomerates and blue-grey slates, coaly slates, gypsum of Portlandian age (Figs. 2 and 5b, section 19). In general, the Saighan Series is a distinct facies showing changes in both lateral and vertical directions. In this case it is very difficult to compile stratigraphic sections and make regional correlations. The exact dating for the overlying marine marls and limestones has been done through marine micro- and macro-fau-

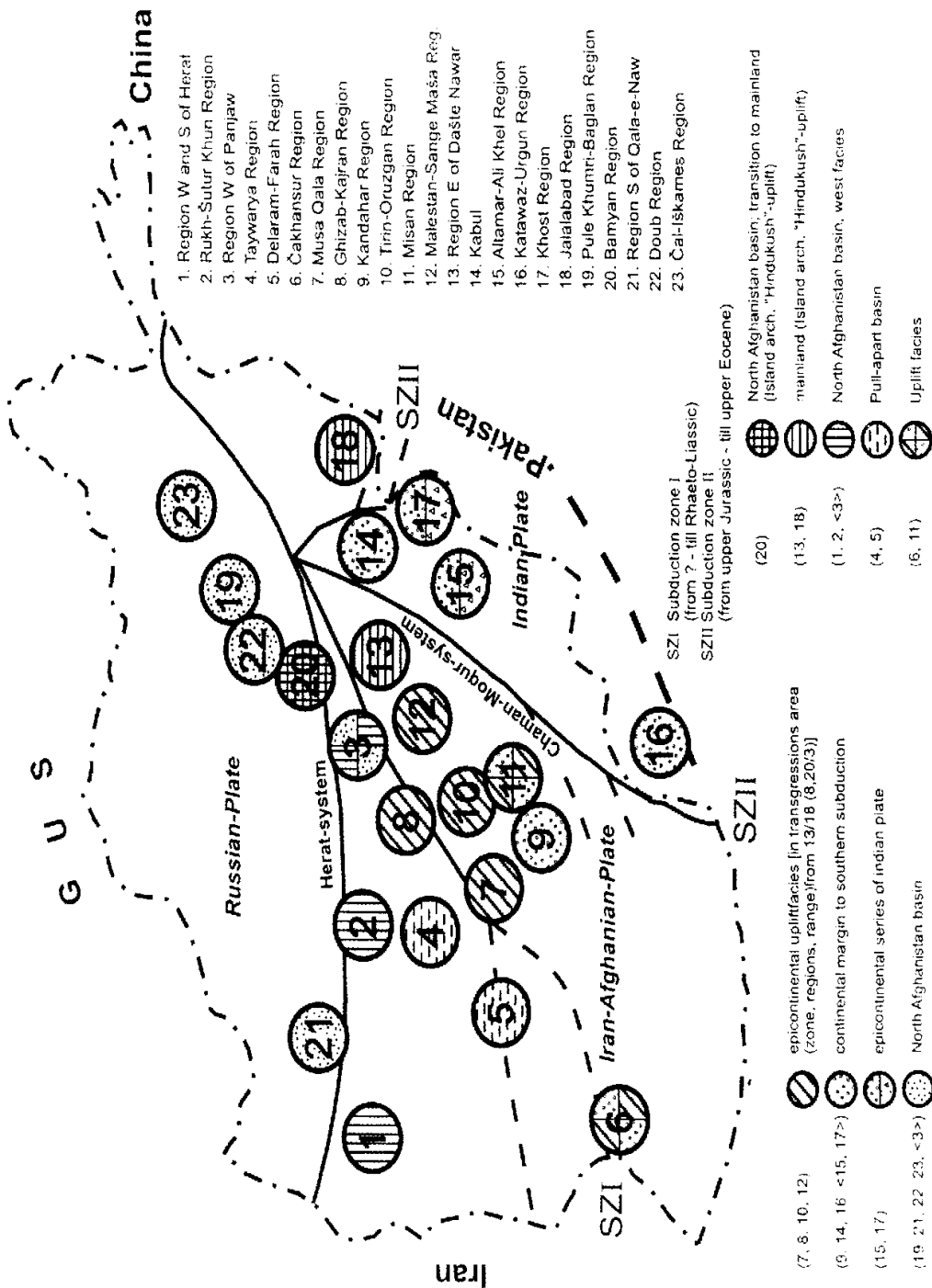


Fig. 2 Three distinct tectonic units, subduction zones SZ I, SZ II, palaeogeographical-paleotectonical explanation of Afghanistan and location of the selected sections (sections 1-23)

na and flora (Rosset, 1954; Rossi-Ronchetti & Fantini-Sestini, 1961; Kaefer 1965, 1967c; Ashraf, 1979) and for the terrestrial blue-grey slates and coal through pollen and spores (Ashraf, 1977) and macroflora (Jacob & Shukla, 1955; Benda, 1964; Schweitzer & Kirchner, 1996). Ashraf (1977) attempted a spore-stratigraphical subdivision of the mainly terrestrial Saighan Series in North Afghanistan with 1850 closed spore samples and rich microflora (98 genera and 168 species which are corroborated by the marine index fossils data). The following spore-zones were defined:

Lower Cretaceous: *Ischyosporites variegatus-Rouseisporites laciniatus-Cicatricosisporites* zone;

Upper Jurassic: *Ischyosporites variegatus-Rouseisporites laciniatus* zone;

Middle Jurassic: *Ischyosporites variegatus-Duplexisporites problematicus* zone;

Lower Jurassic: *Concavisporites-Duplexisporites problematicus* zone;

Rhaetic: *Concavisporites-Duplexisporites problematicus-Apiculatisporites heterospiniger* zone.

These established zones contain dinoflagellates and acritarchs (250 samples with 33 genera and 67 species of dinoflagellates and 2 genera with 6 species of acritarchs) which have also been used as marine index fossils in alternating series of terrestrial and marine sediments (Ashraf, 1979). These species represent 3 bio-zones of different ages, which correspond to 3 different spore-zones:

Lower Cretaceous (bio-zone C) corresponding to: *Ischyosporites variegatus-Rouseisporites laciniatus-Cicatricosisporites* zone;

Upper Jurassic (bio-zone B) corresponding to: *Ischyosporites variegatus-Rouseisporites laciniatus* zone;

Middle Jurassic (bio-zone A) corresponds to: *Ischyosporites variegatus-Duplexisporites Problematicus* zone.

The boundaries of these bio-zones closely correspond to spore-stratigraphical boundaries. This result makes it possible, at least in North Afghanistan, to correlate sequences of purely terrestrial with purely marine sediments of Middle Jurassic to Early Cretaceous age.

2.2 Southern Afghanistan

Most of central and south Afghanistan (Indo-Afghan and Iranian-Afghan plates) with the exception of narrow high mountains were covered with marine Jurassic sediments. The high regions of the central Afghan uplift, which are connected to Hindukush high regions in the east have separated the Jurassic southern terrestrial paralic sediments from North Afghanistan. The marine sediments consist of limestones, marls, shales and sandstones, with a thickness between 200 m (Indien plate) and 2 000 m (Afghan plate). The important marine micro- and macro-fauna in central and south Afghanistan and the detailed geological and palaeontological explanation can be found in Lapparent *et al.* (1966), Lapparent & Termier (1969), Lapparent *et al.* (1970), Fischer (1971), Paulsen (1971), Weippert *et al.* (1970), Wittekind (1973), Mensink (1967), Ziegler (1966), Kaefer (1967c), Bruggey (1970) and Mennessier (1970d). For the lists of important fossils and discovered localities in central and north Afghanistan, see Weippert *et al.* (1970).

3 Lower Cretaceous

3.1 North Afghanistan:

From the Jurassic to Early Cretaceous time the palaeogeographical situation did not change significantly. The Lower Cretaceous of the northern block (Russian plate) represented by Figs. 2 and 5b sections 19, 21, 22 and 23 in general conforms to the underlying Upper Jurassic sections. The Lower Cretaceous was described first by Griesbach (1885a, b, 1886a-c) and Hayden (1911) and is represented by the Red Grit Series. According to Kaefer (1963),

there is a possibility that the red grit facies is a time transgressive within the Lower Cretaceous while on the other hand Lapparent and Lavigne (1965) considered that these facies were coeval throughout their strike. Weippert (1964) observed colour change from grey green to red brown and simultaneous insertion of conglomerates and sandstones (150~200 m) in the Lower Cretaceous of Doab and Ishpushta (Fig. 2 and Fig.5b, section 22). Gabert (1964) considered these green marls, clay, sandstone, limestone and evaporites (400~500 m) to be predominantly marine equivalents of the Lower Red-Grit and to be of Early Cretaceous in age. Lapparent & Lavigne (1965), on the other hand, considered them to be early Late Jurassic in age.

The Lower Cretaceous marine sediments cover a large area towards the north with an increase in thickness and lateral expansions. The most complete Lower Cretaceous sequence is at Pulekhumri-Baglan region (Figs.2 and 5b, section 19). Here there is also a concordant relationship with the Upper Jurassic and a continuation of the evaporitic facies dominated by salt, gypsum and marl deposits. This grades upwards to the red-bed sequence again with an evaporitic facies having a thickness of 150~300 m. A time transgressive unconformity is marked by a conglomerate horizon leading upwards to a more marine fossiliferous facies consisting of limestones, calcareous sandstones and marls. The age of the salt stock (plug) in the eastern Hindukush north flank (Figs.2 and 5b, section 23) is still questionable Upper Jurassic to Tertiary "Miocene" (Hinze, 1964).

The palynological zonation according to Ashraf (1977, 1979) in North Afghanistan is given below:

(1) Spore-zone-Lower Cretaceous: *Ischyosporites variegatus-Rouseisporites laciniatus-Cicatricosisporites* zone; (2) Dinoflagellates and acritarchs bio-zone: Lower Cretaceous (bio-zone C) corresponding to: *Ischyosporites variegatus-Rouseisporites laciniatus-Cicatricosisporites* zone.

The assemblage can be clearly related to northerly landmasses and has no Gondwanic elements.

3.2 South Afghanistan

The Cretaceous deposits are characterized by strong lateral and vertical facies changes. After Wittekind (1973), seven lithofacies units can be distinguished, five units within the Lower Cretaceous and two units only in the Upper Cretaceous. These are composed of several 1000 m of red-brown sandstone, with minor conglomerate, greywacke, siltstone, marls as well as bedded (at the N-coast of Indian plate) and massive limestone. Conglomerate and greywacke are replaced by sandstone and are limited to the regions Khost/Alikhel = active margin (Figs.2 and 5a, sections 2, 3, 7, 8, 10, 11 and 12). The sequence of Early Cretaceous tectonic movements is as follows:

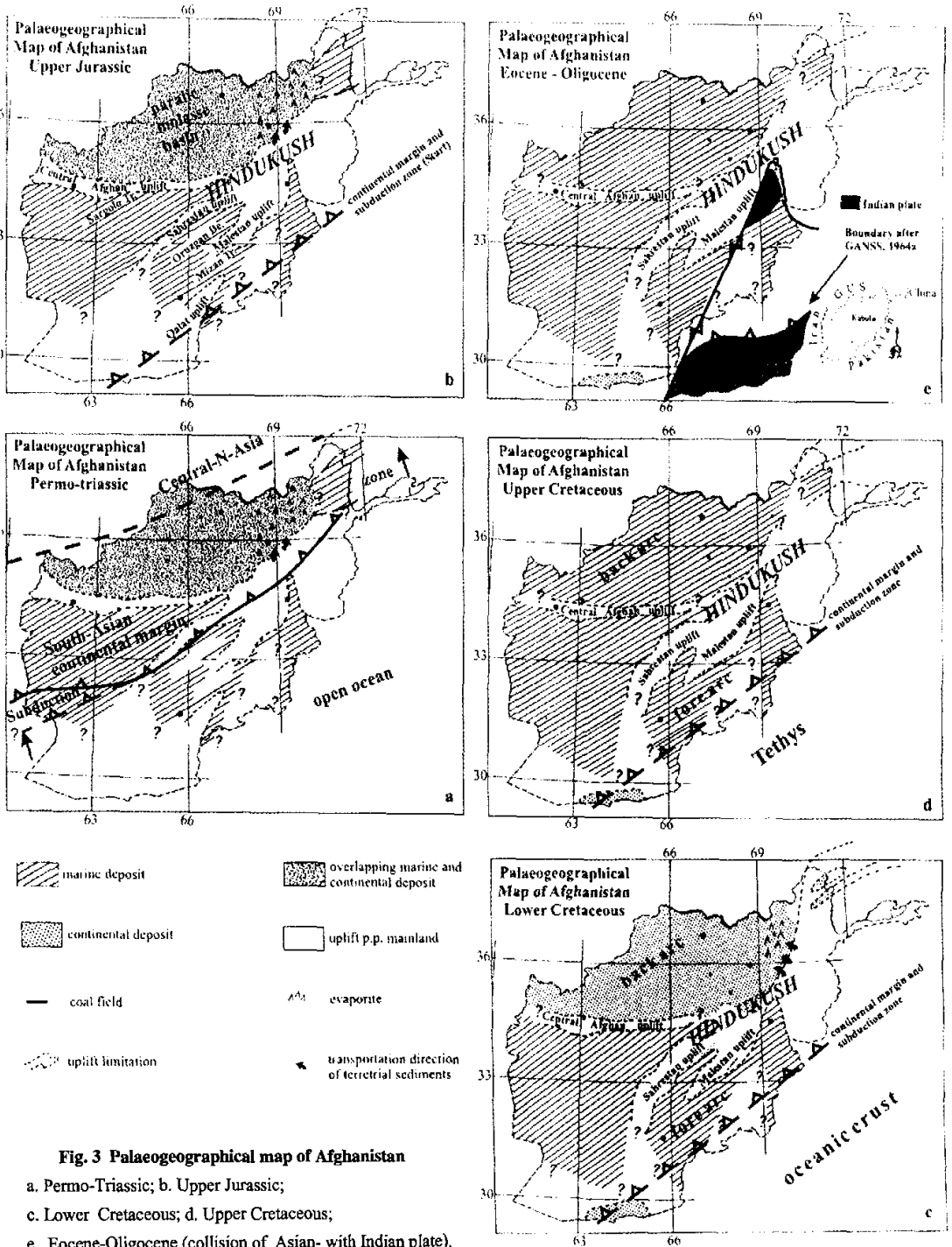
- (1) folding on the south margin central uplift;
- (2) intensive downwarping with the flyschoid sedimentation between Afghan West Border and Panjaw (Figs.2 and 5a, section 3);
- (3) the production of volcanic rocks at Farah (after Harre *et al.*, 1967), the K-Ar age of diorites in the eastern Farah sub-block (99 ± 1.5 Ma) similar to that of Musa Qala and between Kandahar and Qalat (Figs.2 and 5a, section 5, 7 and 9);
- (4) the emplacement of plutonics in west central Afghanistan and between Kandahar and Daste Nawar (Figs. 2 and 5a, sections 9 and 13).

All the Lower Cretaceous stages are found here and this is evident from the fauna. For the list of important fossils and discovered localities in central and south Afghanistan see Weippert *et al.* (1970).

4 Upper Cretaceous

4.1 North Afghanistan

The Upper Cretaceous palaeogeography shows distinct changes. The Upper Cretaceous sea transgressed from the north to the south covering a large part of Asia and deposited the thickest Upper Creta-



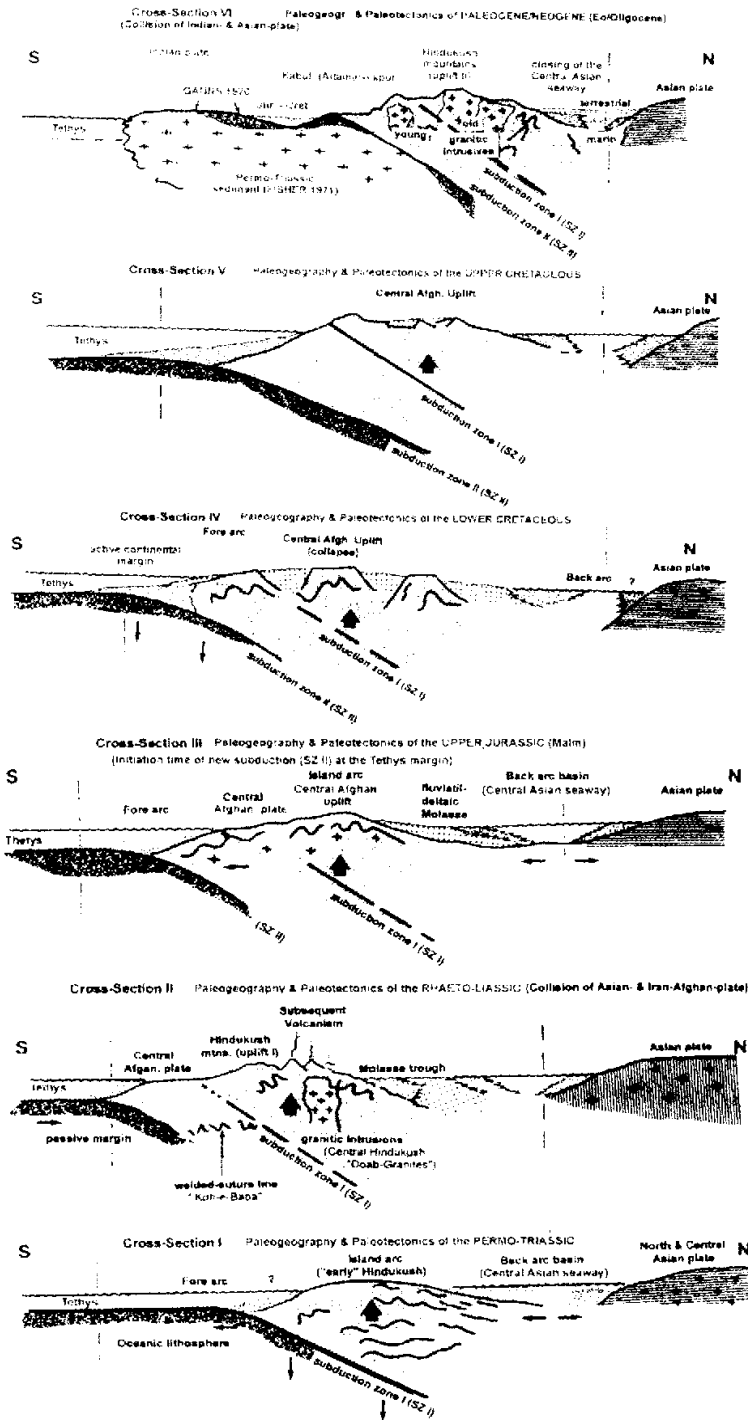


Fig. 4 Structural development, palaeogeography and paleotectonics of Afghanistan area (by a stratigraphic cross-section series)

Cross-Section VI (Paleogene situation) collision of Indian plate with Asian plate

Cross-Section V (Upper Cretaceous situation) transgression, Central uplift only NE, Back arc and Fore arc basins connected towards the W

Cross-Section IV (Lower Cretaceous situation) North: Back arc basin, Central: Uplift and intramontaneous (continental basins), South: Fore arc basin

Cross-Section III (Upper Jurassic "Malm" situation): Central Afghanistan-Iran plate accreted to N-Asian plate, start of new subduction at south margin of N-Asian plate

Cross-Section II (Rhaeto-Liassic situation): collision of Central Afghanistan-Iran plate with N-Asian plate

Cross-Section I (Permo-Triassic situation): plate tectonic situation unclear

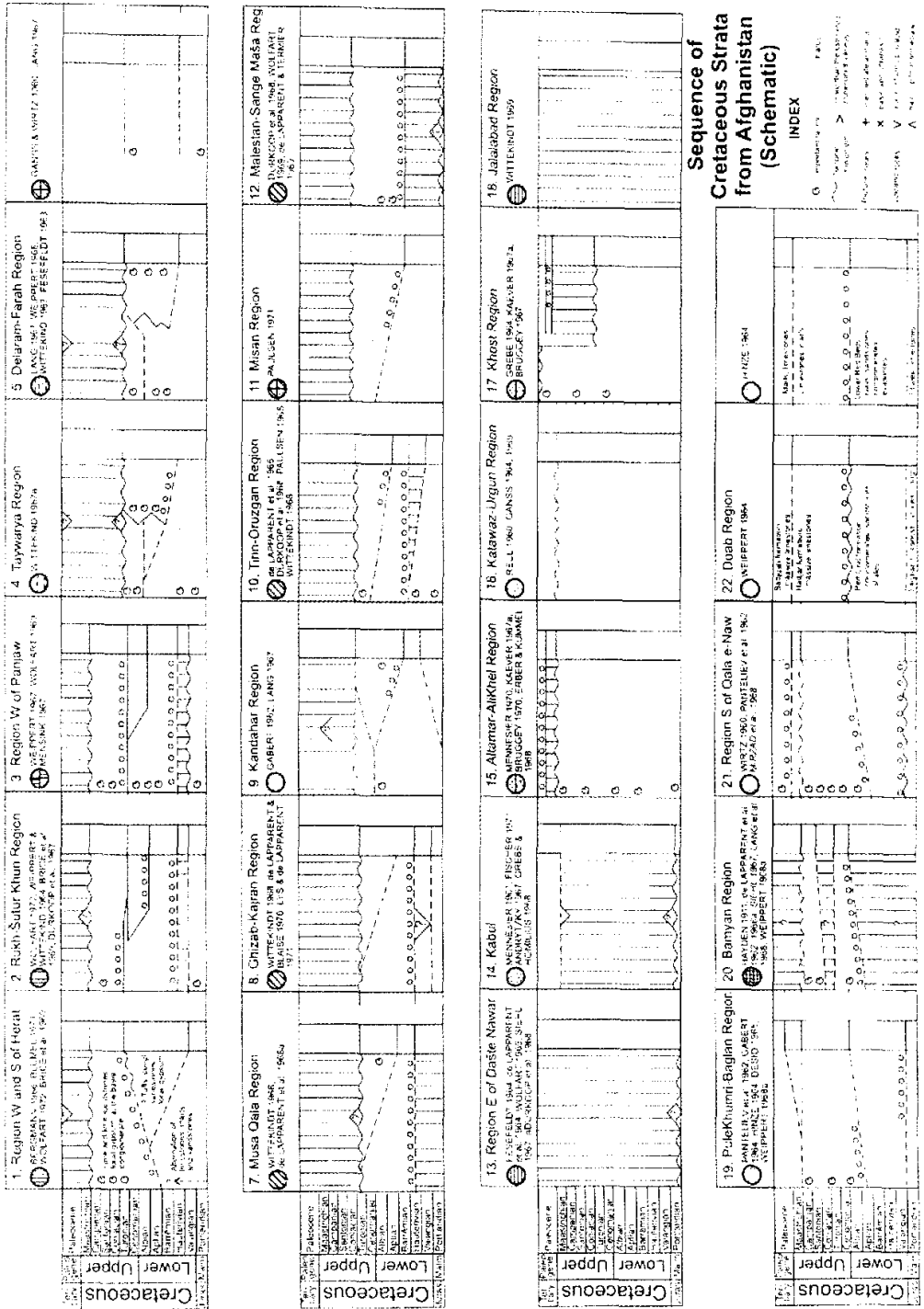


Fig. 5 Sequence of Cretaceous strata from Afghanistan [location of the selected sections (1-23) see Fig.2]

ceous limestone in North Afghanistan. The sediments are richly fossiliferous and are represented by limestone, marls, sandstone and minor gypsum, and accurate faunal dating is possible. In general, due to an increase in thickness and completeness, Upper Cretaceous strata spread out from the northern flank of the Hindukush region (Figs.2 and 5b, sections 19 ~23). In Northeast Afghanistan and Ishputa and Doab, the transition between the Lower Cretaceous and Upper Cretaceous is concordant and that in Dara-i-Yusuf and Saighan is discordant.

4.2 South Afghanistan

The palaeogeographical position in Upper Cretaceous of southern Afghanistan has not changed, only a local transition from the north to the central Afghan uplift in the lower Upper Cretaceous is noticeable. Increased tectonic activities are evident from volcanic activities in numerous fault zones in central and south Afghanistan, e.g. the plutonic eastern Fahra Massif (Cenomanian) and thick ophiolitic sequences at the margin faults of the Katawaz Massif. All Upper Cretaceous stages up to Santonian are found and have been documented by faunal assemblages as documented by Weippert *et al.* (1970).

5 Summary and conclusions

(1) The Jurassic sediments of North Afghanistan constitute part of the Asian (Russian) Block. Continuous marine sediments were deposited in the southern Afghanistan (Indo-Afghan plate and Iranian-Afghan plate). There are two different facies: A) at the active (Upper Jurassic) southern continental margin of the Iran-Afghanistan plate and B) an epicontinental facies at the northern-passive-(Lower Jurassic) margin of the Indian plate. These facies were at that time still separated by the Tethys Ocean. The palynoassemblages of North Afghanistan (Ashraf, 1977) suggest that the eurasian region had no connection with the Gondwanic region.

(2) Evaporitic conditions prevailed in Northern

Afghanistan from the Late Jurassic to Early Cretaceous times with the occurrence of salt and gypsum deposits. This indicates that the regression occurred in a tectonically controlled rifting phases.

(3) In almost all the sections, the Lower Cretaceous is better represented than the uppermost Cretaceous. To the north, the occurrence of the Orbitolina sea has been documented in the Kohistan area of Pakistan and Dras Ladakh region of India. This facies represent the closing of the suture zone between India and Asia (Thakur, 1995).

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| <p>4. Upper view of specimen M-12/RCSP519, ×60</p> <p>5. Upper view of specimen M-12/RCSP520, ×100</p> <p>6. <i>Pandorinellina exigua</i> (Philip, 1966)</p> <p style="padding-left: 2em;">Lateral view of specimen M-15/RCSP521, ×100</p> <p>7,12. <i>Ozarkodina excavata excavata</i> (Branson & Mehl, 1933)</p> <p style="padding-left: 2em;">7. Lateral view of specimen M-12/RCSP523, ×60</p> <p style="padding-left: 2em;">12. Lateral view of specimen M-6/RCSP/527, ×120</p> <p>8. <i>Panderodus</i> sp.</p> <p style="padding-left: 2em;">Lateral view of specimen M-17/RCSP522, ×80</p> | <p>9~11,13~15. <i>Ozarkodina inclinata inclinata</i> (Rhodes, 1953)</p> <p>9. Lateral view of Pa element, M-6/RCSP524, ×80</p> <p>10. Lateral view of Pa element, M-6/RCSP525, ×100</p> <p>11. Lateral view of Pa element, M-6/RCSP526, ×140</p> <p>13. Inner lateral view of Sc element, M-6/RCSP528, ×100</p> <p>14. Inner lateral view of Melement, M-6/RCSP529, ×100</p> <p>15. Lateral view of Sa element (?), M-6/RCSP530, ×60</p> |
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