Palynological Investigations of Umia Formation of Kutch Basin, Gujarat, vis-a-vis Depositional Environment and Age

Sapna Rana², Rekha Rani¹, Sandeep Kumar³, Thakur O.P.¹ and Dogra N.N.¹

¹Department of Geology, Kurukshetra University, Kurukshetra, Haryana, India
²Centre of Advanced Study in Geology, Panjab University, Chandigarh, India
³Geological Survey of India, Eastern Region, Kolkata, West Bengal, India

Publication Date: 23 September 2015

Abstract Mesozoic sedimentary sequence of the Kutch Basin is lithostratigraphically divisible into four formations namely, Patcham Formation, Chari Formation, Katrol Formation and Umia Formation in the ascending stratigraphic order. Two stratigraphic sections viz., Ghuneri Coal Mine Section and Korawadi River Section of Umia Formation were investigated in the present study. The palynological assemblage recovered from the Umia Formation of Kutch Basin comprises 88 species belonging to 48 form genera. Of these, 3 form genera and 9 species are new. These are Venkatapollis indica gen et sp. nov., Aranyasporis cretacea gen. et sp. nov., Pyrgopites mesozoicus gen. et sp. nov., Echninatisporis korawadiensis sp. nov., Concavissimisporites trilobatus sp. nov., Leptolepidites psilatus sp. nov., Cingulatisporites intermedius sp. nov., Taurosperotes mesozoic gen. sp. nov. and Trilobosporites indicus sp. nov. Qualitatively the palynological assemblage of these sections of Umia Formation is dominated by Pteridophytes followed by gymnosperms, bryophytes and fungal spores indicating warm and humid climatic conditions. The age diagnostic palynotaxa such as Crybelosporites, Gabonisporis, Rouseisporites and Aequispiradites which straddle Tithonian-Neocomian time plane are well represented in Bhuj Sections of Umia Formation. The palynotaxa such as Cyathidites, Lycopodiumsporites, Klukisporites, Concavissimisporites, Taurocuspisporites, Schizisporites and Echinatisporis on the other hand are found to extend even up to the Aptian-Albian time. Hence investigated sediments of the Kutch Basin in all probability are of Early Cretaceous time ranging from Neocomian-Early Aptian.

Keywords Palynology; Umia Formation; Early Cretaceous; Kutch; Gujarat; India

1. Introduction

The present paper deals with the palynological investigations of the Umia Formation (Early Cretaceous) exposed in Ghuneri Coal Mine Section (23° 46' 95" N and 68° 50' 43" E) and Korawadi River Section near Dharesi (23° 38' N and 68° 52' E), in Kutch District of Gujarat, India (see Figure 1). The complete sequence of Mesozoic rocks ranging in age from Bathonian to Albian is well exposed in Kutch mainland, which is bounded on the west by Arabian Sea and on the south by Gulf of Kutch.
The present investigations have been undertaken with the objective to explore the palynological microbiota from the Umia Formation and its implications in assigning a precise age vis-à-vis environmental constraints of palynobiota recovered there from.
2. Geological Setting

Mesozoic stratigraphic succession in the Kutch Basin rests unconformably over the Precambrian basement and range in age from Middle Jurassic to Early Cretaceous. Lithostratigraphically, these rocks have been divided into Patcham, Chari, Katrol and Umia formations in the ascending order of stratigraphy (Waagen, 1875). The Patcham Formation is mainly deposited in Kaurbet and in the Islands of Patcham, Khadir and Bela. This Formation is made up of a thick succession of dark pisolithic limestones, olive green shales, cherty limestones, marls and is unconformably overlain by the Chari Formation which is composed of sandy marls, marine limestones and shales. The Chari Formation has further been subdivided into five zones namely, *Macrocephalus* beds, *Rehmani* beds, *Anceps* beds, *Athleta* beds and *Dhosa* oolite beds on the basis of ammonite assemblage in the ascending order (Spath, 1924). The overlying Katrol Formation consists of a thick sequence of shales, limestones, sandstones and grits with lenticular beds of gypseous shales. The Katrol Formation in turn is overlain by the Umia Formation, and is dominantly made up of sandstones, conglomerates and shales. The Umia Formation referred to as Umia Stage (Upper Tithonian-Neocomian) by Krishnan (1968) was divided into Barren Sandstone, Umia Ammonite beds, Barren Sandstone, *Trigonia* beds and Barren Sandstones. Jai Krishna (1987) formally divided the Umia Formation into four members namely, Umia, Ghuneri, Ukra and Bhuj members in the stratigraphic order. The Umia Formation is succeeded by the Deccan traps in the area.

3. Stratigraphic Succession

The stratigraphic classification proposed by Jai Krishna (1987) has been found most suitable for the purpose of the present study because the names like Patcham, Chari, Katrol and Umia are very popular and have been deeply engraved in Indian Geology.

3.1. Patcham Formation

This Formation is exposed mainly in Kaurbet and in the Islands of Patcham, Khadir and Bela. It consists of 520m thick succession of golden oolite, marl, sandstone, limestone and shale. The Formation is only 90m thick in the western Kutch (Jhumara Dome Area) and is made up of greenish shales and numerous bands of thinly bedded hard greenish coralline limestone.

3.2. Chari Formation

The Formation takes its name from the village Chari 50 Km NW of Bhuj and conformably overlies the Patcham Formation. It is exposed in the Habo dome area. This Formation is partially exposed in the Island belt but widely developed in the Kutch Mainland where it attains a thickness of 454m and comprises sandy marls, marine limestone and shales.

3.3. Katrol Formation

The Katrol Formation is named after the east-west trending Katrol-Charwar range in south of Bhuj. It comprises 757m thick marine succession of shales, limestones, sandstones and grits with lenticular beds of gypseous sandy shales. This formation is well exposed in the Kutch-Mainland.

3.4. Umia Formation

The Katrol Formation is overlain by a thick succession of Umia Formation, consisting of sandstones, conglomerates and shales. Earlier this Formation was named as Umia Group by Waagen (1875) and Umia Series by Rajnath (1932) and Krishnan (1968) and as Umia Formation by Jai Krishna (1987). The Deccan Lava flows capping this Formation protect its further erosion.
4. Stratigraphy of Investigated Sections

Two stratigraphic sections viz., Ghuneri Coal Mine Section and Korawadi River Section of Umia Formation were selected and rock samples were collected from these sections for Palynological investigations.

4.1. Ghuneri Coal Mine Section

This section is exposed along a cross-country traverse from east of Ghuneri. Here the total thickness of the succession is 3-3.5m. Lithologically, it comprises fine alternating bands of ferruginous sandstone and carbonaceous shales. The base of the section is characterized by about one meter thick coal seam presently being exploited by mine owners. All the litho units of the section exhibit a peculiar inter-fingering, a characteristic feature of the high-energy marginal deposits. This is also evident from the abundance of current bedding structures in the succession. The section is capped by the trap flows (see Figure 3). Altogether ten palynological rock samples were collected from this section, of which only four samples proved productive for palynobiota.

![Figure 3: Stratigraphic Section of Ghuneri Coal Mine, Bhuj](image)
4.2. Korawadi River Section

Korawadi River Section is located near village Dharesi, northwest of Bhuj on the Bhuj-Narayan Sarovar Highway. Lithologically, the section is mainly made up of black carbonaceous shales and sandstones (see Figure 4). Out of the eight collected samples only five rock samples were found to enclose a rich palynological assemblage both in diversity and number.

Besides this, 50 palynological rock samples were also collected randomly from different localities to substantiate the temporal and spatial distribution of the palynotaxa.

![Stratigraphic Section at Korawadi River, Near Dharesi](image)

Figure 4: Stratigraphic Section at Korawadi River, Near Dharesi

5. Previous Palynological Studies in Kutch Basin

Several workers have palynologically investigated the Mesozoic sediments of Kutch Basin. The work was initiated by Singh et al. (1964), who for the first time reported a rich assemblage of spores and pollen grains from the coal and carbonaceous shale horizons of Ghuneri and Trambau River Sections. The mioflora from the Trambau Carbonaceous shales mainly consists of Pteridophytic miospores, megaspores and coniferous pollen grains while the assemblage obtained from the Ghuneri Coals is diversified in composition and form. The assemblage from both these localities consists of Cyathidites, Contignisporites, Osmundacidites, Lycopodiumsporites, Gleicheniidites, (pteridophytes), Calliallasporites, Araucariacites, Schizosporis, Classopollis (gymnosperms) etc. They assigned a Lower Cretaceous age to these sediments. The palynological assemblage recovered from the Mesozoic sediments of Kutch exposed on the banks of Pur and Pat rivers near Bhuj by Venkatachala (1967 & 69) closely resembles to that of Trambau and Ghuneri plant microbiota described by Singh et al. (1964). The genera common to both are Cyathidites, Contignosporites, Schizosporis, Classopollis and Araucariacites.
Venkatachala et al. (1969a, 69b and 69c) under their systematic study of spores and pollen grains reported a new trilete spore genus *Bhuijasporites* from the Mesozoic sediments of Kutch and revised the morphological description of the spore genus *Trilobosporites* found abundantly in the rock sequence. Jana (1984) recorded a Jurassic miospore assemblage from borehole in Sundernagar District, Gujarat. Palynological studies of Maheshwari & Jana (1986) indicated that the Jurassic-Cretaceous boundary lies somewhere in the Upper Member of Jhuran Formation. Rana et al. (2000) have also made a detailed palynological study on the Mesozoic rocks of Kutch basin.

6. Materials and Methods

Rock samples for the present investigation were collected systematically from two measured sections viz. Ghuneri Coal Mine Section and Korawadi River Section of Umia Formation. During the sampling care was taken to avoid surface contamination or mixing. Special attention was paid to the depth of weathering. Care was also taken to collect samples from fresh surfaces.

All the samples were processed by conventional technique of maceration with HCl, HF, HNO₃ and KOH. In some cases the organic matter of the recovered palynofossils was not clear enough for microscopic study. They were subjected to Acetolysis. All the slides were mounted in polyvinyl Alcohol and DPX. 15-20 slides were prepared for each sample. To facilitate the location of the spores and pollen grains, each grain was scanned with black ink. The slides in which the number of palynomorphs was high, the stage readings of the Vicker’s microscope are noted. Generally 5-15 slides per sample were examined at a magnification of x100. Identifiable and well-preserved specimens of various species were counted and recorded. Thus an estimate of relative frequency of each species in each sample was made. Well-preserved specimens were microphotographed by using a Vicker’s microscope.

7. Palynomorph Assemblage of the Umia Formation of Kutch Basin

The palynological assemblages of the Umia Formation of Kutch basin are made up of the 88 species referable to 48 form genera. Out of these, 3 genera and 9 species are new. For sake of brevity only the checklist of palynological assemblages recovered during the present study from the Umia Formation are given below. The new species will be described in some journal of systematics.

7.1. Fossil Spores and Pollen Grains (88 Species in 48 Genera)

Check list of Pteridophytes

Pteridophytes (65 species referable to 34 form genera)

*Cyathidites*: *Cyathidites minor*, *Cyathidites australis*, *Cyathidites ghuneriensis*, *Cyathidites* sp. I, *Cyathidites* sp. II

*Dictyophyllidites*: *Dictyophyllidites harrissii*

*Appendicisporites*: *Appendicisporites potomacensis*, *Appendicisporites problematicus*

*Concavisporites*: *Concavisporites cutchensis*, *Concavisporites subverrucosus*, *Concavisporites* cf. *C. punctatus*

*Concavissimisporites*: *Concavissimisporites trilobatus* sp. nov. *Concavissimisporites* sp.

*Ceratosporites*: *Ceratosporites cutchensis*

*Baculatisporites*: *Baculatisporites camaeensis*, *Baculatisporites* sp.

*Lycopodiumsporites*: *Lycopodiumsporites ranikorensis*, *Lycopodiumsporites speciosus*, *Lycopodiumsporites* sp.

*Leptolepidites*: *Leptolepidites verrucatus*, *Leptolepidites psilatus* sp. nov.

*Leptolepidites* sp.
**Echinatisporis**: Echinatisporis korawadiensis sp. nov.

**Corrugatisporites**: Corrugatisporites formosus, Corrugatisporites turpites, Corrugatisporites sp.

**Contignisporites**: Contignisporites fornicatus, Contignisporites glebulentus, Contignisporites cooksonii

**Klukisporites**: Klukisporites apunctus, Klukisporites foveolatus, Klukisporites kallameduensis

**Cicatricossisporites**: Cicatricossisporites augustus, Cicatricossisporites dorogensis

**Bullasporis**: Bullasporis minutus, Bullasporites triangularis

**Bhujiasporites**: Bhujiasporites hirustus

**Gleicheniidites**: Gleicheniidites mundus, Gleicheniidites senonicus, Gleicheniidites sp.

**Foveosporites**: Foveosporites sp.

**Sestrosporites**: Sestrospermites dettmannii, Sestrospermites pseudoalveolatus, Sestrospermites sp.

**Dictyotriletes**: Dictyotriletes sp.

**Cingulatisporites**: Cingulatisporites intermedium sp. nov.

**Boseisporites**: Boseisporites punctatus

**Plicifera**: Plicifera sp.

**Densiosporites**: Densiosporites mesozoicus, Densiosporites sp.

**Gabonisporites**: Gabonisporites bacricumulus, Gabonisporites labyrinthus

**Taurocusporites**: Taurocusporites mesozoicus sp. nov.

**Hymenozonotriletes**: Hymenozonotriletes mesozoicus

**Trilobosporites**: Trilobosporites triangularis, Trilobosporites indicus sp. nov.

**Aequitriradites**: Aequitriradites ornatus, Aequitriradites triangularis

**Rouseisporites**: Rouseisporites reticulatus

**Crybelosporites**: Crybelosporites sp.

**Cooksonites**: Cooksonites reticulatus, Cooksonites variabilis

**Monoletes**: Monoletes intragranulosus

**Polypodiisporites**: Polypodiisporites sp. I, Polypodiisporites sp. II

Check List of Gymnosperms

Gymnosperms (22 species belonging to 13 genera):

**Podosporites**: Podosporites tripakshi, Podosporites microsaccatus

**Microcachrydites**: Microcachrydites antarcticus

**Alisporites**: Alisporites thomassii, Alisporites rotundus

**Podocarpidites**: Podocarpidites ornatus, Podocarpidites rarus, Podocarpidites ellipticus

**Callialasporites**: Callialasporites segmentatus, Callialasporites trilettes

**Venkatapollis**: Venkatapollis indica gen. et sp. nov., Venkatapollis sp. I, Venkatapollis sp. II

**Araucariacites**: Araucariacites australis, Araucariacites cooksonii

**Schizosporis**: Schizosporis rugulatus

**Pyrgopites**: Pyrgopites mesozoicus gen. et sp. nov.

**Aranyasporis**: Aranyasporis cretacea gen. et sp. nov.

**Cycadopites**: Cycadopites sakrigalensis

**Ginkgocycadophytus**: Ginkgocycadophytus detritus, Ginkgocycadophytus sp.

**Monoulcites**: Monoulcites ellipticus
Checklist of Bryophytes
Bryophytes (Single Taxon)

**Coptospora**: *Coptospora mesozoica*

### 8. Age and Depositional Environment

The analysis of palynological microbiota recovered from the Umia Formation of Kutch basin reveals the occurrence of Tithonian-Neocomian index taxa namely, *Crybelosporites, Gabonisporis, Rouseisporites* and *Aequitriradites*.

The palynota such as *Cyathidites, Lycopodiumsporites, Klukisporites, Concavissimisporites, Taurocusporites, Schizisporites* and *Echinatisporis* on the other hand are found to extend even up to the Aptian-Albian time. Hence, based on age diagnostic palynological assemblage from the Umia Formation of the Kutch Basin, we infer an Early Cretaceous age for the formation ranging from Neocomian-Early Aptian. Qualitative spectrum of the palynological assemblage of Umia Formation counted in the present investigations is found to be dominated by Pteridophytes followed by gymnosperms, bryophytes and fungal spores, thereby indicating warm and humid climatic conditions.

### 9. Discussion and Conclusions

As a part of the field investigations an area about 50 sq. Km. between latitude 23° 24′ 42″ N and longitude 69° 50′ 43″ E was geologically mapped and formational boundaries of Patcham, Chari, Katrol and Umia formations were delineated. Two stratigraphic sections at Ghuner Coal Mine and Korawadi River near Dharesi were measured and studied for palynobiota. The palynological assemblage recovered from Kutch basin in present study is represented by 88 species belonging to 48 form genera. Out of these 3 genera and 9 species are new. These are *Venkatapollis indica* gen. et sp. nov., *Aranyasporis cretaca* gen. et sp. nov., *Pyrgopites mesozoicus* gen. et sp. nov., *Echninatisporis korawadiensis* sp. nov., *Concavissimisporites trilobatus* sp. nov., *Leptolepidites psilatus* sp. nov., *Cingulatisporites intermedius* sp. nov., *Taurosporites mesozoicus* sp. nov. and *Trilobosporites indicus* sp. nov. The pteridophytes in the present assemblage are represented by 65 species referable to 34 form genera; the gymnosperms are documented by 22 species belonging to 13 genera. Besides, a single genus of bryophyta and a few fungal hyphae were also recovered. Thus qualitatively the palynological assemblage of Kutch basin is dominated by pteridophytes followed by gymnosperms, bryophytes and fungi indicating a warm and humid climate. The Umia formation along with its vast terrestrial fauna contains a variety of pteridophytes, bryophytes and a number of fungal remains. Since these are moist loving elements, their presence in the Kutch Cretaceous mioflora is a definite indicator of the existence of a considerable humidity in the atmosphere. That the climate remained more or less fairly warm is evident by the enrichment of gymnospermous elements during present investigation in the Kutch Basin.

The miofloral assemblage recovered from the Kutch basin during the present study comprises plant genera like *Cyathidites, Dictyophyllidites, Appendicisporites, Concavissimisporites, Ceratosporites, Baculatisporites, Lycopodiumsporites, Leptolepidites, Echinatisporis, Klukisporites, Bullasporis, Cicatricosisporites, Bhujiasporites, Glechenidites, Sestrosporites, Boseisporites, Densoisporites, gabonisporis, Trilobosporites, Rouseisporites, Crybelosporites, Cooksonites, Podosporites, Microcachryidites, Callialasporites, Araucariacites, and Gingkocycadophytopus* etc. Of these, formgenera like *Cybelosporites, Gabonisporis, Rouseisporites* and *Aequitriradites* are considered to be the markers of Neocomian age. The palynotaxa such as *Cyathidites, Lycopodiumsporites, Klukisporites, Concavissimisporites, Taurocusporites, Schizosporites* and *Echinatisporis*, on the other hand, are found to extend even up to the Aptian-Albian time. The above mentioned assemblage share many common elements of the palynological assemblages described from Aptian-Albian sediments of Australia (Dettmann, 1963; Dettmann and Playford, 1968), Canada (Singh, 1964;
Srivastava, (1972) and U.S.A. (Srivastava, 1975). Hence in all probability the studied Kutch sediments enclose Early Cretaceous palynobiota ranging from Neocomian to Early Aptian. The close similarity of the palynological assemblage of Kutch basin with the Early Cretaceous sediments of Australia, United States of America and Canada also points out to the fact that the various land masses possess a uniform climate during Early Cretaceous time. This was perhaps due to their location in an isoclimatic belt or general warming of the earth during that time as postulated by Batten (1984).

References


