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PALYNOFLORA FROM THE LAKSHMIPUR INTERTRAPPEAN DEPOSITS OF KUTCH, GUJARAT: AGE IMPLICATIONS

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ABSTRACT

A diverse spore and pollen assemblage is reported for the first time from the northwesternmost Deccan intertrappeans exposed near Lakshmipur, District Kutch, in the western Indian state of Gujarat. The assemblage is indicative of distinct variations within the Maastrichtian intertrappean palynofloras occurring in different sections across the Deccan province. The flora is significant as it helps to establish a palynological basis for ascertaining temporal differences between the widely separated individual parts of the Deccan volcano-sedimentary province.

Key words: Deccan Traps, Intertrappeans, Late Cretaceous, Palynology

INTRODUCTION

The Deccan Trap volcanic eruptions of peninsular India are believed to have played a significant role in the global environmental changes that caused mass extinctions at the Cretaceous-Tertiary boundary at 65 Ma (e.g. Courtillot *et al.*, 1996). Although these eruptions took place over a total period of about 4 m.yrs. (between 63-67 Ma), the bulk of the activity took place in a short interval, probably within the magnetochron 29R (Courtillot *et al.*, 1986; Duncan and Pyle 1988; Vandamme *et al.*, 1991), which spans the Cretaceous-Tertiary boundary. The effects of Deccan volcanism on contemporary ecosystems, recorded in sediments deposited during periods of quiescence between the eruptive events, is a subject of much current interest (Tandon, 2002; Cripps *et al.*, 2005). Recently conducted palynofloral investigations in the Nand-Dongargaon inland basin of central India, point to a remarkable and gradual floral change from Lameta to successive intertrappean horizons and within intertrappean beds separated in time and space (Samant and Mohabey, 2003, 2004, 2005; Samant *et al.*, 2005). These studies suggest a change from gymnosperm and angiosperm rich flora (coexisting with the titanosaurid dinosaurs) in the Lametas to angiosperm and pteridophyte-dominated flora together with the appearance of dinoflagellates in the freshwater intertrappean ecosystems following the onset of Deccan volcanism. Recently, it has also been shown that the intertrappean palynomorph assemblages can provide an important biostratigraphic tool to distinguish between the Palaeocene and Late Cretaceous (Maastrichtian) intervals in the Deccan volcano-sedimentary sequence (Singh and Kar, 2003). Within the Maastrichtian, however, our understanding of biostratigraphic relationships between the various individual intertrappean deposits across the Deccan province remains poor, and the problem is further compounded by the absence of data on radiometric ages, magnetostratigraphy and other independent constraints in many of the fossiliferous sections, and by complicated Trap chemostratigraphy signals. The present study on the Kutch intertrappeans seeks to provide a basis for ascertaining the spatio-temporal differences in the palynoflora that thrived in peninsular India during the Maastrichtian.

The Kutch region of western India exposes the northwesternmost volcano-sedimentary sequence in the Deccan volcanic province. The intertrappean locality near the village Lakshmipur (23°26'45"N: 69°2'50"E, Figure 1A) has recently come to light as a source of one of the richest freshwater ostracod faunas in peninsular India (Whatley and Bajpai, 2000). Vertebrates are rare at this locality and known forms include freshwater fishes and turtles (Bajpai *et al.*, 1990). Lithostratigraphic details of this section are given in Figure1B. The topmost unit of this section, consisting of grayish black chert with abundant mollusc shells, particularly *Physa*, yielded a rich palynoflora that is recorded in this paper.

For the recovery of palynomorphs from cherts, standard maceration techniques (using HF, HNO_3, and KOH) were employed, followed by sieving of the residue with 10-15 μm sieves. Slides were prepared using polyvinyl alcohol and DPX mountant. The repository of the material described is in the Department of Geology, Banaras Hindu University, Varanasi.

PALYNOASSEMBLAGE

The Lakshmipur palynoassemblage (Plates I and II) includes pteridophytes: *Cyathidites australis*, *Cyathidites* sp. *Cicatricosisporites* sp., *Concavissimisporites* sp., *Contignisporites* sp. *Leptolepidites* sp. *Lygodiumsporites* sp. *Murospora* sp., *Triplanosporites* sp., gympnosperms: *Araucariacites australis*, *Cycadopites* sp., *Callialasporites* sp. and angiosperms: *Aquilapollenites bengalensis*, *Longapertites* sp., *Liliacidites trichotomosulcites*, *Proxapertites operculatus*, *P. microreticulatus*,

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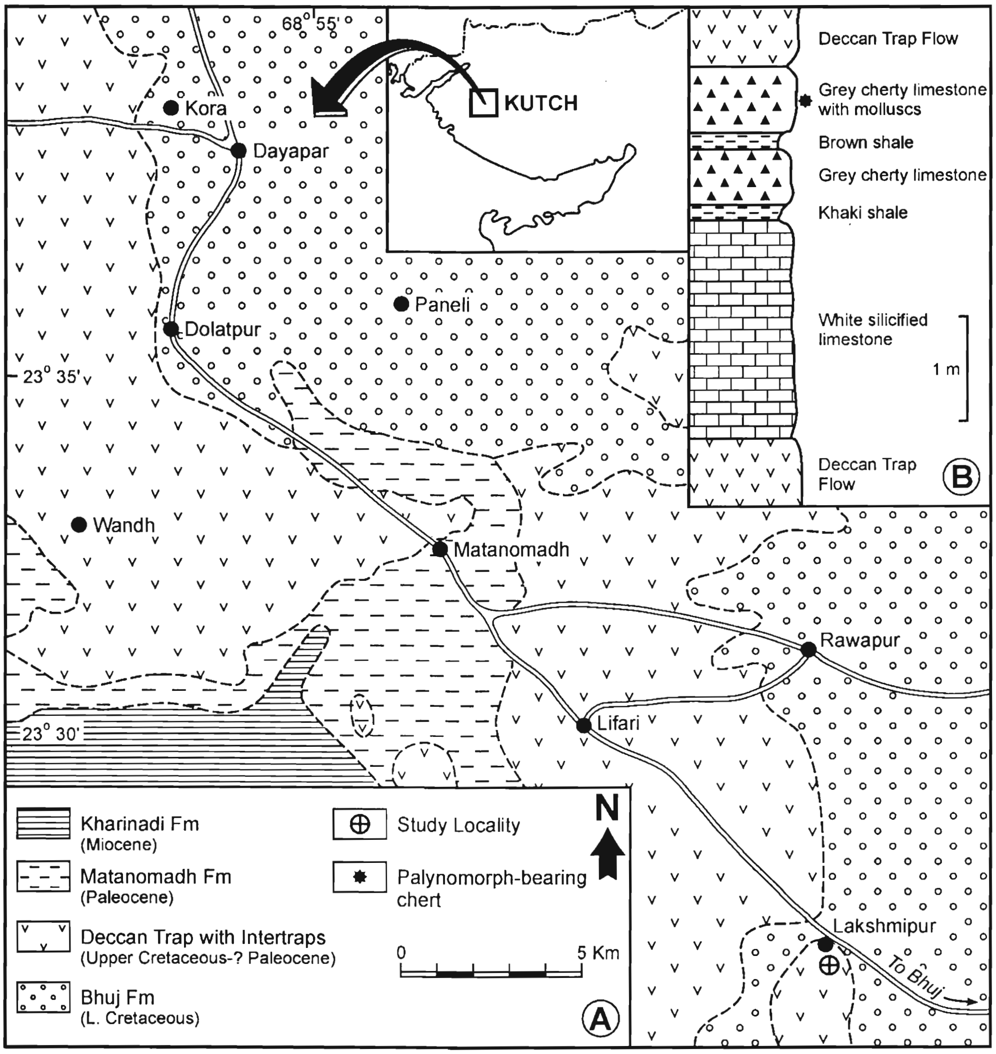


Fig. 1. A: Geological map of the Lakshmipur intertrappean locality of Kutch, Gujarat. B: Lithocolumn of the fossiliferous locality.

Racemonocolpites spp., *Retitricolpites vulgaris*, *Tricolpites reticulatus* and *Tricolpites* sp. A sample count of 200 palynofossils shows that angiosperms constitute about 45.5% of the total assemblage and *Proxapertites* spp. is the most abundant taxon in the assemblage. Pteridophytes constitute about 44.5% of the assemblage (dominant *Cyathidites* spp.) followed by gymnosperms (about 10%) , with *Araucariacites australis* being the common species.

DISCUSSION

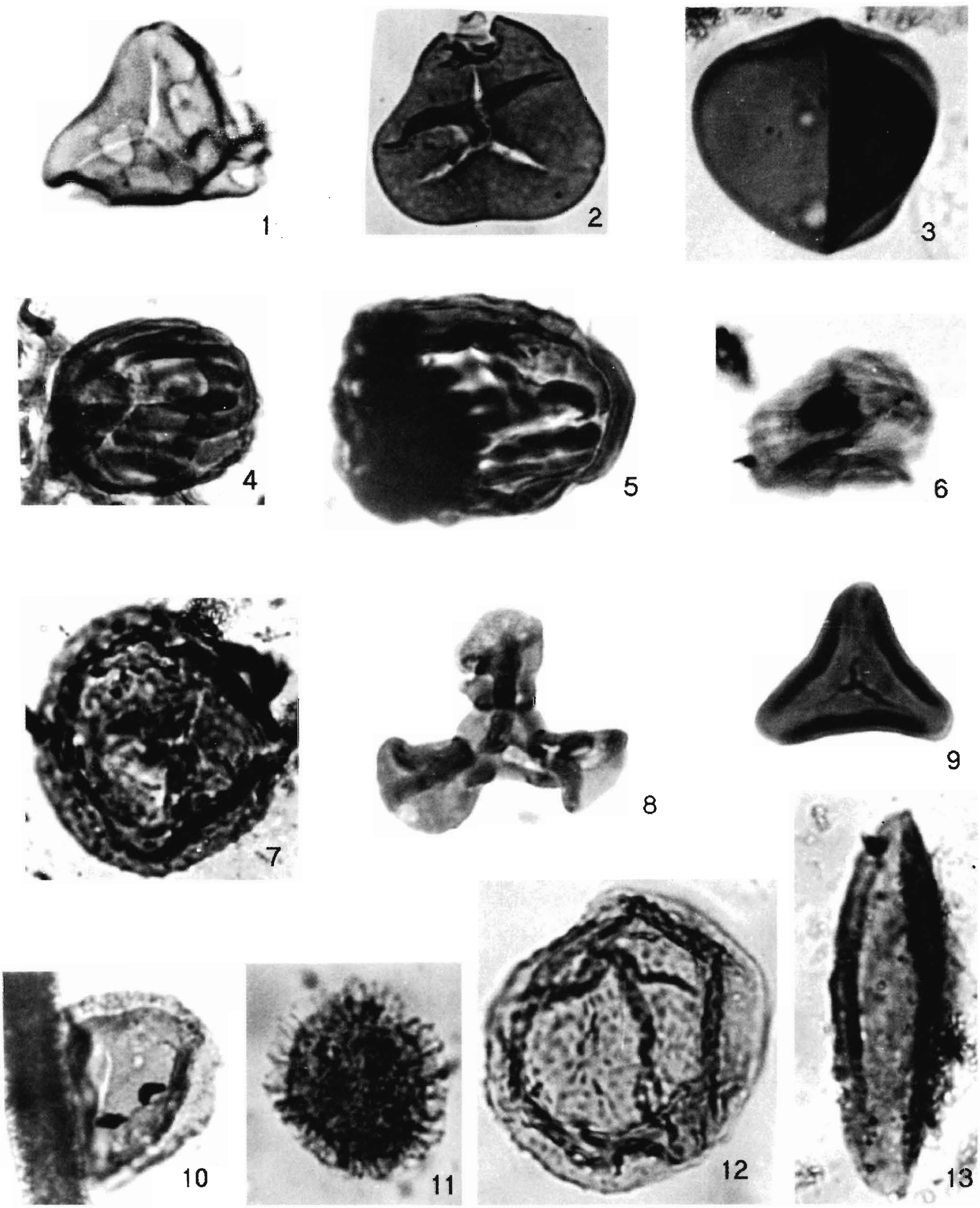
The palynotaxa recovered from the Lakshmipur intertrappeans are quite distinct from assemblages recorded from other known intertrappeans (Table 1). Amongst the pteridophytes, the presence of *Leptolepidites* sp., *Murospora* sp., *Concavissimisporites* sp. and *Contignisporites* sp. is significant. Although these forms are known from the underlying Bhuj Formation (Venkatachala, 1969; Vankatachala and Kar,

EXPLANATION OF PLATE I

(All magnifications 400 X)

1. ***Cyathidites*** sp.
2. ***Cyathidites australis*** Couper
3. ***Triplanosporites*** sp.
4. ***Contignisporites*** sp.
5. ***Contignisporites*** sp
6. ***Cicatricosisporites*** sp.
7. ***Leptolepidites*** sp.
8. ***Concavissimisporites*** sp.
9. ***Murospora*** sp.
10. ***Callialasporites*** sp.
11. **Trilete spore**
12. ***Araucariacites australis*** Cookson
13. ***Cycadopites*** sp.

Plate I



SAMANT AND BAJPAI

Table 1: List of some important palynotaxa from onland intertrappeans.

NASKAL	MOHAGAONKALAN	RANIPUR	PADWAR	DAIWAL	ANJAR	LAKSHMIPUR
Kar, *et al.*, 1998	Kar & Srinivasan, 1998	Mathur & Sharma, 1990	Prakash *et al.*, 1990	Samant & Mohabey, 2003	Dogra *et al.*, 2004	Present study
Pteridophytes	**Pteridophytes**	**Pteridophytes**	**Pteridophytes**	**Pteridophytes**	**Pteridophytes**	**Pteridophytes**
Azolla cretacea	*Azolla cretacea*	*Azolla cretacea*	*Azolla cretacea*	*Azolla cretacea*		
Triporoletes reticulatus	*Triporoletes reticulatus*	*Triporoletes reticulatus*	*Triporoletes reticulatus*	*Triporoletes reticulatus*		
Gabonisporis vigourouxii	*Gabonisporis vigourouxii*	*Gabonisporis vigourouxii*	*Gabonisporis vigourouxii*	*Gabonisporis vigourouxii*	*Gabonisporis vigourouxii*	*Leptolepidites sp.*
Ariadnaesporites sp.	*Ariadnaesporites* sp.	*Gabonisporis* sp.	*Ariadnaesporites* sp.		*Gabonisporis* sp.	*Cicatricosisporites* sp.
	Contignisporites sp.					*Contignisporites* sp.
Gymnosperms	**Gymnosperms**	**Gymnosperms**	**Gymnosperms**	**Gymnosperms**	**Gymnosperms**	**Gymnosperms**
	Ephedripites sp.	*Equisetosporites* sp.	*Ephedripites* sp.	*Araucariacites australis*		*Araucariacites australis*
				Callialasporites trilobatus		*Callialasporites* sp.
				Podocarpidites sp.		*Cycadopites* sp.
				Araucariacites sp.		
Angiosperms	**Angiosperms**	**Angiosperms**	**Angiosperms**	**Angiosperms**	**Angiosperms**	**Angiosperms**
		Aquilapollenites bengalensis	*Aquilapollenites bengalensis*	*Aquilapollenites bengalensis*	*Aquilapollenites bengalensis*	*Aquilapollenites bengalensis*
Aquilapollenites indicus	*Proteacidites* sp.	*Triporotetradites psilatus*	*Diporoconia* sp.	*Turonipollis helmigii*	*Aquilapollenites indicus*	
					Proteacidites reticulatus	
					Proteacidites. sp.	
					Triorites sp.	

1970) and could have been reworked, the possibility that they formed part of the Lakshmipur flora cannot be ruled out at present because palynological data are still insufficiently known from the Late Cretaceous of western India, and these forms may have continued up to the intertrappean times. Significantly, pteridophytic spores such as *Triporoletes reticulatus, Azolla cretacea* and *Gabonisporis vigourouxii*, which are widely recorded from other intertrappean beds (Table1), are absent in the Lakshmipur palynoflora, and in this respect, the latter is distinct from the central Indian intertrappean floras and even the Anjar flora of Kutch.

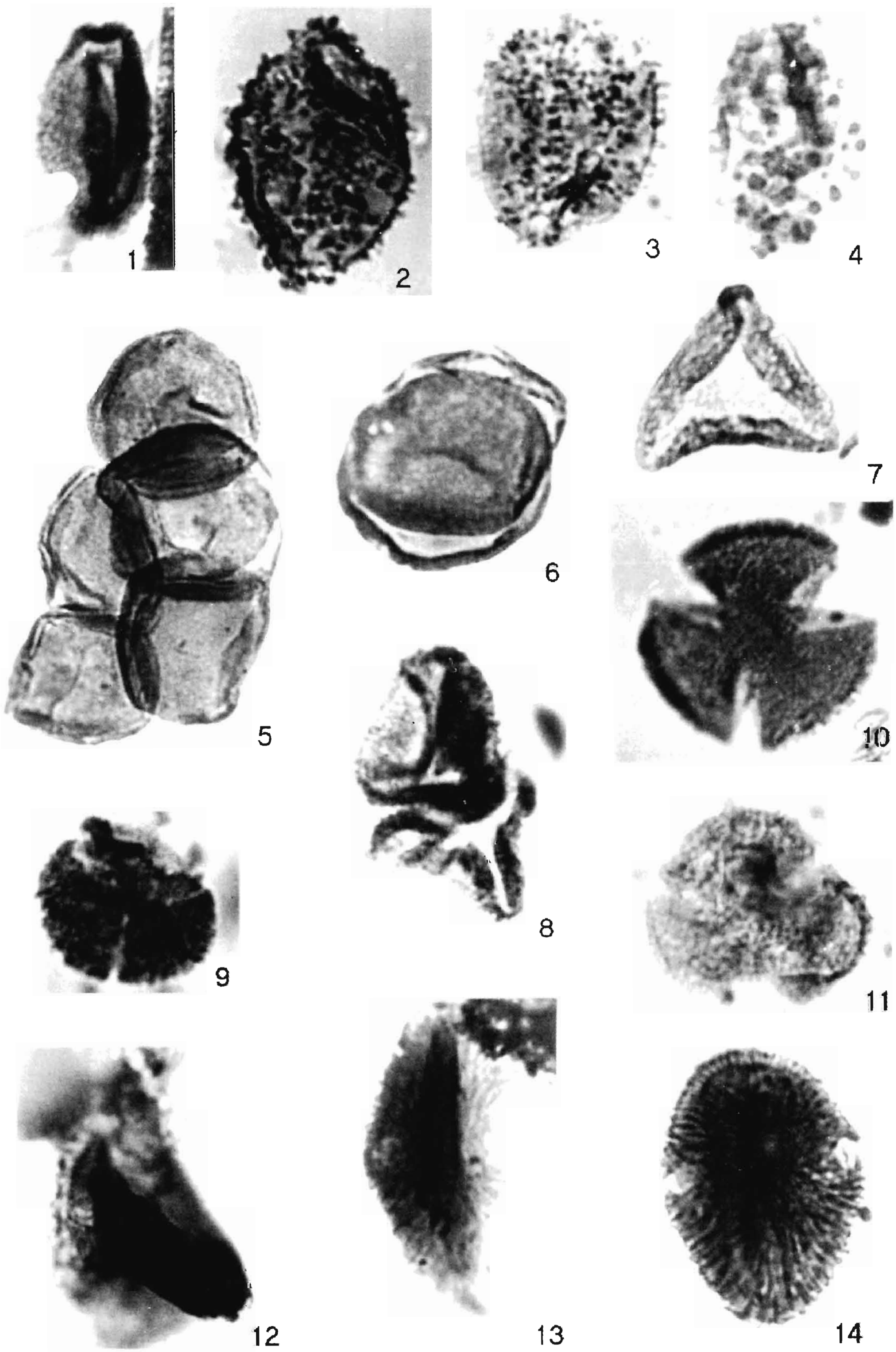
Interestingly, the present study shows that quantitatively, the concentration of gymnosperm pollen grains in the Lakshmipur intertrappeans is higher (10%) in comparison to the gymnosperms known from other intertrappeans where they are either absent (as in Naskal, Kar *et al.*, 1998; Anjar, Dogra *et al.*, 2004) or very scarcely represented (<1%) as in Daiwal, Samant and Mohabey, 2003 and Khandala-Ashta, Samant *et al.*, 2005. In Padwar (Prakash *et al.*, 1990), Ranipur (Mathur and Sharma, 1990) and Mohagaon-Kalan (Kar and

EXPLANATION OF PLATE II

(All magnifications 400X)

1. ***Liliacidites*** sp.
2. ***Racemonocolpites*** sp.
3. ***Racemonocolpites*** sp.
4. ***Racemonocolpites*** sp.
5. ***Proxapertites operculatus*** Van der Hammen in cluster
6. ***P. operculatus*** Van der Hammen
7. **Trichotomosulcate pollen**
8. ***Liliacidites trichotomosulcatus*** Singh
9. ***Tricolpites*** sp.
10. ***Retitricolpites vulgaris*** Pierce
11. ***Tricolpites reticulatus*** Cookson
12. ***Aquilapollenites*** sp.
13. ***Aquilapollenites bengalensis*** Baksi and Deb
14. ***Aquilapollenites bengalensis*** Baksi and Deb

Plate II



SAMANT AND BAJPAI

Srinivasan, 1998) intertrappean beds, gymnosperms are present but statistical data are not available (Table 1).

The angiosperm pollen grains are significantly represented in the Lakshmipur intertrappean beds and they cannot have been reworked from the underlying Bhuj Formation because the latter is devoid of angiosperms (Maheshwari and Jana, 1983). Moreover, the Lakshmipur angiosperms appear to be primitive relative to the pollen grains known other intertrappean beds. The recovered angiosperm palynomorphs are mostly monosulcate, trichotomosulcate, tricolpate and colporoidate forms (Plate II). Available literature on the main stages of evolutionary differentiation of angiosperm pollen grains indicates that the monosulcate reticulate forms appeared first and they were gradually joined by tricolpate reticulate, colporate and porate (*Normapollis* group) forms (Singh, 1975; Norris *et al*., 1975; Jarzen and Nicholas, 1996). Although all aperture patterns (colpate, colporate and porate) and exine characters had appeared by the end of the Cenomanian (Lidgard and Crane,1990), the Maastrichtian time saw considerable experimentation in angiosperm pollen morphology, leading to an increased diversity of forms (such as *Normapollis, Triprojectates* and *Oculat*; Jarzen and Nicholas, 1996). In this respect, the angiosperm palynomorphs recorded from the Lakshmipur intertrappean beds are unique. Distinctly porate forms like *Normapollis* and *Proteacidites* are absent although the floral assemblage is otherwise quite rich. These porate forms are present in several other intertrappean beds (Table 1). The absence of *Normapollis* and *Proteacidites* group is particularly surprising and significant because these forms are well represented in the Anjar section (also in Kutch, about 100 km from Lakshmipur) where they occur in sediments between the third and fourth lava flows (Dogra *et al*., 2004). Radiometric data (^{40}Ar-^{39}Ar) indicate absolute ages of approximately 67 Ma and 65 Ma for the third and fourth lava flows, respectively (Courtillot *et al*., 2000). A very rich and diverse pollen assemblage of the *Normapollis* group is also known from the Late Cretaceous of Meghalaya (Nandi, 1983; Kar and Singh, 1986) and the subsurface sediments of the Krishna-Godavari basin (Prasad *et al*., 1995).

This study shows that palynotaxa occurring near the K/T boundary, such as *Mulleripollis, Equisetosporites, Psilodiporites, Mancicorpus, Rutihesperipites, Striatricorpus, Psittacopollis, Cranwellia* and *Pulcheripollenites* (Prasad and Pundeer, 2002) or those that are distinctly Paleocene forms, such as *Dandotiaspora* spp. *Matanomadhiasulcites* sp., *Dicolpopollis* sp., *Lakiapollis ovatus* and *Psilodiporites* (Singh and Kar, 2003; Gupta *et al*., 2003), are completely lacking in the Lakshmipur assemblage. Overall, on the basis of age marker palynotaxa such as *Contignisporites* sp. (Early Cretaceous to Cenomanian; Filatoff and Price, 1988), *Retitricolpites vulgaris* (Cenomanian; Pierce, 1961), *Proxapertites* spp. (Late Cretaceous to Tertiary; Jetter *et al*., 2001) and *Aquilapollenites bengalensis* (Maastrichtian; Baksi and Deb, 1981), a Late Cretaceous (Maastrichtian) age can be assigned to the Lakshmipur intertrappean deposits. The presence of Cenomanian taxa in these deposits possibly suggests that their true stratigraphic extent was not recognized previously.

The Lakshmipur intertrappean palynology is potentially important as it possibly provides a basis for discriminating age differences within the Maastrichtian part of the Deccan volcano-sedimentary sequence. The assemblage assumes significance in the context of recent models (Mitchell and Widdowson, 1991; Widdowson, 2004), postulating a southward migrating locus of eruptions in the Deccan province as the Indian plate migrated northwards. The northwesternmost position of the Kutch basalts possibly implies that this region should record one of the earliest phases of Deccan volcanic activity. In this context it is relevant to recall some of the recent work on the well-known iridium-bearing intertrappean section of near Anjar in Kutch. These studies, based on microfossils (Bajpai and Prasad, 2000), magnetic susceptibility and Milankovitch cycles as well as stable carbon isotopes (Hansen *et al*., 2001, 2005) suggest that the intertrappeans of Anjar significantly predate the K/T boundary and that these sediments may have been deposited during the earlier part of the magnetochron 29R (within Maastrichtian). It should be pointed out, however, that an alternative viewpoint advocating the presence of a K/T boundary at Anjar does exist (e.g. Bhandari *et al*., 1995, 1996; Shukla and Shukla, 2002). The presently recorded pteridophytic spore and angiosperm pollen grain assemblage suggests that the Lakshmipur section may be older than the iridium-bearing Anjar intertraps and some of the sections in Central India from where Maastrichtian palynofloras are known. Additional studies that help constrain timing within Maastrichtian, including radiometric dating, magnetostratigraphy, geochemical analyses, stable isotope work and palaeontological studies may clarify this interpretation. The record of older palynoflora from the Kutch suggests that this region may have experienced some of the earliest phases of Deccan volcanic activity, apparently consistent with models invoking a general southward decrease in the age of the Deccan Traps with regional complications (Mitchell and Widdowson, 1991; Widdowson, 2004).

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