5. PLANKTONIC FORAMINIFERAL ZONATION

5.1 Planktonic foraminifera from the Sulaiman Range

Among 147, 132 and 70 samples collected from the Dunghan, Shaheed Ghat, Baska and Kirthar Formations from Rakhi Nala, Zinda Pir east and Zinda Pir west sections, 42, 38 and 34 samples yielded poor to well preserved planktonic and benthic foraminifers, respectively. A total of some 96 species and subspecies belonging to 17 different genera of planktonic foraminifera were identified (Tables 1 to 5).

The Rakhi Nala section yielded rich assemblage of the sequence as 96 species belonging to 17 genera were identified from this sequence (Tables 1& 3). The abundance and preservation of individual specimens in the Zinda Pir western section are generally better than those in the eastern side. The distribution of the planktonic foraminifera recovered and identified from Paleogene sequence exposed in the Zinda Pir Anticline are given in Tables 2, 3, 4.

For the definitions of biozones (Figure 8) established herein the Sulaiman Range, mostly the biostratigraphic schemes established by Toumarkine and Luterbacher (1985), Berggren and Noriss (1997), Berggren et al. (1995) and Olsson et al. (1999) are used with some modifications. All the established zones are interval zones based on their first or last appearance datum (FAD or LAD) of internationally recognized index marker species. Moreover, biostratigraphic zones are established along all three sections separately and the results are summarized

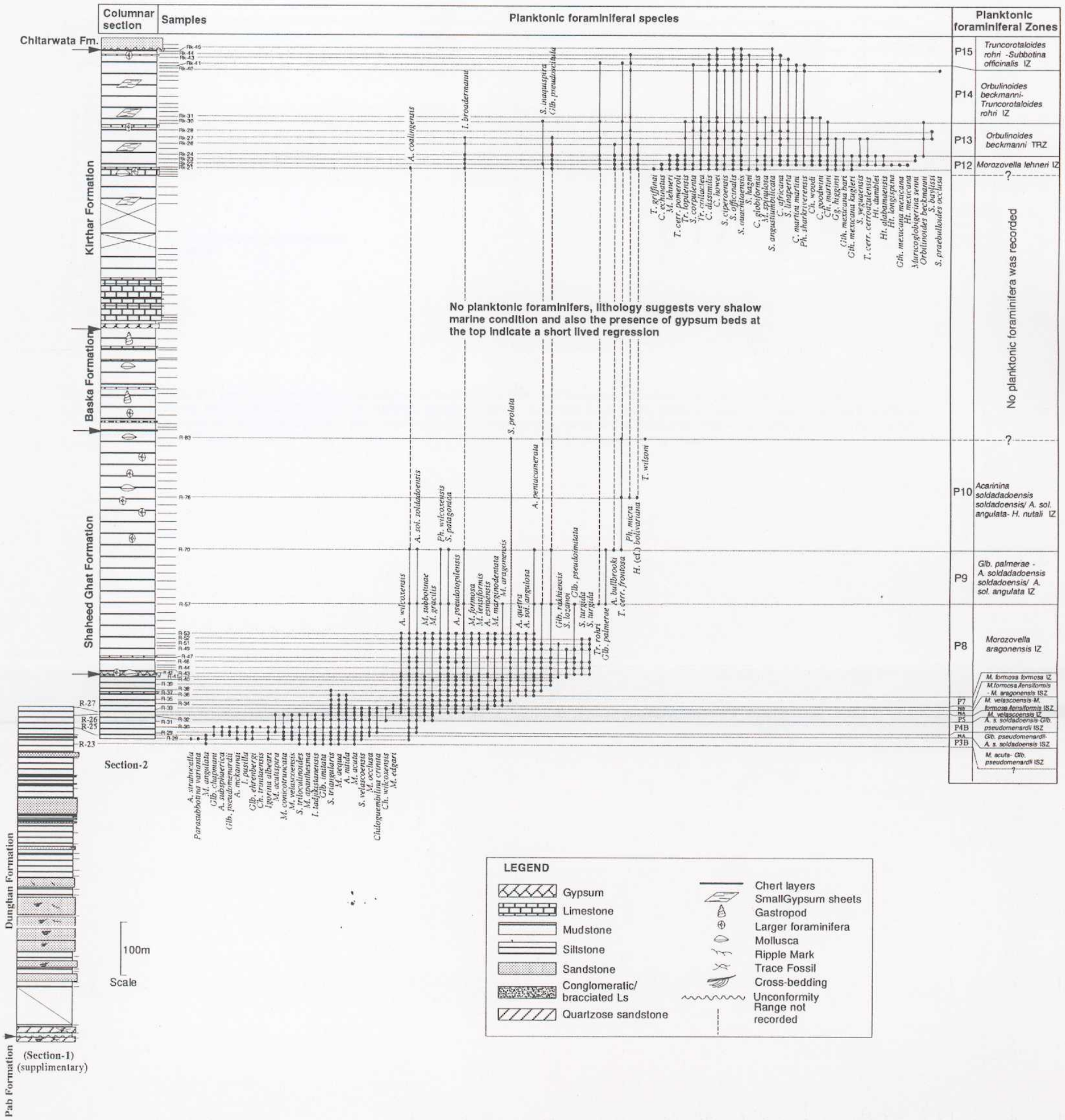

Figure 9: Distribution and stratigraphic ranges of the planktonic foraminiferal taxa, in the Dunghan, Shaheed Ghat, Baska and Kirthar Formations exposed along the Rakhi Nala (river) in the Sulaiman Range, Southern Indus basin, Pakistan. Measured collumnar section shows lithofacies changes and sampling locations. Here small filled circles indicate occurrance of the planktonic foraminifers whereas small horizontal lines against the lithology represent sampling positions and numbers indicate the samples containing planktonic foraminifera.

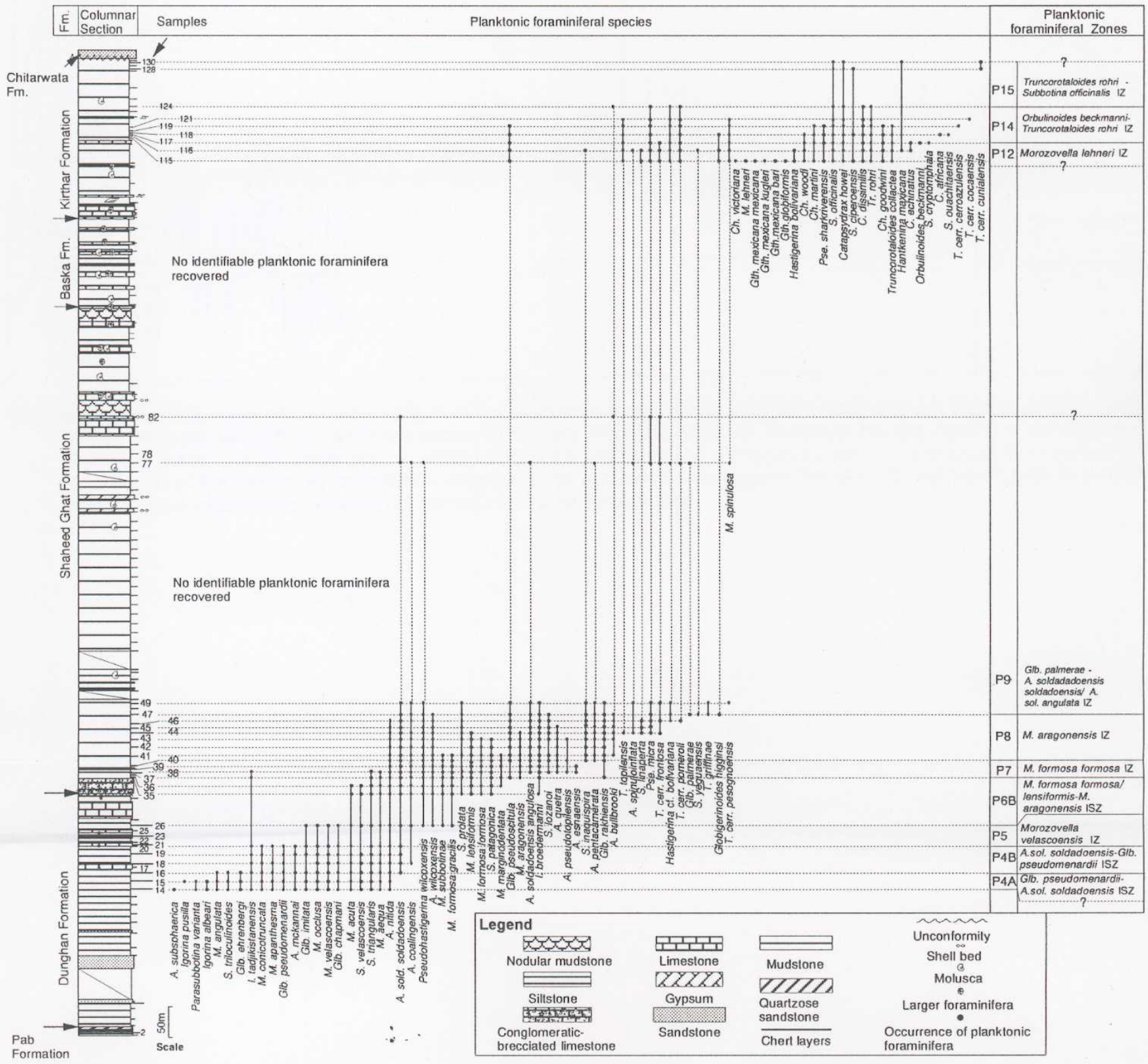

Figure 10. Distribution and stratigraphic ranges of the planktonic foraminiferal taxa from Dunghan, Shaheed Ghat, Baska and Kirthar Formations exposed along the eastern limb of the Zinda Pir Anticline, Sulaiman Range, Southern Indus basin, Pakistan. Measured collumnar section shows lithofacies changes and sampling locations. Here small filled circles indicate occurrance of the planktonic foraminifers whereas small horizontal lines against the lithology represent sampling positions and numbers indicate the samples containing planktonic foraminifera.

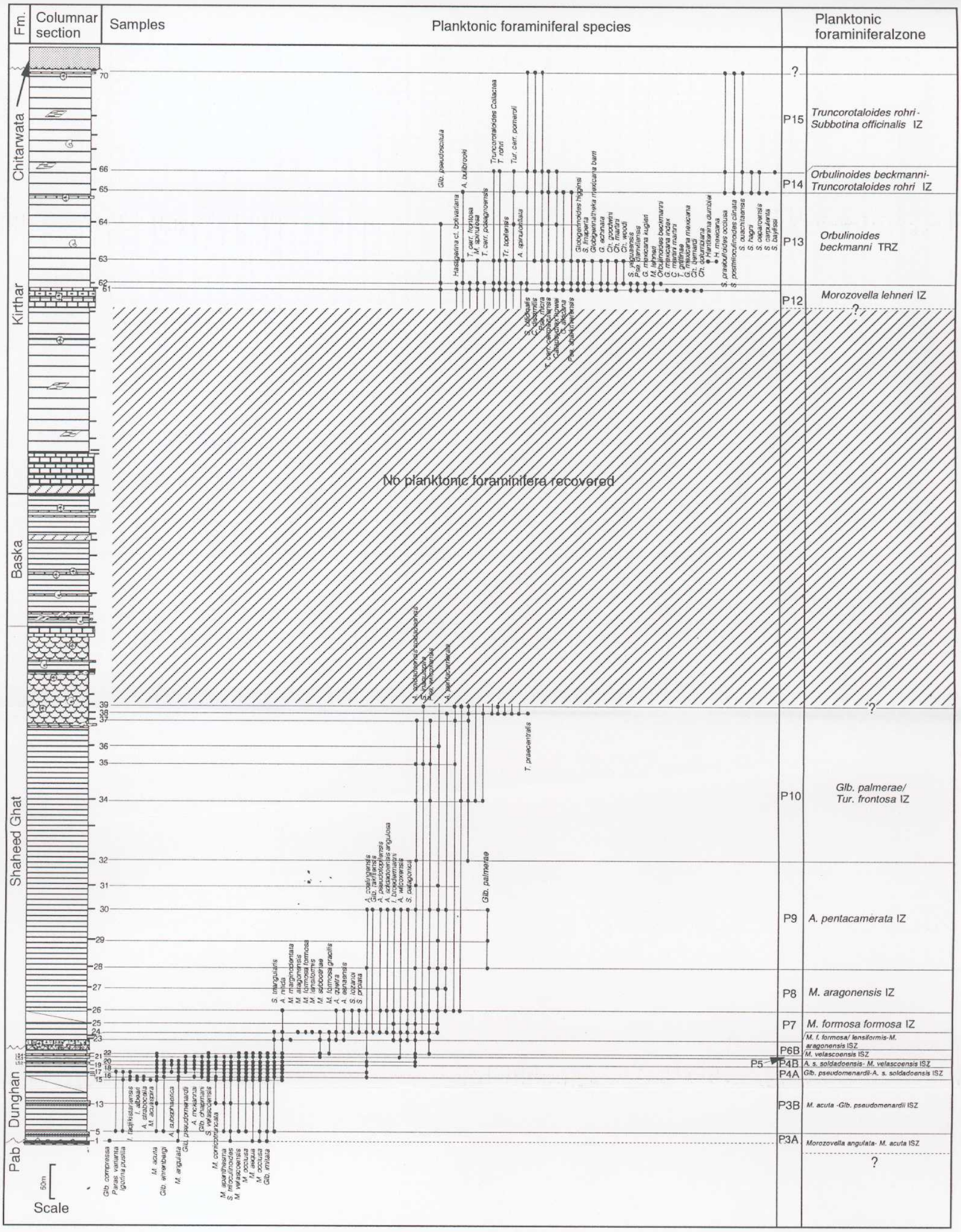

Figure 11. Distribution and stratigraphic ranges of the planktonic foraminiferal taxa from the Dunghan, Shaheed Ghat, Baska and Kirthar Formations exposed along the wstern limb of the Zinda Pir Anticline, Sulaiman Range, Southern Indus basin, Pakistan. Measured collumnar section shows lithofacies changes and sampling locations. Here small filled circles indicate occurrance of the planktonic foraminifers whereas small horizontal lines against the lithology represent sampling positions and numbers indicate the samples containing planktonic foraminifera.

Table 1. Distribution and relative abundance (%) of the planktonic foraminiferal species in the Dunghan Formation exposed along the Rakhi Nala (river), Suallman Range, Southern Indus Basin, Pakistan. Here x = less than 1%

Dunghan Formation																Samples	Planktonic foraminiferal species
R23	R28	R25	R29	R30	R32	R26	R27	R33	R34	R35	R36	R38	R39	R40	R41		
	2	3	1	2	6	6	x	1	x	6	1		3	2	4		*Acarinina coalingensis*
								x	x		2		1		1		*A. esnaensis*
	1		1	1		2											*A. mckannai*
	2	2	2	2	4	2	4	2		4	2						*A. nitida*
											3	5	3	10	4		*A. pentacamerata*
							2	x	1	1	1	2	4	1	3		*A. pseudotopilensis*
											3	1	1	5	4		*A. quetra*
			10	3	14	11	14	18	8	27	22	25	31	36	19		*A. sold. soldadoensis*
											2	3	3	5	5		*A. sold. angulosa*
	4																*A. strabocella*
		1	1	1													*A. subsphaerica*
							1		3	14	11	4	6	4	7		*A. wilcoxensis*
			1				1	1									*Chiloguembelina crinita*
				2													*Ch. trinitaensis*
					x			1									*Ch. wilcoxensis*
		1		1													*Globanomalina chapmani*
	1		2	3													*Glb. ehrenbergi*
						1											*Glb. elongata*
x	1	1		1	x	1											*Glb. imitata*
		2	6	14													*Glb. pseudomenardii*
															5		*Glb. rakhiensis*
													6	2	4		*Glb. pseudoscitula*
	6		1	1													*Igorina albeari*
							1		1	4	3	2	3	2	4		*I. broadermanni*
	7	1	1	1													*I. pusilla*
3	4	3	4	4	4	3											*I. tadjikistanensis*
46	9	58	14	17	33	23	9	11									*Morozovella acuta*
		x	1		x												*M. acutispira*
4	6	2	1	x	5	3	3	1	3	1	1		x				*M. aequa*
18	37	1															*M. angulata*
3		1	5	3		1											*M. apanthesma*
									3	3	11	13	7	8	14		*M. aragonensis*
	2	5	3	2		1											*M. conicotruncata*
							11	1	1								*M. edgari*
								17		1	1	1	x	x	1		*M. formosa formosa*
					1	1	5	4	4	2	5			2			*M. formosa gracilis*
								1	3	4	10	9	6	7	2		*M. lensiformis*
									6	6	2	2		1			*M. marginodentata*
		3	4	2	1	5	2	4									*M. occlusa*
					4	4	30	20	36	12	14	9	6	5	x		*M. subbotinae*
	2	3	16	11	3	1											*M. velascoensis*
												3					*Turborotalia praecentralis*
												2	3	1	5		*Subbotina inaquispira*
															6		*S. loznol*
										4		1	1	2	4		*S. prolata*
							6	6	15	8	2	12	14	3	2		*S. patagonica*
2	1	1		2		3											*S. triloculinoides*
23	12	11	19	16	20	26	8	5	12	3	3	7					*S. triangularis*
	3	3	7	7	5	9	x	1									*S. velascoensis*
	1																*Parasubbotina varianta*
							3	1	5	2	1	2	2		5		*Pseudohastl. wilcoxensis*
226	393	308	383	409	295	343	316	219	300	193	262	199	304	243	303		**Total Counts**
8	18	pp	20	22	15	18	17	19	16	17	20	18	19	18	20		**Species Number**
P3B			P4A	P4B		P5	P6A	P6B	P7		P8						**Zones**

Table 2. Distribution and relative abundance of planktonic foraminiferal species in the Dunghan Formation exposed along the eastern and western limbs of the Zinda Pir Anticline, Sulaiman Range, Pakistan. Here X = less than 1%.

Dunghan Formation																						Planktonic foraminiferal Species
Eastern side							Western side															
ZPE-14	ZPE-15	ZPE-16	ZPE-18	ZPE-19	ZPE-20	ZPE-26	ZPW-1	ZPW-5	ZPW-13	ZPW-15	ZPW-16	ZPW-17	ZPW-18	ZPW-19	ZPW-20	ZPW-21	ZPW-22	Samples				
			5			7					2	1		x	2	5	1		*Acarinina coalingensis*			
x		3	3	1	3						1	1	1	1	2	2			*A. mckannai*			
x	2	2	2	1	3	1				1	3	9	2	2	4	5	2		*A. nitida*			
		15	6	1	14	10								7	11	21	9		*A. soldadoensis*			
										2	15								*A. strabocella*			
x												1		1	x				*A. subsphaerica*			
						1										x			*A. wilcoxensis*			
1	4	1	5	2	2	1					3	4	3	4	3	7	x		*Globanomalina chapmani*			
							5												*Glb. compressa*			
6	4	1						3			4	2	1	2	1				*Glb. ehrenbergi*			
1	3	2		1	2	3	10	3	1	1	1		1	x		1	2		*Glb. imitata*			
2	1	1	5	1	2							2	2	5	2	5			*Glb. pseudomenardii*			
x	1									1	1								*Igorina albeari*			
	1							4		3		2							*I. pusilla*			
2	1	1	8	5	7					1	4	2							*I. tadjikistanensis*			
2	51	23	31	48	30	36		7	35	25	28	17	30	46	25	19	24		*Morozovella acuta*			
										8									*M. acutispira*			
2	4	4	2	1	3	5		9	14	1	4	4	3	1	1	12	6		*M. aequa*			
2	2	4		2	20		5	39	39	16	5	4	12	4	4				*M. angulata*			
1	1	4		2				8	5	2	3	3	5	3	4	1			*M. apanthesma*			
1	1	2	6	6	5				4	5	4	6	14	6	11	x			*M. conicotruncata*			
						1											x		*M. formosa gracilis*			
2	2	4	5	4	2	2		4	1	1		4	3	1	1	2	x		*M. occlusa*			
						9										3	4		*M. subbotinae*			
3	3	6	8	21	8	1		4		2	1	18	14	10	24	1	6		*M. velascoensis*			
4	2	1					5	3		7	2	2	1		1	2			*Subbotina triloculinoides*			
7	12	18	11	6	1	11		4		15	11	5	4	4	4	7	31		*S. triangularis*			
5	5	9	5	1		7				11	6	11	5	4	6	4	9		*S. velascoensis*			
14	1							3				x							*Parasubbotina varianta*			
						5											2		*Pseudohastigerina wilcoxensis*			
367	178	112	69	166	191	352	5	67	79	313	267	264	278	284	271	250	361		**Total Counts**			
20	19	18	14	15	14	15	4	13	7	17	18	20	16	18	18	18	15		**Species Number**			
P4A		P4B				P5	P3A	P3B			P4A		P4B				P5		**Zones**			

Table 3. Distribution of planktonic foraminiferal species identified from Shaheed Ghat, Baska and Kirthar Formations exposed in the Rakhi Nala section. Here the numbers represent actua relative abundance as found in the respective species count numbers.

Shaheed Ghat Formation												Baska Fm.	Kirthar Formation														Formation
R-43	R-44	R-46	R-47	R-49	R-51	R-52	R-53	R-57	R-70	R-76	R-83		Rk-21	Rk-22	Rk-23	Rk-24	Rk-26	Rk-27	Rk-28	Rk-30	Rk-31	Rk-40	Rk-41	Rk-43	Rk-44	Rk-45	Planktonic foraminiferal species
									5			Samples R-83 to R-99 ; Rk-1 to Rk-20 contanin very poorly preserved to no planktonic foraminifera	6	1	8	6	1										*A. bullbrooki*
28	9	16	14	25	14	28	25	1	7				4														*A. coalingensis*
9			2			2	4																				*A. esnaensis*
		2		2	1		1																				*A. pseudotopilensis*
1	9	35	7	7	17	4	4	2	1																		*A. pentacamerata*
					4	3	6																				*A. quetra*
7	4	10	2	2	13	5	15																				*A. soldadoensis angulosa*
54	82	108	42	205	120	87	107	6	25																		*A. sold. soldadoensis*
15				2	3	2	3																				*A. wilcosensis*
														1	1	1					1						*Chiloguimbilina woodi*
														1	1	1		1			1						*Ch. goodwini*
														1	1	1	1	1		1							*Ch. martini*
														3	10	2	1	3	5				6		2		*Catapsydrax africana*
													7	30	8	2	2	2	1	3		25	9	3	1		*C. dissimilis*
													2	3													*C. echinatus*
													2		2		2	2		2		1	4				*C. globiformis*
													16	48	23	4	7	8	32	2	1	36	6	4	3	1	*C. howei*
														4	2	2						10	2				*C. martini martini*
								2	1																		*Globanomalina palmerae*
2	11	3	4	1				1																			*Glb. pseudoimitata*
					1																						*Glb. rakhiensis*
1	2	7	4	15				9	2				9	5	4	1	1	1									*Glb. pseudoscitula*
														4	5	6		1									*Globigerinoides higginsi*
													2	2		3		1									*Globigerinatheka mexicana bari*
													2	1		1											*Gth. mexicana kugleri*
														1													*Gth. mexicana mexicana*
																1		1		3							*Orbulinoides beckmanni*
										1			1	37	43	65	1										*Hastigerina* (cf.) *bolivariana*
														1		1											*Hantkenina alabamensis*
														1		1											*Ht. dumblei*
														1													*Ht. longispira*
														1													*Ht. mexicana*
18	12	30	8	21	2	4	4	3	1				17	9	2	4	5	2									*I. broadermanni*
			1		10	4	5	2																			*Morozovella aragonensis*
					2	3	2																				*M. formosa formosa*
					3	3	5																				*M. formosa gracilis*
													2	4	2	1											*M. lehneri*
3					4	3																					*M. lensiformis*
					2	4																					*M. marginodentata*
													25	13	2	10		1			4					1	*M. spinulosa*
					7	6	15																				*M. subbotinae*
															5	3											*Muricoglobigerina senni*
										1			30	4	5	8	1	1	4		14	1	2		2		*Pseudohastigerina micra*
														2		4					2	1	1				*Ph. sharkriverensis*
2	12	12	41	23	20	14	6	2	2																		*Ph. wilcosensis*
														8	5				1					2	1	1	*Subbotina angustiumbilicata*
														2													*S. azerbaidjanica*
																			1	9							*S. baylissi*
													5	6		1		7	6			2					*S. ciperoensis*
													2	3		2			7	1		2	1				*S. corpulenta*
													2												2		*S. hagni*
2	6	11	7	12	2			2			3			1						5							*S. inaquispira*
														2	6	5		4	2	4		3		10			*S. linaperta*
9	4	5		7																							*S. lozanoi*
													12	12	25	16	1	8	25	9		95	16	25	5	4	*S. officinalis*
													7	1	19	7	1	10	7	4		55	4	1	2	3	*S. ouachitaensis*
10	17	22	29	36	29	33	29	2	1																		*S. patagonica*
																						55					*S. praebull. occlusa*
													2									7	2	14	1		*S. postriloc. clinata*
15	2	23	26	13	6	1	1			5	2																*S. prolata*
6	3	4		2	2	6																					*S. turgida*
														6		3		2									*S. yeguaensis*
													1														*Turborotalia griffinai*
													2	3	1	1											*T. cerr. pomeroli*
														2		1		3									*T. cerr. cerroazulensis*
											2																*T. wilsoni*
									6	1	2		11	3		5		1		1			3				*T. frontosa*
													7	13	22	10		3	1	7	2		10				*Truncorotaloides collactea*
													34	17	3	5		1		1							*Tr. topilensis*
								2					11	25	16	12	1	8		5			4				*Tr. rohri*
182	173	288	187	373	262	212	232	34	51	8	9		221	282	221	196	25	72	92	57	25	293	70	59	19	10	**Total counts**
13	12	13	12	13	17	14	15	12	10	3	3		28	38	26	31	10	19	13	14	7	10	15	7	10	7	**Total species**
P8								P9		P10			P12			P13			P14			P15					**Zones**

Table 4. Distribution of planktonic foraminiferal species identified from Shaheed Ghat, Baska and Kirthar Formations exposed in the Rakhi Nala section, Southern Indus Basin, Pakistan. Here X represents the occurrence of the species.

Shaheed Ghat Formatiom														Baska Fm.		Kirthar Formation									Formation
ZPE-35	ZPE-36	ZPE-37	ZPE-38	ZPE-39	ZPE-40	ZPE-41	ZPE-42	ZPE-43	ZPE-44	ZPE-45	ZPE-46	ZPE-47	ZPE-49	ZPE-77	ZPE-82	ZPE-115	ZPE-116	ZPE-117	ZPE-118	ZPE-119	ZPE-121	ZPE-124	ZPE-128	ZPE-130	Planktonic foraminiferal species
						×	×	×	×	×	×	×			×							×			*Acarinina bullbrooki*
×	×	×	×		×	×	×	×	×		×	×	×												*A. coalingensis*
			×	×																					*A. esnaensis*
×	×	×	×		×	×	×	×	×	×	×														*A. nitida*
					×	×	×	×	×	×	×	×	×	×											*A. pentacamerata*
			×		×			×																	*A. pseudotopilensis*
			×	×	×	×	×	×	×	×															*A. quetra*
			×	×	×	×	×	×	×	×	×	×	×	×											*A. soldadoensis angulosa*
×	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×										*A. soldadoensis soldadoensis*
									×				×				×								*A. spinulointlata*
×		×	×	×	×	×		×	×	×	×	×													*A. wilcoxensis*
																×	×	×	×						*Chiloguimbilina woodi*
																×	×	×	×	×					*Ch. goodwini*
																×		×	×	×					*Ch. martini*
																×									*Ch. victoriana*
																×			×						*C. africana*
																	×	×							*C. echinatus*
																×	×	×	×	×	×	×			*C.dissimilis*
																×	×	×	×	×	×	×	×	×	*C. howei*
																									C. martini
														×											*Globanomalina palmerae*
																									Glb. pseudoimitata
																×	×	×	×	×					*Glb. pseudoscitula*
																									Glb. rakhiensis sp.nov.
																×	×		×						*Globigerinoides higginsi*
																×									*Globigerinatheka mexicana bari*
																×									*Gth. Globiformis*
																×									*Gth. mexicana kugleri*
																×									*Gth. mexacana mexacana*
																								×	*Hastigerina bolivariana*
											×	×	×	×		×	×	×	×	×	×	×		×	*Hastigerina* (cf.) *bolivariana*
												×	×			×	×								*H. griffinae*
																	×				×				*Ht. mexicana*
×		×	×	×	×	×	×	×	×	×	×	×	×												*Igorina broadermanni*
×	×	×																							*Morozovella aequa*
×	×	×																							*M. acuta*
		×	×	×	×	×	×	×	×																*M. aragonensis*
×	×		×	×	×	×	×																		*M. formosa formosa*
×	×	×	×	×	×	×																			*M. formosa gracilis*
																×									*M. lehneri*
×	×	×	×	×	×	×	×	×	×																*M. lensiformis*
×	×	×		×	×	×																			*M. marginodentata*
														×		×	×	×	×	×	×				*M. spinulosa*
×	×	×	×	×	×	×																			*M. subbotinae*
																		×							*Orbulinoides beemanni*
									×	×	×	×	×	×	×	×	×	×	×	×	×	×			*Pseudohastigerina micra*
																×		×	×	×					*Ph. sharkriverensis*
×	×	×	×	×	×	×	×	×	×	×	×	×	×	×											*Ph. wilcosensis*
																									Subbotina baylissi
																×			×				×		*S. ciperoensis*
																		×							*S. cryptomphala*
																					×				*S. hagni*
					×	×	×	×	×	×	×	×	×				×								*S. inaquispira*
									×	×	×	×				×	×								*S. linaperta*
			×		×	×		×	×	×	×	×													*S. lozanoi*
																×	×	×	×	×	×	×	×	×	*S. officinalis*
																			×						*S. ouachitaensis*
×		×	×			×		×	×	×	×	×	×												*S. prolata*
×	×	×	×	×	×	×	×	×																	*S. patagonica*
																									S. praebulloides occlusa
×	×	×	×																						*S. triangularis*
	×	×																							*S. turgida*
×	×																								*S. velascoensis*
												×					×								*S. yeguaensis*
											×		×	×		×	×	×	×	×	×	×			*T. cerroazulensis pomeroli*
														×		×				×					*T. cerr. cerroazulensis*
																							×		*T. cerr. cunealensis*
																									T. cerr. posagnoensis
																									T. precentralis
									×		×		×	×	×	×	×	×							*T. cerr. frontosa*
																×	×	×	×	×					*Truncorotaloides collactea*
																×	×	×	×	×	×				*Tr. topilensis*
																×	×	×	×	×	×	×			*Tr. rohri*
17	15	19	19	15	22	22	17	20	21	16	19	18	15	10	3	28	23	19	19	15	11	7	4	4	**Total species**
P6B		P7			P8							P9		P10		P12, P13				P14			P15		**Zones**

Samples ZPE-50 to ZPE-76 contain either very poorly preserved or no planktonic foraminifera

Samples ZPE-83 to ZPE-114 contain either very poorly preserved or no planktonic foraminifera

Table 5. Distribution of planktonic foraminiferal species identified from Shaheed Ghat, Baska and Kirthar Formations exposed in the Rakhi Nala section.Here X represents the occurrence of the species.

Shaheed Ghat Formation															Baska Fm.	Kirthar Formation							Formation
ZPW-23	ZPW-24	ZPW-25	ZPW-26	ZPW-27	ZPW-28	ZPW-29	ZPW-30	ZPW-31	ZPW-32	ZPW-34	ZPW-35	ZPW-36	ZPW-37	ZPW-38	ZPW-39		ZPW-61	ZPW-62	ZPW-63	ZPW-64	ZPW-65	ZPW-66	ZPW-70	Planktonic foraminiferal species
			×							×					×			×	×		×			*Acarinina bullbrooki*
	×		×		×		×																	*A. coalingensis*
	×		×																					*A. esnaensis*
										×			×					×						*A. nitida*
			×	×	×		×							×										*A. pentacamerata*
	×		×				×																	*A. pseudotopilensis*
×	×		×																					*A. quetra*
	×		×				×																	*A. soldadoensis angulosa*
×	×	×	×	×	×		×			×	×		×											*A. sol. soldadoensis*
														×				×						*A. spinuloinflata*
×	×		×				×																	*A. wilcoxensis*
×	×		×															×	×					*Chiloguimbilina woodi*
																	×	×	×					*Ch. goodwini*
																	×	×	×					*Ch. martini*
																	×	×	×		×			*C. africana*
																	×	×	×					*C. echinatus*
																			×			×	×	*C.dissimilis*
																	×	×	×	×	×	×		*C. howei*
																	×							*C. martini*
					×	×	×																		*Globanomalina palmerae*
	×						×																		*Glb. rakhiensis* sp.nov.
	×	×	×	×	×	×	×	×				×					×	×	×	×				*Glb. pseudoscitula*
																	×	×	×					*Globigerinoides higginsi*
																	×	×	×					*Globigerinatheka mexicana bari*
																	×	×						*Gth. mexicana kugleri*
																	×							*Gth. mexacana mexacana*
			×								×		×		×		×	×						*Hastigerina* (cf.) *bolivariana*
																	×							*H. griffinae*
																			×					*Ht. mexicana*
×	×	×	×				×																	*Igorina broadermanni*
	×																							*Morozovella aragonensis*
	×																							*M. formosa formosa*
×	×																							*M. formosa gracilis*
																	×	×						*M. lehneri*
×																								*M. lensiformis*
×																								*M. marginodentata*
										×							×	×	×					*M. spinulosa*
×	×																							*M. subbotinae*
																								Orbulinoides becmanni
																	×	×	×	×	×	×	×	*Pseudohastigerina micra*
×																	×	×	×		×			*Ph. sharkriverensis*
×	×		×		×		×			×		×		×										*Ph. wilcosensis*
																						×		*Subbotina baylissi*
																					×	×		*S. ciperoensis*
																					×	×		*S. hagni*
	×		×								×				×									*S. inaquispira*
																	×	×	×					*S. linaperta*
	×		×																					*S. lozanoi*
																	×	×			×	×	×	*S. officinalis*
																					×	×	×	*S. ouachitaensis*
	×		×																					*S. prolata*
×	×	×	×				×																	*S. patagonica*
	×		×																		×	×	×	*S. praebulloides occlusa*
×	×																							*S. triangularis*
																	×	×	×	×	×	×		*T. cerroazulensis pomeroli*
																	×	×	×		×			*T. cerr. cerroazulensis*
														×				×						*T. cerr. posagnoensis*
														×										*T. precentralis*
									×	×			×	×	×		×	×						*T. cerr. frontosa*
														×			×	×	×			×		*Truncorotaloides collactea*
														×	×		×	×	×					*Tr. topilensis*
																	×	×	×			×		*Tr. rohri*
13	22	4	19	3	6	2	12	1	1	6	3	2	4	8	5		25	27	21	4	12	12	5	**Total species**
P6B	P7		P8		P9									P10			P12		P13		P14	P15		**Zones**

Samples ZPW-40 to ZPW-59 contain either very poorly preserved or no planktonic foraminifera

in Figures 9, 10, 11. Correlation is made between the established biozones in the Sulaiman Range with internationally recognised zonal schemes as well as with biostratigraphic zones established in other parts of the Indus Basin, Pakistan (Figure 12).

5.2 Paleocene Zonation

Three biostratigraphic zones representing late Paleocene were recognized from the planktonic fauna recovered from the Dunghan Formation distributed in Rakhi Nala and Zinda Pir sections of the Sulaiman Range. These are in ascending order: *Morozovella angulata /Globanomalina pseudomenardii* Interval Zone, *Globanomalina pseudomenardii* Total Range Zone and *Morozovella velascoensis* Interval Zone. Moreover, the *Morozovella angulata /Globanomalina pseudomenardii* Interval Zone and *Globanomalina pseudomenardii* Total Range Zone were further subdivided into two subzones each. The description and discussion of these biostratigraphic zones is given as below.

5.2.1 *Morozovella angulata /Globanomalina pseudomenardii* (P3) Interval Zone

The Zone P3 of Berggren and Norris (1997) and Olsson et al. (1999) is defined as the interval zone between the first appearance datum (FAD) of *Morozovella angulata* and the FAD of *Globanomalina pseudomenardii*. They also subdivided Zone P3 into Subzones P3a and P3b using the FAD of *Igorina albeari*. In this paper, however, I cannot use their subzones because the occurrence of *I.*

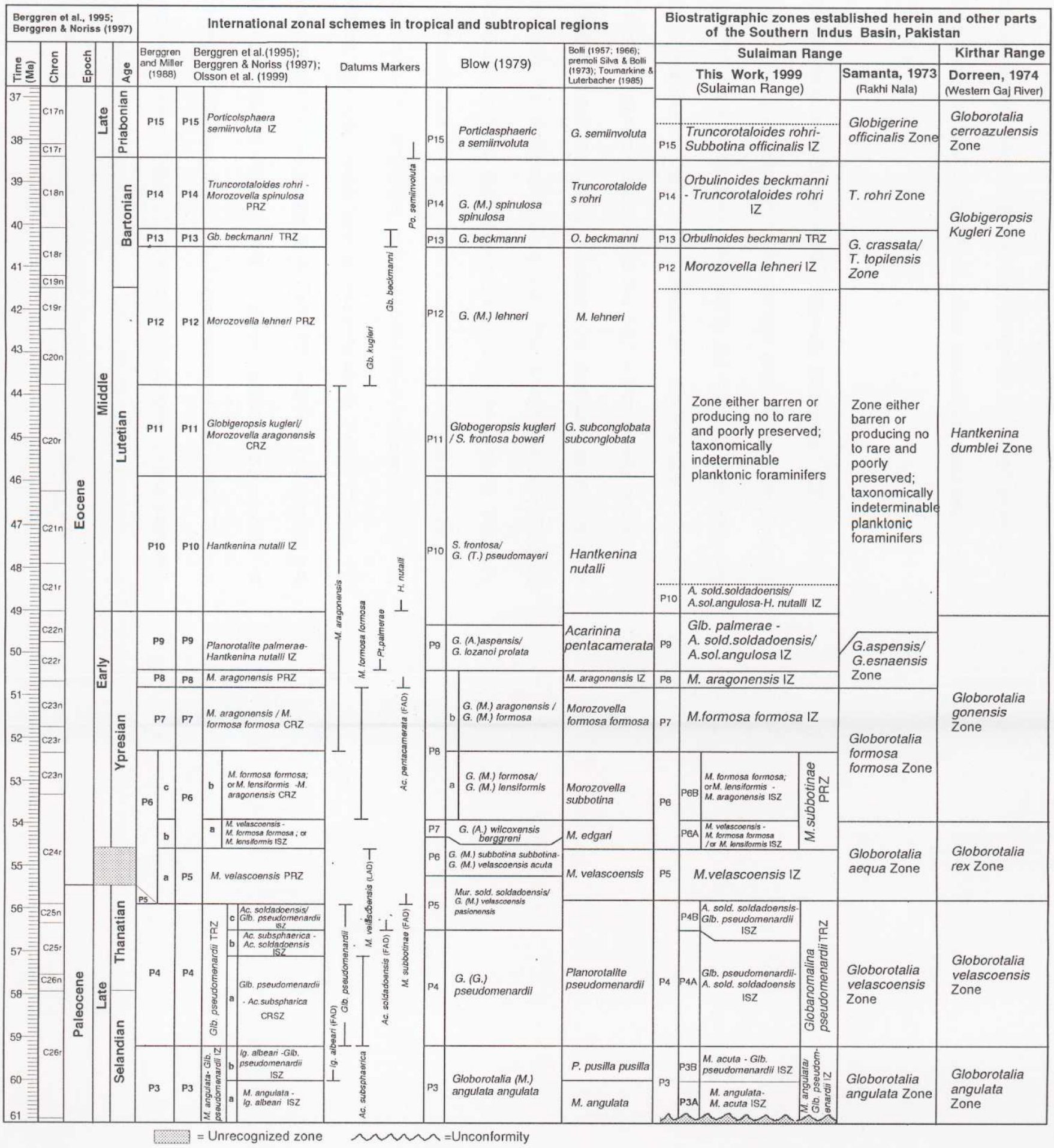

Figure 12. Correlation of the planktonic foraminiferal zones established in the Sulaiman Range (this work) with internationally recognized zonal schemes of Bolli, 1957; Premoli Silva & Bolli, 1973; Blow, 1979; Toumarkine and Luterbacher, 1985; Berggren and Miller, 1988; Berggren et al., 1995; Berggern and Noriss, 1997, and Olsson et al., 1999. Correlation with biostratigraphic zones of Samanta (1973) and Dorreen (1974) established in the Sulaiman and Kirhtar, respectively, is also given.

albeari is sporadic and limited within two intervals, as the upper part of Zone P3 in the western side and Zone P4 in the eastern side of the Zinda Pir Anticline, and in the Rakhi Nala section. Instead, I defined two new subzones described below, using the FAD of *M. acuta.*

5.2.1.1 *Morozovella angulata -M. acuta* (P3A) Interval Subzone

Definition. The lower boundary of this zone is not defined in the Zinda Pir area because of the missing sequence (Figures 9, 10). In the Rakhi Nala, the lower portion of the sequence does not produce any determinable planktonic foraminifera. The upper boundary is placed on the FAD of *Morozovella acuta.*

Occurrence. Recognition of this subzone is restricted to the western section of the Zinda Pir Anticline (Figure 10). The specimens of planktonic foraminifers in this zone are not abundant, ranging only from 20 to 76. The rare occurrence of *M. angulata* is observed in sample ZPW-1, associated with *Globanomalina imitata, Glb. compressa*, and *Subbotina triloculinoides.*

Correlation and age. I used here *Morozovella acuta* (Figure 15-1–5, 10) as a boundary marker for the two subzones of Zone P3. The FAD of *M. acuta* is a reliable datum in the tropical regions and is placed within Subzone P3b of Berggren and Norris (1997) and within the *Planorotalites pusilla pusilla* Zone of Toumarkine and Luterbacher (1985). The other index species in the Dunghan Formation is *Glb. compressa,* which disappears within Zone P3a of Berggren and Norris (1997). The absence *M. acuta* and co-occurrence of *M. angulata* and *Glb.*

compressa in this area indicate that Subzone P3A defined here corresponds to the interval between Subzone P3a and the lower part of Subzone P3b of Berggren and Norris (1997) and Olsson et al. (1999). Hence, the age of Subzone P3A is assigned to the late Paleocene (Selendian).

5.2.1.2 *Morozovella acuta–Globanomalina pseudomenardii* (P3B) Interval Subzone

Definition. The interval between the FAD of the *Morozovella acuta* to the FAD of *Globanomalina pseudomenardii.*

Occurrence. This subzone is observed in the samples in samples R-23 and R-28 from Rakhi Nala section. Samples ZPW-5 to ZPW-16 from the western section of the Zinda Pir Anticline represents this subzone whereas it was not recognized from the Zinda Pir easten section.

Correlation and age. The fauna of this subzone consists abundantly of *Morozovella* forms (*acuta, apanthesma, occlusa,* and *velascoensis*). These species and other three species (*Globanomalina ehrenbergi, Igorina pusilla,* and *Subbotina triangularis)* first appear in sample ZPW-5 and R-23 from Zinda Pir west and Rakhi Nala, respectively. This subzone is correlated with the upper part of Subzone P3b of Berggren and Norris (1997) and Olsson et al. (1999), and *P. pusilla pusilla* Zone of Toumarkine and Luterbacher (1985). The age of this zone is the late Paleocene (Selendian).

5.2.2 *Globanomalina pseudomenardii* (P4) Total Range Zone

The total range of *Globanomalina pseudomenardii* (Zone P4) is recognized as an excellent stratigraphic marker in many tropical regions (e.g. Bolli and Krasheninnikov, 1977; Toumarkine and Luterbacher, 1985). In the studied sections, the FAD of *Globanomalina pseudomenardii* was found in sample ZPE-14 in the eastern section of the Zinda Pir Anticline and in R-25 from the Rakhi Nala section. The last appearance datum (LAD) of the *Glb. pseudomenardii* was observed in all three sections, both east and west sides of the Zinda Pir Anticline (sample ZPE-20, sample ZPW-21, respectively) and Rakhi Nala section (sample R-30). Some 25 species belonging to five genera were identified in this zone, and the total number of planktonic species for the unit volume of sediment increases upward between 200-300 specimens in this zone.

Berggren and Norris (1997) used the respective FADs of *Acarinina subsphaerica* and *A. soldadoensis soldadoensis,* and subdivided their Zone P4 into three subzones (P4a, P4b and P4c). However, I cannot apply this definition in this area, because the stratigraphic ranges of both *A. subsphaerica* and *A. soldadoensis soldadoensis* overlap in the Zinda Pir western section and in the Rakhi Nala section. Olsson et al. (1999) has also demonstrated that the stratigraphic range of *Acarinina subspaerica* may extend upwards, close to Zone P4/P5 boundary. Therefore, I do not here use *A. subsphaerica* as an index marker. Instead, using the FAD of *A. soldadoensis soldadoensis* (Figure 13-6, 11–15), I subdivided Zone P4 into two subzones P4A and P4B as follows.

5.2.2.1 *Globanomalina pseudomenardii–Acarinina soldadoensis soldadoensis* (P4A) Interval Subzone

Definition. This zone is defined as an interval zone between the FAD of *Glb. pseudomenardii* and the FAD of *Acarinina soldadoensis soldadoensis*.

Occurrence. This subzone is recognized from both sides of the Zinda Pir Anticline (samples ZPE-14 to 15 in the east and ZPW-17 to 18 in the west) and from the Rakhi Nala section (samples R-25, R-29).

Correlation and age. The FAD of *A. soldadoensis soldadoensis* is one of the distinctive bio-events in the late Paleocene, which is placed at the Zones P4a/P4b boundary of Berggren and Norris (1997) and Olsson et al. (1999) or within the *Planorotalites pseudomenardii* Zone of Toumarkine and Luterbacher (1985). Moreover, other species assemblage recovered from this zone, except *A. subsphaerica*, suggest that this subzone correspond to Zone P4a of Berggren and Norris (1997) and Olsson et al. (1999). The age of this zone is the late Paleocene, ranging from the latest Selendian to early Thanetian. In the Dunghan Formation, two species of *Igorina* (*albeari, pusilla*) and *Parasubbotina varianta* disappear within this subzone.

5.2.2.2 *Acarinina soldadoensis soldadoensis–Globanomalina pseudomenardii* (P4B) Interval Subzone

Definition. The interval between the FAD of *A. soldadoensis soldadoensis* and the LAD of *Glb. pseudomenardii.*

Occurrence. This subzone is found in samples ZPE-15 to 20 from the east and ZPW-19 to 21 from the west of the Zinda Pir Anticline. In the Rakhi Nala, samples R-29 to R-30 represent this subzone.

Correlation and age. This subzone is equivalent to the joint interval of Subzones P4b and P4c of Berggren and Norris (1997) and Olsson et al. (1999). The age of this subzone is the late Paleocene (Thanetian). In the Dunghan Formation, *Morozovella angulata* and *Globanomalina ehrenbergi* disappear within Subzone P4B, and the LAD of *M. apanthesma, M. conicotruncata, A. mckannai, I. tadjikistanensis, S. triloculinoides,* and *Globanomalina ehrenbergi* were placed at the top of Subzone P4B.

5.2.3 *Morozovella velascoensis* (P5) Interval Zone

Definition. The definition of Zone P5 is the interval zone between the FAD of *Globanomalina pseudomenardii* and the LAD of *Morozovella velascoensis* (e.g. Berggren and Norris, 1997). The base of this zone is found in all the three sections, while the upper limit is not clear in Zinda Pir Anticline as the sequence in the uppermost part of the Dunghan Formation consists of hard siltstone intercalated with limestone produce no foraminifera. This is because of an unconformity between the Dunghan Formation and the overlying Shaheed Ghat Formation. However, the upper limit of this zone is marked by the LAD of *Morozovella velascoensis* in the Rakhi Nala section (sample R-26).

Occurrence. This zone is represented by samples ZPE-20 to 26 in the east, and samples ZPW-21 and 22 in the west of the Zinda Pir Anticline, respectively. From the Rakhi Nala section, it is represented by sample R-26.

Correlation and age. The assemblage of planktonic foraminifers in the Dunghan Formation contains some index species of the latest Paleocene to early Eocene. They are *Morozovella subbotinae, M. formosa gracilis, Acarinina wilcoxensis* and *Pseudohastigerina wilcoxensis*, which appear first in the uppermost part of the Dunghan Formation. In particular, the FADs of *Pseudohastigerina wilcoxensis* and *A. wilcoxensis* were reported to be placed just above or below the Paleocene/Eocene boundary in tropical regions (Berggren, 1969; Stainforth et al., 1975; Beggren and Aubry, 1996). Therefore, the assemblage recovered from the upper part of the Dunghan Formation is assigned to the Zone P5 of Berggren and Norris (1997) and Olsson et al. (1999). The age of this zone ranges from the latest Paleocene to earliest Eocene.

The Paleocene/Eocene boundary is probably placed within the limestone beds containing larger foraminifers between samples ZPE-20 and 26 in the east, and between samples ZPW-21 and 22 in the west. In the Rakhi Nala section, the Paleocene/Eocene boundary lies clearly in the siltstone unit between sample R-32 and R-33 evidenced by the benthic foraminiferal extinction event (personal communication, 1999, Dr. Ritsu Nomura, Shimane University, Japan).

5.3 Eocene Zonation

A total of nine biostratigraphic zones of Eocene age established in the international zonal schemes, were recognised from the marine sedimentary sequence of the Sulaiman Range. These are here given in ascending order: *Morozovella subbotinae* Partial Range Zone, *Morozovella formosa formosa* Interval Zone, *Morozovella aragonensis* Interval Zone, *Globanonomalina palmerae/ A. soldadoensis soldadoensis/A. sold. angulosa* Interval Zone, *A. soldadoensis soldadoensis/A. sold. angulosa - H. nutali* Interval Zone, *Morozovella lehneri* Interval Zone, *Orbulinoides beckmanni* Total Range Zone, *Orbulinoides beckmanni -Truncorotaloides rohri* Interval Zone, and *Truncorotaloides rohri–Subbotina officinalis* Interval Zone. Among them four zones: *Morozovella subbotinae* Partial Range Zone, *Morozovella formosa formosa* Interval Zone, *Morozovella aragonensis* Interval Zone and *Globanonomalina palmerae/A. soldadoensis soldadoensis/A. sold. angulosa* Interval Zone belong to early Eocene age. The zone *Morozovella subbotinae* Partial Range Zone was further divided into two subzones each. Four biostratigraphic zones: *A. soldadoensis soldadoensis/A. sold. angulosa–H. nutali* Interval Zone, *Morozovella lehneri* Interval Zone, *Orbulinoides beckmanni* Total Range Zone and *Orbulinoides beckmanni –Truncorotaloides rohri* Interval Zone belong to middle Eocene and only one zone (*Truncorotaloides rohri – Subbotina officinalis* Interval Zone to early late Eocene age.

5.3.1 *Morozovella subbotinae* (P6) Partial Range Zone

Definition. Biostratigraphic interval defined by the partial range of the nominate taxon between the LAD of *M. velascoensis* and FAD of *M. aragonensis.*

The interval between the LAD of *M. velascoensis* and FAD of *M. aragonensis* is very distinctive and is recognized by several workers (Stainforth et al., 1975; Berggren et al. 1995 and Berggren and Norris, 1997, etc.). However, the subdivisions of the time more or less equivalent to this interval are introduced and interpreted in different ways by different authors. Primoli Silva and Bolli (1973), Toumarkine and Luterbacher (1985) established *M. edgari* interval zone between the LAD of *M. velascoensis* and the LAD of *M. edgari* which is reported missing in the original Trinidad zonation due to a faunal gap (Bolli 1957, Luterbacher 1964, Primoli Silva and Bolli 1973, Stainforth et al., 1975 and Blow, 1979). Recently Berggren et al. (1995), Berggren and Norris (1997), and Olsson et al. (1999) after discovering that the FAD of *M. subbotinae* and LAD of *Glb. pseudomenardii* are juxtaposed have revised their previous concept about the existence of the gap between the two (Berggren and Miller, 1988).

In the present study, the FAD of *M. subbotinae* and the LAD of *Glb. pseudomenardii* were found juxtaposed in Zinda Pir west section whereas the FAD of *M. subbotinae* was slightly higher in rest of the two sections.

5.3.1.1 *Morozovella velascoensis-M. formosa formosa/lensiformis* (P6A) Interval Subzone

Definition. Biostratigraphic interval between the LAD of *M. velascoensis* and FAD of *M. formosa formosa/ lensiformis.*

Occurrence. It is represented by samples R-26, R-27 and R-33 from the Rakhi Nala section (Figure 8), however, this zone was not recognized from the Zinda Pir Anticline sections. The LAD of the late Paleocene index species *(M. velascoensis)* along with six other species (*I. tadjikistnensis, M. acutispira, M. conicotruncana, M. apanthesma, S. triloculinoides,* and *Glb. imitata)* were observed in sample R-26. Moreover, five species (*A. pseudotopilensis, I. broadermanni, M. edgari, Pseudohastigerina wilcoxensis* and *S. patagonica*) also show their first appearance at the base of this subzone.

Correlation and age. The FADs of *M. formosa formosa* and *M. lensiformis* are used as the upper limit of this subzone by Berggren and Miller (1988), Berggren et al. (1995) and Berggren and Norris (1997). Here I also follow the same concept for the twofold (P6A, P6B) subdivision of Zone P6. Based on the occurrence of *Pseudohastigerina wilcoxensis* and *M. edgari,* this subzone can be correlated exactly with *M. edgari* zone of the Primoli Silva and Bolli (1973), and Toumarkene and Luterbacher (1985), to the *G. aequa* zone of Luterbacher (1964), to the lower part of Subzone P6b (*G. subbotinae / Pseud. wilcoxensis*) of Blow (1969), Berggren and Van Couvering (1974), and to the combined P6 (upper part) and Zone P7 (*G (A.). wilcoxensis berggreni* partial range zone of Blow (1979).

The age of this Subzone P6A is the earliest Eocene (earliest Ypresian)

5.3.1.2 *M. formosa formosa/lensiformis–M. aragonensis* (P6B) Interval Subzone

Definition. Biostratigraphic interval between the FAD of *M. formosa formosa/ lensiformis* and of the FAD of *M. aragonensis.*

Occurrence. Samples R-33 to R-34 represent this Subzone from the Rakhi Nala section. From the Zinda Pir Anticline, samples ZPE-26, ZPE-35 and ZPE-36 from the eastern limb whereas sample ZPW-23 from western section respectively, represent this zone. Well-preserved and abundant planktonic foraminifers occur in this Subzone.

Correlation and age. Most of the species found in this Subzone range up from the underlying zones. This subzone is exactly correlated with P6b and P6c of Berggren and Miller (1988), and Berggren and Norris (1997), respectively. This zone is also equivalent to the *M. subbotinae* Zone of Bolli (1957), Primoli Silva and Bolli (1973), Toumarkine and Luterbacher (1985), and to the P8a [*G. (M.) formosa// G. (M.) lensiformis*] of Blow (1979). The age of this subzone is the early Eocene (early Ypresian).

5.3.2 *Morozovella formosa formosa* (P7) Interval Zone

Definition. The interval between the FAD of *M. aragonensis* and the FAD of *Acarinina pentacamerata.*

Occurrence. This zone is represented by samples R-34 to R-36 producing well-preserved planktonic foraminifers. Samples ZPE-37, ZPE-38, ZPE-

39 and ZPW-24, ZPE-26 from Zinda Pir east and west respectively, represent this subzone.

Correlation and age. Biostratigraphic interval between the FAD of *M. aragonensis* and *Acarinina pentacamerata* has worldwide recognition (Primoli Silva and Bolli, 1973; Stainforth et al., 1975; Blow, 1969; Berggren and Van Couvering, 1974; Toumarkene and Luterbacher, 1985. However, Berggren and Miller (1988) and Berggren et al. (1995) have modified the definition of their Zone P7 while taking the LAD of *M. formosa formosa* instead of FAD of the *A. pentacamerata.* I cannot use this concept as I have found *M. formosa formosa* and *A. pentacamerata* overlapping in all three section of the Sulaiman Range. The age of this zone is the middle early Eocene (middle Ypresian).

5.3.3 *Morozovella aragonensis* (P8) Interval Zone

Definition. The interval between the FAD of *Acarinina pentacamerata* and the FAD of *Globanomalina palmerae.*

Occurrence. This zone is represented by samples R-36 to R-41. Samples ZPE-40 to 47 from the Zinda Pir east and ZPE-26, ZPE-27 from the Zinda Pir west respectively, represent this zone. A very rich planktonic foraminiferal assemblage including *Globanomalina rakhiensis* sp. nov. was recorded from this zone.

Correlation and age. The FADs of *Glb. palmerae* and *Turborotalia cerroazulensis frontaosa* are recognized internationally to mark the upper limit of this zone (Bolli, 1957; Primoli Silva and Bolli, 1973; Stainforth et al., 1975; Blow,

1969; Berggren and Van Couvering, 1974; Toumarkene and Luterbacher, 1985; Berggren and Miller, 1988; Berggren et al.,1995).

The age of this zone is the late early Eocene (late Ypresian).

5.3.4 *Globanomalina palmerae-A. soldadoensis soldadoensis/ soldadoensis angolosa* (P9) Interval Zone

Definition. First appearance datum of *Glb. palmerae* is taken as the base of this biostratigraphic interval and the upper limit is marked by the LAD of the *A. soldadoensis soldadoensis/ A. soldadoensis angulosa.*

Occurrence. This zone is recognized in all three sections. From Rakhi Nala section, samples R-57 and R-70 represent this zone whereas samples ZPE-47. ZPE-49, and ZPW-28, ZPW-29, ZPW-30, ZPW-31, ZPW-32, ZPW-34, ZPW-35, ZPW-36, ZPW-37 represent it from Zinda Pir east and Zinda Pir west, respectively.

Correlation and age. Biostraigraphic interval between the FAD of *Glb. palmerae/ T. cerr. frontosa* and the FAD of the *Hantkenina* species has an international recognition, however, different names and boundary criteria have been used. Corresponding to this interval, Krasheninnikove (1957) first established *Globorotalia pentacamerata* Zone, it was also recognized by Stainforth et al. 1975. This zone was later modified as *Acarinina pentacamerata* (Toumarkine and Luterbacher, 1985). Berggren and Miller (1988) established *Subbotina inaquispira* Partial-range Zone is equivalent to which they later established *Planorotalite palmerae-H. nutalli* Interval zone (Berggren et al. 1995). Blow (1979) established

G (A) aspensis/ Globigerina lozanoi prolata Concurrent-range Zone that is equivalent to lower part of the mentioned interval.

In the Sulaiman Range, all three section produce well preserved *Globanomalina palmerae* species which (FAD) is hereby taken as base of this zone. However, any *Hantkenina* species was not identified (recovered) from the sequence exposed in the Sulaiman Range, therefore in order to define the top of this zone, *A. sold. soldadoensis/ A. sol. angulosa* were used. Almost all of the workers have described the age of these two species range till the first appearance of any *Hantkenina* species. Stainforth et al. (1975) has also suggested that the LAD of the *A. soldadoensis soldadoensis* can be used as alternative criteria to define the upper limit of this zone.

The reported age of this zone is late early Eocene (latest Ypresian).

5.3.5 *A. soldadoensis soldadoensis/ A. soldadoensis angulosa- Hantkeninia nutali* (P10) Interval Zone

Definition. The base of this zone is taken as the LAD of *A. soldadoensis soldadoensis/ A. soldadoensis angulosa,* however, the upper limit is not defined as herein the Sulaiman Range, sequence above it do not produce any determinable planktonic foraminifera.

Occurrence. This biozone is represented by samples R-76 and R-83 from the Rakhi Nala section whereas from the Zinda Pir Anticline by samples ZPE-77, ZPE-82 and ZPW-38, ZPW-39 from east and west limbs, respectively.

Correlation and age. After Bolli (1957) who used the total range of the *Hantkenina aragonensis* (has longer range outside the Trinidad), Stainforth et al.

(1975) described *Hantkenina aragonensis* Interval Zone between the FAD of the *Hantkenina aragonensis* to FAD of *Globigerinatheka mexicana.* Toumarkine and Luterbacher (1985) described *Hantkenina nutalli* Interval Zone, Berggren and Miller (1988) *Hantkenina nutalli* Partial Range Zone and later Berggren et al. (1995) established *Hantkenina nutalli* Interval Zone.

In the Sulaiman Range, the overlying sequence do not produce any identifiable planktonic foraminifera, therefore, this zone corresponds to the lowermost part of these zones.

The age of the this zone is early middle Eocene (Lutenian)

5.3.6 *Morozovella lehneri* (P12) Partial Range Zone

Definition. Biostraigraphic interval characterized by the partial range of the nominate taxon between the LAD of *M. aragonensis* and FAD of the *Orbulinoides beckmanni.*

Occurrence. This biostratigraphic interval is recognized from both Rakhi Nala and Zinda Pir areas. Samples Rk-21, Rk-22 and Rk-23 from the Rakhi Nala section, samples, ZPE-115, ZPE-116, and ZPW-61 from Zinda Pir east and west respectively, represent this zone.

Correlation and age. The biostratigraphic interval characterized by the LAD of *M. aragonensis* and FAD of *Orbulinoides beckmanni* is very distinctive and has worldwide recognition. Some workers have defined this interval as partial range zone following the same definition (Blow 1979; Berggren and Miller, 1988;

Berggren et al., 1995) whereas others have defined it as interval zone (Stainforth et al., 1975; Toumarkine and Luterbacher, 1985).

The worldwide recognized and reported age of this zone is middle Eocene (Lutetian-early Bartonian)

5.3.7 *Orbulinoides beckmanni* (P13) Total Range Zone

Definition. This biostratigraphic interval characterized by the total range of the nominate taxon.

Occurrence. This bio-interval is recognized from the Rakhi Nala section very clearly, however, it was not recognized from the Zinda Pir sections. In the Rakhi Nala section, it is represented by samples Rk-24, Rk-27 and Rk-30. From Zinda Pir east sample ZPE-117 and from Zinda Pir west sample ZPW-62 represent this zone. Although, *O. beckmanni* occurred sporadically in the Zinda Pir sections, however, data is insufficient to construct a separate bio-zone along Zinda Pir east. This zone is established in Zinda Pir west section using other associated fauna.

Correlation and age. Total range of this very distinctive species has been used and recognized as reliable index for the Zone *Orbulinoides beckmanni.* Bolli (1957) named this zone as the *Porticulasphaera mexicana* Zone later changed as *Orbulinoides beckhmanni* (Cordy 1968; Blow and Salto, 1868). Toumarkine and Luterbacher (1985) have revealed that this species is found usually missing in lower latitudes and have suggested the use of *Turborotalia* lineage as an alternative. This zone corresponds to P13 Zone of Stainforth et al.

(1975); Blow (1979), Berggren and Miller, (1988), Berggren et al., (1995), and to *Orbulinoides beckmanni* Zone of Toumarkine and Luterbacher (1985).

The world wide reported age of this biostratigraphic interval is late-middle Eocene (Bartonian).

5.3.8 *Orbulinoides beckmanni-Truncorotaloides rohri* (P14) Interval Zone

Definition. The interval between the last appearance of *Orbulinoides beckmanni* and last appearance of the *Truncorotaloides rohri.*

Occurrence. This biostratigraphic interval is recorded from all three sections. In the Rakhi Nala section, samples Rk-31, Rk-40 and Rk-41 represent it. From the Zinda Pir Anticline, samples ZPE-119, ZPE-121, and ZPE-124 from the eastern limb whereas samples ZPW-65, ZPW-66 from the western limb, respectively, represent this zone.

Correlation and age. This zone was originally described by Bolli (1957) from the Trinidad section, and later this interval has received worldwide recognition. Stainforth et al. (1975) and Toumarkine and Luterbacher (1985), have used the same definition as emloyed by Bolli (1957), however, Blow (1979), Berggren and Miller (1988), and Berggren et al., 1995 have named same biostratigraphic interval as the *Truncorotaloides rohri–Morozovella spinulosa* Partial Range Zone. They have used the partial ranges of the nominate taxa between the LAD of the *Orbulinoides beckmanni* and FAD of the *Porticulasphaera seminivoluta.* In my samples, *Globigerinatheka seminivoluta* was not found and thus I have also applied the same concept as that of the Bolli (1957). Moreover,

Stainforth et al. (1975) have suggested that in normal marine sequence abrupt disappearance of all conspicuously spinose to hispid species of planktonic foraminifera mark the top of this zone. In the Sulaiman Range material, also similar results were observed as made by Stainforth et al. (1975).

The assigned age of this zone is late middle Eocene (late Bartonian).

5.3.9 *Truncorotaloides rohri –Subbotina officinalis* (P15) Interval Zone

Definition. The biostraigraphic interval characterized by the last occurrence of the *Truncorotaloides rohri* to the last occurrence of *Subbotina officinalis.*

Occurrence. This bio-zone is recognized from all three section of the Sulaiman Range. In the Rakhi Nala, samples RK- 43, RK-44 and RK-45, from the Zinda Pir Anticline, samples ZPE-128, ZPE-130 from eastern side and sample ZPW-70 from western side, respectively, represent this biostratigraphic interval.

Correlation and age. Different workers have defined this zone differently. Originally Bolli (1957) described the *Globigeropsis semiinvoluta* Zone as an interval between the LAD *of Truncorotaloides rohri* and LAD of *Globigeropsis semiinvoluta.* Later Proto Decima and Bolli (1970) modified the name of this zone as *Globigerinatheka semiinvoluta* using same definition. A similar definition was used by Stainforth et al. (1975) and Toumarkine and Luterbacher(1985). However, Blow (1979) defined it as the *Globigeropsis semiinoluta* Partial Range-Zone between the FAD of the *Porticulasphaera semiinoluta* and FAD of the *Cribrohantkenina inflata.* Berggren and Miller (1988) redefined by Berggren et al.

(1995) as the *Porticulasphaera semiinoluta* Interval Zone as an interval between the FAD of the *Porticulasphaera semiinoluta* FAD of the *Turborotalia cunialensis.*

In the Sulaiman Range, *Globigerinatheka semiinoluta* found missing and therefore the base of the zone is taken as the LAD of the *Truncorotaloides rohri* and the top is tentatively marked by the LAD of the *Subbotina officinalis* due to the poor fauna recovered from the uppermost horizons of the Kirthar Formation (Drazinda Member). Moreover, top of this zone can not be defined as there exists an unconformity immediately above samples RK-45 in Rakhi Nala, ZPW-70 and ZPE-145 from Zinda Pir Anticline.

The age of this zone is early-late Eocene (late Bartonian to early Priabonian).