UNIVERSITY OF RAJASTHAN

STUDIES IN SCIENCE

1968-69

Published by the

SCHOOL OF NATURAL SCIENCES
UNIVERSITY OF RAJASTHAN
JAIPUR

CONTENTS

ECOLOGICAL STUDIES OF DESERT PLANTS CENCHRUS BIFLORUS ROXB.

B. M. Sharma
Department of Botany,
Government College, Sikar (Rajasthan).

1. Introduction :

In the present paper ecology of *Cenchrus biflorus* Roxb. has been described and an attempt made to determine the relationship between the mineral content of its healthy leaves and quantity of available nutrients. A study of its rooting habit on sandy soils has also been made. The present investigation was carried out around Churu town in Bikaner Division of Rajasthan during the year 1960–62. The town lies between 73°5' to 75°5E longitude and 27°5' to 29°0' N latitude. There is a vast expanse of sand all around the town with accumulations at many places leading to the formation of dunes.

2. Methods of study :

Five soil pits 75 cm. to 90 cm. deep were dug near the plant at various spots during the monsoon months in order to study the soil profiles. Soil samples were collected at the surface, 15 cm., 30 cm., 45 cm. and 60 cm. depth from the exposed profiles. The soils were oven dried after collection and analysed. The results have been expressed on the oven dry basis. They were then passed through a finer sieve and packed in polythene bags for chemical analysis. Chemical analysis of the various soil samples was done according to the methods suggested by Piper (1944). Samples were analysed for exchangeable calcium, magnesium, potassium, sodium, phosphorus, total nitrogen, total carbonates and organic carbon. In addition to these pH and loss on ignition were also determined. Potassium was determined by cobaltinitrite method. Results have been expressed as milli equivalents per 100 g. of over dry soil. Klett summerson photo electric colorimeter was used to find out the water soluble phosphorus. Total nitrogen was determined by the Kjeldahl method using selenium as catalyst. Total carbonates were found by the

rapid titration method. Organic carbon was determined by the Walkley and Blacks method of rapid titration. Soil pH was determined in a 1 : 5 suspension by the Cambride pH meter using calomel and glass electrodes. Loss on ignition and nitrogen were determined for the samples from surface and 15 cm. depth while organic carbon was obtained only for the surface soils.

Leaf samples were collected at the time as soil samples from the plant growing at five different sites. The plant was in the flowering stage at the time of collection. Only fully developed and healthy leaves were collected. The samples were dried, ground into fine powder and transferred to bottles. Samples were analysed for calcium magnesium, potassium, sodium and phosphorus. In addition to these ash and silica contents were also determined.

Trench method (Weaver, 1954) was used in excavating the root system both on the sandy plain and sandy dunes. A 90 cm. deep trench was dug around the plant and the whole central soil mass was removed. During this operation, ofcourse the upper dry sand particles fell away automatically but the lower portion remained intact. The roots were separated from the soil mass by first loosening them by dipping in water for some time and then gently pouring water over it which resulted in the complete root system left behind. The root systems were then photographed. Information recorded for each root system included (a) soil character and depth, (b) size and condition of the plant tops, (c) length, depth of penetration and radial spread of roots, (d) moisture contents of the plant tops and roots.

3. Morphology, Distribution and Association :

Cenchrus biflorus Roxb. is an annual grass very common in the area during rainy season The stem is cylindrical, glabrous and tufted. The leaf is alternate, simple, linear-lanceolate and sheathing at the base. The flowers are arranged in a spike, lower spiklets are one flowered and upper two to three. Bristles are hard and numerous. The seeds of this grass are eaten in times of famine in Africa (Bor, 1960). In the area under investigation also, certain tribes eat them in acute famine.

The morphological measurements of the plant growing on dune tops, sandy plains and dune lows have been presented in table 1.

Table 1

Morphological measurements of *Cenchrus biflorus* Roxb.

S.No	Habitat..	Height cm.	Leaf size cm.	Inflo rescence length cm.	Glume size mm.	Palae size mm.	Fruit size mm.
1.	Dune tops	19	6 8	6.1	1.4	1.8	1.9
2.	Sandy Plains	22	7 2	6.3	1.5	2.0	2 0
3.	Dune lows.	37	14.3	11.1	2.0	2.4	2 4

A study of the above table reveals that the plant has a better growth when it is growing in dune lows. This is followed by the sandy plains. Dune tops are comparatively unfavourable habitats.

Cenchrus biflorus Roxb. is a species well distributed in Arabia and Tropical Africa. In India it is common in Punjab, upper Gangetic plain and Rajasthan. (Hooker, 1872-97; Cooke, 1958; and Duthie, 1960).

The main plant species that were growing associated with *Cenchrus biflorus* Roxb. included *Cyperus arenarius* Retz.. *Calligonum polygonoides* Linn. *Gisekia pharnacioides* Linn.; *Leptadenia pyrotechnica* Decne ., *Urochloa panicoides* Beauv. etc. (Sharma, 1962).

4. Soil Analysis :

Table 2 gives details of certain properties of soil supporting *Cenchrus biflorus* Roxb. Description of various profiles is given below.

Cenchrus biflorus Roxb.

Profile 1

The soil colour is yellowish brown throughout the profile. Calcium is low in all the horizons. Magnesium decreases with depth though with a higher value at the 60 cm. horizon. Potassium also behaves similarly but with a higher value at the 30 cm. Phosphorus is almost constant throughout the profile. Sodium alternately decreases in the various horizons. There is a higher carbonate content at the 30 cm. and 45 cm. depth while it is absent or low in the other horizons. Nitrogen is higher in the surface layer of the soil. Organic carbon is absent in the top layer. The soil reaction is alkaline.

Profile 2.

The soil colour is yellowish brown throughout the profile. The calcium and magnesium contents decrease at the 15 cm. depth and remain constant upto 30 cm. but finally increase in the lower horizons. Potassium increases in the 15 cm. herizon and then falls continuously with a rise at the 60 cm. depth. Phosphorus increases slightly with depth. Sodium continues to increase upto the 30 cm. depth, falls at the 45 cm. layer and again rises in the lower horizon. A high carbonate content exists in the lower layers. Organic carbon is absent in the top soil. The soil reaction is alkaline.

Profile 3.

The soil colour is light yellowish brown at the surface and the 60 cm. horizon; pale brown at 45 cm. horison and yollowish brown in the rest. Calcium and sodium increase with depth with a slight fall at the 15 cm. depth. Magnesium falls in the 15 cm. and 60 cm. layers but remains constant at the 30 cm. and 45 cm. depths. Potassium increases with depth, though a fall is observed at the 15 cm. and 60 cm. horizons. Phosphorus is constant upto the 30 cm. depth. Its value then falls and again becomes constant upto the 60 cm. depth. Carbonates and nitrogen are higher in the deeper layers. The C/N ratio is 0.64 and the soil reaction is alkakaline.

Profile 4.

The soil colour in this profile varies from very pale *brown* in the top to light yellowish brown in the deeper layers. Calcium increases with depth though with a fall at the 30 cm. depth. The calcium content at the 15 cm. and 60 cm. depth is equal. Magnesium is higher at the surface layer, otherwise it is low and constant in other horizons excepting at the 45 cm. depth where it rises high. Pottassium after a slight fall at the 15 cm. depth increases and again decreases in the deeper layers. Phosphorus is constant throughout with a lower value in the 60 cm. horizon. There is a higher sodium content in this profile, Carbonates increase with depth. Nitrogen is higher at the 15 cm. depth. The C/N ratio comes to 0.54. The soil reaction is alkiine.

Profile 5.

The soil colour is yellowish brown throughout the profile. Calcium and Potassium increase with depth with a fall at 45 cm.

depth. Magnesium and sodium alternately increase or decrease in the various horizons. Phosphorus is constant upto the 45 cm. depth but rises below. Carbonates are higher in the surface layer and decrease below. There is a bit higher nitrogen content at the 15 cm. depth Organic carbon is absent in the top soil. The soil reaction is alkaline.

5. Foliar analysis :

The result of foliar analysis is summarized in table 3. The ash content varies from 11.2 to 17.0%. Calcium is found to range from 1.0 to 2.4% and potassium from 2.9 to 4.0%. Sodium and Silica content vary from 1.0 to 4.0%. Phosphorus is less than 1.0%. However, the species is fairly rich in nitrogen which varies from 1.33 to 6.93%.

6. Root System :

The plant possessed a fibrous root system. The roots were coarse and penetrated nearly vertically downwards to a length of 27.3 cm. in the species growing on plains and 44.4 cm. in the dune species (Table 4). The roots branched profusely but the laterals were quite short and slender. The colour of the roots was white with a brownish tinge. The roots were slightly longer the stem height.

7. Discussion :

Cenchrus biflorus Roxb. is a dominant grass species of the area under investigation. The soils under this plant are mostly yellowish brown occasionally being light yellowish brown or pale brown. They are coarse, sandy and alkaline. Their calcium content varies from 0.85 to 6 3 m.e % and magnesium from 0.34 to 4.78 m e.% Potassium ranges from 1.29 to 3.67 m.e.%. It increased with depth in most of the profiles studied, phosphorus and nitrogen were poor in the habitats supporting the species. Phosphorus was more or less constant at various depths. Nitrogen was higher in the subsoil in case of the species growing on sandy plains while reverse was the case in the dune species. There was very little organic carbon in the soils supporting the species. Loss on ignition was higher at the 15 cm. depth. The organic carbon determinations in this case confirm that the organic carbon was nil in three and upto the extent of 0.09% in the remaining two habitats. The maximum amount of carbonates observed was 6.5%. They increased with depth.

Foliar analysis of *Cenchrus biflorus* Roxb. reveals that it is rich in ash and silaca. It has a high sodium content and is fairly rich in magnesium and nitrogen contents. As it is rich in sodium it may probably be utilised in reclaiming the saline soils and may also be tried along with other plants capable of absorbing high amounts of sodium in afforestation of calcium poor soils.

The copious development and intensive ramification of the fibrous roots of *Cenchrus biflorus* Roxb. serve a very useful purpose and make more than a valuable asset in soil improvement. After the depth of the serial parts an intimate mingling of organic material with the minerals in the soil is achieved and this raises the capacity of the soil for the retention of the rain water and helps to bind the soil particles.

The nutritional status can better be understood by an understanding of the amount of the mineral elements in the leaves and its corresponding quantity in the soil and subsoil (Lundegardh, 1939). Accordingly the relation between foliar and soil elements can be studied. The following correlation can be seen.

1. Foliar calcium, magnesium and potassium increase with a corresponding increase of these elements in the soil exchange.
2. A clear correlation between the foliar sodium, phosphorus and nitrogen with the corresponding elements in the soil could not be established. However, indications do exist which support the idea that the element in the leaves and the soil are positively correlated.

8. Acknowledgements :

I am grateful to Dr. G.S. Puri, Professor of Botany, University of Science and Technology, Kumasi, Ghana under whose guidance the present investigation was carried out. Thanks are due to Dr. S.C. Pandeya, Reader in Botany, University School of Sciences, Gujrat University, Ahmedabad for helpful suggestions.

9. Literature cited :

1. Bor N.L 1960 The grasses of Burma, Ceylon, India and Pakistan. *Pergamon Press, Oxford, London.*

2. Cooke, Theodore 1958 The Flora of the Presidency of Bombay. Vols. 1 to 3. *Bot. Sur. India, Culcutta.*

3. Duthie, J.F. 1960 Flora of the Upper Gangetic Plain. *Bot. Sur. India, Culcutta.*

4. Hooker J.D. 1872–97 Flora of British India. *Vols. 1 to 7., London.*

5. Lundegardh, H. 1943 Leaf analysis as a guide to soil fertility. *Nature, 151 : 310–11.*

6. Piper, C.S. 1944 Soil and Plant Analysis. *Univ. of Adelaide, Adelaide.*

7. Sharma, B.M. 1962 Studies on the vegetation of Arid Zone of India VIII. Composition of some scrub. Communities of Churu, Rajasthan. *Proc. Nat. Acad. Sci., India. 32 : 157–168.*

8. Weaver, J.E. 1954 North American Prairie. *Johnson Publication Co., Lincoln, Nebraska.*

Table 2

Physical and Chemical Characters of soil under *Cenchrus biflorus* Roxb.

Date of Sampling : 10th October, 1960.

Soil pit No. and Habitat	Soil Character		Soil Horizon 0 cm.	15 cm.	30 cm.	45 cm.	60 cm.
(1)	(2)		(3)	(4)	(5)	(6)	(7)
1	Dune						
	Colour		10 YR 5/8 Yellowish brown	10 YR 5/6 Yellowish brown	10 YR 5/6 Yellowish brown	10 YR 5/4 Yellowish brown	10 YR 5/4 Yellowish brown
	pH		8.1	8.1	8.0	8.15	8.0
	Calcium	m e.%	0.92	0 95	0.85	0.85	0.99
	Magnesium	m.e.%	3.35	2 39	1 91	1.67	1 91
	Potassium	m.e %	2.13	1.74	2.05	1.81	1.69

(1)	(2)		(3)	(4)	(5)	(6)	(7)
	Sodium	m.e.%	1.63	1.78	1:69	1 76	1.72
	Phosphorus (Water Soluble)	m.e.%	0 0840	0.0858	0 0887	0.0863	0 0880
	Carbonates	%	0.0	0.5	1.5	1 5	0.0
	Total Nitrogen	%	0.1218	0 0378			
	Loss on Ignition	%	0.82	0.95			
	Organic Carbon	%	0.0				
2	Dune						
	Colour		10 YR 5/4 Yellowish brown	10 YR 5/4 Yellowish brown	10 YR 5/8 Yellowish brown	10 YR 5/4 Yellowish brown	10 YR 5/4 Yellowish brown
	pH		8.15	8.25	8.3	8.25	8.2
	Calcium	m.e.%	1.13	0.92	0 92	1 38	1.34
	Magnesium	m.e.%	0.72	0.48	0.24	1.67	1.67
	Potassium	m.e.%	3.03	3 67	1.93	1.76	2.12
	Sodium	m.e.%	5.72	7.81	8 50	4.96	7.39
	Phophorus (Water Soluble)	m.e.%	0 0830	0.0852	0.1042	0.1052	0.1050
	Carbonates	%	0 0	0.0	2.0	2.0	2.5
	Total Nitrogen	%	0 0504	0 0462			
	Loss on Ignition	%	1.17	1.7			
	Organic Carbon	%	0.0				
3	Sandy plain						
	Colour		10 YR 6/4 Light Yellowish brown	10 YR 5/4 Yellowish brown	10 YR 5/4 Yellowish brown	10 YR 6/3 Pale brown	10 YR 6\4 Light Yellowish brown
	pH		8.3	8.2	8.15	8.15	8.2
	Calcium	m.e.%	2 51	2.48	5.69	5 84	6.30
	Magnesium	m.e.%	1.19	0.72	1.67	1 67	1.43
	Potassium	m.e.%	1.77	1.29	1.96	2 39	2.04
	Sodium	m.e.%	6.39	6.15	7.72	7.55	8.04
	Phosphorus (Water Soluble)	m.e.%	0.1063	0.1060	0.1058	0.0764	0.0785
	Carbonates	%	2.0	3.0	5 0	6.5	5.5
	Total Nitrogen	%	0.1386	0.1722			
	Loss on Ignition	%	1.62	1.57			
	Organic Carbon	%	0.09				
4	Sandy plain						
	Colour		10 YR 7/4 Very Pale brown	10 YR 6/4 Light Yellowish brown	10 YR 5/4 Yellowish brown	10 YR 6/4 Light Yellowish brown	10 YR 6/4 Light Yellowish brown
	pH		8.25	8.2	8.3	8.2	8.3
	Calcium	m.e.%	1.38	1.77	1.24	1.45	1.77
	Magnesium	m.e.%	3.11	1.67	1.67	2.87	1.67

(1)	(2)		(3)	(4)	(5)	(6)	(7)
	Potassium	m.e.%	1.94	1.77	2.26	2.16	2.09
	Sodium	m.e.%	5.51	8 06	6.58	6.54	8.13
	Phosphorus (Water Soluble)	m.e.%	0.0740	0 0738	0.0730	0.0723	0 0685
	Carbonates	%	0.0	1.0	1.5	2.0	3.0
	Total Nitrogen	%	0.1092	0.1932			
	Loss on Ignition	%	1.00	1.25			
	Organic Carbon	%	0.06				
5	Sandy Plain						
	Colour		10 YR 5/4 Yellowish brown	10 YR 5/4 Yellowish brown	10 YR 5/4 Yellowish brown	10 YR 5/4 Yellowish brown	10 YR 5/4 Yellowish brown
	pH		8.15	8.1	8.15	8.2	8.15
	Calcium	m.e.%	1.38	1.42	1.49	1.31	1.59
	Magnesium	m.e.%	2.87	4.78	3.59	4.78	4.55
	Potassium	m.e.%	2.22	3.18	3.42	2.14	3.19
	Sodium	m.e.%	1.87	1.63	1 87	1.79	1.99
	Phosphorus (Water Soluble)	m.e.%	0.0639	0.0692	0.0652	0.0680	0.1124
	Carbonates	%	6.0	4.0	2.5	3.5	1.0
	Total Nitrogen	%	0.1596	0.1638			
	Loss on Ignition	%	0.87	0.95			
	Organic Carbon	%	0.0				

Table 3

Showing the results of Foliar Analysis of *Cenchrus biflorus* Roxb.

S. No.	Foliar Constitutents	Site 1	2	3	4	5
1.	Ash %	11.2	13.10	12.00	13.20	17.00
2.	Silica %	4 00	2 10	2.00	1.00	1 20
3.	Calcium %	1.60	1.00	2 40	1.80	1 80
4.	Magnesium %	2.184	0.655	3.276	4.149	2.184
5	Phosphorus %	0.144	0.360	0.144	0.144	0.720
6.	Sodium %	3.90	1.87	3.90	4.05	3.75
7.	Potassium %	3.25	2.93	3.04	3 38	4.06
8.	Nitrogen %	1.68	6.93	1.75	6.30	1.33

Table 4

Average Measurements of Root and Shoot Systems of *Cenchrus biflorus* Roxb

S. No.	On Dunes	On Plains
Shoot :		
1. Height in cm.	42.5	22.5
2. Lateral Extension in cm.	6.7	3.4
3. Fresh Weight in g.	2.47	1.17
4. Dry Weight in g.	1.82	0.78
5. Loss in Weight		
(a) in g.	0.65	0.39
(b) in %	26.2	33.3
Root :		
1. Depth of main root in cm.	44.5	27.3
2. Lateral Extension in cm.	7.4	5.8
3. Longest Lateral in cm.	44.5	27.3
4. Fresh Weight in g.	0.39	0.26
5. Dry Weight in g.	0.13	0.13
6. Loss in Weight		
(a) in g.	0.26	0.13
(b) in %	66.6	50.0
7. Root-Shoot Ratio		
(a) in Length	1:1	1:1
(b) in Dry Weight	1:14	1:6

GRASSES OF UDAIPUR (RAJASTHAN)

by

K. D. Ramdeo

Department of Botany,

M. B. College, University of Udaipur.

UDAIPUR.

Introduction :

Udaipur (24.29° – 24.43° N and 73.37° – 73.49° E) is situated in the south east of Rajasthan at a height of 587 metres above mean sea level. It roughly lies 126°4 Km north of the Tropic of Cancer. This basin is bowl-shaped and is girdled by the Aravalli hills. About two third of the total area of the basin consists of plains and the rest of hills. The main stream is Berach and a large number of seasonal streams. The more impotant artificial lakes and tanks are Udai-Sagar, Pichola and Fateh Sagar.

The climate of the basin is generally moderate and heat is never excessive. It is some what different from adjacent semi-arid regions of Rajasthan. The average annual rainfall is reported to be 623 mm.

Rajasthan is the third largest state in the country and is very little known florestically and ecologically. The important contributions on the grasses of this state are of Ramachandran (1950), Gandhi et-al (1961) and Vyas (1962–63).

Gramineae is the dominant family and *Eragrostis* is the dominant genera that enter into the composition of flora of Udaipur. The present paper includes the comprehensive data of phenology, ecology and distribution of grasses in the Udaipur basin and is an out-come of the efforts of several past years.

TAXONOMIC DATA

The nomenclature of grasses listed here has been adjusted according to Bor (1960).

Sub family Panicoideae

1. *Saccharum spontaneum* Limn.

   An erect tall grass. Common near cultivated fields. Fls. Oct.—Nov. (674)

2. *S. Sp.*

   A perennial tall grass near water reservoirs. Fls. Oct.—Nov. (730).

3. *Apluda aristata* Linn.

   A tall grass upto 5′ (692)

4. *A. mutica* Linn.

   A small grass with gemiculate, delicate stem. Abundant near moist places. Fls. Sept.-Oct. (691)

5. *Sorghum halepense* Pers.

   Tall stout grass upto 6′ with stiff roots. Fls. rainy season. (690).

6. *Chrysopogon montanus* Trin.

   A perennial gregarious grass used as fodder. Common on hills. Fls. Sept.-Nov. (693)

7. *Bothriochloa pertusa* (Linn.) A. Camus.

   An annual or perennial grass. Abundant on dry rocks. Fls. Sept.—Oct. (670)

8. *Dichanthium annulatum* (Forsk.) Stapf

   Perennial tufted herb. Common in hills and plains. Fls. rainy season. (672)

9. *Themeda quadrivalis* O. Kuntz.

   A stout annual gregarious grass, 4–6′ high, stem terete panicles dense. Common. Fls. Oct.-Dec. (697)

10. *Heteropogon contortus* (Linn.) Beauv ex R & S.

    A gregarious tufted annual grass. Abundant on hills. Fls. Oct.-Dec. (671)

11. *Coix lacryma - jobi* Linn.

    Annual, tall, erect plant. Rare near flowing water channel. Fls. rainy season. (696)

12. *Panicum psilopodium* Trin.

    A tufted annual grass. Common in waste lands and fields. Fls. Jul.-Nov. (666)

13. *Setaria glauca* Beauv.

    A tufted grass. Common in fields. Fls. Sept.-Oct. (688)

14. *S. verticillata* Beauv.
Annual. Panicle long and coarsely bristle and sticks readily to ones clothings. Fls. Aug.–Sept. (698)

15. *Echinochloa crus-galli* (Linn.) Beauv.
A creeping or erect grass. Common along the margins of water reservoirs and wet lands. Fls. Jan.–Mar. (667)

16. *E. colonum* (Linn.) Link.
A tufted slender grass. Fls. rainy season. (668)

17. *Paspalum distichum* Linn.=*P. geniculatum* Heyne
A perennial grass. Fls. Oct.–Nov. (673)

18. *Brachiaria ramosa* (L.) Stapf
A suberect grass. Common on tectonic plains. Fls. Aug.–Nov. (669)

19. *Digitaria sanguinalis* (Linn.) Scop.
A slender grass, common. Fls. rainy seasson. (687)

*20. *Pennisetum pedicellatum* Trin.
An annual branched from base and above. Fls. Sept–Oct. (710)

21. *Cenchrus setigerus* Heyne.
A tufted grass of low hills. (689).
Sub family Pooideae,

22. *Polypogon monspeliensis* Desv.
A slender grass erect and decumbent yellowish stem. Common near nallah and river. Fls. rainy season. (684).

23. *Aristida funiculata* Trin.
A slender grass annual. Fls. Sept.–Dec. (686).

24. *Chloris virgata* Sw.
An annual tufted leafy grass. Common on hills. Fls. Sept.–Oct. (676)

25. *Cynodon dactylon* Pers.
A creeping grass. Common in moist places. Fls. most of the year. (683)

26. *Dactyloctenium aegyptiacum* Beau.
Small annual fodder grass. Common in fields. Fls. rainy season. (682)

27. *Desmostachya bipinnata* (Linn.) Stapf
A perennial coarse grass of plains. Fls. rainy season. (681)

28. *Eleusine indica* Gaertn.

An annual robust erect tufted grass. Common at all places. Fls. Aug.-Oct. (685)

29. *Eragrostis tenella* (Linn.) Beauv ex Roem & Schult.

A slender elegant grass. Abundant in tectonic plains. Fls. Oct.-Nov. (677)

30. *E. coarctata Stapf.*

Slender and erect herb. Common near water tanks and gardens. Fls. Sept—Nov. (678)

31. *E. japonica* Trin.

A branched whorled grass. (700)

32. *E. unioloides* Nees

Annual glabrous grass. Internodes long panicle oblong or ovoid. Glumes Keeled. Fls. Sept.—Nov. (679)

33. *E. poaeoides* Beauv.

An annual much more delicate grass. Panicle ovate. Branches solitary capillary spikelets linear to ovate. Fls. Sept.—Nov. (680)

34. *Sporobolus diander* Beauv.

A tufted slender grass. Common. Fls. rainy season. (694)

35. *Dendrocalamus strictus* Nees

A shrub mostly confined to hills near kewara ki Nal, and abundant in moist humid valleys. Fls. winter season. (675)

36. *Tragus biflorus* Schult.

Annual, small, decumbent herb. Rare near moist places. Fls. Sept.-Nov. (695)

DISCUSSION

Out of the twenty eight genera and thirty six species enumerated here, 17 genera and 21 species belong to the sub-family Panicoideae and 11 genera and 15 species to the sub-family Pooideae.

Panicoideae, is represented by three tribes—Andropogoneae, Maydeae and Paniaceae. Sub-family Pooideae is represented by Seven tribes—Agrostideae, Aristideae, Chlorideae, Eragrosteae, Sporoboleae, Zoysieae and Bambuseae. The tribes, Andropogoneae and Paniaceae both are equally represented with 8 genera and 10 species each and represent the largest number.

The following table gives a statistical summary of grasses collected from the investigated area.

Table 1

Details regarding the genera and species of grasses are given below :

Sub-family	Tribe	Genera		No. of species
		Total	Names	
1	2	3	4	5
A. Panicoideae	Andropogoneae	8	Saccharum	2
			Apluda	2
			Sorghum	1
			Chrysopogon	1
			Bothriochloa	1
			Dichanthium	1
			Themeda	1
			Heteropogon	1
	Maydeae	1	Coix	1
	Paniceae	8	Paicum	1
			Setaria	2
			Echinochloa	2
			Paspalum	1
			Brachiaria	1
			Digitaria	1
			Pennisetum	1
			Cenchrus	1
B. Pooideae	Agrostideae	1	Polygogon	1
	Aristideae	1	Aristida	1
	Chlorideae	1	Chloris	1
	Eragrosteae	5	Cynodon	1
			Dactyloctenium	1
			Desmostachya	1
			Eleusine	1
			Eragrostis	5
	Sporoboleae	1	Sporobolus	1
	Zoysieae	1	Tragus	1
	Bambuseae	1	Dendrocalamus	1
Total	**10**	**28**		**36**

The common grasses in the hills are :

(a) *Top of hills. Heteropogon contortus, Eragrostis uniloides, Tragus biflorus, Sporobolus diander* and *Cenchrus setigerus.*

(b) *Middle zone. Eragrostis tenella, Chrysopogon montanus, Chloris virgata* and *Apluda aristata.*

Sporobolus diander is the common grass in the valley. The common grasses in tectonic plains are *Setaria glauca S. verticillata, Apluda mutica, Dichanthium annulatum, Digitaria sanguinalis* etc. The moist banks and water reservoirs are represented by grasses such as *Paspalum disticum, Saccharum spontaneum, Echinochloa crus-galli, Sporobolus diander* and *Bothriochloa pertusa.* The proper ruderal grasses are *Eragrostis tenella, Panicum spilopodium* and *Polypogon monspeliensis.*

An analysis of the distribution and composition of the grass flora of Udaipur basin reveals that the tropical element is very well developed and claims the highest number of species. While the other element such as Alpine is absent and temperate, mediterranean grasses are few or poorly developed.

SUMMARY

1. This paper deals with the flora of Gramineae found in Udaipur basin.
2. 36 species belong to 28 genera and 10 tribes have been reported.
3. Sub-family Panicoideae is represented by 17 genera and 21 species, while Pooideae with 11 genera and 15 species
4. Ecological observations of the species occuring under different topographical situations have been made.
5. Out of the 36 species collected, 1 species (marked with * in Taxonomic Data) is a new record for Rajasthan.

ACKNOWLEDGEMENT

It gives me an immense pleasure to express my gratitude to late Dr. B.N. Mulay, Professor and Head of the Department of Botany, Birla College, Pilani, under whose guidance, the present work was carried out. I am grateful to Dr. N.C. Nair of the Botanical Survey of India, Dehradun, who spared his valuable time for checking all the identification of the plant species.

REFERENCES

1. Bor, N.L. (1960) Grasses of Burma, Ceylon, India and Pakistan, Oxford.
2. Gandhi, S.M. Bhargava, P.D. & Bhatnagar, M.P. (1961) Grasses of Jaipur. Proc. Nat. Aca. of Sci. India. XXXI, Part 11. 183—192.
3. Ramachandran, K.R. (1950) Common grasses found round about Pilani. Proc. Indian Sci. Congr. Poona, 1950, 65–66.
5. Vyas, L.N. (1962–63) On the grasses of Alwar (Rajasthan) Univ. Rajasthan Studies Biol. Sci.

CYPERACEAE FROM UDAIPUR
(SOUTH EASTERN RAJASTHAN)

by

K.D. Ramdeo

Department of Botany, School of Basic Sciences and Humanities, University of Udaipur, Udaipur.

Udaipur basin (24.29°–24.43° N and 73.37°–73.49°E) is located in the South-east of Rajsthan at a height of 587 metres above mean sea level. It lies roughly 125.4 Km. north of the Tropic of Cancer. The topography of the basin is dominated by the oldest mountains Aravallis. About one third of the total area of basin (bowl-shaped) is hilly and rest of tectonic plains with river beds and moist banks of water reservoirs. The rock types around the basin belong to the Archaeans, the Raialos and the Delhi group of rocks. The climate is generally moderate and heat is never excessive with an annual rainfall of about 613 mm.

Of the important few works on the flora of Rajasthan contributions dealing exclusively with the Cyperaceae are those of Chavan and Sabnis (1960) and Vyas (1966). Cyperaceae is one of the dominant family of the flowering plants in the composition of Udaipur flora. A complete list of Cyperaceous plants of Udaipur has been prepared in order to make the flora more comprehensive.

From the investigated area 18 species belonging to 3 genera have been collected. The cyperaceous flora prefers moist banks and the common species during rainy season are *Cyperus distans*, *C. eleusinoides*. *C. aristatus*, *Fimbristylis tenera* and *Scirpus erectus*. But *Fimbristylis dichotoma*, *Cyperus nivens* and *C. iria* flourish well during winter season.

List of Plants Collected.

1. *Cyperus iria* Linn.

   A glabrous tufted weed with grass like broad leaves, abundant on moist banks. Fls. Dec.–Jan. (651)

---

* Part of the thesis approved for the degree of Ph D. by the University of Rajasthan 1966-67

2. *C. distans* Grah.
   A tall robust perennial leafy sedge. Fls. Sept.—Nov. (652)
3. *C. niveus* Retz.
   A glabrous sedge with a woody rhizome. Fls. winter season. (653)
4. *C. conglomeratus* Rottb.
   A glabrous green sedge. Fls. winter season. (654)
5. *C. eleusinoides* Kunth.
   Perennial, rootstock woody, stem with smooth angles. Fls. Sept.-Oct. (655)
6. *C. exaltatus* Retz.
   A large glabrous herb. Fls rainy season. (656)
7. *C. rotundus* Linn.
   Glabrous, stolons slender and elongate, Fls. Aug.-Oct. (657)
8. *C. aristatus* Rottb.
   A small glabrous annual. Fls. Sept.-Oct. (658)
9. *C. compressus* Linn.
   A glabrous tufted annual. Fls. Aug.-Oct. (659)
10. *C. atkinsoni* C.B. Clarke
    Rhizome short, woody, stem caespitose, thickened at the base. Umbel simple. Glumes cymbiform. Fls. Oct.-Nov. (701)
11. *C. difformis* Linn.
    A glabrous annual herb. Stem long tufted. Fls. Oct.-Dec (660)
12. *C. flavidus* Retz.
    An annual tufted herb. (661)
13. *Fimbristylis dichotoma* (Linn.) Vahl
    A small tufted pubescent sedge of moist places. Fls. winter (662)
14. *F. ferruginea* Vahl
    A tufted erect herb with a short rhizome. Fls. Oct.-Nov. (663)
15. *F. spathacea* Roth
    A tufted rigid sedge. Spikelets often congested. Glumes keeled. Nut dull black obovoid. Fls. Sept.-Nov. (664)

16. *F. tenera* Roem & Sch.
    An erect angular, smooth tufted herb. Fls. rainy season. (665)

17. *Scrpius erectus* Poir.
    A sedge with terete stem. Spikelets in a single lateral head. Glumes ovate concave incurred. Nut black. Fls. Sept. (702)

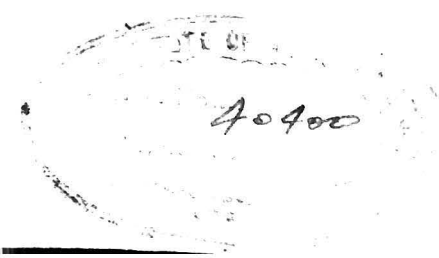
18. *S. maritimus* Linn.
    A sedge with creeping rhizome. Leaves, grass-like and keeled. Inflorescence umbellate, nut smooth and pale yellow. Fls. Nov. (703)

Acknowledgement

I am deeply indebted to late Dr. B.N Mulay, Professor and Head of the Department of Botany, Birla College, Pilani, under whose constant guidance the present work was carried out. I am highly grateful to Dr. N.C. Nair, Botanical Survey of India, Dehradun, who spared his valuable time for checking all the identification of plant species.

References

1. Chavan, A.R. & Sabnis, S.D. 1960 Cyperaceae from Mt. Abu. J. Indian bot. Soc. 39 : 27–29.
2. Vyas, L.N. 1966 Cyperaceae from Alwar (Eastern Rajasthan). Indian Forestor, 92: 9.



MORPHOSTRUCTURAL EVOLUTION OF THE AFRICAN CONTINENT

(with 5 Plates)

by

K. P. Rode
Udaipur (India)

The African Continent has long been considered as amongst the most stable and probably the oldest of the continental features of the earth's crust. It gives abundant geomorphological indications of its rigidity with which it has faced the various major crustal movements since the Cambrian times without being seriously disturbed except along the northern and southern periphery. It also gives abundant indications of long periods of peneplanation whereby the land has been reduced to low extensive plateaux and plains and vast desertic wastes.

The geological history, however, yields evidences which show that large parts of the continent were under sea even as late as the Cretaceous and early Tertiary whereas igneous activity was rampant over vast regions of the continent till the late Tertiary and even in the Quaternary. (P.L. 1). This suggests the youthful aspect in the geological evolution of most regions of this continent.

Africa has long been known as an important part of the old geological supercontinent the Gondwanaland with India and Australia on the east, South America in the west and Antarctica on the south closely interconnected to permit free migrations of land animals and plants over the whole land mass for major part of the geological time.

The coal formations of the Permocarboniferous period are known to be spread over vast areas in Africa as in India and South America with very characteristic floral and vertebrate faunal assemblages preserved in them. It is, however, very curious that in all the three continental regions of S. America, Africa and India, it is only the southern, peninsular portions which bear Gondwana type forma-

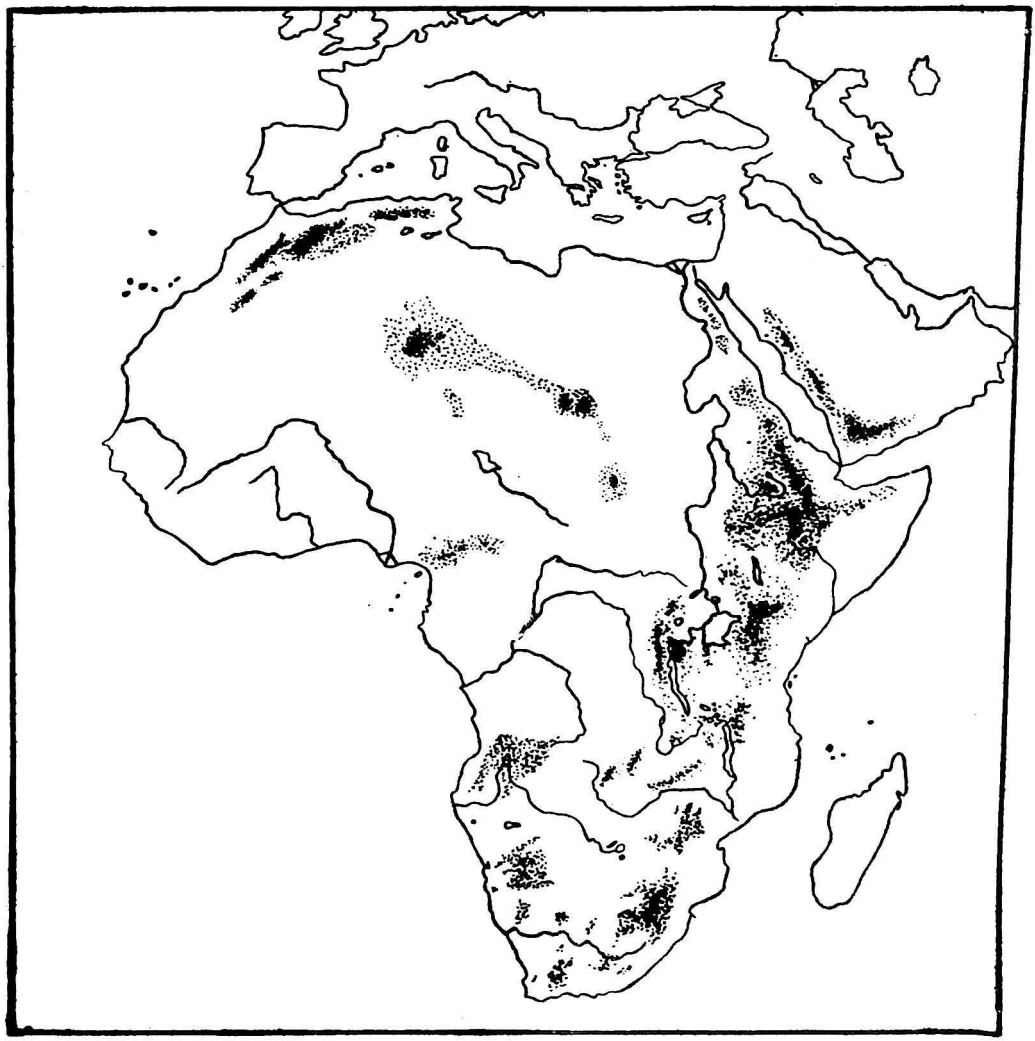
tions whereas the northern, broader portions of all these three continental regions exhibit marine facies of development often showing close relations to the Tethys and with no development of Gondwana sediments. As pointed out by the author in his earlier paper on the Origin of Southern Continents (International Geological Congress at Mexico) that a line drawn for the Pacific coast of South America near Arica on the Chile-Peru border to Mt. Everest in the Himalayas divides each of the three continental blocks into two halves, the northern one as essentially marine with largely Tethyan sediments and the southern one as typically continental with Gondwana sediments. In India the Gondwana sediments are confined to the peninsular portion south of the Narmada-Sone Axis. In Africa the Glossopteris bearing Karroo (Gondwana) formations are confined to the peninsular Africa south of the Cameroon-Aden Axis. In the same way in south America also the Gondwana types of Santa Katherina sediments are confined to peninsular South America south of the Amazon basin. It is surprising that if these continental masses existed as such before the Gondwana period terrestrial faunal and floral elements of that period should have failed to cross the above imaginary line to migrate to the northern portions of the same continents. No physical barriers appear to have existed during these periods which prevented such migration of faunal and floral elements. Nor does any palaeoclimatological barrier appear to have intervened to prevent Gondwana types of sediments to be deposited in the northern portions.

It is, therefore, clearly inexplicable why these northern portions in all the three continental masses of South America, Africa and India should have behaved so differently from those to the south throughout the geological history.

There is another remarkable feature, this time purely physical which curiously is common to all these three continental masses. They all bulge westward in the northern half and taper to the south in the southern half. Is there any explanation for this physical feature which is so prominent in all the three continental masses ? This is clearly inexplicable if the three continental masses were independent entities since early geological times. In any attempt to study the geological evolution of any one of these three continental units it would be useful to study the modes of evolution of the other

PHYSICAL FEATURES OF AFRICA

PLATE 1



Physical Features of Africa

two units also and to see if the crustal processes operative in the evolution of the one were not operative in the other two cases as well.

Confining now to the evolution of the African continent we may first study the evolution of the peninsular part of the same south of the Cameroon-Aden Axis, which exhibits typical development of Gondwana facies of rock formations. This includes the high-level plateaux largely made of young eruptive rocks in Ethiopia (Southern part), Somaliland, Kenya, Uganda, Tanganyika, Nyasaland, N & S Rhodesia and the Union of S. Africa running some what parallel to the eastern margin of the African peninsula and the lower plateaux of S.W. Africa, Angola and Gabon along the west coast with low basins of Congo and Bechuanaland enclosed in the central part of the peninsula between the high level features on either side. The Congo basin is separated from the Bechuana low plains by a transverse high level ridge-like plateau running between Angola and Tangayika and which forms the water divide between the Congo and the Zambezi River basins. Geostructurally, the trend lines of rock formations together with the constituent hill ranges are highly irregular in their orientation and show a fitful, patchy development over short stretches except in the main Karroo basin in S. Africa. (Pl. 2). It is only in this southern territory that we find a complete development of the various geological formations right from the Archaean to the Tertiary. The development of the various rock formations in the Karroo basin constitutes the type which is representative for the rock formations developed anywhere in the peninsular Africa, south of the Cameroon-Aden Axis.

The Table 1 gives the equivalence of the various rock formations developed within different portions of this Peninsular Africa and in the neighbouring island of Madagascar.

The most noteworthy feature is the remarkable similarity of rock formations not only of sedimentary types but even of igneous intrusive and extrusive types developed in patches over the whole of the peninsular Africa. Even the mineral deposits of gold, diamond, itabirite, manganese, chromite, copper, tin and coal occur fitfully in disconnected patches over the whole region yet exhibiting identical rock and mineral associations. It is difficult to visualise the conditions in which rock formations, both igneous and sedimentary, belonging to the whole range of geological periods since the Archaens

have been developed associated with their characteristic mineral deposits and spread over in patches over the whole of this vast area of the Peninsular Africa south of the Sahara.

It is, however, to be emphasised that the trend systems of rock formations as developed in different portions exhibit highly irregular patterns except in the Karroo basin of South Africa.

When, however, we study the trend system as developed in Uganda-Kenya-Tanganyika region we see a remarkable trend pattern which closely resembles that of the Karroo basin except that the Uganda-Kenya pattern has strikes trending largely N-S. whereas those of the Karroo trend NE-SW

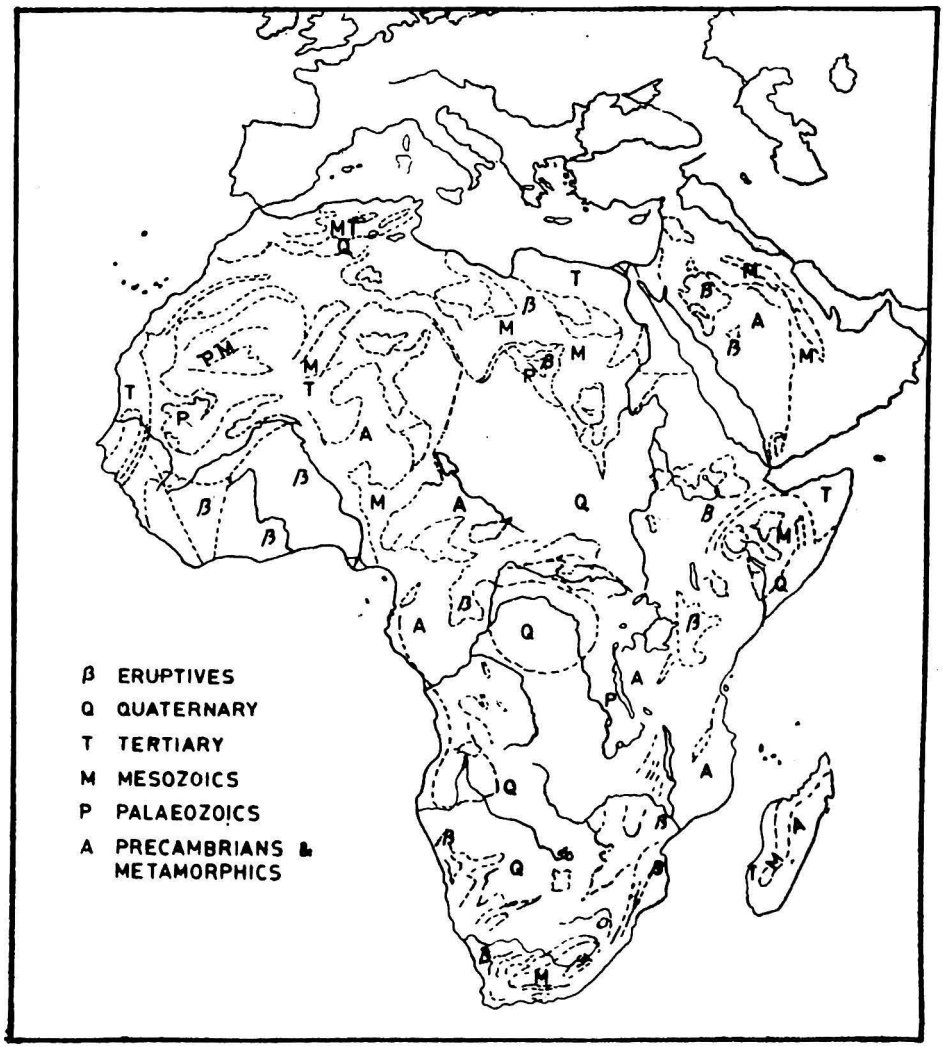
The southern coastal outline of the Karroo basin is remarkably similar to that of the Tanganyika-Alberta lake Rift Valley system and if we superpose the trace of the Karroo sheet trend system after rotating it by 90°, over that of the Uganda-Tanganyika sheet we observe remarkable identity in trend patterns in size and in directions. (Pl. 5).

The bulk strike pattern which in Tanganyika region is NS is seen to change to NNW-SSE in east Congo-N. Rhodesia region, to NW-SE in West Congo—N. Rhodesia region, to WNW-ESE in Angola S. Rhodesia region (Zambezi Trend), to W-E in SW Africa-Bechuana region and finally to WSW-ENE in South African Union. (Pl. 5).

These gradual deflections of trend patterns of rock formations are reflected in the gradual changes of directions of river systems in this Peninsular Africa as examplified by the almost N-S Rift Valley system in the Uganda-Tanganyika region, the NNW-SSE trending tributaries of the Congo and the Upper tributaries of the Zambezi, the E-W trending Lower Zambezi and the NE-SW trending Orange Limpopo River systems in the Cape region.

The fitful development of the Gondwana formations in this peninsular region of Africa closely follows this pattern of strike changes and it is, therefore, necessary to look into the causes for the development of these peculiar physical as well as geostructural features observed in these regions.

GEOLOGICAL SKETCH OF AFRICA PLATE 2



Geological Sketch of Africa.

Can we imagine that the various rock formations, observed in these regions and belonging to the various geological periods since Archaen, may have been deposited all over the Peninsular Africa and that later erosion has brought about fitful preservation of these formations in the patchy way as we see them today ?

The trend divergences in different basins of occurrence do not lend themselves to any one system of folding affecting large regions simultaneously particularly when African continent is supposed to have escaped or to have withstood all deformational movements since the Cambrian.

No satisfactory mode of evolution of these geostructural features can be visualised on the basis of any existing geotectonic concepts.

The present author while dealing with the evolution of Southern Continents has shown that the only way to explain these features is to visualise that the Karroo sheet as demarkated by the Orange Limpopo rivers on the north and the oceans on the remaining sides was for this region the only primary basin which before the evolution of the African continent in its present form occupied the region of the Uganda-Tanganyika in the Rift Valley Zone characterised by the enormous development of Kenya eruptive rock formations. (Pl. 5).

The Karroo sheet in this Uganda position was intimately associated with the Madagascar sheet on its east in the Kenya-Tanganyika-Somali region and due to the activity of enormous basic eruptives of the Kenya-Kilimanjaro (19000') highlands during Post-Cretaceous period these two sheets were lifted up from their basement and were moved away bodily in different directions. The Madagascar sheet moved south to Mozambique and then south east through the positions of Zanzibar, Comore, Mayolle islands to its present position in the Indian Ocean whereas the Karroo sheet rotated radially anticlockwise with its hub in the region of Katanga-Nyassa-Rhodesia. The Zwartenberg-Cape folds moved successively from the Tanganyika lake region west and southwestward through the various positions of Congo tributories viz. Lumani, Labilash, Kasai (Kwango Cassanje bands in Congo State) and the positions of

Upper Zambezi, Cuando, Cabango (in Angola) through Damaraland-Namaqua land to its present position in the Cape region. During these movements the Karroo sheet left enroute several traces of its basal and peripheral portions in the form of fragmentary sedimentary packets together with their characteristic mineral deposits of gold, chromite, copper, coal, manganese, diamond etc. etc.

This would explain the bulges and embayments in the coast line both along the east and west coasts of peninsular Africa as also the fitful occurrences, with divergent trends, of various rock formations and ore deposits found repeatedly in different parts of peninsular Africa from Uganda to the Cape. This would further explain the formation of vast eruptive plateaux along the eastern border of Africa from Ithiopia through Kenya, Tanganyika, Rhodesia to S. Africa and also the low irregular raised platforms along western coastal zone as well. In the same way the radial orientation of river system and the enclosed nature of Congo and Kalahari basins can also be explained.

It will thus appear that peninsular Africa during early Tertiary period consisted only of a small land mass confined to the region of Ithiopia-Kenya-Uganda and structurally comprising all rock sheets now found distributed on the expanded region of peninsular Africa upto the Cape.

It is posible, as will be shown later that this expansion of the continental mass of peninsular Africa took place through Sheet Movements while the horn portion of Africa comprising of Uganda, Kenya, Ithiopia and Somaliland was still resting as a sheet complex over the base of peninsular India south of Narmada-Sone Axis. (Pl. 4).

In dealing with the nature of evolution of the northern half of the African mass we are faced with the all pervading desert topography almost from the Atlantic coastal belt of Mauritania, continuously through the Sahara to the Red Sea and even beyond into Arabia. Here the huge mantle of desert sand is found to envelop the solid geology of the region and as such the main evidence of geology is largely vitiated. Even as such the little that we know of this region is sufficient to give us a glimps of the trends of geological evolution which this part of the African continent is likely to have undergone.

GEOSTRUCTURAL MAP OF AFRICA

PLATE 3

Geostructural Map of Africa.

Geomorphologically, besides the vast sand covered desertic plains and low lands, the region shows development of certain arcuate hills and plateaux which show peculiar distribution in this vasttract. Starting from east to west we find (1) the Nubian (Egypt) uplands forming the western fringe of the Red Sea showing a convexity to the east. This is followed by low lands characterised by the Nile and the well known Quatara depression.

Further west we find successively similar and sometimes more pronounced curved uplands always with a convexity to the east. Amongst these may be mentioned (2) the Libya Ennedi Arc, (3) the Libya Tibesti Arc, (4) the Fezzan Murzuch Arc, (5), the East Ahaggar-Tassili Arc, all more or less parallel, trending N-S with convexity to the east. (Pl. 3)

Geologically, many of these arcuate uplands are characterised by early Palaeozoic and Mesozoic sediments abundantly associated with Tertiary eruptives with 'V' shaped outcrops distributed en echelon in a WNW—ESE direction (PL. 2) This peculiar distribution of the Lower Palaeozoic-Mesozoic sediments in association with Tertiary eruptives right in the heart of the Sahara and almost unaffected by desert erosion calls for an explanation not easily available. The regular arcuate outcrops, even of the Tertiary eruptive rocks occurring repeatedly in a E—W direction, can not be ascribed to any orogenic or epeirogenetic movements of Tertiary or Post-Tertiary age since the shield like continental mass of Africa is thought to have withstood all such late folding movements.

The only process capable of bringing about such morphostructural features is that of sheet movements in which some sedimentary sheet complex with arcuate outline, while moving in an east-west direction during crustal expansion may have left traces of its basal sheet, enroute, as the eruptive material in which it was caught up consolidated during movement due to cooling.

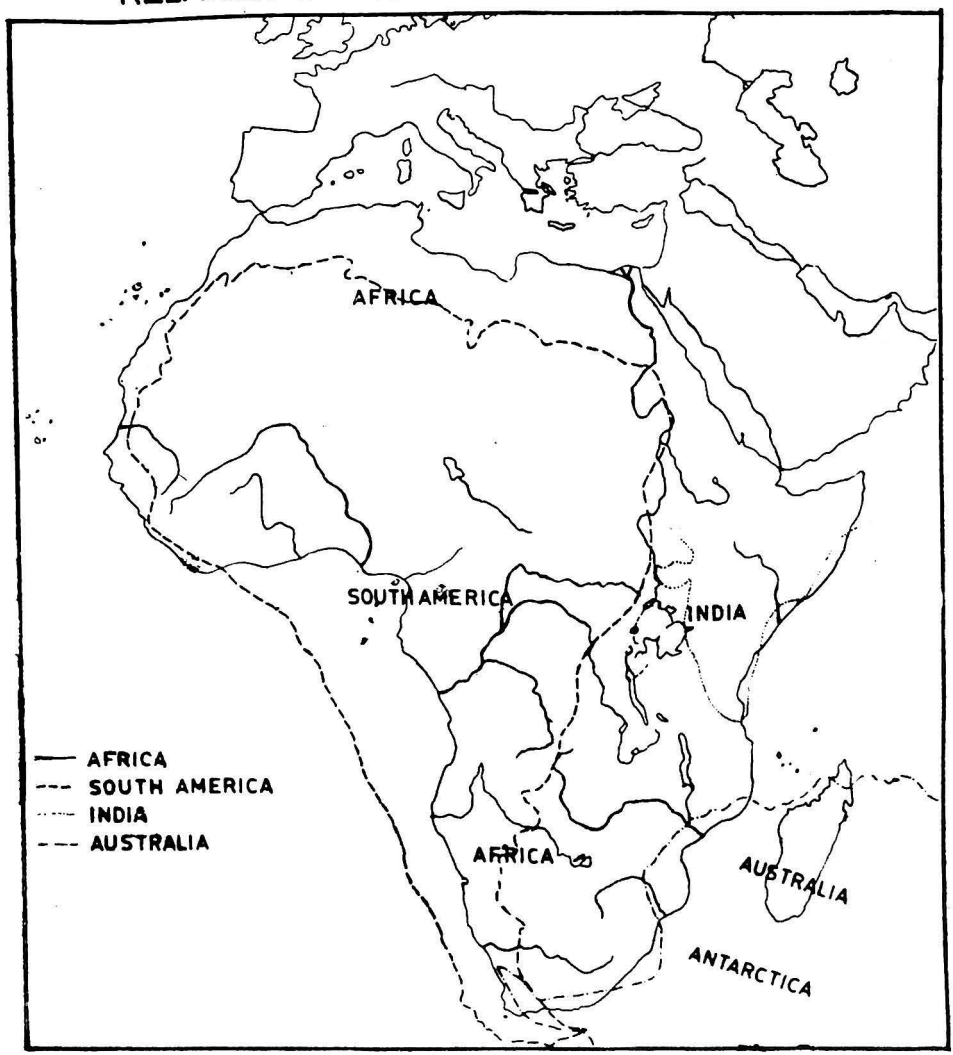
We have earlier seen that the southern or the peninsular portion of Africa evolved and expended during the radial movements of the Karroo sheet over the Abyssinean-Kenyan basic eruptives from the Uganda-Tanganyika position to its present South African position and that during this movement it has left, all along the route, numerous arcuate outcrops of rock formations which were integral and largely

basal portions of the Karroo sheet. In tracing the evolution of northern Africa, we do not find the development of a complete geostructural sheet like that of the Karroo which during its movements may have left traces enroute. For this we have to study the structure of S. America to find the actual sheet complex which may be responsible for these peculiar features of N. Africa.

In his paper on "The Evolution of Southern Continents" (Rode, 1958) the author had shown that the whole mass of the South American Continent was resting as a sheet over the basement of the African continental platform and that the complete evolution of S. American continental plate took place *paripassu* with that of its African basement. (P. 4). The best indication of this is in the evolution of the southern or peninsular part of S. America conjointly with that of the peninsular portion of Africa. When the Karroo sheet was in the Uganda-Tanganyika position the Parana sheet of Brazil was also part of this sheet complex as an intermediate sheet between that of the Uganda-Tanganyika sheet (below it) and the Karroo (above it). When the Karroo sheet moved radially anticlockwise to the Congo position the Parana sheet also moved with it to the Congo position as a joint sheet packet. In the next movement the Parana sheet was left behind in Congo basin and the Karroo sheet rotated further northwest to the position of Kasai-Zambezi drainage basin. At this time the alluvial flats of the La Plata were being formed in the region of Gran Chaco in northern Argentina while still situated in the Congo region. Similarly when the Karroo sheet occupied the region of Angola—S. Rhodesia the alluvial flats of central Argentina were being formed in the region of Cardoba—Buenos Aires. During the next stage of the Karroo sheet in the region of Damara-Namaqualand—Southern Rhodesia the alluvial flats of south Central Argentina in the region of Rio Negro and Chubut were being formed and finally when the Karroo sheet reached its present Cape stage the plains of Patagonia and falkland islands came into existance with Tierra del Fuego folds resting over the Zwartenberg Cape foldings.

It would thus appear that the evolution of the whole of peninsular part of South America took place simultaneously with that of peninsular Africa due to the anticlockwise rotational and en echelon movements of the Karroo basin from the region of Rift lakes to its present position. It thus appears equally plausible that the evolu-

RELATION OF THE GONDWANA LANDS PLATE 4



Relations of the Gondwana Lands.

tion of northern Africa took place simultaneously along with that of northern portion of South America.

In tracing the evolution of this northern portion of South America we have somewhat clearer indications to follow.

In his paper on the "Nature of Central American Orogeny" read at the Mexican Session of the International Geological Congress 1956, (Wadia Commomoration Volume, 1965) the author has shown that the Guiana sheet lying E—W between the Amazon and the Orinoco rivers once occupied the N—S position in NE Brazil in the region of Goais and Piaui ranges and that later it shifted through a slight clockwise rotation to the position of Moto Grosso—Catingas Plateau in north western Brazil in the southern drainage basin of the Amazon and the Tocantine R. This Guiana sheet (also intimately associated with the Colombian Venezeulan Andes) gradually rotated clockwise to its present position north of the Amazon basin now with an E.W. trend.

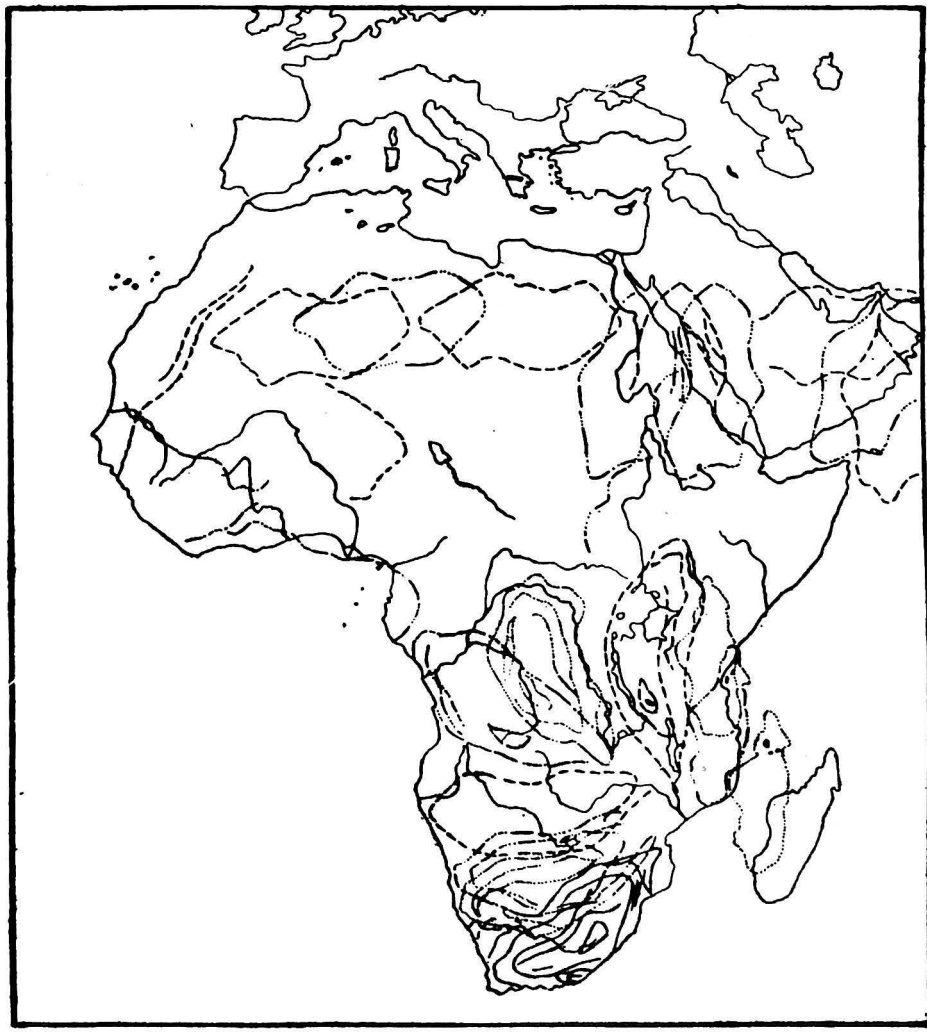
When we study the geomorphological and geological maps of north Africa we are struck by many features which simulate those in the Brazil-Guiana region of S. America. The somewhat disconnected Kordofan, Darfur, Ennedi, Tibesti, Djado, Ahaggar and Tademait highland range running obliquely in NW direction, almost from the Ethiopian highlands right upto the Moroccan Atlas ranges is strikingly similar both in form and length to the north eastern coast line of South America from NE corner of Brazil to the Venezuelan Andes and remarkably, even the western or Atlantic coast of N. Africa corresponds almost exactly with the western on Pacific Coast of S. America between Peru and Columbia as becomes evident if we superpose the S. American Sheet over that of S. Africa. In this superposed position Guiana coincides with the Ahaggar Arc of Africa. This superposition further brings out many other similarities between the two continental regions. The various arcuate features repeated successively as observed in the Sahara region of N. Africa very much simulate the Amapa curvative of the Guiana Sheet which appears to have left these arcuate traces along the trail of its migration during the various stages of continental expansion of the Afro-American mass. The basal sheet which served as a platform for the migration of the Guiana Sheet constituted the Sahara plateau.

In this reconstruction the Columbian Venezuelan Andes appear only as a continuation of the Moroccan-Algerian Atlas whereas the extensive depression in Tunisia, Algeria, south of the Atlas ranges corresponds to the valley of the Orinoco south of the Venezuelan Andes.

From all these geomorphological and geotectonic correspondences in the African and S. American regions it is only obvious that the evolution of the two continental masses must have taken place simultaneously due to common processes of sheet movements and during these stages the African tableland only served as a constantly expanding platform over which lateral movements of the two primary geo-structural features the Karroo Sheet in the south and the Guiana Sheet in the north, together with their respective Atlas-Andean Orogenic belts, brought about the complete evolution of the two continental sheets originally in a superposed position and largely during the Tertiary Period. It is only lately during the Pleistocene to Recent geological periods that the upper structural sheet of S. America moved enmass away westward from its African basement in successive stages exposing the basal platform now seen as the African continent. In this way alone we can explain all the geomorphological, geostructural, faunal and floral peculiarities associated with these two major continental masses in the southern Hemisphere.

It may be pointed out at this stage that the two primary structural sheets (1) the continental sheet of Karroo and (2) the largely marine sheet of Guiana which are prominently concerned with the evolution of Afro-American Continental masses were both originally situated in the Indo-Himalayan region, the former essentially in the Gangetic basin and latter in the upper Indus basin. The Karroo sheet while in this Indian stage was also associated with the other Gondwana sheets, the Madagaskar sheet in the south Tsangpo basin and the Australasian-Gondwana sheets in the north Tsangpo, Upper Salween, Mekong basins of Tibet region upto the Upper Cretaceous period. It was during the period of the Deccan Trap eruptions some time in the Cretaceous—early Tertiary period that these various sheets started migrating away from their Tibeto Himalayan Homeland with a radial or fanwise movement first giving rise to the evolution of the Deccan Peninsular basement for Karroo Madagascar sheets and the Antarctic basement for the Madagascar-Australasian sheets. The Guiana Sheet moved first over the Kash-

TRENDS OF SHEET MOVEMENTS IN AFRICA PLATE 5



Trends of Sheet Movements in Africa.

mir-Punjab-Rajasthan basement and later over the Perso-Afghan and Arabian basement. It was during this movement that the eastern portions of the African continents the Egypt Arabian mass on the north and the Ethiopean Kenya Somaliland portions in the south were formed while they were still on the Indian basement.

It is again possible that the further rotational movements of the Karroo sheet in anticlockwise direction in SW. and Guiana sheet in a clockwise direction in NW. were nearly completed and that way brought about the full development of the Afro-S. American compound continental mass before this huge land mass left the Indian basement.

The various stages of evolution through successive sheet movements have been depicted in Pl. 5.

In this reconstruction the Andes of Venezuela were intimately associated with Marocco-Tunisian Atlas Ranges and these two together as closely packed sheets were, in an earlier stage, superposed over the fold ranges of Taurus in Asia Minor whereas the Guiana sheet was resting over the Armenian-Syrian basement.

In his paper on the nature of Alpine Orogeny and Crustal Evolution (Rode K.P. 1962) the author had shown that the Alpine ranges in still earlier stages were situated in the region of Pamir and the Tibeto-Kashmir Himalayas. At this period sometime in the Cretaceous early Tertiary the present Mediterranean Sea had not come into existence and the whole Afro-American continental mass with its Arabian sub-stage was still situated in the Indo-Gangetic drainage regions of the Tibeto-Kashmir-Nepal Himalayas. This represents the primary home of all the Palaeozoic Tethyan and Gondwana series of those sedimentary rock formations which later moved as parts of sheet complexes ultimately to form the continents of Africa and S. America during Tertiary to Recent periods. It was again in the Tibeto Himalayan region now in the eastern portion representing the source regions of the Brahmaputra, Salween, Mekong and the Yangtse Kiang that the remaining Gondwana sheets of Madagascar Australia and Antarctica were all intimately associated together and which through series of Sheet Movements again during Tertiary-Recent periods gave rise to separate continental masses.

The Evolution of the African continent as elaborated above through the process of Sheet Movements enables us to follow up the trends and stages of evolution quite precisely both in time and space and thus enables us to realise the true significance of every geomorphological and geostructural feature which characterises this vast continent.

Thus the most peculiar features of the Rift Valleys including the Red Sea depression are products of the lateral west-ward migration of Afro-Brazilean continental sheets over the Arabo-African basement platform particularly in regions where eruptive lavas were thick enough to be preserved with or without metamorphism as elevated sides of the Rift Valleys. In other regions enormous degradation and crush products formed during these sheet movements led to the development of thick sandy, fragmental wastes with disorganised underground water system and which now appear as extensive deserts as in the Sahara and Kalahari regions.

The folded Atlas Ranges of N. Africa abruptly disappearing unaccountably both in the east and west now appear under the new concept to be the detached continuations of the folded Taurus Ranges in Asia Minor on the east and appear continued on the west in the Venezuelan Andes. Similarly the solitary Cape foldings in S. Africa which also abruptly terminate at their east and west ends now appear to be continuation of the Tierra del Fuego Andean folds S. America on the one hand and of Western Antarctica on the other.

From this treatment of the evolution of the African continent it is obvious that the processes and mechanism of crustal evolution through Sheet Movements as envisaged here are universally operative and indicate trends and stages of continental evolution which can be deciphered very precisely both in time and space for the whole world.

REFERENCES

Rode K. P. 1958—Origin of Southern Continents, Proceedings-XX Session International Geological Congress, Commission de Gondwana, pp. 3-24, Mexico—1958.

Rode K. P. 1965—Nature of Central American Orogeny, Mining & Met. Institute of India (Wadia Commemoration Volume) 1965.

Rode K. P. 1962—The Nature of Alpine Orogeny and Crustal Evolution. Presidential address-Proceedings, 49th Indian Science Congress—Pt. II, Cuttack 1962.

TIME-CONTRACTION IN A GRAVITATIONAL FIELD.

by

Dr. M L. Gupta.

Government College, Ajmer.

Abstract : The expression for the inertial mass in a gravitational field deduced in a previous paper (Gupta 1958, 1962) leads to the conclusion that clocks should run faster in a gravitational field than in field-free space. This conclusion is found to have no effect on the explanation of the red-shift of spectral lines being due to a using up of the energy of the photon in escaping through the gravitational field of a massive body[1]. An interesting conclusion of the time-contraction effect is that the velocity of light in a gravitational field measured in units belonging to the field is the same as in field-free space, which therefore appears to be a universal constant.

It has been shown [1,2] that the effect of a gravitational field on matter is to decrease its intertia from *'m'* in field-free space to $m\left(1-\frac{GM}{rc^2}\right)^3$ in the field. Thus the inertial and gravitational masses of a body are not the same in a gravitational field. This conclusion is at variance with the equality of the inertial and gravitational mass asserted in the theory of relativity without any theoretical or experimental proof. It must be pointed out that the experiment of Eotvos performed with a view to test this equality, proves only the proportionality of the two masses and not their equality. [3] The possibility that the proportionality constant may be a function of the gravitational field and the same for all kind of matter has been completely ignored in the theory of relativity. The proof of the expression of inertial mass however shows that this in fact is the case, and the proportionality constant is a function of the gravitational field, being $\left(1-\frac{GM}{rc^2}\right)^3$ and is the same for all type of matter. The expression for the inertial mass in a gravitational field therefore contradicts neither experiment nor reason.

Expression for the moving mass of a body in a gravitational field :—

We have also seen [1,2] that the change of inertial mass leads to a change in the expression of Newton's second law of motion in a gravitational field. If we define the inertial momentum of a body as (inertial mass X velocity), then the second law of motion assumes the form [2],

force = rate of change of inertial momentum.

$= \left(1-\frac{GM}{rc^2}\right)^3 \frac{dM}{dt}$ where M is the intrinsic momentum = (intrinsic mass x velocity)---

The law of mass-energy equivalence may also be written in a slightly different form, utilizing the expression of the inertial mass as,

$E'=m'c'^2$ where E' is the total energy of the mass (*i.e.*, its intrinsic energy plus the potential energy), m' the inertial mass $=m\left(1-\frac{GM}{rc^2}\right)^3$ and $c'=c\left(1+\frac{GM}{rc^2}\right)$ is the velocity of light at any point distant r from the gravitational body [1]. Thus we have,

$$E'=m\left(1-\frac{GM}{rc^2}\right)^3\left(1+\frac{GM}{rc^2}\right)^2c^2=mc^2\left(1-\frac{GM}{rc^2}\right)$$
$$=\left(mc^2-\frac{GMm}{r}\right)$$

which is obviously the whole energy of the mass m in the gravitational field.

Let us now find, how the expression of the moving mass changes on account of the change in the expression of these two fundamental laws.

We follow the same method as was used in previous work (Gupta 1953-54 a) for deducing the expression of the moving mass in field-free space.

We have

$F.\,ds=dm'c'^2$ where $F.ds$ is the work done by the force F on the body placed in a gravitational field. The energy acquired by the

body due to this work is equal to $dm'c'^2 = dmc^2\left(1-\frac{GM}{rc^2}\right)$ as shown above. In field-free space, it would simply have been dmc^2. It is clear that in the gravitational field, the energy acquired would be less by the amount of the potential energy.

Now $F=\frac{dM'}{dt}$ where M' is the inertial momentum.

$$=\left(1-\frac{GM}{rc^2}\right)^3\frac{dM}{dt}$$ where M is the intrinsic momentum *i.e.* (intrinsic mass × velocity).

Thus $\left(1-\frac{GM}{rc^2}\right)^3\frac{dM}{dt}.ds = dm'c'^2$

$$=dm\left(1-\frac{GM}{rc^2}\right)^3 c^2\left(1+\frac{GM}{rc^2}\right)^2$$

or $dM.v = dmc^2\left(1+\frac{GM}{rc^2}\right)^2$

$$=dmc'^2.$$

Mulitplying both sides by m.

$$M\,dM = mdm\,c'^2.$$

Since c' does not depend on m, it may be regarded as a contant. Hence we have on integration

$\frac{M^2}{2}=\frac{m^2c'^2}{2}+k$ where k is an integration constant. Now when $m=m_o$, $M=0$

Hence $k=-m_o{}^2c'^2/2$

Putting the value of k, we have,

$$M^2=(m^2-m_o{}^2)c'^2$$

or $m^2v^2=(m^2-m_o{}^2)c'^2$

Hence $m=\frac{m_o}{\sqrt{1-v^2/c'^2}}$ where $c'=c\left(1+\frac{GM}{rc^2}\right)$

Thus the intrinsic mass of the moving body in a gravitational field is different from what it is in field free space for the same velocity, in which case m is given by the expression $m_o/\sqrt{1-v^2/c^2}$. The above expression however bears a close resemblance to that for

the moving mass in a moving system in field-free space, where m was found to be given by the, formula. (Gupta 1953–54b)

$$m = m_o / \sqrt{1 - v^2/c'^2} \qquad \text{with } c' = \sqrt{c^2 - u^2}$$

u being the velocity of the system through space, and $\sqrt{c^2-u^2}$ being the measured velocity of light in any direction in the moving system, time being measured by a world-clock. This expression led to a time-dilatation effect or slowing down effect for clocks placed on a moving system. In the gravitational field since c' is larger than c, the expression for the moving mass may be expected to lead to a 'time-contraction' effect.

Effect on the rate of vibrating bodies :—

Let a vibrating body such as a clock or revolving body (like the electron going around the nucleus of an atom) and a unit mass be transferred to some position in a gravitational field by bringing the body into the field or vice-versa. The intrinsic mass of thevibrating or revolving body in field-free space is given by,

$$m = \frac{m_o}{\sqrt{1 - v^2/c^2}}$$

where v is the effective velocity of the vibrating or revolving body in field-free space.

Now since the vibrations of the body do not change the state of rest of the body as a whole, it continues to remain at rest in the gravitational field and its mass compared to the transferred unit mass is still m. If without the internal vibrations, the body has a mass mo, which in terms of the transferred unit mass would be the same as in field-free space, then 'm' in the gravitational field would be given by,

$$m = \frac{m_o}{\sqrt{1 - v'^2/c'^2}}$$ where v' is the effective velocity

of the internal vibrations in the gravitational field and c', the velocity of light at the position of the field considered. Equating the two expressions for m, we have,

$$\frac{m_o}{\sqrt{1 - v^2/c^2}} = \frac{m_o}{\sqrt{1 - v'^2/c'^2}}$$

or $$\frac{v^2}{c^2} = \frac{v'^2}{c'^2}$$

$$\text{Hence } v' = v.\frac{c'}{c} = v\left(1+\frac{GM}{rc^2}\right)$$

Thus the velocity of all internal vibrations would be increased in the above manner. The speed of a clock would thus increase and would be $\left(1+\frac{GM}{rc^2}\right)$ times its rate in field-free space. The speed of rotation or revolution of a body would similarly increase. One second of the clock placed in the gravitational field would thus be smaller than one absolute second in the ratio of $1/(1+GM/rc^2):1$. In the relativity terminology, the effect may be called the 'time-contraction' effect.

The conclusion of a 'time-contraction' in a gravitational field is in direct contradiction of the time dilatation effect deduced in the general theory of relativity and used by it to explain the red shift of spectral lines the arguement being that the atomic oscillators slow down in a gravitational field and hence the frequency of the emitted light is smaller and the lines shift towards the red. We know however from the quantum theory that the emission of light from an atom is not due to any oscillatory process inside the atom, but is due to a transition of the electron from a higher energy state to a lower one, the frequency or the wave-length being determined by the energy emitted from the atom. In fact it may be shown on the basis of simple energy considerations that the redshift of spectral lines may satisfactorily be explained in terms of a time-contraction effect. This point would be discussed in a separate note.

One important consequence of the 'time-contraction' effect may however be pointed out here. Assuming that there is no change in the lengths of scales when they are *at rest* in a gravitational field, it is easy to see that the velocity of light in the gravitational field, which is $c\,(1+GM/rc^2)$ in units of world time, would be,

$$c\left(1+\frac{GM}{rc^2}\right)\cdot\frac{1}{\left(1+\frac{GM}{rc^2}\right)}=c \quad \text{in the units of}$$

time of the clock placed inside the field. The velocity of light is therefore 'c' in the gravitational field in the same sense in which it is 'c' in any inertial system, and is therefore a universal costant. This result which is also at variance with the result given by the relativity

theory however appears to be quite satisfying from the view-point of the symmetry and invariance of natural laws.

REFERENCES

1. Gupta, M.L. University of Rajasthan Studies, Physical Sciences, Vol. V, 1958.
2. Gupta, M.L. Ibid. Vol. VIII, 1962.
3. Bergmann, P G. Introduction to the theory of Relativity.
4. Gupta, M.L. University of Rajasthan Studies, Physical Sciences, Vol. III, 1953-54.
   (a) (8, 54); (b) (9, 83)

ACETYLACETONATE DERIVATIVES OF TIN

V. D. GUPTA

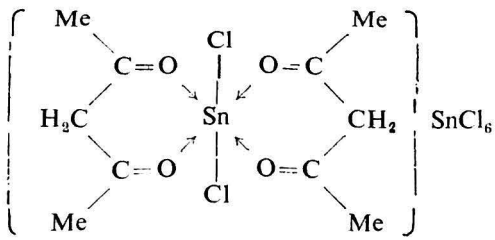
The Chemical Laboratories, University of Rajasthan, Jaipur.

Metal acetylacetonates have been extensively investigated and reviewed (1, 2). The derivatives of tin belong to the most exhaustively studied class of acetylacetonate complexes, in which under suitable conditions the enolic proton is removed. In the present article, a full coverage of the various aspects of tin(iv) acetylacetonate chemistry has been attempted.

In 1924, Morgan and Drew (3) reported that the reaction of stannic chloride with acetylacetone at the room temperature yielded a product with the composition, $SnCl_4Hacac$ which was assumed to be an equimolecular mixture of $(acac)_2SnCl_2$ and H_2SnCl_6. Recently, it has been observed by Mehrotra and Gupta(4) that the product remains unchanged when heated under reduced pressure (0.1 mm.) at 60-70° and decomposed above 90-100° as follows :

$$2SnCl_4\ Hacac \longrightarrow (acac)_2SnCl_2 + SnCl_4 + 2HCl$$

In view of its conducting nature in nitrobenzene, it has been assigned the following formula :



(I)

A product of similar molar conductance (II) was obtained by passing HCl gas in an equimolar mixture of $(acac)_2SnCl_2$ and $SnCl_4$. Their indentity (I and II) was ascertained by mixed m.p. and infrared spectra. It was found that $(acac)_2SnCl_2$ had a negligible conductance in nitrobenzene. The molar conductance of H_2SnCl_6 was

found to be about 9.6 mhos. Thus, the conductance of a simple equimolecular mixture of these would have been of the same order (9.6 mhos) as that of H_2SnCl_6. Experimental determination of conductances of both I and II gave values of about 22 mhos for their molar conductances. All these observations lend support to the above formula for this derivative. The most plausible mode of its formation has been shown as :

$$SnCl_4 + 2Hacac \longrightarrow [(Hacac)_2SnCl_2]\,Cl_2$$

$$\xrightarrow{SnCl_4} [(Hacac)_2SnCl_2]\,SnCl_6$$

The mechanism has been supported by the isolation of a compound almost corresponding in analysis to the product, $[(Hacac)_2SnCl_2]Cl_2$ by the slow addition of stannic chloride to a large excess of well cooled acetylacetone. To substantiate the above idea, the intermediate product $[(Hacac)_2SnCl_2]\,Cl_2$ was also isolated indirectly by the reaction between bis(acetylacetonate) tin dichloride and dry hydrogen chloride gas in benzene. The reaction of this intermediate derivative with stannic chloride furnished the original product $[(Hacac)_2SnCl_2]\,SnCl_6$, though the reaction has been reported to be slow due to the insoluble nature of the $[(Hacac)_2SnCl_2]Cl_2$. Dilthey(5) and Rosenheim (6) obtained a crystalline product with empirical formula, $(acac)_2SnCl_2$ by the reaction of stannic chloride with ezcess acetylacetone under reflex. On account of its high m.p. (202-203°), a trimeric structure, $[(acac)_3Sn]_2SnCl_6$ was assigned to it by Dilthey(5) assuming it to involve a cation similar to silicon $[(acac)_3Si]^+$ (7) However, Morgan and Drew (3) found $(acac)_2SnCl_2$ to be monomeric in boiling benzene in contrast to Dilthey's presumption. A study of the reaction of stannic coloride with acetylacetone undertaken by Mehrotra et.al. (4) in various stoichiometric ratios invariably yielded only bis-substituted derivative, $(acac)_2SnCl_2$ and further substitution could not be possible. On the basis of its monomeric nature (determined cryscopically), infra-red spectra and non-conducting behaviour in nitrobenzene, an octahedral structure has been proposed (4).

Recently, the formation of bis(acetylacetone) tin dichloride has also been reported by tinphenyl cleavage (8) in diphenyltin dichloride with acetylacetone preferentially above 150° in the absence of solvent. However, for such exchange process no mechanism has been advanced by these workers. It may be mentioned that in

general the displacement of chlorine from tin (IV) is favoured in the presence of a solvent. A trans-octahedral configuration has been suggested on the basis of absorption spetra and molecular weight data, although no correlation of the ir data with specific stereochemistry has been discussed. Contrary to this report, Nyholm and coworkers (9) observed a high dipole moment for bis(acetylacetonato) tin dichloride (as 8.8 D) and concluded a cis-structure. In 1967 (10) the reaction of tin oxide chloride with acetylacetone has been found to lead to the known compound, $(acac)_2SnCl_2$.

The synthesis of butyltin acetylacetonates, $Bu_2Sn(acac)_2$ and $Bu_3Sn(acac)$, by the reactions of the appropriate chloride with acetylacetone in the presence of stoichiometric amount of sodium methoxide (11) or alkaline condensing agent (12) and by the direct interaction of the corresponding methoxide with acetylacetone (13) has been described in patent literature. Recently Mehrotra and Gupta (14) have characterised compounds, $Bu_2Sn(acac)_2$ and $Et_3Sn(acac)$ obtained by the action of acetylacetone on the corresponding ethoxide in required ratio and emphasized their monomeric nature (determined ebullioscopically in benzene) involving 6- and 5-coordinate tin atoms respectively. The condensation of oxides, Bu_2SnO and $[Et_3Sn]_2O$ with acetylacetone (15) in dioxan also resulted in the formation of $Bu_2Sn(acac)_2$ and $Et_3Sn(acac)$. An interesting reaction of $R_3SnCH_2.COCH_3$ (where R=Me and Pr) with acetylacetone gave corresponding acetylacetonate along with the formation of dimethyl ketone (16). In order to study the electronic effect of the substituents on tin (IV) atom and acetylacetonato ligand through the tin atom Okawara et.al. (17) synthesised a series of bis-substituted compounds, $R_2Sn(acac)_2$ and $Sn(acac)_2RX$ by the following routes :

$$R_2SnCl_2 + 2MeONa + 2Hacac \xrightarrow{MeOH} R_2Sn(acac)_2 + 2NaCl + 2MeOH$$

$$RSnX_3 + 2Hacac \xrightarrow{H_2O} Sn(acac)_2RX + 2HX$$

(R=Me, Et, C_2H_3 and C_6H_5; X=Cl, Br and I)

The isolation of diphenyltin bis(acetylacetonato) complex has been described by Nelson and Martin (18) by thallous acetylacetonate and Ph_2SnCl_2 The coordinated carbonyl group in the infrared absorption and monomeric nature suggested the presence of six-coordinate tin in the compound. A chromatographic study of its

possible isomer pattern gave a single elution peak presenting evidence that the complex existed predominantly in trans form in non-polar solvents. A high dipole moment as 4.0 D obtained for $Ph_2Sn(acac)_2$ by these workers (18) appears to be surprising although they considered it to be due to atomic polarization arising from bending of the chelate rings relative to the metal ion.

Trans configuration in dimethyltin bis(acetylacetonate) has been concluded by Okawara and coworkers (19, 20) because of the presence of only asymmetric Sn–C stretch in the ir spectra; the vibration was found to be Raman active as predicted by the selection rule. The four Sn–O bonds seemed to be equivalent.

A discussion of the n.m.r. spectra of the compounds of the type $Sn(acac)_2XY$ appeared to be interestingly relevant in light of the different configurational interpretations offered by workers. The n.m.r. spectra for Sn(IV) complexes, $(acac)_2SnX_2$ (X=Cl, Br and I) (21) strongly supported the dipole moment evidence (9); the cis-isomer with C_2 symmetry (the two fold axis bisecting the X–Sn–X angle) would result into two ring methyl and one γ-proton peaks as found experimentally (21, 22). In $R_2Sn(acac)_2$ (R=Me and Ph), the trans-orientation would have D_{2h} symmetry and only one ring methyl and γ-proton signals have been obtained (23).

For $(acac)_2SnX_2$ spin–spin coupling between Sn^{117} (7.67%) and Sn^{119} (8.68%) and both the ring methyls and γ-proton has been observed (21, 24) and three notable features involved have been discussed. First, the coupling constants to both γ-proton and C(2)–Me, C(4)–Me increase in the order I<Br<Cl. It may be tempting to mention here that no such coupling for acetylacetonato protons has been encountered either in $Me_2Sn(acac)_2$ (23) or $Sn(acac)_2PhCl$ (24). Secondly, the replacement of the γ-proton by methyl did not affect the magnitude of the coupling constants, offering an evidence for $\sigma - \pi$ type interaction mechanism. Lastly a small but significant difference between ring methyls coupling constants has been noted which increased in the order I<Br<Cl; this has been accounted to the different environments of the two methyl groups in any one acac ring.

The cis-configuration for $(acac)_2SnCl_2$ has been, furthermore, supported by Faller and Davison (25) on the basis of ir and Raman

spectra. These workers (25) have explained the collapse of the two methyl signals in the n.m.r. spectra at 140° by the conversion of one enantiomer of the cis product to the other at a rate which was too fast to be measured on the n.m.r. scale.

An alternative structural approach for $(acac)_2SnX_2$ has been sought where the splitting of the n.m.r. spectral peaks for methyl protons has been considered to be caused by the distorted structure of the acetylacetonate part of the molecule containing somewhat localized double bonds (24). However it has been commented (21) that such distorted structure has not been found in any one of the many X-ray structural determinations of chelate β-diketone compounds nor was it consistent with the large dipole moment of $(acac)_2SnCl_2$ in solution (9). The appearance of four methyl and two γ-proton signals in an analogous compound $Sn(acac)_2PhCl$ (24) has been accounted to anisotropic magnetic effect of the phenyl group. However, these observations have been further found in accord with the cis-configuration (21) of the molecule, $Sn(acac)_2PhCl$ having no symmetry elements.

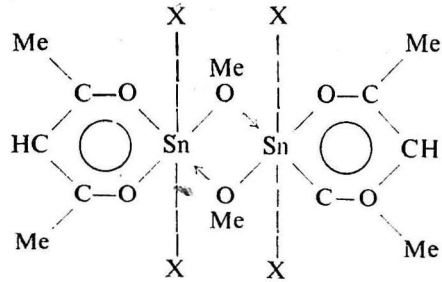
In later publications, Kowasaki et.al. have studied the temperature dependence of the n. m. r. spectra of $(acac)_2SnCl_2$ (26) and $Sn(acac)_2MeX$ (27) (X = Cl and Br). In dichloro product (26), the methyl signal dependence has been explained due to the exchange between two distorted octahedral configurations in which the $Sn(acac)_2$ portion remains planar. However, in methyl halo derivatives (27), they have mentioned the presence of an equilibrium between cis and trans forms being stable at -30° and 20°, respectively.

A study of long range spin-spin coupling (28) between magnetic tin nuclei and protons in derivatives, $Sn(acac)_2RX$ (R=Me or Et; X=Cl, Br or I) revealed an increase in coupling with the increase of covalent character of the Sn—O bond. In a large number of such compouuds the inductive effect of the substituents has been investigated by the correlation of the chemical shifts of the acetylacetonato protons with the Sn-O and C:O stretching frequencies (29). Anisotropic effects of benzene on the n.m.r. spactra of dimethyltin bis (acetylacetonato) and methyltin bis(acelylacetonato) halide complexes have also been studied (30).

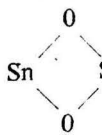
Sn-halogen stretchings have been assigned in the far ir spectra (31) of some tin(IV) acetylocetonates without establishing any

configuration unequivocally. Single crystal X ray and infrared studies on $(acac)_2SnX_2$ (32) (X=Cl, Br or F) have indicated similarity between these compounds but these are not isomorphous. Tobias et.al. (33) have measured formation constants for $(Me)_2Sn(acac)_2$ in aqueous solution.

A large number of interesting methoxy (acetylacetonato) tin dihalides(34) and their alkyl substituted products (35), (MeO)(acac) SnXY (X=Y=Cl, Br and I; X=Cl or Br and Y=Me, C_2H_3 or Bu) have been described by the partial methanolysis of their corresponding acetylacetonates. Their ir spectra revealed the following structure :



indication of the special stability of the four membered ring



A cobalt carbonyl derivative of 6-coordinate tin has been reported (36) by the reaction of $(acac)_2SnCl_2$ with tetracarbonyl cobalt anion, as a crystalline compound of the composition $(acac)_2SnCo_2(CO)_7$ which was found to be essentially diamagnetic structure involving Co-Co bond as proposed by ir and mass spectrophotometric data.

It would be interesting to include a contrasting difference in the acetylacetonate chemistry of tin from that of silicon and germanium. $(acac)_2SnCl_2$ does not appear to react with $FeCl_3$(37,9) and $SbCl_5$ (9) whereas complexes of the type $[M(acac)_3]FeCl_4$ and $[M(acac)_3]SbCl_6$ have been characterised during analogous reactions of silicon (9) and germanium (9,38).

REFERENCES

1. J. P. Fackler, Jr., Progress in Inorg. Chem., 1967, *7*, 361.
2. F. Bonati, Organometallic Chem. Rev., 1966, 1,379
3. G. T. Morgan and H. D. K. Drew, J. Chem. Soc.. 1924, 372.
4. R.C. Mehrotra and V. D. Gupta, J. Ind. Chem. Soc., 1963, *40*. 911.
5. W. Dilthey, Ber., 1903, *36*, 923.
6. A. Rosenheim, W. Lowenstamm and L. Singer, Ber., 1903, *36*, 1833.
7. W. Dilthey, Ann., 1906, *344*, 300.
8. W. H. Nelson and D.F. Martin, J. Organometal. Chem., 1965, *4*, 67.
9. M. Cox, J. Lewis and R.S. Nyholm, J. Chem. Soc., 1964, 6113.
10. I.R. Beattie and V. Fawcett, J. Chem. Soc. (A), 1967(10), 1583.
11. G.P. Mack and E. Parker, U.S. Patent, 2,604, 483; C.A., 1953, *47*, 4358.
12. G.P. Mack and E. Parker, U.S. Patent, 2,727,917; C.A. 1956, *50*, 10761.
13. G.P. Mack and E. Parker, U.S. Patent, 2,745,819; C.A., 1957, *51*, 9214.
14. R.C. Mehrotra and V.D. Gupta, J. Organometal. Chem., 1965, *4*, 237.
15. W.P. Neumann and F.G. Kleiner, Tetrahedron letters, 1964 (49), 3779.
16. S.V. Ponomarev, E.V. Machigin and I.F. Lutsenko, Zh. Obshch. Khim., 1966, *36*(3), 548
17. R.Ueeda, Y. Kawasaki, T. Tanaka and R. Okawara, J. Organometal. Chem., 1966, *5*, 194.
18. W.H. Nelson and D.F. Martin, J. Inorg. Nucl. Chem., 1965, *27*, 89.
19. R. Okawara, Y. Kawasaki and T. Tanaka, abstract VIII ICCC, Vienna, 1964, 432.
20. Y. Kawasaki, T. Tanaka and R. Okawara, Bull. Chem. Soc., Jap. 1964, 37, 903.
21. J.A.S. Smith and E.J. Wilkins, J. Chem. Soc. (A), 1966 (12), 1749.
22. J.A.S. Smith and E.J. Wilkins, Chem., Commun., 1965 (16), 381.
23. M.M. McGardy and R.S. Tobias, J. Amer. Chem. Soc., 1965, *87*, 1909.
24. Y. Kawasaki and T. Tanaka, J. Chem. Phys., 1965, *43*(9), 3396.
25. J.W. Faller and A. Davison, Inorg. Chem., 1967, *6*, 182.
26. Y. Kawasaki and T. Tanaka, Inorg. Nucl. Chem. Lett., 1967, *3*, 13.
27. Y, Kawasaki, T. Tanaka and R. Okawara, Inorg. Nucl. Chem. Lett., 1966, 2, 9.
28. Y, Kawasaki, J. Inorg. Nucl. Chem., 1967, *29*, 840.
29. Y. Kawasaki, T. Tanaka and R. Okawara, Bull. Chem. Soc., Jap., 1967, *40*, 1562.
30. Y. Kawasaki, Mol. Phys., 1967, *12*, 287.
31. I. Douck, M.J. Frazer, Z. Goffer, M. Goldstein, B. Rimmer and H.A. Wills, Spectrochim. Acta, 1967, *23*A, 373.
32. M. Cox, R.J.H. Clark and H.J. Milledge, Nature, 1966, *212*, 1357.
33. M. Yasuda and R,S. Tobias, Inorg. Chem., 1963, *2*, 207; 1307.
34. Y. Kawasaki and R. Okawara, J. Inorg. Nucl. Chem., 1965, *27*, 1168.
35. Y. Kawasaki, T. Tanaka and R. Okawara, J. Organometal. Chem., 1966, *6*, 95.
36. D.J. Patmore and W.A.G. Graham, Chem. Communs., 1967(1), 7.
37. R.C. Mehrotra, V.D. Gupta and P.P. Sharma, Unpublished observation.
38. W.K. Ong and R.H. Prince, J. Inorg. Nucl. Chem., 1965, *27*, 1037.