

INTERNATIONAL SPELEOLOGICAL UNION
KARST DENUDATION EXPERIMENT

QUEENSLAND SITES

REPORT FOR THE FIRST THREE YEARS
1979-1982

Compiled by K.G.GRIMES
1983

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INTRODUCTION

The Commission of Karst Denudation of the International Speleological Union decided in September 1977 to organise a world-wide comparative study of karst denudation rates using limestone tablets. The program is being co-ordinated by Prof. Ivan Gams, president of the Commission.

A number of sites have been established in Australia. This report describes four sites located in three areas in Queensland and presents the results for the first three years of exposure (1979 - 1982). Fig 1 shows the location of the sites.

At each site six tablets were exposed (see appendix 1): two in the air, two on the ground surface, and two buried in the soil. The tablets were weighed before placement and were re-weighed each year. Results are compared with rainfall for each period and with soil type at each site.

AREA DESCRIPTIONS

Three areas in Queensland were selected for the establishment of sites (Fig 1): near Camooweal in the northwest of the state, near Chillagoe in the north, and near Rockhampton in the central east coast. Two sites were set up at Camooweal, on different soil types, and one each at Chillagoe and Rockhampton. The Camooweal sites are in a warm arid climate, the Chillagoe site is in a humid tropical climate, and the Rockhampton site in a humid warm temperate climate.

CAMOOWEAL AREA

LOCATION: About 150km northwest of Mt Isa in northwestern Queensland, Australia. Refer to the Mt Isa & Camooweal 1:250,000 or Wooroona & Camooweal 1:100,000 topographic maps. Fig 2 locates the two sites within the area.

CO-ORDINATES: Latitude 20°S, Longitude 138°E.

LOCAL EXPERIMENTERS: Mount Isa Caving Club (see appendix 2 for addresses).

GEOLOGY: The Cambrian Camooweal Dolomite forms an extensive area in this northeastern part of the Georgina Basin (Smith 1972). The dolomites and limestones are flat lying, well bedded, and moderately to well jointed. They are poorly exposed and much of the area is blanketed by thick black soils or red lateritic soils. The two experimental sites cover these two major soil types. Silicified rises are associated with the lateritised areas.

The area is a plateau which has suffered only minor dissection since its uplift in the Tertiary. Stream channels are rare and the few dolines are scattered at a density of only 0.5 per sq.km. (Grimes 1974). The area is one of retarded karst development (Grimes 1974, 1977).

VEGETATION: The natural vegetation varies from treeless tussock grasslands (the Mitchell Grass Plains) on the black soils to savanna woodlands on the lateritic soils and outcrop areas. Dense Gidgea woodland occurs along some of the major streams (Perry & Christian, 1954).

CLIMATE: The regional climate varies from arid in the south (BWhw in the Koppen system: Dick, 1975) to semi-arid in the north (BSHW). At Camooweal the mean annual rainfall is 387mm and the mean annual temperature is 25.6°C. Details of rainfall, temperatures, and humidity for Camooweal are given in the table. The area has an estimated 3200 hours of sunshine per year. Fogs and frosts are non-existent. Dew occurs rarely (an estimated 10 nights per year). Sources of data are the Queensland Regional Office of the Commonwealth Bureau of Meteorology and local information.

LONG TERM MONTHLY CLIMATIC AVERAGES, CAMOOWEAL P.O. (25 km NW of the sites)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL mm													
Average	92	87	61	14	11	12	5	3	6	12	28	50	387
Raindays	8	8	5	2	1	1	1	0	1	2	4	6	39
TEMPERATURE °C													
Mean Max	38.1	37.1	35.2	33.5	28.8	26.4	25.7	28.2	32.1	36.3	37.9	38.5	33.2
Mean Min	24.9	24.2	22.2	18.7	13.7	10.3	8.9	10.9	14.9	19.9	22.6	24.0	17.9
HUMIDITY													
R.H.%	49	52	48	41	42	48	40	30	26	28	28	38	39

SITE DESCRIPTION : BLACK SOIL (MITCHELL GRASS PLAINS)

LOCATION: In "The Don" paddock about 28km SE of Camooweal.

CO-ORDINATES: Latitude 20°9'30"S, Longitude 138°14'00"E. 210700mE & 7768700mN on the Australian Map Grid.

LANDOWNER: Stanbroke Pastoral Co. (see Appendix 2 for address)

SITUATION: Fig 6 shows the location of the site and photo 1 shows the terrain and the vegetation. The site is located at an elevation of about 240m on a treeless Mitchell Grass plain. There is a 50% cover of tussock grass, and 50% bare soil. The ground surface is flat with a gilgae micro-relief.

SOIL: The soil is a heavy mid-brown (10YR 4/4) cracking loam, with some chert pebbles. Testing by the Department of Primary Industries (DPI), Brisbane, indicated soil pHs from 7.9 to 8.7 (see Appendix 3).

TABLET PLACEMENT: See Appendix 1 for standard layout of all sites.

TABLET	LOCATION
898 & 900	suspended 1m above ground.
899 & 901	on bare ground surface.
970 & 971	buried 20cm deep.

SITE DESCRIPTION: RED LATERITIC SOIL (KALKADOON CAVE AREA)

LOCATION: In "The Don" paddock about 25km SE of Camooweal.

CO-ORDINATES: Latitude 20°9'00"S, Longitude 138°14'00"E. 210800mE & 7771800mN on the Australian Map Grid.

LANDOWNER: Stanbroke Pastoral Co. (see Appendix 2).

SITUATION: Fig 7 shows the location of the site and photo 2 shows the terrain and the vegetation. The site is located at an elevation of about 240m in savannah woodland with tussock grass covering 50% of the ground. There is a low limestone rise 10m to the south and a blind valley 100m to the north which leads to Kalkadoon Cave. The site itself has a flat ground surface.

SOIL: The soil is a red (10R 4/6) loamy fine sand. Soil pH is between 7.1 and 7.3 (see Appendix 3).

TABLET PLACEMENT: See Appendix 1 for standard layout of all sites.

TABLET	LOCATION
894 & 895	suspended 80cm above ground.
896 & 897	on partly grassed ground surface.
968 & 969	buried 20cm deep.

CHILLAGOE AREA

LOCATION: About 130km west of Cairns in northern Queensland. Refer to the Atherton 1:250,000 and Chillagoe & Mungana 1:100,000 topographic maps. The elevation is about 400m. Fig 3 locates the site within the area.

CO-ORDINATES: Latitude 17° 19'S, Longitude 144° 32'E.

LOCAL EXPERIMENTERS: Chillagoe Caving Club (T.Robinson, P.Kinnear: see appendix 2 for addresses).

GEOLOGY: Steeply dipping cherts, greywackes, siltstones and limestones of the Siluro-Devonian Chillagoe Formation form a belt of country along the western margin of the Hodgkinson Basin (de Keyser & Wolff, 1964). The limestone lenses are up to 2km long and 600m wide and have been eroded to form towers up to 80m high with surrounding limestone pavements. The area was previously considered to be a relict tower karst resulting from alternating periods of wet and dry climates (e.g. Ford, 1978). But recently the possibility of structural control on the development of the towers has been suggested (Jennings, 1981, 1982).

VEGETATION: The towers are of bare sculptured limestone with scattered clumps of vine thicket. The limestone pavements and other rock types carry a savannah woodland with some denser forest along the water courses. (Galloway et.al., 1970)

CLIMATE: The climate is humid tropical, Aw in the Koppen scheme (Dick, 1975). Annual rainfall at Chillagoe is 855mm with a summer maximum. Long term rainfall averages are given below. Long term temperatures are not available for Chillagoe but the mean for the four years of the experiment was 26.1°C. Temperatures for Mareeba, some 100km to the east, are listed below. The area has an estimated 3000 hours of sunshine per year. Dew is estimated as occurring on about 100 nights per year. Frost is nonexistent and fogs are very rare. For further details see Robinson (1982).

LONG TERM MONTHLY RAINFALL AVERAGES, CHILLAGOE (5km NE of site)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL mm													
Average	209	220	149	28	13	11	4	4	6	14	56	141	855
Raindays	13	13	11	3	1	1	1	0	1	2	5	9	60

LONG TERM MONTHLY CLIMATIC AVERAGES, MAREEBA (100km to east of site)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL mm													
Average	195	267	218	38	22	17	5	9	5	13	47	92	928
Raindays	16	17	15	11	6	5	3	3	3	3	6	10	98
TEMPERATURE °C													
Mean Max	31.2	31.1	29.6	28.4	26.6	25.1	25.3	26.6	28.1	30.7	31.9	32.1	28.9
Mean Min	20.8	21.2	19.9	17.1	14.8	12.9	11.2	11.7	12.9	15.6	18.4	19.8	16.4

SITE DESCRIPTION: ROYAL ARCH TOWER

LOCATION: Beside the Royal Arch Tower, about 5km SW of Chillagoe town.

CO-ORDINATES: Latitude 17° 11'S, Longitude 145° 00'E. 234100mE & 8098200mN on the Australian Map Grid.

LANDOWNER: National Parks and Wildlife Service (see appendix 2 for address).

SITUATION: Fig 4 shows the location of the site and Photo 3 shows the terrain and vegetation. The site is located at an elevation of 410m on the flat soil covered pediment about 20m from the base of the tower. The ground surface is relatively flat with open grassland set in savannah woodland. It accepts runoff from the tower and tends to become waterlogged under wet season conditions (Robinson, 1982).

SOIL: The soil is a 'terra rosa' (Uf 6.31 - Northcote); a red-brown (5YR 4/4) uniform medium clay, with a blocky structure and a smooth ped fabric. Some limestone pebbles are present. PH varies from 6.5 at the surface, to 6.8 at the tablets (30cm), and increases to 7.5 at 1.2m (M. Godwin, pers.comm.).

TABLET PLACEMENT: See Appendix 1 for standard layout of all sites.

TABLET	LOCATION
890 & 891	Suspended 1m above ground.
960 & 961	On grassed ground surface.
962 & 963	Buried at a depth of 0.34m.

ROCKHAMPTON AREA

LOCATION: About 25km North of Rockhampton, in central coastal Queensland, Australia. Refer to the Rockhampton 1:250,000 or Ridgeland 1:100,000 topographic maps. Fig 5 locates the site within the local area.

CO-ORDINATES: Latitude 23°10'30"S, Longitude 153°29'30"E. 243400mE & 7435100mN on the Australian Map Grid (zone 56).

LOCAL EXPERIMENTERS: R.J.Ladynski and G.J.Toop of the Central Queensland Speleological Society (see appendix 2 for addresses).

GEOLOGY: The Early Devonian Mt Holly Beds form a small inlier within a Permian sequence (Kirkegaard et.al.,1970; Shannon,1970). The beds comprise acid to intermediate volcanic rocks with interbedded sediments including limestone lenses up to 250m thick. Dips are generally steep. The limestones form high rocky hills standing above the surrounding undulating country. Local relief is up to 100m. The limestone outcrops are characterised by bare Karren surfaces (Spitz- Rinnen- and Rillenkarren predominate). Caves occur in all outcrops, with Mt Etna and Limestone Ridge having the most extensive systems.

VEGETATION: The natural vegetation is moderately dense Eucalypt forest with some vine thicket in the valleys and on the limestone outcrops (Webb & Tracey,1970; Hamilton-Smith & Champion,1975). Much of the area has been invaded by thickets of Lantana camara, an introduced scrambling weed. Small areas have been cleared for cultivation or grazing.

CLIMATE: The regional climate is humid warm temperate (Cfa in the Koppen 1936 system - Dick, 1975). At Rockhampton, about 25km to the south, the mean annual rainfall is 943mm and the mean annual temperature is 22.3°C. Details of rainfall, temperatures, and humidity for Rockhampton, and rainfall for Milman (7 km NW of the area) are given in the table. The area has an estimated 2900 hours of sunshine per year. Fogs occur about 10 - 20 days per year in the winter. Frosts are rare. Dew occurs about 90 nights per year (estimated). Sources of data are the Queensland Regional Office of the Commonwealth Bureau of Meteorology, Dept.Nat.Dev. (1965), and local information.

LONG TERM MONTHLY CLIMATIC AVERAGES, ROCKHAMPTON (25 km S of site)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL mm													
Average	179	187	110	58	41	58	41	22	29	45	61	112	943
Raindays	12	11	11	6	5	6	5	4	4	6	7	9	86
TEMPERATURE °C.													
Mean Max	31.4	31.1	30.2	28.7	25.9	23.5	22.9	24.8	27.4	29.7	31.1	31.7	28.2
Mean Min	21.7	21.7	20.4	17.6	13.5	10.8	8.6	10.5	13.1	16.8	19.5	20.8	16.3
HUMIDITY													
R.H.%	52	54	51	47	44	43	39	37	36	38	43	47	44

LONG TERM MONTHLY RAINFALL AVERAGES, MILMAN (9km NW of site)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
RAINFALL mm													
Average	167	200	110	57	38	47	39	22	18	45	66	115	924
Raindays	10	11	9	6	5	4	4	4	3	4	6	8	74

SITE DESCRIPTION: KARST GLEN

LOCATION: On 'Karst Glen', about 3km ENE of The Caves (Fig 8).

CO-ORDINATES: See above

LAND OWNER: R. J. Ladynski. (see Appendix 2 for address)

SITUATION: The site is located at an elevation of 115m in a saddle within hilly country. Fig 8 shows the exact location within the property, and the site and surrounds are illustrated in Photo 4. The site is on a heavy brown loam about 20m downhill from a limestone outcrop. The ground surface slopes to the SE. The original vegetation has been cleared and the area has been cultivated. The present vegetation consists of one to two metre high Sorghum saccharatum grass which has been removed from the immediate area of the site. Some weed regrowth has occurred between weighings.

SOIL: The soil is a deep, brown (2.5 YR 4/4), heavy loam. Soil pHs between 6.9 and 7.0 were measured by the DPI (see appendix 3).

TABLET PLACEMENT: See Appendix 1 for standard layout of all sites.

TABLET	LOCATION
892 & 893	Suspended 1m above ground.
965 & 966	On bare ground surface.
964 & 967	Buried at a depth of 0.25m.

According to Köppen Scheme
(Slightly modified)

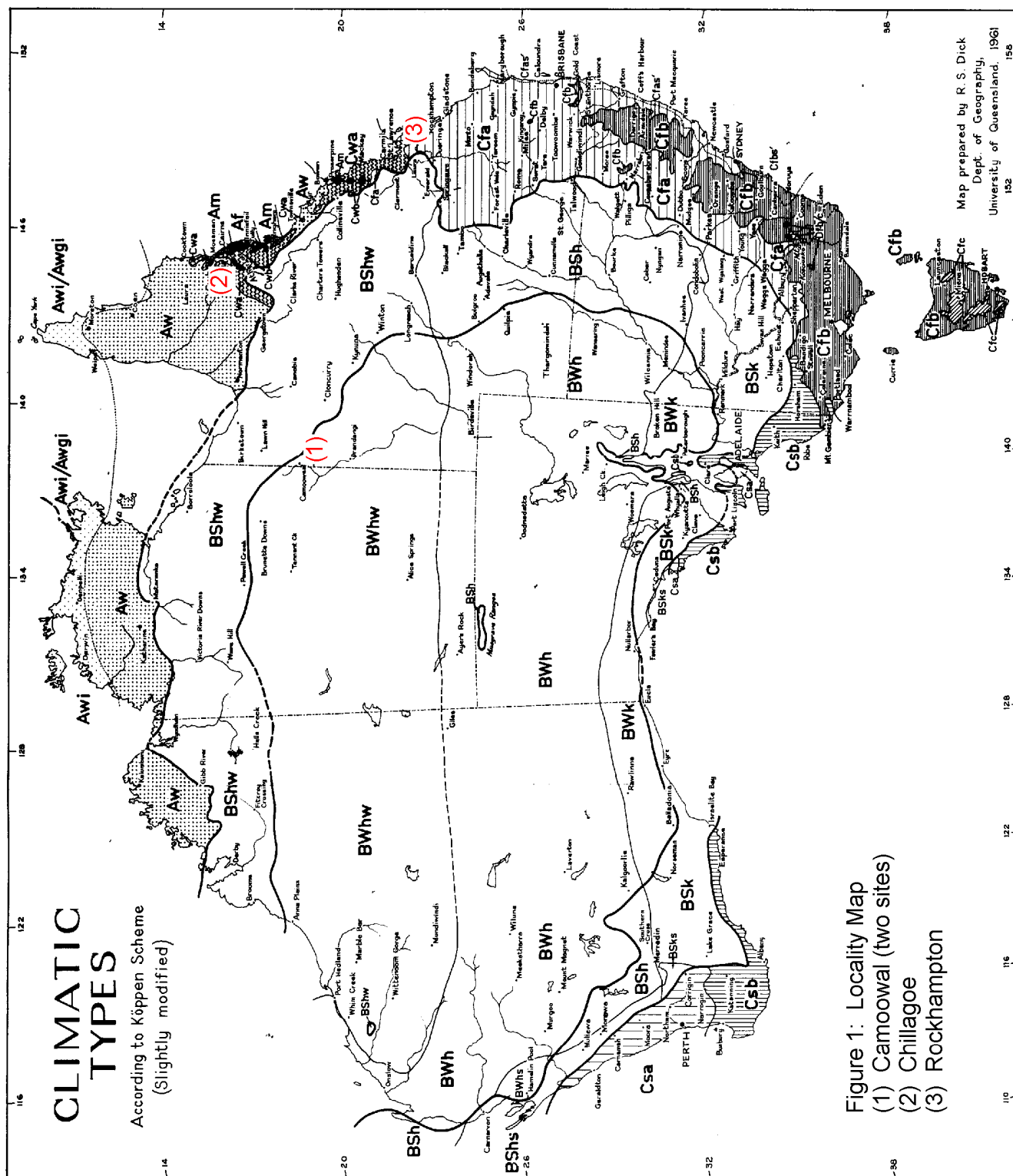


Figure 1: Locality Map

- (1) Camooyal (two sites)
- (2) Chillagoe
- (3) Rockhampton

Map prepared by R. S. Dick
Dept. of Geography,
University of Queensland, 1961

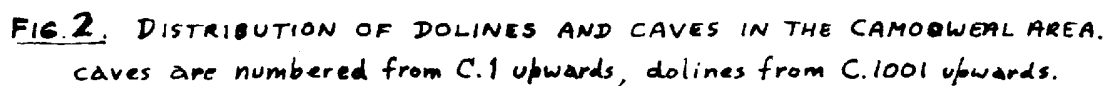
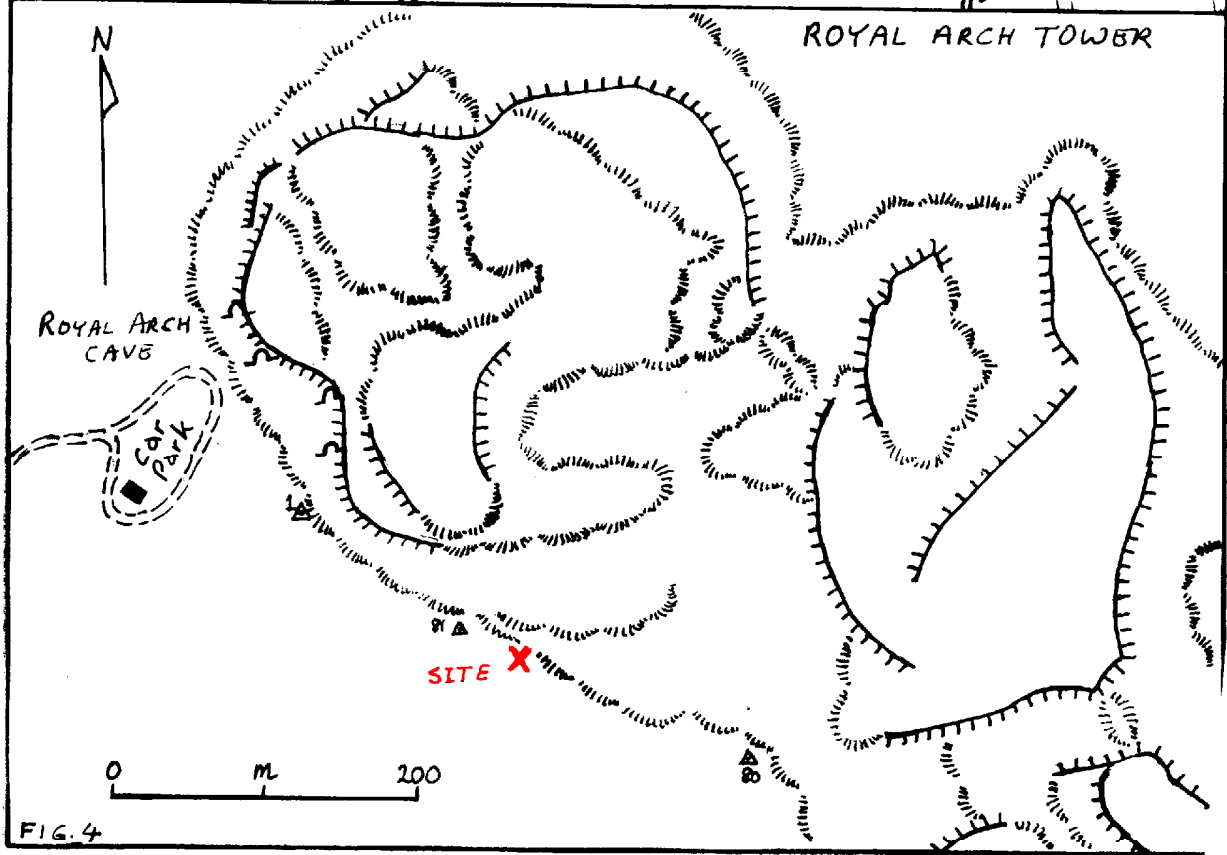
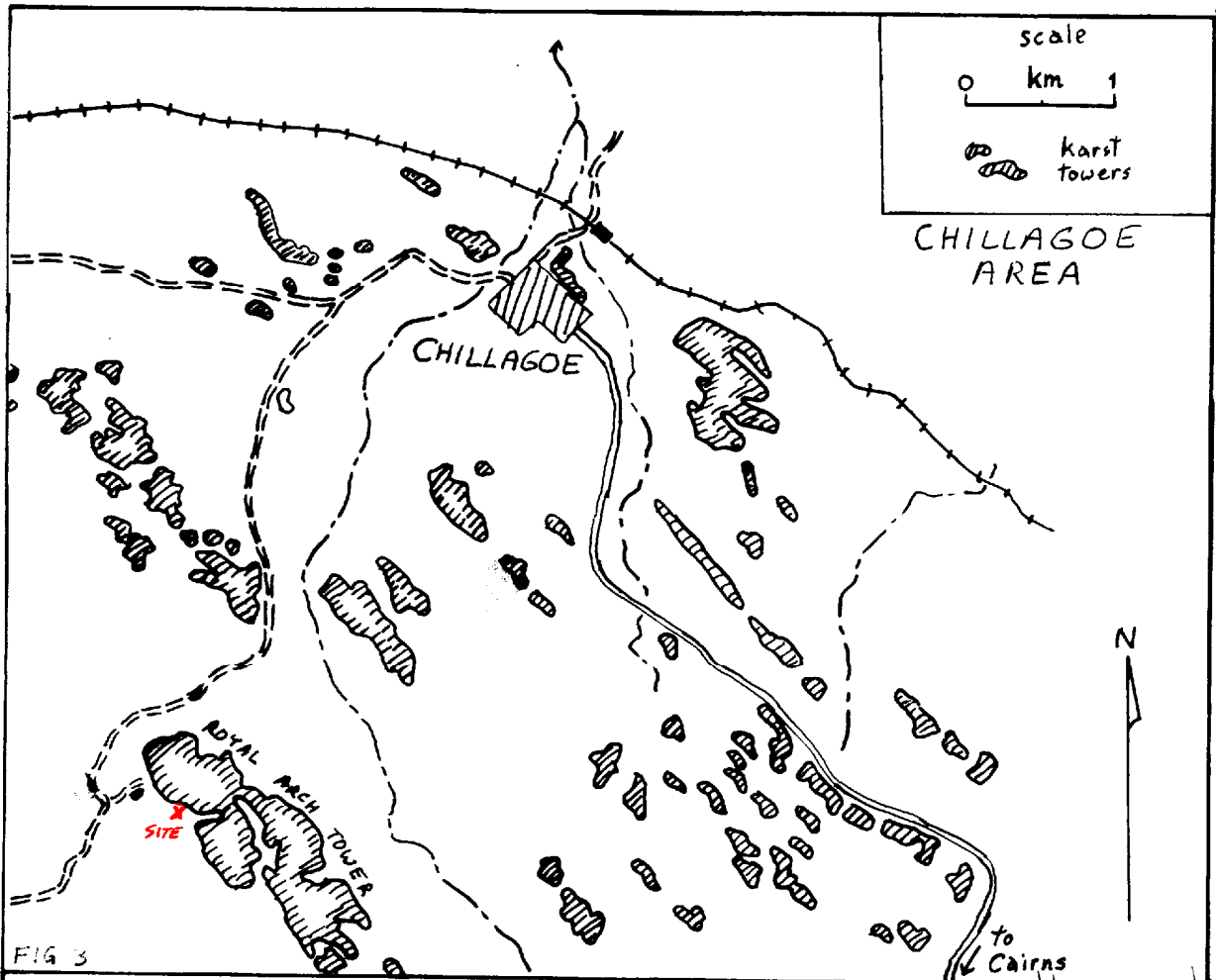


FIG.2. DISTRIBUTION OF DOLINES AND CAVES IN THE CAMOOWEAL AREA.
CAVES ARE NUMBERED FROM C.1 UPWARDS, DOLINES FROM C.1001 UPWARDS.





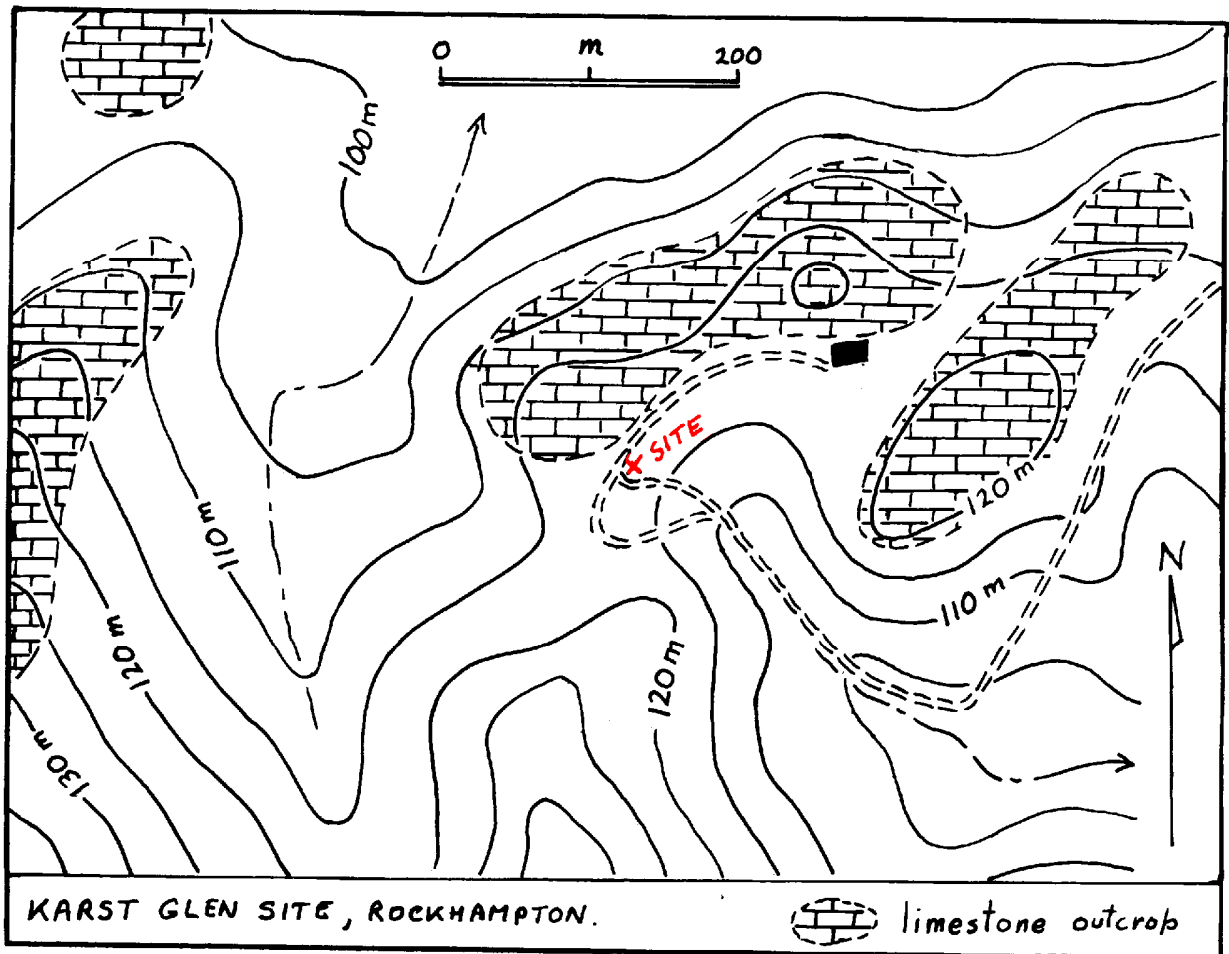
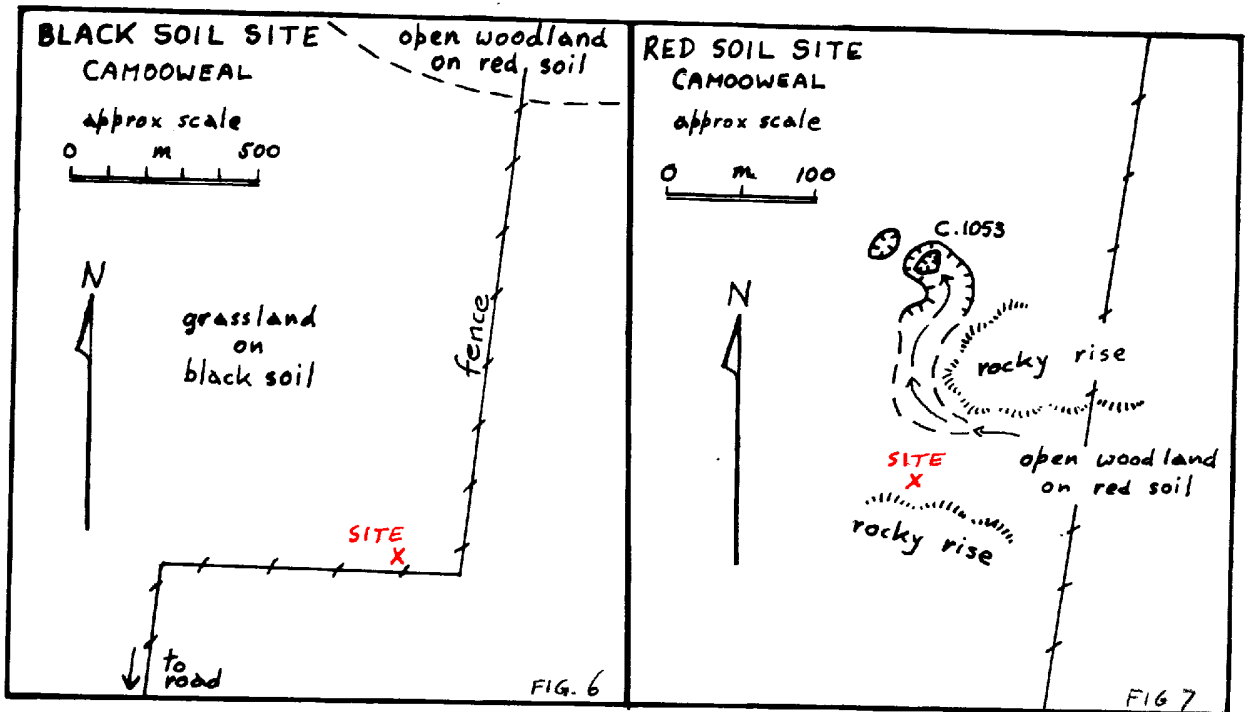
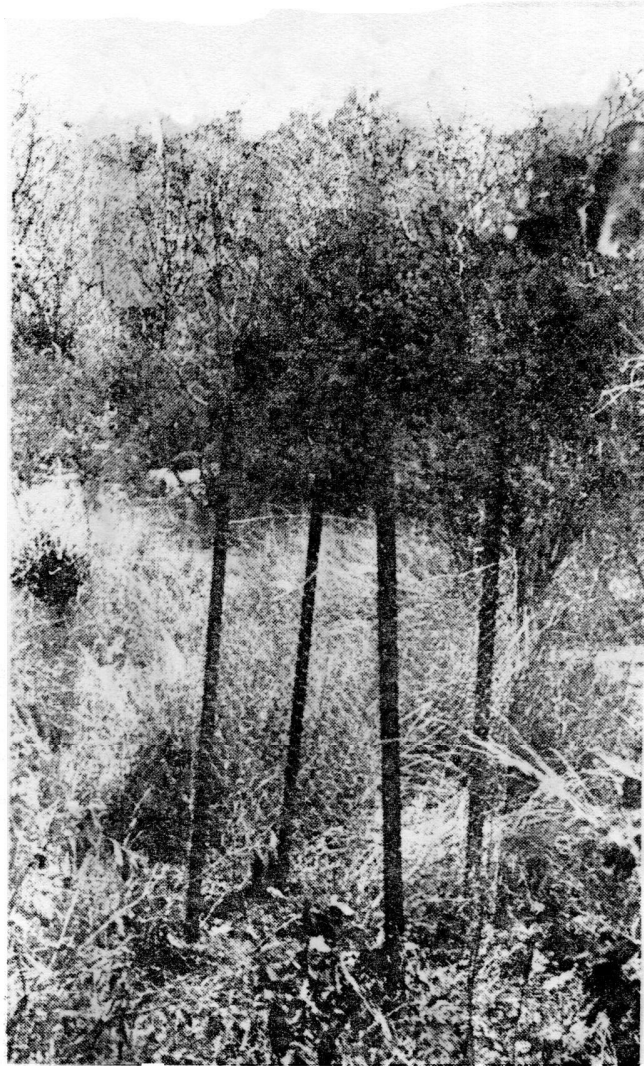




Photo 1: Camooweal, Black Soil Site



Photo 2: Camooweal, Red Soil Site



The experiment site, Royal Arch Tower, Chillagoe.



Photo 4: Rockhampton, Karst Glen Site.

RESULTS
1979-1983

CAMOOWEAL AREA

MONTHLY RAINFALL at Camooweal P.O.: 10-7-79 to 3-12-82

1979:							JUL	AUG	SEP	OCT	NOV	DEC
mm							0	0	0	33	1	5
days							0	0	1	1	2	5
1980:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
mm	43	43	29	2	7	0	1	11	0	5	1	23
days	11	9	4	3	2	0	1	4	0	3	2	3
1981:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
mm	74	172	0	0	54	8	4	0	1	1	71	22
days	16	15	0	0	3	1	2	1	2	2	10	8
1982:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
mm	84	132	145	6	0	0	0	0	0	7	9	22
days	14	10	10	3	0	0	0	0	1	1	3	9

MONTHLY TEMPERATURES at Camooweal P.O.

1979:							JUL	AUG	SEP	OCT	NOV	DEC
Max °C							26.1	29.3	33.5	35.4	38.9	40.1
Min °C							6.9	11.2	16.5	18.7	22.4	24.5
1980:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max	37.8	38.4	37.4	34.3	27.7	27.6	25.4	29.6	34.8	37.2	39.9	39.5
Min	24.5	25.4	23.0	20.8	10.9	11.0	8.7	12.9	16.4	21.0	23.4	24.8
1981:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max	35.3	25.2	26.5	35.4	29.3	26.7	26.8	31.3	32.9	35.5	36.1	40.8
Min	24.4	23.6	19.4	18.8	14.8	10.7	11.4	13.7	17.1	17.1	22.1	25.0
1982:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max	39.9	36.2	34.0	33.4	29.8	25.6	25.0	29.0	31.4	35.1	38.6	40.0
Min	25.7	24.0	21.9	18.3	11.8	7.1	5.5	13.1	14.2	16.3	22.3	24.2

TABLET DATA: BLACK SOIL (MITCHELL GRASS PLAINS) SITE

10-7-79 to 2-8-80: 389 days exposure. 163mm total rain (153mm/year)

POSITION	TABLET	LOSS mg ¹	LOSS mg/day	LOSS mg/day/cm ²	surface area
Air	898	11 ²	-	-	
	900	14	0.036	0.0012	
Surface	899	17	0.044	0.0015	
	901	31 ³	-	-	
Buried	970	24	0.062	0.0020	
	971	14	0.036	0.0012	

4-8-80 to 21-6-81: 317 days exposure. 346mm total rain (395mm/year)

POSITION	TABLET	LOSS mg ¹	LOSS mg/day	LOSS mg/day/cm ²	surface area
Air	898	- ⁵			
	900	- ⁴			
Surface	899	22	0.069	0.0023	
	901	26	0.082	0.0026	
Buried	970	- ⁴			
	971	2	0.006	0.0002	

26-9-81 to 3-12-82: 530 days exposure. 481mm total rain (331mm/year)

POSITION	TABLET	LOSS mg ¹	LOSS mg/day	LOSS mg/day/cm ² surface area
Air	898	11	0.021	0.0007
	900	-		
Surface	899	20	0.038	0.0013
	901	19	0.036	0.0011
Buried	970	-		
	971	3	0.006	0.0002

TABLET DATA: RED LATERITIC SOIL (KALKADOON) SITE

10-7-79 to 2-8-80: 389 days exposure. 163mm total rain (153mm/year)

POSITION	TABLET	LOSS mg ¹	LOSS mg/day	LOSS mg/day/cm ² surface area
Air	894	18	0.046	0.0016
	895	14 ²	-	-
Surface	896	17	0.044	0.0014
	897	27	0.069	0.0023
Buried	968	33	0.085	0.0028
	969	39	0.100	0.0032

4-8-80 to 21-6-81: 319 days exposure. 346mm total rain (395mm/year)

POSITION	TABLET	LOSS mg ¹	LOSS mg/day	LOSS mg/day/cm ² surface area
Air	894	- ⁴		
	895	- ⁴		
Surface	896	16	0.050	0.0016
	897	- ⁴		
Buried	968	22	0.069	0.0023
	969	26	0.082	0.0026

29-6-81 to 3-12-82: 530 days exposure. 481mm total rain (331mm/year)

POSITION	TABLET	LOSS mg ¹	LOSS mg/day	LOSS mg/day/cm ² surface area
Air	894	-		
	895	-		
Surface	896	- ⁴		
	897	-		
Buried	968	6	0.011	0.0004
	969	-3	-0.006	-0.0002

Notes: ¹ all weights are ± 5 mg in accuracy

² suspending wire broken, the tablet had suffered some abrasion and some accumulation of tar: The weight loss is therefore not reliable.

³ tablet damaged during recovery: The weight loss is meaningless.

⁴ tablet broken or lost completely.

⁵ tablet chipped, but re-used next period.

COMMENTS:

The tablets were weighed on a Mettler balance (± 5 mg) at the Mt Isa State School science laboratory. Air-dried weights were used for the first measurement, oven-dried weights thereafter. The lack of precision and reproducibility of weights on this balance was a problem. Because of this and the low annual weight losses the results should only be used for general comparison and not for detailed calculation.

The first period was a drought year with less than half the average annual rainfall. The soils were quite dry when the tablets were excavated and there had been no vegetation growth since the sites were set up in the previous year. The second period had a little under the normal rainfall, and the adjusted rainfall for the third period of 17 months was 331mm/year, also a little under the average.

Tablet breakage and disturbance to the sites were major problems in this area, and the experiment was abandoned at the end of the third period.

CHILLAGOE AREA

MONTHLY RAINFALL at Chillagoe. Observers: P. & V.Kinnear.

1979:					MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
mm					0	8	5	0	0	14	7	45
days					0	3	4	0	0	2	2	7
1980:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
mm	294	185	124	8	6	4	0	0	0	30	54	101
days	15	16	12	4	2	2	1	1	0	2	3	6
1981:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
mm	459	354	46	27	54	3	0	0	3	7	52	179
days	22	22	7	3	6	1	0	0	1	3	7	10
1982:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
mm	240	31	130	34	3	3	0	1	2	0	39	131
days	11	7	9	7	2	2	0	1	1	0	2	7
1983:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
mm	77	65	143	95								
days	4	8	11	8								

MONTHLY TEMPERATURES: Chillagoe. Observer: P. & V. Kinnear
(no observations exist prior to 6-6-79)

1979:					MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max °C					n.d.	26.3	25.2	27.1	29.8	33.6	34.3	36.0
Min °C					n.d.	19.1	16.5	16.8	19.7	22.9	23.7	25.2
1980:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max	34.7	33.3	31.1	29.9	28.7	27.2	27.4	27.4	31.4	34.3	35.9	34.8
Min	25.4	25.1	23.4	21.3	19.6	16.7	15.8	17.6	18.0	22.3	24.1	25.5
1981:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max	31.5	32.9	32.9	31.7	28.5	26.1	27.9	30.1	30.2	32.2	34.8	35.3
Min	24.2	25.5	22.8	21.4	19.2	15.5	18.0	18.4	19.0	22.6	25.1	25.2
1982:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max	33.9	33.2	32.5	29.5	28.1	25.6	25.9	26.0	30.7	33.1	34.5	35.0
Min	25.3	24.2	22.9	21.3	17.2	13.2	13.7	16.0	18.5	19.0	22.6	24.1
1983:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max	35.3	35.6	32.6	31.9								
Min	24.9	25.1	23.7	23.1								

TABLET DATA: ROYAL ARCH SITE

7-5-79 to 5-5-80: 364 days exposure. 689mm total rain (691mm/year)

POSITION	TABLET	LOSS mg	LOSS mg/day	LOSS mg/day/cm ²	surface area
Air	890	11	0.030	0.0010	
	891	10	0.027	0.0009	
Surface	960	25	0.069	0.0022	
	961	21	0.058	0.0019	
Buried	962	119	0.327	0.0106	
	963	98	0.269	0.0087	

10-5-80 to 4-5-81: 359 days exposure. 1084mm total rain (1102mm/year)

POSITION	TABLET	LOSS mg	LOSS mg/day	LOSS mg/day/cm ²	surface area
Air	890	30	0.084	0.0028	
	891	29	0.081	0.0026	
Surface	960	29	0.081	0.0026	
	961	48	0.134	0.0043	
Buried	962	189	0.521	0.0171	
	963	199	0.554	0.0180	

MONTHLY TEMPERATURES at Rockhampton.

1979:						JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max °C						24.2	23.4	25.5	27.4	30.3	31.6	33.9
Min °C						12.0	9.3	9.7	14.6	18.1	20.2	22.7
1980:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max	33.1	30.7	29.6	28.6	24.0	24.0	22.8	24.0	29.2	31.3	32.0	31.5
Min	23.7	22.7	20.3	18.6	11.0	11.0	8.6	12.2	12.4	18.6	20.3	21.1
1981:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max	29.0	31.6	31.5	28.8	25.4	23.0	23.0	25.3	27.3	27.8	29.8	33.7
Min	21.4	23.7	20.4	18.1	14.1	9.8	11.9	9.8	14.5	16.5	20.5	23.0
1982:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max	33.5	32.6	31.3	28.6	26.6	22.8	23.0	24.2	26.8	29.0	30.4	32.7
Min	23.7	22.6	22.0	18.6	14.1	6.9	7.3	12.4	13.4	14.5	19.1	21.2
1983:	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Max	32.2											
Min	22.0											

TABLET DATA: KARST GLEN SITE

16-6-79 to 14-6-80: 364 days exposure. 934mm total rain (937mm/year)

POSITION	TABLET	LOSS mg	LOSS mg/day	LOSS mg/day/cm ² surface area
Air	892	27.5	0.076	0.0025
	893	26.9	0.074	0.0024
Surface	965	45.6	0.125	0.0041
	966	42.0	0.115	0.0037
Buried	964	85.3	0.234	0.0075
	967	81.2	0.223	0.0075

16-6-80 to 13-6-81: 363 days exposure. 666mm total rain (670mm/year)

POSITION	TABLET	LOSS mg	LOSS mg/day	LOSS mg/day/cm ² surface area
Air	892	24.8	0.068	0.0022
	893	20.4	0.056	0.0018
Surface	965	58.3	0.161	0.0052
	966	101.8	0.280	0.0089
Buried	964	74.2	0.204	0.0065
	967	77.4	0.213	0.0071

17-6-81 to 18-1-83: 579 days exposure. 671mm total rain (423mm/year)

POSITION	TABLET	LOSS mg	LOSS mg/day	LOSS mg/day/cm ² surface area
Air	892	32.3	0.056	0.0018
	893	31.4	0.058	0.0018
Surface	965	20.5	0.035	0.0012
	966	38.7	0.067	0.0021
Buried	964	18.9	0.033	0.0010
	967	19.5	0.034	0.0011

COMMENTS:

For the first period the tablets were dried in the air before weighing, for subsequent periods the tablets were oven dried at 80°C for 24 hours. The tablets were weighed on a Mettler balance in the Chemistry Department of the Capricorn Institute of Advanced Education.

The first period had normal rainfall. The second period was below average, and the rain during the third long period (19 months) was very low when adjusted to an annual figure of 423mm/year.

The solution rates for the surface tablets in the 1980-81 period seem to be anomalously high.

DISCUSSION

The solution rates for the buried tablets showed a fair correlation with the rainfall within any one site, but varied considerably between sites (Fig 9). The affect of the differing soil types and drainage would appear to be of equal importance to that of the rainfall.

One significant factor seems to be the soil acidity. At Camooweal, where the two sites would have received similar rainfalls, the black soil site (pH 8.7) showed significantly lower solution rates than the red soils (pH 7.1-7.2) for the first two periods, and in the third period solution rates were so low that the difference is not meaningful. The soil pH of 6.8 at Chillagoe is only slightly lower than that at Rockhampton (6.9-7.0), yet for periods of comparable rainfall the solution rates at Chillagoe were nearly twice that at Rockhampton. This suggests some other factor which differed between the areas.

One factor could be temperature, Chillagoe being 4°C warmer, but this should effect all tablets and there are no comparable differences for the surface or suspended tablets in the two areas.

A more significant difference could be that of slope: The Chillagoe site is flat and poorly drained, whereas the Rockhampton site is on a hill slope and presumably better drained. Thus the soil surrounding the Chillagoe tablets would remain waterlogged for longer periods after rain than at Rockhampton. The Camooweal sites are also flat and poorly drained, which might explain why soil solution rates at the red soil site for the 1980-81 period were higher than those for Rockhampton in 1981-82, when rainfalls were similar. This being in spite of the greater acidity of the Rockhampton soil.

The Chillagoe site could also be receiving runoff from the nearby tower. Robinson (1982), in discussing the variations between years at Chillagoe, comments on the possible affects of varying rainfall intensity and distribution on solution rates.

The surface tablets show some correlation with rainfall, but no other obvious differences between areas. The rates for the Rockhampton tablets in 1980-81 seem anomalous: this is the only case where surface tablets have dissolved at higher rates than the buried ones at the same site. Analyses of soil samples taken during this period show unusually high phosphorus levels at the ground surface (Appendix 3), suggesting contamination from fertilizer. The high solution rates could be due to the increased biological activity caused by this fertilizer.

If we ignore these two measurements then a slight increase in solution rates is noticeable for the higher rainfalls, but in the lower rainfall areas there is little correlation (Fig 9). Robinson (1982) suggests that differences in vegetation cover (tall tropical grasses) could explain some of the variation between periods at Chillagoe. This could also be a factor at Rockhampton.

The suspended tablets show a very weak correlation with rainfall in the high rainfall end of Fig 9.

ACKNOWLEDGEMENTS

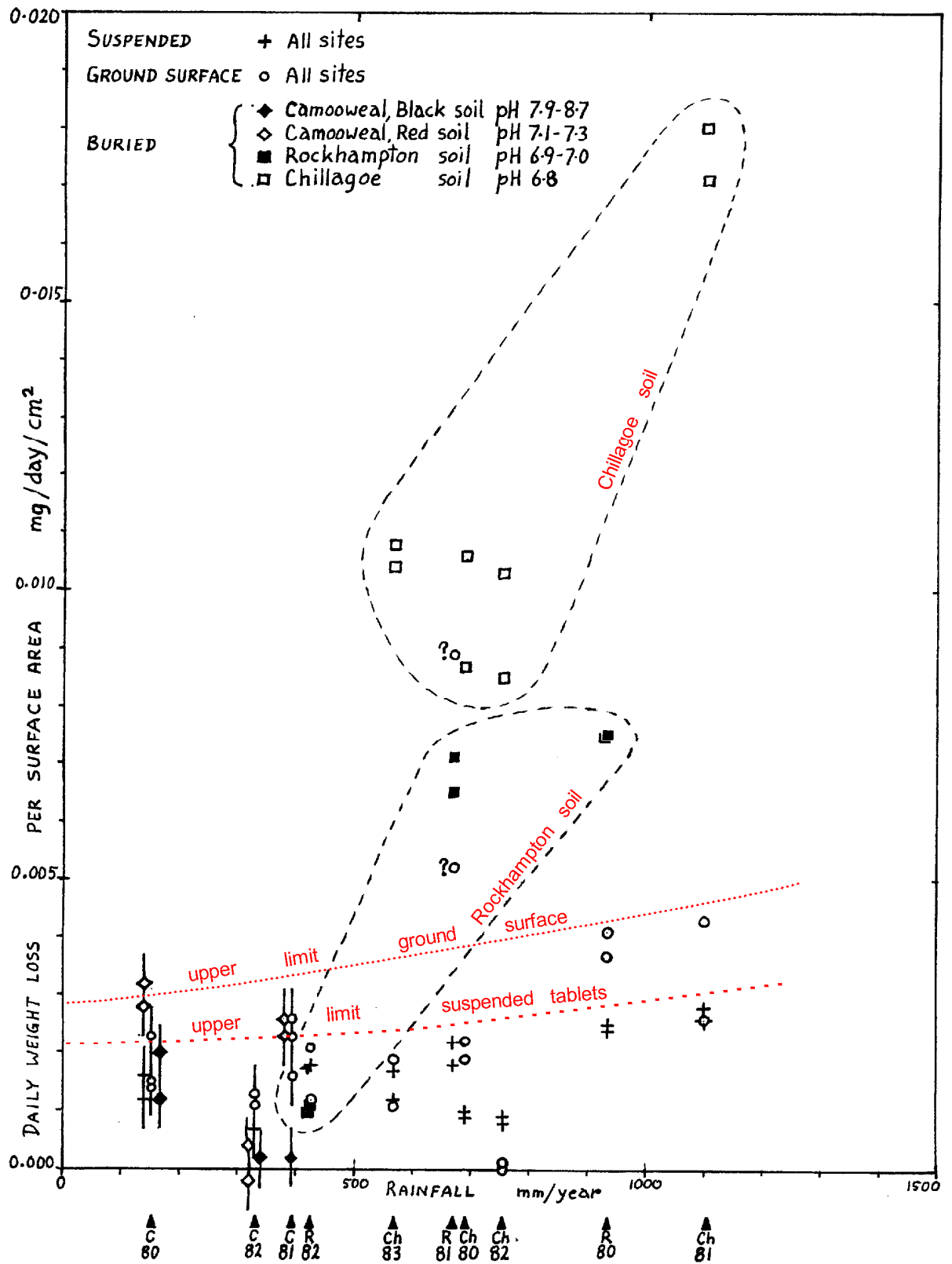
We are indebted to R.Jenson of Rocklands station, to the National Parks and Wildlife Service at Chillagoe, and to R.Ladynski of Karst Glen for allowing us to set up the sites on their land.

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Staff of the Cairns State High School, the Capricorn Institute of Advanced Education, and the Mt Isa State High School made electrical balances available and assisted with the weighing of the tablets.

FIG 9

SOLUTION RATE VERSUS ANNUAL RAINFALL



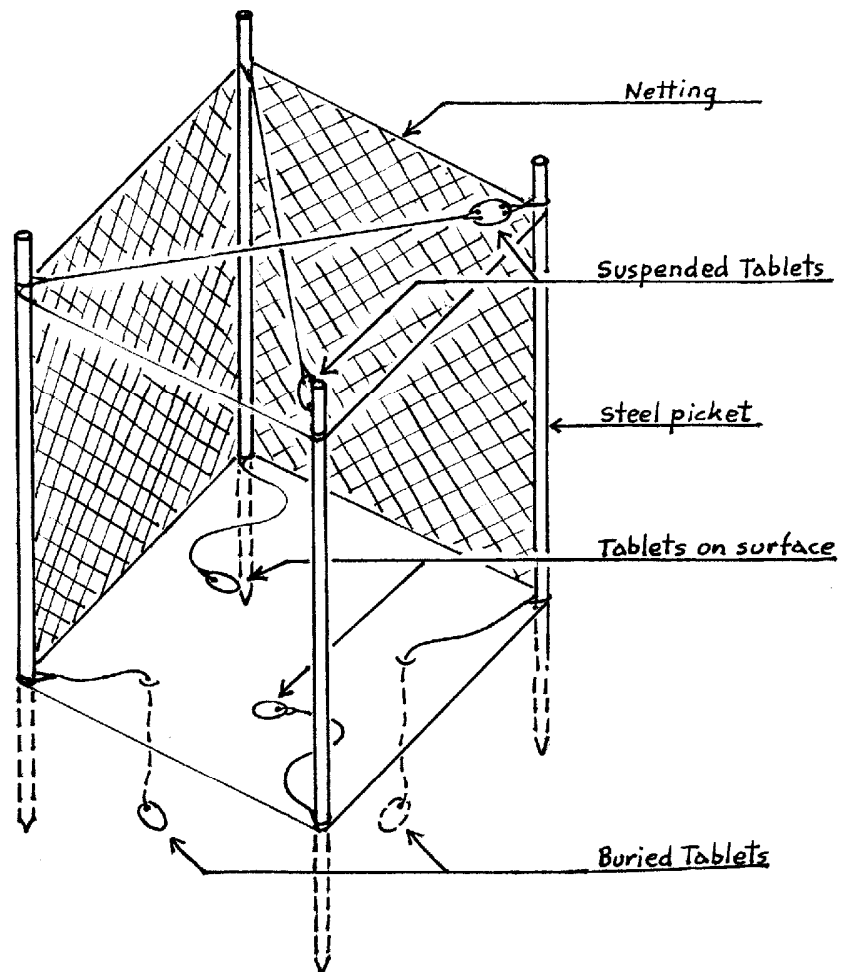
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APPENDIX 1
LAYOUT OF A TYPICAL DENUDATION SITE

Figure 10 shows the layout at a typical site. At each site six tablets were exposed. Each tablet is a disk about 40mm in diameter and from 2 to 4mm thick, with one or more holes drilled near the edge for attachment to plastic insulated wire. At each site two tablets were buried between 20 and 35cm deep in the soil; two were left on the ground surface; and two were suspended horizontally in the air by wires from steel star pickets. Different coloured wires were used to identify the tablets.

Fig 10: typical site layout



APPENDIX 2
ADDRESS LIST

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CO-ORDINATOR FOR QUEENSLAND SITES:

K.G.Grimes,
13 Dewar Tce.,
SHERWOOD QLD 4075
AUSTRALIA

CAMOOWEAL AREA: operated by the Mt Isa Caving Club

Dick Otto,
76 Erap St.,
MT ISA QLD 4825

Landowner: Stanbroke Pastoral Co.,
"Rocklands",
CAMOOWEAL QLD 4828

CHILLAGOE AREA: operated by the Chillagoe Caving Club

T. Robinson,
"Lagoona",
Smithfield,
via CAIRNS QLD 4871

Landowner: National Parks and Wildlife Service,
c/- The Overseer,
National Parks and Wildlife Service
CHILLAGOE QLD 4871

ROCKHAMPTON AREA: operated by the Central Queensland Speleological Society

G.J. Toop,
National Parks and Wildlife Service,
c/- Biology Department,
Capricorn Institute of Advanced Education,
Yaamba Rd.,
ROCKHAMPTON NORTH, QLD.,4701

Landowner: R. Ladynski
"Karst Glen"
c/- The Caves Community Mail Bag,
ROCKHAMPTON QLD 4702

APPENDIX 3
SOIL ANALYSES

At each site 4 soil samples were collected: two from the surface and two from the depth of the buried tablets. For each pair, one was at the site and one was taken a metre away from the site.

The analyses were done by the Department of Primary Industries, Queensland.

Location	Lab.No.	pH 1:5	E.Cond. ms/cm	Cl ppm	Extr.P ppm
CAMOOWEAL, Black soil:					
at site, surface	9561	7.9	0.037	9	10
at site, 0.35m down	9562	8.7	0.064	9	4
1m out, surface	9559	8.4	0.047	8	6
1m out, 0.35m down	9560	8.7	0.064	9	4
CAMOOWEAL, Red soil:					
at site, surface	9563	7.3	0.019	7	9
at site, 0.35m down	9564	7.2	0.074	18	30
1m out, surface	9565	7.2	0.043	7	21
1m out, 0.35m down	9566	7.1	0.024	8	4
CHILLAGOE:					
at site, surface	5888	7.1			
at site, 0.30m down	5889	6.9			
1m out, surface	5890	6.7			
1m out, 0.30m down	5891	7.0			
ROCKHAMPTON:					
at site, surface	9567	6.9	0.068	13	93 ¹
at site, 0.25m down	9568	6.9	0.035	14	11
1m out, surface	9569	7.0	0.039	11	77 ¹
1m out, 0.25m down	9570	7.0	0.033	12	21

¹ Note the anomalously high values for extractable Phosphorus from the Rockhampton surface samples, which might be due to fertilizer.

Subsequent to the above analyses, M.Godwin had additional tests done for Chillagoe which yielded the following depth profile:

Depth m	pH
0.00	6.5
0.30	6.8
0.60	7.0
0.90	7.5
1.20	7.5

APPENDIX 4
INITIAL TABLET DATA, 1979

Tablet No.	Diameter mm	Thickness mm	Holes No.	Area sq.cm.	Initial weight gm
890	*	*	4	30.25 *	9.6017
891	*	*	4	30.0 *	9.0400
892	41.47	2.86	4	30.298	9.8390
893	41.5	2.88	4	30.370	9.8482
894	41.38	2.64	4	29.831	8.9754
895	41.49	2.32	4	29.486	7.7144
896	41.55	2.99	4	30.611	10.2509
897	41.48	2.98	4	30.498	10.2006
898	41.48	2.6	4	29.907	8.9219
899	41.56	2.62	4	30.049	8.9991
900	41.6	2.37	4	29.715	8.2186
901	41.52	3.68	4	31.643	12.7495
960	*	*	1	30.65 *	11.2553
961	*	*	1	31.0 *	12.2212
962	*	*	1	30.7 *	11.4581
963	*	*	1	30.8 *	11.7496
964	41.55	3.75	1	31.396	13.0769
965	41.46	3.37	1	30.749	11.6810
966	41.56	3.63	1	31.246	12.5885
967	41.44	2.66	1	29.752	9.1745
968	41.51	2.7	1	29.904	9.4707
969	41.5	3.45	1	30.915	12.0912
970	41.48	3.11	1	30.422	10.7787
971	41.53	3.26	1	30.698	11.3825

* Dimensions of these tablets were not measured before installation. Areas have been estimated from comparison with other tablets having a similar mass.