SOLAR AND LUNAR ECLIPSES

Eclipses of the Sun and Moon occur when the Sun, Earth and Moon are in the same straight line, or nearly so. When the Earth is between the Sun and the Moon, the shadow of the Earth can fall on the Moon and produce an eclipse of the Moon. This must occur at full Moon, but it does not happen at every full Moon because the orbit of the Moon round the Earth, and of the Earth round the Sun are slightly tilted relative to each other, and at most times of full Moon the shadow of the Earth passes above or below the Moon. Because an eclipse of the Moon consists in a shadow falling on the surface of the Moon, lunar eclipses are visible from all points on the surface of the Earth at which the Moon is above the horizon at the time of eclipse.

Eclipses of the Sun take place when the Moon is between the Sun and the Earth. The shadow of the Moon then falls on the Earth. At this time the dark side of the Moon is seen from the Earth, so that eclipses of the Sun take place at new Moon. They do not occur at every new Moon because of the relative tilt of the two orbits already mentioned. Thus, at most times of new Moon the Moon, if visible, would appear to pass above or below the Sun, and the shadow of the Moon will miss the Earth and there will be no eclipse. The Moon has a diameter of only 2160 miles, compared with 7900 miles for the Earth and the extreme dimensions of the shadow of the Moon are not much bigger than the Moon itself, so that when a solar eclipse occurs, it will be visible only from a limited area of the Earth's surface, namely that area which is in the Moon's shadow at some time during the brief period of the eclipse.

The shadow of the Moon, a small body, produced by the light from the Sun, which is a large body, 864,000 miles in diameter, at a distance of about 93 million miles from the Earth, consists of two parts. There is an inner cone limited in length, from within which no part of the Sun is visible. This is the umbra. There is an outer cone, which spreads out indefinitely with increasing distance from the Sun, from within which the Sun is seen partly obscured. This is called the penumbra. By a co-incidence, the dimensions and distances from the Earth of the Sun and Moon are such that the Moon and Sun appear to be almost the same size. Although the Sun is about 400 times as large as the Moon, it also happens to be just about 400 times as far away from the Earth as the Moon is. Thus at a solar eclipse the Moon can just blot out the Sun completely, or, in other words, the tip of the umbral cone of the shadow just reaches the Earth. This ia a pure accident, and the Moon is the only satellite in the solar system for which this is true, so that the Earth is the only planet from which total solar eclipses can be regularly seen. However, the distance of the Moon from the Earth, which averages 238,900 miles, varies within wide limits. When an eclipse occurs with the Moon relatively near the

Earth, that is, when it looks large, the Moon is big enough to blot out the Sun completely, and there is a total eclipse of the Sun. When a solar eclipse occurs with the Moon near its maximum distance from the Earth, it looks smaller and is not big enough completely to blot out the Sun's disc. When this happens, even when the Moon passes directly in front of the Sun, the Sun's disc is never completely obscured, and there is always left visible a thin ring or "annulus" of the Sun, even at maximum obscuration. Such eclipses are called "annular" eclipses and the eclipse of January 25 is an annular eclipse. It does not fall short of total, for at maximum obscuration about 99 per cent of the solar diameter will be covered. The tip of the umbral cone does not quite reach the surface of the Earth, but an astronaut, 2000 miles above the surface would see a total eclipse.

It has already been remarked that solar eclipses can be seen only from a limited area of the Earth. The penumbra of the shadow from within which the eclipse will be seen as partial may sweep over a total area of about ten per cent of the surface of the Earth all told -- the figure depends very much on circumstances. The umbral cone from within which an eclipse can be seen as total, or the belt from within which an eclipse can be seen as annular, depending on which type is in question, is very narrow indeed. The annular belt for the eclipse of January 25 is only about 30 miles wide, and crosses South Africa from Quoin Point, by way of Bredasdorp, Heidelberg (Cape), Graaf Reinet, and Howick, until it reaches the Indian Ocean coast at St. Lucia Bay. Within this belt there will be less than one per cent of the normal intensity of sunlight during the half to three quarters of a minute of the annular phase. Before this, the sunlight will decrease to this minimum and thereafter increase. Outside this belt the eclipse will be a partial one, but, even as far north as Johannesburg the maximum eclipse will be about 90 per cent. As the light decreases birds will probably be seen going to roost deceived by the appearance of sunset.

WARNING: Althouth the total light from the Sun will be greatly reduced, the crescent left visible will still be very bright. There will not be enough light to dazzle the eyes, and force the viewer to turn his head away, but anyone who looks steadily at the eclipsed Sun will have an extremely bright spot on the sensitive retina of his eye. The lens of the eye will act like a burning glass and a hole will be burned in the retina causing a permanent blind spot. This eye-damage can be avoided by the use of a dark screen such as a heavily exposed piece of photographic film. To test whether the screen absorbs enough light, try looking at the Sun on a normal day; if the sunlight can comfortably be borne when looking through the screen, it is dark enough for use during the eclipse. Do not look at the Sun at any time during the eclipse without this protection.

Eclipses of the Sun and Moon are not particularly rare: there can be as many as seven in a year, of which four or five are solar. Eclipses of the Sun seen from a given point are rare, and total eclipse tracks, or annular belts pass close to a given point only very infrequently. The

last total solar eclipse visible in South Africa was on October 1st 1940, while the last annular eclipse to be seen in South Africa was on Christmas Day 1954. Whenever a total or annular eclipse occurs, there is always a lunar eclipse at the previous or following full Moon, a fortnight before or after, sometimes both. In this case there is a penumbral eclipse of the Moon on the night of January 9-10. This is not a very striking phenomenon: the light of the full Moon will be dimmed for about 40 minutes about 10.00 p.m. S.A. time.

THE ANNULAR SOLAR ECLIPSE OF 1963 JANUARY 25

Data for visibility of this eclipse from southern Africa are given in two Tables and a Map. The first Table gives predicted circumstances for major centres in southern Africa, from which the eclipse will be seen as partial. The predictions are of the following quantities:

(i) Beginning (technically, "First Contact"): the moment at which the black disc of the Moon first impinges on the Sun, together with the position angle, reckoned from the north point of the Sun anticlockwise to the naked eye, through east, south and west, of the point on the edge of the Sun at which this first contact will occur.

(ii) Mid-eclipse. The time of maximum obscuration of the Sun together with the magnitude of the eclipse, expressed in percentage of the solar diameter then obscured.

(iii) End, (technically "Last Contact"): the same information as for the beginning of the eclipse but referring to the last instant of the eclipse when the Moon is just leaving the Sun's disc.

The second Table and Map give predictions for points inside the annular belt. From points within the belt the Moon will, for a short time be seen completely silhouetted against the Sun leaving a narrow ring or annulus of light visible. For each selected station in the second Table the data for Beginning and End are as in the first Table. In addition, for points in the annular belt times and position angles of Second and Third Contacts are given. These contacts define the moments at which the Moon is just wholly in front of the Sun, with the edge of the Moon's disc just internally tangential to that of the Sun. The time of middle is midway between these contacts, and the actual contact times may be found by applying half the time of duration of annular phase to the time of mid-eclipse. Thus at Bredasdorp the duration is 36 seconds = 0.60 minutes = 2 x 0.30 minutes. Second contact, the beginning of the annular phase is thus at 16h 46m.04 - 0m.30 = 16h 45m.74, and third contact at 16h 46m.04 + 0m.30 = 16h 46m.34. The position angles of second and third contacts are given, and, throughout the annular phase 99.0% of the solar diameter will be covered at Bredasdorp. Circumstances at the other selected points in the second Table may be similarly deduced.

For other places in the annular belt, approximate circumstances may be read off the Map. The three lines traversing the Map show the central line and northern and southern limits of the annular belt. Inclined dotted lines, drawn for times at intervals of one minute, with alternate ones marked, show the places where mid-eclipse will occur at the given times. Along the central line the duration of the annular phase in seconds is marked. The duration of the annular phase (from second to third contact) falls to zero on the northern and southern limiting lines.

To illustrate the use of the Map consider the prediction of eclipse circumstances at Vlaklaagte and Kendrew, for which special calculations have not been made. Vlaklaagte lies on the central line between the (unmarked) dotted line for 16h 51m and that for 16h 52m. Mid-eclipse will occur at Vlaklaagte at about 16h 51m 40s and the duration of the annular phase will be about 39s.3, equally distributed about this central line. To obtain an estimate of the times and positions of first and last contacts, the data for the nearest places given in the Tables may be interpolated. Thus Vlaklaagte is about half way between Zeekoegat and Graaf Reinet and interpolation (for circumstances of beginning and end only) give approximate times 15h 36m.7, 17h 57m.6 for beginning and end at position angles 252° and 73° respectively. In the same way, mid-eclipse at Kendrew will occur at about 16h 52m 30s, but since this lies on the southern edge of the annular belt, the annular phase will be very brief, in fact almost instantaneous. The first and last contacts will be closely similar to those given for Graaf Reinet in the second Table.

TABLE I

Partial Eclipse

Place	Beginning		Middle		End	
	Time	P.A.	Time	Mag.	Time	P.A.
Cape Town	$15^h\ 27^m.61$	251°	$16^h\ 45^m.80$	96.4%	$17^h\ 54^m.66$	74°
Johannesburg	15 52.89	246	17 03.86	89.9	18 06.42	79
Pretoria	15 53.71	245	17 04.45	89.1	18 06.88	79
Bloemfontein (Boyden)	15 46.29	249	16 58.93	94.5	18 02.91	76
Port Elizabeth	15 37.25	255	16 50.68	94.7	17 55.80	70
East London	15 41.39	255	16 53.38	94.2	17 57.29	70
Durban	15 49.71	253	16 59.59	97.6	18 01.67	72
Kimberley	15 44.86	247	16 58.40	92.1	18 03.12	79
Windhoek	15 48.00	232	17 02.66	68.3	18 07.59	90
Bulawayo	16 04.04	238	17 12.15	76.3	18 12.24	86
Salisbury	16 09.77	236	17 15.61	73.4	18 13.86	88
Livingstone	16 06.43	232	17 14.10	67.4	18 13.61	91
Zeekoegat	15 34.72	251	16 50.23	98.9	17 56.86	73

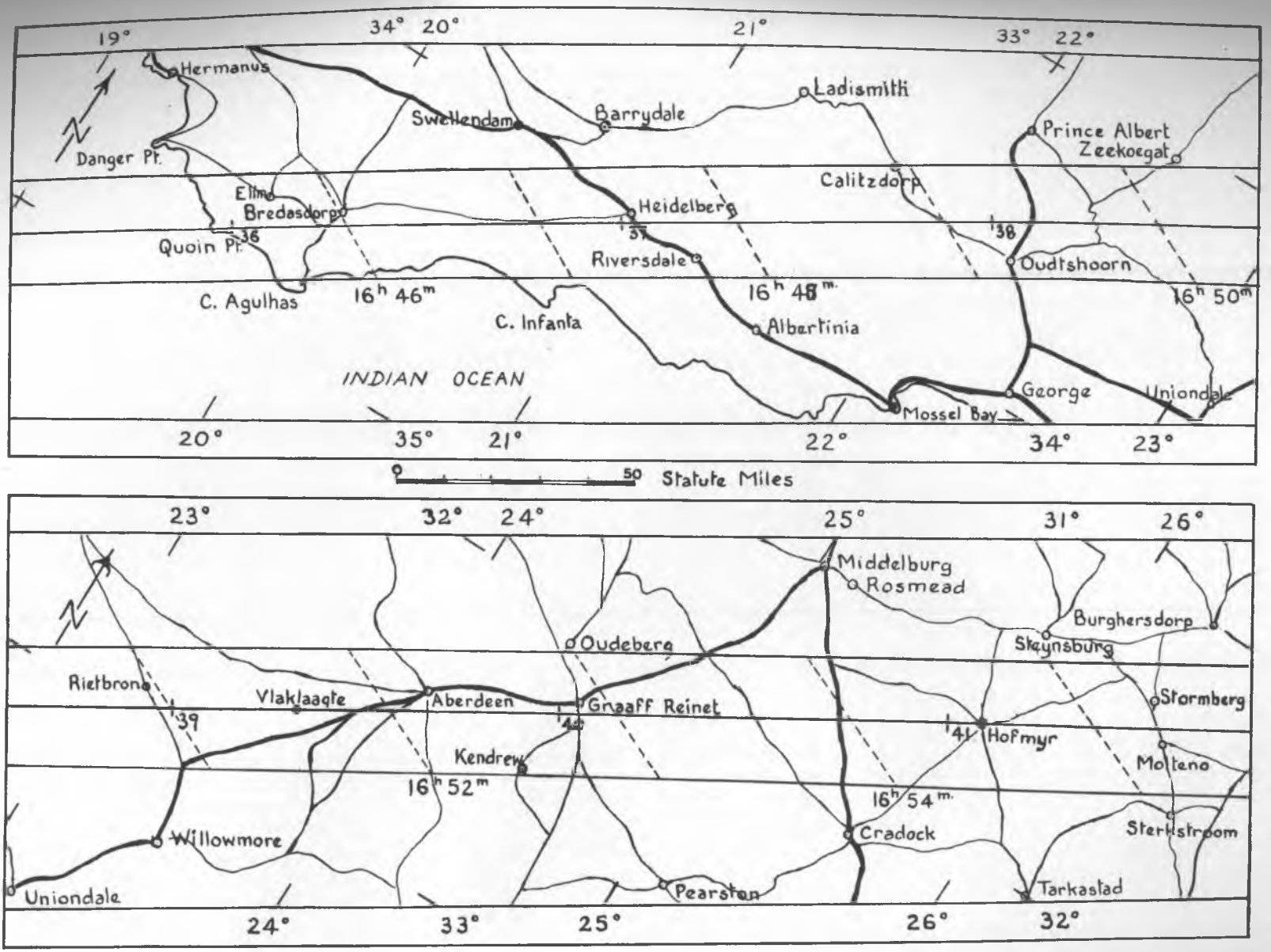
All Times in South African Standard Time

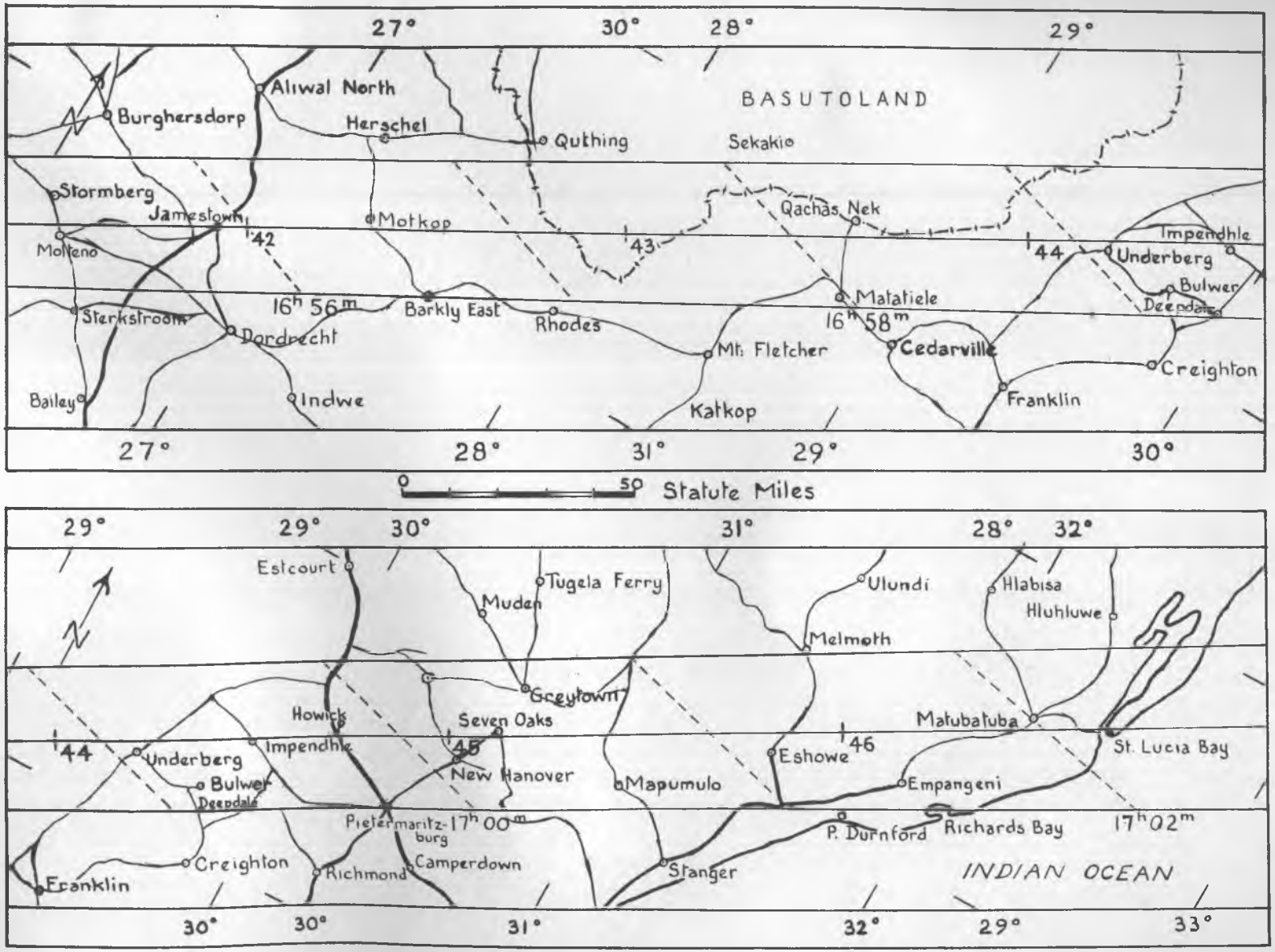
TABLE II

Annular Eclipse

Place	Beginning		Annular Phase					End	
	Time	P.A. 1 st Contact	Middle Time	Max Mag	P.A. 2 nd Contact	P.A. 3 rd Contact	Duration of Ann. Phase	Time	P.A. 4 th Contact
Bredasdorp	$15^h28^m.93$	252°	$16^h46^m.04$	99.0%	239°	85°	36 sec	$17^h54^m.11$	73°
Heidelberg	15 30.92	252	16 47.47	99.0	243	81	37	17 55.02	73
Riversdale	15 31.40	252	16 47.71	99.0	293	32	28	17 55.07	73
Oudtshoorn	15 33.63	252	16 49.25	99.0	301	24	25	17 56.04	73
Graaf Reinet	15 38.72	252	16 52.86	98.9	247	77	40	17 58.33	73
Howick	15 49.49	252	16 59.83	98.7	269	56	43	18 02.24	73
Pietermaritzburg	15 49.47	252	16 59.74	98.7	323	2	14	18 02.10	72
Eshowe	15 51.61	252	17 01.14	98.7	271	54	43	18 02.89	73

All Times in South African Standard Time


19°
34° 20°
21°
33° 22°
Hermanus
Danger Pt.
Swellendam
Barrydale
Ladismith
Prince Albert
Zeekoegat
Calitzdorp
Elim
Bredasdorp
Heidelberg
Quoin Pt.
Riversdale
Oudtshoorn
C. Agulhas
16h 46m
C. Infanta
16h 48m.
16h 50m
Albertinia
INDIAN OCEAN
George
Uniondale
Mossel Bay
20°
35°
21°
22°
34°
23°
50 Statute Miles
23°
32° 24°
25°
31°
26°
Middelburg
Rosmead
Burghersdorp
Oudeberg
Skeynsburg
Rietbron
Vlaklaagte
Aberdeen
Graaff Reinet
Stormberg
Hofmyr
Kendrew
Molteno
16h 52m
16h 54m.
Willowmore
Cradock
Sterkstroom
Uniondale
Pearston
Tarkastad
24°
33°
25°
26°
32°


27°
30°
28°
29°
BASUTOLAND
Aliwal North
Burghersdorp
Herschel
Quthing
Sekakio
Stormberg
Jamestown
Molteno
Motkop
42
43
Qachas Nek
44
Impendhle
Underberg
Bulwer
Deepdale
Matatiele
16h 58m
16h 56m
Barkly East
Rhodes
Sterkstroom
Dordrecht
Mt. Fletcher
Cedarville
Creighton
Franklin
Bailey
Indwe
Katkop
27°
28°
31°
29°
30°
50
Statute Miles
29°
29°
30°
31°
28°
32°
Estcourt
Tugela Ferry
Muden
Ulundi
Hlabisa
Hluhluwe
Melmoth
Greytown
Howick
Seven Oaks
45
Matubatuba
44
Underberg
Impendhle
Eshowe
46
St. Lucia Bay
Bulwer
Deepdale
New Hanover
Mapumulo
Empangeni
Pietermaritz-burg
17h 00m
P. Durnford
Richards Bay
17h 02m
Creighton
Richmond
Camperdown
Stanger
INDIAN OCEAN
Franklin
30°
30°
31°
32°
29°
33°