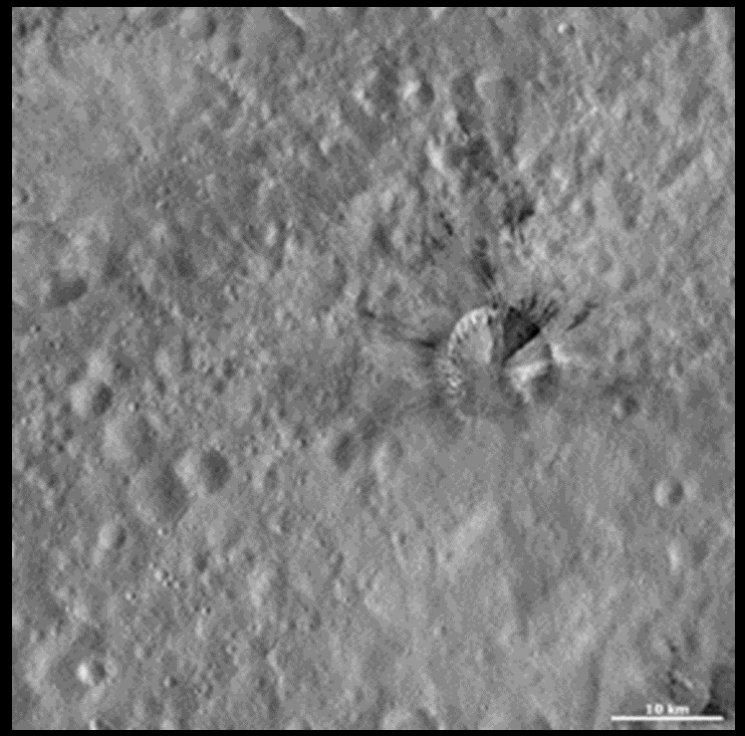
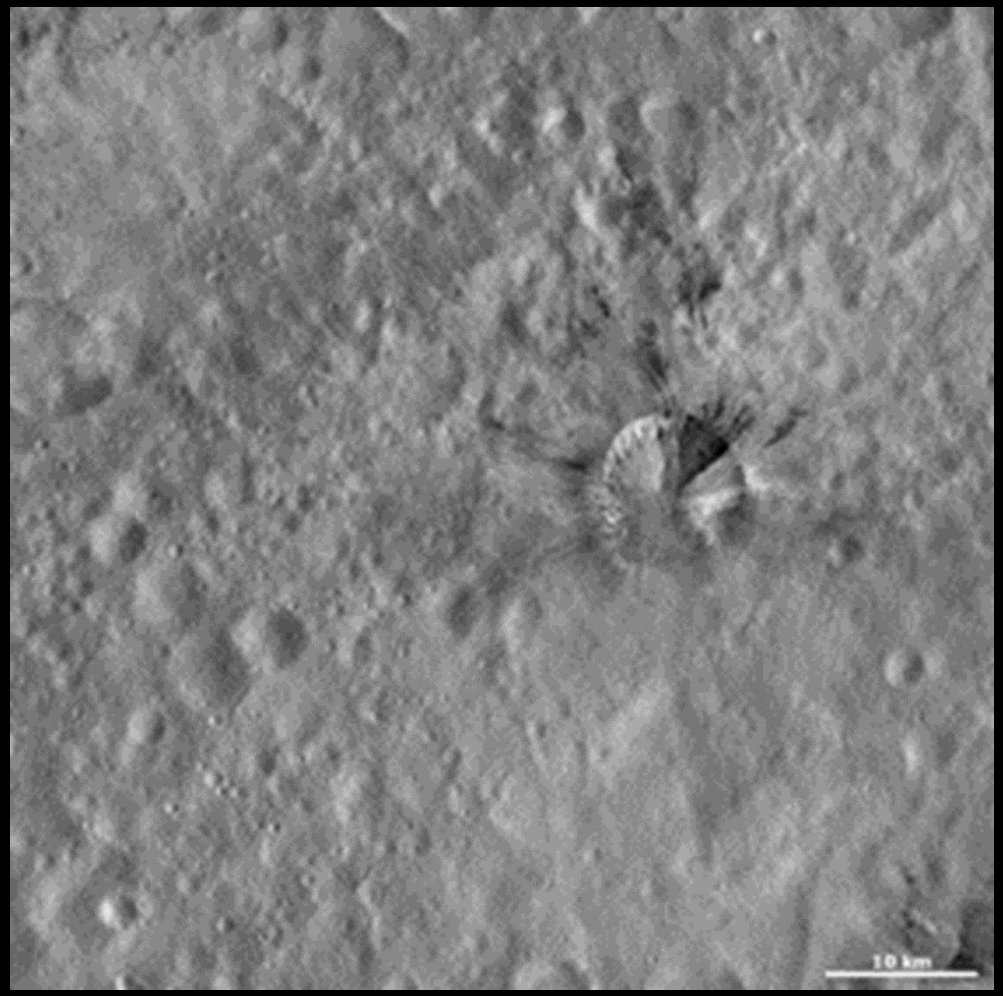
From Vesta to the Kalahari, on the trail of the Motopi Pan meteorite



Tim Cooper

Director, Comet, Asteroid and Meteor Section

Image credit: left NASA/JPL-Caltech/UCAL/MPS/DLR/IDA, right Dr Peter Jenniskens



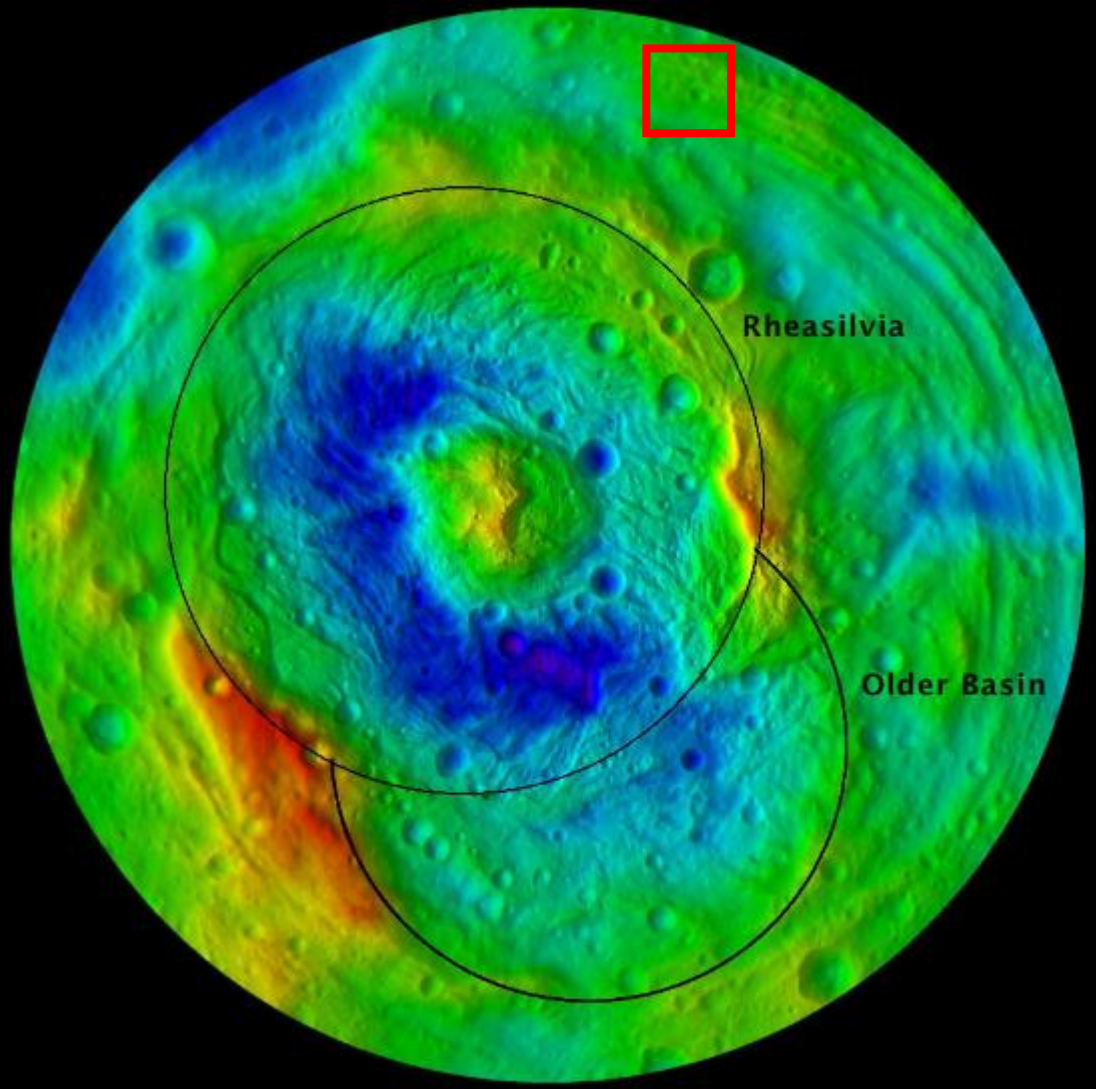
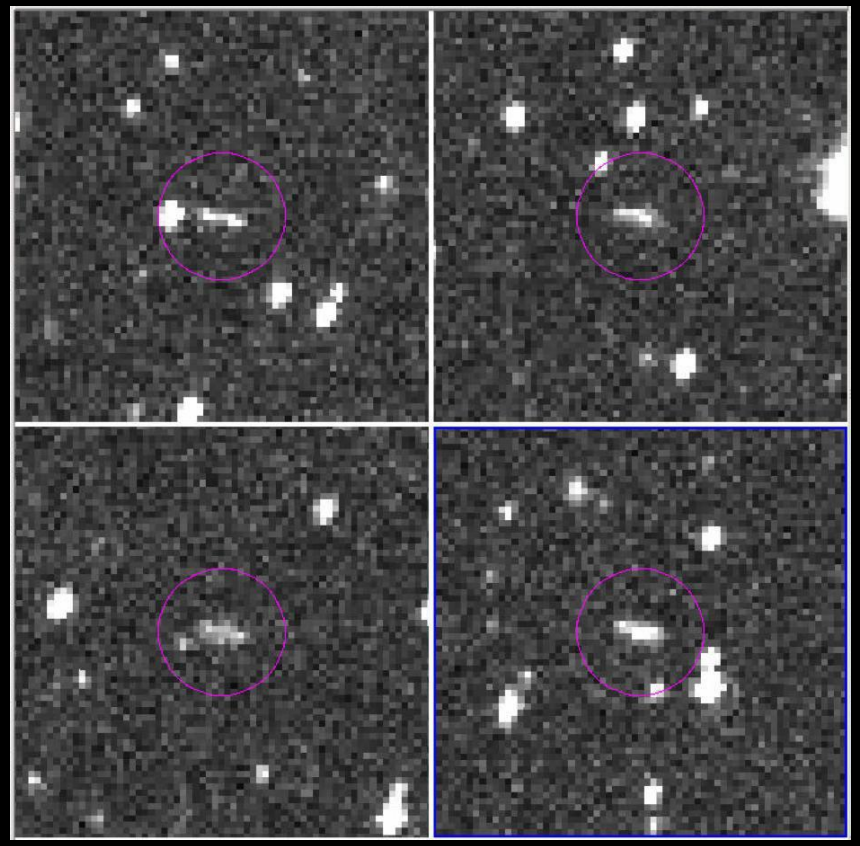


Image credit: NASA/JPL-Caltech/UCAL/MPS/DLR/IDA

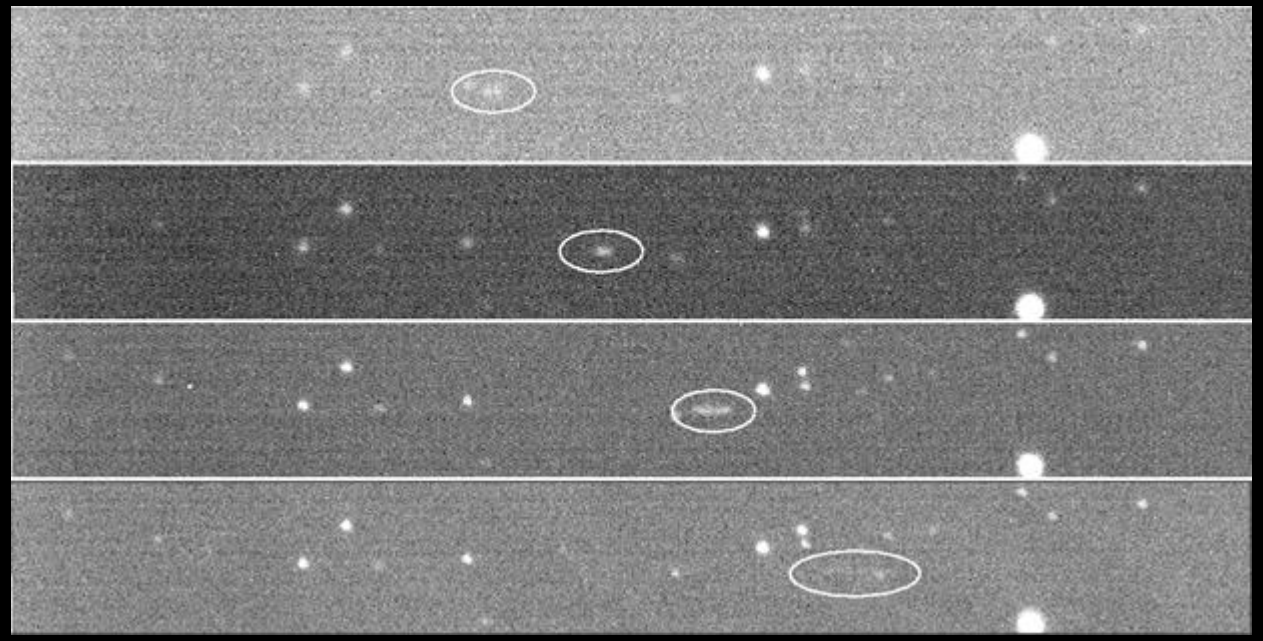
First images of 2018 LA
2018 June 2, 08h22 UT

Absolute magnitude	= 31.1
Albedo	= 0.25
Diameter	= 156 cm
Spin rate	= 244 sec
Geocentric velocity	= 17 km/s



Catalina Sky Survey discovery images of 2018 LA

Image credit: Catalina Sky Survey
https://www.jpl.nasa.gov/images/asteroid-2018-la



SkyMapper Southern Survey g,r,i, and z colour bands
(Wolf et al. 2018)

Adapted from images by Bill Gray

2018 June 2 , 18h44 local time

Meteoriet

By my pale op plaas kamera naby Ottosdal.

Die meteoriet het naby deelpan geval volgens ooggetuies.

#Meteor #Meteoriet

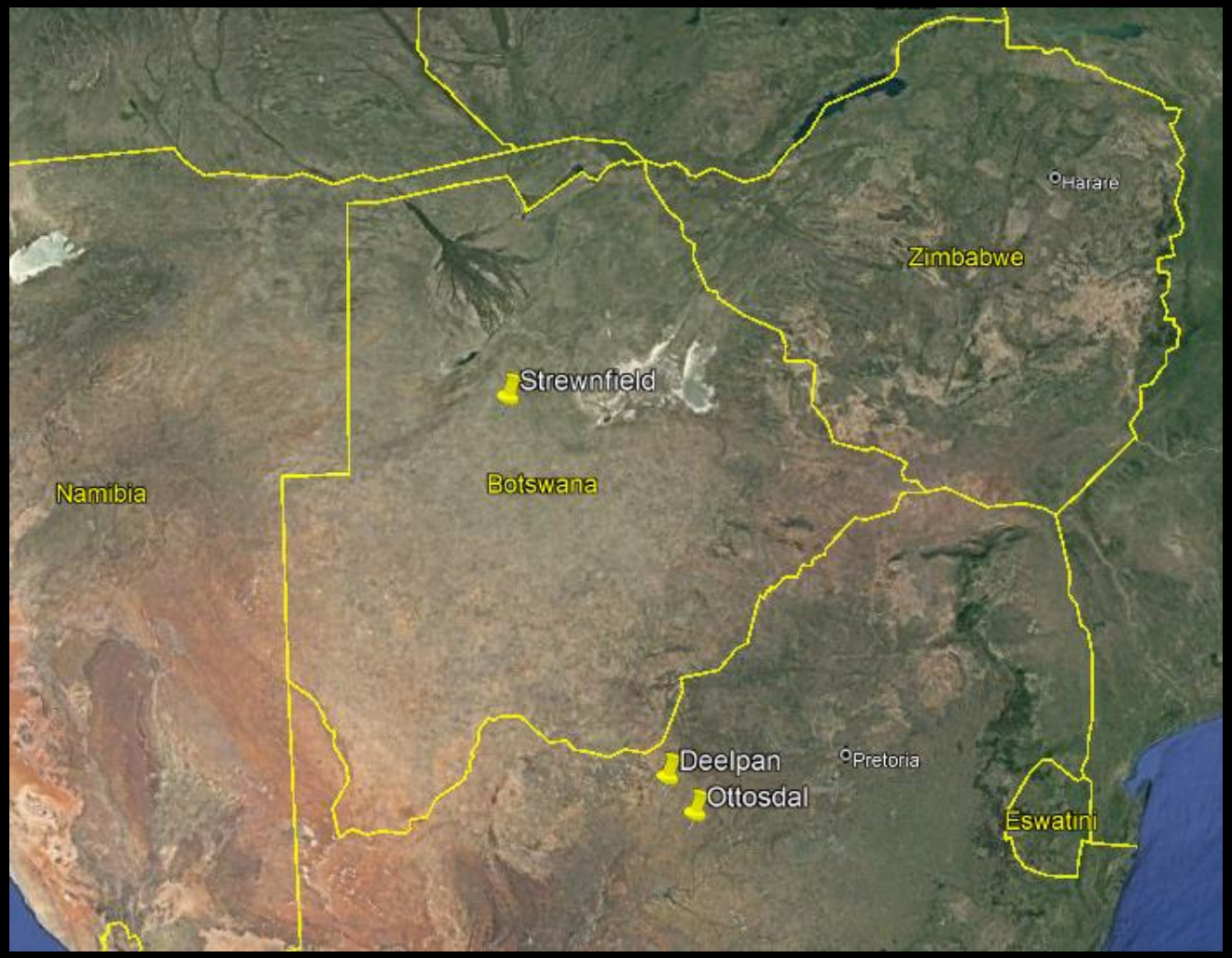
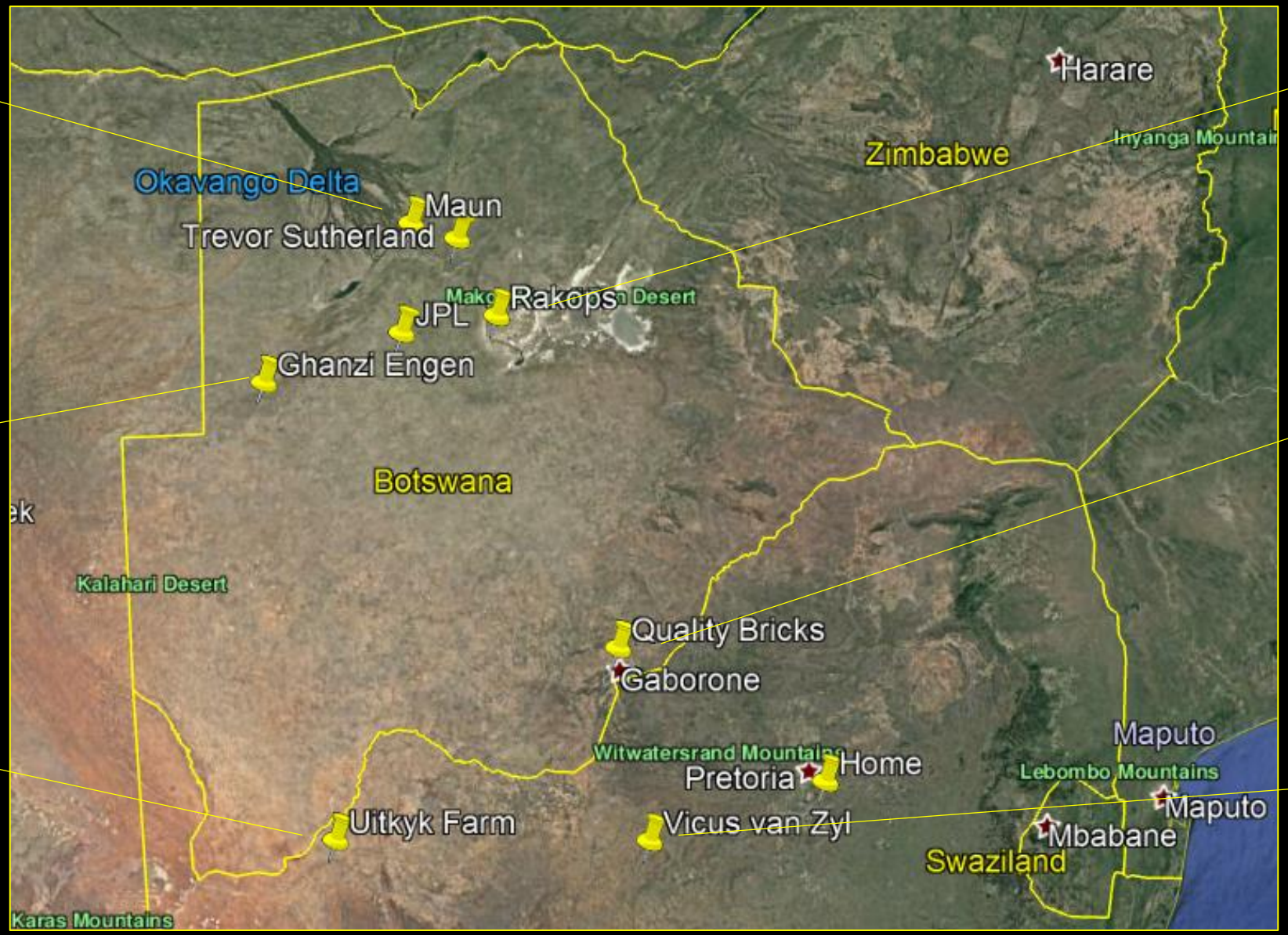


Image credit: left Barend Swanepoel,
Map on right from Google Earth

Ottosdal – Deelpan = 68 km, Ottosdal – Strewnfield = 680 km

Video observations



Original image credit: Barend Swanepoel
Stacked images from Jim Albers.

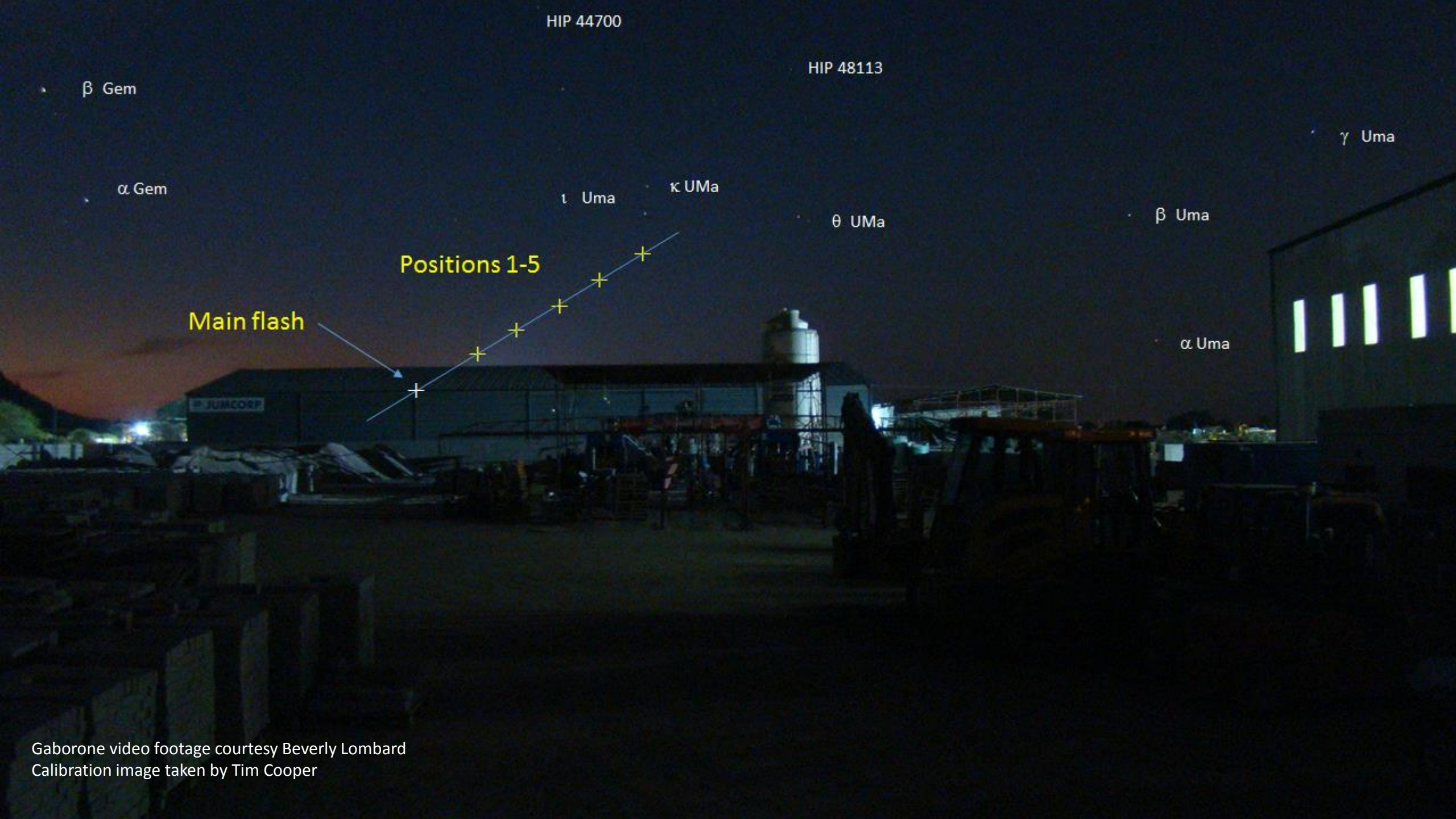
Calibration image by Tim Cooper

Ottosdal video footage
Calibration image taken by Tim Cooper

Gaborone video footage courtesy Beverly Lombard

Gaborone video footage courtesy Beverly Lombard
Calibration image taken by Tim Cooper

Gaborone video footage courtesy Beverly Lombard
Calibration image taken by Tim Cooper



Gaborone video footage courtesy Beverly Lombard
Calibration image taken by Tim Cooper

Ghanzi video footage secured by Tim Cooper

Maun

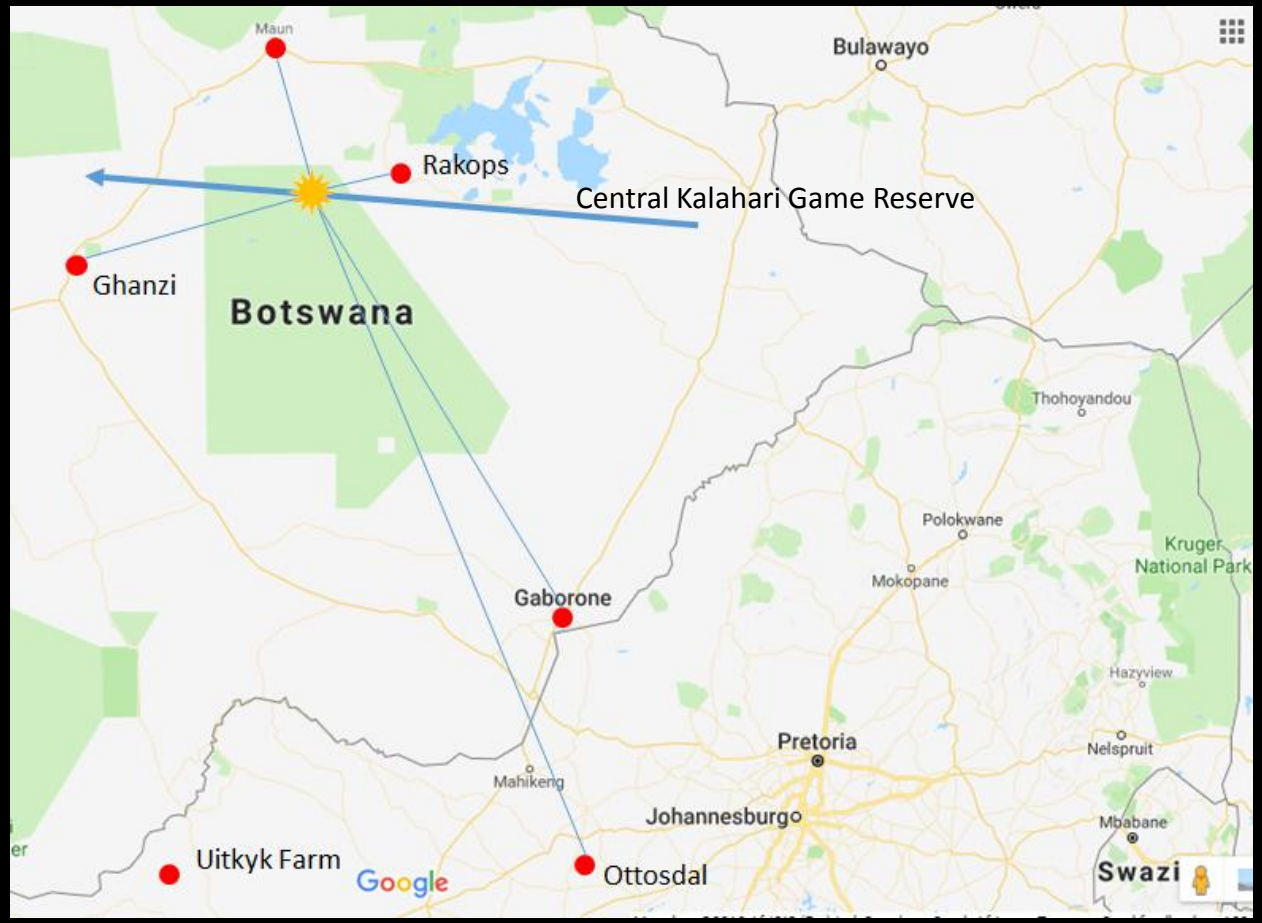
Rakops

Maun and Rakops video footage secured by Peter Jenniskens and Oliver Moses

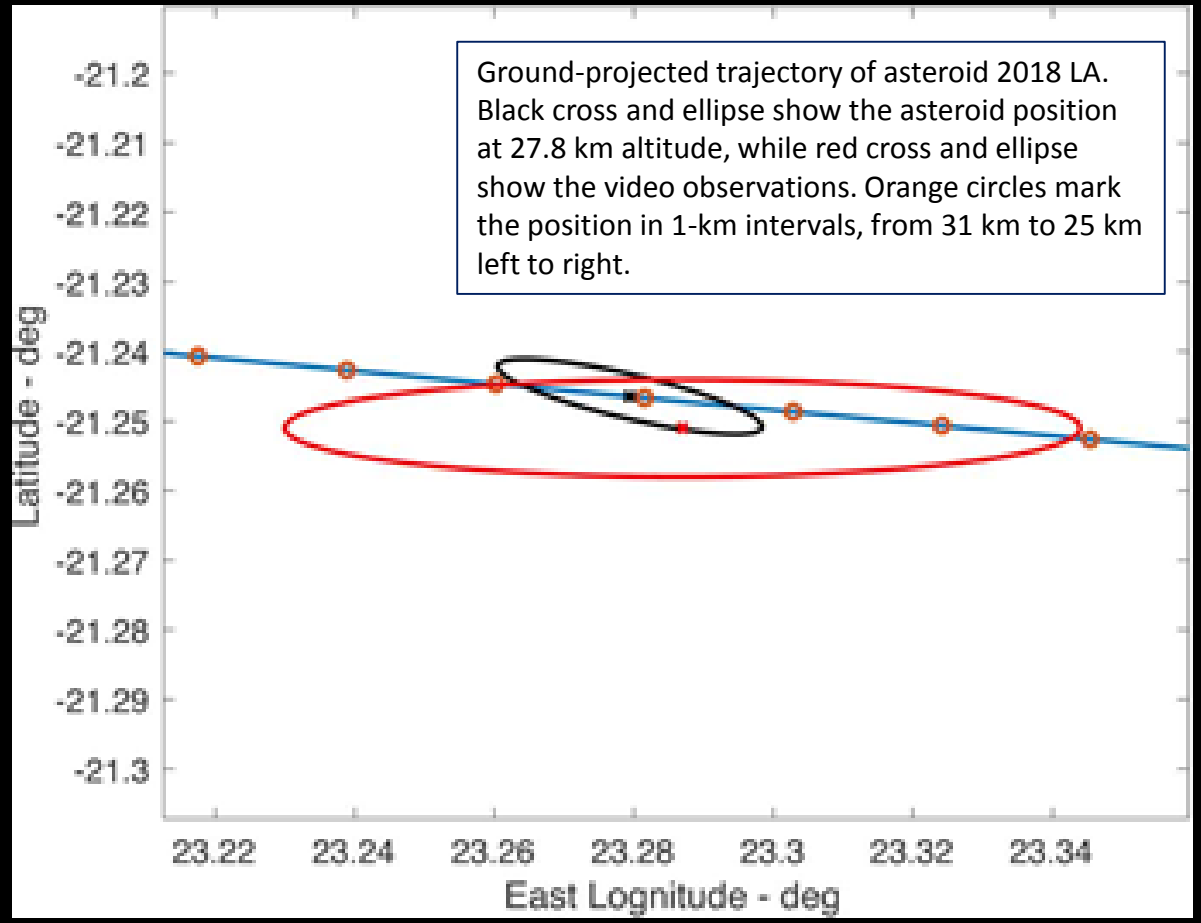
Video observations

Station	Latitude (°S)	Longitude (°E)	Alt. (m)	Range (km)	Time† (UTC)	Azimuth (° from N)	Elevation (°)
Maun	20.005011	23.42756	945	139	16:44:11.109	183.48±1.7	11.79±0.80
Rakops	21.030190	24.402380	926	120	16:44:11.500	257.80±0.20	(12.28)
Ghanzi	21.69500	21.653473	1143	175	16:44:11.500	73.13±1.10	7.80±0.20
Gaborone	24.64617	25.815750	1063	457	16:44:11.500	325.63±0.20	1.27±0.20
Ottosdal	26.752972	26.18866	1575	680	16:44:11.500	333.79±0.20	0.12±0.20
Kuruman	Uncalibrated						

CCTV image observations



Courtsey Google Maps



Courtesy Jenniskens et al, https://doi.org/10.1111/maps.13653

Members of the expedition which found 22 fragments, October 9-12, 2018

Standing left to right Tim Cooper (ASSA), Oliver Moses (ORI), Mohutsiwe Gabadirwe (BGI), Thebe Kemosedile (ORI), Sarah Tsenene (DWNP), Kabelo Dikole (BGI), Mosarwa Babutsi (Botswana National Museum, Gaborone), kneeling Kagiso Kgetse (DWNP) and Peter Jenniskens (SETI Institute). Photo by team member Odirile Sempho.

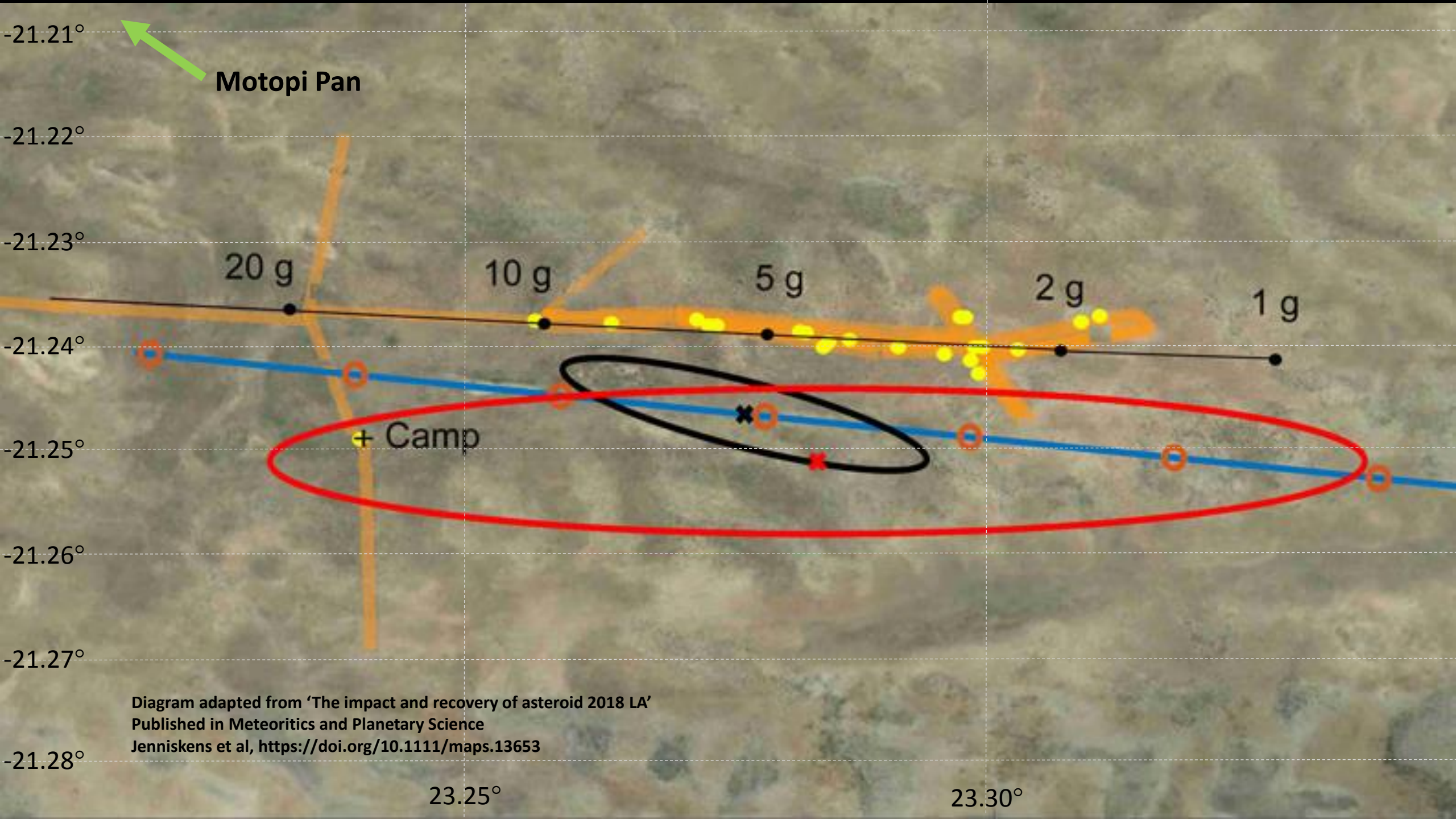


Diagram adapted from 'The impact and recovery of asteroid 2018 LA'
Published in Meteoritics and Planetary Science
Jenniskens et al, https://doi.org/10.1111/maps.13653

Fragments of meteorite Motopi Pan

Images credit Peter Jenniskens, adapted from 'The impact and recovery of asteroid 2018 LA'
Published in Meteoritics and Planetary Science, Jenniskens et al, https://doi.org/10.1111/maps.13653


MP-01* 17.92g


MP-02 4.28g


MP-03 10.08g


MP-04* 13.16g


MP-05 2.59g


MP-06* 8.55g


MP-07 0.51g


MP-08 3.95g


MP-09* 4.96g


MP-10 0.89g


MP-11 4.51g


MP-12 3.60g


MP-13* 3.76g


MP-14* 4.35g


MP-15 2.71g


MP-16 1.35g


MP-17* 4.93g


MP-18* 0.90g


MP-19* 6.19g


MP-20 1.85g


MP-21 7.60g


MP-22 4.73g


MP-23 8.85g

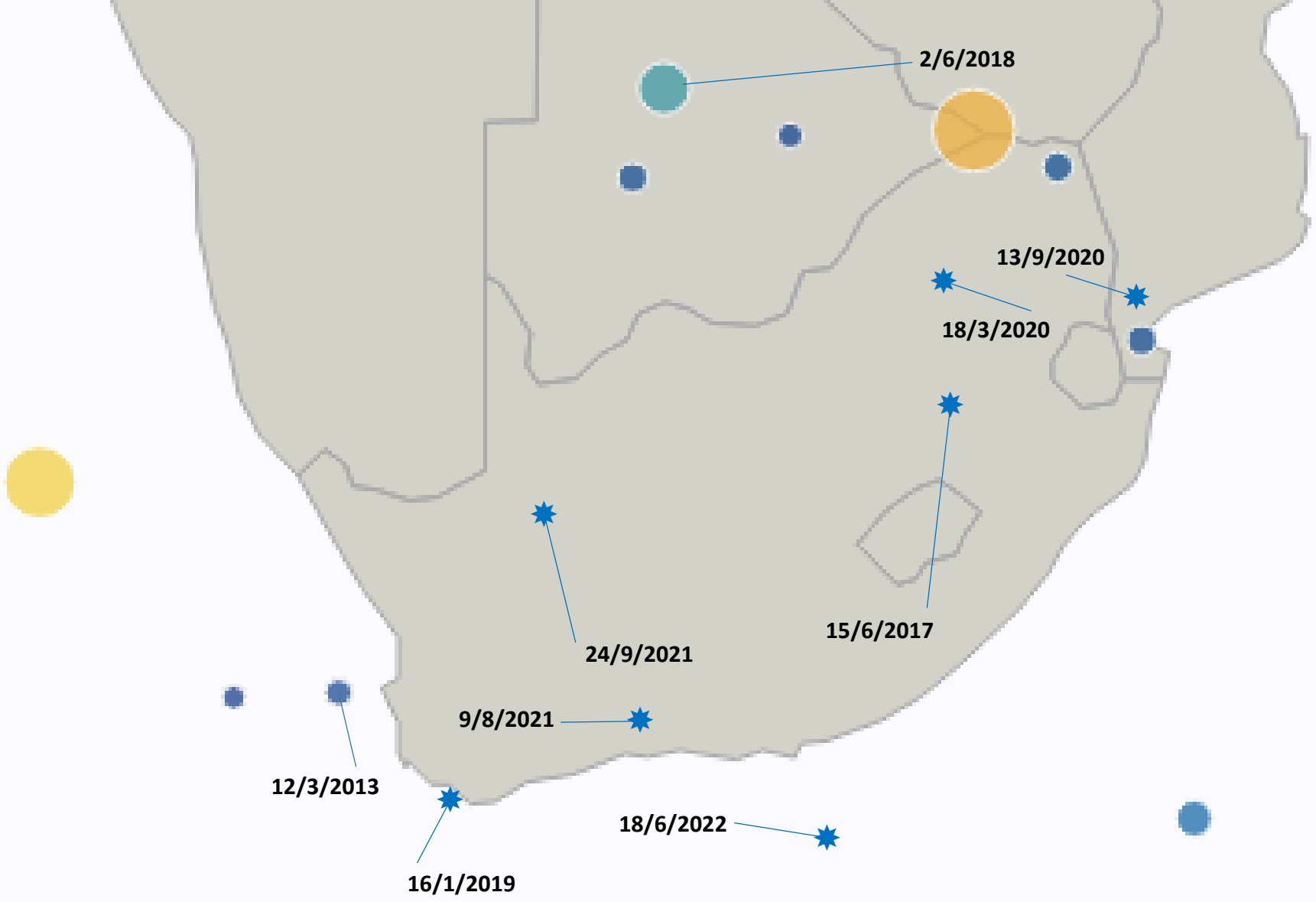
Fragments of meteorite Motopi Pan

MP-#	Latitude (ºS)	Longitude (ºE)	Alt. (m)	Date (2018)	Time (UTC)	Finder	Affil. †	Mass (g)
01*	21.24848	23.23866	1002	6/23	07:00	Lesedi Seitshiro	BIUST	17.92
02	21.23612	23.25528	1004	10/9	10:50	Mohutsiwa Gabadirwe	BGI	4.28
03	21.23696	23.27134	1001	10/10	13:00	Oliver Moses	ORI	10.08
04*	21.23880	23.28254	989	10/10	14:26	Thebe Kemosedile	ORI	13.16
05	21.23959	23.29484	991	10/11	07:28	Mohutsiwa Gabadirwe	BGI	2.59
06*	21.23887	23.29740	994	10/11	07:54	Peter Jenniskens	ORI	8.55
07	21.23888	23.29785	994	10/11	08:00	Sarah M. Tsenene	DWNP	0.51
08	21.23862	23.29811	996	10/11	08:24	Kagiso Kgetse	DWNP	3.95
09*	21.23689	23.30645	996	10/11	09:10	Kagiso Kgetse	DWNP	4.96
10	21.23633	23.30866	997	10/11	09:45	Kagiso Kgetse	DWNP	0.89
11	21.23968	23.30086	991	10/11	12:45	Sara M. Tsenene	DWNP	4.51
12	21.23979	23.29714	990	10/11	14:10	Mohutsiwa Gabadirwe	BGI	3.60
13*	21.23708	23.27264	998	10/12	07:14	Kagiso Kgetse	DWNP	3.76
14*	21.23629	23.29703	996	10/12	09:06	Kabelo Dikole	BGI	4.35
15	21.23626	23.29700	995	10/12	09:10	Oliver Moses	ORI	2.71
16	21.24087	23.29789	994	10/12	09:45	Peter Jenniskens	ORI	1.35
17*	21.23889	23.29038	1005	10/12	12:50	Kagiso Kgetse	DWNP	4.93
18*	21.23765	23.28587	997	10/12	13:20	Mohutsiwa Gabadirwe	BGI	0.90
19*	21.23812	23.28381	996	10/12	13:38	Tim Cooper	ASSA	6.19
20	21.23758	23.28099	994	10/12	13:53	Peter Jenniskens	ORI	1.85
21	21.23743	23.28025	992	10/12	14:04	Mohutsiwa Gabadirwe	BGI	7.60
22	21.23619	23.27041	997	10/12	15:07	Peter Jenniskens	ORI	4.73
23	21.23646	23.26306	991	10/12	15:37	Mohutsiwa Gabadirwe	BGI	8.85

Table adapted from that in Meteoritics and Planetary Science
Jenniskens et al, https://doi.org/10.1111/maps.13653

Evidence for Rubria crater as source

- The petrography and mineralogy are that of Howardite-Eucrite-Diogenite meteorites, which have their origin on Vesta.
- Reflectance spectra are similar to other HED meteorites, associated with an origin on Vesta.
- Semi-major axis vs. inclination are diagram consistent with the region from the inner main belt, where Vesta and its Vestoids are found.
- Cosmic ray exposure age matches crater ageing models on Vesta, and are indicative of an origin from Rubria crater ~22.8 Ma ago.



Adapted from Fireballs reported by US Government Sensors, https://cneos.jpl.nasa.gov/fireballs/. Additional fireballs reported to ASSA added as * with probable path indicated

Conclusions

- Bright bolide 2 June 2018 from asteroid 2018 LA
- Calibration of video images led to determination of strewn field location
- Direct images of bolide and shadows from disruption equally of use
- Search of strewn field location discovered fragments which were analysed and could be traced to asteroid 4-Vesta, probably Rubria ~22.8 Ma ago
- Several recent bolides over southern Africa, some may have dropped meteorites, but insufficient video footage was obtained
- Opportunities exist to locate further meteorites using this methodology

Scientific results by 66 authors (2018 LA Consortium) published in Meteoritics and Planetary Science, Vol. 56, 844-893