Donaldjohanson Coordinate System Description

Version 1 (October 2025)

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During the Lucy encounter the L'LORRI instrument acquired resolved imagery of the visible and illuminated regions of (52246) Donaldjohanson, providing stereo information useful for shape reconstruction, with a coverage of about 40% of the total body surface area. The rest of the body has been completed by fitting a 2-ellipsoid contact binary and by using symmetry considerations, with the goal of obtaining a closed shape and a first-order estimation of the body volume. This preliminary coordinate system has been defined by aligning it along the principal axes of inertia of the derived shape model. Due to the long rotation period of Donaldjohanson, no appreciable rotation was detected on the resolved images from the Lucy encounter. The analysis of lightcurves from ground-based observations and from unresolved photometry during the Lucy approach phase result in a synodic rotation period of 251.09 h with prograde rotation (Marchi et al., 2025). However, the lightcurves also show the signature of force-free precession, which is currently not yet incorporated in the rotation model. The orientation of the Donaldjohanson-fixed frame in the International Celestial Reference Frame (ICRF; Archinal et al., 2011) is modeled with $\{\alpha, \delta, W0 + W1\ \Delta t\}$, where α represents the spin pole right ascension, δ represents the spin pole declination, $W0$ represents the ephemeris position of the prime meridian at the reference epoch of J2000 = JD 2451545.0, i.e. 2000 January 1, 12 hours Terrestrial Barycentric Time (TDB), $W1$ represents the rotation angular rate, and Δt represents the time elapsed since the reference epoch. However, given the free-precession state of Donaldjohanson (not currently modeled), the above-mentioned planetary constants define the orientation of the body's principal axes of inertia around the epoch of the Lucy encounter (on 2025-04-20T17:51:16 UTC), rather than its spin axis orientation, and can be considered accurate only for that epoch. It is planned to issue a future version of the Donaldjohanson dynamical reference system that incorporates its free precession. The table below reports the constants for the preliminary rotation model as well as the body semiaxes.

Model	α [deg]	δ [deg]	W0 [deg]	W1 [deg/day]	a [km]	b [km]	c [km]
donaldjohanson_v12.tpc	324.66115	50.95721	293.17865	34.409504086	4.4	2.2	1.55

The corresponding SPICE keywords and values contained in the text PCK are as follows:

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BODY20052246_POLE_RA = ( 324.66115 0.000 0.000 )
BODY20052246_POLE_DEC = ( 50.95721 0.000 0.000 )
BODY20052246_PM = ( 293.17865 34.409504086 0.000 )
BODY20052246_LONG_AXIS = ( 0.0 )
BODY20052246_RADII = ( 4.4 2.2 1.55 )
```

The prime meridian itself is defined via the geographical coordinates of a primary feature (a boulder) and two secondary features (two craters). These features were selected based on criteria as dimensions (smallest features that could be reliably measured), symmetry, good visibility and illumination conditions across several images.

We provide secondary features to increase the likelihood that a feature defined in this coordinate system will be visible in any future resolved observations of this body. The coordinates of the feature centers, both in terms of geographical coordinates and pixel coordinates (1-based) on image *lor_0798443290_04598* are given in the table below. For a definition of the LLORRI image naming convention please refer to document *22668.07-LLORRI-SIS-01*, *"Lucy Software Interface Specification - LOng Range Reconnaissance Imager (L'LORRI) Data Products".*

Feature	X	Y	latitude	E. longitude	R [km]
Boxgrove Saxon, Boulder (1)	588	124	+11.22°	337.97°	3.538
Mungo, Crater (2)	608	85	+10.78°	342.45°	3.636
Narmada Crater (3)	607	351	+22.52°	320.65°	2.532

The features are also marked up in Fig 1 (LLORRI image lor_0798443290_04598), Fig. 2 (close-up view of the textured shape model) and Fig 3 (context view of the textured shape model).

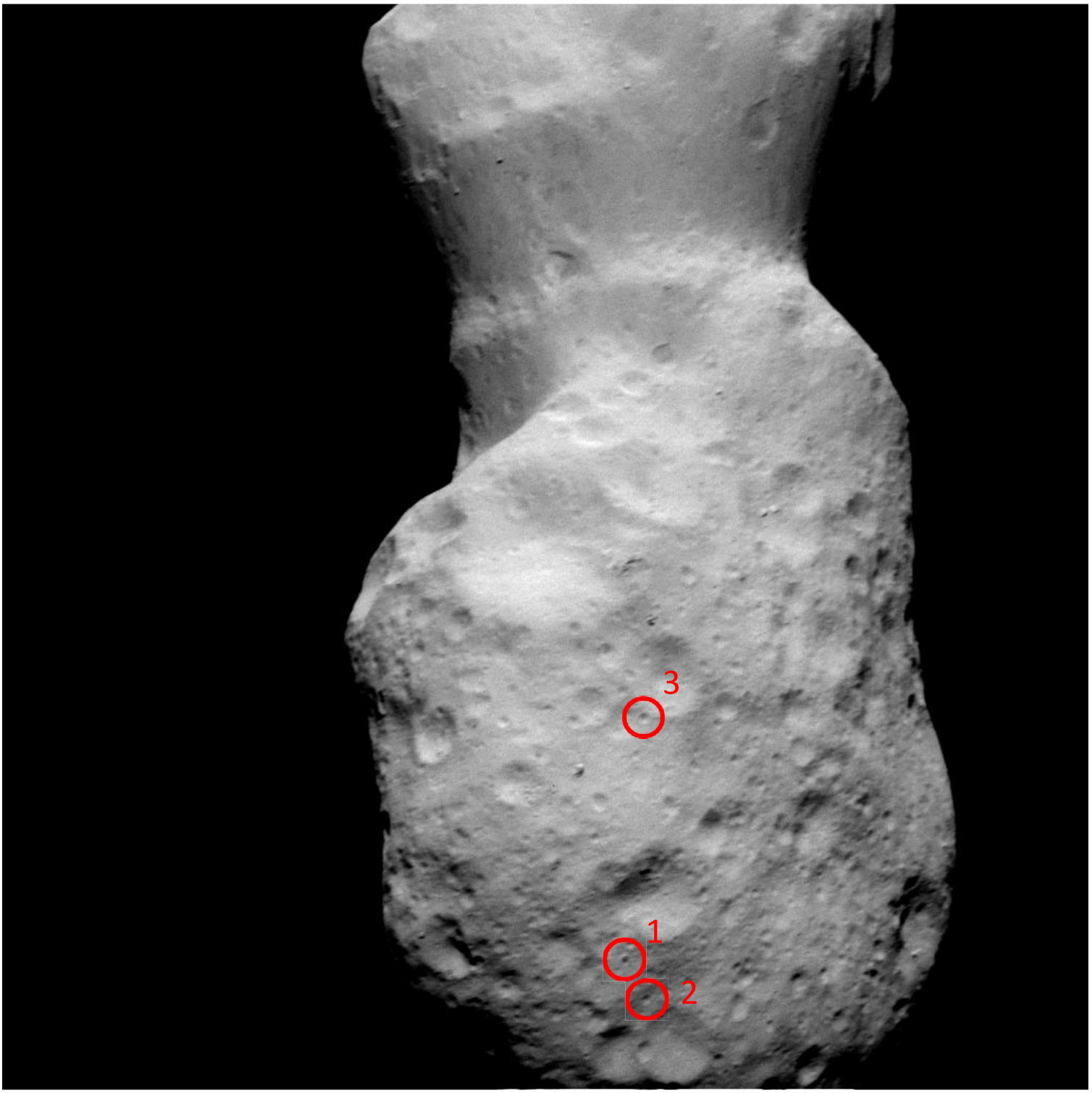

Figure 1. Geographical features defining the prime Meridian as seen on L'LORRI image lor_0798443290_04598. The origin (pixel 1,1) is on the bottom left.

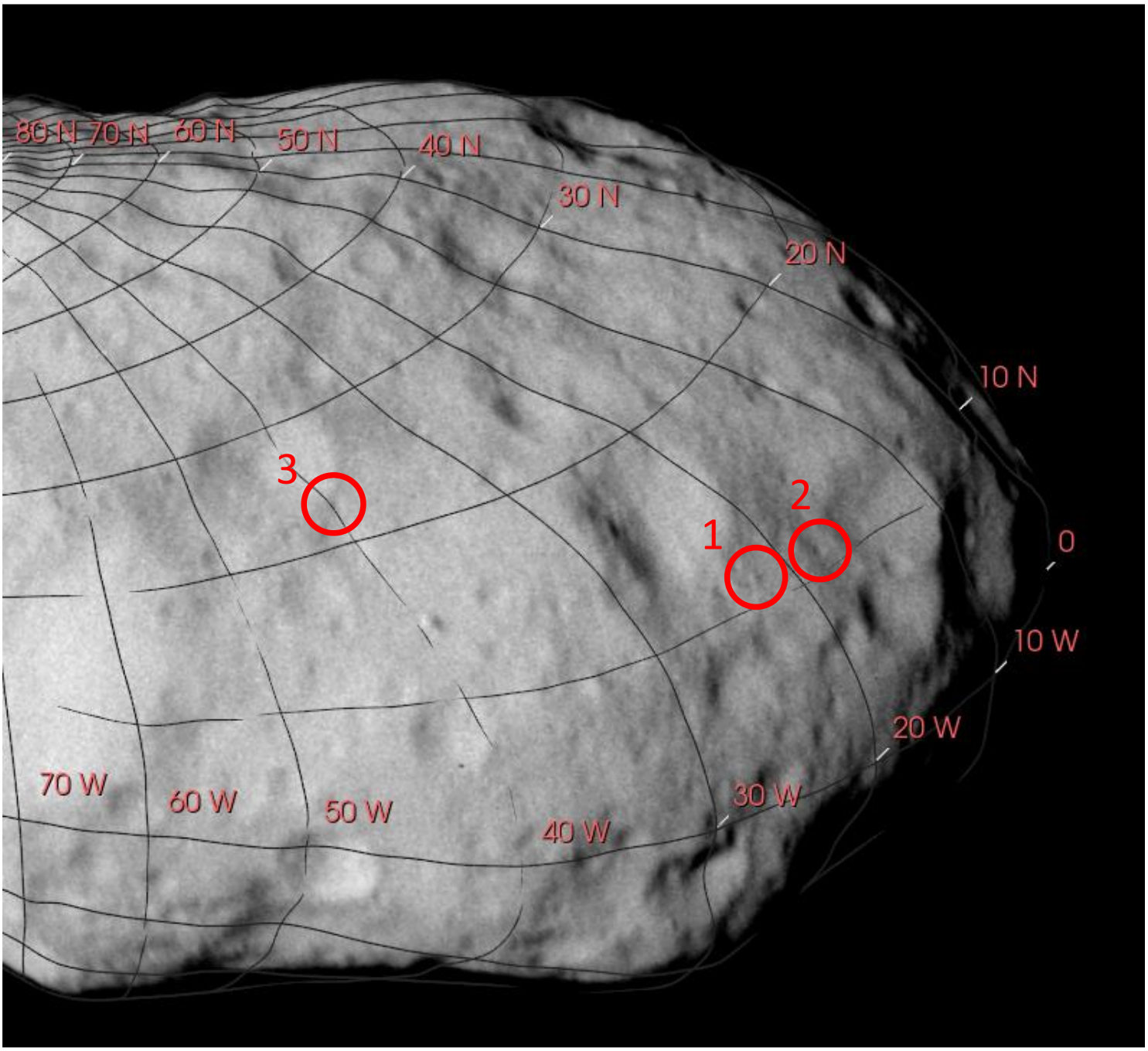

Figure 2. Geographical features defining the prime Meridian marked-up on the textured shape model. The texture is based on a mosaic of select LLORRI images. Please note that the grid reports West longitude values, whereas the coordinates of the key features are reported in the table in the East longitude system.

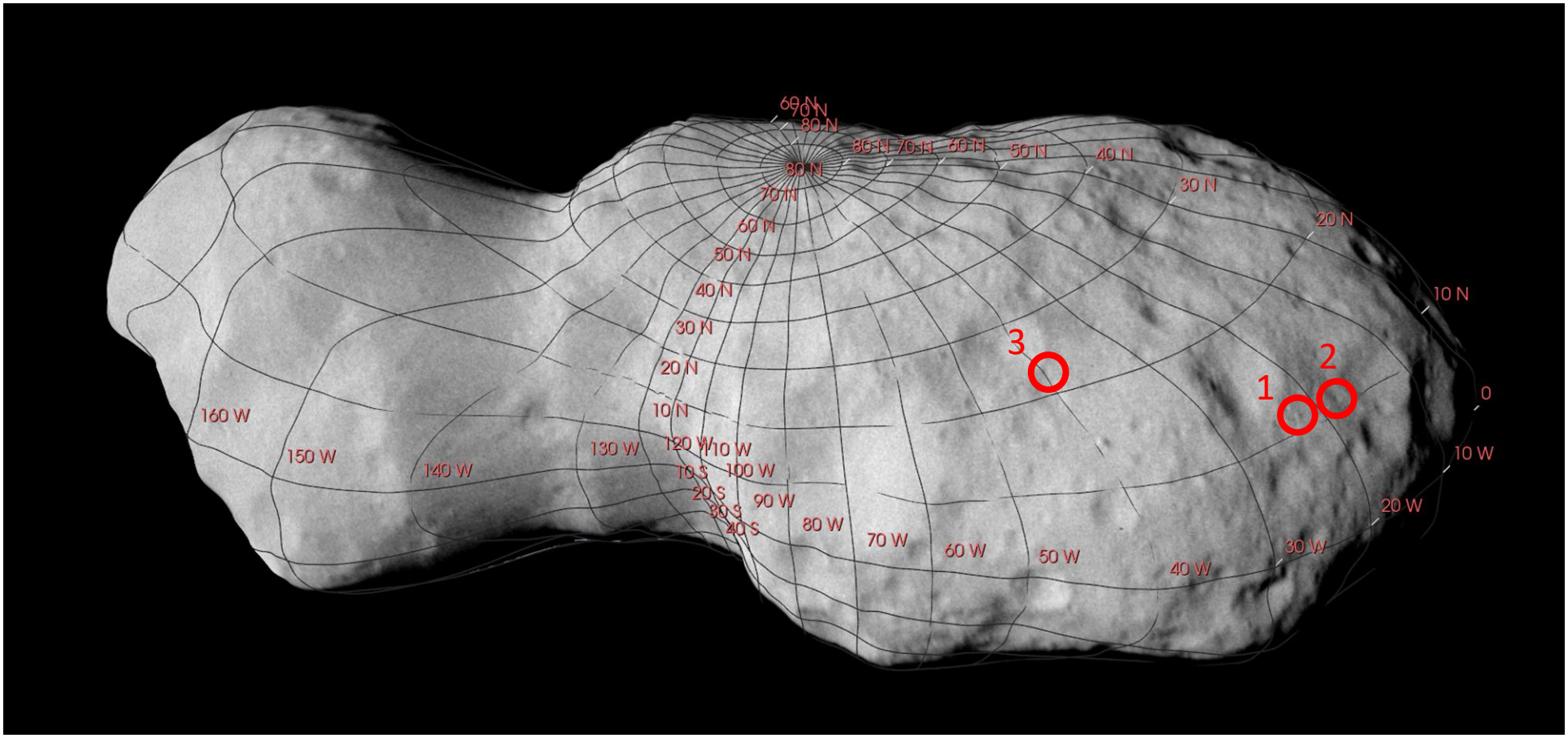

Figure 3 Context view of the Donaldjohanson textured model. The texture is based on a mosaic of select LLORRI images. Please note that the grid reports West longitude values, whereas the coordinates of the key features are reported in the table in the East longitude system.

Archinal, B. A., M. F. A'Hearn, E. Bowell, A. Conrad, G. J. Consolmagno, R. Courtin, T. Fukushima, D. Hestroffer, J. L. Hilton and G. A. Krasinsky, G. Neumann, J. Oberst, P. K. Seidelmann, P. Stooke, D. J. Tholen, P. C. Thomas, I. P. Williams, 2011. Report of the IAU Working Group on Cartographic Coordinates and Rotational Elements, 2009. Celes. Mech. & Dyn. Astron. 109, 101-135.

Marchi et al, The Lucy flyby of asteroid (52246) Donaldjohanson: A bilobed object with a complex history. September 2025, Submitted.