The axial ratios of boulders on asteroid 25143 Itokawa: Comparison with fragments from impact experiments.

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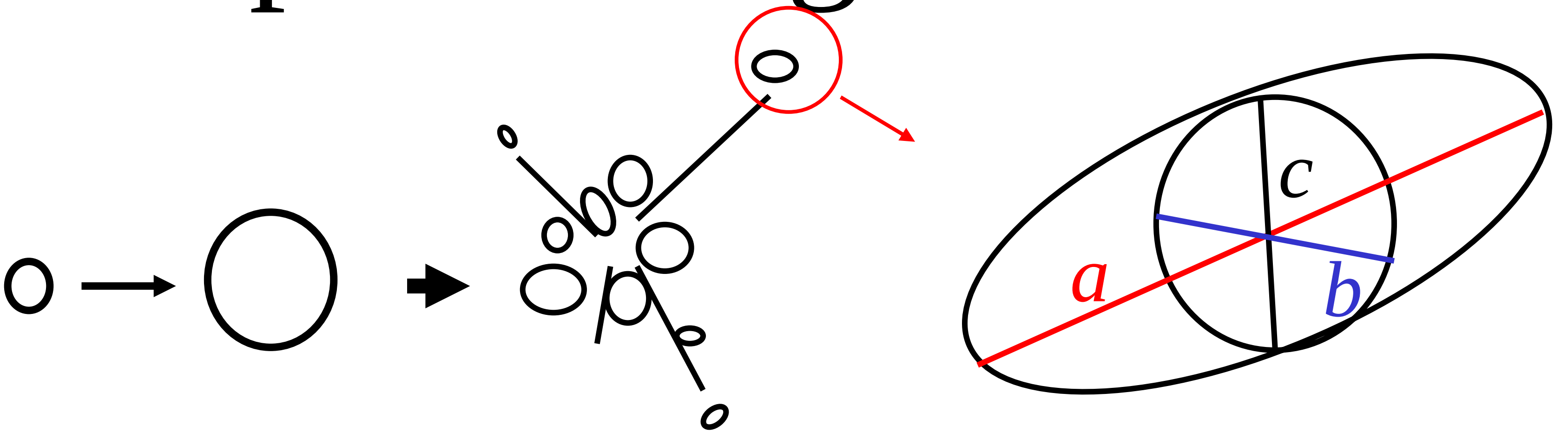
◆Shape of Fragments



Laboratory Impact Experiment

Size ~ less than 0.1 m

$$b / a \sim 0.7$$
$$c / a \sim 0.5$$

=

Axial Ratio (mean)

$$a : b : c = 2 : \sqrt{2} : 1$$

(Fujiwara et al. 1978, Capaccioni et al. 1984, Bianchi et al. 1984)

◆Shape of small asteroid

Mathilde Gaspra Ida Eros Itokawa

Light curve observation

(Catullo et al. 1984, Binzel et al. 1989, Harris and Pravec 2007)

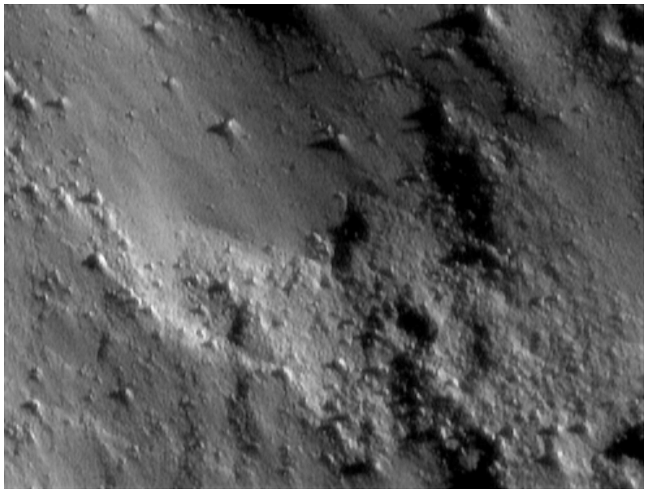
The shape of small asteroid with size of **10^2 – 10^4 m**

||

The shape of fragments in laboratory impact experiments

◆Boulders on asteroids

Surface of Eros



100m

Surface of Itokawa

The number of boulder (>15m) is 6760. (Thomas et al. 2001)

The number of boulder (>5m) is 373. (Michikami et al. 2007)

Numerous boulders were discovered.

→ We can estimate the shape distribution of fragments with size of **0.1- 100 m**.

◆Purpose

In order to investigate whether the shape distribution of boulders is similar to that of the fragments in laboratory impact experiments,
we report the shape distribution of boulders with size of 10^{-1} to 10^{2} m on the surface of Itokawa.

	Size[m]
Fragments in laboratory	10^{-4}-10^{-1}
Boulders on asteroids	10^{-1}-10^{2}
Small asterorids	10^{2}-10^{4}

◆Analysis

(I) Global mapping of boulders with size of 5-30m

Eight images acquired from AMICA data,
19-26th, October 2005 (1pixel ~ 0.4 m)

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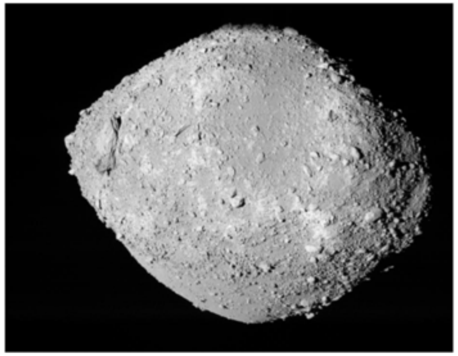
Eight images acquired from AMICA data, 19-26th, October 2005
(1pixel ~ 0.4 m) Distance from Itokawa 3.78-4.91km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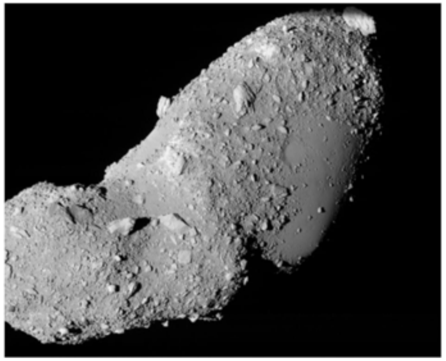
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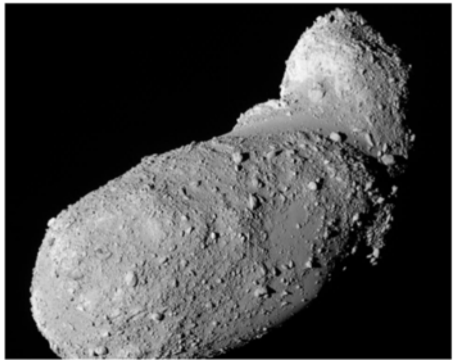
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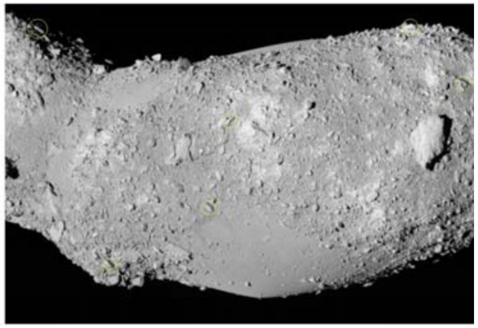
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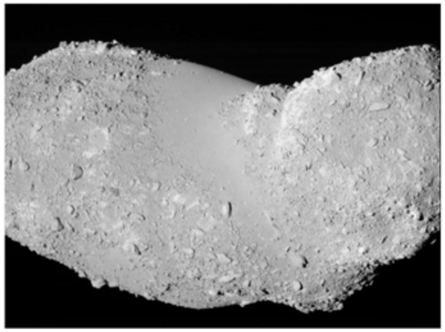
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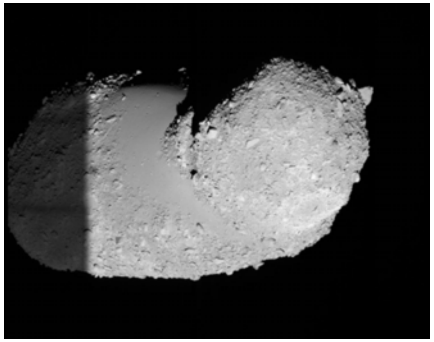
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◆Analysis

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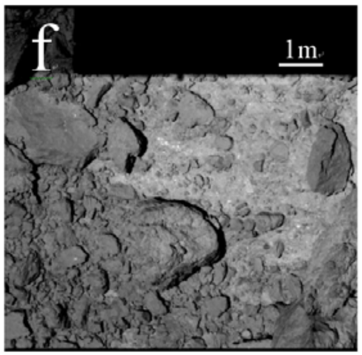
(II) Small boulders with size of 0.1-5m

Six close-up images acquired from AMICA data, 9-12th, November 2005 (1pixel ~ 0.6–6 cm)

(II) Small boulders with size of 0.1-5m

Six close-up acquired from AMICA data, 9-12th, November 2005 (1pixel ~ 0.6–6 cm) Distance from Itokawa 60-600 m



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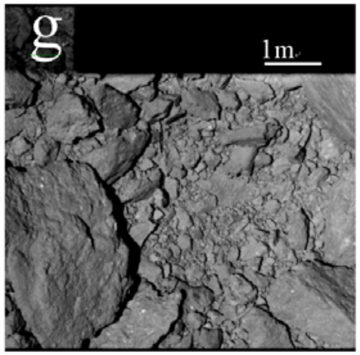

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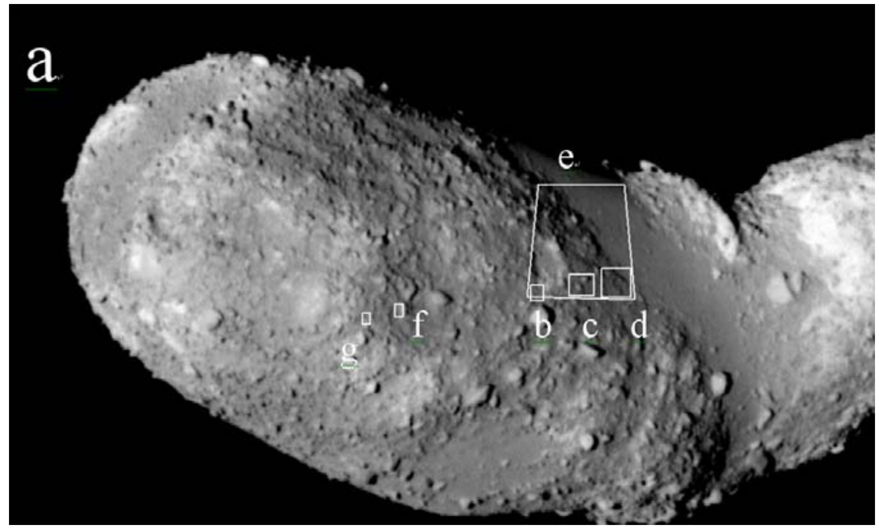

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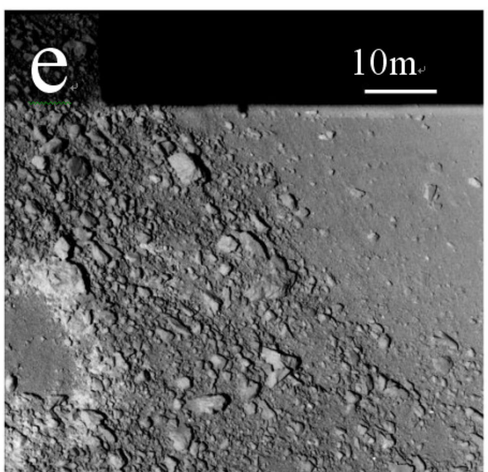

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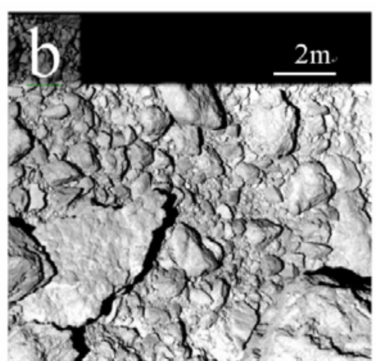

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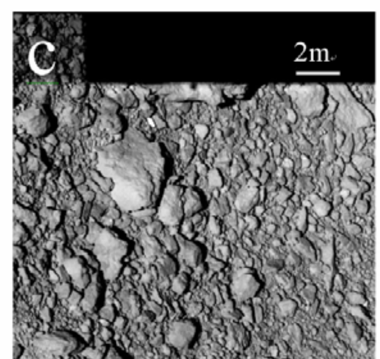

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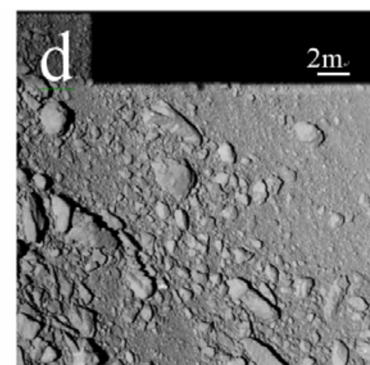

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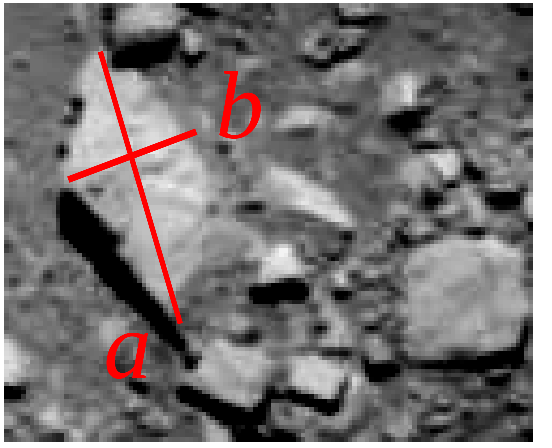
◆Analysis



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(II) Small boulders with size of 0.1-5m

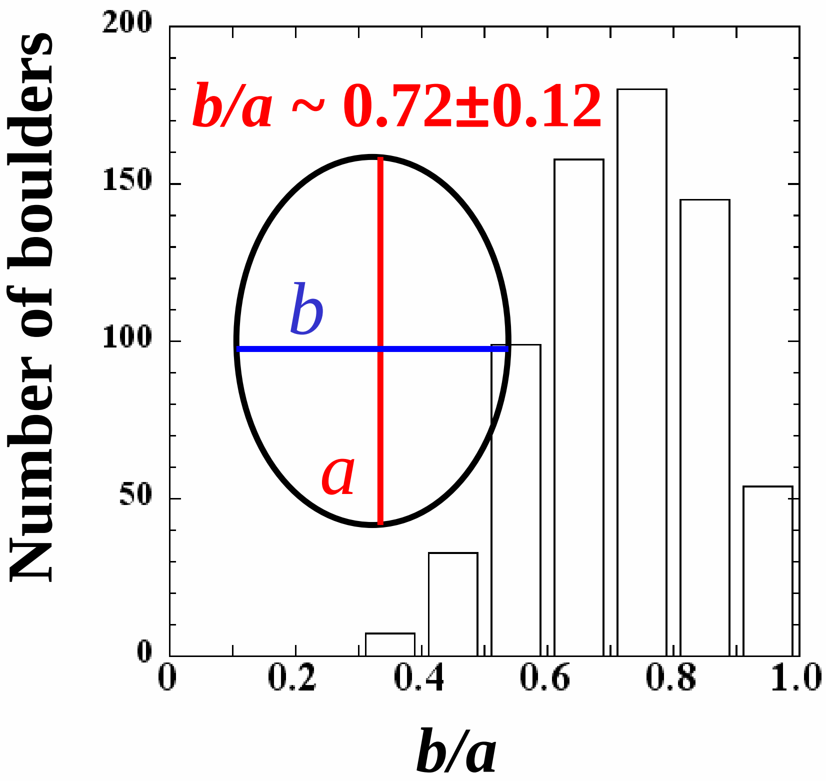
Six close-up acquired from AMICA data, 9-12th, November 2005 (1pixel ~ 0.6–6 cm)

・ Positive relief feature is defined as boulder.

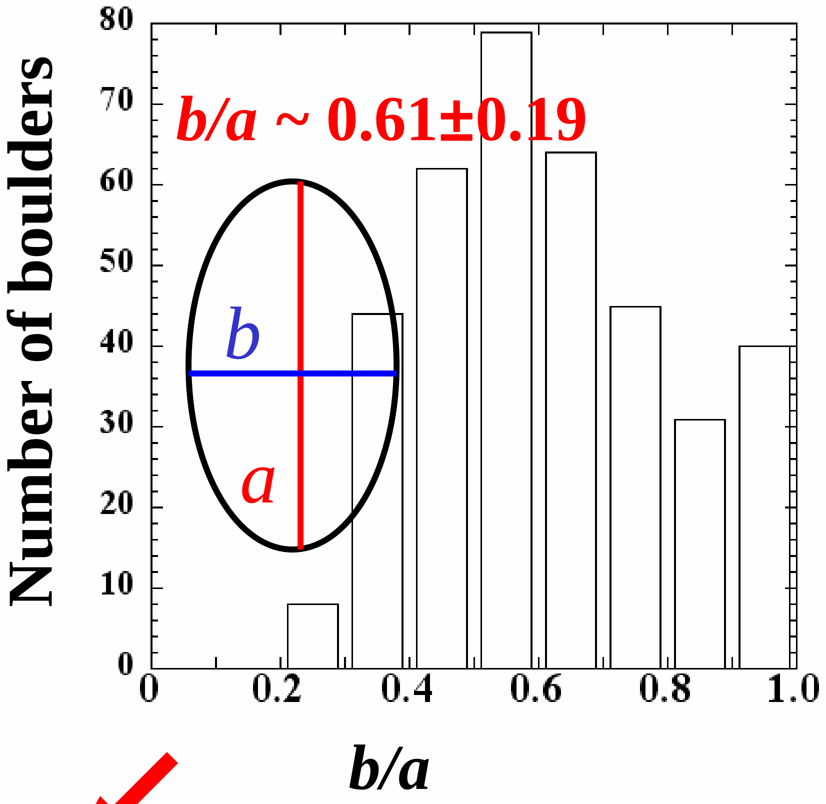
・ We have measured the apparent axes *a* and *b*, which represent the maximum dimensions of the boulder in two orthogonal planes ($a \geq b$).

◆The shape distribution of boulders

Fragment (<0.1m) in laboratory



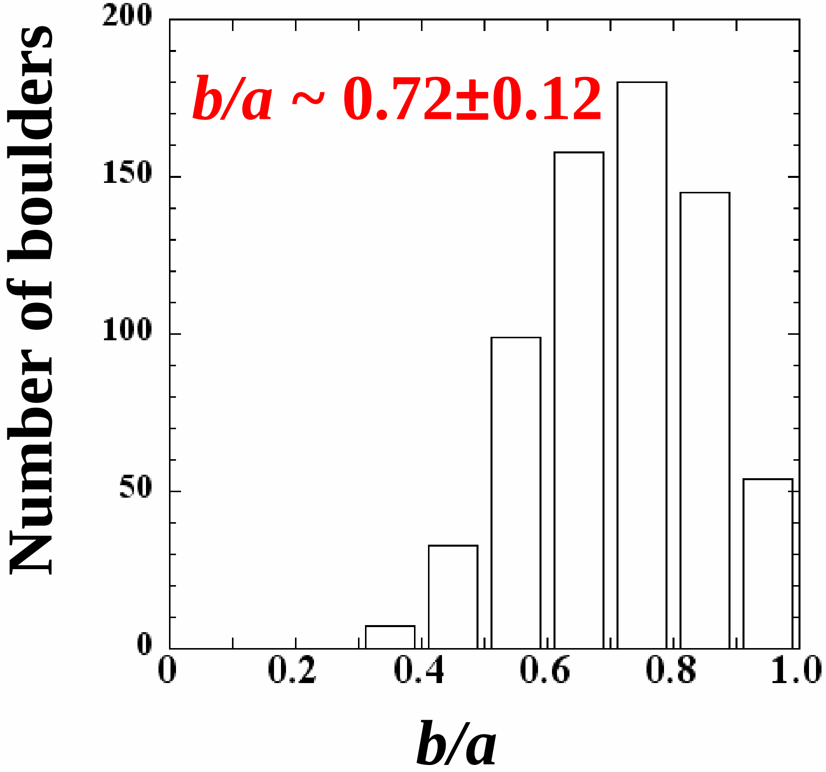
Boulder (5-30m)



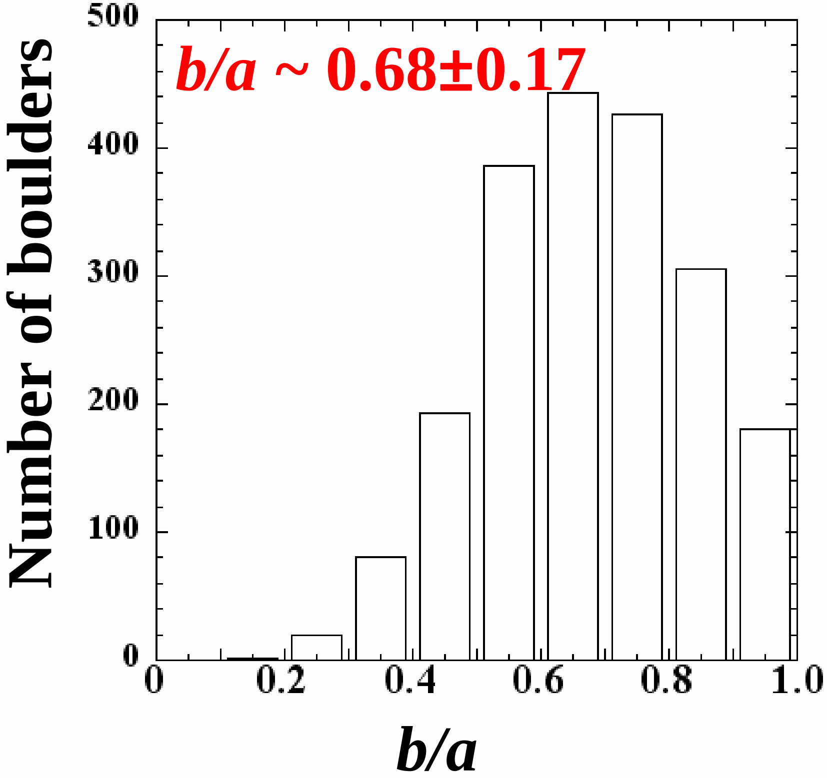
It looks like the typical boulders of Itokawa have more elongated shapes as compared with that of fragments in laboratory.

◆The shape distribution of small boulders

Fragment (<0.1m) in laboratory



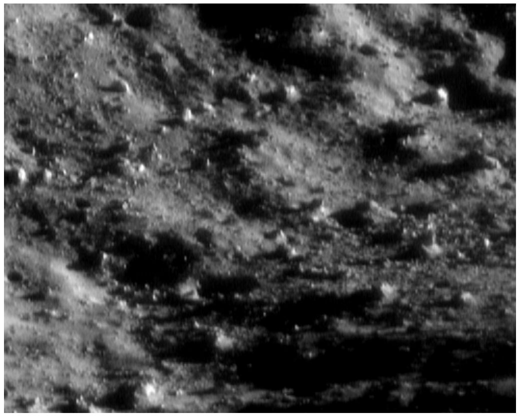
Boulder (0.1-5 m)



(III) The boulder of Eros

Boulder (60-220 m)

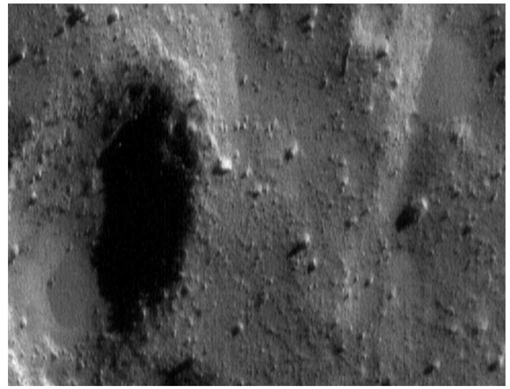
[Image ID 015313598] Rim of Saddle region



1.5km

Boulder (4-17 m)

[Image IDs 0156087736, 015588661]

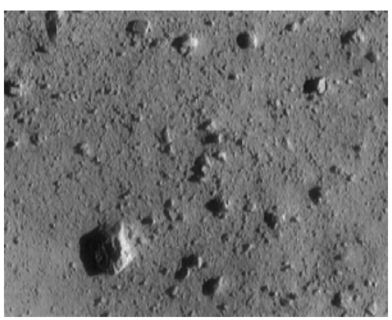


230m

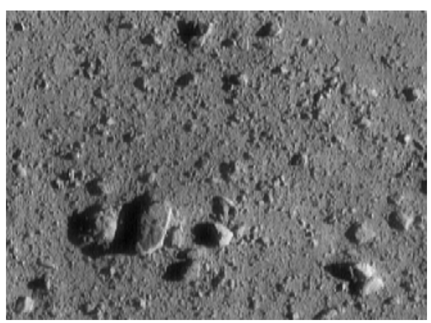
230m

Boulder (0.1-4 m)

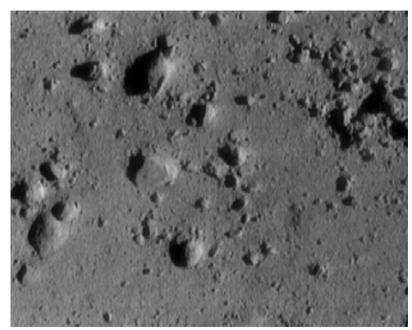
[Image IDs 0157417133, 0157417198, 0157417593] Four close-up Images



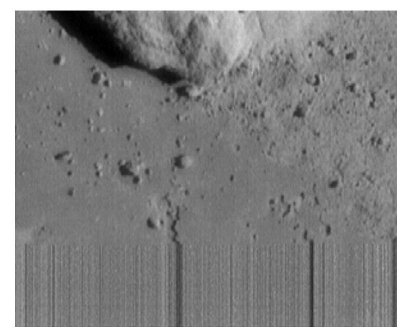
54m



33m



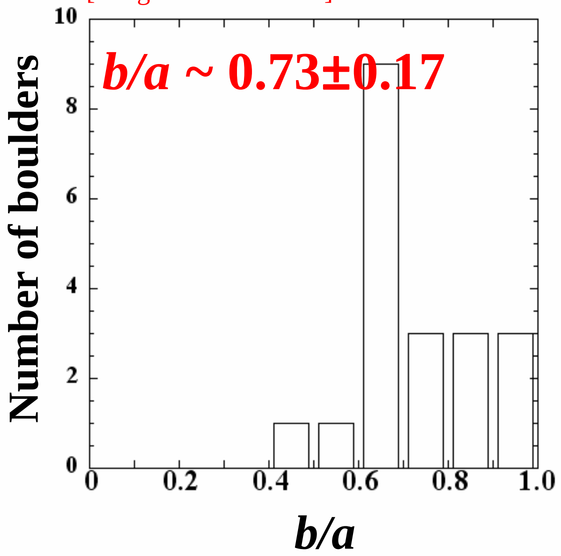
12m



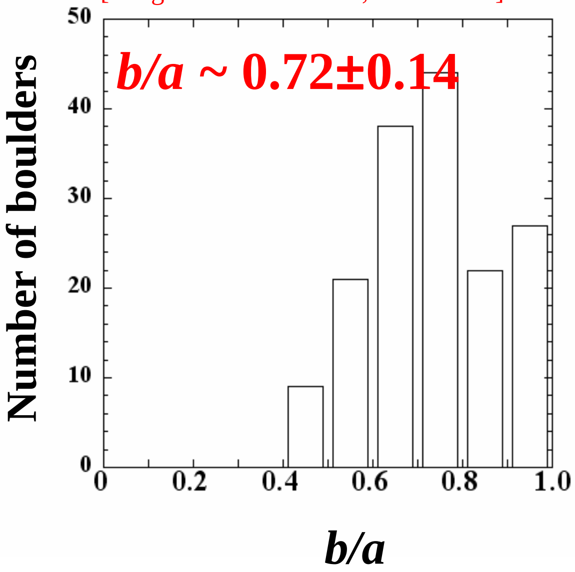
6m

◆The shape distribution of boulders (Eros)

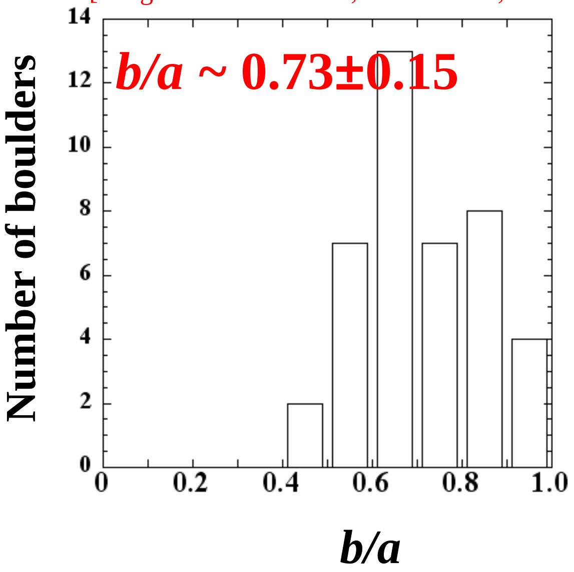
Boulder (60-220 m)
[Image ID 015313598]



Boulder (4-17 m)
[Image IDs 0156087736, 015588661]



Boulder (0.1-4 m)
[Image IDs 0157417133, 0157417198, 0157417593]



The apparent mean axial ratios of Eros's boulders are similar to that of fragments in laboratory.

◆Summary

The apparent mean axial ratios (*b/a*) of boulders are

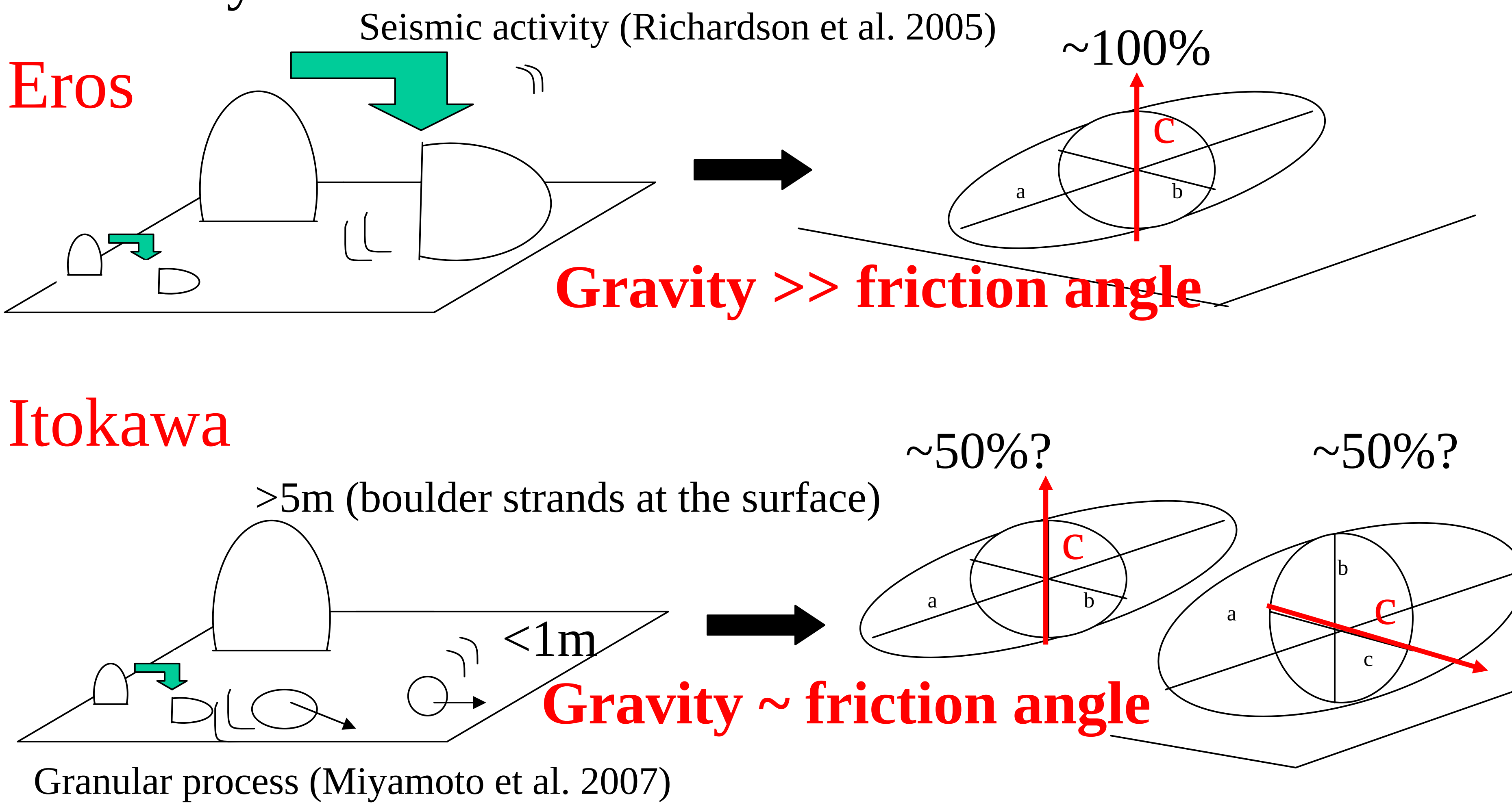
	Counted Number	Size Range	Axial ratio
Itokawa	(373)	5-30m	0.61(±0.19)
Itokawa	(2033)	0.1-5m	0.68(±0.16)
Eros	(20)	60-220m	0.73(±0.17)
Eros	(41)	4-17m	0.72(±0.14)
Eros	(163)	0.1-4m	0.73(±0.15)
(Laboratory		< 0.1m	0.72(±0.12))

It looks like the typical boulders of Itokawa have more elongated shapes as compared with that of fragments in laboratory.

→ Why ???

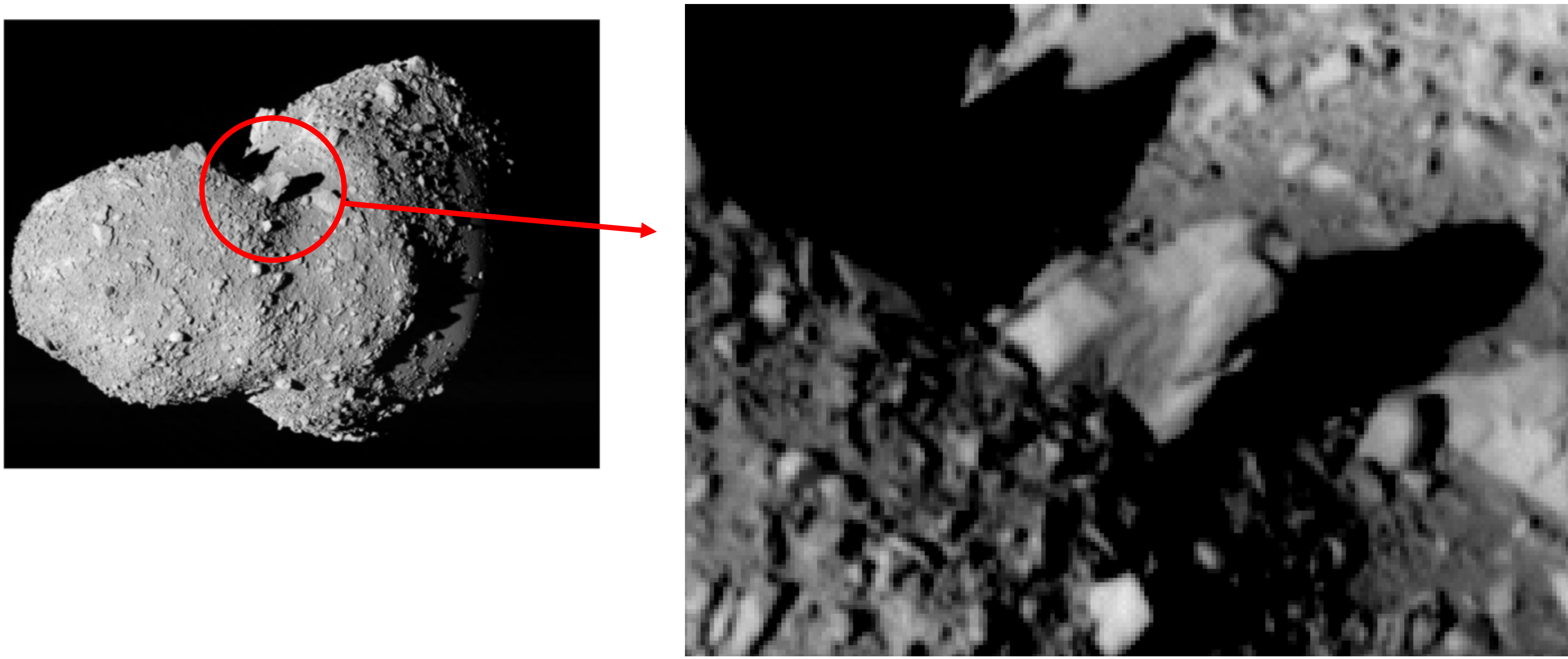
◆Discussion

One possibility is that, the actual shape distribution of the boulders on Itokawa is similar to that of the fragments in laboratory.



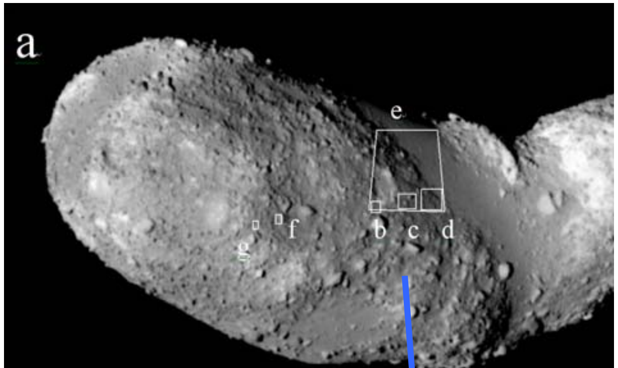
End

Some boulders keep the original position and stranded at the surface.



This large boulder is even taller than they are wide, which is a rather unstable orientation.

The difference of the axial ratio between small boulder (< 5m) and large boulder (> 5m) on Itokawa



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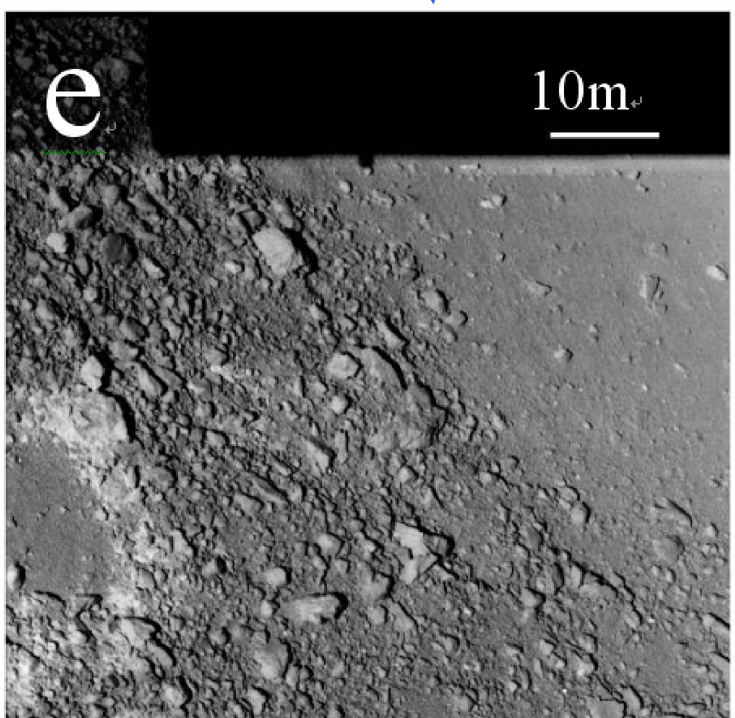


ST2532629277

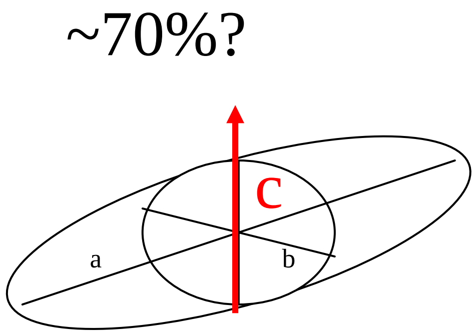
The apparent mean axial ratio decreases with increasing the size of boulders in the range from 0.1 to 5 m.

Axial ratio (*b/a*)	Size	(Counted Number)
0.68 **(±0.16)**	0.6-5.4 m	(495)
0.66 **(±0.16)**	1.0-5.4 m	(309)
0.60 **(±0.16)**	2.0-5.4 m	(53)

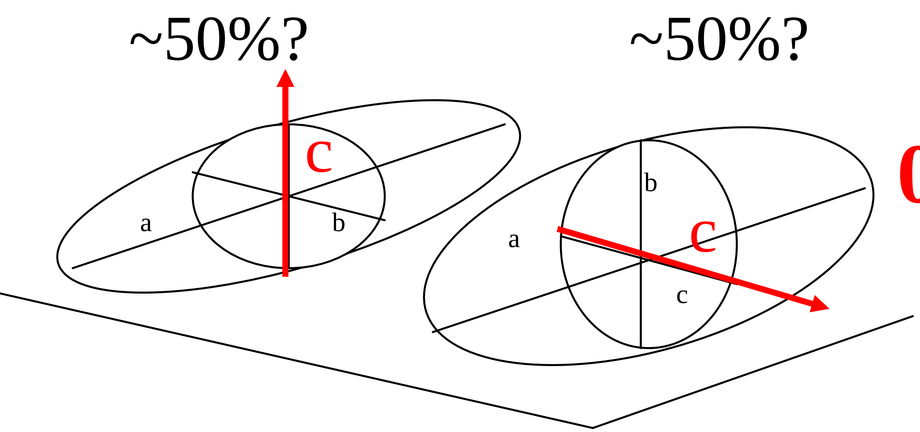
Axial ratio: decrease   Size: increase

The apparent mean axial ratio decreases with increasing the size of boulders in the range from 0.1 to 5 m.

Small boulder (>5m)



Large boulder(>5m)



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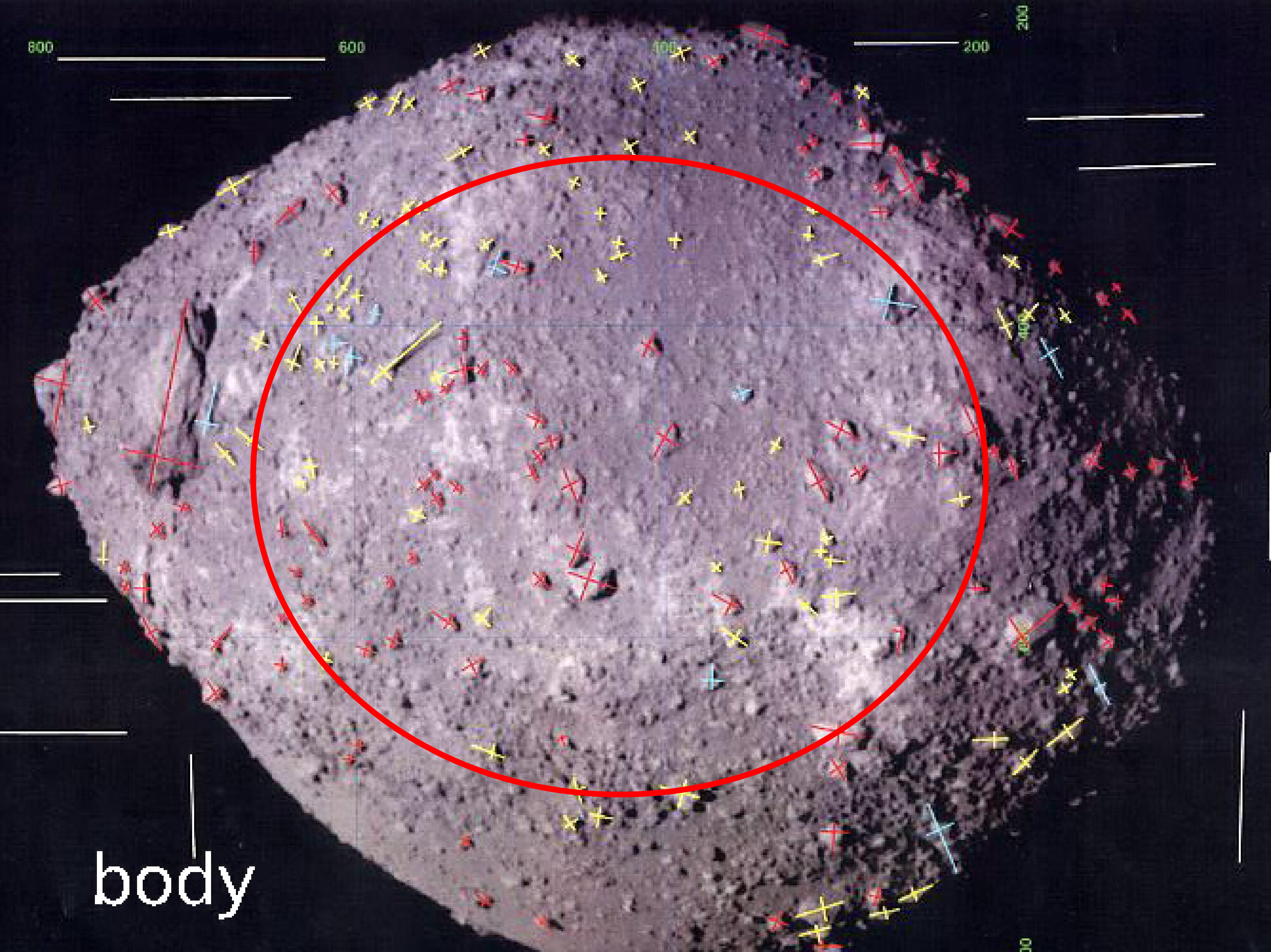
0.60 **(±0.16)**	2.0-5.4 m	(53)

Axial ratio: small

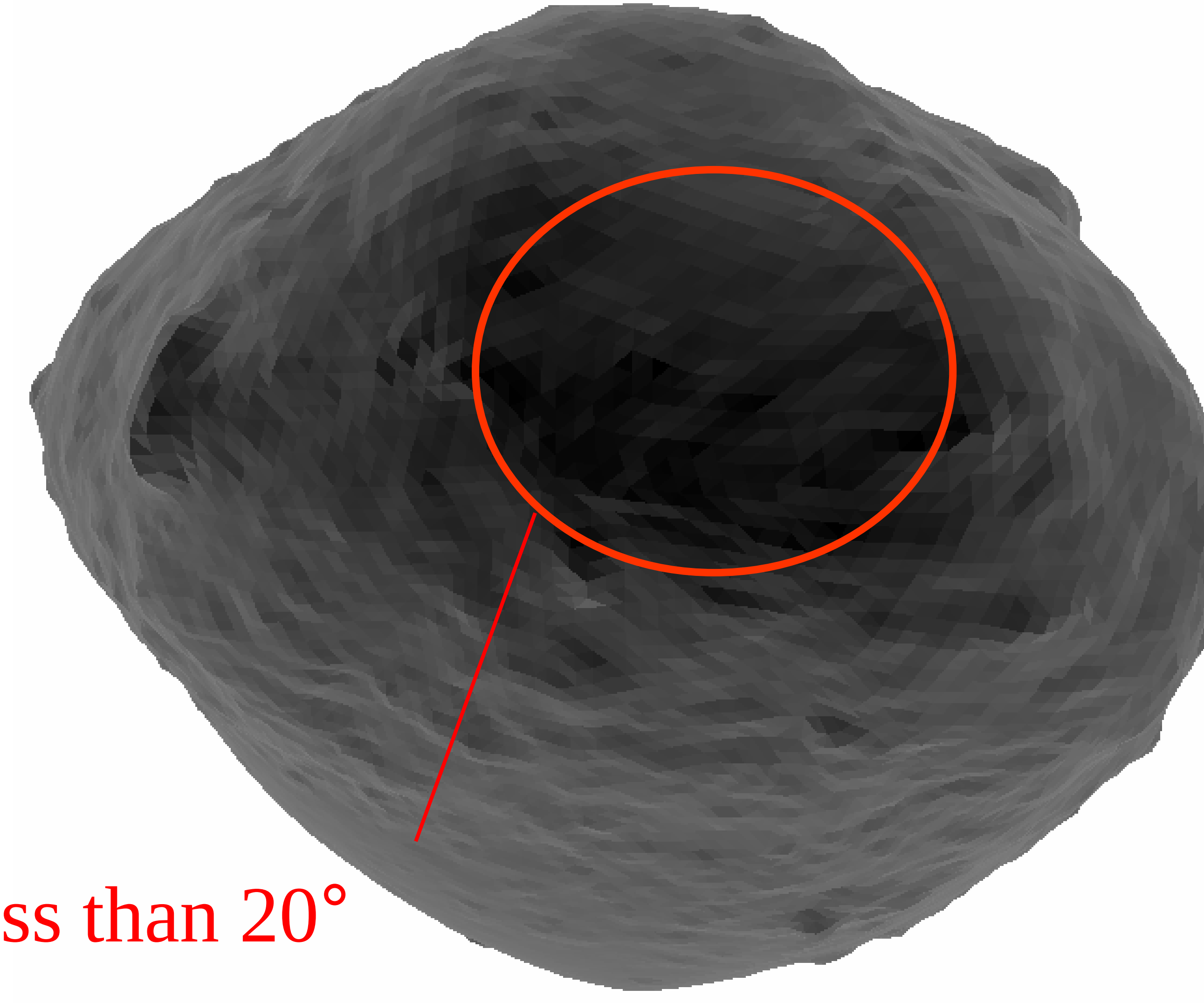
Size: large

The influence of the emission angle


800
600
200
body

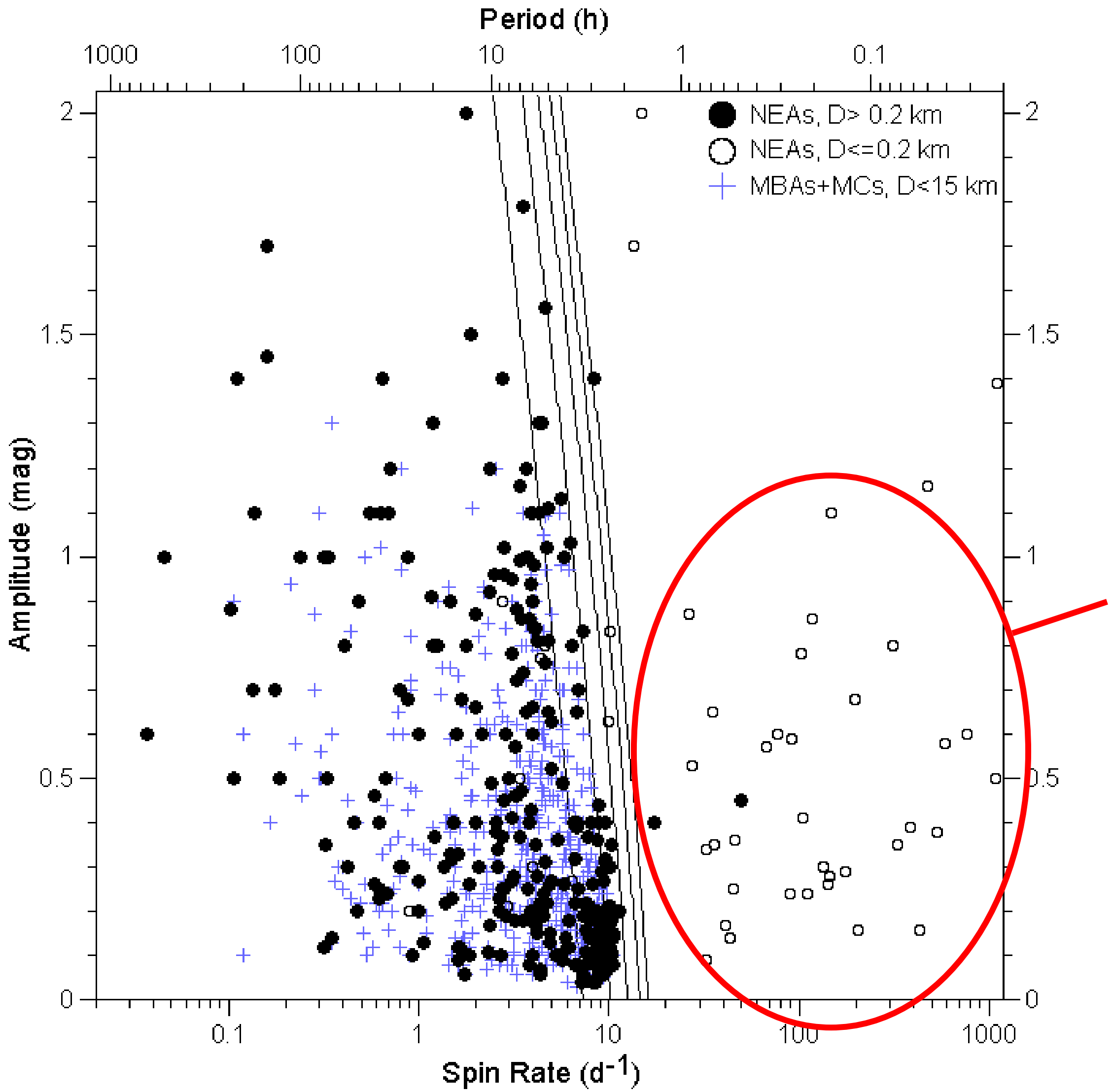
We counted the boulders which were observed on the emission angle less than 20 degree.

The axial mean ratio of these boulders (the counted number is 76) is 0.62 ±0.18, and this value is similar to that of the total boulders over the entire surface.



Shape distribution of small and fast-rotation asteroids

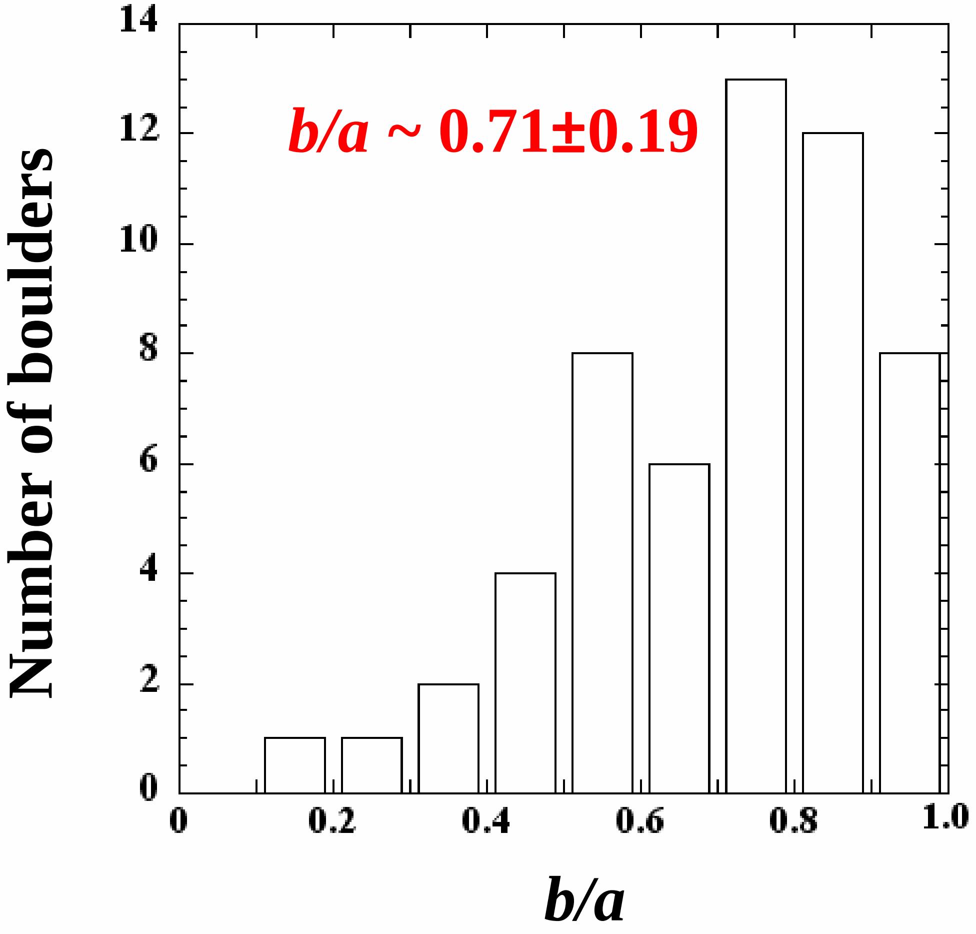
Shape distribution of small and fast-rotation asteroids



According to Holsapple 2007, these asteroids are monolithic bodies generated by impact cratering or catastrophic disruption of the parent asteroids.

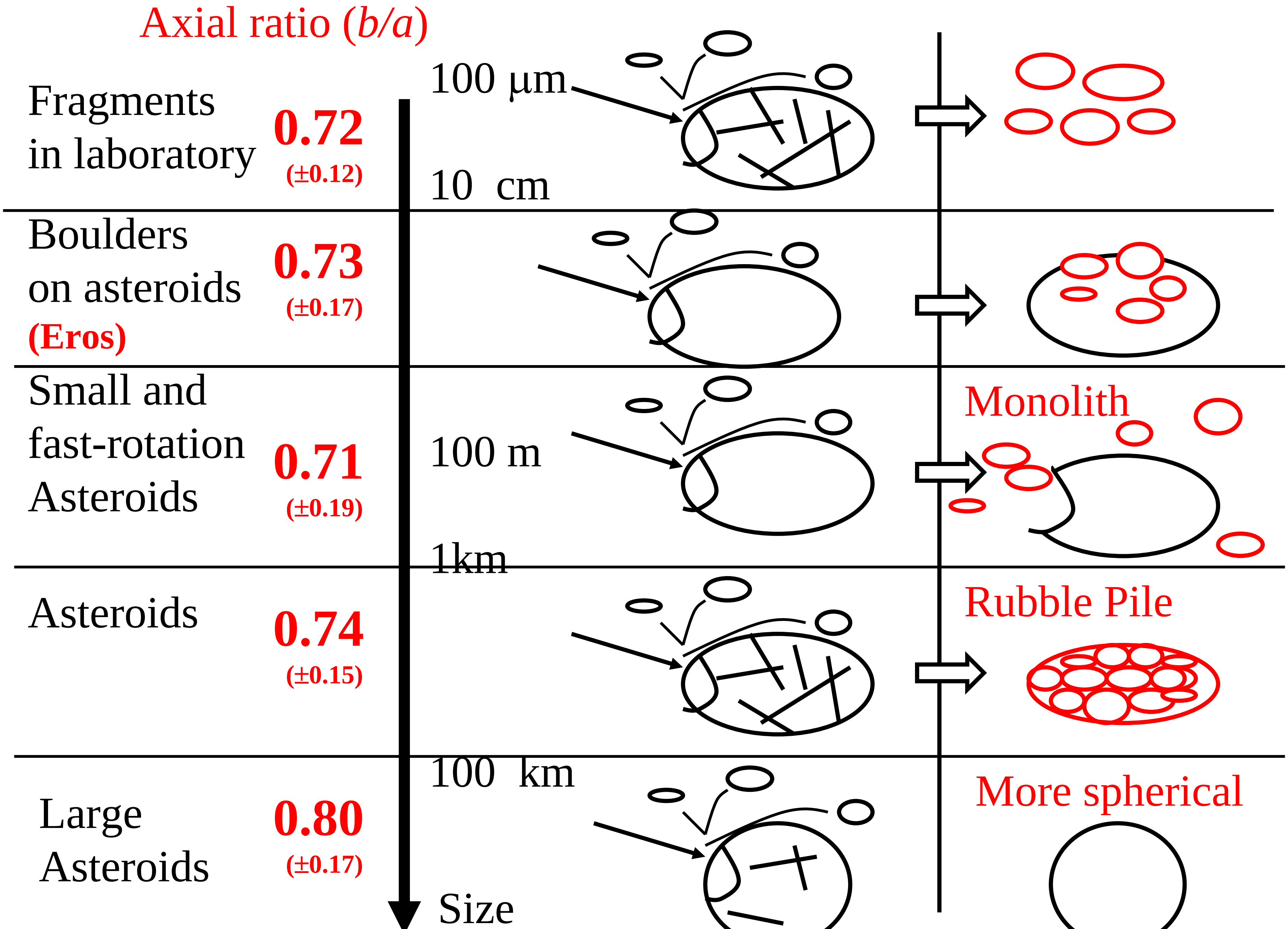
Small and fast-rotation asteroids

(diameter < 200m and rotation period < 1hr)



The shape distribution of small and fast-rotation asteroids is similar to that of fragments in laboratory.

The mean axial ratio of fragments, boulders and asteroids

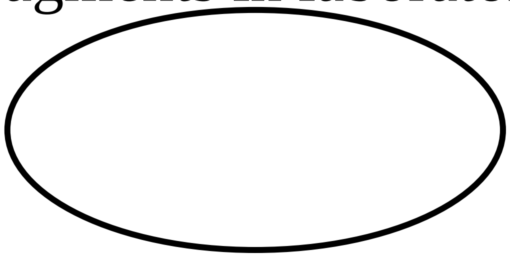

Axial ratio (b/a)
Fragments
in laboratory
0.72
(±0.12)
Boulders
on asteroids
(Eros)
0.73
(±0.17)
Small and
fast-rotation
Asteroids
0.71
(±0.19)
Asteroids
0.74
(±0.15)
Large
Asteroids
0.80
(±0.17)
100 μm
10 cm
100 m
1km
100 km
Size
Monolith
Rubble Pile
More spherical

Other possibility

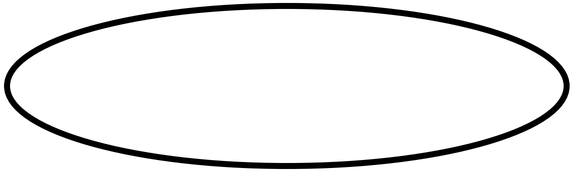
Other possibility

1) The actual shape distribution of the boulders on Itokawa differs from that of the fragments in laboratory.

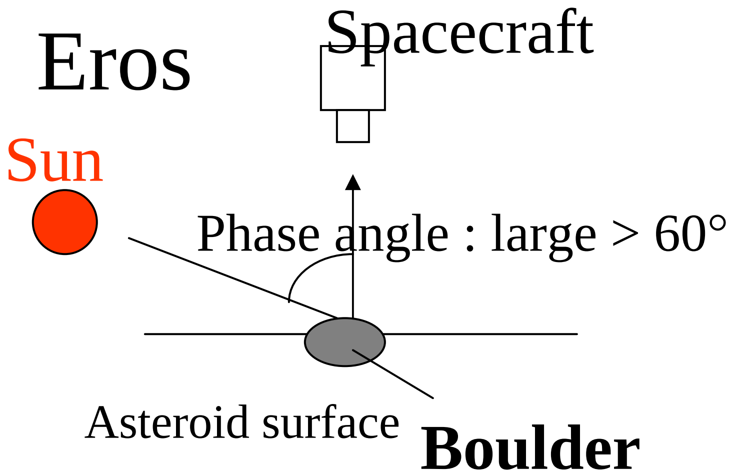
Fragments in laboratory

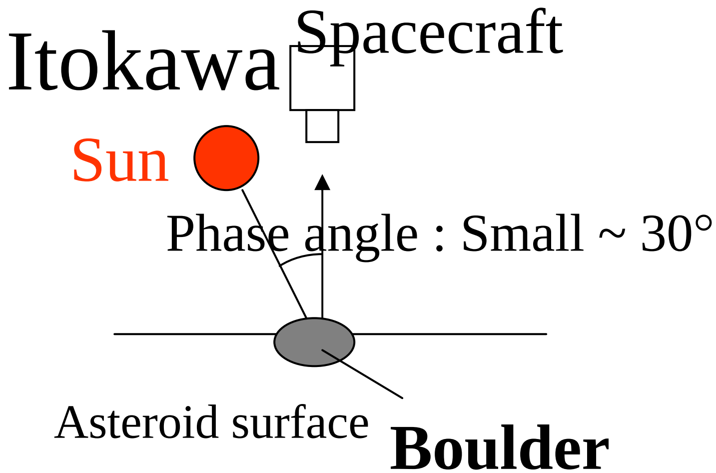


Itokawa



2) The influence of the phase angle on the axial ratio





Three axis ratio

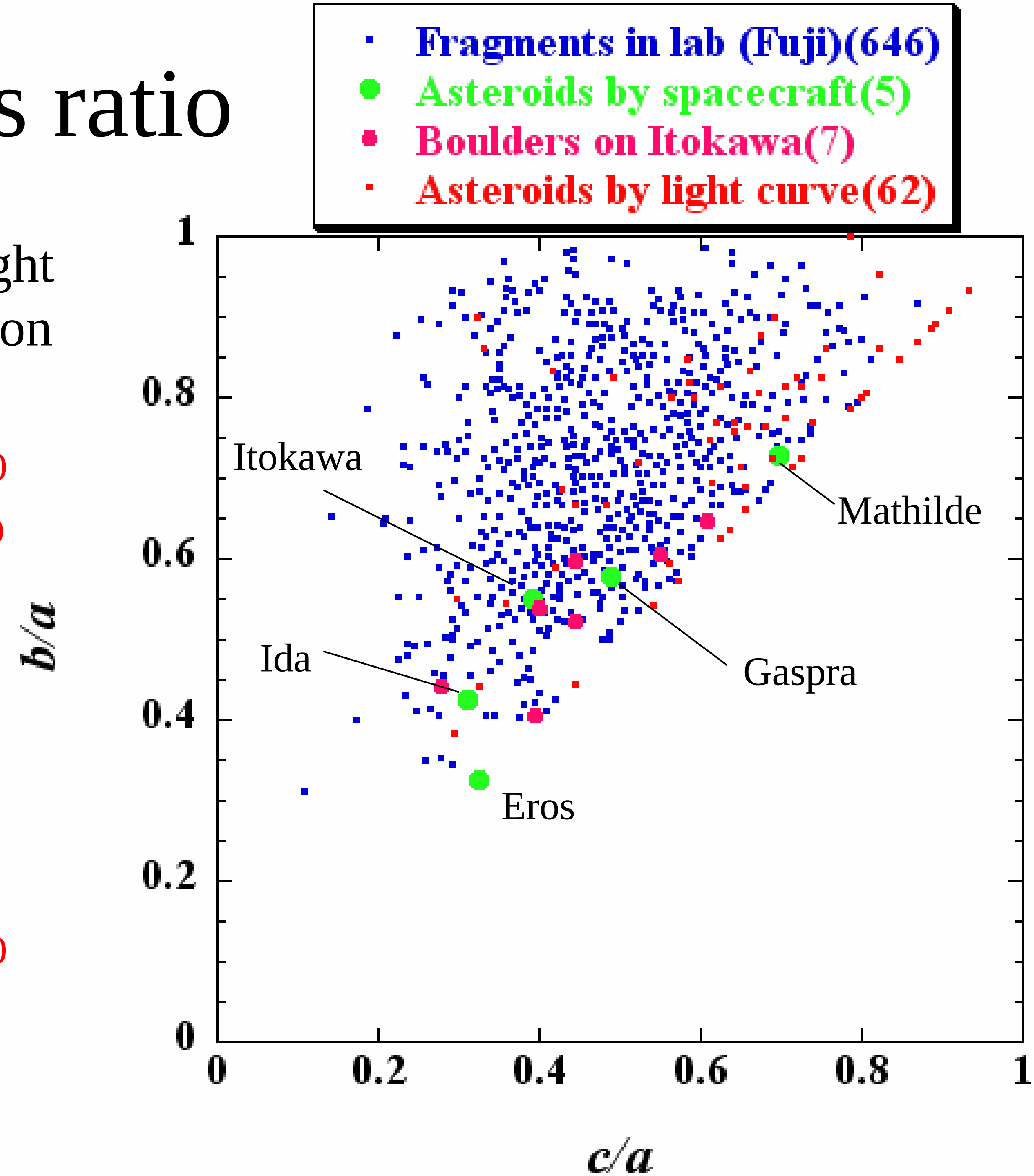
Three axis ratio

Asteroids by light curve observation

b/a ~ 0.76 **(±0.13)**
c/a ~ 0.64 **(±0.16)**

Fragments in laboratory

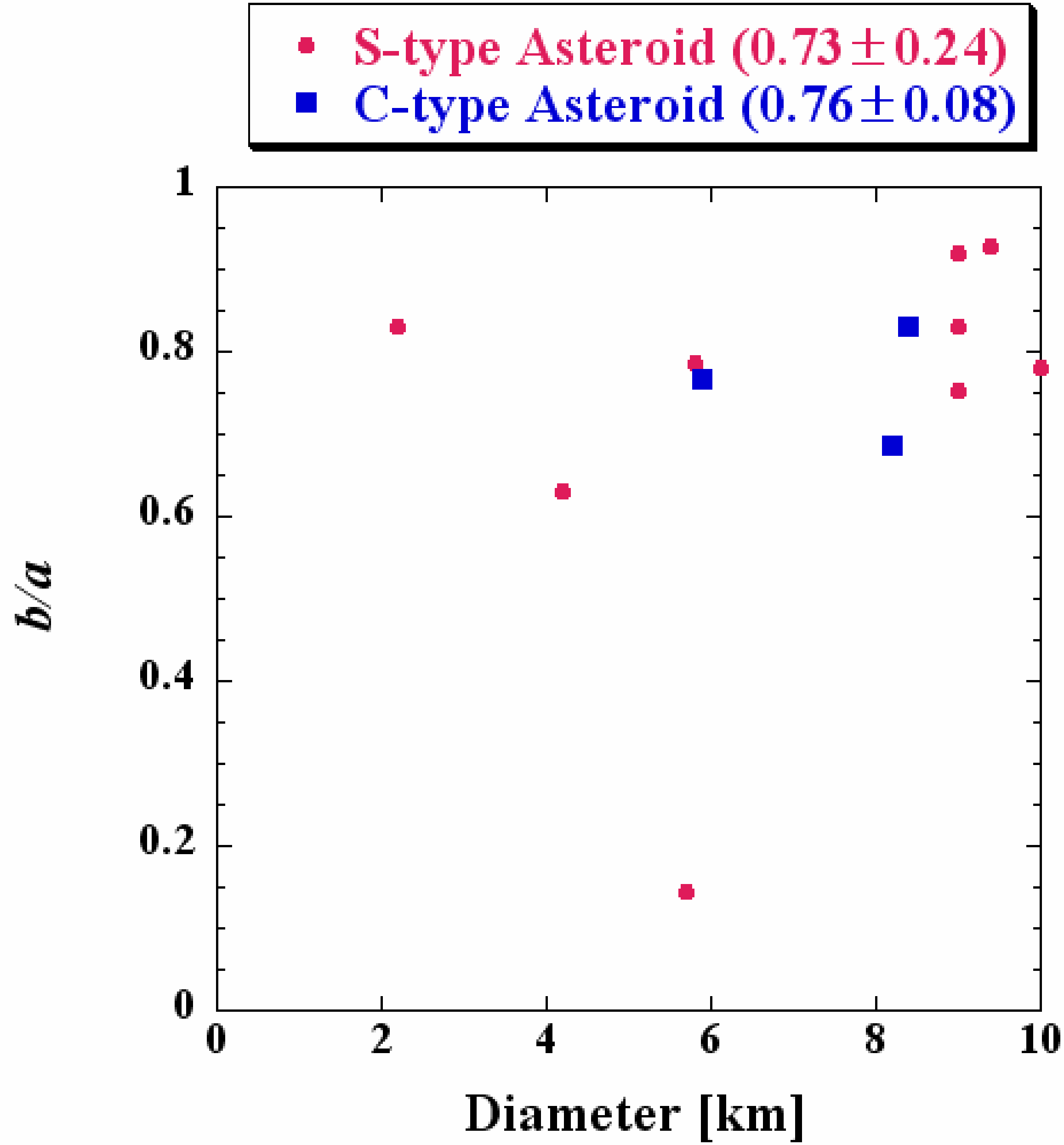
b/a ~ 0.72 **(±0.12)**
c/a ~ 0.49**(±0.16)**



Axial Ratio of Asteroid and Taxonomic classification

Axial Ratio of Asteroid

(< 10 km) and Taxonomic classification



Taxonomic classification according to the method of Tholen (1984, 1989).