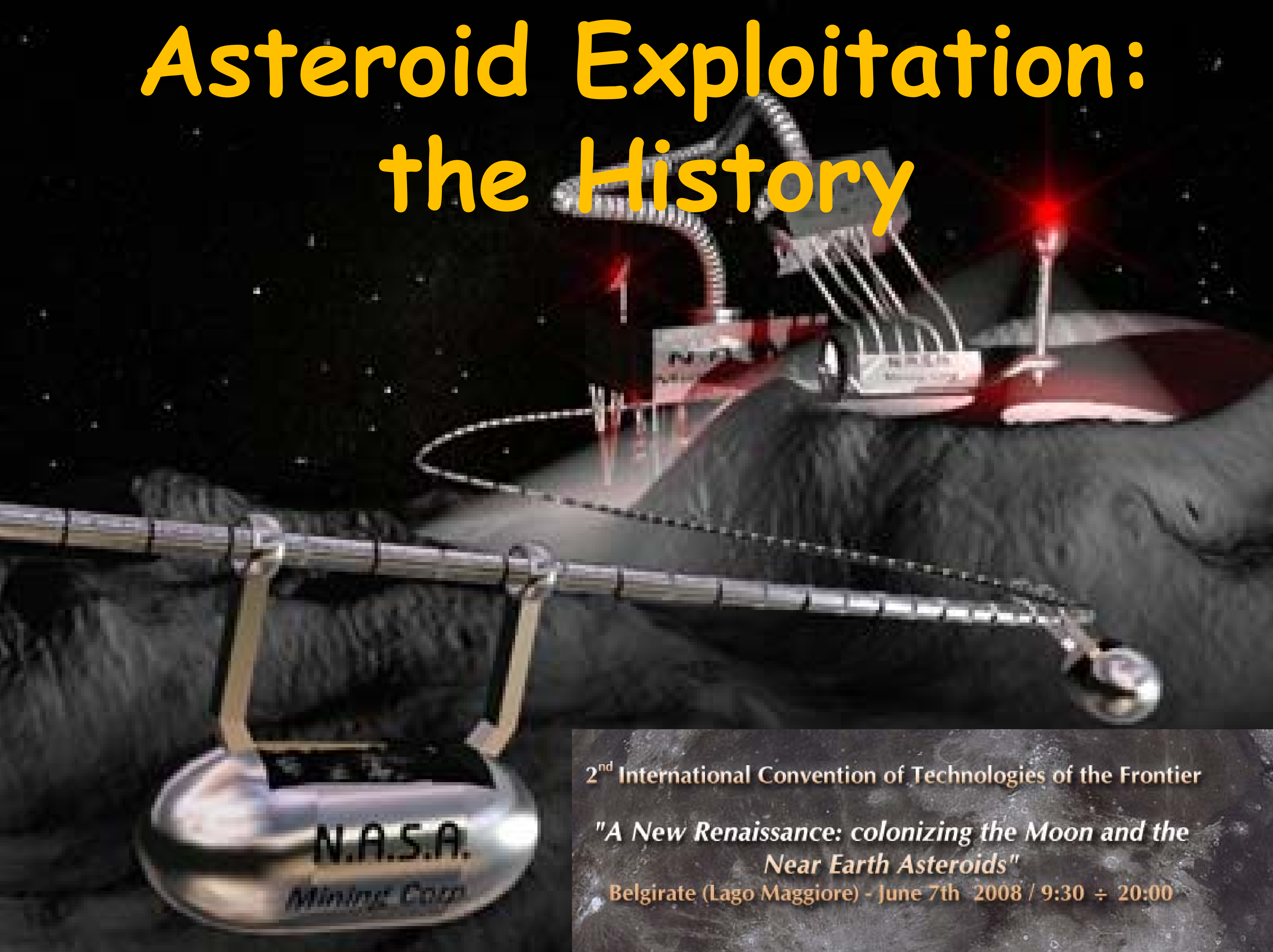
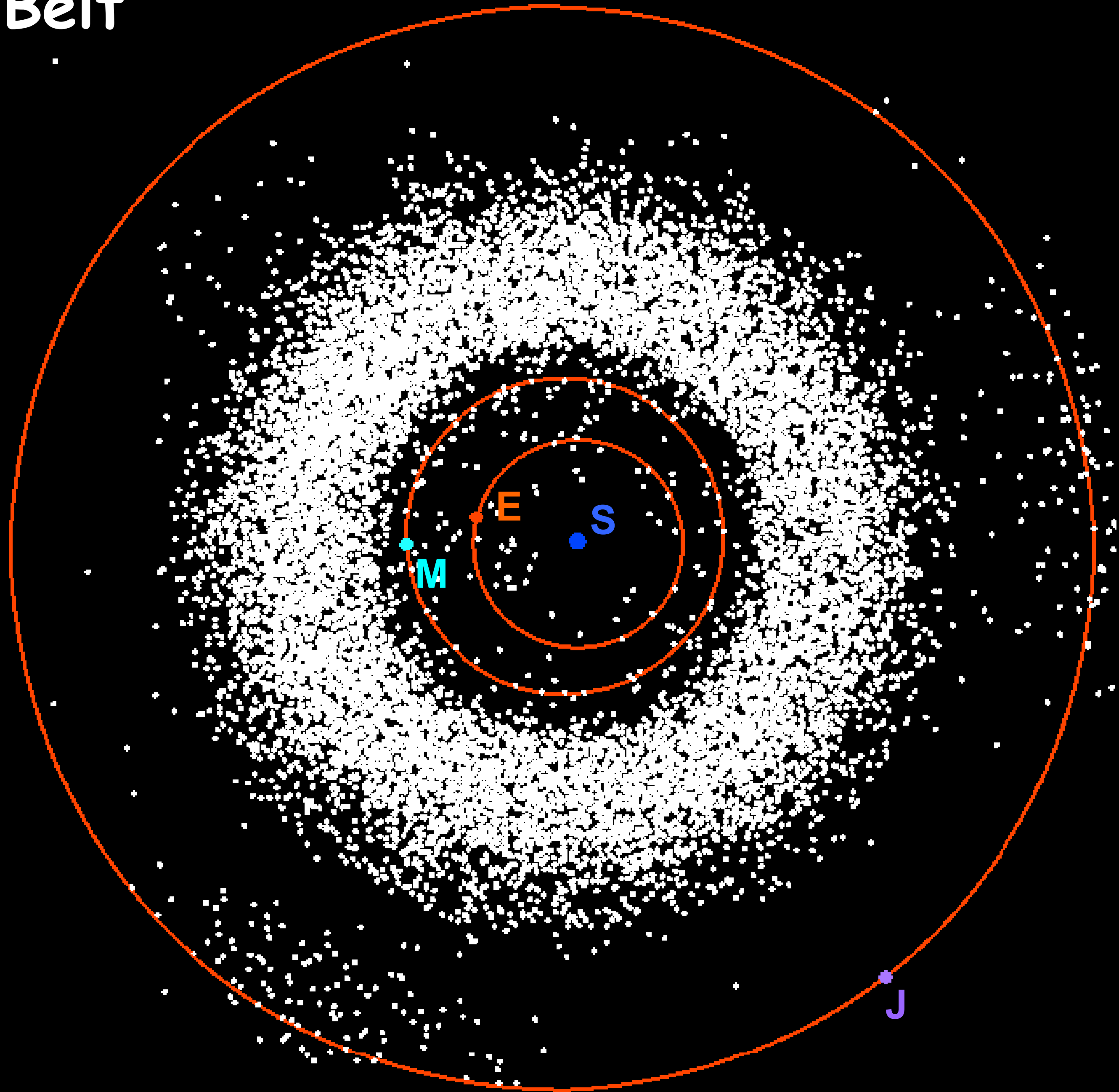
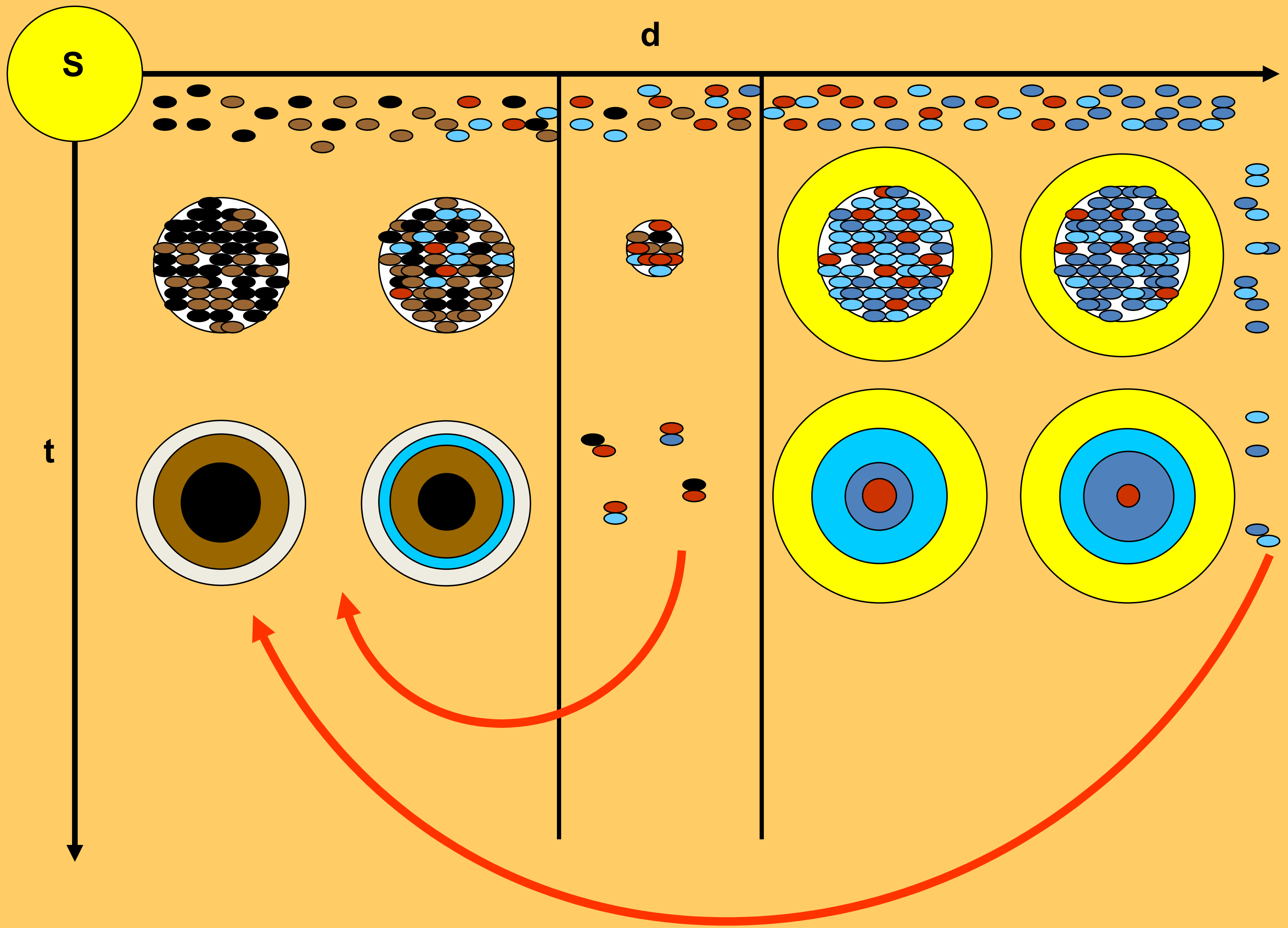
Asteroid Exploitation: the History



Asteroid Belt



Physical Structure


S
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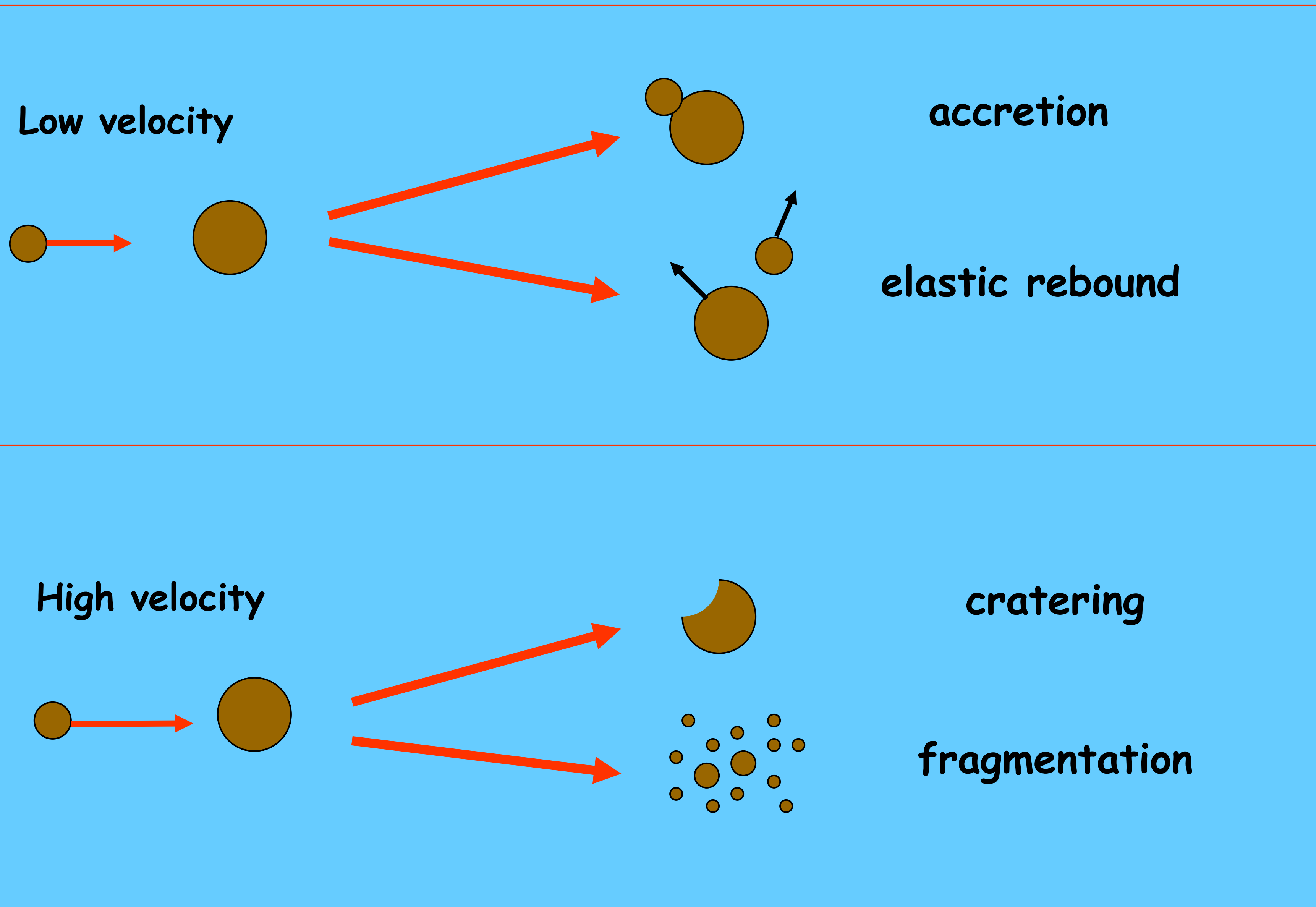
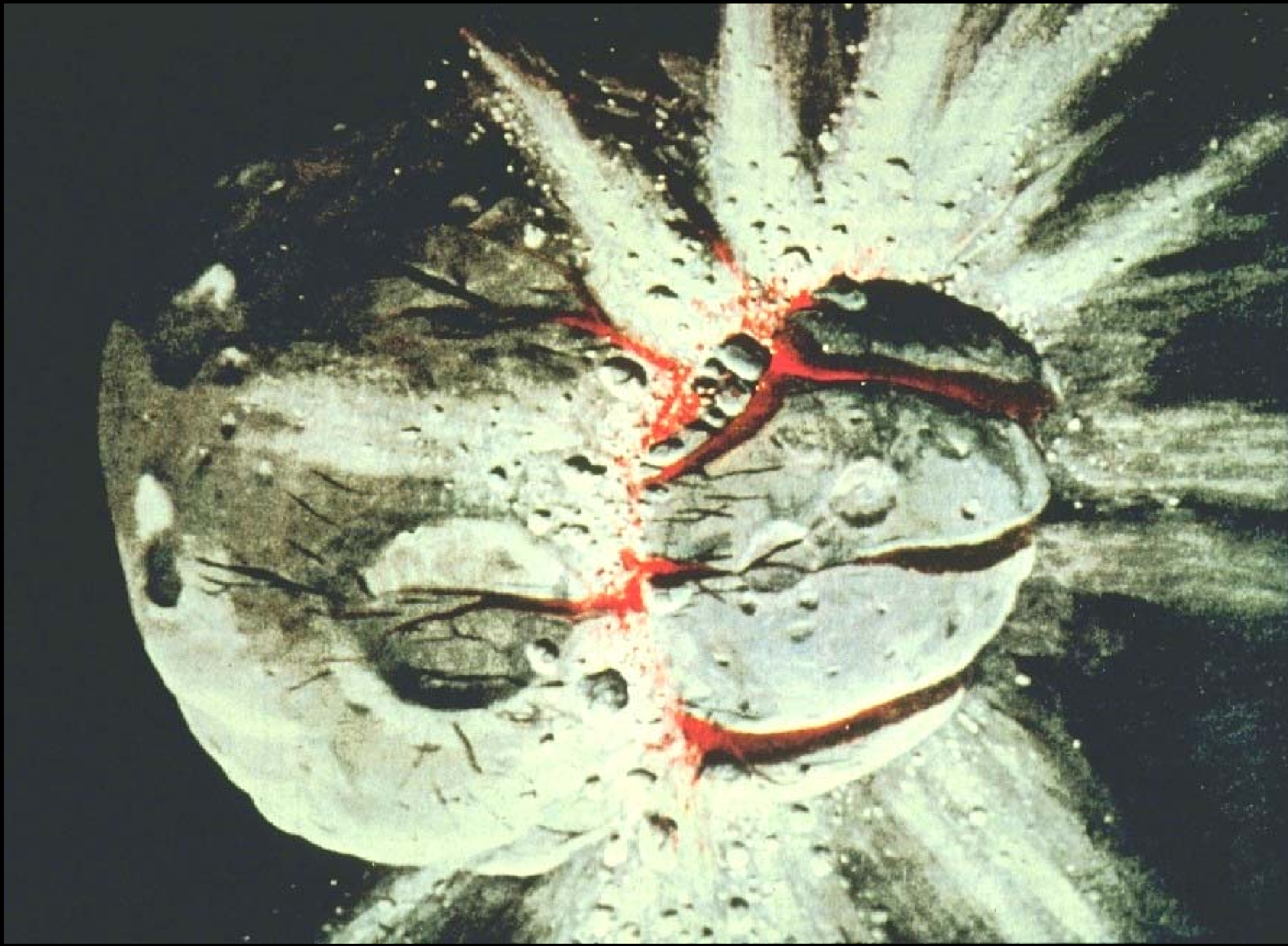
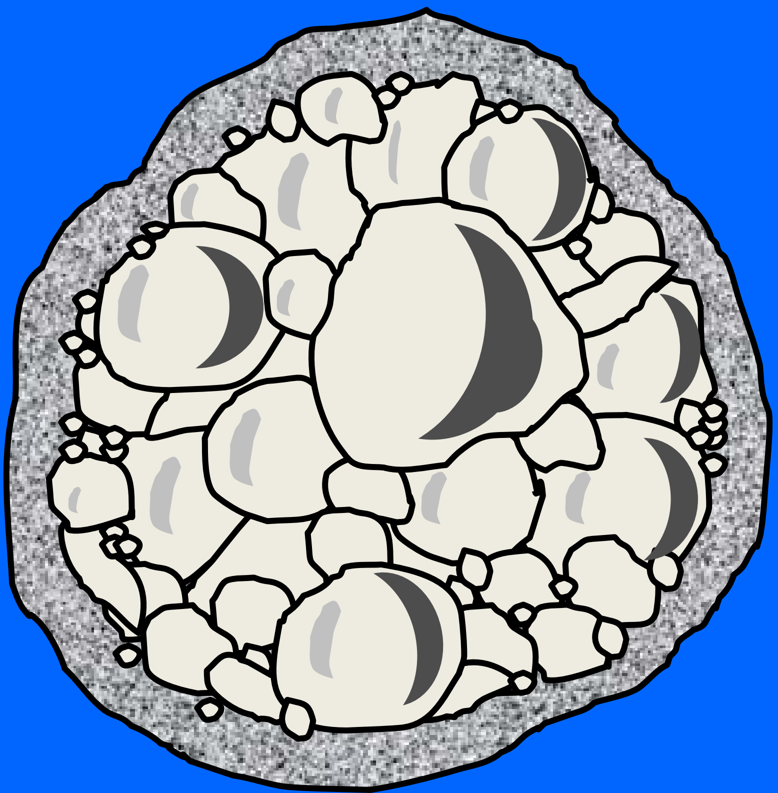
Planetesimal impacts





“pile of rubble” structure



discovered in 1981 …

Carl Barks, 1960

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Walt Disney's UNCLE SCROOGE, No. 29, March-May, 1960. Published quarterly by Dell Publishing Co., Inc., 750 Third Avenue, New York 17, N. Y.; George T. Delacorte, Jr., Publisher; Helen Meyer, President; Paul R. Lilly, Executive Vice-President; Harold Clark, Vice-Pres.-Advertising Director; Albert P. Delacorte, Treasurer. Second-class postage paid at New York, New York, and at Poughkeepsie, New York. Subscriptions in U.S.A. and Possessions and Canada 40c per year. Subscriptions for Pan-American and foreign countries 70c per year. **Dell Subscription Service:** 321 West 44th Street, New York 36, N. Y. Printed in U.S.A. Designed and produced by Western Printing & Lithographing Co.

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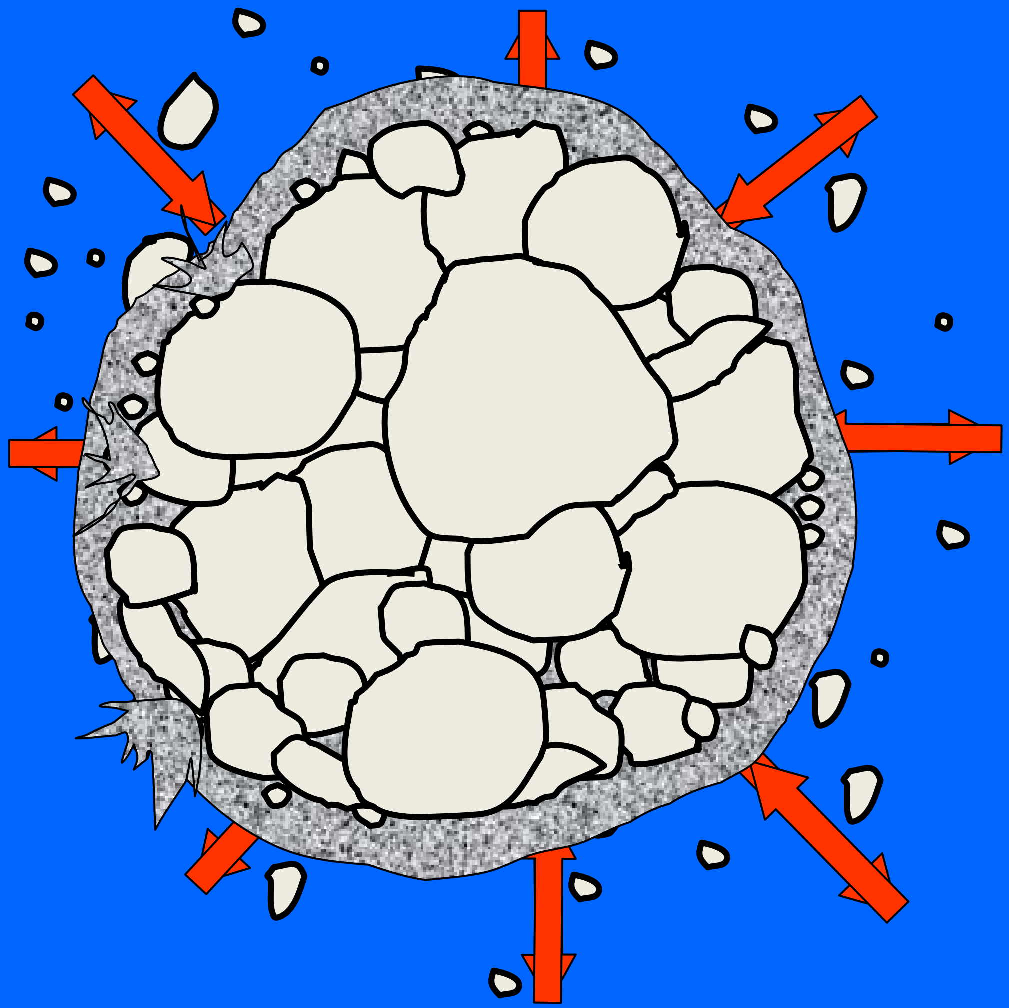
DELL COMICS ARE GOOD COMICS


SEE! THEY'RE JUST CINDERS AND ROCKS, LIKE I SAID!
I'LL HOP OUT AND CHECK THE GRAVITY!


GOOD GRAVY! THEY'RE NOT EVEN *GLUED* TOGETHER!

“pile of rubble” formation



Abundance of Useful Materials 1

- What are the most useful materials?
  - Water (ice, -OH silicates, hydrated salts) for
    - Propellants
    - Life support
  - Native ferrous metals (Fe, Ni) for structures
  - Bulk regolith for radiation shielding
  - Platinum-group metals (PGMs) for Earth
  - Semiconductor nonmetals (Si, Ga, Ge, As,…) for Earth or Solar Power Satellites

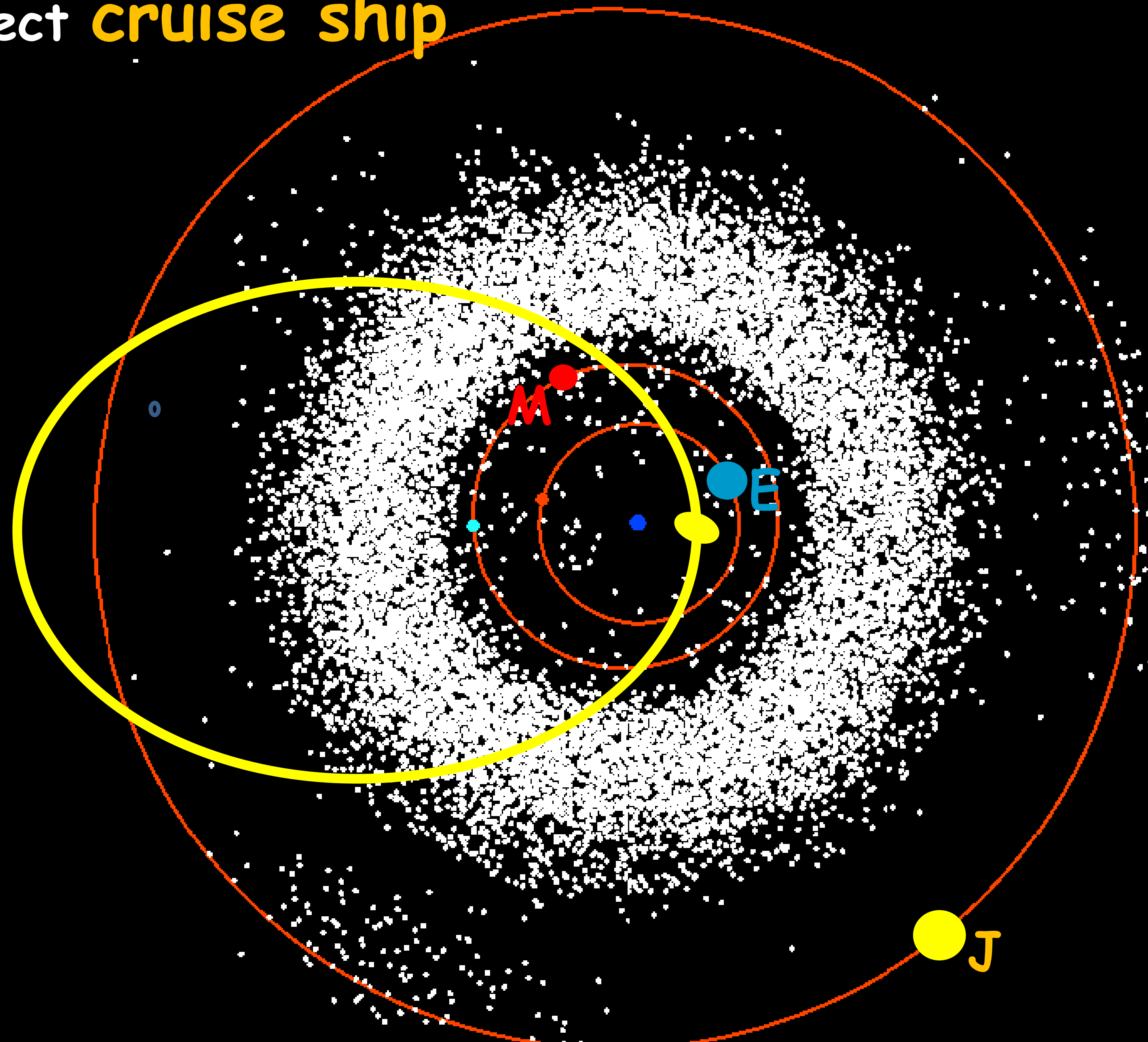
One Small Metallic NEA: Amun

- 3554 Amun: smallest known M-type NEA
- Amun is 2000 m in diameter
- Contains about 30x the total amount of metals mined over human history
- Contains $3x10^{16}$ g of iron
- Contains over 10^{12} g of PGMs with Earth-surface market value of about $40 T

NEAs as Traveling Hotels

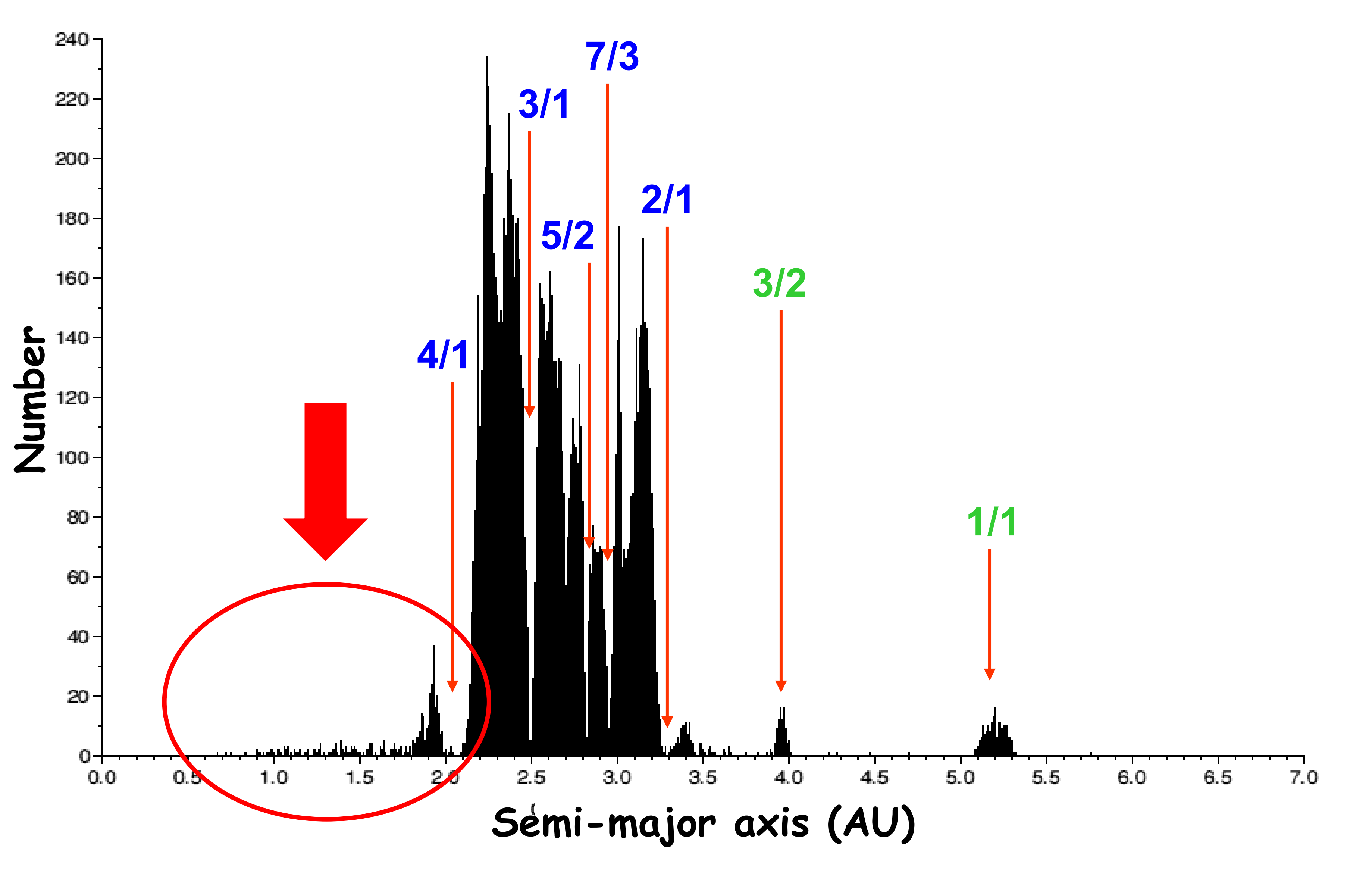
- Typical NEAs have perihelia near Earth and aphelia in the heart of the asteroid belt
- NEA regolith provides radiation shielding
- Asteroid materials provide propellants
- Earth-Mars transfer orbits possible
- Traveling hotels/gas stations/factories… colonies?

a perfect cruise ship



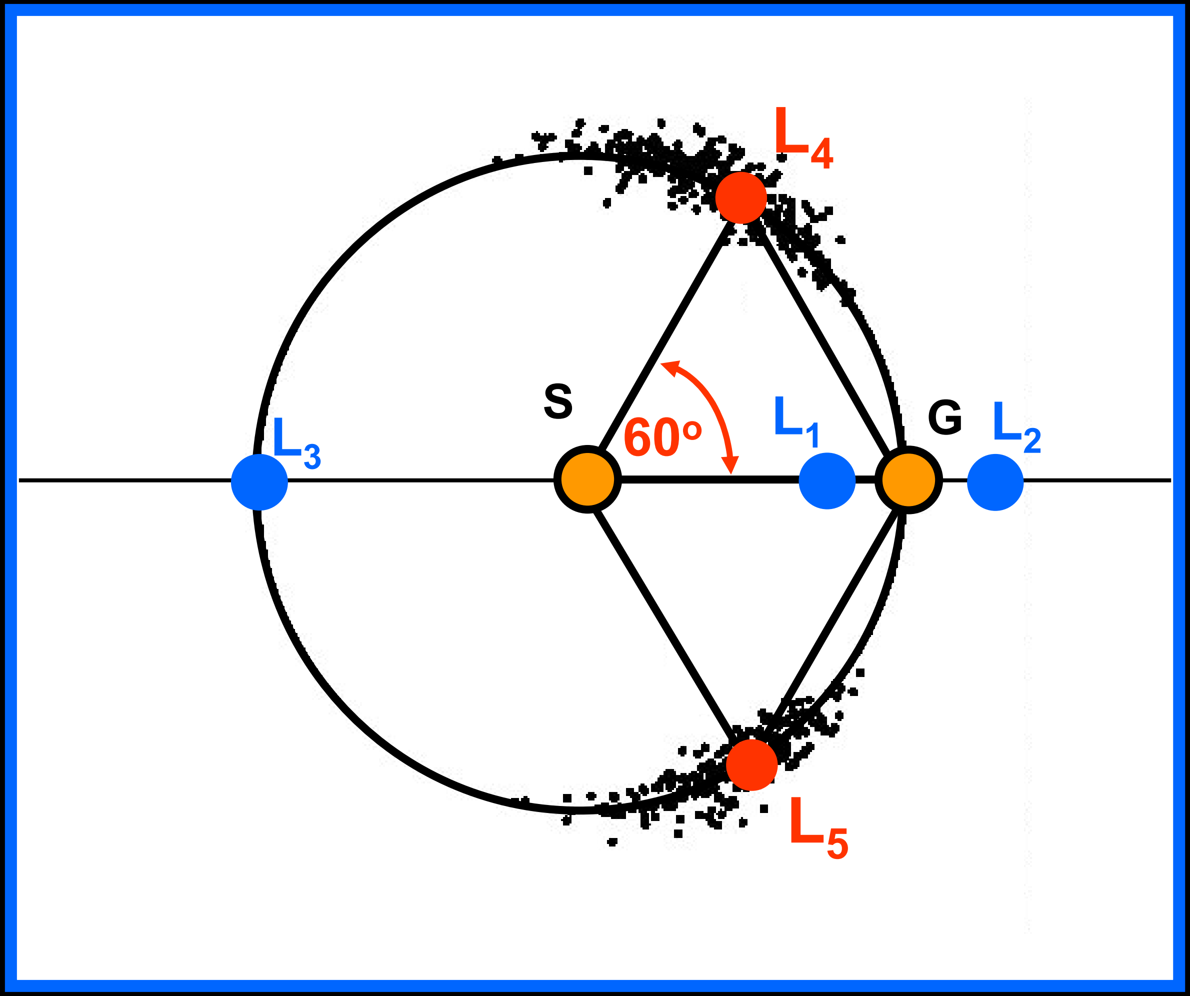
Dynamical Structure

Resonances with Jupiter

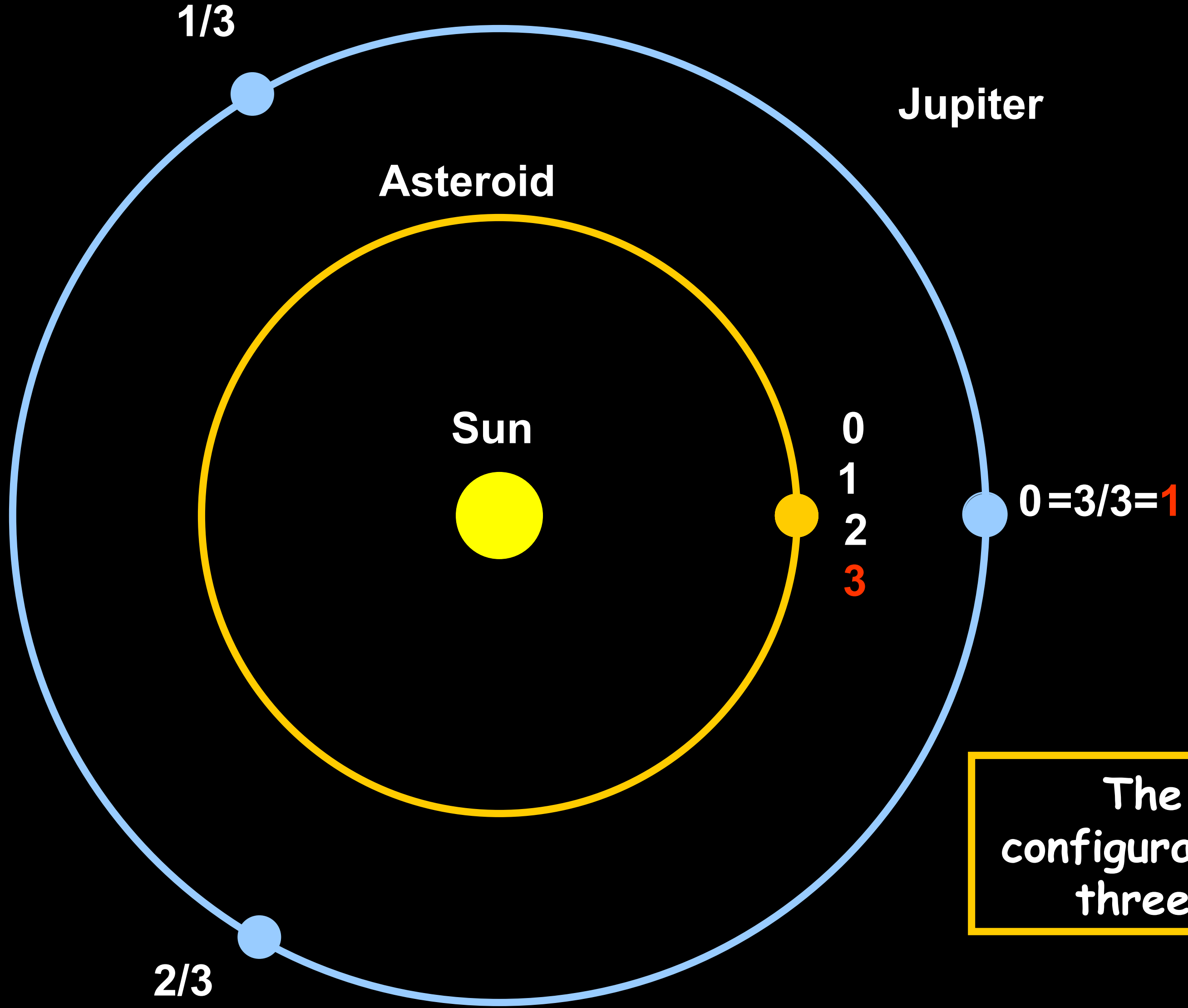


The Trojans of Jupiter

(Resonance 1/1)

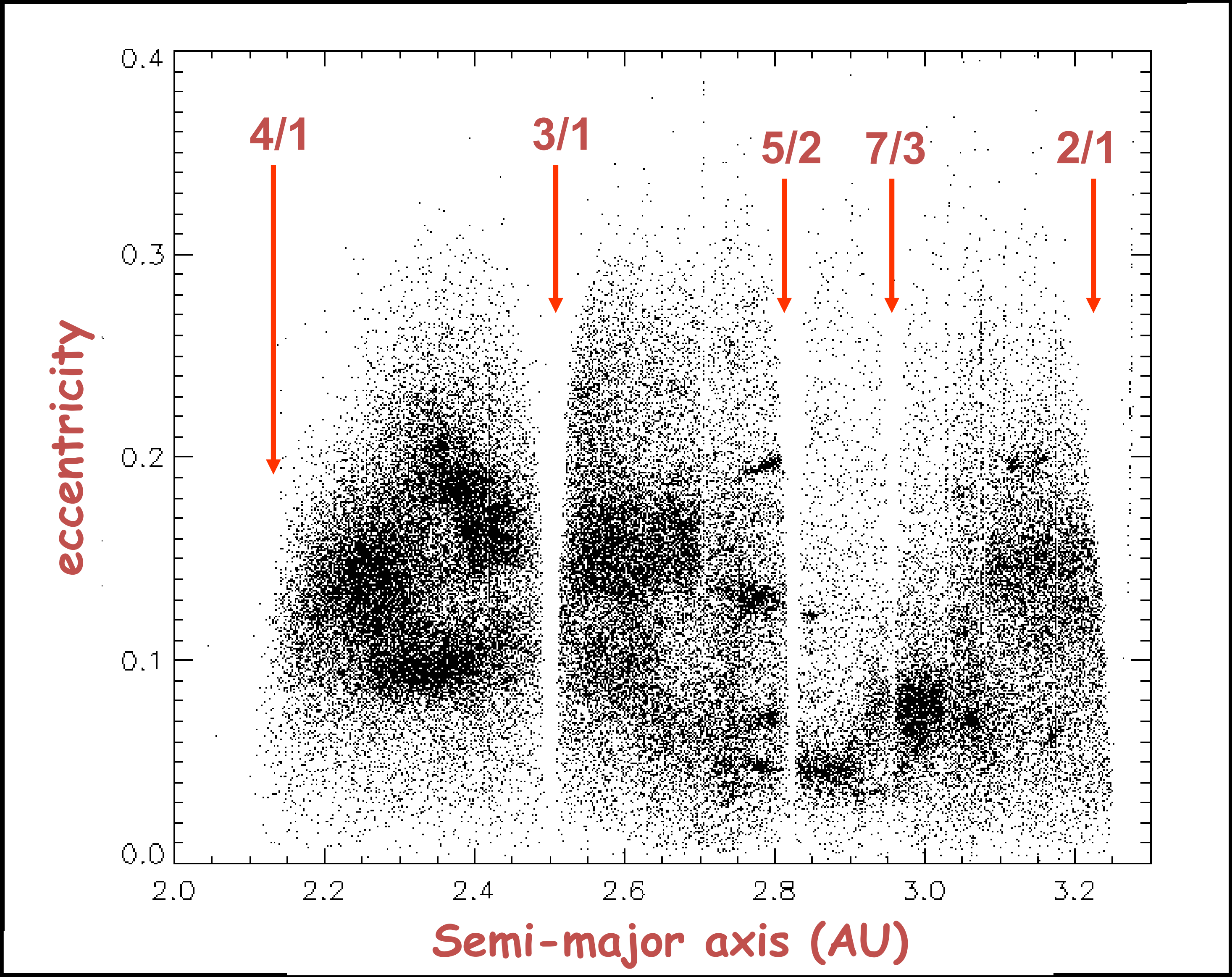


Resonance 3/1 with Jupiter

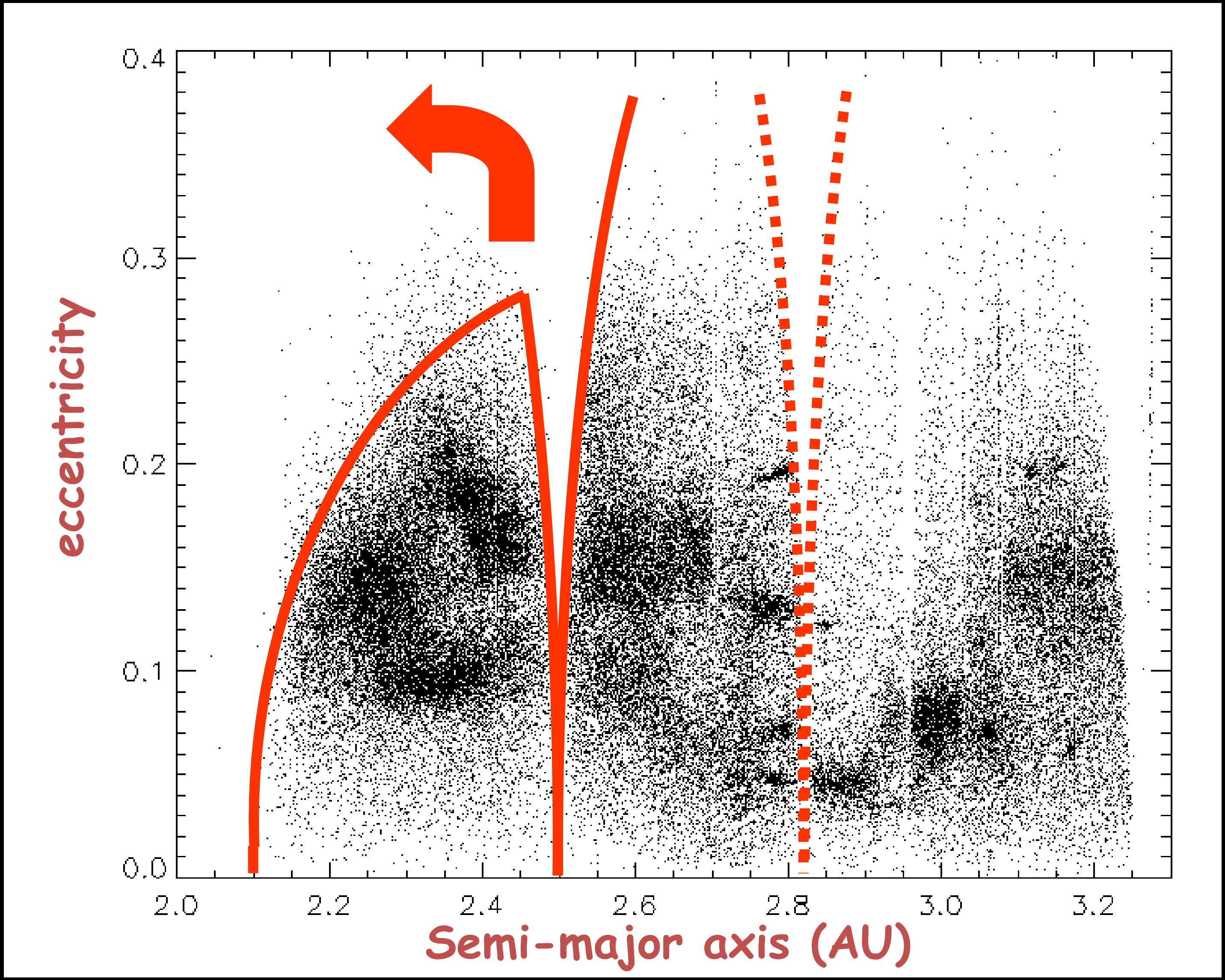


The same configuration every three orbits

Resonances withJupiter



Origin of Near Earth Asteroids




M0151295144F4
December 3 2000 23:08:30 21° 146°

A short summary of an article of 1969 …

A blinding light crosses the night sky of Quito, Bogotà, Medellin; an enormous shaking in the ground and in the air spreads in the unexplored jungle of Nord-Ovest Columbia; for the first time a conscious effort of human mind harnessed the energy of the Solar System and improved the always lower resources of fundamental minerals of the Earth.

Year : 1994 Day : *August 25*

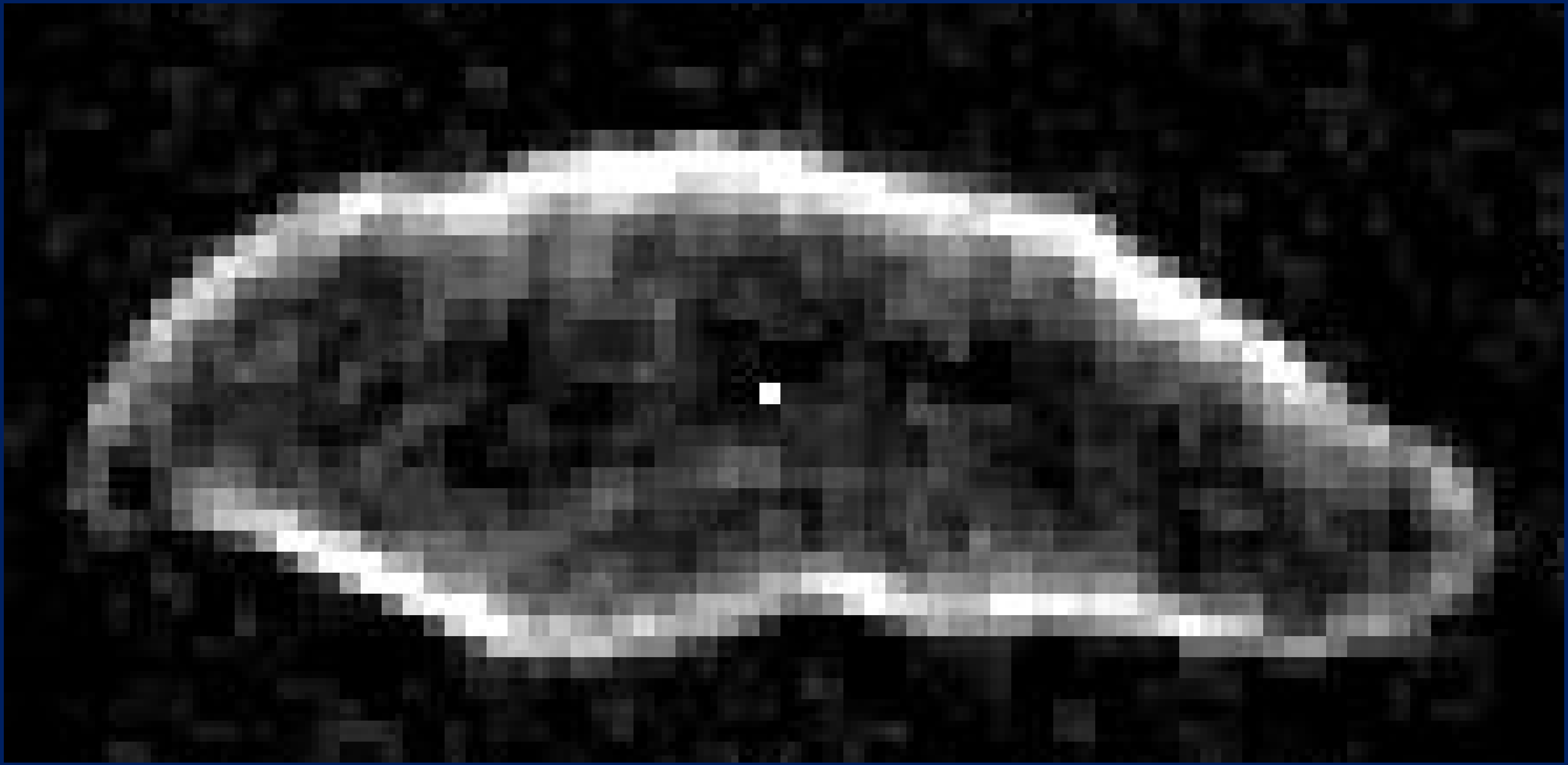
Result : a new inter-oceanic canal an the possibility to exploit a treasure of about 300 bilions of USD (*1969*) in nichel and other heavy elements such as osmium, iridium, platinum, gold, etc.

Problems: enormous, stimulating, constructive …

From: *Exploration and exploitation of Geographos in 1994*
by Samuel Herricks, Caltech, L.A.

Submitted to publication: 1971 (*rejected*)
Published: 1979

Asteroid Geographos (5 x 2 km)
August 30, 1994



Radar image obtained with the Goldstone Radio Telescope, California, USA

The "New" Canal

Is it possible ?

Maybe Yes !

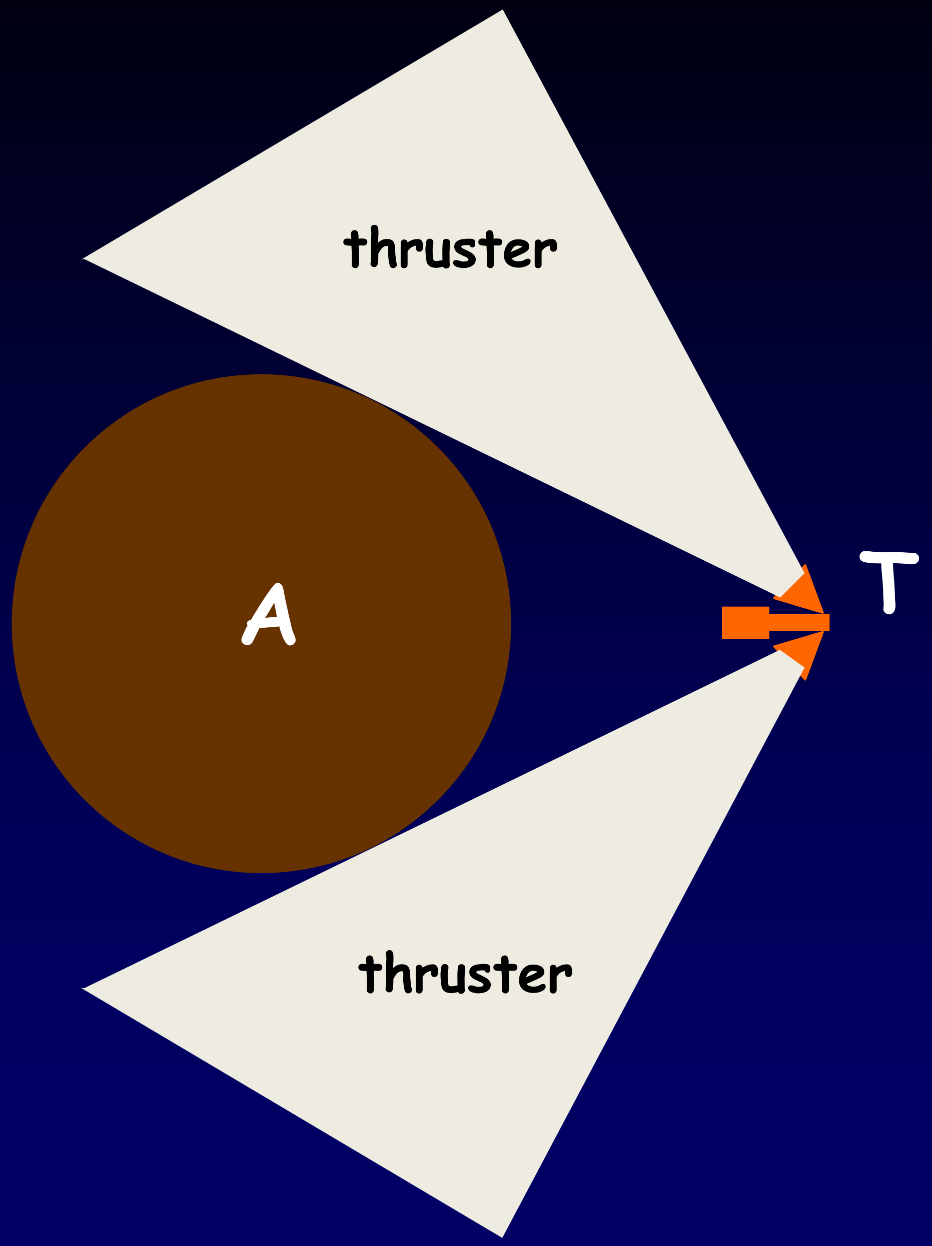
The problem is similar to deflect an asteroid from a colliding trajectory with the Earth …

Gravitational Tractor

The faint gravitational attraction of the tractor, whose engines allow a stable position, gives a continous acceleration to the asteroid in the right direction

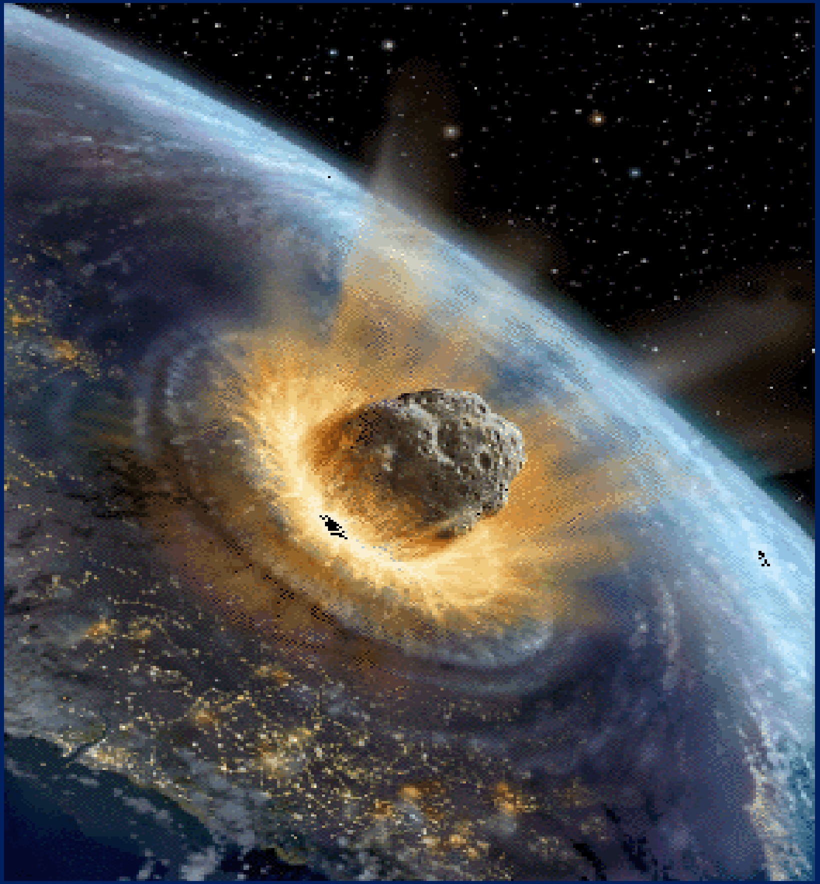
A : Asteroid

T : Gravitational Tractor



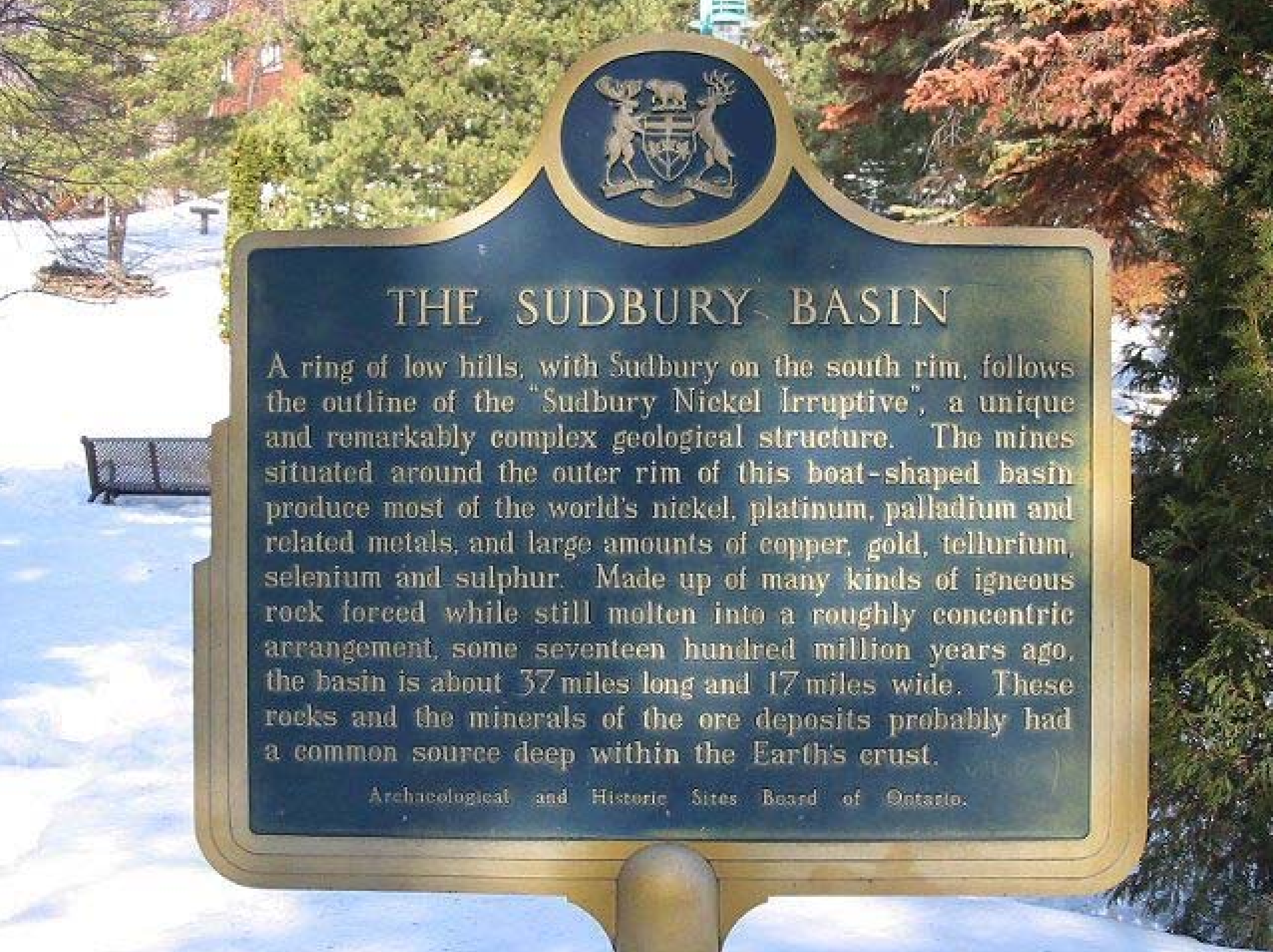
This solution is independent from the internal structure of the asteroid : it depends only on the mass

We have already done it !!



1.8 bilion years ago …


© 1992 MAGELLAN Geographix, Santa Barbara, CA
ONTARIO
Lake Superior
Sudbury
Toronto
Wisconsin
Lake Michigan
Lake Huron
Michigan
Lake Erie
New York


THE SUDBURY BASIN
A ring of low hills, with Sudbury on the south rim, follows the outline of the "Sudbury Nickel Irruptive", a unique and remarkably complex geological structure. The mines situated around the outer rim of this boat-shaped basin produce most of the world's nickel, platinum, palladium and related metals, and large amounts of copper, gold, tellurium, selenium and sulphur. Made up of many kinds of igneous rock forced while still molten into a roughly concentric arrangement, some seventeen hundred million years ago, the basin is about 37 miles long and 17 miles wide. These rocks and the minerals of the ore deposits probably had a common source deep within the Earth's crust.
Archaeological and Historic Sites Board of Ontario.

Original Diameter : 245 km

The history of Sudbury, Ontario, began -- literally -- with a bang.

The site that is now a Canadian mining town of about 162,000 people was formed some 1.85 billion years ago when an asteroid 6 to 12 miles in diameter slammed into Earth. The space rock rolled through the area and cracked our planet's crust, producing a mother lode of nickel, copper and platinum.

"The moment of impact was so great that it carved out an area 20 kilometers (12.4 miles) deep," according to David Pearson, a geologist at Laurentian University in Sudbury.

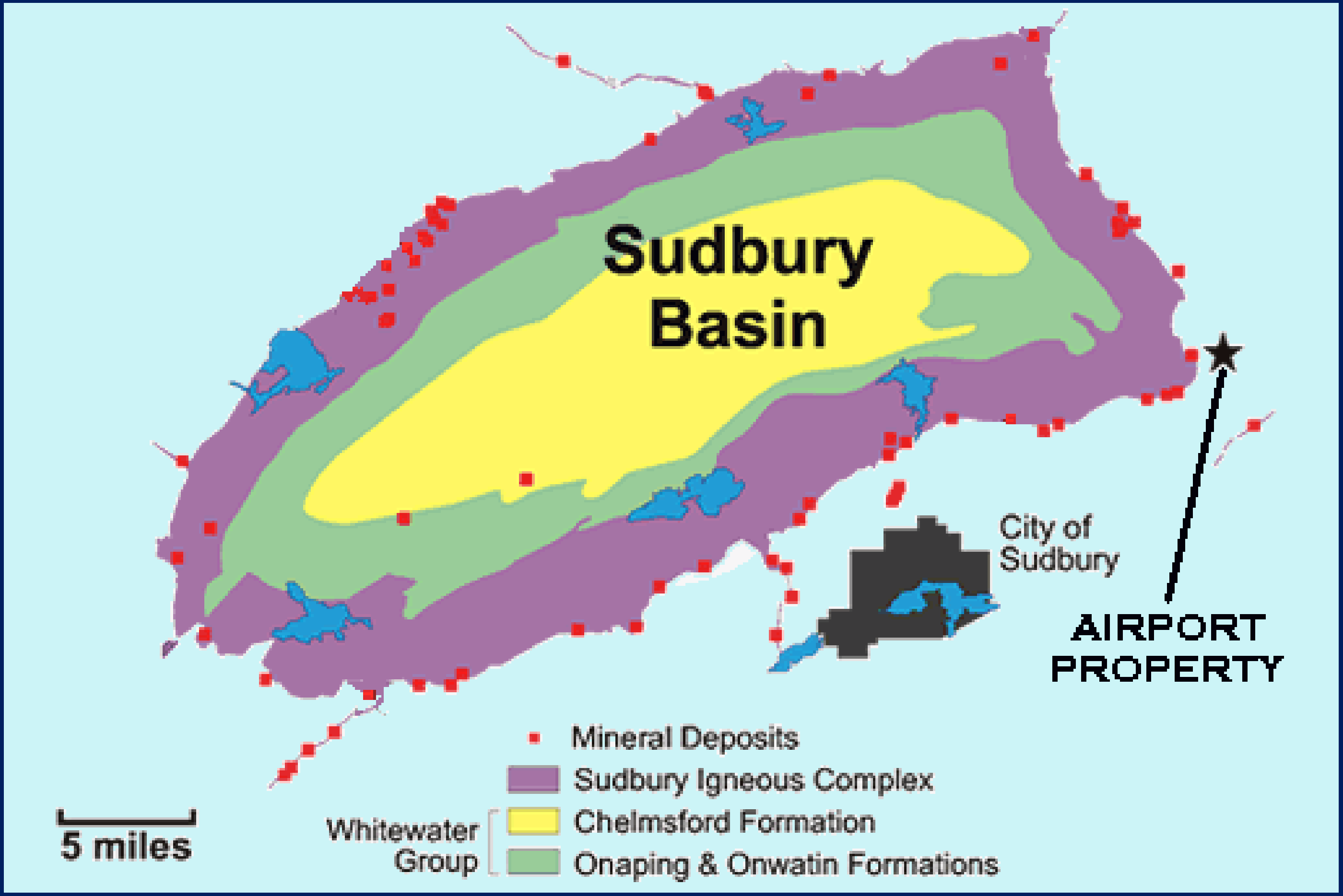
The extreme energy of the impact, said to have the equivalent energy of 10 billion Hiroshima bombs, vaporized the asteroid and melted rocks together to form the basin.

The cosmic object's impact was not only geological but economical as well.

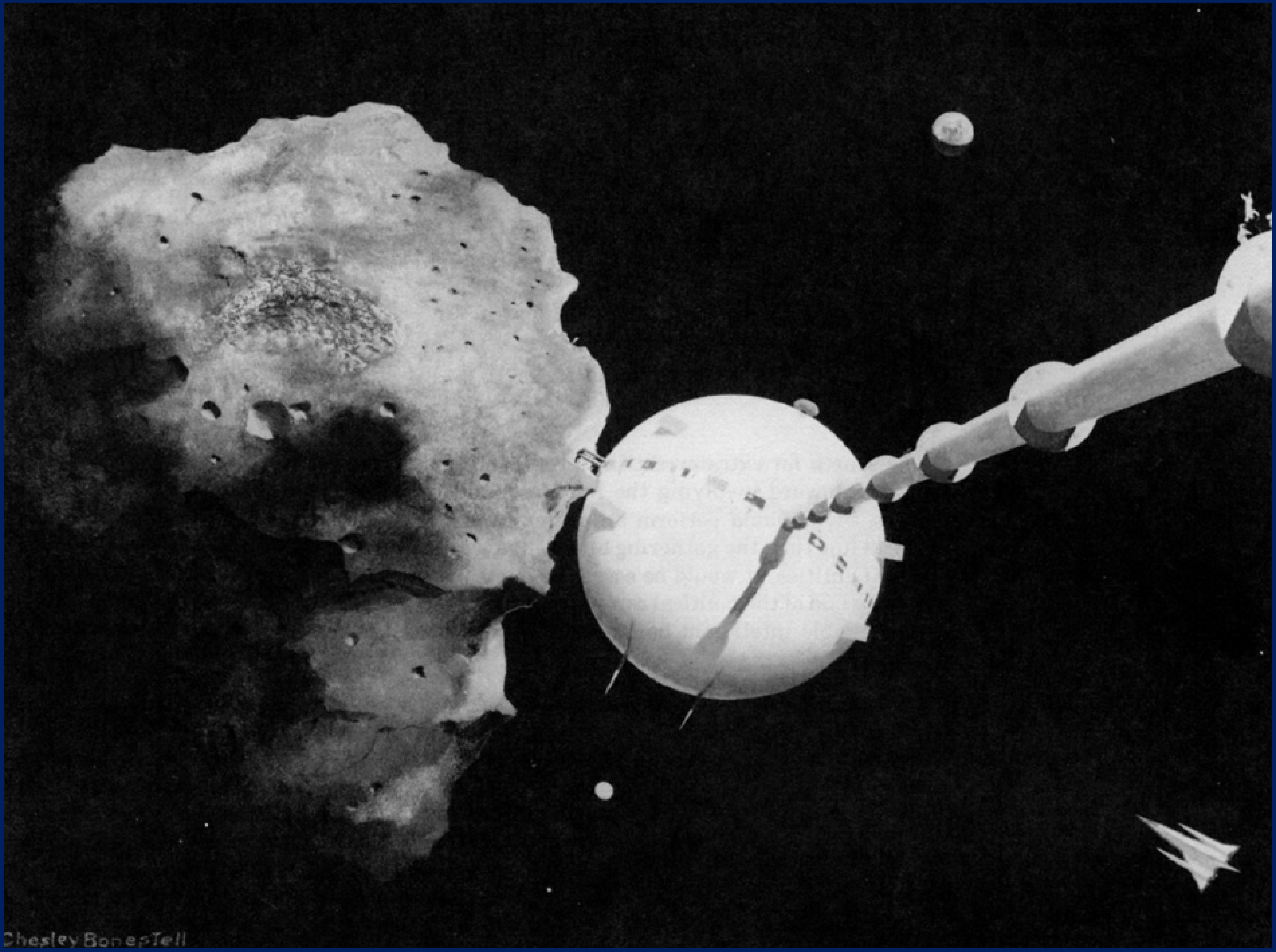
Today mining is a $3 billion-a-year business for Sudbury, where the first miners set up shop more than 100 years ago. The kidney-shaped basin where the asteroid hit is one of the world's largest deposits of nickel, measuring about 40 miles long by 16 miles (65 kilometers long by 25 kilometers) wide.

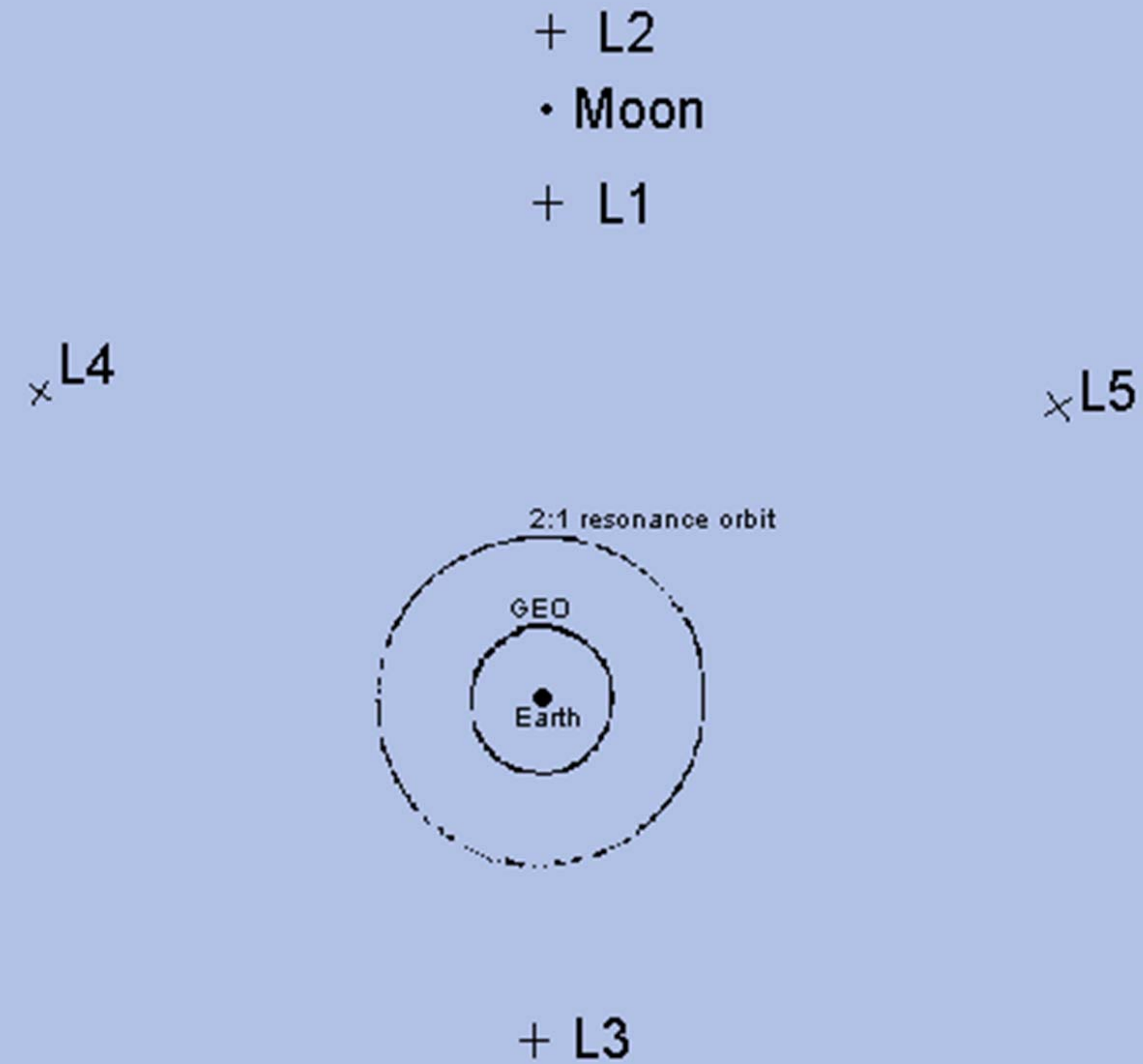
The riches remained undiscovered until 1883, when workers building the Canadian Pacific Railway stumbled upon the basin. That set off a stampede of people interested in prospecting the precious metals.

In 1891, the Canadian Copper Company was formed to mine metal, mostly copper, from the basin. The company later became the International Nickel Company (INCO) after it was discovered that the ore from the basin, which was sent to refineries in the United States and Wales, actually contained a more valuable metal -- nickel.

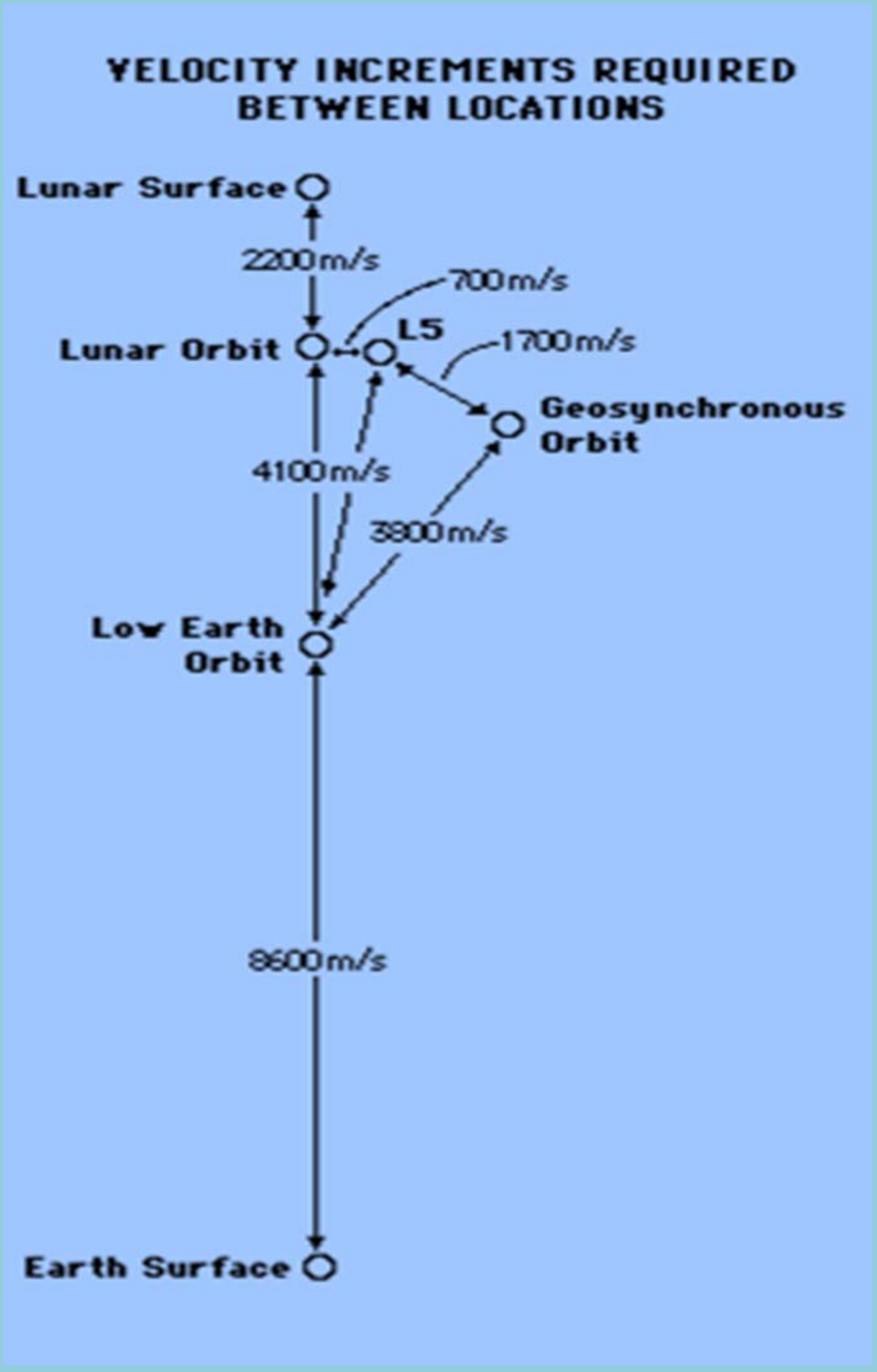

Sudbury Basin
City of Sudbury
AIRPORT PROPERTY
Mineral Deposits
Sudbury Igneous Complex
Whitewater Group
Chelmsford Formation
Onaping & Onwatin Formations
5 miles

The future




L2
Moon
L1
L4
L5
2:1 resonance orbit
GEO
Earth
L3

How to move in the "Big Earth"

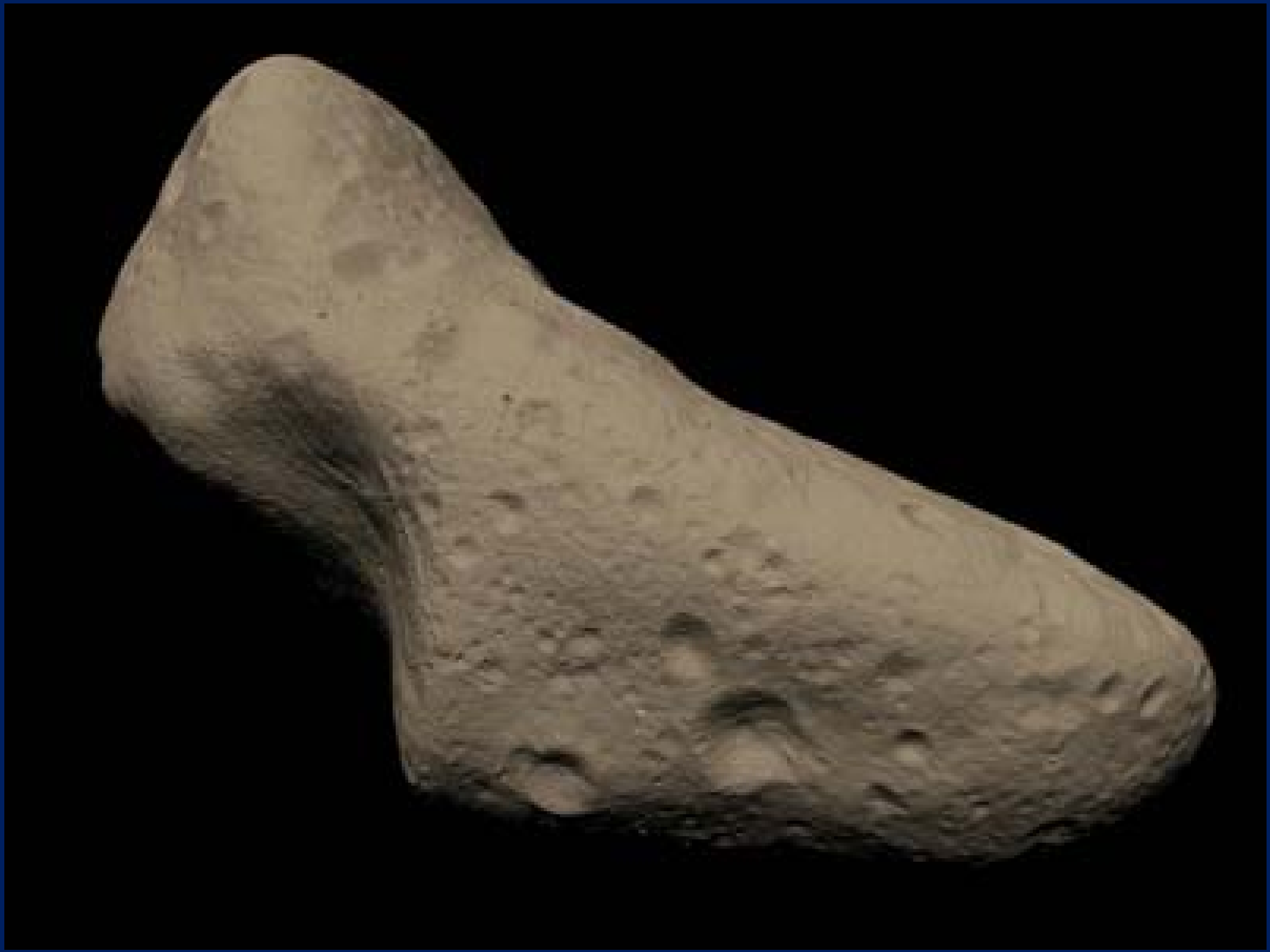


Asteroids are the more convenient targets

Mission	Delta-V
Earth surface to LEO	8.0 km/sec
LEO to NEA	< 5.5 km/sec
LEO to Moon surface	6.3 km/sec
LEO to moons of Mars	8.0 km/sec

LEO : Low Earth Orbit (300-1500 km)
NEA : Near Earth Asteroids

Some example …



PROVISIONAL DESIGNATION	DELTA-V (KM/S)	DELTA-V (ASTEROID)/ DELTA-V FOR THE MOON	MARS	H (mag)	a (AU)	e	i (deg)
2007 UN12	3.856	0.643	0.612	28.7	1.054	0.064	0.2
1991 VG	3.998	0.666	0.635	28.5	1.027	0.049	1.4
2006 UB17	4.082	0.680	0.648	26.3	1.140	0.103	2.0
2001 GP2	4.094	0.682	0.650	26.9	1.038	0.074	1.3
2005 LC	4.116	0.686	0.653	26.8	1.133	0.102	2.8
2005 QP87	4.149	0.692	0.659	27.7	1.233	0.175	0.3
2000 SG344	4.169	0.695	0.662	24.7	0.977	0.067	0.1
1998 KY26	4.207	0.701	0.668	25.5	1.232	0.202	1.5
2003 SM84	4.222	0.704	0.670	23.0	1.126	0.082	2.8
2001 QJ142	4.225	0.704	0.671	23.5	1.062	0.086	3.1
2000 AE205	4.247	0.708	0.674	23.0	1.164	0.137	4.5
2008 AF3	4.263	0.710	0.677	26.1	1.223	0.198	2.7
2005 YA37	4.295	0.716	0.682	22.4	1.280	0.228	2.2
2006 QQ56	4.299	0.716	0.682	25.9	0.987	0.046	2.8
2003 YS70	4.308	0.718	0.684	29.1	1.288	0.237	0.4
2004 FN8	4.325	0.721	0.687	27.1	1.169	0.144	5.3
2005 ER95	4.329	0.721	0.687	25.4	1.223	0.159	3.3
2005 RK3	4.335	0.723	0.688	23.7	1.248	0.185	3.7
2007 VU6	4.338	0.723	0.689	26.5	0.975	0.091	1.2
2005 GN22	4.342	0.724	0.689	26.5	1.289	0.208	2.3
2004 BV18	4.357	0.726	0.692	25.9	1.335	0.254	2.2
2006 JY26	4.357	0.726	0.692	28.4	1.012	0.084	1.4
2001 AV43	4.358	0.726	0.692	24.9	1.277	0.238	0.3
2006 DN	4.395	0.732	0.698	24.5	1.380	0.276	0.3
2006 BZ147	4.400	0.733	0.698	25.4	1.023	0.099	1.4
2004 WH1	4.406	0.734	0.699	24.0	1.197	0.202	2.6
2006 HW50	4.406	0.734	0.699	24.4	1.235	0.191	5.5
2006 MV1	4.422	0.737	0.702	26.8	1.312	0.239	4.4
2004 EU22	4.425	0.737	0.702	24.0	1.175	0.162	5.3
2001 US16	4.428	0.738	0.703	20.2	1.356	0.253	1.9
2006 UQ216	4.429	0.738	0.703	27.3	1.104	0.163	0.5
2002 NV16	4.456	0.743	0.707	21.4	1.238	0.220	3.5
2007 DD	4.464	0.744	0.709	25.8	0.990	0.117	2.5
2006 SK61	4.467	0.744	0.709	26.1	1.380	0.264	0.4
2005 EZ169	4.481	0.747	0.711	24.9	1.315	0.214	2.7
2003 EZ16	4.482	0.747	0.711	22.9	1.176	0.140	5.8
2003 WP25	4.487	0.748	0.712	24.3	0.991	0.121	2.5
2005 OH3	4.496	0.749	0.714	26.0	1.237	0.168	4.8
1993 BX3	4.500	0.750	0.714	21.0	1.395	0.281	2.8
2003 GA	4.505	0.751	0.715	21.2	1.281	0.191	3.8
2007 YJ1	4.508	0.751	0.716	25.3	1.265	0.179	4.0
1999 SF10	4.515	0.752	0.717	24.2	1.278	0.253	1.2
2006 CL9	4.521	0.753	0.718	22.8	1.346	0.237	2.9
2006 BQ7	4.522	0.754	0.718	26.5	1.347	0.257	5.0
2007 EE26	4.524	0.754	0.718	26.1	1.246	0.242	1.0
1998 KG3	4.525	0.754	0.718	22.3	1.162	0.119	5.5
1993 KA	4.531	0.755	0.719	26.0	1.255	0.197	6.0
1999 CG9	4.536	0.756	0.720	25.2	1.061	0.063	5.2
2005 TA	4.536	0.756	0.720	27.2	1.280	0.250	2.8
2006 HZ5	4.548	0.758	0.722	24.5	1.202	0.206	4.3

PROVISIONAL DESIGNATION	DELTA-V (KM/S)	DELTA-V (ASTEROID)/ DELTA-V FOR THE MOON	MARS	H (mag)	a (AU)	e	i (deg)
2000 FJ10	4.553	0.759	0.723	21.3	1.319	0.235	5.3
2005 JT1	4.568	0.761	0.725	25.7	1.418	0.302	1.6
2007 WZ4	4.573	0.762	0.726	24.3	1.360	0.281	2.9
2006 QV89	4.578	0.763	0.727	25.3	1.192	0.224	1.1
2003 YN1	4.579	0.763	0.727	24.9	1.335	0.243	5.2
2008 BT2	4.581	0.764	0.727	24.2	1.175	0.079	3.1
2001 KM20	4.605	0.767	0.731	23.6	1.184	0.209	3.7
2007 UD6	4.608	0.768	0.731	28.3	1.232	0.243	1.7
1998 HG49	4.615	0.769	0.732	22.0	1.201	0.113	4.2
2005 HB4	4.616	0.769	0.733	24.4	1.355	0.228	2.5
2006 HE2	4.618	0.770	0.733	26.5	1.065	0.157	1.2
2004 KE1	4.619	0.770	0.733	21.6	1.299	0.181	2.9
1997 UR	4.626	0.771	0.734	23.2	1.459	0.312	2.3
2004 SU55	4.630	0.772	0.735	24.7	1.375	0.237	1.2
2007 HB15	4.631	0.772	0.735	27.8	1.252	0.255	1.1
1998 SF36	4.632	0.772	0.735	19.2	1.324	0.280	1.6
2006 BP147	4.639	0.773	0.736	26.5	1.287	0.241	5.6
1999 JU3	4.651	0.775	0.738	19.2	1.189	0.190	5.9
2004 FM32	4.651	0.775	0.738	27.1	1.099	0.163	3.8
2001 QE71	4.657	0.776	0.739	24.4	1.078	0.158	3.0
2006 BG99	4.669	0.778	0.741	25.7	1.410	0.285	4.7
2007 TF15	4.670	0.778	0.741	25.0	1.108	0.042	4.2
1997 WB21	4.672	0.779	0.742	20.3	1.461	0.317	3.4
2007 VV6	4.678	0.780	0.743	24.8	1.416	0.280	3.8
2004 JN1	4.682	0.780	0.743	23.7	1.085	0.176	1.5
2004 XG29	4.687	0.781	0.744	25.6	1.409	0.313	0.2
2004 OW10	4.687	0.781	0.744	24.5	1.221	0.247	1.5
2006 BL55	4.688	0.781	0.744	24.3	1.452	0.308	3.9
2005 ES1	4.691	0.782	0.745	26.8	1.355	0.295	1.9
2007 HC	4.691	0.782	0.745	25.2	1.156	0.208	3.2
1994 CJ1	4.698	0.783	0.746	21.4	1.489	0.325	2.3
2007 TT24	4.706	0.784	0.747	27.0	1.440	0.280	0.8
2006 SU49	4.711	0.785	0.748	19.6	1.413	0.312	2.5
2004 BW18	4.712	0.785	0.748	22.5	1.372	0.253	5.1
2006 HX30	4.719	0.787	0.749	26.1	1.478	0.309	1.0
2006 HU50	4.720	0.787	0.749	24.7	1.288	0.247	5.9
2006 KS1	4.722	0.787	0.750	25.4	1.469	0.314	3.6
2002 FB	4.723	0.787	0.750	27.6	1.207	0.188	7.1
2006 KL103	4.724	0.787	0.750	25.5	1.449	0.284	0.3
2006 SF281	4.726	0.788	0.750	27.1	1.493	0.321	1.5
2007 TE71	4.731	0.789	0.751	24.3	1.244	0.188	7.4
2006 DX	4.747	0.791	0.753	24.4	1.142	0.166	6.2
2007 HL4	4.747	0.791	0.753	24.2	1.118	0.089	6.5
2003 CC	4.748	0.791	0.754	20.2	1.501	0.327	2.3
2004 QA22	4.752	0.792	0.754	27.9	0.951	0.122	0.6
2003 BN4	4.755	0.793	0.755	24.8	1.269	0.171	5.6
1996 XB27	4.755	0.793	0.755	22.2	1.189	0.058	2.5
1994 EU	4.759	0.793	0.755	25.5	1.378	0.278	6.5
2000 SJ344	4.764	0.794	0.756	22.6	1.140	0.175	5.8
2007 FB	4.768	0.795	0.757	26.2	1.312	0.263	5.8

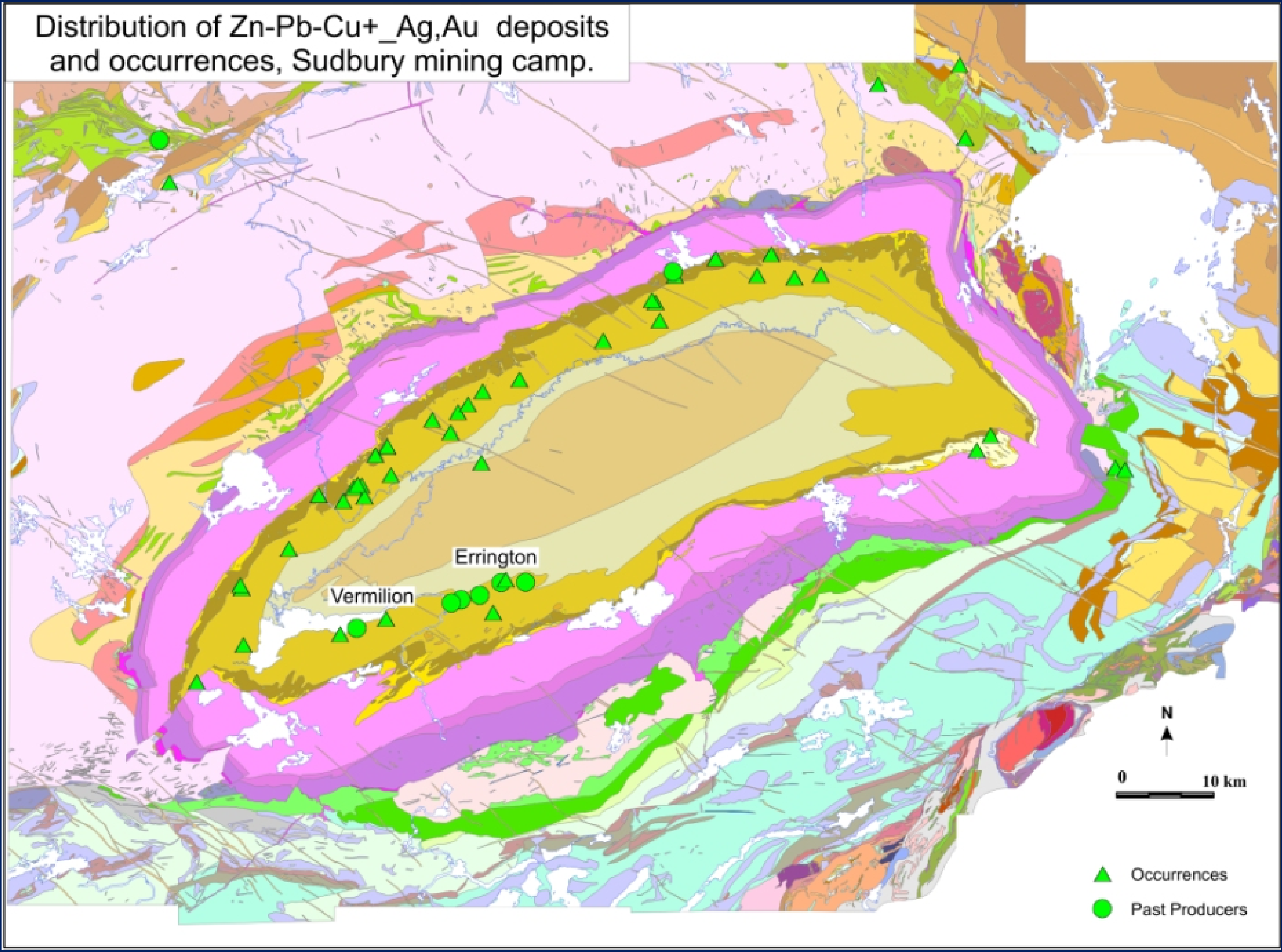
We must reach them before they reach us !

Dobbiamo raggiungerli prima che ci raggiungano !

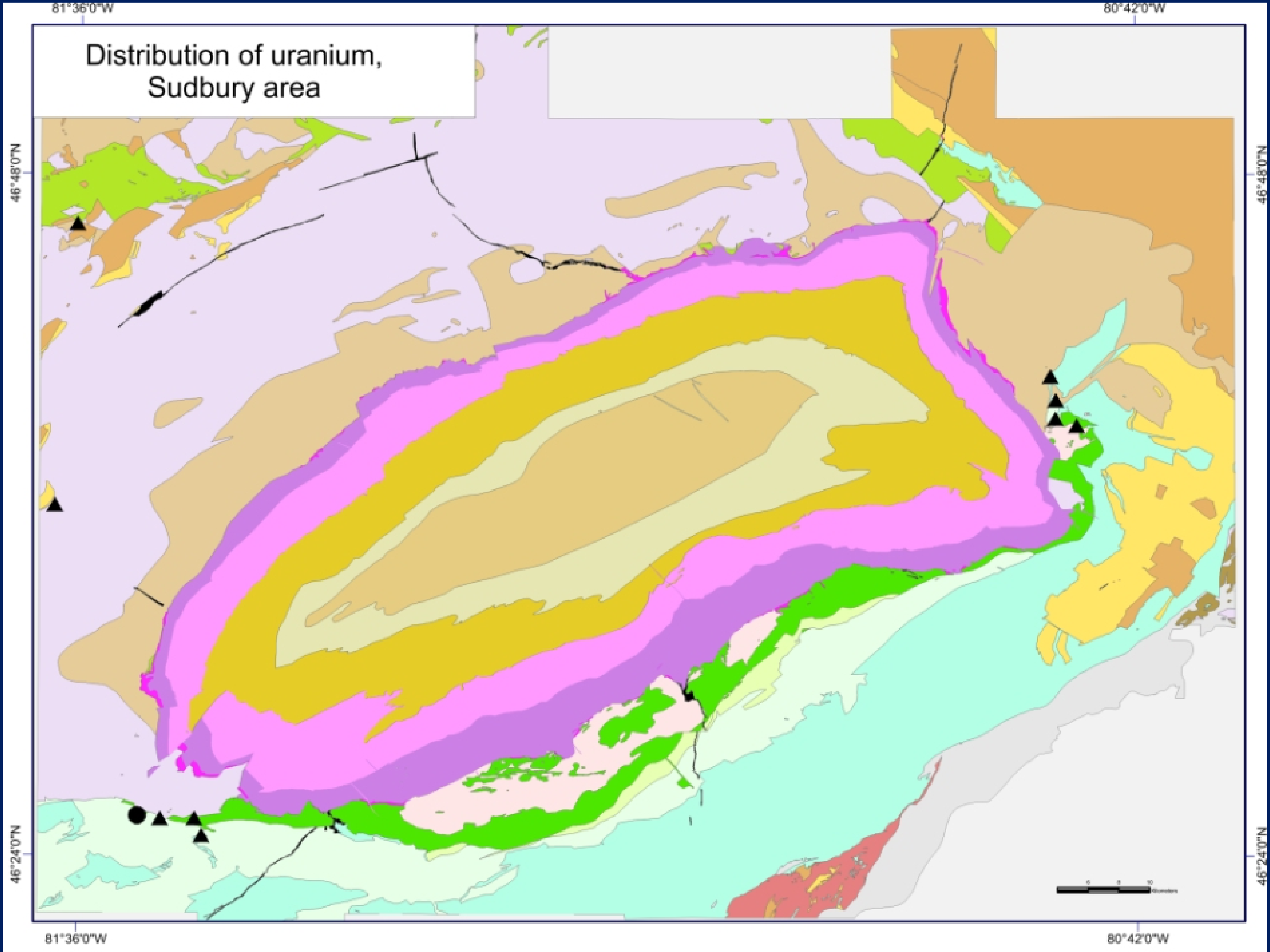
Una luce accecante attraversa il cielo notturno di Quito, Bogotà,Medellin; un enorme tremore sia in terra che in aria si propaga nella giungla inesplorata della Columbia di Nord-Ovest; per la prima volta uno sforzo cosciente della mente umana ha imbrigliato l’energia del Sistema Solare e ha aumentato le sempre più carenti risorse terrestri di minerali fondamentali.
L’anno: il 1994
Il giorno 25 agosto
Il rixultato: lo scavo di un nuovo canale inter-oceanico e la possibilità di sfruttare un tesoro del valore di circa 300 miliardi di dollari (al 1969 n.d.a.) in nichel ed altri elementi pesanti quali l’osmio, l’iridio, il platino, l’oro, ecc. rari sulla Terra
I problemi: enormi, stimolanti, costruttivi…

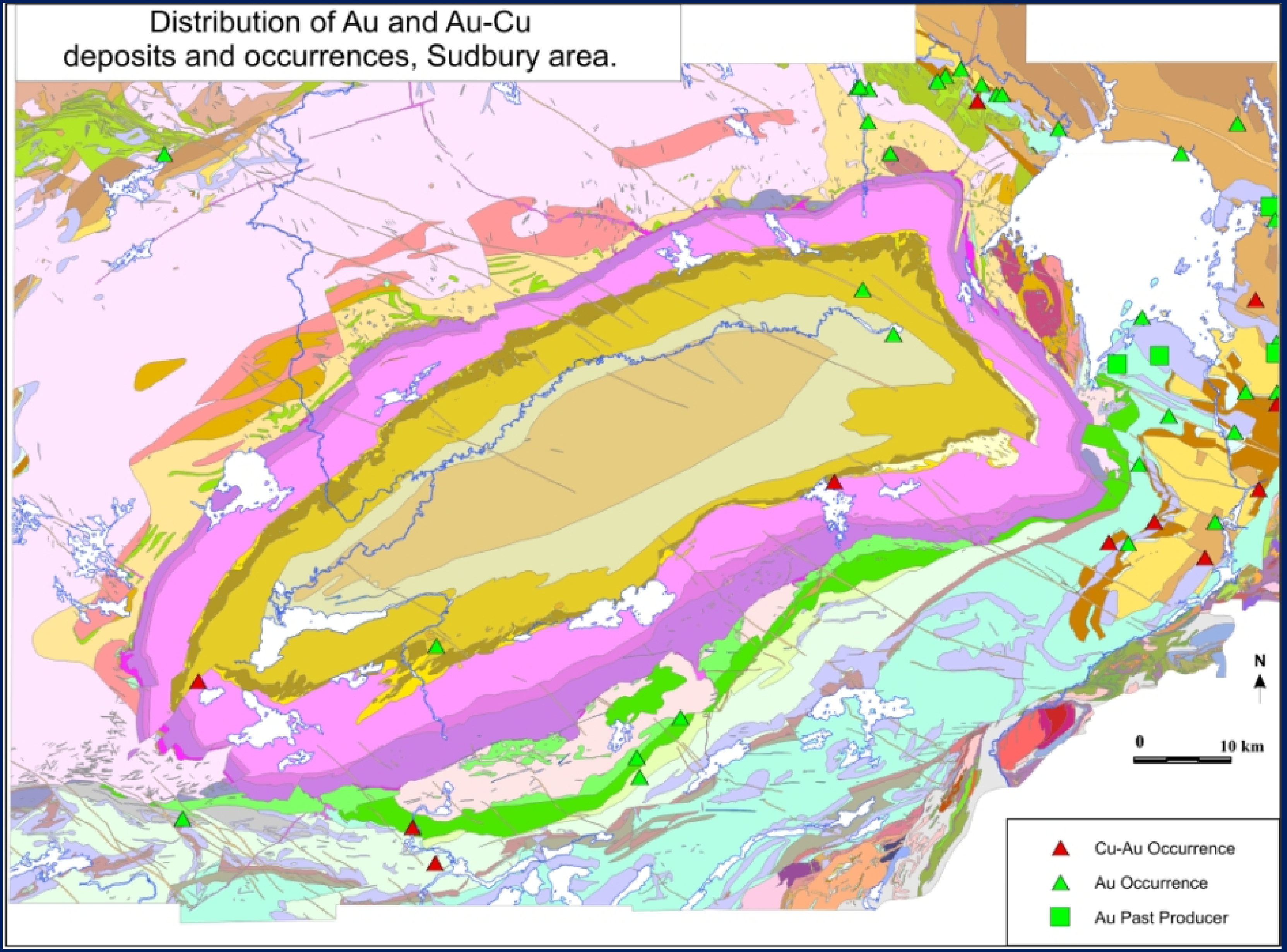
Tratto da : esplorazione e sfruttamento di Geographos nel 1994
Di Samuel Herricks, Caltech, L.A.
Sottoposto alla pubbliaczione: 1971
Pubblicato: 1979

Distribution of Zn-Pb-Cu+_Ag,Au deposits and occurrences, Sudbury mining camp.



Distribution of uranium, Sudbury area




Distribution of Au and Au-Cu
deposits and occurrences, Sudbury area.
N
0
10 km
Cu-Au Occurrence
Au Occurrence
Au Past Producer