Acknowledgments

I ended up only having a day to prepare this talk. So of necessity I flipped between many sources on and offline to get information to compile. In some cases I cribbed mercilessly. I would like to flesh this information out so any help from those of you more knowledgeable, especially you real rocket scientists and astrophysicists, would be much appreciated.

Some sources I used:

Entering Space - Robert Zubrin

Mining the Sky - John S. Lewis

Wikipedia

NEAR-EARTH ASTEROID TRACKING

Near Earth Objects

Near Earth Objects Map

Encyclopedia of Science

and especially the wonderful site:

Permanent: Asteroid mining, space colonies, commercialization

Slides and SL Talk Content

Mining the Sky

Abundant Resources in Near Earth Asteroids

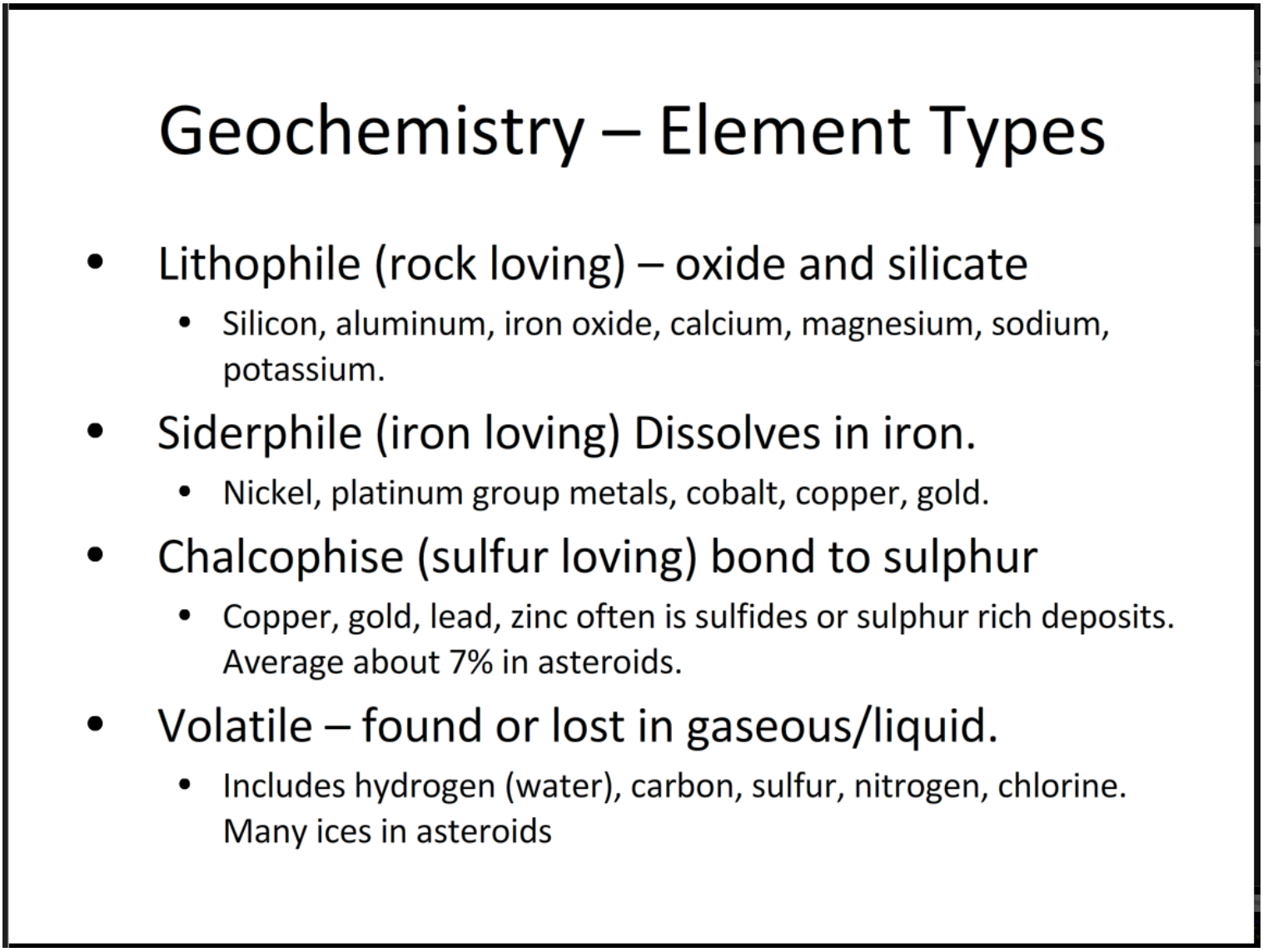
How much material?

- There are about 200000 Near Earth Asteroids of diameter >= 100 meters

[2010/04/24 11:10] Serendipity Seraph: So why is this exciting? How much and of what kind of material? What kind of difference can it make?

"Near Earth Asteroids" are asteroids whose orbits either cross Earth's orbit around the Sun or approach Earth's orbit. There are about 200,000 Near Earth Asteroids of size 100 meters diameter and larger.
[2010/04/24 11:10] Serendipity Seraph: An asteroid that's only 100 meters wide (as wide as a football field) is about 3 million tons of material. (That's 100 meters wide, long, and tall.) Such a "floating mountain" has the mass of 100,000 Shuttle payloads, i.e., about two million tons. We know today of much larger Near Earth Asteroids -- kilometers wide and trillions of tons. The bigger ones have been known for many decades, but modern electronic telescopes are detecting asteroids smaller than 100 meters, which still have far more than enough
[2010/04/24 11:11] Serendipity Seraph: material for space industrialization and settlement.

[2010/04/24 11:11] Serendipity Seraph: So what kind of material. Lets break it down..



[2010/04/24 11:11] Serendipity Seraph: Material accumulation in planets and planetoids and other objects tends to group or clump together due to chemical, temporal and process based affinities. This gives a common set of expectations of what you will find together in asteroids as well.
[2010/04/24 11:12] Serendipity Seraph: Lithophile material is fairly light plus those minerals that dissolve easily in water and other mediums that are likely to rise toward the surface. Some of the light materials precipitate from the atmosphere or surrounding space (as in surface hyrogen from solar wind).
[2010/04/24 11:12] Serendipity Seraph: Siderphile material tends to predominate in the molten cores of planets and larger bodies along with minerals that bind with iron. Some of this is thrown up to the

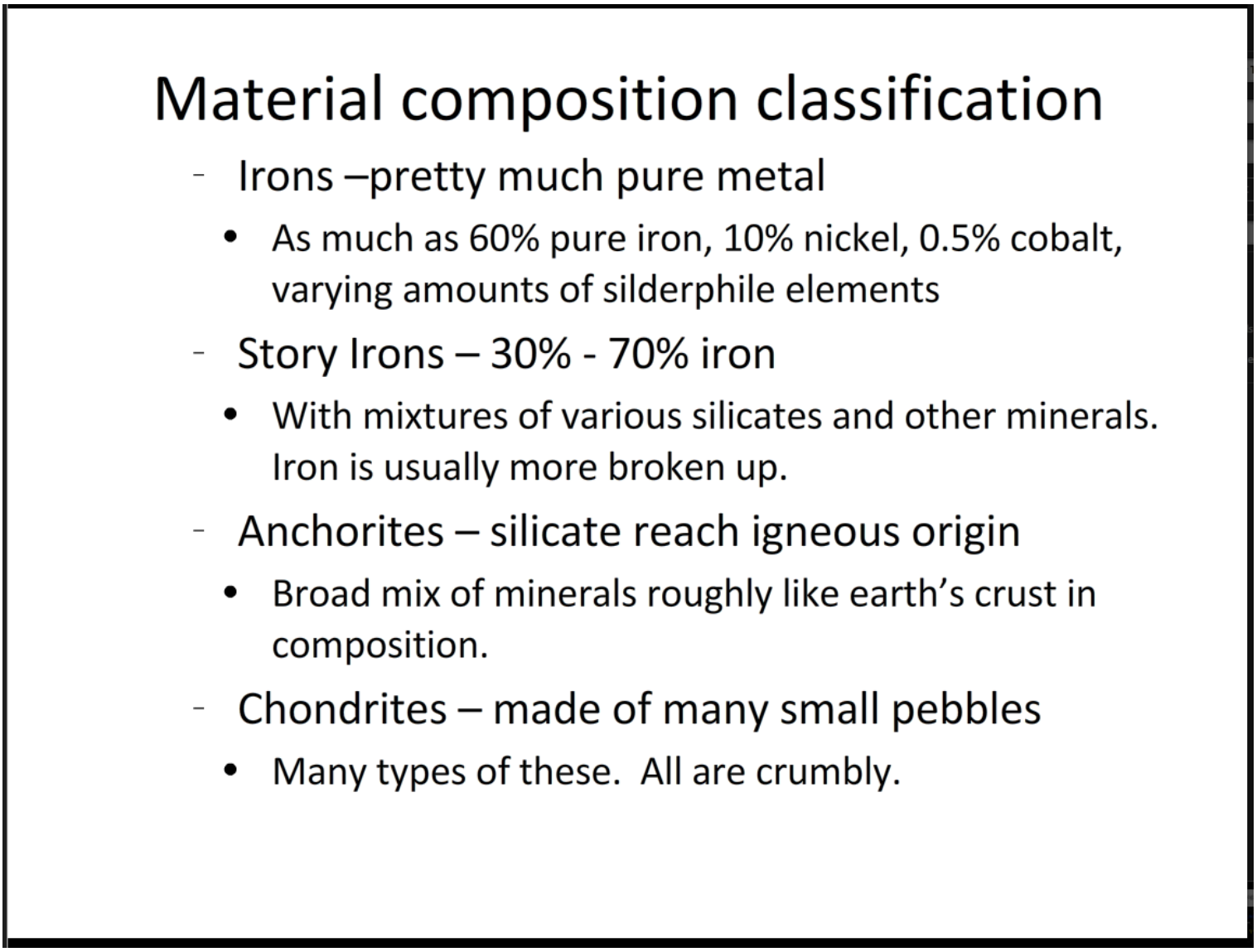
surface in vulcanism.
[2010/04/24 11:12] Khannea Suntzu: !
[2010/04/24 11:13] Serendipity Seraph: Chalcophile material bound to sulphur intersects on some elements that bind to both sulphur and iron. But more sulphur comes to the surface of planets in volcanic activity than iron due to lighter weight.
[2010/04/24 11:13] Serendipity Seraph: Where volatiles come from is an interesting question. Amara Graps has some very interesting papers on where Earth got its water. Hydrogen of course is the most common element and oxygen is also plentiful. There are many volatiles in asteroids bound up as ices.

Basic Composition Types

Type	Composition	Percent	Albedo		
C – Carbon	Carbon	> 75%	0.03 – 0.09 (very dark)		
S – Silicate	Metallic iron,iron-silicates, magnesium silicates	17 %	0.12 – 0.22 (relatively bright)		
M – Metallic	Iron/nickel	< 7 %	0.10 – 0.18		
D – Dark	Water ice/ frozen CO mixed w/ rock	< 1 %	0.05 (dark and reddish)		

[2010/04/24 11:14] Zobeid Zuma: You can also categorize them as differentiated or non-

differentiated asteroids.
[2010/04/24 11:14] Serendipity Seraph: Here we have the rough percentages of predominate elements/chemistry in asteroids. and the albedo (reflectivity) of objects in which these elements predominate. But this table is a very rough cut which subsequent slides expand.
[2010/04/24 11:14] Zobeid Zuma: i.e. whether they were once part of a gravitationally differentiated body
[2010/04/24 11:15] Serendipity Seraph: yes zoe and some of the subsequent slides will do something similar



[2010/04/24 11:15] Serendipity Seraph: or by composition as this slide does and is common when talking of meteorites
[2010/04/24 11:16] Serendipity Seraph: which is our primary evidence on asteroid composition as well

[2010/04/24 11:17] Serendipity Seraph: Because Chondrites are rather crumbly they are one of the easiest types of asteroid to process. They are also quite plentiful as they include much of the C group that 70% of asteroids belong to.

Chondrite subtypes #1

- **"Enstatite"** (E) chondrites are around 35% free Fe-Ni granules.
- **"High iron"** (H) chondrites average about 19% Fe-Ni.
- **"Low-iron"** (L) chondrites average 9% Fe-Ni.
- **"Low iron, low metal"** (LL) and "high iron, low metal"
  - (HL) chondrites are a technical scale that reflects different abundances of free metal versus metal oxides, in the neighborhood of 5% Fe-Ni granules plus about 15% to 30% iron oxide in minerals (e.g., magnetite, silicates), due to the level of oxygen depletion in the silicate mix.

Carbanaceous Chondrites

- C1 carbanaceous chondrites
  - Average about 10% water in clay mineral matrix
    - magnesim salts 5%-15%, 2-5% carbon as graphite, hydrocarbons, organics, several % sulphur
- C2 carbaneous chondrites
  - Little magnetite, little less water, carbon, and sulfur.

[2010/04/24 11:17] Serendipity Seraph: The nonmetal ingredients of meteorites consist predominantly of silicates, oxides and sulfur minerals, which can be typically broken down as follows: silica (SiO2) typically
[2010/04/24 11:18] Serendipity Seraph: between 35% and 40%, magnesia (MgO) between a whopping 20% to 25% (in contrast to Earth's surface), aluminium (Al2O3) between only 2% and 3% (in contrast to Earth and the Moon's crusts), and calcia (CaO) around 2%. Iron sulfide (FeS), also
[2010/04/24 11:18] Serendipity Seraph: called "troilite" (and "fool's gold"), usually occurs as around 6% of these meteorites.
[2010/04/24 11:19] Khannea Suntzu: hmmm I am thinking, kinda like the fresh material deposited by volcanoes? Very powdery?
[2010/04/24 11:19] Serendipity Seraph: As regards the precious (and "strategic") metals such as the platinum group, cobalt, gold, gallium, germanium, and others, the lower the Fe-Ni metal content, the

more enriched the Fe-Ni metal is in these rare and precious metals and elements. These elements readily dissolve into the metal that exists, and the less metal that exists, the less diluted they are. Many asteroids are richer in most of these precious metals than the richest Earth ores which we mine. Further, these metals all occur in one ore when
[2010/04/24 11:19] Serendipity Seraph: it comes to asteroids, not in separate ores.

The world's largest nickel ore mine is processing the remains of a large meteorite!

Some chondrites are poor in volatiles, while others are rich in volatiles, such as water and carbon.
[2010/04/24 11:19] Zobeid Zuma: Chondrites I think are the non-differentiated types, which would mean they're not quite like anything found on Earth.
[2010/04/24 11:20] Serendipity Seraph: we are talking very pure ore here folks. purer than much of what is mined on earth

[2010/04/24 11:20] Khannea Suntzu: Condrites are the mid asteroid belt carboneceous, low 'volatile' asteroids?
[2010/04/24 11:21] Serendipity Seraph: chondrites are slowly formed amalgamations insteard of big solid chunks from some one event generally
[2010/04/24 11:21] Serendipity Seraph: but they do make it to earth once strongly enough fused together.
[2010/04/24 11:22] Khannea Suntzu: Hmmm can I visualise that as 'compared by a concrete like chemical process'?
[2010/04/24 11:22] Serendipity Seraph: The carbanaceous chondrites are very interesting for water and volatiles.
[2010/04/24 11:22] Serendipity Seraph: that works K

[2010/04/24 11:23] Serendipity Seraph: here we get it broken down by type..

Composition from Meteorites

	Mineral	Metal rich C2	Matrix rich C1 or C2	Typical chondrite	Iron
Free Metals	Fe (iron)	10.7%	0.1%	6 – 19%	~89%
	Ni	1.4%	--	1-2%	~10%
	Co	0.11%	--	~0.1%	~0.5%
Volatiles	C	1.4%	1.9 – 3.0%	~3%	--
	H20	5.7%	~12%	~0.15%	--
	S	1.3%	~2%	~1.5%	--
Main minerals		Clay matrix Mg olivine w/ Fe0	Clay matrix olivine	Olivine Pyroxene Free Metal	Solid Metal
Physical	g/cm3	3.3	2.0 – 2.8	3.5 – 3.8	
	Grain size	~0.2mm	--	~0.2mm	Solid metal
	Strength	Mod friable	Weak to mod friable	Moderately friable	Steel

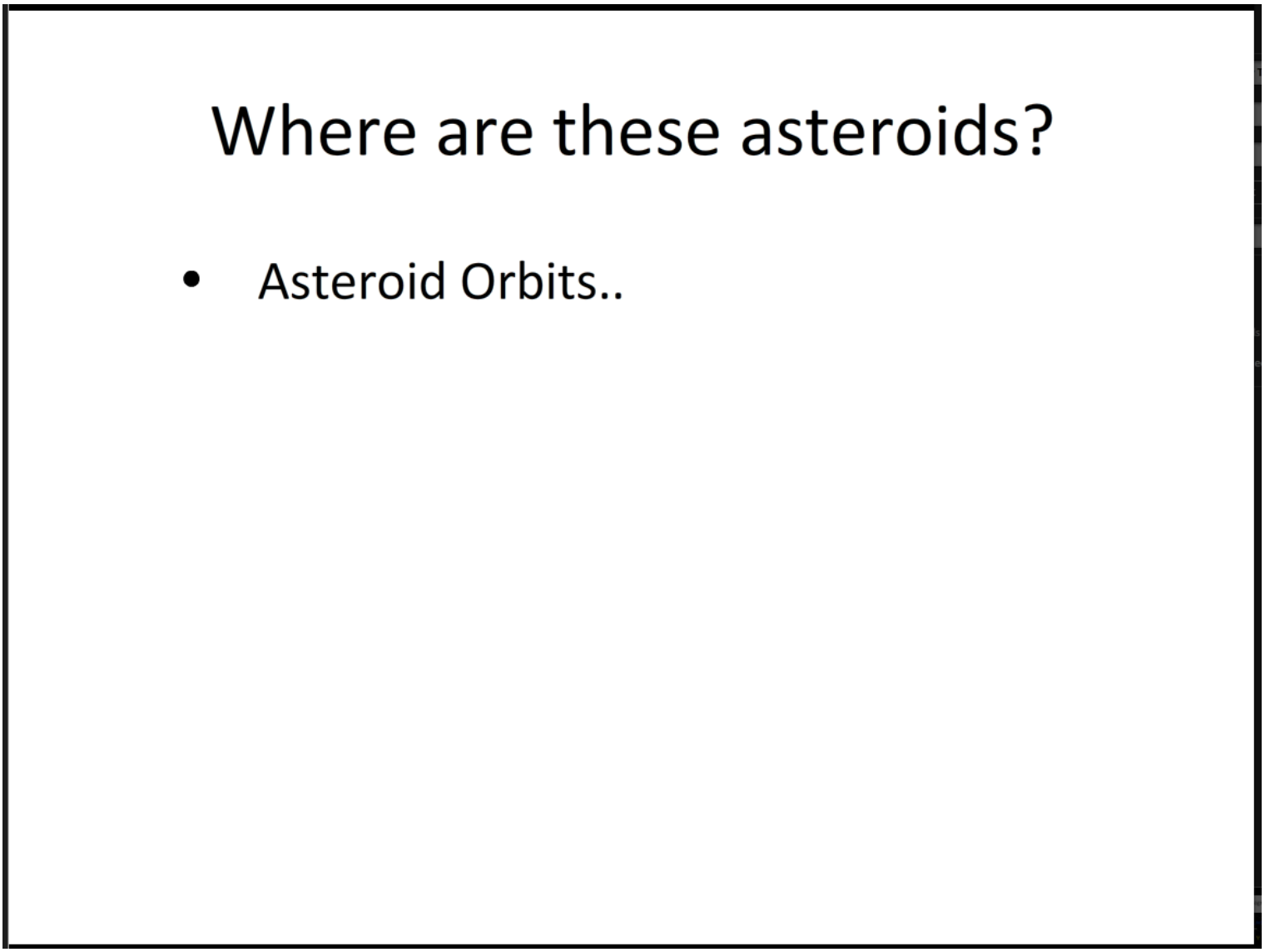
Meteorite Composition #2

	Mineral	Metal rich C2	Matrix Rich C1,C2	Typical Chondrite	Iron Meteorite
Mineral Oxides	FeO	15.4%	22%	~10%	--
	SIO_2	33.8%	28%	38%	--
	MgO	23.8%	20%	24%	--
	Al_2O_3	2.4%	2.1%	2.1%	--
	Na2O	0.55%	~0.3%	0.9%	--
	K2O	0.04%	0.04%	0.1%	--
	P2O5	0.28%	0.23%	0.28%	--

[2010/04/24 11:23] Serendipity Seraph: note the high iron content in many asteroids with nickel and cobalt
[2010/04/24 11:24] Serendipity Seraph: all the basic structural material you could want for building out in space.
[2010/04/24 11:25] Serendipity Seraph: look at the water content of C1, C2 chondrites. I was amazed by this. And water plus heat can be cracked for rocket fuel of course
[2010/04/24 11:26] Serendipity Seraph: please forgive I forgot to subscript some formulas here
[2010/04/24 11:26] Bryce Galbraith: :)
[2010/04/24 11:27] BrainCrave OHare: (well that kind of ruined the presentation for me)

[2010/04/24 11:27] Serendipity Seraph: there are also many oxides that are quite useful and important chemically. I was suprised that many elements needed to support organic life are so plentiful in asteroids.

[2010/04/24 11:27] Bryce Galbraith: Yep
[2010/04/24 11:28] Zobeid Zuma: The main elements needed for life are CHON -- carbon, hydrogen, oxygen, nitrogen
[2010/04/24 11:28] Serendipity Seraph: not only do we have the structural materials neeeded and the fuel waiting for us "up there" but also much of the organic matrix for building space colonies and other biomes
[2010/04/24 11:28] Extropia DaSilva: Oo hands off my MB construction material;)
[2010/04/24 11:29] Serendipity Seraph: more than enough for everyone extie
[2010/04/24 11:29] Khannea Suntzu: /me sternly points Trophy to the centaurids



Inner System Asteroid Orbits

Region	Group/family	Semi axis	Perihelion	Aphelion
Aphelion < 0.983	Apopheles			< 0.983
Aphelion > e. perihelion	Aten	< 1.00		> 0.983
Perihelion < e. aphelion	Apollo	> 1.00		< 1.015
Never crosses	Amor	> 1.00	1.017 – 1.30	
Crosses Mars	Mars-crosser		1.30 – 1.66	
Mars L5	Mars Trojan	1.524		

[2010/04/24 11:29] Serendipity Seraph: Amor, also known as Earth-grazing asteroids, one of three groups of near-Earth asteroids. The orbits of Amor asteroids have perihelia between 1.017 AU (Earth's aphelion distance) and 1.3 AU (Mars' perihelion distance). The prototype of the group is the one-km-wide (1221) Amor, discovered in 1932 by Eug√®ne Delaporte. The largest members are (1036) Ganymed, with a diameter of 40 km, and (433) Eros. About 1,500 Amors have been catalogued.
[2010/04/24 11:30] Serendipity Seraph: Amor that is. Some of these pass close enough to be useful. One wild scheme is to hollow one and use it for earth/mars transport :)

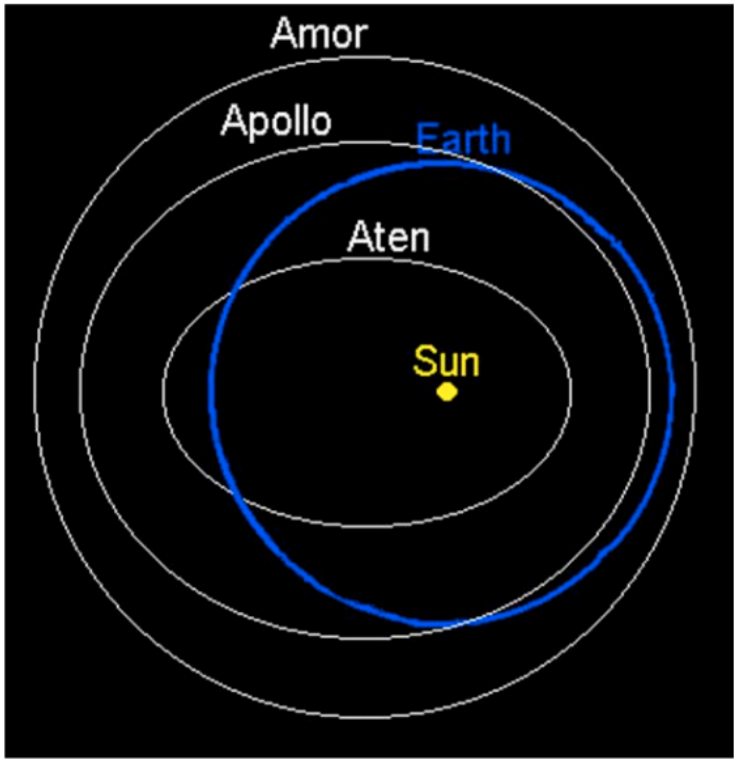
[2010/04/24 11:31] Serendipity Seraph: The Apollo category:
[2010/04/24 11:31] Serendipity Seraph: Also known as Earth-crossing asteroids, Apollo group asteroids have semimajor axis greater than 1.0 AU and perihelion less than 1.017 AU (Earth's

aphelion distance).
[2010/04/24 11:31] Serendipity Seraph: Some Apollo objects can approach closer than Mercuryto the Sun, the record-holder being 1995CR with a perihelion distance of 0.12 AU. Other notable members of the group include (1862) Apollo (the prototype), (1866) Sisyphus (the largest, with a diameter of about 8 km), (3200)Phaeton, (1685) Toro, and (4179)Toutatis.
[2010/04/24 11:32] Serendipity Seraph: But these are still fairly irregular orbits for our purposes. More interesting are the Atens

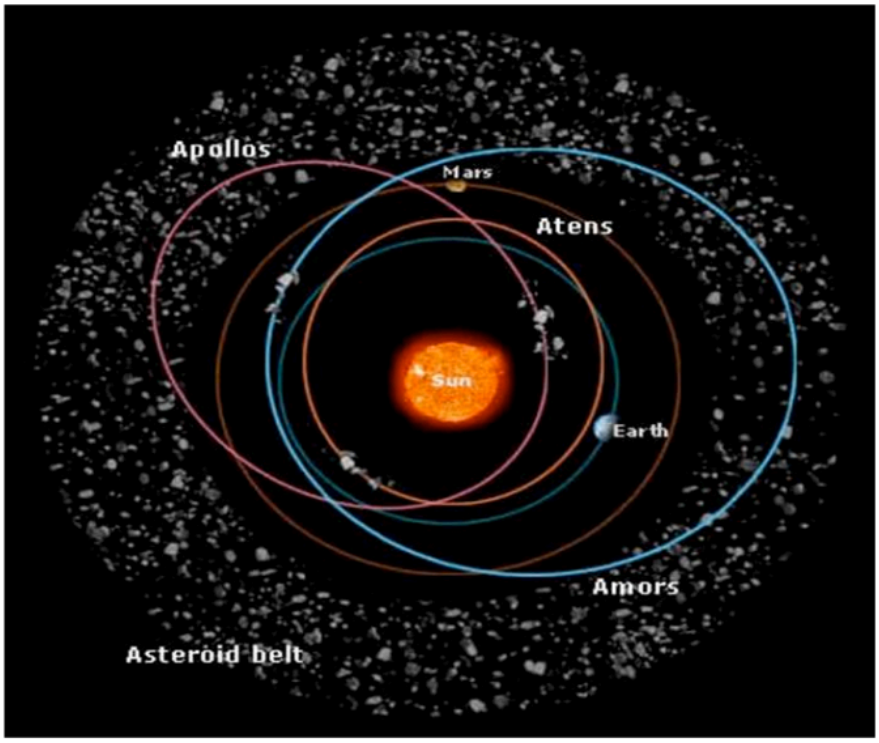
[2010/04/24 11:32] Khannea Suntzu: Each one would fit greater New York. On the surface.
[2010/04/24 11:32] Serendipity Seraph: One of the three groups of near-Earth asteroids; Atens have semimajor axes less than 1.0 AU and aphelia greater than 0.983 AU, so that they orbit mostly inside Earth's orbit. The prototype for the group, (2062) Aten, was discovered in 1976 by the American astronomer Eleanor Helin, has a diameter of less than 1 km, and is of class S.
[2010/04/24 11:33] Serendipity Seraph: The Atens are also some of the scariest asteroids of course as they spend much more time in same orbital

[2010/04/24 11:33] Serendipity Seraph: Apoheles are asteroids whose aphelion is less than 0.983¬†AU, meaning they orbit entirely within Earth's orbit. Other proposed names for this group are Inner-Earth Objects or Interior Earth Objects (IEOs) and Anons (as in "Anonymous"). As of March 2008 there are only five known Apoheles with an arc of observations greater than 20 days ; while there are other four possible candidates, but with a too short arc of observations.
[2010/04/24 11:33] Khannea Suntzu: But fortunately their orbits resonate :)
[2010/04/24 11:34] Extropia DaSilva: But it is only a matter of time, K.....
[2010/04/24 11:34] Khannea Suntzu: At this stage a minor impact would be good for humanity, paradoxically enough.

Orbital Diagram

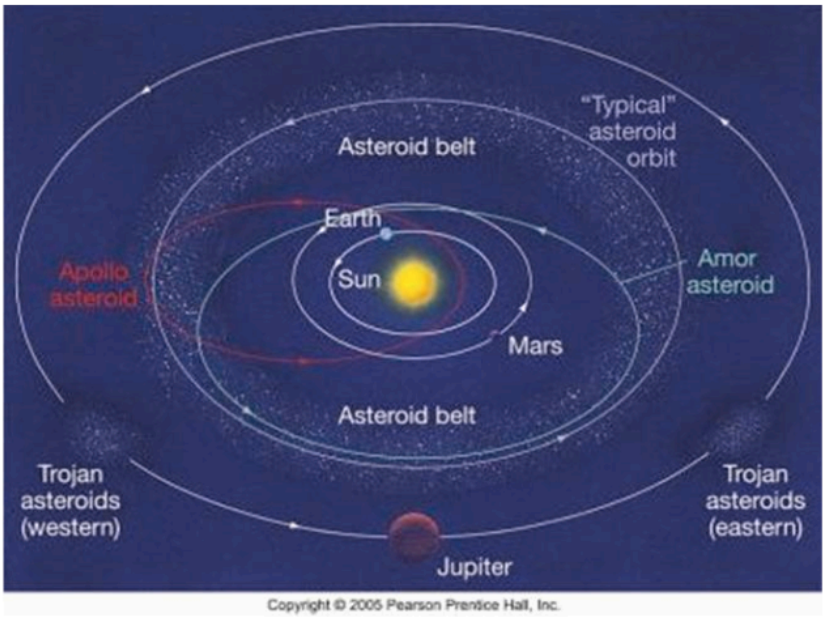


Apollo asteroid orbits

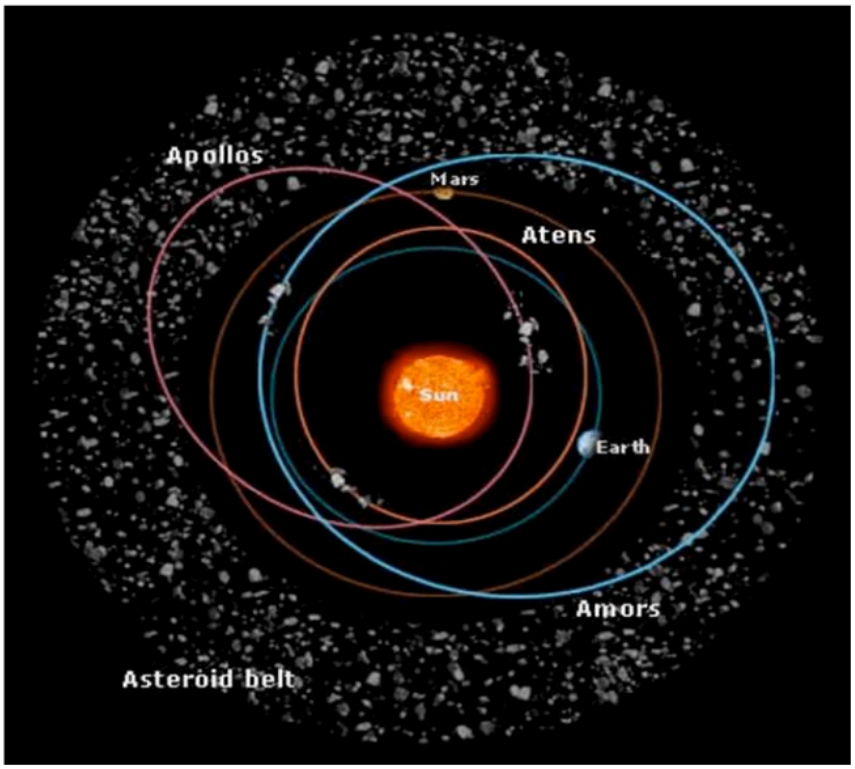


[2010/04/24 11:35] Serendipity Seraph: note the way both Apollo and Atens have orbits that you could conceivably build a ferry inside a hollow asteroids for traveling from earth space to Mars or even the main belt.

Amor asteroid orbits



Aten asteroid orbits



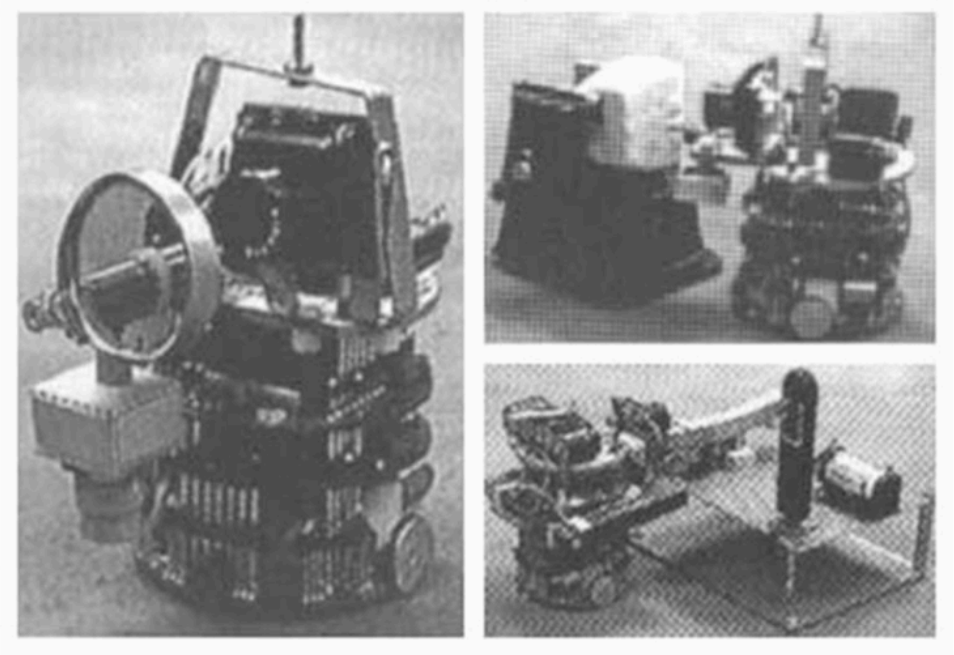
[2010/04/24 11:37] Serendipity Seraph: So, how do we get there? This talk won't cover that in much detail. (good for other talks). But a few mentions of some things done to date..
[2010/04/24 11:37] Extropia DaSilva: Fly?

How Do We Get There

- Who is we?
  - Astronauts, unmanned probes, robotics, telepresence
  - Probes
    - http://www.permanent.com/a-probes.htm
  - SKITS – SSI, USC, JPL
    - multiple very small telerobots (Sub-Kilogram Intelligent Tele-robots)
    - "A typical scenario for this research would be to release a number of vehicles with some communication capability, and with a specialization of functions on a simulated landscape. Humans would control the overall deployment policy but the telerobots would have some autonomy to deal with obstacles....

[2010/04/24 11:38] Serendipity Seraph: This [probes] link has much more info on probes to date than I had time to digest into slides.
[2010/04/24 11:38] Serendipity Seraph: One think I found very interesting was the work with small robots done by JPL and company..

Skit device family



[2010/04/24 11:39] Serendipity Seraph: These cute little buggers are not much bigger than a coffee cup. A lot of them are released at once on an asteroid to survey it and do some other tasks.

SKIT

- One concept researched in greater depth was a group of SKITs that are attached to a net which in turn is attached to the asteroid.
- A base is formed at one place on the net. The net serves more than one purpose:
  - The net provides anchoring and mobility
  - The net provides wired communications between SKITs and the net base
  - The net provides power to the SKITs from the net base (e.g., solar power plant and rechargable batteries)
  - The net serves as a large antenna for communications to the orbiting craft, as well as to Earth - a bigger antenna means better two-way communications with Earth

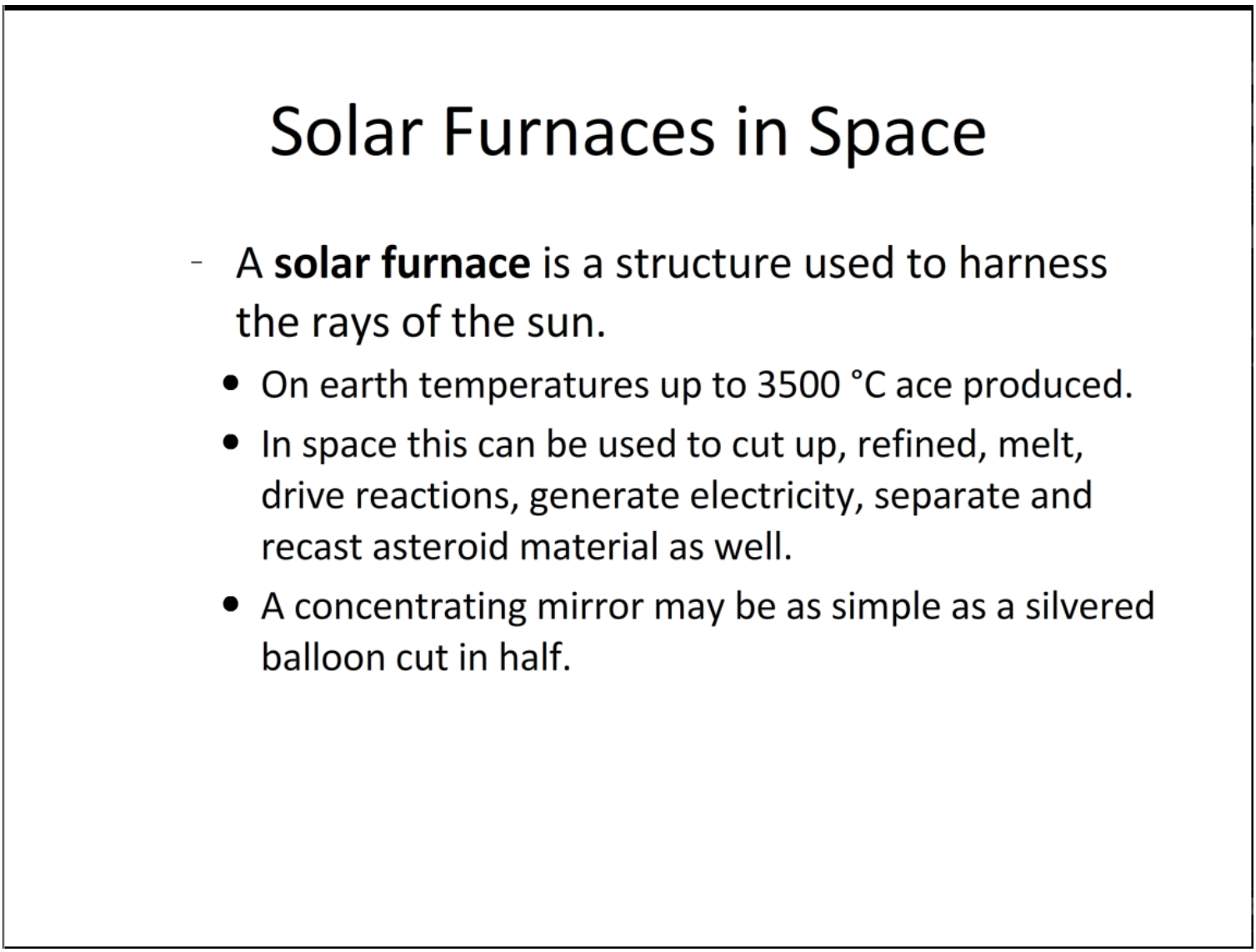
<quote>
[2010/04/24 11:40] Serendipity Seraph: "Our intent was to develop a research program involving actual hardware development to produce prototypes of intelligent miniature tele-robots that could later be improved, space-qualified and used in precursor missions for space resource prospecting, mining and manufacturing. In addition we focused our attention on the effective utilization of the abundant and rich untapped resources of asteroids,Ä¶
[2010/04/24 11:40] Serendipity Seraph: "Our plan was to study the relative merits of miniature size robots, with various degrees of intelligence for the initial phase of this process,Ä¶ The leverage these [size and weight] constraints may provide are substantial benefits in the areas of reliability, high coverage and low cost,Ä¶
[2010/04/24 11:40] Serendipity Seraph: "The primary prospecting objectives for asteroids are surface imagery and a detailed determination of their composition. These diagnostic elements should be measured with sufficient global coverage to determine the scale and extent of chemical

heterogeneity. In addition, in order to get samples that are pristine, a drill or some similar tool will be needed."
[2010/04/24 11:40] Serendipity Seraph: The study did not try to come up with one recommended probe set, but rather to come up with concrete design alternatives which a prospector could choose from, depending upon the prospector's objectives, budget and other judgement factors. Tradeoff analyses are a main part of this research.
</quote>

[2010/04/24 11:41] Serendipity Seraph: Pretty impressive work. This was late 90s.

<quote>
[2010/04/24 11:41] Serendipity Seraph: "An impressive, complete setup of SKITs was demonstrated by the researchers in May 1997 at the Space Studies Institute's (SSI) Conference on Space Manufacturing XXIII in Princeton, New Jersey, using a base unit and several SKITs, each robot being a little smaller than an average coffee cup."
</quote>

[2010/04/24 11:41] Extropia DaSilva: Really?
[2010/04/24 11:41] Extropia DaSilva: Cool:)
[2010/04/24 11:42] Extropia DaSilva: Are these swarm bots, then?
[2010/04/24 11:42] Bryce Galbraith: wow, pretty interesting...
[2010/04/24 11:42] Serendipity Seraph: yeah, I thought so so I had to throw them in. :)
[2010/04/24 11:42] Khannea Suntzu: Stiltskins. Balls with one meter flexible stilts. Just roll about, Can last years.



[2010/04/24 11:43] Serendipity Seraph: One thing good to know is that it is very easy to build solar furnaces in space. Note they aren't shabby even on earth.
[2010/04/24 11:44] Extropia DaSilva: There is a pretty big solar furnace at the centre of our system.
[2010/04/24 11:44] Bryce Galbraith: :)
[2010/04/24 11:44] Serendipity Seraph: which gives the energy for producing small ones wherever we like..
[2010/04/24 11:44] Khannea Suntzu: Oh gods solar furnaces. If people *knew* ionized arc welders, focussing arrays. In a vacuum. Almost as if The Goddess put it all ready for use.
[2010/04/24 11:44] Serendipity Seraph: yep..

Mining and Processing

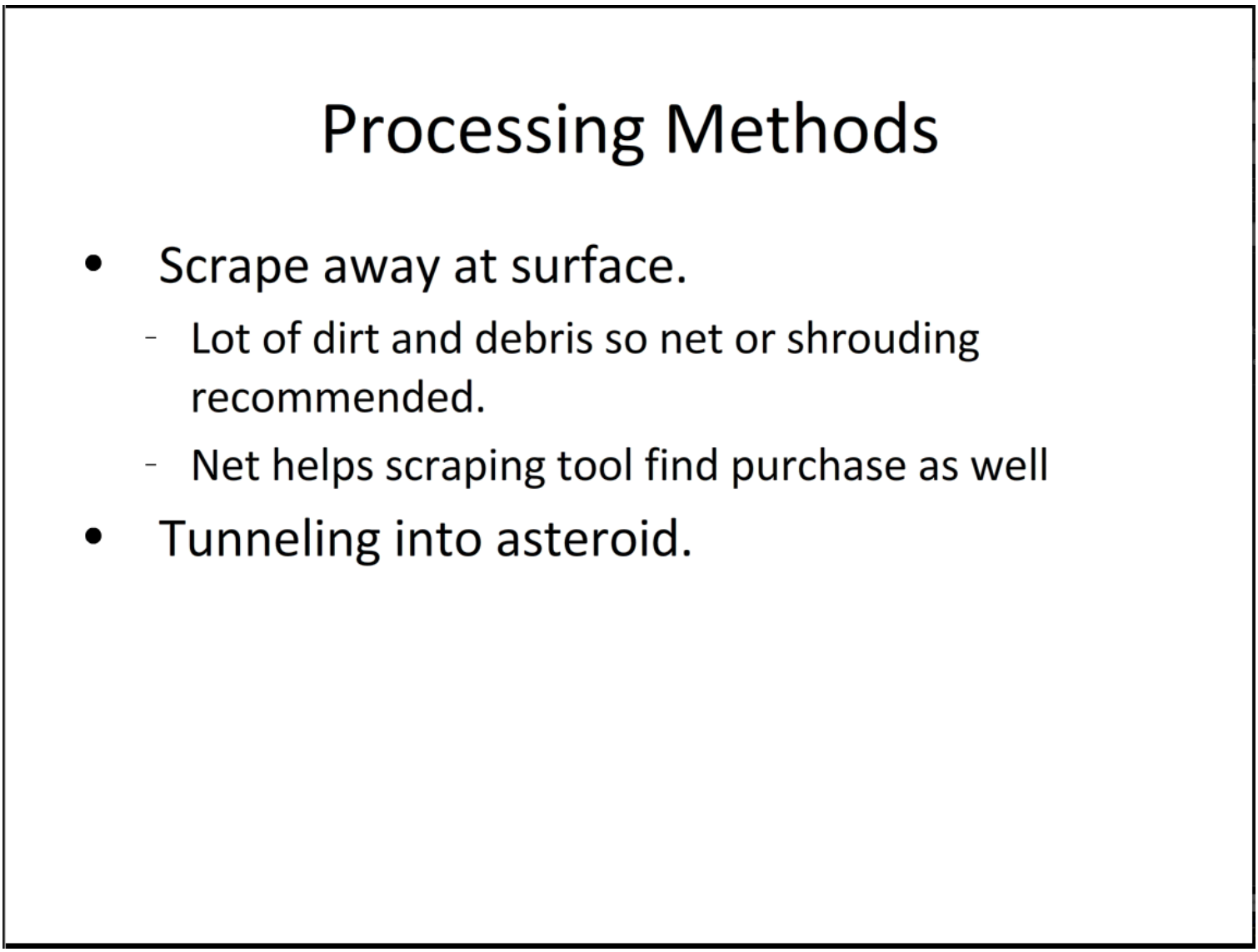
- Two options
  - Bring back raw material
  - Process on-site
    - Bring back processed material and produce fuel for the return trip.

[2010/04/24 11:45] Serendipity Seraph: of these two options obviously the second is vastly superior. And not that hard as we will see.

Working Environment

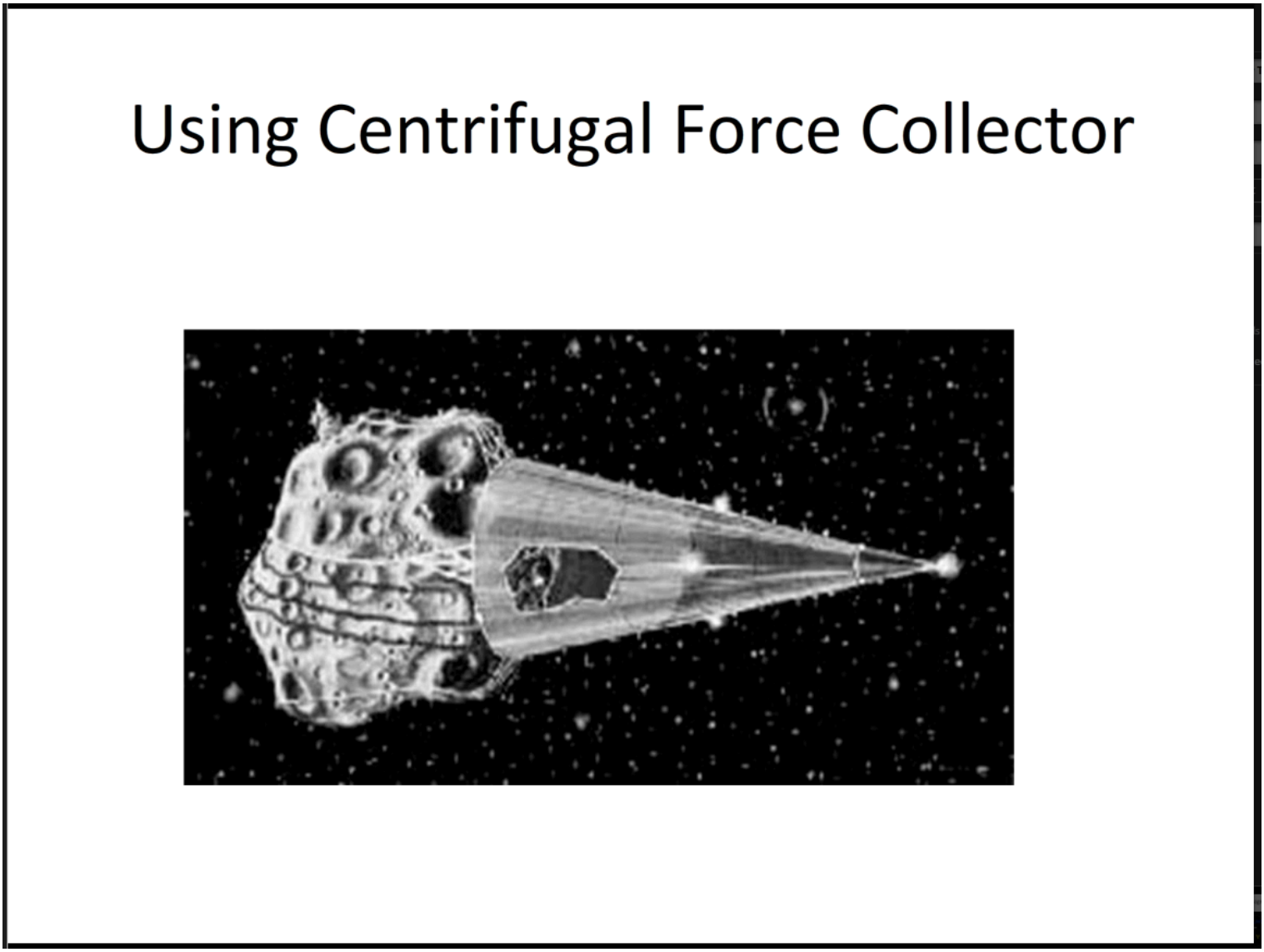
- Environment
  - Ultra low gravity
  - Only operational stresses
  - Low transport cost
- Staying attached to surface
  - Netting
    - Stay attached
    - Comm and other purposes
    - Catch all stray material

[2010/04/24 11:47] Serendipity Seraph: gravity so low you can easily jump away from all but the hugests asteroids. no gravity well to fight with. more an issue how to stay attached and get tools to keep in contact with work surface



[2010/04/24 11:47] Serendipity Seraph: Most Earth mining depends upon gravity to hold the cutting edge against the ore. (However, for many Earth mining operations this is not enough, and other means are employed, e.g., cables and reels.) Scraping away at the surface of the asteroid requires holding the cutting edge against the outer surface of the asteroid. This would require either local harpoons or anchors imbedded into the surface of the asteroid, or cables or a net around the asteroid for the cutter to hold onto.
[2010/04/24 11:48] Khannea Suntzu: Nah. Tents. Then pump them full of regolith. Instant domes.
[2010/04/24 11:48] Serendipity Seraph: that works too and similar to a slide coming up in a few
[2010/04/24 11:49] Serendipity Seraph: Some studies adopted tunnelling to mine an asteroid. The cutter holds itself steady by the walls of the tunnel -- pushing against the walls or cutting into them. Tunnelling prevents consumption of the entire asteroid, but desirable ore veins or cracks can be followed.
[2010/04/24 11:49] Khannea Suntzu: Problem is all that dust gets blown against by solar storms.

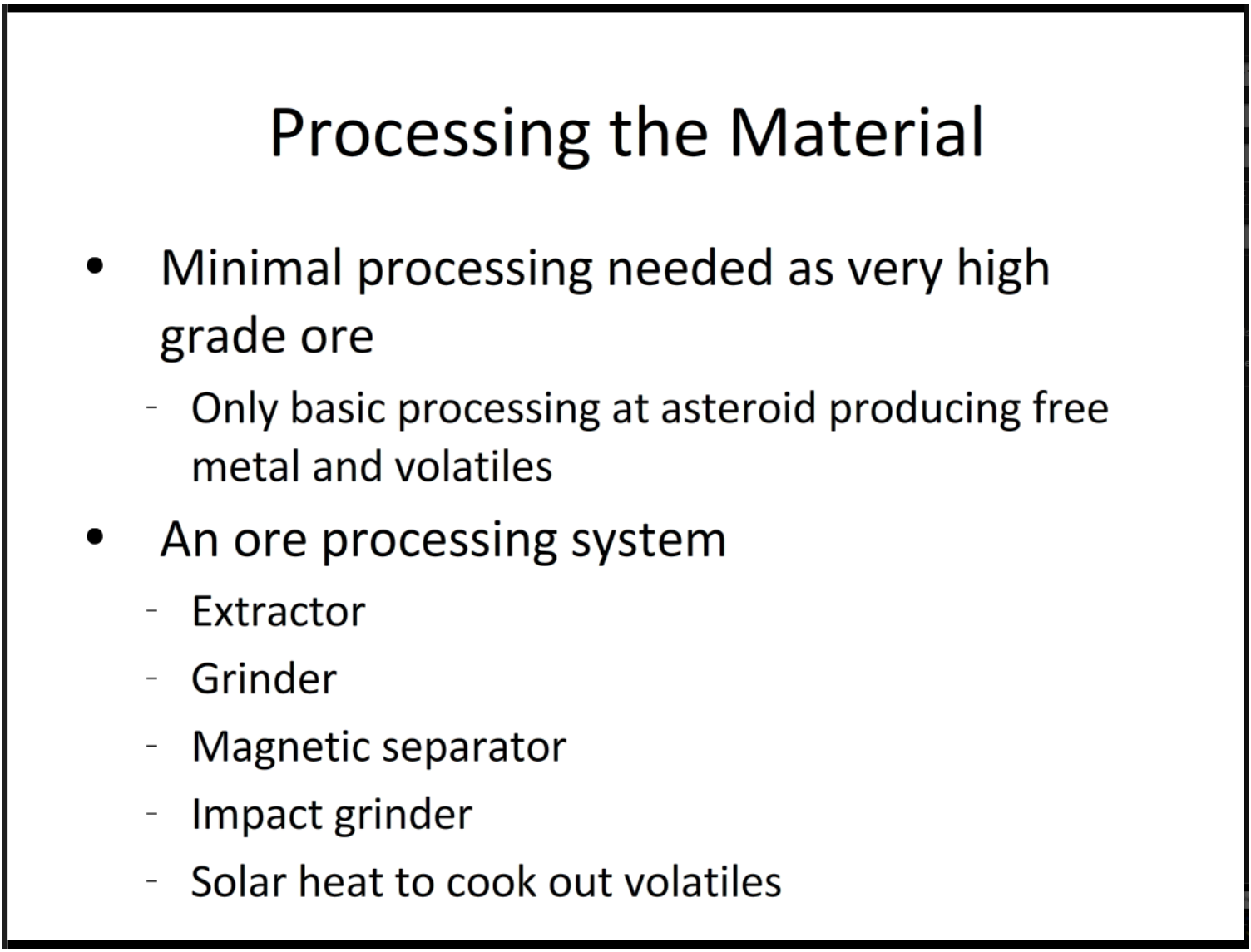
Gets very VERY electrostatic.
[2010/04/24 11:49] Serendipity Seraph: will cover that in a sec, K
[2010/04/24 11:49] Serendipity Seraph: Another candidate process for extracting volatiles from within near Earth asteroids which are dormant comets (currently estimated to be around 40% of near Earth asteroids) is to drill into the asteroid, much like we do for oil and natural gas.



[2010/04/24 11:51] Serendipity Seraph: A centrifugal tent a la Nasa ideas nicely draws the material blown up to a collection point
[2010/04/24 11:51] Khannea Suntzu: Geodesic domes held aloft with short space elevators... Why are my nipples hard?
[2010/04/24 11:51] Extropia DaSilva: That would be my wandering fingers, sweets;)
[2010/04/24 11:52] Serendipity Seraph: the nipple is a collection bag or ball for volatiles

[2010/04/24 11:52] Serendipity Seraph: personally I think it looks like a mouse nose. :)
[2010/04/24 11:53] Serendipity Seraph: other types are more like a great bag around the area that is then closed and moved to processing units
[2010/04/24 11:54] Khannea Suntzu: All this with our victorian "Aliens2" technology is hot. But add nanotecvhnological replicators and I get a little dizzy.

[2010/04/24 11:54] Serendipity Seraph: I cribbed a processing scenario from www.permanent.com, (<http://www.permanent.com/a-mining.htm>)



<quote>
[2010/04/24 11:54] Serendipity Seraph: At the input chute, the ore will be ground up and sieved into different sizes as the first step of a basic ore processing system. Most asteroids probably offer far

more crumbly material than we could consume in one mining expedition.
[2010/04/24 11:55] Serendipity Seraph: Simple mechanical grinders, using a gentle rocking jaw arrangement for coarse crushing and a series of rollers for fine crushing, could be arranged in a slowly rotating housing to provide centrigufal movement of the material. Vibrating screens are used to sift the grains for directing them to the proper sized grinders.
[2010/04/24 11:55] Serendipity Seraph: The streams of material are put through magnetic fields to separate the nickel-iron metal granules from the silicate grains. Alternatively, the streams can be dropped onto magnetic drums, whereby the silicates and weakly magnetic material deflect off the drum whereas the magnetic granules and pebbles stick to the magnetic drum until the scrape off point. Repeated cycling through the magnetic field and perhaps additional grinders can give highly pure bags of free nickel iron metal.
[2010/04/24 11:56] Serendipity Seraph: An optional additional piece of equipment is an "impact grinder" or "centrifugal grinder" whereby a very rapidly spinning wheel accelerates the material down its spokes and flings it against an impact block. Any silicate impurities still attached to the free metal are shattered off. It's feasible to have drum speeds sufficient to flatten the metal granules by impact. A centrifugal grinder may be used after mechanical grinding and sieving, and before further magnetic separation. In fact, most of the
[2010/04/24 11:56] Serendipity Seraph: shattered silicate will be small particles which could be sieved out.
[2010/04/24 11:57] Serendipity Seraph: The nonmagnetic material is channelled into a solar oven where the volatiles are cooked out. In zero gravity and windless space, the oven mirrors can be huge and made of aluminum foil. The gas stream is piped to tanks located in a cold shadow of space. The tanks are put in series so that the furthest one away is coldest. This way, water condenses more in the first one, carbon dioxide and other vapors in the tanks downstream.
[2010/04/24 11:57] Serendipity Seraph: Rocket fuel for the delivery trip to Earth orbit can be produced by separating oxygen and hydrogen gases from the mix, or by electrolysis of water. Alternatively, the hydrogen could be chemically bonded with carbon to produce methane fuel. On the simpler end, simple steam rockets could be used. This is all discussed in chapter 3 on transportation in space.
[2010/04/24 11:58] Serendipity Seraph: Thin, relatively lightweight spherical tanks could be sent to store the frozen volatiles. Ultimately, tanks for storing frozen volatiles for sending to Earth orbit can be manufactured by some of the nickel iron metal, by use of a solar oven for melting the nickel iron metal. A cast can be made from sand or glass-ceramic material from melted leftover ore.
[2010/04/24 11:58] Serendipity Seraph: Some silicate material from the asteroid can be shipped back to Earth orbit to be used for making glass, fiberglass, ceramics, "astercrete", dirt to grow things in, and radiation shielding for habitats and sensitive silicon electronics.
</quote>

[2010/04/24 11:58] Serendipity Seraph: !!!
[2010/04/24 11:58] Khannea Suntzu: So basicly, an ecology of industry about a order of magnitude cheaper than on a planetary surface. Great, and when you discuss this on Digg people become abusive - *tax payer money, ball of dirt zomfg*

<quote>

[2010/04/24 11:59] Serendipity Seraph: Undesired material can be put in a big wastebag container, or "sandbags", or cast into bricks by a solar oven, used for shielding the habitat from space radiation, creating more cold shadows, or just removed from the mining operation's space. (If waste were simply ejected at escape velocity, it would not significantly increase the number of meteors in interplanetary space. However, it's cheaper to skip the ejector equipment and just bag it all.)
[2010/04/24 11:59] Serendipity Seraph: Finally, I should add that some studies consider processing all the asteroidal material by solar oven, skipping the magnetic separators, impact grinders, etc. This approach would utilize giant superlightweight mirrors to concentrate sunlight onto a cavity containing any matrix of material, to first extract the volatiles, and then raise the temperature to more than 1600C (2900F). Only the free metal would melt at the latter temperature. However, separating the molten metal from the silicate matrix seems a
[2010/04/24 12:00] Serendipity Seraph: little tricky. Thus, I don't review that alternative here. Similar methods, "vacuum vapor distillation" as well as high temperature electrolysis, are discussed in chapter 4 on industrial processes.
</quote>

Humans required

- General engineers to set up systems and handle repairs and glitches
- Telepresence operators in space to avoid lag
  - About 3 minutes to most targeted NEO
    - Note most chemicals needed to support human presence are available in asteroids

Next Subjects

- Getting there
  - Launch vehicles and costs
- Manned vs Unmanned
- A rough mission plan
  - Good start is at http://www.permanent.com/m-1stmis.htm

[2010/04/24 12:00] Serendipity Seraph: That looks like a design to me! Lets do it!
[2010/04/24 12:01] Bryce Galbraith: Sounds good... :)
[2010/04/24 12:01] Extropia DaSilva: So what are we going to build? A particle accelerator the size of the orbit of neptune, so we can probe the Planck Level?
[2010/04/24 12:02] BrainCrave OHare: apologies, but have to run to another discussion. thanx seren for all the research and thoughts
[2010/04/24 12:02] Khannea Suntzu: I have argued this road online for well over a decade. Less than -1% of people think it makes any sense. Very few think it is profitable. "let's solve problems on earth first"
[2010/04/24 12:02] Serendipity Seraph: For starters, a full industrial presence in local space complete with space habitats
[2010/04/24 12:02] Serendipity Seraph: and ship building in orbit

[2010/04/24 12:03] Extropia DaSilva: K, do these people stop to consider how important sattelite data is, when it comes to monitoring the 'health' of our planet?
[2010/04/24 12:03] Serendipity Seraph: space based solar is an obvious immediate target
[2010/04/24 12:03] Serendipity Seraph: solving the energy crisis on earth is problem #1
[2010/04/24 12:03] Serendipity Seraph: many resources we are missing on earth can be safely dropped in desert areas with suitable ablation shells
[2010/04/24 12:03] Extropia DaSilva: Agreed.
[2010/04/24 12:04] Khannea Suntzu: yah goddam
[2010/04/24 12:04] Bryce Galbraith: Great presentation Seren :)
[2010/04/24 12:05] Serendipity Seraph: and there is gold in them there rocks, and platinum, tons of it. So financing more missions shouldn't be that hard even discounting the value of the energy and materials sent back to earth and the huge worth of the useable materials in space.
[2010/04/24 12:05] Metafire Horsley: /me likes this presentation ^^
[2010/04/24 12:05] Khannea Suntzu: Did you run across any price estimate>
[2010/04/24 12:06] Serendipity Seraph: Price estimates for doing this for real I did not get into in this presentation. Some of them are proprietary or obscure to get hold of (not on net yet).
[2010/04/24 12:06] Zobeid Zuma: The big problem of course is getting there. You're not going to do it with a launch system that flies only a few times a year and takes 20,000 to keep it running. (i.e. Space Shuttle)
[2010/04/24 12:06] Zobeid Zuma: 20,000 people on the payroll, I mean :P
[2010/04/24 12:06] Serendipity Seraph: but I imagine a few sea dragons could put up the necessary machinery and you would want a lot of cheap probes looking for best targets perhaps first anyway
[2010/04/24 12:07] Bryce Galbraith: Does that include lawyers and accountants too Zobeid? :)
[2010/04/24 12:07] Zobeid Zuma: Probably.
[2010/04/24 12:07] Serendipity Seraph: I want to do another talk soon on how to get there. And find some real rocket scientists to help me.. :)
[2010/04/24 12:07] Khannea Suntzu: Oh no this is impossible in the current economical paradigms. Pay-off is only after bizarre investment tresholds, and when pay-off comes the influx of ores comes in such amounts it collapses markets.
[2010/04/24 12:07] Zobeid Zuma: It's man-rated so every one of the zillions of components is required to have a full accounting trail.
[2010/04/24 12:08] Metafire Horsley: Then better start with tiny asteriods first, Khannea ;)
[2010/04/24 12:08] Fael Illyar: yes... we'd need an economic system that could stay stable with such an influx...
[2010/04/24 12:08] Serendipity Seraph: Actually a few large launches to get the big stuff out there (and it is not that big really) and then smaller launches to rotate crews and such.
[2010/04/24 12:08] Serendipity Seraph: is what I imagine
[2010/04/24 12:08] Bryce Galbraith: I'm definitely interested in the resource problem too...
[2010/04/24 12:08] Khannea Suntzu: Makes no difference. A small asteroid is what, a kilometer. That chunk has more platinum than we currently have winnable on earths surface.
[2010/04/24 12:09] Serendipity Seraph: it is not impossible. well within the means of private citizens and an excited public
[2010/04/24 12:09] Fael Illyar: but what I'm curious about is why have it manned? wouldn't it be simpler to have remote controlled robots to do the groundwork?

[2010/04/24 12:09] Khannea Suntzu: There are people who are *opposed* to this. Because it is all fascist and clearly part of a conspiracy to enslave us.
[2010/04/24 12:09] Serendipity Seraph: Some corporations could do this now..
[2010/04/24 12:09] Fael Illyar: should be less massive amount of material to get up there.
[2010/04/24 12:09] Serendipity Seraph: except for launch resources..
[2010/04/24 12:10] Serendipity Seraph: we are already enslaved in many ways so what is the big deal? :)
[2010/04/24 12:10] Extropia DaSilva: One problem is that we are still at the 'hot air baloon' stage in terms of materials science. When we are able to mass produce materials close to the full theoretical strength, we will have very very light, but very very tough materials to build our spacehips from. And that will make space travel more economical.
[2010/04/24 12:10] Serendipity Seraph: how would more resources, options and riches than most can dream of enslave us exactly?
[2010/04/24 12:11] BB Lutwag: http://www.adciv.org/Colonising_Space
[2010/04/24 12:11] Ju Roussel: (more does not mean public good...)
[2010/04/24 12:11] Serendipity Seraph: more always means more..
[2010/04/24 12:12] Khannea Suntzu: I was being sarcastic. What I am saying is that a whole demographic in the US and EU is progress hostile, and increasingly so. I have found these people don't want these megascale projects, period. They will think of arguments after.
[2010/04/24 12:12] Bryce Galbraith: Thanks for the presentation Seren :) Really interesting discussion today...
[2010/04/24 12:12] Serendipity Seraph: and what the heck is pubiic good? more available more cheaply increases real wealth of everyone generally
[2010/04/24 12:13] Serendipity Seraph: If it is done privately do we need to care what they blather about though?
[2010/04/24 12:13] Extropia DaSilva: You know how antiH+ types twist our plans, though. They will probably turn this into a scenario where the Elite leave a dying planet and the masses get to stay behind and drown in the accumulated filth of a century of rampant industrial growth.
[2010/04/24 12:13] Ju Roussel: it's the distribution mechanism that decides whether society benefits, or just a tiny groups.
[2010/04/24 12:15] Serendipity Seraph: Well, frontiers are sort of like that. The more adventurous and/or desperate and skilled take advantage first.
[2010/04/24 12:15] Khannea Suntzu: Yes Extropia. So, maybe we *should* say this? Create a fake organisation claiming *precisely* this? 'project getthehelloutletthemeeksortitout'
[2010/04/24 12:15] Metafire Horsley: What's the point of that, Khannea?
[2010/04/24 12:15] Serendipity Seraph: But there is a lot of room out there and I expect moving to space will someday be cheap with that much building material and support chemistry in place.
[2010/04/24 12:16] Serendipity Seraph: I like that K. grab it on godaddy. :)
[2010/04/24 12:16] Khannea Suntzu: Make the luddites scared. *shit if they do that, we are doomed* Sort of like 'we can't afford a space industrialization gap'
[2010/04/24 12:17] Serendipity Seraph: what will be worrisome is that the spacers can drop rocks on their head and tell them to go jump..
[2010/04/24 12:17] Serendipity Seraph: eventually..
[2010/04/24 12:17] Khannea Suntzu: :)

[2010/04/24 12:17] Extropia DaSilva: Ok, so say we build the spaceships, the robots, the tech, and now the asteroids are ours to mine. We have space-based solar and the energy problem is solved for as long as the Sun is shining. Now what? What do we build with this material?
[2010/04/24 12:17] Zobeid Zuma: Starships, of course. :)
[2010/04/24 12:17] Metafire Horsley: Bigger cars ;)
[2010/04/24 12:18] Khannea Suntzu: Cities. Venus viles. 3D low gravity paintball.
[2010/04/24 12:18] Khannea Suntzu: Have fun
[2010/04/24 12:18] Fael Illyar: a Starship could count as a house too :)
[2010/04/24 12:18] Khannea Suntzu: Monastries speculating the nature of g-d in the middle of the death star crater on Mimas.
[2010/04/24 12:18] Serendipity Seraph: first the above. then eventually starships, dyson spheres (or rings). the sky in NOT the limit
[2010/04/24 12:18] Fael Illyar: more than a house.
[2010/04/24 12:18] Serendipity Seraph: *is Not
[2010/04/24 12:19] Metafire Horsley: Dyson spheres are boring. I want Dyson cubes! :D
[2010/04/24 12:19] Extropia DaSilva: Hmmm..Now I am thinking 'Halo 10' will be a real life action game played out on an actual Niven Ring.
[2010/04/24 12:19] Serendipity Seraph: yes, something I didn't mention is that the easy way to bring lots of material back to earth orbit is to nudge it just so into lunar trajectory and sling shot it back. Don't have to burn pure delta V from fuel
[2010/04/24 12:20] BB Lutwag: get everyone plugged in, turn the earth into a cube and fly it around the galazy
[2010/04/24 12:20] Serendipity Seraph: the asteroids are cheaper to reach than the moon and no pesky gravity well at other end. but the trip is a bit longer
[2010/04/24 12:20] Metafire Horsley: Seriously, who will make the first move into asteroid mining?
[2010/04/24 12:20] Khannea Suntzu: We arent there yet. I'll be perfectly happy living two centuries in an adequate body, applying bandaids on a scraped knee, looking out of my radiationshielded window at the vacuum distiller columns venting over the surface of Toutatis.
[2010/04/24 12:21] Serendipity Seraph: another talk should be on all the reasons we need to settle/exploit the moon and how.
[2010/04/24 12:21] Metafire Horsley: Because we have to run away from the luddites? o.O
[2010/04/24 12:21] Khannea Suntzu: I'll be one of those nuisance people on the asteroids asking 'but WHY do we need dyson spheres? Lets solve the problems in our overcrowded asteroids slums first'
[2010/04/24 12:21] Extropia DaSilva: Well, the Moon is an ideal spot for a SETI mission, because the dark side is totally shielded from all the chatter coming from us.
[2010/04/24 12:22] Zobeid Zuma: Yes, I'm in favor of that Extie. (And not just for SETI but for lots of good astronomy.)
[2010/04/24 12:22] Serendipity Seraph: I expect a nation state or large corporation.
[2010/04/24 12:22] BB Lutwag: need to do what we can, start by organizing existing current knowlege and thinking as open source & creative commons on wikis like the advanced civilization wiki
[2010/04/24 12:22] Metafire Horsley: What's SETI good for when the first signal we get probably will be "We are the Borg. Resistance is futile!"?

[2010/04/24 12:23] Khannea Suntzu: I really think who does it is inconsequential. The single issue here is getting out of the gravity well.
[2010/04/24 12:23] Zobeid Zuma: I think of SETI as a sort of specialized subset of astronomy. We want to find out "what's out there". Of which, little green men are merely on possibility. :)
[2010/04/24 12:23] Serendipity Seraph: But lange prizes might change that.. or large support from a lot of people, some very well funded (billionaires)

… then we got off into SETI and other things…