MINING WITH LIMITED FORCE TOOLS AND MICROSCALE MINING MACHINES. THE ANTS OF TOUTATIS

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Introduction

Early in mans rise to our present technological plateau mining was done by heating the rock face and then quenching it with water. This would shatter the rock; this is called the thermal stress method. Later iron metallurgy gave miners picks and bars, wedges and gads, tools hard enough to drive into natural cracks in ore and force them apart.[i]

Technology for mining on Earth has moved beyond these tools. With the invention of rock drills and dynamite, technologies that consume large amounts of power and materials became the standard method. I suggest a reexamination of the older mining technologies and continuing their evolution with a different set of modern technology and methods. These older tools evolution had stopped when the new inventions became clearly superior for mining on Earth, but the evolution of these tools could continue on asteroids and possibly planets.

One of the evolved tools would be an adaptive wedge that could move deeply into fractures and fissures.

Another tool design evolved from the pickaxe, powered by heat differentials, could develop significant amounts of kinetic energy in small areas.

Still another tool design would be a solar powered rock crusher, to break rocks into fragments suitable for further processing.

And for moving, separating, and segregating materials, a miniature robotic Ant. It would have the ability to make crude separations of material from the crushed rock.

The adaptive wedge would work by taking advantage of materials that can change dimensionally. The wedges could use the principals of piezoelectric, magnetostriction, and thermal expansion. When the adaptive wedge is at its minimal dimensions, it is placed into a fracture. The wedge then increases its dimensions to force the fracture. The vibrations generated by the impacts of an evolved pickaxe could also power the wedge. Acting together with an evolved pickaxe, the wedges would exploit the minute vibrations created by the impact of the pickaxe. As these vibrations open and close cracks minutely, the wedges could creep deeper into the cracks and act to widen them. This would also pin some of the motion and resiliency of the rock to allow the evolved pickaxe to more effectively transmit kinetic energy to those points holding the rock face together.

The evolved pickaxe could use a thermal spring to power it. A thermal spring could be manufactured from a bimetallic material similar to those used in mechanical thermostats. It could be coiled much like a standard spring. When heated the spring would stretch out. The thermal spring could be positioned behind a mechanically latched weight. The spring would be heated and its thermal elongation will generate compressive forces. Releasing the latch holding the weight will accelerate the weight into impact with a cutting head. To reset the spring, just remove the heat source, it will cool and pull the weight back into its latched position. The difference between sun and shadow on an asteroid could power the evolved pickaxe.

The solar rock crusher would take advantage of thermally expansive materials or shape memory alloys. These mechanical effects could either, crush the material as in a vise, or both shear and crush the material, as in a mortar and pestle.

The Ants would provide mobility, crude analysis, and the basis for a multifunctional platform. With small sensors positioned near their “jaws”, they could determine if the fragment they were carrying were magnetic or conductive. This could be a first step in segregating materials for processing.

The mining of asteroids using the equipment and techniques that are available on Earth

would be economically prohibitive due to the weight and size of the equipment used. Given the limiting factor of launch weight and the need for equipment redundancy, mining based on the use of swarming microrobots and adaptive mechanics would allow mining to be done, albeit at a slower pace. Advances in micro-fabrication, microassembly techniques, and robots with insect-like intelligence, a micro-robot with the capability to aid in mining hard rock could be designed.

These Ants could be an important part of a mining system for asteroids and planetary surfaces. Like the insects, the Ants would have a hierarchy of functions. The larger ants could move the rock pieces broken loose by the pickaxe to the solar crusher, while smaller Ants would sort the crushed material into segregated piles. Some functions would remain on the surface of an asteroid to generate power, and maintain communications to transmit and receive data with Earth.

Control of the relatively unintelligent Ants would be with a Central Artificial Intelligence that would coordinate their activities. Understanding the physical area of the control environment and obtaining relevant information from the Ants would be significant problems that are not well understood at this time. This can be overcome by experimentation. Current robotic colonies have few members and can perform only simple tasks due to the cost of building and maintaining large colonies of robots. These limitations on the type, complexity, and cost of robot colonies can be overcome by microrobots. Microrobots could be prototyped in large numbers, then used in concurrent experiments. Theories of robot colony control could be put to the test on actual rocks. The algorithms that control the colony could be modified and tested rapidly, under realistic conditions. Kind of an Ant farm.

The mining operation would obviously be a very slow process, a process that would work over long periods of time to complete large excavations or significant ore extraction. The primary advantage of such a system would be a very light launch package with a lot of redundancy.

Toutatis was placed in the title, because it is a very near earth-crossing asteroid that could be a potential long-term threat to the planet, and to Human civilization. If a small colony of these robots were landed on Toutatis, they could investigate the nature of the asteroid to determine its composition and structure. If it were then necessary to excavate a hole to place the nuclear charges to divert the asteroid, the Ants could see to this task. Or the hole could be drilled as a precaution to allow placement of nuclear charges at some future date.

I believe these ideas would require a multidisciplinary approach that is far beyond the resources at my command. I am sure that, as different people with different backgrounds, examine these ideas many unique uses will come to mind.

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[i] Larry C. Hoffman, The Rock Drill and Civilization, Invention and Technology summer 1999 pages 56-63