BULETINUL Universităţii Petrol – Gaze din Ploieşti	Vol. LXII No. 4A/2010	117 - 124	Seria Tehnică

Application of Similarity Theory to Establish Important Parameters to Drill on Mars

Marius Stan

Universitatea Petrol-Gaze din Ploiesti, Bd. Bucuresti, nr. 39, Ploiesti
mstan@upg-ploiesti.ro

Abstract

The concernments for the development of research capacity with direct implications of the Romanian research over the international competitively are materialized by forming a research team from the Petroleum Gas University of Ploiesti, a research project about the possibilities of placing a well on Mars through a technological process of drilling at different depth with an equipment festinated to this scope.
.

Key words: *drill, water, well, mars, similarity theory*

Introduction

This research paper will be based on the information already known about the Mars Planet, at international level and on the NASA and ESA preoccupations for findind a human team in order to establish new explorations of the planet ressources in the near future, justifing in this way the opportunity of approaching this theme, and taking into account the preoccupations and the experience in the drilling domain of our country.

The Main Characteristics of Planet Mars

The planet has a redish surface because of the iron(III) oxide. The planet radius represents half of that of Earth, and its mass just a tenth of the Earth's mass, it is less dense, but its surface area is not so different in comparison with that of the Earth.Mars and Earth are the same age, a.i. 4,6 milliard years.

Physical characteristics

Equatorial radius: 3396 km , 53.25 %Earths
Mass: 6.39 × 1023 kg,10,7 %Earths
Volume: 15 %Earths
Mean density: 3900 kg/m3
Gravity: 0.38 g (3.7 m/s^2)
Sidereal rotation period: 1.029 day

Orbital period: 1.881 years
Orbital speed: 24.1 km/s
Distance from Sun:
Average: 1.524 ua (227.9 millions km)
Maximum: 1.665 ua (249.1 millions km)
Minimum: 1.382 ua (206.7 millions km)
Orbital eccentricity: 0.0935
Inclination: 1° 51'
Sattelites:2
Predominant Gas: CO2
Temperature: -140…+20 °C

Atmosphere

The Martian atmosphere is thin.The surface pressure is 0.70.9 *k*Pa, while that of Earth is 101.3 *k*Pa.

The composition atmosphere consists of: 95% Carbon dioxid, , 3% Nitrogen, 1.6% Argon, and contains traces of oxygen and water.The atmosphere is quite dusty, containing particulates about 1.5 μm in diameter which give the Martian sky a tawny color when seen from the surface.The fact that methane has been detected confirms the presence of gases. Volcanic activity, cometary impacts, and the presence of methanogenic microbial life forms are among possible sources. During a pole's winter, it lies in continuous darkness, chilling the surface and causing 25–30% of the atmosphere to condense out into thick slabs of CO_2 ice (dry ice)

Climate

Mars Seasons are the most Earth's Like. However, the lengths of the Martian seasons are about twice those of Earth's, as Mars' greater distance from the Sun leads to the Martian year being about two Earth years in length. Martian surface temperatures vary from lows of about −140 °C (-220 °F) during the polar winters to highs of up to 20 °C (68 °F) in summers. Mars also has the largest dust storms in the Solar System. These can vary from a storm over a small area, to gigantic storms that cover the entire planet. They tend to occur when Mars is closest to the Sun, and have been shown to increase the global temperature.

Geology

The surface of Mars appears to be composed primarily of basalt. Observations show that parts of the planet's crust have been magnetized. One theory demonstrates the existence of plate tectonics.That means that on Mars there has been water otherwise it wouldn't have been found some minerals.

The Exploration of the Planet

Missions in the past

The first successful mission was launched in 1964 by NASA. The first objects that reached the martial land were two proves sent by the Russians, in 1971, but they both lost contact after few seconds. In 1975, there followed the Viking program, and two vehicles set on the land in 1976

and remained operational for many years.

Current missions

The failure with the Mars Observer satellite followed in 1992. Then, 1996, NASA launched Mars Global Surveyor, which was a real success, the first cartographic mission ending in 2001. Only a month after the Surveyor was launched, the Mars Pathfinder mission followed, a robotized exploring vehicle set in Ares Vallis.

In 2003, ESA (European Spatial Agency) launches Mars Express, which consists of the satellite Mars Express Orbiter and the lender Beagle. In the beginning of 2004, they announced the discovery of metan in the martial atmosphere. ESA announces in 2006 the existence of the aurora borealis on Mars. Also in 2003, NASA sends on Mars the rovers Spirit and Opportunity. These two brought convincing proves that there has once been water on Mars.

The next mission

The following mission, Phoenix Lander, programmed in 2007, followed by Mars Science Laboratory in 2009 si Phobos-Grunt have the purpose to bring evidence from the natural satellite Phobos.

The European Spatian Agency hopes to send men on Mars sometimes between 2020 and 2025. In the begining, ESA had planned an exhibition with the USA, but the USA law forbids any exchange of spatial information concerned on the spatial technology, which led to a competition between the two. The *Swedish Stas Barabash*, leading the ASPERA - 3 explorer's team, published in January 2003 a paper concerning this matter. Having the grounds of this new information, he considers that there are huge quantities of water and carbon dioxide on Mars.

The Existence of Water on Mars. Present and Perspectives

Based on the information communicated by Mars Global Surveyor, it has been affirmed that the lack of protection against the cosmic radiation made the martial atmosphere to be simply "blown" by the solar wind. Meanwhile, new facts have come to contradict that hypothesis.

The European explorer Mars Express, helped by the instrument ASPERA – 3 (Analyzer of Space Plasmas and Energetic Atoms) has also found that Mars is losing atmosphere, but it is all about 20 grams/ second. Focusing upon this rhythm of loss of the atmosphere, then, in all its history, Mars has only lost a layer of water measuring few centimeters and only a thousandth of the Carbon Dioxide from the atmosphere.

We already know many things about the martial water, thanks to the observations made by the explorers Mars Odyssey and Mars Express. We know that there are huge quantities of water on Mars, and they will be charted by the followinf martial missions. Barabash has declared to the New Scientists magazine that : "There are huge quantities of water. In order to garner it somewhere, really huge basins are needed. The chances to find this water in a liquid condition are quite big now.

As the NASA specialist claim, the explorer Mars Global Surveyor has already proved that liquid water sometimes flows on Mars, and the natural question didn't impede to show up **Does the undersoil of Mars hide large quantities of water and carbon dioxide?** Here is a question that waits for an answer from the following missions.

Mars has an air-free atmosphere and lacks the magnetic field that might protect it against cosmic radiation. These cosmic radiations might kill any form of life present at the planet's surface. The four researchers continued afar.

They realized a mathematic pattern of the martial shell, and then calculated the depth where the flux of cosmic radiation would be reduced enough to make life possible. So, the four researchers determined that life on Mars would only be possible at the depth of few meters.

There should be dug really deep in order to detect it. The only mission capable to detect samples at this depth will be Exo Mars of ESA. It consists of the dispatching of a rover on the martial surface in 2013, that will be equipped with a digging installation meant to gather samples of soil in different depths (2 m for the beginning).The researchers recommend that the following missions should focus upon the places where the martial land is relatively young, like Elysius, a place where liquid water was present few millions of years ago.

Nowadays, according to the information communicated by the European explorer Mars Express, we have a glacial ocean in there, covered with a thin layer of soil. This time, one of the main missions will be to search for microscopic forms of life, and there has already started the getting up of the edification of the new spatial European explorer.

The next spatial European spatial mission, already named Exomars, will leave to Mars in 2011. Until then, the researchers from numerous European laboratories have already started the detailed work with the construction of the spatial explorer and of the equipments installed on it.

The explorer Exomars is a part of the Aurora program, in the ESA. This program has the main purpose to realize an European long term plan for made for the European researchers to explore the Moon, Mars and the asteroids.

The researchers have at their disposal European founds of almost 80 millions euros in order to make a machine that may accomplish all the complex tasks in the analysis and determination of possible form of life, but having low size and weight.

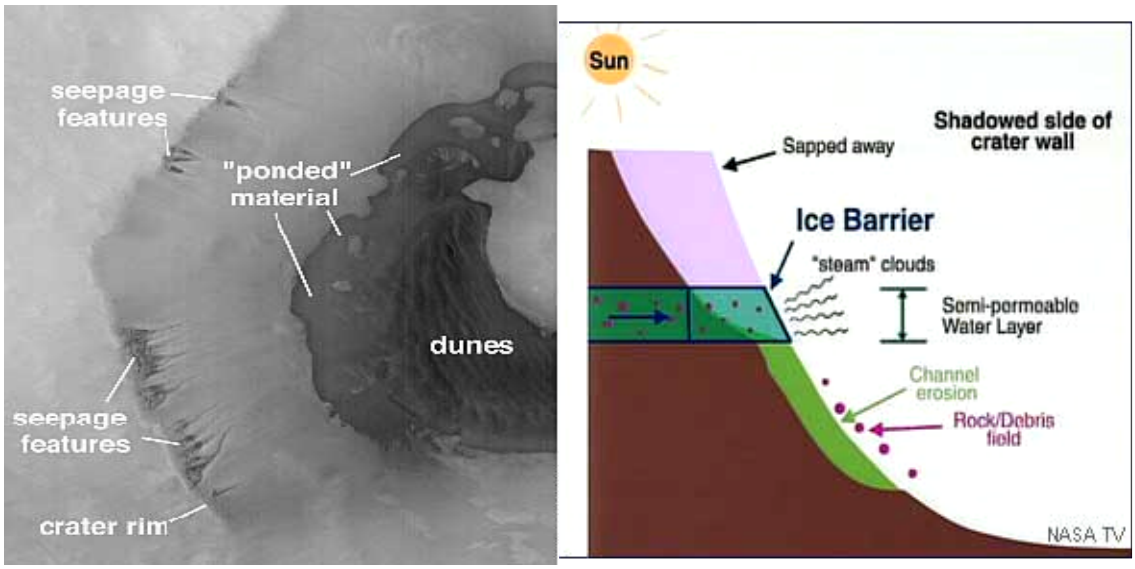
For instance, the weight of the machine that will detect the possible forms of life should be smaller than 800 grams under the circumstances in which the explorer Exomars is meant to weight at most 150 kilograms, and among the afloat machines there should also be installed a digging appliance.

The Exomars explorer will posses afloat a machine with the purpose to analyze the samples of martial soil, searching for microscopic ways of life, similar to the microbes or bacteria on Earth. In "Mars, habitable. Past and present" Thomas McCollom from the Astrobiological Center of the University in Colorado, USA, affirms that even though the temperature on Mars of about 120 degrees excludes the possibility of the existence of water on surface, " there might be a water-bearing with a planetary diffusion to a certain depth in the underground. " Geological proves also exist (NASA sources) that testify that water had once flown on the surface.

NASA made public some undiscovered pictures of an anormous crater on Mars, pictures that might contribute to the better knowledge of the red planet, from its forming until today. The pictures were taken by the mobile robot Opportunity, with the help of the orbiter Mars Reconnaissance Orbiter (MRO), launched by NASA in august 2005, and placed on the permanent orbit around Mars.

The Victoria crater is probably he the biggest crater that will ever be studied by NASA with the help of two robots sent on Mars – declared Doug McCuistion, the manager of the exploration program, in a press conference in Washington, and quoted by Yahoo Actualities(the 9th of October, 2007). This crater is 5 times bigger than any other explored by Opportunity on Mars up to now. "It *is an open window to the past of the planet*". Doug McCuistion declared. The geologic layers are easily seen in the margins of the crater, this allowing the drawing out of

some important information about a more extended period than any other made before, after studying some smaller craters.



None of the spatial derricks that have reached Mars till now incorporates a drilling system that can surpass the area exposed to the bombardment of the cosmic rays (some metres). NASA send a permanent laboratory on the Red Planet in 2009.

The experts of the American Spatial Agency hope that Mars Reconnaissance Orbiter, located at above 290 kilometres altitude from the planet's surface, will offer them useful data in order to send a human team expedition on Mars.

The High Resolution Experimental Chamber offered surprising details. Canals have been identified that may have contained water in the past. Furthermore, a valley covered in a layer of old clay, billions of years old, may constitute evidence that water used to exist on Mars in the far away past. That would be the best argument favoring the appearance of micro-organic forms of life on the Red Planet, in a certain moment in time. NASA experts want to install a permanent scientific laboratory on Mars, beginning with 2009. This will be a variant, at a larger degree, of the robots Spirit and Opportunity, that have been on the planet since 2004.

As compared to the other two robots sent by NASA on Mars, Spirit and Opportunity, Phoenix will be a stationary robot, that will explore the planet through vertical diggings done by its metallic arms. The collected samples of soil will be analysed inside the robot's body, endowed with professional laboratory equipment and the results will be sent to NASA.

Similitude Criteria

When analyzing the engineering systems through similitude between Earth and Mars, the following are adopted:

- in the systems functioning, three fundamental physical units exist: the length L, the mass M and the time T;
- the ratio of some unit`s values derived in the two systems does not depend when choosing the fundamental units used for determining the derived units;

- if the measurement units variations of some fundamental physical units determine the variation of a derived physical unit, then a unique function exists (that can realize the correspondence between the respective fundamental units and the derived one).

For the two physical phenomenon, having the same class, to be similar, it is necessary and sufficient that their adequate similitude criteria to be equal, and the oneness conditions to be proportional. For example, if the chosen measurements are unit 1 (m_1), unit 2 (m_2) and unit 3 (m_3), by applying Theorem π, it results:

$$[L]^0\,[M]^0\,[T]^0 = [m_1]^{\alpha}\,[m_2]^{\beta}\,[m_3]^{\gamma}\cdot\{\,[L]^a\,[M]^b\,[T]^c\,\}^{\delta} \tag{1}$$

General Similitude Criteria Earth – Mars

It will be described the phenomenon that accompanies the technology of dry rotor–percussion drilling with air circulation on Earth and martian *air* on Mars.

This phenomenon implies reporting the movement of some masses and fluids towards an inertial reference point where the masses forces are reduced to gravitational accelerations. The determining units are (Tab. 1):

L – length;
v – speed (velocity);
ρ – density;
t – time;
p – pressure;
g – gravitational acceleration;
n – rotation speed of gas compressor shaft;
D – diameter of the rotor-percussion drill that operates the drilling bit;
σ – mechanical tensions;
ρ – density of working agent;
Q – flow;
M – bit moment;
P – power.

The machine that undertakes the technological process of drilling contains three main systems of work(the manouevre system , the circling system and the circulation system). Setting these systems to work is electrical. The drilling technology also requires, among others, the existence of the drilling tools and the drilling bit.

It is known that the method, which is already a classic one, used mainly in drilling terrestrial derricks is that of hydraulic circular drilling.

The machine that undertakes the technological process of drilling contains three main systems of work(the manouevre system , the circling system and the circulation system). Setting these systems to work is electrical.

The drilling technology also requires, among others, the existence of the drilling tools and the drilling bit.

Example:

$$a_{\text{Mars}} = a_{\text{Tera}}\cdot\sqrt{\frac{g_{\text{Mars}}}{g_{\text{Tera}}}} = a_{\text{Tera}}\cdot\sqrt{\frac{0.38\cdot g}{g}} = \sqrt{0.38}\cdot a_{\text{Tera}} \approx 0.62\cdot a_{\text{Tera}}$$

Table 1. Similarity criteria Earth - Mars

No.	Physical greatness	Simbol	Similarity criterion Invariant Π
1	Acceleration	**a**	$\Pi = \frac{a \cdot t}{\sqrt{L \cdot g}}$
2	Force	**F**	$\Pi = \frac{F \cdot t}{m \cdot \sqrt{L \cdot g}}$
3	Tension Mechanics	**σ**	$\Pi = \frac{\rho \cdot A^2 \cdot \sqrt{L^3 \cdot g}}{\sigma \cdot t}$
4	Pressure	**p**	$\Pi = \frac{n \cdot D \cdot L \cdot p}{\rho \cdot g \cdot Q}$
5	Time Force the rotary engine(bit)	**M**	$\Pi = \frac{n^2 \cdot D^5 \cdot \rho}{M}$
6	Power Mechanics the rotary engine(bit)	**P**	$\Pi = \frac{n^3 \cdot D^5 \rho}{P}$

Conclusions

Drilling derricks on Mars will not take place with the aim of exploiting carbon deposits whose investment is debatable, but will have an exploratory character, that of discovering useful minerals and first of all, some water resources or/and thermal water resources.

The water derricks will be of paramount importance in the prospects of a future colonization of the planet and the project is included in the plan of interests of international spatial agencies, that conduct studies and researches on the atmosphere of the planet.

From some of the accessed and notified data in various magazines resulting that the activity of exploring the martian soil will increase considerably in future time.

Our approach to problems regarding gravitation will involve the theory of similitude. The circulation of the drilling fluid will be replaced by that of the gas that composes the planet's atmosphere: mainly carbon dioxide , similar to the case of drilling with air used in conditions that are specific to terrestrial drilling .

The requirements of applying the method of circulation without liquid fluid will be analysed through similitude. It is known that the method, which is already a classic one, used mainly in drilling terrestrial derricks is that of hydraulic circular drilling.

Furthermore, it is known that, presently, in order to production better the deposits of oil and terrestrial gas there are derricks to drill in all directions , including along the productive layers, derricks with many ramifications, derricks that use the effect of gravitational so on and so forth.

References

1. A v r a m, L. S t a n, M., Study concerning the use of terrestrial experience in the domain of trial boring during the well water drilling on the Mars surface, *Buletinul Universitatii Petrol-Gaze din*

Ploiesti, Seria Tehnica, No 1/2010.
2. S t a n, M., *Metode avansate de proiectare a utilajului petrolier,* Editura Universitatii Petrol-Gaze din Ploiesti, 2006.
3. *** NASA Press Release summarizes the report of the Mars Program, March 28, 2000.

Aplicarea teoriei similitudinii în stabilirea unor parametri de foraj importanţi pe suprafaţa planetei Marte

Rezumat

Acest articol de cercetare se bazeaza pe informaţiile referitoare la caracteristicile planetei Marte, cunoscute la momentul actual pe plan mondial şi preocupările NASA şi ESA de a amariza cu echipaj uman în vederea explorării resurselor planetei în viitorul apropiat, justificând astfel oportunitatea abordării unui astfel de proiecti, date find preocupările şi experienţa ţării noastre si a Universităţii Petrol-Gaze din Ploiesti în domeniul forajului. Rezultatele studiului constau in stabilirea unui numar de 6 criterii de similitudine pentru unii parametrii prezenti la tehnologia forajului rotativ uscat, utilizat si pe Pamânt. Ideea de baza a lucrarii este aceea de a pune la dispozitie unele instrumente utile in stabilirea corelatiilor cu Pământul a parametrilor definitorii ai unor instalatii capabile sa deservească in viitor eventuale activităţi de foraj extraterestru.