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Jain Geography: A Reappraisal

Jeo Raj Jain, Narendra Bhandari and J.K. Surana

ABSTRACT

The geography of the Earth, all the planets and their satellites in our solar system and many astronomical objects outside the solar system are well documented based on high resolution photography and observations made by using modern techniques aboard spacecrafts. Their shapes, sizes, orbital and rotational velocities, locations, characteristics of their surfaces and atmospheres are known with high degree of accuracy. However, when these observations are compared with the traditional interpretation of ancient Jain scriptures, serious disagreements emerge, leading to the argument that the “Jain geography” is erroneous and should be modified. In our opinion, these discrepancies arise mainly because the diagrams given in the scriptures are symbolic, heavily ornamented, artist’s conceptions or pictograms, and not geographical, geological or geometrical diagrams. For example, Earth, because it is depicted as a circle, has been erroneously taken as flat, disk shaped body. Based on some diagrams given in the scriptures, two Suns and two Moons going round the earth have been postulated, Sun being nearer to Earth than the Moon. Some diagrams imply that the Jambudvipa (earth?) and other lands (planets?) are sequentially surrounded by oceans of different compositions, each being twice the size of the previous land or water body. The problems are further compounded because neither it has been possible to rationalise the units of distance and time given in Jain scriptures nor can they be converted into modern units in a consistent manner.

We make an attempt here to reinterpret various diagrams given in Jain Texts. We take the view that, Hindi (and its related Indian roots) is the only language in the world which translates geography as *Bhoogol*, emphasising that *Bhoo* (earth) is *Gol* (spherical), ruling out all other interpretations about shape of the Earth (like a flat disk) and setting all controversies about its shape at rest. We further show that, with some assumptions, a better agreement with the modern geography is possible. Amazingly, we also find that some information which has come to be known only recently with modern techniques, is mentioned in the scriptures. Even so, many problems remain,

and it calls for further study of various aspects of the earth and other habitable planets described in Jain scriptures.

Key Words: Geography, Geology, Jambu dvipa, astronomy, Meru, climatic cycles, kaal chakra.

Scriptures Quoted: Jambudvip Pannati, Surya Pannati, Chandra Pannati, Jivabhigham sutra, Bhagvati sutra.

1. Introduction

Science has made tremendous progress in observational techniques as well as theoretical modeling during the last four hundred years, particularly since Galileo first looked at celestial bodies with his small telescope and Newton enunciated the three laws of motion (Mohanty, 2015). Remote sensing by space based observations has given us clear, factual, picture of geography and motion of the Earth and other planets of our solar system. All the planets of the solar system have been explored by flyby-, orbiting- or landing- missions by American, Russian, European, Japanese, Chinese and Indian spacecrafts. Samples of the moon, asteroids and comets brought back by space missions and rocks from moon, mars, asteroids, comets, meteors etc. falling on Earth as meteorites and interplanetary dust particles have been studied in the laboratory for their chemical, mineral and isotopic composition and formation ages. Thus we have a reasonably good knowledge of the constitution of various planetary bodies of the solar system and their formation as well as evolutionary and chronological histories. Thousands of planets beyond the solar system, around other stars of our galaxy, termed Exoplanets, have also been identified and some of them are located in 'habitable zone', i.e. having equitable temperature with liquid water, around their central stars. In addition we have fair knowledge of our Milky way and other galaxies. Most of these factual descriptions can not be ignored and can only be refined to a limited extent.

Jain scriptures have described the geography of the earth, motion of the sun, moon and planets in great detail in *Jambudvîpa Pannati*, *Surya Pannati* and *Chandra Pannati*. The Earth's geography, descriptions of planets, their satellites and the Sun, cosmology (galaxy and Universe) and astrobiology, i.e. life beyond the Earth, are all treated together in these texts, each of which have since developed into separate subjects in their own right. The Jain Agams were documented centuries after the period of Mahavira (~600 BCE) and historical maps show that the geographical and geological features of the world were accurately known at that time. Lunar calendar was invented long time ago and solar and lunar eclipses were accurately predicted, even during Ramayana and Mahabharata times. much before the period of Mahavir. This leads us to believe that geography of the

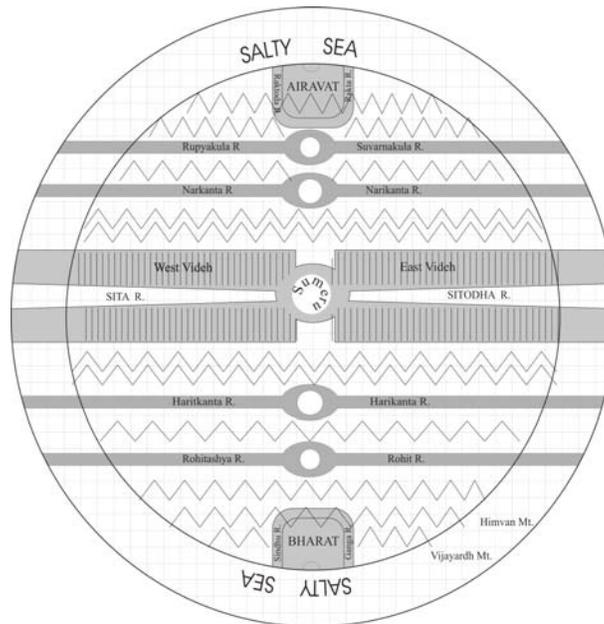


Fig. 8.4

One of the figures from scriptures depicting the earth. It has been wrongly interpreted by several scholars as the geography of the earth showing a flat disk like earth surrounded by annular salty sea, all around, and east west trending mountains, rivers and continents etc. In our opinion, this figure only depicts some geologic features of the northern hemisphere, specifically 7 mountain ranges, 7 rivers and 7 continental landscapes (forests, deserts etc), without any relevance to their geometry or relative locations. Only a few names of the rivers (Sindhu, Ganga) and mountain ranges (e.g. Himvan, now called Himalayas) have survived through time. Some minor North-South trending mountain ranges (in the original figure) are not shown here for sake of clarity. Sumeru (north pole) is the axis of the earth around which the spherical earth rotates as shown in Fig 8.6. The Bharat kshetra (India) is located in the southern most region of this hemisphere.

These figures are actually pictorial representations based on the symbolism prevalent in olden times that have been erroneously interpreted literally as geographical maps, without understanding their symbolic codes. These drawings (Figure- 1,2 and 3) are more like an artists conception, and have been mistakenly taken to imply a flat, disk-like earth, rotating around a *Meru* (rocky axis), alternate annular lands surrounded by annular oceans (*lavan samudra*), rivers flowing westward as well as eastward, two suns and two moons, etc. accompanied by many highly precise, mind boggling calculations of their dimensions and the distance of sun, moon and planets, sometimes to accuracy of up to five digits (see Appendix X for details).

Surely at the time of Mahavira (about 600 BC), the geography, at least of India and neighboring lands, was well known, as evidenced by maps of the Earth of that era. Mahavira walked through the length and breadth of India and Alexander the

Great, with his army, came to India from Greece soon after, much before the *Āgams* were compiled. Even a lay man would not imagine rivers flowing in straight configuration, in a symmetrical way and lands being annular in shape. We must therefore reckon these pictures merely as symbolic representations, and not as actual geographical maps, in their literal or geometric sense. It is important to first understand the style of representation prevalent at that time, before interpreting them. As pointed out by J. R. Jain (2013), the scriptures used a style or code using unnatural symmetry and emphasizing on ornamentation of geometric features in the form of decorative diagrams¹

Earth and orbits of sun, Moon and planets were well known at that time. This laid the foundation of astronomy in India, at least two millennia ago and was followed by great scholars like Aryabhata, Bhaskaracharya, Varahmihir and others who established a rich tradition in astronomy and mathematics.

Even so, serious discrepancies exist in the traditional interpretation of *Āgams* and observations. To resolve these problems, we introduce some current views based on geological, geomorphological, fossil, and chronological records and then compare them with the traditional ideas related to geography, motion of planets and habitable planets given in Jain texts.

To provide a frame work for comparison of Jain concepts with modern theories, we give some basic data about earth and solar system, according to the traditional, prevalent interpretation of Jain scriptures in a series of Appendices at the end of this article. Some relevant aspects of the Hindu cosmology is also included for comparison. The cosmological aspects are discussed separately in an accompanying article (Jain *et al.*) and here we confine to a few specific issues of Jain geography to show that some concepts and data can be, at least qualitatively, reconciled with the observations.

2. Geography according to Jain scriptures

The Jain scriptures describe earth, moon, sun and other five planets (Mercury, Venus, Mars, Jupiter and Saturn)¹ of the solar system, stars (e.g. Swati and Abhijit) and black holes (Tamaskaya and Krisnaraji) etc. and mention possible existence of life, in other *dvîpas*, beyond earth. These descriptions are accompanied with pictorial diagrams, which are difficult to understand. As a case study, we consider here three of these diagrams: Jambudvîpa (Fig. 1), Meru (Fig. 2), and various habitable

1. Perhaps the existence of the outer two planets, Uranus and Neptune was not known at that time since they have not been depicted in these diagrams. They were discovered only recently.

2. For units of space and time, See for example books by Nath Mal Tatia, Muni Kanak Nandi ji, and R.M.Jain and A.Jain (This volume).

planets from Jambu dvipa to Nandishwar dvipa (Fig. 3). If the reinterpretation given here is found to be logical, then it can then be extended to other descriptions and diagrams given in the Agams.

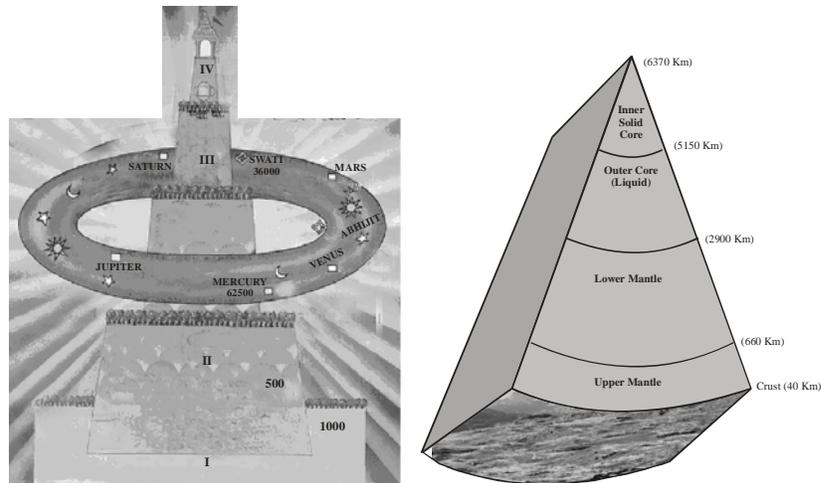


Figure 2: Interior section of the Earth. The symbolic figure from scriptures (left) showing five divisions is compared with the currently accepted section of the earth (right) with five divisions of crust, upper mantle, lower mantle, outer liquid core and inner solid core. The sky is depicted as an annular ring with two suns, two moons, stars (e.g. Abhijit), constellation (Swati) and planets (Mercury, Venus, Mars, Jupiter and Saturn). In our opinion, the conventional interpretation that there are two suns and two moons going round the flat earth, one in the northern part of the disk of the earth and the other in the southern part of the disk is erroneous. Two suns and two moons is the artists way of depicting that the same moon physically revolves around the earth and the earth physically revolves around the same sun. In contrast the planets are shown only once, since they do not revolve around the earth.

3. Geological and Biological Evolution of the Earth

Origin and evolutionary history of the Earth and life on earth has been well established based on isotopic analyses of various types of rocks and study of fossils found in sediment deposits. We discuss some of the relevant data below.

3.1 Geologic History of the Earth

The evolutionary chronology of the Universe, that is time of its formation and

major stages in its evolution are reasonably well documented by observations of black body radiation (corresponding to temperature of 2.7K), astronomical observations as well as theoretical modeling. The Big Bang theory indicates that the Universe formed about 13.7 billion years ago and some of these aspects will be discussed in the accompanying articles (Rangarajan; Jain *et al*). Briefly, our solar system, i.e. the sun and planets started forming about 4.56 billion years ago and the first signs of life appeared on the earth in form of primitive algae about 3.5 billion years ago. We know the way the universe, galaxies, various types of stars and the Sun have evolved since they were formed. Our Solar system, i.e. the sun and the planets, including the Earth, formed due to collapse of a fragment of a cold, dense, rotating Giant Molecular Cloud. The surface and geography of the Earth is not a stable feature but a continuously changing phenomena. The continents and other land-masses were not in the present configuration, but existed as a supercontinent called Pangaea (see Fig. 4), consisting of all the continents which exist now, in a joint single land mass, from about 300 to 180 million years ago. Pangea later broke up into two major continents due to plate tectonics: Laurasia and Gondwana. Laurasia was composed of Europe, North America and Asia, while Gondwana was composed of Africa, South America, New Zealand, Madagascar, India, Antarctica, Arabia, Iran, Australia etc. All of them are moving even now, albeit at a slow rate. By about 100 million years ago, Indian continental plate began to drift northward from its position alongside Africa, and rifts developed in Gondwanaland. The opening between India and Africa gradually became the Indian Ocean. Due to plate tectonics, the Indian Plate split from Madagascar and collided with the Eurasian Plate (China), resulting into the origin and uplifting of the Himalayas about 55 million years ago and it continues to move roughly northwards at the rate of 3 to 5 cm per year even now.

The Earth has been going through cold and hot cycles throughout its history. Several temperature excursions occurred over the earth between 3 million

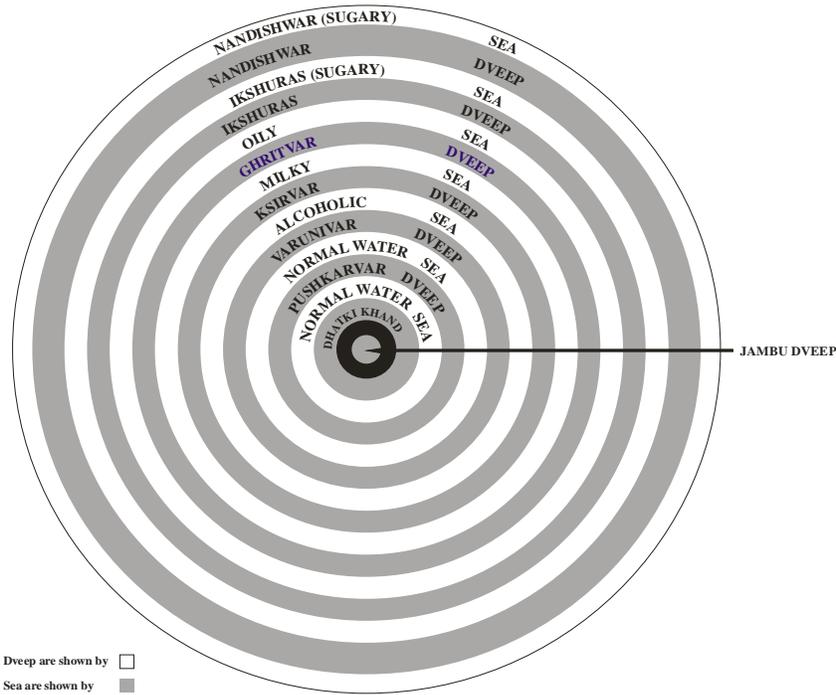


Figure 3: Eight habitable planetary bodies starting with Earth (Jambu dweep) to Nandishwar dweep are shown as annular rings. This has been literally (and erroneously) interpreted as annular geometry of various planets surrounded by annular seas whereas the main purpose of this diagram is to show that the compositions of various types of seas around different habitable planets, made up of salty water around the earth, normal water around two planets (Dhataki Khand and Pushkar dweep), alcoholic sea around Varunivar dweep, milky sea around Kshirvar dweep, oily sea around Ghritvar dweep and sugary sea around Ikshuras dweep. The largest planet is Nandishwar dweep, surrounded by sugary sweat sea. It may be noted that recently some planets with calcium-rich water (appears milky, because of the colour of calcium carbonate), planets and seas containing organic oily-tar like compounds have been discovered. Some planets or satellites (Titan, e.g.) have abundant organic matter and cold temperature so that lakes or seas of methane or ethane or alcohol and around a star Rho Ophiuchi, organic sugars (glycoaldehyde) have been detected. Comets are also known to have alcohols and sugars.



Fig. 4. Pangaea. It was a supercontinent that existed from about 300 to 180 Ma ago. The outlines of the modern continents and other landmasses are indicated in this figure. Pangaea later broke-up to become two major continents; Laurasia and Gondwana. Laurasia was composed of Europe, North America and Asia, while Gondwana was composed of Africa, South America, New Zealand, Madagascar, India, Antarctica, Arabia, Iran, Australia etc. and 14000 years ago, comprising 34 cold periods with intermediate warm periods (inter glacials) of around 10,000 years each (Fig. 6 b). The forests receded during the glacial times, but the climate was favourable for habitation during warm periods. The civilisations began along major river systems around 40000 years ago, classified as Paleolithic (Old Stone age). The humans colonised various parts of the continents during the past 15000 -10000 years BP (Before Present); The New Stone age, with advanced stone tools (Neolithic period) started around 8000 years BP. These dates are based on geological (mainly sedimentary), fossil, climatic records and archaeological excavations. We summarise the fossil records below.

3.2 Fossil records

The history of life on the Earth reveals that life first appeared on the earth about a billion years after the earth was formed. The life, in form of single celled algae (*sthawar*), i.e. prokaryotes began only around 3.5 billion years ago and then, from this common root, all the species belonging to fungal, animal and plant kingdom evolved by Darwinian evolution. The mobile species, which could move from one place to another, originated about 540 million years ago. The period of 490- 420 million years ago was the age of marine fishes, 240-200 million years ago was the age of amphibians and 200- 65 million years ago was the age of reptiles. The forests evolved around 200 million years ago and the flowering plants around 100 million years ago. The mammals mainly evolved during Tertiary period (65- 4 million years ago). The gorilla and chimpanzee diverged around 4-6 million years ago. The early bipeds evolved around 4 million years ago into *Australopithecus* and later into *Hominids*. The members of genus *Homo* successively evolved as *Homo habilis* (2.3 million years ago), *Homo erectus* (1 million year ago), Neanderthals (100,000 years ago) and *Homo sapiens* as modern man (35,000 years ago). The *Homosapiens* used stone tools, and the humans colonised various parts of the continents during 15,000 – 10,000 years B.P. The oldest record of human-like presence on the earth dates back to 3.2 million years in the form of the fossil “Lucy”, with a height of 1.1 meter and weight of 29 kg, found in Ethiopia in the year 1974. Darwinian mechanism of natural selection i.e.struggle for existence and survival of the fittest, seems to have played the key role in the evolution of species from algae to humans over the past 3.5 billion years.

4. Comparison of Jain Geography with Modern Observations

Although many of the above, well established, observations are not mentioned, geography has been given much importance in Jain Agams. We discuss Figs. 1, 2 and 3 here and see if they can be reconciled with the current models based on remote sensing, geologic and fossil records. The traditional interpretation does not agree with the facts but a fair comparison is only possible if the style of representation of various features in these figures, prevalent during that era is understood. In absence of this information, we try to see if, with certain assumptions, they would agree with the observations. This discussion is bound to be speculative and subjective; even so we take the following approach.

4.1 Jambu Dvip

We approach the problem in the following way. Usually, a three dimensional sphere is schematically projected or drawn on a two dimensional sheet of paper as a circle. This diagram (Fig.1), therefore, must not be taken to mean that the Jambu dvip (earth) is a flat disk. We go by the Hindi word ‘*Bhoogol*’, a term used for geography, implying that the ‘*Bhoo* (earth)’ is ‘*gol* (round)’.

Since it is not possible to show both the faces of the spherical earth in one

diagram, it may be that the upper half of the circle represents the front face (western hemisphere) of the spherical earth and the lower half, its rear face (eastern hemisphere) is shown here from the north pole to equator, so that the whole northern hemisphere, rotating around Meru (rotational axis of the Earth) can be depicted in one diagram. Essentially this is an areal, polar view of the earth from above the north pole. The smaller circle represents the Equator and the Bharat Kshetra, presumed to be Greater India, encompasses south china, Tibet, Burma, Thailand, Indonesia, Srilanka, Afghanistan etc. The Bharat kshetra, which borders the equator of the Earth and is surrounded by a salty sea (outer circle), validates this interpretation. The diagram represents six major rivers of the eastern hemisphere and six of the western hemisphere and several mountain ranges. Except for westward flowing Sindhu and eastward flowing Ganga, whose names have survived, the names of other rivers have changed over the millennia with the passage of time. Appendix-1 gives the modern names of rivers corresponding to those given in this diagram. It may be noted that these are all major (longest) and culturally important river groups, although some may have changed their courses during the past few millennia. We can proceed in a similar way and identify the mountain ranges, where except the Indian mountain ranges (Vijayavardh i.e. Vindhyachal) and Himvan (Himalayas), other ranges have to be identified in terms of modern nwmes. If this interpretation is correct, then we can conclude that Sumeru or Meru represents the rotation axis of the earth. Most calculations (e.g. durations of day and night, seasons) in Surya Pannati and Chandra Pannati have been based on observations over high northern latitudes. Thus the Jambu dvipa could be the earth itself or just the northern hemisphere.

4.2 Rotation axis (Meru) and Interior Section of the Earth

We now try to understand Fig. 2, in the light of the above discussion, again ignoring the decorative and religious icons. A ring of planets and stars are shown going round the Meru Parvat. As discussed above, Meru may be taken as the rotation axis of the earth. The cross section along the axis is divided in 5 parts. We compare this figure with the currently established internal structure of the earth. It has five sections: crust, upper mantle, lower mantle, outer core and inner core. These divisions seem to be qualitatively consistent with the sections given in Fig. 2, although the depths or thicknesses of various sections do not agree with their actual thicknesses and location within the Earth. This is partly because linear and areal dimensions are not distinguished in these descriptions. Even so, it is clear that the rotation of the earth was well known in ancient times.

When seen in this perspective, it can be inferred from Fig. 2, where two identical suns and two identical moons (in the same phase) are shown on the opposite sides of the earth, that these represent their apparent orbital paths, as appearing from the front and rear hemispheres of the earth. This should not be taken to mean

that there are two suns and two moons. Moon and sun look identical from everywhere and it does not seem plausible that people who were intelligent enough to correctly invent lunar calendar to a high degree of accuracy, and predicted eclipses precisely, were not aware of the fact that the earth has only one sun and one moon. It may be noted that in Fig. 2, the five planets¹ (Mercury, Venus, Mars, Jupiter and Saturn, marked by squares) are shown singly and not in pairs, like the sun or the moon are shown, to distinguish their orbital paths with respect to the earth. They are shown singly, may be because this is the artist's way of indicating that neither the earth goes around these planets nor these planets go around the earth. This is the way (by showing in pairs or singly) the motion of moon around earth, of earth around Sun, and of planets relative to the Earth has been distinguished in this diagram. By the same logic, some stars like Abhijit and Swâti are also shown singly. These diagrams are not to scale so that the distances measured from such diagrams, say between earth (Meru) and sun or earth and moon and other planets can not be used to imply that the sun is nearer to the earth than the moon² is. Such measurements are therefore erroneous.

4.3 Habitable planets and their compositions

We now consider Fig. 3, which depicts different types of planets (or habitable zones) as we go away from Jambu Dvip. Each land in this figure is surrounded by an ocean (with waters having different compositions), and size of each successive outer structure is depicted twice the size of the immediately previous one. Based on the above discussion of Fig. 1 and 2, it appears unlikely that scholars who wrote the *Āgams* did not know the actual shapes of planets and depicted them as annular in shape. Going by the disk-like structure of Milky way Galaxy, some scholars have proposed that this figure represents our galaxy. This inference can not be true because galaxy is spiral in shape and the approximation from spiral to circles can not be ignored. If so, Fig. 3 probably describes other habitable planets in the suns neighborhood. Some scholars have chosen to consider that this figure represents other planets within the solar system, as we go away from the Earth. In our opinion, this figure represents various types of planets and oceans in the universe, which may harbour life. Be as it may, it is clear that some of these planetary bodies are surrounded by seas of oil (*ghritavar*), sugar cane juice (*ikshu ras*), sweet liquid water, milky liquid, salty water, or wine (*dâru*) etc. Planets with these types of composition (alcohols, sugars, oils and sweet and saline waters) have been recently discovered in the outer solar system. Several spacecrafts have gone near various outer planets which are rich in carbon, hydrogen, nitrogen etc. and planets with carbonaceous, tar like oily substances have been recently discovered, which may justify the name *Ghritvar* (oily) sea. Likewise, Milky looking liquid may be oceans rich in calcium carbonate, which dissolves in water and make it appear milky. Recently some stars and planets, rich in carbon been discovered where under high

pressure, carbon has been converted into diamond. In Agams such diamond earths, besides, sandy, dark and other types of planets also find a mention.

In this context, we mention some recent results obtained by space missions sent to explore outer planets of our solar system. The Galilean satellites of Jupiter, i.e. Callisto, Ganymede and Europa, have been found to have undersurface oceans, some with saline water and Io has abundant sulfur and sulfur compounds. Cassini-Huygens mission of NASA explored Saturn and its satellite Titan (Lorenz and Mitton, 2002). It found that Titan has lakes of hydrocarbons i.e. liquid ethane, methane, and propane and possibly alcohol (Mitri et al, 2007), which may match with the oceans of liquor i.e. 'daru' mentioned in Agams; Cassini spacecraft also made flyby's of Enceladus, the large icy moon of Saturn, and found evidence for undersurface ocean and active water geysers or fountains (Spencer and Nimmo, 2013). Organic matter, found on the outer planets and satellites synthesises into sugars and give rise to sweet sugary oceans, akin to *ikshuras* oceans. NASA's Wide-field Infrared Explorer (WISE) found glycolaldehyde molecules ($C_2H_4O_2$, sugar) around a sun-like star in Rho Ophiuchi, a star-forming region. It is a young star, called IRAS 16293-2422, and is part of a binary (or two-star) system. It has a mass similar to the sun and is located about 400 light-years away in the constellation of Ophiuchus.

We can not justify many numbers mentioned in these diagrams, till we understand what they actually represent, but some attempt has been made by Jeoraj Jain in his book. In this context, it may be noted that the ratio of land area of the Jambudvîpa to the area of its surrounding salty ocean, mentioned as 1:2, seemingly agrees with the earth the land to sea surface area is 1:2.

6. Chronology of the Universe and Jain Kal-chakra (The Wheel of time)

Modern chronology of origin and evolution of the Universe, solar system including various planets, earth and meteorites coming from distant objects of the solar system are well documented based on astronomical observations and precise methods of radioactive dating. Some of these data, going back to 13.7 billion years when our universe originated from the Big Bang, will be discussed below. In comparison the Jain chronology, based on conventional interpretation, is said to be going back to 10^{14} years, about 10,000 times too large compared to the age of the Universe. Jain cosmology is a Steady State cosmology as discussed in more detail in an accompanying article (Jain *et al.*, 2015). It assumes that the universe is eternal, without beginning or end, and has always been, in a gross sense, like as it exists now. However, even in the steady state scenario, there are many cycles of change. One possibility is that the universe is eternal, as Jainism postulates, and the birth of the universe in Big Bang, is but the last cyclic phases, which repeats itself, within the Steady State model. However, based on a number of evidences, we argue below that the age of the universe, mentioned in Jain scriptures, is unacceptable

and, when the units of time and distance are rationalized, it turns out that the Jain kalchakra (Fig. 5) is related to the earth and not to the cosmos; the word cosmic in kalchakra relates to the external (mainly solar) influence on the earth's climatic cycles, and not to the Cosmic cycles of the galaxy or Universe.

6.1 Jain Kâl Chakra

The concept of cycles within a steady-state universe is traditionally termed as the cyclic nature of the universe (Fig. 5) as depicted by Jain wheel of time (*kâl chakra*). It postulates the existence of several cycles operating within a large cycle. One complete cycle is divided into two half cycles, *Utsarpini* (ascending) and *Avasarpini* (descending). Each of these half cycles has a period of 10 *kodâkodi* (KK), the exact equivalent of which in years is uncertain¹, but it is generally (and erroneously) assumed to be very large, and sometimes estimated as 1 KK equal to 10^{14} years. The cosmic cycle keeps on repeating *ad infinitum* and will continue forever. Each of the half cycles is further divided into six sub-divisions (called "Aara"). According to Jain scriptures, we, on the planet earth are presently living in the 5th Aara of the Avasarpini kal which is said to have begun 3 years and 8½ months after the Nirvan of Bhagvan Mahavira (524 BCE). According to the Jain texts, this Kalchakra is said to be applicable only to the Aryakhand of Bharat and Airavat regions of the Loka, implying that it is not a cycle operating on the universe (cosmic cycle) but only related to some part of the Earth. The six sub-divisions (Aaras) have been named according to a "happiness index" (Appendix 3), ranging, during Avasarpini, from Happy-happy to Unhappy-unhappy, implying a gradual change and are probably related to climate (from comfortable to harsh). This sequence reverses in Utsarpini cycle, as shown in Fig. 5. The periods of the various cycles, i.e. Aaras are: 1st cycle - 4 KK, 2nd cycle - 3 KK, 3rd cycle - 2 KK, the sum of the periods of 4th, 5th and 6th cycles is 1 KK. The periods of 5th and 6th cycles are 21000 years each. The traditional explanation of Jain Kalchakra is given in Appendix 3 and also compared with Hindu cycles of Yuga and Mahayuga.

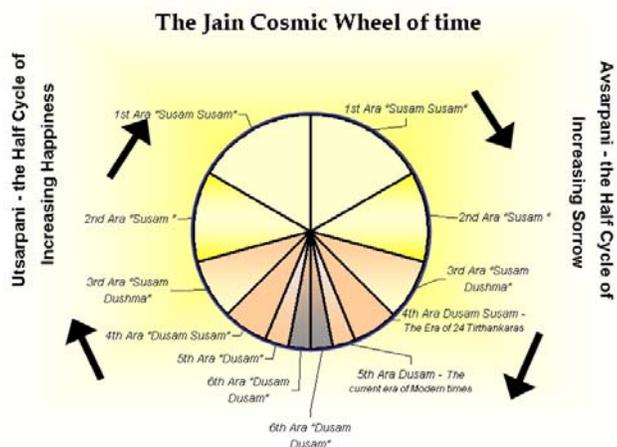


Fig. 5. Jain Kal Chakra depicting ascending and descending cycles, each divided in 6 Ara’s.

Change in the eccentricity of the earth’s orbit (which changes the distance of earth from the sun) which varies with a period between 95 and 400,000 years. The orbital geometry of the earth is shown in Fig 6a and Milankovitch periodicities are shown in Fig.6 b. Although the solar insolation changes slightly with the orbital geometry, the earth’s atmosphere amplifies the effect and the extreme change in temperature ranges between -3 to +3 °C, enough to drive the earth into glaciation and warmer periods, called “interglacials”. These data have been discussed in some detail by Bhandari (2010) and www.jainscholars.com.

The temperature cycles have been experimentally verified by climate markers (isotope ratio of oxygen (Oxygen16/Oxygen18, a proxy for temperature). Oxygen has three isotopes, weighing 16,17 and 18, with respect to hydrogen =1. Oxygen 16 is most abundant and 17 is least abundant. The ratio of various isotopes in a compound, e.g. water depends on temperature of formation. Therefore the rain water has oxygen isotopic ratio which depends on cloud or atmospheric temperature. In the polar regions, precipitated rain deposits as snow and forms ice sheets on Greenland and Antarctica, preserving the time sequence, from year to year and season to season. The deeper layers are older, having deposited in the remote past and the surface regions represent contemporary snow/rains. By determining oxygen isotope ratio in layers of ice in Arctic or Antarctic ice or sediments, one can obtain temperature of the earth at the time of their deposition. These data in such ice or sediment cores show a 100000 year cycle, going through cold glacial and warmer interglacial epochs, as shown in Fig. 6 b. It is possible that the Jain kalchakra cycles

are also climatic cycles, because their names are related to “degree of happiness and unhappiness” (see Appendix 3, Table 1). Happiness may be reflecting comfortable, warm, equitable climate when food productivity increases and “unhappy” epoch may be denoting unfavourable or cold, harsh climate. The sequential degree of changes from happy to Unhappy mentioned in the Jain texts implies that the earth climate changes slowly. It cannot be a mere coincidence that two of the Milankovitch cycles (~21000years) agree with the period of 5th and 6th *āra*. The 100, 000 year climatic cycle, however, does not match with the traditional value of period of 3rd *āra*. N. Bhandari (nbhandari.com) and R. M. Jain (2010) have argued that the period of third *āra* is actually 100000 years and the time unit *kodākodi* used in Jain texts means 100,000 years (see the accompanying article by R.M.jain and A.Jain). A larger, important geological cycle (of probably volcanic periodicities on Earth) is 33 million years.

Appendix -1: River systems mentioned in Jambu Dvip

Table 1. Major Group of Rivers of the world, from equatorial regions (#1) to poleward (#7), corresponding to the daigram of Jambu dvipa (Fig.1).These rivers are shown in the world map below.

Eastern hemisphere			Western Hemisphere	
	Fig.1	Modern name	Fig.1	Modern name
1	Sindhu	Indus	Narikanta	Riogrande
2	Ganga	Ganges	Narkanta	Mississippi
3	Rohitasha	Volga	Rupyakala	Niger
4	Rohita	Huang, Yangtze	Suvarna kala	Nile
5	Harikanta	Amur	Raktoda	Amazon
6	Haritkanta	Rhine, Danube	Rakta Congo	
7	Sitoda	Mckenzie	Sita	Ob

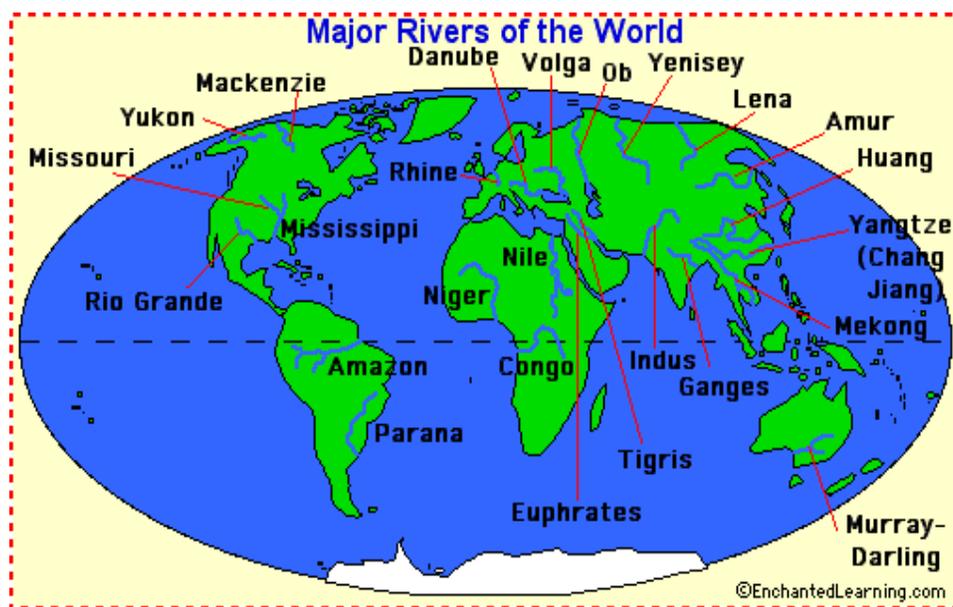


Figure 7. Major river systems of the world.

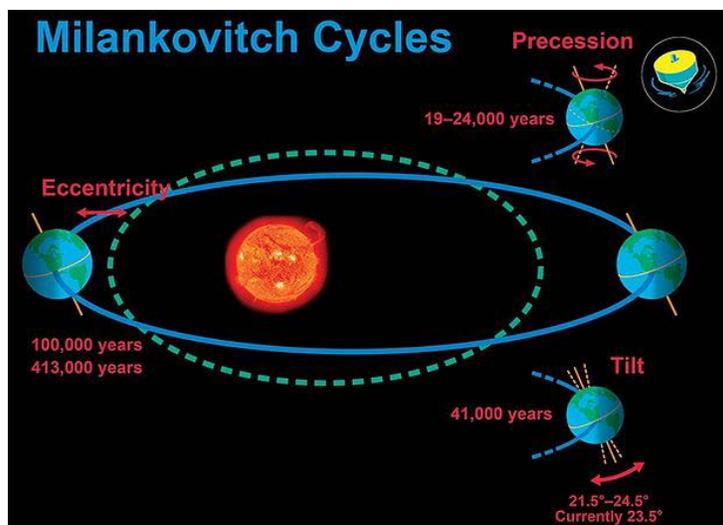


Fig. 6a.

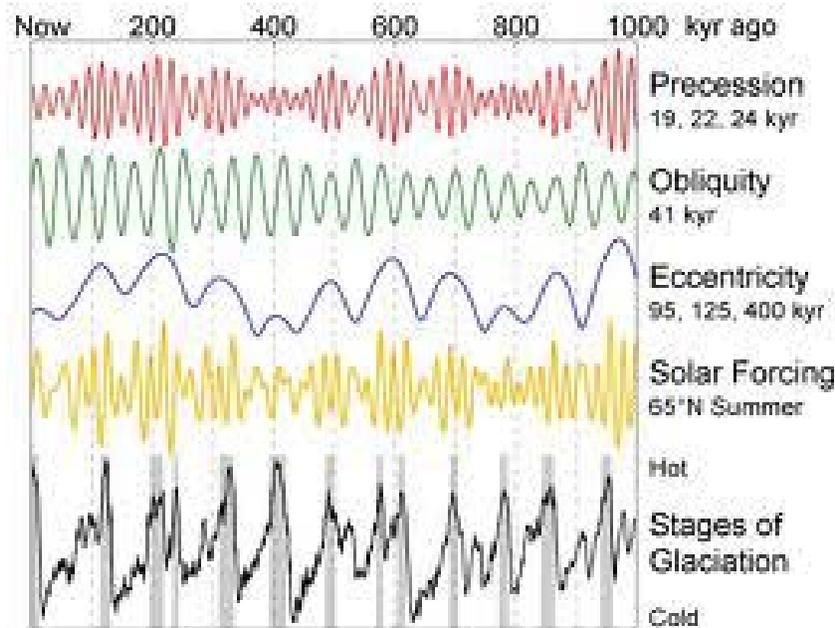


Fig. 6a (top) and b (bottom): The earth's orbital geometry around the sun and the periodicities due to precession (~19000, 22000 and 24000 years), obliquity (41000 years) and eccentricity (95000 to ~400,000 years), and precession (100000 years). The time axis is shown at the top in kilo years. All cycles operate simultaneously, giving rise to a cumulative or composite curve shown at the bottom with 100000 years periodicity. This curve represents glacial and interglacial stages in the ~100000 year cycle. The temperatures are highest at the peak (interglacial) and lowest at the trough (glacial) epoch. The maximum change in temperature is -3 to +3°C. Currently we are at the peak of interglacial epoch (Reproduced from Wikipedia).

6.2 Climatic cycles on the Earth

Modern cosmology finds that cycles with several periodicities are operative on earth. These include climatic cycles, geological cycles and astronomical cycles and cosmological cycles in the order of increasing periodicity. many of these cycles have been established by study of chemical, isotopic and fossil records preserved in sediments collected from sea-beds or ice cores taken from Greenland and Antarctica, which can be used as a proxy for climatic (e.g. temperature) and geological (e.g. volcanic, and impact) events on the earth. Considering only the important ones, there is diurnal cycle, monthly lunar cycle and annual solar cycle. The climate

of the Earth depends on solar irradiance received by the Earth. Milankovitch, a Russian scientist, showed that the solar irradiance received on earth (solar insolation) depends on three cycles, the precession of equinoxes (which changes inclination of the spin axis of the earth) with a period of about 21000 years (being the average of 19 thousand and 24 thousand years when at the aphelion and the perihelion, the northern hemisphere is tilted away from the sun and towards the sun respectively), obliquity of the earth, which also depends on the inclination of earth's axis to the ecliptic (the plane in which earth moves around the sun in its orbit) which changes with a period of 41000 years and The sun moves in the galaxy, up and down from the plane of the galactic disk like a carousel, around the galactic nucleus. The astronomical cycles, i.e. the motion of sun (and the earth) in and out of the galactic plane is about 60 million years and one rotation period of sun around the galaxy is about 250 million years. The sun itself has a life expectancy of about 10 billion years and we are about half way through in its life cycle. Effects of some of these cycles on the earth, particularly their biological effects, have been debated and the 60 million year cycle, mentioned above, has been linked to mass mortality on earth due to impact of material from the galaxy, as the sun moves in and out of the galactic plane. Superimposed on these periods are random events like impact of comets and large asteroids, which can create havoc on life on earth and wipe out a large fraction of the civilisation and most of the species. The impact of about 10 km size planetary body, 65 million year ago, linked to extinction of dinosaurs is one such established event (Bhandari et al, 1994).

7. Concluding Remarks

Although the reinterpretation of the three sketches (Fig. 1, 2 and 3) and Kal chakra taken from the Agams helps us to reconcile them with the current views of the earth' geography, climatic periodicities and possible compositions of habitable planets beyond earth, as described above, it should be considered only as one of the possibilities. There may be other ways of looking at them since some important discrepancies still remain. Alternative possibilities, therefore, need to be explored. We would like to point out some discrepancies in our explanation given above, when compared with Jain texts. Firstly, there is no mention in Agams that Jambudvipa is rotating around Meru (rotation axis of the Earth). Also, only the Jyotishka Loka is mentioned to be rotating around Meru. Hence, this presumption may not be in line with the scriptures. The Mahavideh Kshetra, a region considered to be abode of some enlightened Arhats, is traditionally not considered as part of the Jambu Dvipa. Further the Agams mention some geographical boundaries which humans cannot trespass, whereas our interpretation does not include any such limits. Lastly, the relative positions/heights (distances) of stars, Sun and planets above the Earth (Jambudvîpa) in the texts do not match with the modern findings and ought to be corrected. In spite of these limitations, the current analysis has provided some scientific basis for understanding a few concepts mentioned in Jain Agams.

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Appendix 2: Sun-Earth-Moon system

Some Jain scholars have tried to justify existence of two suns and two moons in the following manner:

A theory of formation of planets postulates that solar system came in to existence when two stars (one of them being our sun) had a close encounter and pulled out material from each other, by their gravitational force, in a cigar shaped mass, which subsequently coalesced into planets. The other star then moved away on its course and it is not possible to identify it now. This theory is no longer in vogue and has been replaced by the theory of solar nebula in which Sun and planets formed from a cold, rotating, dense molecular cloud.

The two moon theory is explained on the basis that the Earth, at times, temporarily captures another satellite as asteroids (or near-earth objects) accidentally which comes too close to it. At present, earth has another companion moon (called object SO16) moving around the earth in a horse-shoe shaped orbit. Such events are plausible and have occasionally occurred in the past. A recent (2011) computer simulation by Jutzi and Asphaug (2011) has shown that the earth indeed had two moons in the beginning, soon after the infant Earth was struck by a large asteroid, which then merged into one Moon in a slow-motion collision. These explanations are meant to achieve an agreement between Jainism and modern observations and were probably not in the mind of scholars who compiled Agams.

Appendix 3: Jain Kalchakra and Vedic cycles

This Jain Kalchakra is the cosmic cycle consisting of two parts, an ascending and a descending half cycle, called Avsarpini and Utsarpini. The Utsarpini follows the Avsarpini and the Avsarpini follows the Utsarpini .Thus the cycle keeps on repeating *ad infinitum* and will continue forever. Each of the half cycles is further divided into six sub-divisions (called "Aara"). These cycles are applicable only to the Aryakhand of Bharat and Airavat regions of the Loka and currently we are in 5th Ara of Avasarpini Kal.

The six sub-divisions (*Aras*) have been named according to a "happiness index", ranging, during Avasarpini, from Happy-happy to Unhappy-unhappy, implying a

gradual change probably related to climate (from comfortable to harsh). This sequence reverses in Utsarpini cycle and the Utsarpini kal also has six sub-divisions in reverse order (trending from Unhappiness to Happiness). The time duration of each sub-division as well as the life span, height and number of bones of human beings progressively decreases (Table 1).

Table: 1. Traditional concept of Jain Kal-chakra (Avsarpini-kal)

Average for Humans

Aara	Name	Period	Height	Age	# of backbones
I	Happy-happy	4 KK Sagaropam	6000 dhanush	3 palyopam	256
II	Happy	3 KK Sagaropam	4000 dhanush	2 palyopam	128
III	Happy-unhappy	2 KK Sagaropam	2000 dhanush	1 palyopam	64
IV	Unhappy-happy	1KK Sagaropam	42,000 yrs.		
			500 dhanush	crore purva	48
V.	Unhappy	21,000 yrs.	7 hath	130 yrs.	28
VI	Unhappy-unhappy	21,000 yrs.	1 hath	20 yrs.	12

KK= Koda-kodi sagaropam (very large time unit), palyopam= medium time unit, dhanush= length of bow, hath= length of human hand (see Appendix 3 and the paper by R.M.Jain and A Jain, This volume).

Vedic Cycles

According to Vedic religion, the life in the universe is created and destroyed once every 4.1 to 8.2 billion years which is one full day (day and night) of Brahma. The cycles are repeated *ad infinitum*. A complete Yuga cycle comprising of Four Yugas: Satya yuga, Treta yuga, Dwaper yuga and Kali yuga following a periodic ratio of 4:3:2:1 (Table. 2). The ages see a gradual decline of dharma, wisdom, life span, stature and physical strength. Kali Yuga, the present period, is estimated to have begun from 20th February, 3102 B.C.

A complete Yuga or Maha yuga is equal to 4.32 million years. One thousand Maha yuga make a Kalpa of 4.32 billion years, which is close to the current scientific estimate of the age of the Earth =4.56 billion years based on radioactive dating.

Table: 2. Hindu cycles of Yuga and Mahayuga- Four Age Cycle.

Yuga Characteristics Duration (years) Stature (height) Age(years)

1. Satya Virtuous (No sin) 4x 432,000 21 cubist 100,000

2. Treta Virtue/Sin(3:1) 3x 432,000 14 cubist 10,000

3. Dwapar Virtue/Sin(1:1) 2x 432,000 7 cubist 1,000

4. Kali Virtue/Sin(1:3) 1x 432,000 3.5 cubist 100

One Maha Yuga 4.32 million

One Kalpa= 4.32 billion years

Appendix 4: Estimation of time and distance units used in Jain texts (following Rajmal Jain, 2011)

The traditional historic units mentioned in Jain scriptures have been redefined based on modern scientific data.

In this approach: Koda = 1000, Kode = 100, Kodi = 10. **Time/ Muhurt:** 1 Day = 8 Prahar, 1 Prahar = 4 Purva / Ghadi. **Length:** Dhanushya= (i) Cross-section of the vessel (bio. scale) = /< 5mm. (ii) Length of 'Dhan' (grain) = 4 – 5 mm.

Appendix 5. History of the earth

Era	Period in years Before present	Brief history (major climate, culture and landmarks)
Quaternary	15,000 -10,000	Climate cool-warm-cool. Colonisation of Modern humans, Development of farming culture.
	18,000-15,000	Little Ice Age.
	40,000 - 18,000	N. hemisphere under snow. Forests recede.
	35,000	Civilisation began along major River systems. Development of fully modern humans, <i>Homo sapiens</i>
	120,000-40,000	Development of <i>Neanderthal</i> people with larger brain size, strong and powerful.
	500,000	Primitive man capable of planning and hunting.
	1.8 - 0.2 million	<i>Homo-erectus</i> flourished.
	1.0 million	Development of <i>Homo erectus</i> .
	2.5 - 2.0 million	Old Stone Age. Development of <i>Homo habilis</i> .

	3.14 million	Fossil 'Lucy' found in Ethiopia in 1974.
	4.0 - 3.0 million	Warm temperate climate. Forests start receding.
	4.0 million	Evolution of <i>early bipeds</i> .
Tertiary	65- 4.0 million	Age of Mammals.
65- 4 m.y	45- 40 million	Tethys sea closed.
	55 million	Origin of Himalayas.
Mesozoic	100 million	Indian Continental Plate began to drift northward.
250- 65 m.y.		Evolution of Flowering Plants.
	200 million	Evolution of Forests.
	200- 65 million	Age of Reptiles.
	240- 200 million	Age of Amphibians.
Palaeozoic	490-420 million	Age of Marine fishes.
750-250 m.yrs.	540 million	Origin of Mobile species.
Pre-Cambrian	3.5 million	Beginning of life in the form of Algae.
4.5 b.y.- 570 m.y.		
	4.54 billion	Formation of the Earth.
	4.56 billion	Formation of the Solar system.

Appendix 6. Time cycle based on Forest ecosystem

In pre-historic times the “Kalpvriksas” (the benevolent trees) were capable of giving all that is required in fulfilling the needs of all human beings, animals and other life forms. This period may be considered as the 1st Aara (Happy-happy) of the planet earth.

In natural forest areas all life forms live in harmony and are symbiotic with mutually cooperative relationship. The carnivorous animals, birds, insects etc. mainly work as scavengers in nature, the waste converted into manures directly. In forest eco-system, the population of all life forms remain optimum matching the availability of food.

When the greedy man started over-exploitation of nature beyond its capacity,

the damage and degradation of mutually sustained eco-systems began. That's how the regression i.e. the good to bad trend begins. It represents various Aaras of the Avsarpini-kal as described in Jain scriptures. This downward trend continues with the degradation of forest eco-system, increase in pollution and decrease in the moral values of human beings.

The history of the earth indicates the evolution of early bipeds (Neanderthals), warm temperate climate and fully developed forests around 4 million years ago. That period marks the perfect symbiotic conditions on the earth and can be considered to be the beginning of 1st Aara of the Avsarpini-kal on the earth. Similarly, the period and duration of subsequent Aaras have also been computed and given in Appendix 3, Table 1.

Appendix 6, Table: 1. Trend of Avsarpini-kal in relation to the Planet Earth

Aara Appx. Period B.P./ (duration) in yrs. Brief description

I 4–1 million (3 million), People very- very happy. Perfect symbiotic conditions. All needs fulfilled by “Kalptarus”. Plants and animals cause no harm to each other. Even carnivorous animals act as scavengers. Air, water and soil in purest form.

II 1 million to 200,000 (800,000) People by and large happy. Slightly degraded stage. Increase in population. Pressure on natural resources. Early Old Stone Age.

III 200,000–15,000 (185,000) People partially happy. Decreasing natural resources. Rapid evolution of modern human culture (50,000 years B.P.) Beginning of farming culture (15,000 B.P.). Period of Bhagwan Rishabhdev around 14,000-15,000 years B.P.

IV 15,000 – 2,500 (12,500) People more unhappy. Forests suffer onslaught because of expanding agriculture, Period of 23 *Thirthankars*.

V 2,500 to Present, People by and large unhappy. Regular decrease in Moral values. Advances in Science and Technology but regular decrease in natural resources and increase in Pollution.

VI ?? People very-very unhappy. Worst living conditions. Exhaustion of natural resources, destruction of Forests and trees. Highly polluted environment, acidic rains etc.

The beginning of 1st Aara, also somewhat corresponds with the beginning of Satya yuga of Vedic religion (Appendix 3, Table: 2). The later part of Dwapar yuga may be considered to be the period of the first 23 *Thirthankars* and the beginning of Kali yuga to be the period of Bhagwan Mahaveer.



Dr. Jeoraj Jain, Ph.D. Engineering (Dr.-Ing.) from Germany. Worked with Tata Motors and as Technical and Investment Consultant Recipient of National Award in Fabrication Technology. He has several Technical papers to his credit. Research involves structure and quality of water. Authored several books. Proposed a theory of life without DNA and RNA and a theory on the mechanism of characterization of water. Developed a new code to decipher the ancient Lokakash maps.



Professor NARENDRA BHANDARI (Ph.D., Physics). Research in Planetary and Space Sciences, Tata Institute of Fundamental Research, Mumbai, University of California, San Diego, and Physical Research Laboratory, Ahmedabad. Studied moon samples brought by Apollo and Luna missions of NASA and USSR. Made pioneering contributions to India's first Mission to Moon, Chandrayaan-1, Member, Moon Mission Task Force, Science Advisory Board of ISRO and Mars Orbiter Mission. Elected President, International Lunar Exploration Working Group (2005-2007). Awarded Outstanding Achievements Award of ISRO, Vikram Sarabhai award in Planetary and Space Sciences, National Mineral Award of Government of India and Special Certificate of NASA. Authored several books: Planetary Science; Jainism: Over 250 Research papers.



JINENDRA K. SURANA, M.Sc (Geology) Univ. of Rajasthan. Formerly Superintending Hydrogeologist, Government of Rajasthan; State Engineer, Algeria, Member, Science Study Centre, Udaipur, Scholar of Jain philosophy.