Galactic Encounters, Apollo Objects and Atlantis:

a Catastrophical Scenario for Discontinuities in Human History

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Dedicated to the memory

of my my late uncle, dr. Umberto Risso.

He led me to scientific investigation.

Summary: Recent findings about interactions of the Earth with extraterrestrial bodies, particularly comets and Apollo-like objects, are reviewed, with special attention to climatological effects. We discuss the hypothesis that the last glaciation was started by a collision over a continent and was terminated by a collision over an ocean. We propose that during the glaciation sufficiently good climatic conditions in the lower latitudes made possible for mankind to develop a high level of civilization. The Platonic story of Atlantis is interpreted as an essentially correct description of a political power active in the final period of the last glaciation. Arguments are given to identify the island of Atlantis with Hispaniola. The catastrophe which destroyed the Atlantis civilisation is identified with the oceanic collision which terminated the glaciation. In this framework we also propose a new interpretation of the flood stories in the Bible and in the Gilgamesh epics, and of the origin of the Camunian civilisation.

1. Introduction

The idea that collisions between the Earth and celestial bodies have occurred in the past and have been responsible for dramatic geological and biological effects, including orogenesis and destruction of many species, was commonly accepted until the nineteenth century (see Whinston [1] and various statements in Laplace). In the second half of the last century, due mainly to the influence of Lyell in geology and of Darwin in biology, the concept of slow evolution by exclusively terrestrial mechanisms became dominant. In the early Fifties of this century Immanuel Velikovsky, drawing upon immense erudition, fought a lonely battle in favor of catastrophism of extraterrestrial origin. He not only invoked great catastrophes to explain geological features, but claimed that relatively minor catastrophes occurred in historical times, in particular in the first two millennia B.C. He related events like the plagues of Egypt and Sennacherib's army destruction under the walls of Jerusalem to natural catastrophes in the course of a great work [3, 4, 5, 6] aimed at synchronizing the traditions of Israel with the history of the neighbouring peoples. This work led him to propose a substantially revised chronology of Egyptian and related histories.

While this is not the place to discuss the historical revision proposed by Velikovsky (that errors of centuries affect Egyptian chronology, upon which the chronology of the other ancient peoples is based, has now been claimed by astronomers as Clube and Napier [7] and by several historians, see for instance Bimson [121], James [122] and Rohl [123] or, for a more radical chronological revision, Heinsohn [136,137]) we have to observe that the extraterrestrial bodies which are now considered to be the main agents of the catastrophes, say the Apollo objects, were unknown to Velikovsky. Indeed, even if the first Apollo was discovered in 1932, in the Fifties the existence of such objects went practicallyunnoticed in the scientific community and no attention was paid by the astronomers to the question of their possible collisions with the Earth.

Drawing upon astronomical information from mainly Babylonian sources, Velikovsky [8] was led to attribute the origin of the terrestrial catastrophes to interactions with Venus and, to some extent, with Mars, planets which he claimed to be recent offsprings of Jupiter and Saturn. There are substantial arguments against this hypothesis, to which Velikovsky was in some sense forced in absence of the type of information that we now possess. A remarkable explanation of the special role of Venus and Mars in Babylonian records has now been given by Clube and Napier [7], in terms of orbital periods commensurability between these planets and the comets Hencke and Halley.

The hypothesis however that the orbits of the planets have changed during the period when Homo Sapiens has been living on the Earth, variously estimated from several thousand years to possibly more than one million years, cannot be completely discontinued, due to the recent discovery of the chaoticity of the planetary orbits, implying the possibility of very rapid changes with possible catastrophic effects. The so called polar planetary model, developed mainly by Talbott [124] and coworkers publishing in the journal Aeon, but going back to still unpublished work of Velikovsky, assumes that during man memory the planetary system passed from a previous configuration, related to the golden age, where Sun, Earth, Mars, Venus and Saturn revolved in an aligned configuration, to the present one via a catastrophical collapse of the previous configuration. For a study of the equations defining the polar configuration see Grubaugh [125], Spedicato and Huang [126], Spedicato [141].

In the Seventies sufficient information was collected about Apollo objects and the cratering history of the Earth and the Moon to arise again interest in the collisional hypothesis, and to give it a sound scientific basis. Possibly the first work to divulge the importance of the Apollo objects as agents of catastrophes was Wetherhill's article [9] on Scientific American in 1979. While already in 1979 Clube and Napier [10] independently rediscovered the terrestrial catastrophism of Velikovsky on the new basis of Apollos and comets impacts, in 1980 worldwide attention was given to the claim of Alvarez et al. [11] (but see also Ganapathy [12], Smit and Hertogen [13], Hsu [13] and, for a different view, Officer et al. [84]) that the disappearance of the dinosaurs 65 millions years ago was due to a collision with a large extraterrestrial object. The claim was based upon geological traces attributed to the impact which are found in a narrow layer of deposits marking the separation of the Cretaceous and the Tertiary geological sediments. The layer contains an unusually large amount (hundred of times greater than normal, around 10^5 tons of iridium) of minerals, like iridium, which are rare on the Earth, but common in extraterrestrial objects, like meteorites, and in interstellar dust. It was also found, see Wolbach, Lewis and Anders [78], that the layer contains a high amount of graphitic carbon, presumibly due to worldwide fires triggered by the heat wave associated to the impact. The total amount of carbon is such that much of the world vegetation and part of the surface deposits of fossil fuels must have been ignited.

The location of the impact is now considered to be the so called Colombian basin, extending partly in the Caribbean Sea and partly in the Yucatan peninsula. Here a 300 km diameter buried crater, the Chicxulub crater, has been found surrounded by huge ejecta deposits, see Hildebrand and Baynton [79]. In the past other locations had been considered, including Ireland, the Manson crater in Iowa and a location close to Cuba, see Bohor and Seitz [80].

Theoretical work by Clube and Napier [7, 10, 14, 15, 16, 17], following the discovery of molecular clouds (see Cohen et al. [18] or Edmunds and Solomon [19]), has nowput catastrophism in the fascinating and far reaching scenario of birth, evolution and death of planetesimals and cometary bodies. Numerical and experimental work on the effects of collisions has been performed by many authors, giving useful quantitative information. It will take however long to obtain a definitive picture, in view of the extreme complexity of the nonlinear phenomena under consideration.

Even more "exotic" catastrophical extraterrestrial agents have recently been considered. They include:

1 - Fargion and Doron [142] have argued that the remote solar system space between the Kuiper belt and the Oort cloud has a significant population of planets with sizes between the Earth and Jupiter. The perihelion of these planetsis close to the Sun and their orbital period is of several million years. When approaching the perihelion they may pass close to the Earth with catastrophical effects due to tidal effects. They may also be captured bythe Sun and may have contributed to over 3% of its mass. Fargion andDoron do not discuss however the possibility of a close passage during Homo Sapiens time (i.e. in the last few hundred thousand years).

2 - Dar, Laor and Shaviv [143] have considered the possibility that the solar system would occasionally cross the very high energy jet produced by the collapse of a neutron binary system, an event that at thepresent known scale of the Universe appears to happen about once a day (as indicated by sudden bursts of ? rays that have been associated to the event). The jets are expected to reach distances of a few hundred light years before disruption. Their crossing by the Earth would take a few weeksduring which period bombardment by high energetic particles (particularly muons produced by secondary reactions in the atmosphere) would affect life even at great depths in the oceans and in the soil. The event would be able therefore to explain the "big five" mass life extinctions in the last 600 million years. However one cannot see how it would explain the special geological features that are also associated with the extinctions.

3 - Collar [144] and Abbas et al. [145] have considered the passage of the solar system through one of the clumps of the dark matter that many cosmologists believe must exist in order to explain otherwise impossible dynamical phenomena in galactic and extragalactic systems (but see Van Flandern [146] for an approach where dark matter is not needed via reinterpretation and modification of the Newton gravitational law). The crossing of a dark matter clump would lead to absorption of dark matter by mainly the Earth nucleus, whose temperature would substantially increase. This extra thermal energy would finally escape to the Earth surface after an estimated period of 5 million years, in the form of huge venting of magma. The quoted authors hypothesize that this is the reason of the huge magma fields that are known as the Deccan and the Siberian traps, extending over hundred of thousand of square kilometers. They also notice that during the relatively short time of the clump crossing, estimated at a few years, also living beings would absorb some dark matter with very likely carcinogenic effects. The proposed mechanism would therefore explain the fact, that now seems well proven, see Stanley and Yang [147] or Benton [148], that the greatest mass life extinctions show two peaks, separated by some 5 million years.

4 - From the observation that all last five big extinctions happened while the solar system was crossing one of the spiral arms of our galaxy (the solar system crosses all arms of the galaxy in about four of its revolutions around the galaxy, since it has a proper velocity of about 70 km/sec with respect to the arms), Leicht and Varisht [149] have proposed, in addition to impacts whose likelihood is known to be much higher when crossing a galactic arm, catastrophical effects due to the passage in proximity of a supernova, supernovas being much more frequent inside spiral arms.

In this paper we shall review the state of knowledge on Apollo objects and comets as agents of catastrophes, disregarding the previously considered galactic catastrophical events, whose occurrence is certainly much less frequent and most probably can be disregarded in the context of the holocen period. We shall describe the main features of the aftermath of an impact, in particular the effects on the climate. We shall propose that the last glaciation was initiated by a continental impact and was terminated by an oceanic impact. We shall then argument that a civilisation, the "Atlantis civilisation", flourished towards the end of the glaciation in the lower latitudes to be suddenly destroyed in the aftermath of an oceanic collision. Information about this civilization is contained in Plato's Timaeus and Critias. Platonic details about Atlantis will be discussed, showing that they can be accepted as plausible and that they lead to a precise identification of the Atlantis location.

Arguments will be given to explain in the framework of an oceanic collision the biblical story of Noah and the Sumerian story of Utnapishtim. These stories will be considered as describing the aftermath of an oceanic collision experienced at two different locations, probably not the same collision that terminated the Atlantis civilization. Finally, a tantalizing hypothesis will be offered on the origin of the unique Camunian civilisation.

2. Apollo objects and comets

The name Apollo is applied to a class of asteroid-like objects, whose perihelion lies inside the orbit of the Earth (see Krinov [20] or Watson [21] for a general presentation of these and similar objects). The first Apollo was discovered and given this name by Reinmuth, in 1932. In 1937 a similar object, named Hermes, passed at only 800.000 km from the Earth. Over one hundred Apollos of diameter at least one kilometer are presently known. Some of them have a diameter over ten kilometers. The first object in this class of large Apollos was discovered in 1978 and named Hephaistos. There is an object (Amor object 1036, also named Ganymed) with a diameter close to 39 kilometers. The best studied Apollo is Toutatis, which on 8 December 1992 passed at just 0.0024 astronomical units, i.e. 9.4 lunar distances, from the Earth. Toutatis has a potato-like form, like comet Halley, principal axes of km 1.92, 2.40 and 4.60, almost homogeneous density, perihelion at 0.92 AU and eccentricity 0.63, see Ostro et al. [115] and Hudson and Ostro [116].

The search for Apollos goes on actively, quite a number of them having been found in 1983 using the satellite based IRAS telescope. The number of Apollos with a diameter of over one kilometer is estimated to be at least one thousand, with possibly more than one hundred concentrated in the Taurid-Arietid meteor stream.

Various proposals have been made about the origin of the Apollos. A study by Hartmann [22, 23] of the ages of the craters in the solar system, particularly in the Moon, whose craters are attributed to impacts with Apollo-like objects, has shown that, apart from superimposed fluctuations, the rate of cratering has been essentially constant in the last three billion years. However it was thousand of times higher when the first rocks were formed some 4.5 billion years ago. This observation suggests that a large number of Apollo-like objects were formed coevally with planets in the condensation of the primeval nebula, the process which according to most theories led to the formation of the solar system. However most of the original Apollos have by now disappeared in collisions with planets and their satellites. The present population must be essentially formed by new Apollos, which are generated in some way to compensate the loss of older Apollos in collisions with planets and the Sun.

One of the possible sources of Apollos is the asteroid belt, from which asteroids can be expelled into Apollo orbits through gravitational perturbation by Jupiter; also fragments of asteroids can be injected into Apollo orbits after impacts with comets or other bodies in the same belt. Numerical considerations on the size of the present Apollo population and on the possible rate of replenishing from the asteroid belt indicate however that this source is inadequate, albeit the problem is still not completely settled (Whetherill [24], [120]). Degassed comets or fragments of comets are presently considered to be the main source of the Apollo population.

A general theory on the formation and evolution of comets up to their catastrophic end in collisions with larger bodies has been developed by Clube and Napier [7, 14, 16] and other authors (e. g. Yabushita [25], Napier and Staniucha [26]). Here we synthetize the theory by main lines:

- Comets, together with meteorites and dust grains, are formed in the huge (up to one million solar masses or more) cold molecular clouds found in the galactic spiral arms and in the galactic plane, through a process of accretion, which can also lead to the formation of planets and stars.

- Apart from a marginal number of comets whose orbits lie in the region of the planets, most of the comets of the solar system are supposed to belong to two main populations:

A - the Kuiper belt, estimated to consist of about 10^{12} bodies at a heliocentric distance of some 10^4 A.U. The existence of the Kuiper belt, about which many doubts were voiced till not long ago, seems now to be confirmed by the discovery of bodies belonging to it of sizes up to 600 km, see [150]. Many astronomers now deem that Pluto is a body that was removed not too long ago form the Kuiper belt and at the beginning of 1999, in correspondance with the fiftieth anniversary of Pluto discovery, there was serious discussion in Internet whether it should be removed from the official list of the planets. The removal of Pluto from the much farther away Kuiper belt into its present orbit can be explained by several processes, in particular by special tidal gravitational effects, as shown by Del Popolo and Spedicato [151]

B - the Oort cloud, whose existence is still hypothetical, see for instance Van Flandern [146], consisting of possibly 10^{14} comets in highly elongated orbits (spanning up to 50.000 astronomical units, say half the distance to the closest star), with periods of a few million years. While the traditional view of the origin of the Oort cloud, see Oort [27], considers it to be coeval with the solar system, Clube and Napier claim that only a marginal portion is left of the primordial cloud, most comets having being acquired after the solar system was formed, through the following mechanism. The solar system is known to orbit around the galactic center with a period of about two hundred million years and an average speed of about 230 km/sec. The orbit has a component perpendicular to the galactic plane which is crossed up and down about every 30 million years. During its movement the solar system crosses also galactic arms, which are populated by molecular clouds, often arranged in numerous groups. The last crossed galactic arm was the Orion arm, which contains molecular clouds in the Gould belt. The time of the crossing is no more than five-ten million years ago, possibly much less if deceleration effects on the solar system are taken into account. While crossing a galactic arm or the galactic plane, there is a significant probability to pass through or very near to a molecular cloud. In such a case the solar system undergoes a strong gravitational perturbation, the effect of which is twofold. First a large part of the comets in the Oort cloud lying outside a radius of some 10^3 astronomical units are stripped away. Secondly, on leaving the molecular cloud, the Sun captures a number of planetesimals from the cloud itself. As the solar system has crossed molecular clouds many times since its formation, most of the primordial comets have been lost, hence the majority of the comets in the Oort cloud are now of interstellar origin. Moreover the periodicity inherent in the crossing of the galactic arms and of the galactic plane becomes reflected in periodicities (cycles of 200, 60, 30 million years) of events in the inner solar system. Such cycles have been observed on the Moon and on the Earth in events like cratering rate (see Grieve and Dence [28], Rampino and Stothers [29], Alvarez and Muller [30]), magnetical reversals (see Doake [31]), geological boundaries, principal plate movements and glacial ages (see Mc Crea [32]), biological extinctions (see Mc Crea [32], Fischer and Arthur [33], Raup and Sepkoski [34]).

- The number of comets in short period orbits is small and their orbits are generally dynamically unstable due to gravitational perturbations by the planets and mass variation following degassing and fragmentation. The life of a comet in short period orbit as an object which can produce a shiny tail when approaching the Sun (active comet) is only of a few thousand years; after this span of time the degassed comet becomes a new member of the population of the Apollos (or of other similar bodies, like the Amor objects). Evidence of this evolution is seen in comet Encke, whose orbital parameters and luminosity have drastically changed since it was first observed; comet Encke is currently considered to be on the way of becoming a new Apollo. Conversely, the large Apollo object Hephaistos has orbital parameters very similar to those of comet Encke. It is currently supposed that both Hephaistos and Encke are fragments of a larger comet which fragmented not long ago. The limited life of short-period comets implies that a replenishing source must be active. The Oort cloud itself appears to be the required source, through the following mechanism (see Everhart [35, 36]). When a comet of the Oort cloud approaches perihelion, it becomes subject to gravitational perturbation by the larger planets. Numerical simulations, see Yabushita [25], show that in most cases the effect of the perturbation is to inject the comet into a hyperbolic orbit, therefore expelling it from the solar system. In a few cases however the orbital parameters can be changed into those of intermediate period comets (those orbiting beyond Saturn), which evolve later into the short-period orbits and finally into the (relatively stable) Apollo orbits.

- When a large comet (say of diameter greater than 100 km) is captured from the Oort cloud, the resulting evolution presents various and complex features. Episodes of fragmentation into smaller comets and boulders are expected. One cause are tidal stresses due to Jovian gravity which can destroy any body in certain size and material strength intervals. Another cause may be exothermal reactions in the interior of the comet due to chemical reactions or phase transition (at 153 K the ice structure changes from amorphous to crystalline liberating energy). The result of these fragmentations (which apparently are often observed in the sky as a sudden flaring, followed by the discovery of a new comet) is that there is an accumulation of smaller active comets, of Apollos, of boulders, of dust and gases (the mass of these up to half the mass of the large captured comet) along an ellipsoidal torus, with angular concentrations, spreading with time, along the directions corresponding to the fragmentation episodes. Experimental data from zodiacal light, interplanetary dust, the distribution of meteor streams and fireballs, the structure of the orbits of the Apollo and the short-period comets, have led Clube and Napier [7, 17, 81, 82] to the following conjecture: a large comet (100-200 km diameter) has been captured some 20.000 years ago, has undergone fragmenting and degassing phenomena and in the course of these has dramatically interacted with the Earth. In particular it has been responsible for the last glaciation and for minor catastrophes in the last millennia, including those attributed by Velikovsky to an extraterrestrial agent. Clube and Napier suggest moreover that a yet undiscovered large fragment (diameter around 30 km) of the original comet is orbiting along the torus; tentative orbital parameters which could lead to its observation are estimated. It is finally predicted that in a next future (around the year 2030) the Earth will cross again that part of the torus which contains the fragments, an encounter that in the past has dramatically affected mankind.

We conclude this section with a reference to alternative theories. Whitmire and Jackson [37] and Davis et al. [38] assume the existence of an unseen companion of the Sun, named Nemesis, of the size of a black dwarf, with an orbital period corresponding to the observed 30 million years cycle in the biological extinctions. On approaching perihelion Nemesis would gravitationally perturb the system of external comets, producing effects similar to those previously described in connection with the crossing of molecular clouds.

Whitmire and Matese [85] and Van Flandern et al. [86] postulate the existence of a tenth planet beyond Pluto, named planet X, which could produce the considered periodical cometary perturbations by gravitational effects on a belt of comets lying beyond Neptune. Finally, Van Flandern [146] has presented several substantial arguments in favour of the explosion of a planet in the region of the asteroid belt a few million years ago, a proposal originally considered by many authors in the past but not with the wealth of arguments given by him. Such an explosion, in addition to explaining the formation of the asteroid belt itself and several other features of the solar system, would have led to the formation of a large number of cometary bodies, many of them evolved now into Apollos.

3. Collisions of Apollos with the Earth: transient effects

As the perihelion of the Apollos lies inside the orbit of the Earth, it follows on precession reasons that the Apollos will periodically cross the orbit of the Earth. On the average, the frequency of the event for a given Apollo is one crossing every five thousand years. Of course, orbit intersection does not necessarily mean impact, as the Earth will generally be far away when the Apollo crosses its orbit. However, there is a finite probability of an impact, readily estimated at 5^{-9} per year per single Apollo. This probability implies an average lifetime for the Apollos of two hundred million years, which is reduced to thirty million years if impacts with other planets are considered, and to about fifteen million years if impacts with the Sun are considered, an event which only recently has appeared to be possibly the most common fate for such objects, see Farinella et al. [117].

With an estimated population of 2000 Apollos of at least one kilometer diameter, it follows that more than nine impacts with such objects are expected on the average every one million years. If the estimated distribution of Apollo sizes is taken into account, the impact with a larger Apollo, say of ten kilometer diameter, is expected every 50-100 million years. On the other hand, impacts with smaller bodies (say 100-200 meters diameter) are expected every few centuries. See Spedicato [106] for arguments that a super Tunguska impact occurred on the Pacific Ocean close to year 1178. If close fly-bys are considered, then every century an Apollo of at least one kilometer size is expected to pass closer than the Moon, an observation that led NASA, see [39], to plan a rendez-vous between an Apollo and a TIROS satellite.

Impacts with active short-period comets are similarly possible. However the number of such impacts is expected to be a small fraction of those with Apollos, since there are much fewer such comets than Apollos.

The last known large body which impacted on the Earth was the famous Tunguska object. On June 30, 1908, at 7.17 a.m., a great explosion occurred in the sky over the basin of the Stony Tunguska river in central Siberia. The explosion was heard in a radius of about one thousand kilometers; a column of fire arose from the ground to an estimated height of 20 km and was visible 400 km around. Trees were destroyed and burnt, in a peculiar way, over an area of ten thousand square kilometers. Before the explosion, a bright trail was observed in the sky over western China. For many following nights the sky was unusually luminous over Europe and western Asia, allowing to read newspapers without the help of artificial light. Due to the remoteness of the affected area, the first scientific exploration in situ was made only in 1927 by the soviet geologist Kulik. No visible fragments of the exploded body were found locally, the object having apparently vaporized in the atmosphere. Later accurate field work uncovered from the soil peculiar black and shiny metallic spheres. Numerous small shallow craters 50 - 200 meters diameter were found, see Hughes [87]. The metallic spheres have shown a typical extraterrestrial high content of iridium, nickel, cobalt and other metals. Analysis of Antarctic ice cores by Ganapathy [40] has similarly shown that an unusually high content of iridium and other metals is present in the layers corresponding to the year 1912 with an uncertainty of two years; a natural interpretation is that the Antarctic iridium was deposited after worldwide stratospheric diffusion of the vaporized debris of the Tunguska object. From the Antarctic data, a global fallout of 7 million tons has been estimated; assuming that the exploded object was of the carbonaceous chondritic type, its size would have been about 160 meters. However, there is still much uncertainty about the composition and the size. For instance, Turco et al. [41] assume that the body was a loose collection of particles of dust and ice (as most comets are supposed to consist), with a density of 0.003 g/cm^3 , a mass of 3.5 million tons, and thus a diameter for spherical shape of 1.3 km. From the estimated orbital parameters (speed 40 km/sec, approach angle 30 degrees) the object could well have been a fragment of comet Encke. The energy corresponding to Turco's data is 1.4? 10^{25} erg, approximately the same liberated in the explosion of five hundred hydrogen bombs of one megaton (500 MT); the energy corresponding to Ganapathy's data would be 1000 MT. Estimates as low as 10 MT or 30 MT have also been given (Ben-Menahem [103], Deacon [104]), while La Violette [105] again argues for energies in the range 250 - 1000 MT. An important effect of the Tunguska atmospheric explosion, analyzed by Turco et al., may have been the production of large amounts of nitric oxide (up to 30 million tons), leading to a strong depletion (30%) of the stratospheric ozone.

While the overall effects of the Tunguska event were negligible (but had the impact occurred a few hours later, it would have brought havoc in Europe), impacts with more energetic Apollos are expected to have dramatic consequences on the biosphere and the lithosphere. The description of these effects cannot be quantitatively accurate, due to the extreme complexity and nonlinearity of the phenomena. The effects depend on many factors, including the composition of the Apollo (whether chondritic, metallic or icy), the kinetic energy (proportional to the mass and to the square of the velocity with respect to the Earth; this can vary between 15 km/sec to over 70 km/sec with an expected value around 25 km/sec), the approach angle and the location of the impact (in particular whether continental or oceanic).

For sake of exemplifying, we shall consider an Apollo object of "typical" parameters, say diameter 1.4 km, chondritic density 3.3 g/cm^3 and relative speed 25 km/sec. The energy of this object would be about 3? 10^{28} erg, about the same liberated in the explosion of one million hydrogen bombs of one megaton 10^6 MT). This energy is comparable with the energy liberated in the largest historically observed earthquakes 10^{25} erg, with the yearly average earthquake budget 5? 10^{25} erg) and with the total heat flow from the Earth 1.8? 10^{28} erg). Impacts with larger Apollos (around 10 km diameter) would have energies in the billion MT range, their frequency being O(10^8) years. Even impacts with energies in the trillion MT range could have occurred in the Earth history, probably in the first 1.5 billion years since solidification of rocks, when the Apollos population, as estimated from the frequency of Moon cratering, was several orders higher than now.

Let us now consider, at least qualitatively, the effects of the impact with the hypothesized "typical" Apollo. Of the available energy, only a few per cent would be spent in the atmosphere, punching an almost instantaneous hole and creating a heat and pressure wave. The ablation effects of the atmosphere would be negligible and the Apollo would reach the surface of the Earth with almost unchanged mass and velocity. The heat and pressure wave created in the atmosphere would propagate outwards at tremendous speed, with lethal effects in a radius of hundred of kilometers. For a larger Apollo with energy in the billion MT range the atmospheric disturbance would be colossal and extended over hemispheric areas. For instance it can be estimated, if ten per cent of the initial energy goes into the blast wave, that at 2000 km from the impact point the wind velocity would be 2400 km/h, with a duration of 0.4 h, and the air temperature would increase by 480 degrees. At 5000 km the velocity would be 400 km/h, the duration 0.8 h and the temperature would increase by 60 degrees. At 10.000 km these numbers would be respectively 100 km/h, 14 h and 30 degrees. Additional effects in the atmosphere would be chemical reactions leading to the formation of poisonous substances, like cyanogen, or nitric oxide, which would completely remove the protective layer of stratospheric ozone. Also, particle acceleration processes generating neutrons in the MEV range might produce, inter alia, radiocarbon C_{14} (see Brown and Hughes [42]). This process, which may be present in lesser events, including fireballs, has important consequences on the radiocarbon dating method (note that Velikovsky [5] predicted radiocarbon variations due to extraterrestrial causes).

Suppose now that the impact point lies on a continent. An additional few per cent of the available energy is transmitted to the continental crust under the form of seismic wave, generating a worldwide earthquake. In the case of energies in the billion MT range, land waves meters high would probably occur. A transfer of momentum to the tectonic plate and to the underlying mantle would also occur; the transferred momentum would exceed the existing one for bodies of a few kilometers diameter. While enhanced volcanism would probably follow events even in the 10^4 MT range, the change of plate movement directions for the more energetic 10^7 MT) events would very likely enhance orogenesis and also start magnetic reversals (see Velikovsky [2], Clube and Napier [15], Opik [43]); notice that there is now evidence of very rapid change of the geomagnetic field during a reversal, up to 6 degrees per day, see Coe et al. [114]). Thus impacts with large Apollos would have important geological and astronomical consequences, with a periodicity induced by the crossing of the molecular clouds. Shifting of plates by substantial amount could also happen. With the support of Einstein, Hapgood [107] proposed that a shifting was the main factor of the last glaciation, but he considered such a shifting to be caused by centrifugal effects due the asymmetry in the Earth induced by the presence of polar ice.

Most of the initial available energy (around 80%) is spent in creating a crater and (around 10%) in injecting dust, including the vaporized Apollo itself, into the stratosphere. The amount of dust is expected to be over one hundred times the mass of the impacted Apollo. For the hypothesized Apollo the dust production would be many times greater than the dust emitted during the greatest volcanic eruption of historical times (say the Tambora eruption of 1815; according to Strommel [44] about 100 km^3 of debris were produced, only part of them injected in the stratosphere as fine dust, enough however to produce a substantial worldwide cooling . It should be noted however that the greatest eruption known for the last 100.000 years, the eruption of the Toba volcano in Indonesia, is not associated with a glaciation despite the emission of estimated 1000 km^3 of debris; if dust is not emitted with sufficient energy it cannot spread all over the globe). Moreover enhanced volcanism would probably add dust during a long period after the impact, an effect which probably showed up dramatically after the impact which terminated the Cretaceous, see Officer et al. [84]. In the case of a larger Apollo, the amount of dust may well be in the order of many thousand cubic kilometers, shielding completely the surface of the Earth from sunlight.

The problem of determining the evolution of a dust cloud injected in the stratosphere and its effects on the amount of light reaching the Earth surface is very complex. The diffusion time from a single source over the whole planet is expected to be about three months (see Lamb [45]). Clearing should begin at the lower latitudes, being virtually complete in about six months. The time for complete removal of the stratospheric dust seems to be around three years and essentially independent of the initial total amount of dust.

In the formation of the crater the energy is spent in minor part in fracturing and heating the rocks, mostly in ejecting them. For high energetic impacts a portion of the ejects consists of liquefied rocks, which becoming solid form the so-called tektite fields. Most of the ejected material will however be solid and will accumulate in a circular ring around the cavity. The size of the crater depends in a complex way on the energy of the Apollo and on other factors; an approximate formula states that the energy E required to excavate a crater of diameter D grows with relation $E = D^{3.4}$. For the hypothesized Apollo a crater of some twenty kilometers diameter is expected; for the largest Apollos craters of hundred kilometers would be generated. For sufficiently large energies, the crater has a complex structure, with a central uplift due to rebound of the rocks. The bottom of the crater is covered by broken rocks (breccia), forming a layer possibly hundreds of meters deep (see for instance Grieve [88] or Melosh [89]). On the Earth hundreds of craters have been detected by now and their size distribution corresponds to the expected one. Some craters (Popigai in Siberia, Sudbury in Canada) are in the 100 km diameter range.

The expected depth of a crater is only a fraction of its diameter. As the continental crust has an average depth of about 80 km, no venting of magma is generally expected. Only for the very rare events in the trillion megaton range, the continental crust might be broken with magmatic emissions. We conjecture that the origin of the few very old volcanic structures that are found in the interior of tectonic plates, like the Tibesti plateau in the Sahara, can be attributed to such continental super-impacts.

Suppose now that the impact point is located on the surface of an ocean. As oceans cover almost three fourths of the Earth surface, most impacts will be oceanic. It is a remarkable indicator of the work yet to be done in oceanic exploration the fact that until 1987 no traces had been found of craters in the oceanic floor, of which there should be plenty (even taking into account the fact that no rocks in the oceanic bed are older than 200 million years). The first underwater crater was detected in 1987, see Jansa and Pe-Piper [90], on the North Atlantic continental shelf, 200 km south-east of Nova Scotia. It is a complex type crater, with a diameter of 45 km and a central uplift 1.8 km high and 11.5 km large. The crater is covered by a layer of about 600-800 meters of breccia and by 200 meters of sediments deposited after the formation. The impact is estimated to have occurred about 50 million years ago, the size of the impacting body evaluated at 2-3 km. Structures which may be associated to oceanic craters are the so called oceanic plateaus, found for instance in the Central Pacific. They seem to consist of the huge amount of lava flowed after an impact fissured the oceanic bottom, see Rogers [91].

When dealing with oceanic impacts, an important observation has to be made about the oceanic floor: it can be part of the submerged continental shelf (whose area is a good fraction of the emerged lands) or it can be the proper oceanic floor. In the first case the oceanic floor consists of a solid crust with a depth of thirty kilometers or more (up to the Mohorovic discontinuity, see Franchetau [46] or Burchfield [47]). In the second case it is very thin, about 2.5 km under the oceanic ridges, increasing to about seven kilometers near to the continental shelf. The difference in depth between the continental and the oceanic crust plays a fundamental role in the different climatic effects of continental or oceanic impacts.

The main transient effects of an oceanic impact are the following: blast wave in the atmosphere, formation of a transient crater in the water and subsequent tsunami, earthquake following the impact with the oceanic floor, formation of a crater in the oceanic floor and possible emission of magma. The blast wave and earthquake effects are similar to those in the continental case, but the earthquake would probably be less severe, due to the lesser strength of the oceanic crust.

Let us consider the other transient effects. Approximate analysis of the temporary crater in the water and of the following tsunami has been performed for instance by Gault et al. [48] and by Strelitz [49]. Assuming an ocean of infinite depth, the hypothesized Apollo of 10^6 MT energy would create a temporary, approximately hemispheric crater, quite similar in shape to a crater in rock, since in both cases the post-shock overpressure in the materials greatly exceeds their strength. The crater would have a maximum depth of 13 km and a maximum diameter of 30 km. Most of the available energy (92%) would be spent in ejection of water, shock heating and formation of waves, the remaining being transformed into potential energy of the displaced water. The formed crater would soon collapse, a column of water ten kilometers high developing over the impact point. The collapse of the column originates a system of waves, with amplitudes decreasing, in free ocean, inversely with the distance. The height of the waves would be about one kilometer at 100 km from the impact and 100 meters at 1000 km. On approaching the shores substantial amplification of the wave height would follow, the exact value of the amplification depending on the geometry of the coast. A global catastrophic tsunami, with substantial continental flooding, would be therefore the consequence of an oceanic impact.

In the previous analysis, an infinite depth of the ocean was assumed. As the average oceanic depth is only 3.7 km (with a maximum of 11 and a value of only 2.5 over oceanic ridges), all Apollos in the energy range over 10^6 MT would hit the oceanic floor with still a substantial part of their initial energy. A quantitative study of the cratering effects in the oceanic floor has not yet been made, at the knowledge of this author. Therefore the following considerations will be qualitative. A worldwide earthquake would be generated, as previously observed, not as severe as in the continental impact case, but probably enhancing the tsunami effects. Breaking of the thin oceanic floor and emission of magma is expected, if the impact occurs on the proper oceanic floor. If little energy is left in the Apollo when it reaches the oceanic floor, the emission of the magma may be essentially a slow venting, an enhanced form of sub water volcanism, with heating effects proportional to the affected area (possibly thousand of square kilometers) during a quite long time period. When much energy is available, as first approximation the existence of the oceanic crust may be disregarded and the impact may be considered equivalent to a direct impact on a bed of magma. A crater would be formed in such a bed, with ejection of large amounts of hot magma, in the order of hundred or thousand cubic kilometers. The heating effects would be at first order proportional to the volume of the displaced magma, determining the almost instantaneous evaporation of several times that volume of oceanic water. Subsequent slower venting with surface heating effects would go on for some period. Of course, the clouds formed by the evaporated water would be carried around the globe by the winds and a truly "universal flood" would inevitably follow.

Finally, observe that little dust is expected to be injected in the stratosphere following an oceanic impact. The darkening of the sky, if any at all, would last even for the largest event two or three months at most (see Emiliani et al. [50], O'Keefe and Ahrens [51], Poupeau [52]). This will be reflected in the climatic consequences, that, as discussed in the next section, are of heating the globe in the case of oceanic impacts, of cooling it in the case of continental impacts.

Before discussing the climatological effects of an impact, we briefly mention, for completeness, some possible effects on astronomical parameters of the Earth:

- changes in orbital parameters are discussed by Brunini [118]; both impacts and close encounters with comets or asteroids of the previously discussed size, modelled by a Brownian motion, can change semimajor axes by about 10^{-5} AU over the usually assumed total solar age of circa 4 billion years; the change per impact would therefore be very small, of the order of few meters

- under certain conditions on the impact location and momentum size and direction by gyroscopic effects there can be a change in the Earth rotation axis, including a reversal, see Barbiero [109]. As consequence of a reversal the northern and southern sky emispheres would interchange and the Sun would appear to rise in the West instead that in the East. According to an Egyptian tradition related by Herodotus, in the past twice the Sun has been rising in the East and twice in the West, which is an indicator of three inversions in human memory. Quite intriguingly the Egyptian priest in Plato's story of Atlantis, see the following section 5, speaks of three "major" catastrophes. A natural criterion for qualifying a catastrophe as major would certainly be the interchange of the southern and northern skies and of the rising and setting points of the Sun

- changes in the duration of the day and in the obliquity of the rotation axis might also be considered, but to our knowledge no quantitative estimates have ever been made.

4. Impacts of Apollos: climatic effects and a hypothesis on the last glaciation

In this section we shall consider the climatic effects of Apollo impacts, showing that global cooling is expected after a continental impact, while global heating should follow an oceanic impact. Under suitable conditions a glaciation can be started in the first event, while an existing glaciation can be terminated in the second event. The hypothesis will be discussed that such has been the case with the last glaciation.

As discussed in the previous section, a major effect of a large continental impact is the injection in the stratosphere of hundred or thousand cubic kilometers of fine dust, which then spreads over the whole globe, possibly completely shielding sunlight. Clearing of the sky initiates after a few months at lower latitudes and is completed after two or three years (at least if possible additional dust injection by enhanced volcanism is disregarded). Now a dust veil which completely screens radiation from the Sun must also produce a greenhouse effect on the Earth, blocking the escape into the space of the terrestrial heat. In usual conditions the surface heat content of the Earth per unit volume is larger in oceans and at lower latitudes. In a globe surrounded by a permanent perfectly insulating dust veil the equilibrium thermal condition should be characterized by an essentially uniform temperature distribution. As most of the surface heat is contained in the oceans, the sudden formation of a dust veil blocking the Sun radiation would cool the oceans at lower latitudes and warm them at higher latitudes, through a heat exchange process characterized by violent storms. An almost thermally stationary world would finally result, where the only thermal changes would be the slow temperature increase due to the heat flow from the interior of the Earth and the transient effects related to tectonic movements, like earthquakes and volcanic eruptions.

Of course, the above picture describes an unreal situation, since no permanent completely insulating dust veil is ever expected on our planet. However the mechanism leading to that state would be operating for some time and the expected result, under the present conditions of the Earth, would be the starting of a glaciation. This type of process has been studied mainly by Hoyle and

Wickramasinghe [53], see also Hoyle [54]. These authors have criticized the traditional mechanisms for explaining glaciations in terms of small variations in the Earth albedo or solar radiation, claiming that the Earth heat exchange mechanism between lower and higher latitudes can cope well with the effects of small variations. Mathematical work by Chalikov and Verbitsky [55] on a global Earth climate model has indeed confirmed the stability of the Earth climate for a wide range of perturbed solar regimes.

With the diffusion of the dust veil over the globe, the atmosphere would cool rapidly over the continents, while remaining relatively warm over the oceans. Thus the usual thermal nonequilibrium conditions which drive the normal heat exchange through winds, rain, snow etc. would be enhanced and violent and long lasting storms would be expected worldwide.

At lower-middle latitudes the storms would bring heavy rain that could fill interior continental depressions. This is what happened during the last glaciation, when depressions covering million square kilometers were filled with water (for instance lake Tchad in Sahara, lake Murray in Australia, the Caspian Sea, the many salty lakes in Xinjang and Tibet, in the Armenian and Iranian plateau and in western United States). At middle or high latitudes the storms would bring snow and ice would be formed by accumulation of snow. As the direction of the storm carrying winds depends at large on the Coriolis force, related to the rotation of the Earth and unaffected by the impact (unless a pole inversion had occurred), we expect a peculiar pattern in the distribution of the ice cover. This is what we indeed observe in the last glaciation. In the northern hemisphere, for instance, most of the Pacific water should be carried eastwards, in the direction of North America. In fact, as expected, North America was covered by ice, approximately north of the line Portland - New York, while eastern Siberia, northern China and Korea were essentially ice free. Similary we expect snowy storms originating in the Atlantic to have affected the whole of central-northern Europe and part of western Siberia (as it actually happened), but possibly not central Siberia, the clouds clearly getting depleted after moving several thousand kilometers over a continental area.

The configuration presented by the Earth after the settling of the dust veil would thus be one of extended ice cover at high latitudes, of filling up of internal continental depressions, of a lower oceanic level (variously estimated at between minus 60 - minus 130 meters at the end of the last glaciation) and lower oceanic temperature with corresponding reduced evaporation. In other terms, a typical glaciation configuration would have resulted in a very short period. Geological evidence for almost sudden onset of many glaciations is now available, see Bryson [56], Ruddiman et al. [57], Yapp and Epstein [58].

That such configuration can be essentially stable is proved a posteriori by the fact that, apart from climatic oscillations which are present also in our postglacial times, the last glaciation lasted some twelve thousand years (from about 22.000 A. D. to about 10.000 A.D.). Physical conditions which can maintain a glaciation are the following:

- periodical replenishing of the dust veil due to increased volcanism (expected after a continental impact!) or, in the Clube-Napier scenario of a large fragmented comet, to the crossing of the dust filled portions of the torus associated to the comet fragments

- increased albedo of the Earth surface due to the extended ice and snow cover

- increased albedo of the stratospheric layer due to the extended presence of ice crystals of the type named by Hoyle "diamond powder".

Some comments are needed on the last physical condition. Tiny droplets of water in the stratosphere under certain conditions can stay liquid (supercooled liquid phase) till the temperature drops to -40 ° C, when they suddenly crystallize in the "diamond powder" form, which reflects almost completely sunlight. The temperature of such droplets in the stratosphere depends essentially on the amount of radiation absorbed in the peculiar wavelength emitted when water vapour condenses. In present conditions "diamond powder" is found permanently only over the poles, where it is responsible of many optical phenomena. During the last glaciation, due to reduced evaporation from the colder oceans, the "diamond powder" layer surely extended over a larger region, probably up to the middle latitudes. Incidentally, no "diamond powder" layer could be formed if the oceanic temperature, and thus evaporation, would be sufficiently high. Now, oceanic temperature depends on continental masses distribution, being lower when a continent lies near a pole, higher otherwise, the difference being up to ten degrees. Antartica reached the South Pole about forty millions years ago and many glacial episodes have since occurred. There have been very long geological periods without glaciations when no continent was near the poles. However a continent can be on a pole and glaciations may not occur (as it happened 500 millions years ago, when North Africa was at high latitudes), since they depend on collisional episodes, which are modulated by the previously discussed crossing of galactic molecular clouds.

Let us now consider how a glaciation can be terminated by an oceanic impact. In the previous section we have seen that oceanic impacts have very different consequences than continental impacts. Smaller tectonic effects and lower emission of fine dust are expected. The main features are a colossal tsunami and the production of large amount of water vapour (following the formation of the temporary crater, the release of magma and the enhanced submarin volcanism). The overall climatic effects are clearly in the sense of a global heating. In particular, Emiliani et al. [50] have conjectured that the extinction of the dinosaurs 65 million years ago was due to the rapid global heating (at least l0 degrees) which followed the impact in the Caribbean sea.

An oceanic impact occurring in a period of glaciation could well provide the mechanism for terminating the glaciation. The following actions would indeed be operating:

- the tsunamic waves would invade million square kilometers of continental areas, including ice covered regions. Partial melting of ice would follow, due to the higher temperature of oceanic water and its salt content, which lowers the melting point. While the volume fraction of melted ice cannot be great, the surface fraction of area liberated from ice cover would be greater, decreasing the albedo

- the huge amount of water vaporizing from the impact point would condense in clouds carrying thermal energy from the ocean and the exposed mantle in clouds towards continents. Great storms would bring warm rains capable of melting the ice layer in areas where it is thinner, thereby reducing the albedo

- the radiation emitted in the condensation phase of the water vapour would be orders greater then the normal radiation in that wavelength, leading to substantial reduction of the "diamond powder" layer and its associated albedo.

The paroxystic effects associated with an oceanic impact are expected to last only a few days (the tsunami) or a few weeks (the "universal deluge" following magmatic emission). It is unlikely that all the ice cover can be eliminated in such a short period, and in fact this is not what is observed from geological evidence. It is however possible that the albedo factor be modified so profoundly for the Earth to revert, in a few additional centuries, to the climatic conditions of non glacial times. This agrees with the geological records, see for instance Broeker et al. [92], which indicate a warming of about 7 centigrades in a period now estimated at just about 50 years, see Lehman and Kergwa [111]. Note that an accurate date for the shift between the Dryas (the terminal phase of the glaciation) and the Preboreal has been recently set by analyis of lacustral sediments at 11.450 years BP with 80 years uncertainty, see Björck et al. [112]. At that time a huge influx of fresh water entered the North Atlantic ocean, evidence of very rapid melting of the ices. If the last glaciation was started by a continental impact, a problem is that no continental crater aged about 24.000 years and of diameter 10 - 20 kilometers is presently known, as it would be expected for a kilometrically sized impacting Apollo. Disregarding the possibility that the crater is yet undetected (it could lie on a submerged continental shelf or under Amazonian jungle where erosion by rain is heavy) we can consider the hypothesis that the impact was in the super Tunguska class (a body of a few hundred meters diameter, getting possibly fragmented in the atmosphere). The Meteor (or Barringer) crater in Arizona has an uncertain age, some estimates putting at about 20.000 years. Its diameter is one kilometer, the depth 200 meters. It was made by an iron body of an estimated 100 meters diameter; the energy involved may have been a few thousand megatons. We do not expect that enough dust was injected in the atmosphere by this single event to start the last glaciation. However, under the Clube-Napier assumption of the capture and fragmentation of a large comet, that episode might have been one in a series of Tunguska or super Tunguska impacts (note that an oceanic impact of an object of that size would not provoke magmatic emission). Moreover enhanced strong volcanism might have followed the Arizona impact, due to the proximity of the volcanoes rich Coast Range and Mexican Cordillera.

Another open question relates to the location of the oceanic impact that we hypothesize terminated the glaciation. We conjecture that the location was in the North Atlantic, somewhere east of the Carolinas. A fall in the Pacific would have created a minor tsunami in the Atlantic, the Pacific being almost isolated during the last glaciation (the Magellan Straits were almost blocked by ice, Australia was almost connected by a land bridge to Asia, America and Asia were connected via the Bering straits). The evidence from the Atlantis story that we interpret in the next section points to a great tsunami and a flood originating from the Atlantic area. We also remark, with Velikovsky [2], that elliptical flat depressions (the Carolina bays), filled with water, with major axis pointing south-eastwards to the Atlantic, characterize in number of thousands the Carolina coast (extending also from New Jersey to Florida). The time of their formation is not certain, but may well be the end of the last glaciation. If this is the case, the Carolina bays would have been formed by fragments of an object impacting in the Atlantic.

Finally, extensive evidence for multiple Apollo or cometary impacts in seven points of the Earth (on the ocean south of Mexico, east of Chile, near the Azores, between Norway and Greenland, south of Sri Lanka, south of Tasmania and close to Indochina) has been given by the Austrian geologists Alexander and Edith Tollman [128] and dated at circa 7500 B.C. With reference to the three great catastrophes quoted by the Egyptian priest in the Atlantis story, this event could be interpreted as the second catastrophe (the one of Noah?), the first one being that which destroyed Atlantis, the third one the flood of Deucalion (and of Noah?).

5. An interpretation of the Platonic story of Atlantis

In two famous books, written around 360 B.C., Timaeus and Critias (of the second only a part is extant) Plato has given information on a political power, Atlantis, which dominated the western world nine thousand years before his time. The story of Atlantis was told by Critias (an old man of 80 years, a relative of Plato and in his youth one of the thirty tyrants), during a discussion with Socrates. Before telling the story, Critias spent a night trying to recollect in his memory all the details. He had originally heard the story, when he was a ten years old child, from his grandfather, Critias senior. The story had so much impressed him that details came to his memory even after so many years. Critias senior had got the story from his father Dropides, a brother of Solon, according to Diogenes Laertius. Solon got the information on Atlantis in Egypt. He had planned to write a poem about it, but he could not realize his wish due to his many political commitments.

The way Solon got the story on Atlantis is the following. In the city of Sais, an important religious center in the Nile delta till now little explored archeologically, he began a discussion with priests about the oldest events in the Greek tradition, like the story of the first man Phoroneus and the survival of Deucalion and Pyrrha from the flood. While he was trying to estimate by generation counting the time of these episodes, he was interrupted by a very old priest (possibly the one named Sonchis in Plutarch's Life of Solon), who claimed that his Greek stories were not of great age. In fact, the priest said, the Greeks had kept memory of some catastrophic events, like the Phaeton story, which was the consequence of the interaction between the Earth and a heavenly body, and also the Deucalion flood, which was only a minor catastrophe, but had lost completely the memory of a previous greater catastrophe, a great deluge which swept most of their ancestors into the sea, leaving only few survivors. The memory of that event had survived among the Egyptians and was preserved in written form in their temples in Sais (as confirmed by Crantor, an early commentator of Plato, who lived about 300 BC; he wrote that a traveller in his time had seen these inscriptions). The reason for this was that the ancestors of the Egyptians were living at those times on high lands as herdsmen and shepherds and had not been much affected by the deluge. The catastrophe had happened nine thousand years before; one thousand years later the first Egyptian institutions were established.

Before the catastrophe, the priest said, there was a political power, Atlantis, whose basis was on an island located opposite the straits known as the Pillars of Hercules, separating the Mediterranean from the Atlantic (the Gibraltar straits). Atlantis was in control of the following regions:

- islands further on

- parts of a continent lying beyond, which completely surrounded what could be called the true ocean, the Mediterranean being only a lake in comparison, and, on this side of the Atlantic, which was navigable at those times, of Europe up to Italy (Thyrrenia) and Africa (Libya) up to Egypt.

The army of Atlantis started a military operation to extend control over the eastern basin of the Mediterranean, fighting against the ancestors of the Greeks and of the Egyptians. Atlantis was defeated and lost control of the western Mediterranean basin. Just after the end of the war there was an earthquake and a flood of extraordinary violence. In a single terrible day and night the fighting armies were swept away and the Greek cities were washed to the sea. The Atlantis island was swallowed by the sea and vanished. The ocean became impassable to navigation and muddy waters appeared in the region of the vanished island.

The above information is found in Timaeus. In Critias the discussion mainly concerns the political situation at those times in Greece and in Atlantis, but additional information on Atlantis is also available. It is stated that the catastrophe was the third one before the Deucalion flood and that it was night when the flood fell upon Greece. Some geographical features of the island of Atlantis are given. It had many mountains "higher and more beautiful than any existing today". There were rivers, lakes, pastures and woodlands with abundant timber. Aromatic spices and many fruits were found. There was plenty of domestic and wild animals, including elephants. There were mines, some producing "orichalc", a substance "gleaming like fire", the most precious at that time, except gold. In the southern part of the island there was a plane, of rectangular shape, used for agriculture, completely irrigated by a system of canals; the plane was protected by a chain of hills from the northerly winds. Half way along the plane there was a lake of circular form, whose diameter was ten kilometers and whose center was fifteen kilometers distant from the coastline. The lake had been connected to the sea by a canal, one hundred meters large and thirty meters deep. In the centre of the lake there was a small island, of one kilometer diameter, surrounded by two rings of land, each one separated from the other by water. In the central island there was a palace, build of white, black and yellow stone which had been cut from the central island itself and from the surrounding rings. In the outer rings there were temples, gardens and an area for athletic activities. The lake was used as a well protected port, frequented by ships from all the lands controlled by Atlantis. The commercial and residential areas were build around the lake and along the canal. The whole city, the capital of Atlantis, was surrounded by a circular wall centered on the palace and whose radius was fifteen kilometers, including therefore a total area of about 700 square kilometers.

Some numbers on Atlantis dimensions are the following. In Timaeus it is stated that Atlantis was larger than Asia and Africa (Libya) combined. In Critias that the irrigated plane was three thousand stades long and two thousand large, say about 600 by 400 kilometers.

About Atlantis more than 3600 works have been written, see for instance the bibliographies in Bramwell [59], Spanuth [60], Pinotti [138], Zhirov [93] and particularly Kukal [94]. Before the second world war the discovery of submerged mountains in the Atlantic ocean excited those looking for a submerged continent; however it was just the discovery of part of the oceanic ridges which are now known to extend for over 60.000 km in the middle of oceans. More recently, after the discovery of the great Santorini eruption in the second millennium BC (see Warren [95] for a discussion of dating problems), it was theorized, see for instance Carpenter [61] or Luce [62], that Atlantis was Minoan Crete, destroyed by the tsunami which followed the collapse of the volcanic chamber in Santorini. This theory, which is widely accepted today, requires so many substantial changes to the Platonic text, that it is equivalent in our opinion to rejecting the text. Other theories which require substantial changes include those of Spanuth [60], who put Atlantis in Helgoland, and of James [108], who related Atlantis with the capital of the ancient kingdom of Tantalus, in western Turkey, which was apparently destroyed by a great mud flow. An intriguing identification of Atlantis with the Lesser Antarctica peninsula in Antarctica has been proposed by Barbiero [133] and redeveloped by Flem-Ath [110]. The idea that the Atlantis story derives from a memory of the flooding of the continental shelf of Northern Europe following the increase of the sea level after the end of the last glaciation has been developed by Castellani [152].

In our scenario the information in the Platonic text is accepted as essentially correct. Only two major modifications are made, namely in the statements relating to the size of Atlantis and of the irrigated plane. We accept the numbers, but we change their attribution. We think that an error slipped in the survived manuscript at a later time, or that Critias memory failed in correctly assembling the details, something about which there should be no wonder, as he was trying to recollect information obtained seventy years before.

Before giving our interpretation of the Platonic text, it is important to look again at the configuration of the Earth during the last glaciation (making use, for instance, of the map given by Kukla in Scientific American, see Broecker [63]). Ice covered northern Europe, west Siberia and much of northern America. The climate was dryer and colder than now in the regions below the ice line, which could however maintain a substantial population of large herbivores, including mammoths, large carnivores, like ursus speleus, and man. At lower latitudes, corresponding to presently arid regions as northern Mexico, the Sahara and the Mesopotamian-Caspian region, climatic conditions were wetter than now and probably favorable to cattle breeding and agriculture. In particular, the Sahara was a huge grassland, its mountains were forested, large lakes filled the depressions and great rivers were flowing, as has been spectacularly confirmed by radar photographs from the Shuttle. In western and central Asia the climate was favorable too, thanks also to the presence of a huge inner sea which inglobed the Black Sea (during the glaciation the Black Sea was not connected with the Mediterranean), the Caspian Sea and probably lake Aral, for an extension almost equal to that of the Mediterranean. Finally, heavy vegetation covered the circumcaribbean region, parts of central Africa and the circumpacific regions of Asia and Australia from middle China to southern Australia. It is a remarkable observation that during the glaciation the amount of land made inhospitable by the ice cover was more than compensated by the availability of good grasslands in areas which are now desert (more than twenty million square kilometers between Africa and western-central Asia) or covered by jungle (the Amazonian basin was probably mainly a grassland, albeit recent analysis of sediments on the bottom of a lake indicated that the forest was still present, with a different vegetation structure, corresponding to less warm conditions, see Colinvaux et al. [113]).

If we assume that the climate variations during the twelve thousand years of the last glaciation were comparable to those of post glacial times, then the conditions for the development of a civilization would have been, during that time, similar, if not better, to those that have permitted in the following twelve thousand years the development of the present civilization. We assume that this was indeed the case and that the story of Atlantis and many other traditions that we do not consider here, relate to the final stage of that civilization. We assume that the catastrophic event of Plato's story was the oceanic impact which terminated the last glaciation, as previously hypothesized. The great Atlantic tsunami devastated America, Europe and Africa. The ocean penetrated possibly for thousand of kilometers into the Amazonian basin and the Sahara. Immense devastation affected the Mediterranean region. No architectural structure, already weakened by the earthquake that preceded the tsunami, could have resisted. A tsunamic wave of the envisaged size would not only flatten a city, but carry away its debris, leaving virtually no trace. The deluge following the magmatic emission would have affected mostly Europe, northern Africa and west-central Asia, bringing havoc where the tsunami could not reach. Finally, the melting of ice and the subsequent elevation of the sea level by 60 meters would have changed the coastline configuration and affected the direction of currents, thereby justifying the claim that Atlantis had vanished and the ocean had become impassable. We can well wonder how much of our civilization structures could resist to a similar event.

Let us now consider the details of Plato's story and set them in our scenario for the end of last glaciation. The date given for the catastrophe, corresponding to circa 11.600 B.P., fits well the commonly accepted starting time for the withdrawal of the ices (as said in the previous section, this time is now estimated at 11.450 B.P.). Note that very precise dating for these events cannot be made using radiocarbon or sedimentary analysis; a five per cent uncertainty in our opinion should be accepted without difficulty (we note that for a core of Antarctic ice only one century old, an 8% error in dating the layers was assumed by Ganapathy [40]!). Remark also that while our approach to glaciations assumes a rapid onset of ice cover, just a few months, the disappearance of the ice cannot be sudden, the thicker layers requiring possibly thousand of years to melt (in fact, we are still in the last throngs of deglaciation, as shown by the positive bradisism in Sweeden and the continuing loss of glaciers in the northern hemisphere, albeit factors due to human activity play now a major role).

The city of Atlantis is located by Plato beyond the pillars of Hercules and it is noted that the ocean was navigable at that time. Control was exercised by Atlantis over islands beyond and parts of the continent which surrounded completely the true ocean.

Our interpretation is that the island of Atlantis is the large Caribbean island that was encountered by Columbus in his first voyage, was named by him Hispaniola and is presently split between Haiti and the Dominican Republic. The local name at the time of Columbus was Quisqueya, which had the notable meaning of "Mother of Lands" (a remembrance of its dominant role in past times?). This assumption implies of course that man lived in America during the last glaciation, a fact which is now confirmed by increasing archaeological evidence, see for instance Morell [100]. The islands beyond Atlantis therefore are the other large Caribbean islands (Cuba, Jamaica) and the continent further on is America. As already observed, during the last glaciation the Bering straits were a land bridge, Australia was almost connected with Asia, and thus a huge continent almost completely surrounded the Pacific Ocean (the true ocean of Plato's story). One might actually wonder whether, at least during the austral winter season, ice from Antarctica didn't effectively close the passage to the Atlantic and Indian oceans. One should at this point notice the existence of a few additional classical sources that suggest knowledge in the Old World about America that has some relation with the information on the Atlantis story. One is a passage in Plutarch's De facie quae in lunae orbe apparet, containing the following:

- a man visited Carthago from a land on the other side of the Atlantic

- the man described a region on that land, located at about the latitude of the Maeotian Sea on the greath mouth of a river, which was visited in ancient times by the ancestors of the Greeks

- the region can be identified with the estuary of the St Laurence; we may notice that Vinci [153] has strongly argued that the Homeric world should be set in the Baltic and Northern Sea at a time, the optimal climatic that ended about 1600 BC, when navigation conditions in the Northern Atlantic were probably favourable.

The other passage is a statement attributed by Aelian [154] to Theopompus which says:

- there are two continents on Earth. One consists of Europe, Africa and Asia; the other is far away in the middle of the ocean

- in the far away continent there were two great cities: one (the capital of the Atlantis empire?) was inhabited by people bent on war and conquest; the other (possibly one of the great cities whose remains in the form of huge earthen mounds are found in the central part of the United States?) was inhabited by peaceful people. Notice that if the Atlantis age came to termination via a huge tsunami associated with the end of the last glaciation, it is expected that the Caribbean sea waters invaded large part of the lower and middle Mississippi basin, destroying and washing away most of any structures built by man.

Identification of Atlantis with Hispaniola is strengthened by the Platonic description of the island: high beautiful mountains, rivers, lakes, a plane, precipitous coasts, forests and animals. Hispaniola has indeed mountains over 3000 meters (Pico Duarte is 3175 meters high), some of them (for instance La Selle, 2680 meters) being located very near to the coast. The effect of the height of such mountains for an observer from the sea should be compared with that made on an observer of Monte Bianco (4807 meters) from the bottom of Val d'Aosta. Such mountains could well have seemed higher than anything known to observers from Greece or Egypt. The luscious tropical forest that covered Hispaniola, in glacial times and until some years ago (now the island has been largely deforested), was surely a reason of attraction for visitors from the Mediterranean basin. It is interesting to note that Columbus was truly fascinated by the natural beauty of the Caribbean islands, a theme which often recurs in his diaries. Rivers and lakes (including two lakes below sea level, Imani and Enriquillo) are plentiful in Hispaniola. The reference to elephants may not necessarily relate to the present African variety (but some exemplars could have been shipped there) but to the American variety of proboscidates (mammoths or mastodons), which disappeared in the catastrophe terminating the glaciation.

The reference to the coasts of Atlantis being precipitous is very indicative of Hispaniola (but see Collins [161] for arguments in favour of Cuba). Hispaniola's coasts are mostly high and inaccessible. Moreover the ocean is deep around Hispaniola, implying that the shape of the island during glacial times, when the ocean was 60-130 meters lower, was essentially the same as now, while, for instance, Cuba was substantially larger and a great island was located where are now the Bahamas. A roughly rectangularly shaped plane lies in the south-eastern corner of Hispaniola (Santo Domingo is located there), with a range of hills on its northern side. Here may have been the irrigated plane described by Critias. If this is so, then the capital city of Atlantis should be located in a now submerged site along the southern part of the Dominican republic, somewhere along the present minus 60-130 meters sea depth level. Another possible location could be the flat area, with mountains both on the north and the south side, which is named the Plaine de Cul-des-Sac and which contains a number of lakes, particularly the lake Enriquillo. This lake is very salty and its surface is below the sea level (-44 meters). This whole area was occupied by the sea in Quaternary times, see Wendell et al. [96] or Butterlin [97], and could well contain coralline structures now covered by recent sediments. The information about the ring structure of the central part of the capital of Atlantis and the colored stones carved there suggests indeed that the site had a coralline atoll structure, exposed when the onset of the glaciation lowered the level of the oceans.

The Platonic text states that Atlantis was larger than Libya and Asia combined and that the irrigated plane was about 600 by 400 km. No vanished land of that size has existed in recent geological times, no plane of that size and characteristics is found now in the Earth, nor even in present times has man been able to irrigate a connected piece of land of such dimensions. The data in the text are erroneous. We believe however that they transmit an actual information, which has been put wrongly in the text, most probably through a memory slip by Critias. Our opinion is that the reference to the size of Atlantis should be a reference instead to the continent beyond, say America, part of which was stated to be under control of Atlantis, or to the empire of Atlantis, which included parts of Africa and of Europe. The dimensions given to the plane are remarkably close to the dimensions of Hispaniola itself (which are essentially unchanged if water level is dropped 60-130 meters), which are about 650 by 300 kilometers. Thus we think that the last reference was actually to the Atlantis island itself.

Some final considerations have to be made about the claim that Atlantis was in control of the western Mediterranean basin and waged war against the ancestors of Greeks and Egyptians. According to the Platonic story the ocean was navigable and the Atlantis capital had a great port. The development of navigation is a characteristic of civilization and is naturally expected, in viewing the end of the last glaciation as a period of flourishing civilization. Which types of boats could be available those times? To this question unfortunately only unprobable archaeological findings could give an answer. However we point out that large distances over oceans and substantial transfer of men and materials can be performed using very primitive navigational means. This has been proved in the classical exploration voyages of Thor Heyerdahl [64, 65], who crossed the Pacific (from Peru to the Tuamotu islands) on a balsa raft, and the Atlantic (from Morocco to Trinidad) on a reed boat build by lake Tchad fishermen according to millennia old design. Heyerdahl [66] was also able to find in Polynesia local confirmation of the statement made by Sarmiento de Gamboa [67] that Tupac Inca once made a circumpacific voyage with a large balsa fleet carrying more than 20.000 men. Heyerdahl's work has thus shown that even boats as simple as rafts can transport over oceanic distances a great army.

Boats of the simple type considered by Heyerdahl cross oceans essentially following currents (but see again Heyerdhal [66] for the remarkable flexibility offered by guara boards on balsa rafts). It is possible in present times to leave and return to a Peruvian port via Polynesia along a circular route following currents. It is presently possible to leave the Pillars of Hercules (Gibraltar) and reach America via currents in about two weeks, but not to return there, the Gulf stream moving towards Scandinavia. But during the last glaciation the Atlantic ocean was covered by ice north of a line New England-Ireland and the Gulf Stream had a different direction. In fact it has been shown, see Pinet et al. [98] and Keffer et al. [99], that the Gulf Stream during the Quaternary glaciation moved towards Gibraltar. Thus a two ways connection between America and Europe was possible even using most primitive boats.

Finally, we may deduce some additional information from the Platonic story. The catastrophe happened probably between late spring and early autumn, those being the time limits for military operations in classical times and, a fortiori, in glaciation times. Presence of fresh flowers in the stomach of frozen mammoths is a confirmation. It was night when the first devastation occurred in Greece, probably due to the earthquake, the seismic waves being much faster than the tsunamic waves. It may have taken a dozen hours for the front of the tsunami to have reached Greece and there may have been many rebound waves; this would explain the night and the day of convulsions. The coastal areas of Greece and the Aegean islands must have been fully affected by the tsunami with almost complete wiping out of the population. This may explain the loss of memory of Atlantis in Greek tradition (unless a remembrance is found in the Golden Age stories of Hesiod), Greece itself having been repopulated later by populations coming from unaffected areas (central-eastern Asia?). It is worth recalling here the thesis of Vinci [153], according to whom the Miceneans came to Greece around the middle of the second millennium BC from the Baltic area, mixing in Greece with the local preexisting populations that was conquered by them. Therefore any memory the Greeks may have of very ancient events should most probably relate to events set in Northern Europe.

Egypt must also have been fully devastated by the tsunamic wave. However, populations on the Aethiopian highlands (the herdsmen and shepherds of Timaeus), possibly connected with old Egyptians and other populations then thriving in the Saharian grassland, would have escaped the tsunami and probably also the following deluge. Among these populations on the margin of the great empire of Atlantis the memory of Atlantis must have survived to be transmitted to their descendants. They repopulated the Nile valley and established the first Egyptians institutions one thousand years after the great catastrophe.

We conclude noting that an explanation of the Atlantis story and of the end of the last glaciation in terms of a meteoritic impact was also given by Muck [101]. However he assumed a location of the island of Atlantis in the middle of the Atlantic Ocean and its disappearance by direct hit effect. He also assumed that the presence of Atlantis in that position affected the Gulf Stream movement and was responsible of the last glaciation. These arguments are against established geological knowledge.

6. An interpretation of the biblical and Sumerian flood stories

Legends on deluges which almost destroyed mankind are found among many peoples (more than 600 such legends have been counted). Here we shall be concerned only with the biblical and Sumerian tradition. Our conjecture is that the two sources describe the survival of two distinct groups of people in the area affected by a deluge following an Apollo impact. In the first version of this essay we assumed that the Atlantis story and the biblical and Sumerian deluge stories related to the same event. Of this identification we are no more sure now and we prefer to think that the biblical-Sumerian deluge is a later event, probably the second or last of the three great catastrophes referred to by the priest in Sais. We do not discuss here the problem of dating this event, but we are sympathetic with Patten [134], who dated it at circa 2500 BC. Patten derived this date using the internal chronology of the Bible, essentially following Thiele [135], and arguments from his theory of periodic approaches of the planet Mars to the Earth, resulting by gravitational tide effects in catastrophical events on the Earth similar to those produced by an oceanic Apollo impact. Notice also that the readjustement of the Egyptian chronology advocated, as referred before, by Velikovsky, Bimson, James, Rohl, Clube and Napier, would put Menes and the first dinasty after the deluge. For arguments that the Sphinx and the great Giza Pyramids were build well before Menes, most probably at the time when the Atlantis civilization flourished, see West [129], Gilbert and Bauval [130], Hancock [131] and Schoch [155].

The biblical story of Noah is contained in Genesis 6-9, with additional references in other parts of the Bible. It is not possible here to discuss the many interpretational problems connected with biblical texts. Just remember that more than a thousand Hebraic words are known only from the Bible, where they appear only once and that new insight into controversial passages comes from the recent important work of Salibi [156, 157, 158], who has argued that the original land of the Hebrew was the Asir region in southern-western Arabia, implying that comparison with the surviving dialects of Arabic in that region is very useful for clarifying the Biblical language. We shall just state the main usually undisputed content of the story and then give our interpretation. The content of the Genesis is the following:

- before the deluge mankind had multiplied on the Earth; much violence affected the human society

- Noah, warned in dream by God that a catastrophe would destroy mankind, built a wooden ark, 300 cubits long, 50 large, 30 high, insulated with pitch externally and with a material called gopher internally (perhaps an eatable material, a mixture of roasted barley and water. This is a basic staple of many primitive people, for instance the ancient Guanche populations of the Canary islands, who called it, quite intriguingly, gofio. It is still the national food of Tibetans, who call it tsampa)

- after Noah had taken refuge in the ark with his family and various animals, "the fountains of the great deep were broken up and the windows of heaven opened " (as in the Holy Bible revised authorized version)

- "the rain was on the Earth for forty days and forty nights; the waters increased and lifted the ark"; "the waters prevailed on the Earth and the high hills were covered"

- after five months the ark touched land on some mountains of Armenia, Urartu in the text (usually and probably incorrectly translated as Ararat); after four more months Noah left the ark, the land having finally dried up.

The Sumerian story of the deluge has been found on a number of tablets with cuneiform inscriptions from Anatolia to southern Mesopotamia. The dating of the tablets varies from the beginning of the second millennium B.C. to the seventh century B.C. (the tablets from the library of Ashurbanipal in Nineveh). The languages are also various, say Sumerian, Akkadian, Hurrian, Assyrian, Hittite, old Babylonian. Despite some differences among the content of the tablets, there is consensus that they all derive from a unique Sumerian source. The first tablets were found in the second half of last century and were published in 1882. Intriguing evidence that the Sumerian flood story had also survived in the oral tradition in the Armenian region comes from the Armenian writer Gurdijeff, born in 1877 in Alexandropolis (later Leninakan, in the Armenian province of Kars). In his posthumous book "Rencontres avec des hommes remarquables" [102], he says that his father Adash was one of the last story tellers of the Transcaucasian region. One of the songs of his father was named "The Legend of the Flood before the Flood". A few years before first world war Gurdijeff read on a magazine the story of Gilgamesh. He was astounded to see that the story was almost identical with the 21st song of the Legend of the Flood before the Flood. If his testimony is true, we have a strong evidence that an oral tradition can survive accurately for thousand of years. The intriguing name "flood before the Flood" might indicate that the Sumerian flood was not the last of the (three?) great floods referred to in the Platonic text.

The story of the deluge in the Sumerian tradition is imbedded in the epics of Gilgamesh, a great king of the Sumerian city of Uruk, who probably lived in the third millennium B.C. (see Kramer [68]). Briefly, Gilgamesh developed a deep friendship with Enkidu, previously a wild man living in the forests. With him he made an expedition to a far away land of great cedar trees where he killed the monster Humwawa. On the return to Uruk, the gods took vengeance of the death of Humwawa and made Enkidu die of a disease. Deeply affected by the loss of his friend and afraid of his own destiny of mortal being, Gilgamesh went on a new trip to the distant land where lived Utnapishtim (in the Assyrian text; Ziusudra in the Sumerian text), the man who survived the deluge and was granted immortality by the gods. There Gilgamesh, whose request for immortality was not accepted, was told the story of the deluge. Notice that arguments are given in Spedicato [159] that the place of Humwawa should be identified with the high valley of Baltistan, in present Pakistan, close to the Khunjerab pass and that Humwawa might have been a giant yeti; Utnapishtim place is identified with the Ani Machi Mountain Range, in present Chinghai in China, a massif surrounded on three sides by the Yellow River and traditionally a sacred mountain of the Ngolok local tribe. The story is the following (see Kramer [68] for a translation of the incomplete Sumerian text, or Sandars [69] for the Assyrian text, or Pettinato [119] for most of the survived texts):

- before the deluge man had greatly multiplied and many cities were build. The incessant activity of man disturbed the gods, who decided to send a deluge

- Utnapishtim, a man of the city of Shurrupak, was warned by the god Ea in a dream of the impending catastrophe. He built a large square boat, whith sides of 120 cubits, covered it with a roof, insulated it with pitch and there he took refuge with his family and various animals

- at first light of dawn a black cloud appeared at the horizon and daylight turned to darkness. A tempest raged with increasing fury. For six days and nights (in the Assyrian text; seven in the Sumerian text) the wind blew and torrential rains and flood overwhelmed the world

- after seven days the storm subsided; the boat touched land on the slope of the mountain of Nisir; the world was desolated and mud covered everything.

In Critias the priest of Sais states that there were three great floods before and including the Deucalion flood, the one which destroyed Atlantis being the first and the greatest. Excavations in Mesopotamia in 1929 by Woolley [70] have shown the existence of a sedimentary layer, later shown to extend 600 km inland from the Persian gulf, which separates strata both containing archaeological artifacts; the age of the layer has been estimated at 4000 years B.C.. It is current opinion that the flood responsible for the layer is the one referred to in the Utnapishtim-Ziusudra legend and that the Noah story is just another, possibly later, version of the same event.

In our interpretation the biblical and the Sumerian stories may describe the same event, but as witnessed by two different groups of survivors, in two different points of the world.

Now, a basic question. Who has the best chances of surviving in the area affected by the tremendous consequences of an oceanic Apollo object impact? Surely no one in the large coastal areas affected by the tsunamic waves. Almost surely no one in the flat lands or valleys in the interior continental areas affected by the deluge following the evaporation of thousand cubic kilometers of water. Possibly someone living in caves on the slopes or top of mountains or someone navigating in a boat provided with food (or made at least partly by eatable materials...) in an inner lake or in an inner sea, where tsunamic effects could not reach.

We conjecture that Noah was a man living possibly on trade along one of the several inner lakes which are found in the eastern Anatolian plateau (such as Van Golu in Turkish Armenia, Ozero Seven in Armenia, lake Urmiah in present Iranian Kurdistan, but formerly part of Armenia). According to our previous climatological considerations, Central Asia, Mesopotamia and the Mediterranean had a favorable climate during the last glaciation. Civilization most probably evolved in these regions and the natural way of transit between them was through present Armenia. Existence of boats for trasporting goods on the Armenian lakes should be expected, justifying the technological ability shown by Noah in building a large (raft-like notably) boat.

We similarly conjecture that Utnapishtim-Ziusudra was a man involved in trade by boats somewhere along the eastern coast of the great inner sea which during the last glaciation connected the Black Sea, the Caspian and the Aral (or even possibly along the inner lakes extending in the Xinjang province of China). Our geographical differentiation is suggested by the following important variations between the Sumerian and biblical texts:

- the Utnapishtim story tells that a great black cloud appeared on the horizon at dawn and that daylight turned to darkness. The reference to this surely impressive phenomenon is not present in the biblical text. A natural explanation is that the cloud front passed over Armenia during night, hence the sudden change from daylight to darkness did not occur. The extra time for a cloud front to reach Central Asia would well be several hours, to which a time lag for longitudinal difference should be added, thereby explaining the different time of the day the deluge locally started

- in the Utnapishtim story the deluge lasts only six or seven days, much less than the forty days of the Bible, moreover the increase of the water level does not appear so impressive as in the biblical text. A front cloud bringing rain from the Atlantic would exhaust itself moving eastwards and thus a minor amount of water would be washed over Central Asia than over Armenia. Also the maximum distance reachable by the cloud front is expected to be a decreasing function of time, as the magmatic emissions responsible of the evaporation would decrease in time; this would explain the shorter duration of the deluge in Central Asia.

Our conjecture that the Utnapishtim flood was witnessed in Central Asia also agrees with a possible central Asian origin of the Sumerian people that has long been suspected. Indeed the Sumerian language is not Semitic, but is related to Turkish languages of Central Asia (even with Hungarian). Populations with anthropocentric features similar to those of the Sumerians are found in Afghanistan and Beluchistan (Keith, quoted in Cream [71]). Connections between the Sumerian and the Harappan civilizations have been hinted and Heyerdahl [72] has shown that Mesopotamia and the Indus valley can be reached by sea using reed boats. Our conjecture then that Utnapishtim was a man of Central Asia would imply that his descendants, or some of them, moved southwards, leaving some groups along the way, and reaching finally Mesopotamia via the Indus valley and the Indian ocean (or via Iran). It is quite possible that knowledge about good living conditions in Mesopotamia before the deluge had persisted among these itinerant populations.

We can also do some speculations about the descendants of Noah. In the changed conditions after the deluge the descendants of Noah probably became shepherds in the eastern Anatolian - northern Mesopotamian regions. The finding in Ebla of the largest tablets collection of the third millennium B.C. has given startling information, like the existence of personal names in Ebla of biblical type (Abraham, Esauh, David), and the existence of a city named Ur in northern Syria (see La Fay [73] for a review of the work of Mattia and Pettinato on Ebla); it should also be noticed that a fortress named Ur and located in northern Siria is referred to by Ammianus Marcellinus. The Bible states that Abraham, a man whose native land was Nacor in northern Mesopotamia, came from Ur of the Chaldeans to Canaan. Well before Ebla was discovered, Velikovsky [5] gave many arguments in favor of the thesis that the Chaldeans were people of northern Mesopotamia - eastern Anatolia to be identified with the Hittites. Thus we strongly suspect that the biblical Ur of the Chaldeans was not the Sumerian Ur (why indeed call it "of the Chaldeans") but a city of northern Mesopotamia indicated by the Ebla findings. For arguments that Abraham was not of Semitic, but of Indoeuropean stock, as Armenians and Chaldeans are, see Barbiero [127]. Notice that Abraham moved to the land given him by the Pharaoh from the city of Haran (now Harran, in southern Turkey), where he left relatives and where Jacob returned to get his two wives Leah and Rebecca. About 50 km north-west of Haran lies the ancient city of Edessa, whose role in Christianity has been very important (his king Abgar exchanged letters with Jesus according to apocryphal sources; according to tradition the Shroud was hidden in a cavity of its walls and there rediscovered after an earthquake). The name Edessa was given by the Macedonians in remembrance of an ancient Macedonian capital. The present name is Urfa and Hurri was the name before the Macedonian conquest. It was an important city in the second millennium BC related with the Hurrite and Mitanni kingdoms. Local traditions insist that Abraham dwelt there, see Middleton [132], and a cave is still now shown where he was supposedly born (see the guidebook Turkey in the Lonely Planet series). For a location of Ur in Persia five days from Nisibis see Egeria [140], who visited Edessa around 380 AD.

7. A conjecture about the origin of the Camunian civilization

We conclude this essay by considering the possibility that a group of people survived the deluge in northern Italy and that their descendants gave origin to the Camunian civilization. During the last glaciation the Po valley was free from ice, the climate there being similar to that found now in prearctic regions. Similarly free of ice were the lakes which characterize the entrance of many valleys of the Alps, the glaciers filling however most of the valleys (the situation was different in some previous glaciation, when glaciers excavated the depressions now filled by the lakes). A population of hunters and fishermen lived in northern Italy, particularly near the shores of the lakes, where villages existed consisting of huts built on poles. The winter was severe and the summer season was very important for collecting food to be preserved, dried or smoked, for the winter.

Consider now the fate of these populations in the deluge which followed the impact of the Apollo object in the Atlantic considered in the framework of the Atlantis story. The Po valley is essentially protected by the Alps and the Appennines from the tsunami waves coming from the Atlantic, the effect of these being probably restricted to a limited area near the Adriatic. The effect of the deluge would however be totally destructive for populations living in the proper Po valley. But a peculiar geographical feature characterizes the entrance of the Val Camonica, the site where the civilization of the Camunians developed for thousands of years, from the end of the Ice Age to the Roman conquest, leaving a continuous documentation of hundred of thousands inscribed rocks (see Anati [74, 75, 76, 77] and Dufrenne [160]).

The geographical feature is the following: there is a relatively large lake (Lake Iseo) at the entrance of the valley, in the middle of which lies Montisola, the largest island of the Italian lakes. Montisola, about two square kilometers, is hilly, its summit about 400 meters above the level of the lake. Most probably fishermen lived in Montisola, possibly not in pole villages, dangerous animals in relatively small Montisola having certainly been eliminated, but on caves or huts along the slopes of the island. We believe that a group of people in Montisola would have had a good probability of surviving the deluge. In fact, due to its small surface, the effects of the water washing down the slopes would have been limited; the deluge in the nearby area would have increased the level of lake Iseo, but not so much to completely cover Montisola. If the event happened in summer or early autumn (Patten [134] gives arguments for late October), reserves of food for the winter would have already been available, allowing survival during the weeks of paroxistic deluge; moreover the effect of the deluge on the lake fish on which the Montisola population lived was probably marginal. The people of Montisola found themselves possibly the only survivors in a desolated and changed world and may have attributed this fact to the special place where they lived. This belief could well explain why the Camunians did not move for millennia from the valley where their ancestors survived the deluge. Our interpretation might also shed some light for a nonstandard interpretation of the over 300.000 inscriptions on rocks found in Val Camonica, where motifs appear that can be probably related to cosmic events.

8. Final remarks and conclusion

In the previous sections we have developed a scenario to explain the end of the last glaciation, the stories of Atlantis, Noah and Utnapishtim, and the origin of the Camunian civilization, in the framework of an event of extraterrestrial origin, say the impact of an Apollo object over the Atlantic ocean. We are well aware that our scenario, how apparently coherent and intriguingly fascinating it may be, cannot be considered proved, containing an unavoidable high amount of speculation. Open questions concern in particular whether the last glaciation was actually ended by an impact, whether a civilization of the Atlantis level existed in the final period of the last glaciation, whether the Noah and Utnapishtim deluges were contemporary with the Atlantidean catastrophe. Future research on Apollo objects, crater traces on the Earth and global climate models, will help in assessing the validity of our scenario.

While it is improbable that archaeological research may sometimes prove or disprove the Noah and Utnapishtim stories (but additional useful documentary sources most probably are to be found in the thousands of unexcavated tells of the Middle East; see also Fasold [139] for a discussion of artecfacts related to the Noah's ark on mount Judi, about 30 km south of mount Ararat) it is not excluded that the development of deep water archaeology and radar exploration techniques able to photograph below sedimentary deposits will clarify the issue about the city of Atlantis, which we conjectured lies at least sixty meters below sea level in the southern part of Hispaniola.

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