Gnetum gnemon L. reduces their hunger. The Shompens and a few Nicobarese still depend on the fruits of screw pines (*Pandanus* spp.) for their staple food. The Onges dig out tubers of *Tacca leontopetaloies* (L.) O.K. and consume them as we do potatoes and Cassava. As stressed by Gadgil[6], information for monitoring population of thousands of species of human significance needs to be continually collected from traditional knowledge.

Over an intensive study on the ethnic tribes of these islands, T. S. Naidu (personal communication) of Pondicherry University was alarmed that the 3 primitive tribes, viz. Onges, Great Andamanese and Shompens numbering 104, 37 and 187 respectively, were on the brink of extinction and our knowledge on their primitive and traditional lifestyle would be completely wiped out from this world unless we take some steps to save these aborigines and their habitats from imminent extinction. Sami[7] reports that the present population of Great Andamanese is decimated by pneumonia, syphilis and measles to just 20. The dwelling sites of these rare tribals are threatened by various calamities and are on high extinction risks. Thus there is an urgent need to take steps to conserve their habitats, flora and fauna.

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ACKNOWLEDGEMENT. I thank Dr P. K. Hajra, Director, Botanical Survey of India, Calcutta for encouragement and facilities.

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The Permian mass extinction – Are the killers from outer space?

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The history of life is not necessarily progressive; it is certainly not predictable. The Earth's creatures have evolved through a series of contingent and fortuitous events.

– Stephen Jay Gould

It was decimation on an unprecedented scale – over 90% of marine species, 80% of vertebrates and more than 30% of insect genera vanished from Earth[1,2]. Land plants were not left untouched either, and vegetation was hit to such an extent that their decay brought about supremacy of fungi thriving on rotting and dead wood over the continents for a brief geological span[3]. The close of Permian and early Triassic, the P–Tr times, about 250 million years ago (Ma), witnessed this orgy of destruction of the living species that had so abundantly evolved over the preceding 300 million years since the early Palaeozoic era. Though the march of life on Earth has been punctuated by bouts of such extinctions (at least 5 major ones during end of Ordovician, late Devonian, end of Permian, end of Triassic and end of Cretaceous, see Figure 1), the end Permian annihilation was the worst in the planet's history, pushing to the background the much worked out and publicized Cretaceous–Tertiary (K–T) event, 65 million years ago, that witnessed the exit of dinosaurs and other genera, to a mere 47%. Over the past few years, scientists have been examining various types of geological records and other tell-tale evidences to identify some of the possible mass killers, both earth bound and beyond; however, most of the suspected agents do not appear to be the perpetrators of the P–Tr extermination, when evaluated against 'taxonomic, physiological, ecological and biogeographic patterns of extinction'[4]. Climatic changes, see-level fluctuations, dissolved oxygen depletion in oceanic waters leading to anoxia and suffocation, enhanced carbon dioxide build up on land and water, volcanism and its after effects and, very recently, a killer asteroid from outer space, are some of the agents advanced to explain the P–Tr extinction.

Many researchers believe that the end Permian extinction was due to a certain chain of natural events affecting the chemistry of air, land and water. Their onset was supposed to have been triggered by mantle changes during that period. This had resulted in ocean spreading, parting of land masses and drop in sea level leading to emergence of continental shelf, all of which precipitated severe inland erosion and burial of vast amounts of soil and vegetation[5]. The abrupt shifts in ^{12}C to ^{13}C ratios found in the sediments of this age, due to the greater abundance of

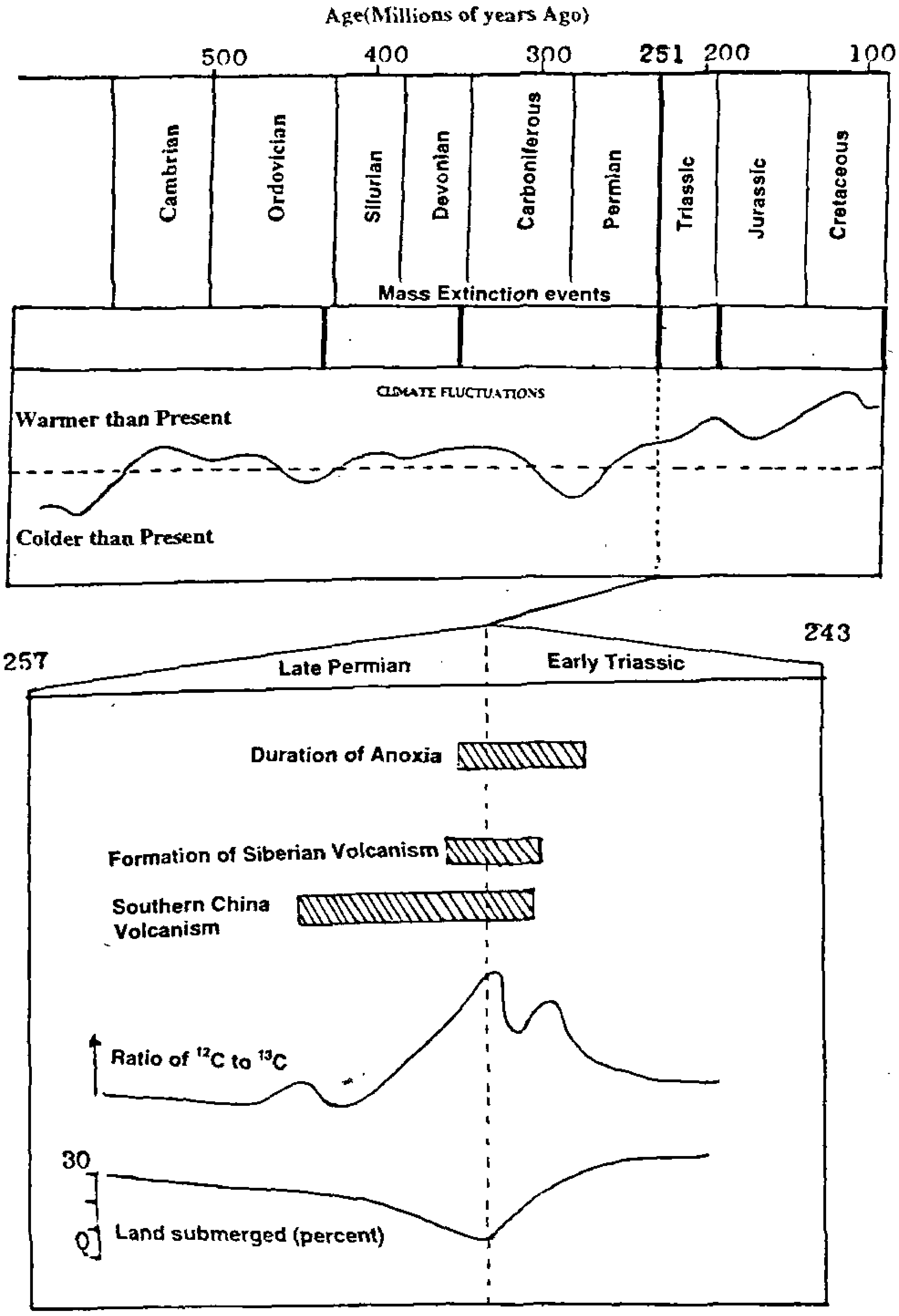

Figure 1. Environment during the Permian times and mass extinction events since the Cambrian (adapted from Erwin[1,2]).

lighter ^{12}C, are considered ample evidences for such burial[1] (biogenic carbon generally shows enrichment of the lighter isotope ^{12}C, whereas non-biogenic carbon has more of the heavier isotope ^{13}C and hence the influx of vast amounts of organic matter upsets the normal ratio in favour of the lighter isotope). Oxidation of these organic matters led to depletion of oxygen and increase of carbon dioxide in the atmosphere and consequent rise in global humidity and temperature, trends that were detrimental to the survival of life. The reduction of atmospheric oxygen had also an adverse impact on the availability of dissolved oxygen in the oceans and this gradually led to the development of anoxic (lack of oxygen) conditions and suffocation of marine life (Figure 1). Further upsets to survival of life occurred around early Triassic when marine transgression took place and ocean waters engulfed coastal habitats, killing the communities of life there.

Last year, R. K. Bambach of Virginia Polytechnique and State University, A. H. Knoll of Harvard University along with their colleagues offered a different interpretation to the chemical changes in the oceans[4]. Anoxia, they felt, cannot explain the particular patterns taken by the P–Tr extinctions and instead, the real culprit may be the increased carbon dioxide in the oceans brought about by the consumption of dissolved oxygen by the decaying organic matter. In the present times, anoxic condition does not easily develop in the ocean bottom zone due to good churning up of the oceans; the latter process effectively replaces the oxygen consumed through the circulation of oceanic currents of heavier, oxygen-rich surface waters. These currents are triggered when the waters from the cold polar regions, being denser and heavier, sink to the oxygen-deficient bottom zone of the ocean and circulate around the world before surfacing again. Such natural replenishments of oxygen (called thermohaline circulation) were non-existent during the Permian times, when the seas formed one unbroken stretch surrounding the supercontinent of Pangea. The climate, also, was too warm then to have supported an icy polar region to initiate the circulating ocean currents and bring about the churning up processes. As a result, carbon dioxide concentration in the ocean waters rose to as much as 30 times the present-day levels. Depletion of atmospheric carbon dioxide (a reverse greenhouse effect) followed, inducing a drop in global temperature, and thus initiating polar glaciation and commencement of ocean currents. This oceanic water circulation was supposed to be responsible for pushing up the relatively light anoxic bottom waters to shallower regions at the top. This influx, they contend, extinguished the marine life there, particularly those with passive respiration which were prone to accumulate carbon dioxide in their tissues, a condition known as hypercapnia or CO_2 poisoning. At this stage, exchange of carbon dioxide with the atmosphere revived, leading to global warming, melting away of polar ice and gradual decrease of thermohaline circulation once again. The adverse climatic and ocean chemistry and accompanying extinction episodes thus waxed and waned over the successive geological spans. These cyclic bouts are not much evidenced in the geologic strata of the P–Tr times but, the authors have drawn support to their hypothesis from the well-preserved geological evidences of such episodes that had occurred, at least four times, during the eras preceding the Permian period, between 800 and 540 million years ago. They feel that these on and off ocean current episodes must have continued during later periods also and brought about the decimation of life cyclically.

Advocates of volcanism cite the Siberian and south China outpourings mainly responsible for the P–Tr extinctions. The Siberian eruptions commenced during the late Permian and extended into early Triassic for about 1 million years while the south China volcanism started much earlier and was active till early Triassic (Figure 1). According to them, these prolonged eruptions altered the global climate, induced acid rains, and reduced the ozone layer protecting life from the lethal U–V radiation from the Sun. Large quantities of methane were believed to have been abruptly released which in due course got converted to carbon dioxide and water. According to one view, the large influx of methane as well as carbon dioxide may have been responsible for the mass extinction. The volcanism was also supposed to have set off extensive forest fires which destroyed the living habitats of several species, besides poisoning the atmosphere by belching out toxic effusives. Recently, Samar Abbas and Afsar Abbas of the Institute of Physics, Bhubaneswar, hypothesized that the elusive 'dark matter' pervading the universe could be the cause for the Siberian volcanism. They envisage that Earth could capture as many as 10^{18} of these particles per second whose steady accumulation and annihilation through collision with materials of Earth's interior could, over geologic time, build up sufficient heat to melt the mantle and trigger volcanic eruptions. Though these appear staggering, many scientists feel the adverse impacts of volcanism are exaggerated. Also, the commencement of Siberian eruptions is vague and some scientists even doubt whether this volcanism preceded the main mass extinction at all. Their destructive after-effects, they say, may at best be limited to a very small area only and doubt their potential to bring about the scale of mass decimation of life witnessed during the late Permian.

Though similar harbingers of death and destruction were attributed to the mass purge of dinosaurs and other species during the Cretaceous–Tertiary period, the meteorite impact view[6] had gained wide acceptance mainly due to supportive evidences gathered during the last seventeen years. These include the detection of unusual amounts of iridium in the geological formations of the times, discovery of shocked quartz at the impact crater site, and ample indications for post-impact climatic repercussions affecting the fauna and flora. None of these convincing impact-related proofs has been reported in the few catastrophic impact views[7] put out for the P–Tr extinctions.

Recently, Gregory Retallack of the University of Oregon has announced that his discovery of quartz crystals from P–Tr boundary rocks showing unusual damage to their crystallinity, points to an asteroid impact during this period[8]. The observed damage to the quartz grains appears in the form of intersecting glass-filled planar deformation fractures (PDFs) which he claims are generated due to an asteroid collision. He had collected these crystals from the P–Tr boundary near Sydney, Australia and also from the Transantartic Mountains in Vicrorialand, Antarctica. These sites, though well separated today, were lying adjacent within the continent of Pangea existing at the time of the supposed impact during the Permian times. His suspicion about the asteroid connection was a sequel to the sharp changes in the carbon isotope ratios his colleagues had earlier reported from the sediments at this site. Such sharp changes are usually noticed when considerable volumes of organic material get intermixed during sedimentation, a process that can arise subsequent to an asteroid impact. The life-destroying potential of such impacts is today well known and documented by researchers who investigated the K–T event.

Though Retallack's shocked quartz grains displayed the characteristic impact induced PDFs, the typical strain effects, seen usually as colour bands under a microscope, were not reported by him. Scientists are now reexamining them for other unreported after-effects, such as the changes in the mineral's refractive index, more PDFs, intersecting at the correct angles and presence of shock-induced glass (products of rapid cooling of impact-melted rock material) at the site. Particularly sought after will be the samples showing anomalous iridium contents, typical contaminants from extraterrestrial bodies. If these findings favour Retallack's views, we have a perpetrator of the P–Tr mass extinction on the lines of the K–T event. A seismological view, yet to be confirmed, but rather supporting the asteroid hypothesis, points to the antipodal volcanism believed to be triggered by past impacts. The Siberian volcanism took place exactly on the opposite side of the proposed late Permian impact site in southeast Australia and also the massive Deccan volcanism in India erupted almost opposite to the Mexican impact site of the K–T meteorite.

Geologists have now a wide range of Permian killers, but to pin any one of them as the sole culprit, may not be acceptable as the magnitude and patterns of extinctions on land and sea appeared to be rather the outcome of a combination of adverse events taking place simultaneously or in quick succession. Even the widely accepted meteorite-related causes attributed to the K–T mass extinctions is not considered as global as made out by the proponents. It is found that the K–T meteorite's damage to life was confined to mid-latitudes only, and the impact of the collision was hardly noticeable in the then polar regions[9]. As Douglas Irwin observes 'all possibilities mentioned may have contributed. None of them alone could have caused an extinction of this size, but it was bad luck of the exquisite Permian faunas to have all these interact about the same time[1]'.

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