Telling it like it was

Deep Time: How Humanity Communicates Across Millennia
by Gregory Benford
Avon: 1999. 225 pp. $20

Peter T. Landsberg

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From there to here: our desire to leave a marker for the future existed back in ancient Egypt.

To transfer information at some point in time to a period that could be later by millennia is not an easy proposition, but such transfers have a long history. Think of the pyramids and the various structures that are known as the Seven Wonders of the World. Apart from the Cheops pyramid in Giza, Egypt, most did not survive as long as their creators had hoped. But the point is that the ancient structures that did survive serve a useful purpose: they furnish us with a guide to the sort of life lived many centuries ago. And, of course, they gave reigning emperors some assurance that they would be comfortable in their afterlife. The cave paintings in the Lascaux cave, on the other hand, may represent art for art's sake, or may also have had a magical purpose. We just do not know.

In the present era, it is not the wish for comfort in the hereafter, or the desire to exercise a religious impulse, that causes us to signal to the future. Our motivation is scientific fervour. The 1977 Voyager missions to the outer planets, for example, contained a phonograph record of the shouts and songs of humanity (plus instructions on how to use it). This reminds one of the 1971 Pioneer mission, which carried a plaque showing two nude humans greeting the infinite with a wave. Far more complicated ideas had also been considered by the scientists of the various space agencies. For example, the finders of a payload would have been able to date a launch to within a million years or so had it provided a current view of the Andromeda galaxy. The reason? The galaxies rotate, though rather slowly, and the observed rotation would have revealed roughly how much time had passed.

Gregory Benford notes that the 1997 Pathfinder spacecraft deposited the names of members of the Planetary Society on Mars — probably not essential information for future cosmic travellers. Indeed, as Benford says, " as a projection of pure vanity, it resembles the International Star Registry, which sells people certificates stating what stars have been named after them".

"Deep time", a period of the order of a millennium or so introduced by the author, is also relevant for those who wish to save our biological diversity. Benford relates how he wrote a paper in 1992 in which he proposed to take representatives of all threatened species and suspend them in liquid nitrogen for the indefinite future. This paper was rejected by *Science* and *Nature*, but eventually caused considerable discussion after its publication in the *Proceedings of the National Academy of Sciences*. The idea is to go beyond "the piecemeal strategies of seed banks, of germ plasma", to make up an, admittedly incomplete, collection of threatened species. There is a full discussion of this suggestion in a chapter called "The library of life". The problem of showing precisely where radioactive waste is buried is discussed in a chapter entitled "Ten thousand years of solitude". The markers should presumably survive thousands of years, but there is a case also, as pointed out by the author, for not marking them at all, so as to prevent future theft.

Deep Time offers an unusual combination of ideas that give food for thought, even though some seem rather far-fetched. In a future edition, Benford might improve the organization of the text, for example by giving a table of dates and other details of the satellite launchings that are discussed. Also, a list of markers — 'headstones' — actually used to indicate burial sites of radioactive waste would help. Further, the author's colleague Frank Drake, who is mentioned repeatedly, is presumably connected with the well-known equation that gives a rough estimate of the number of advanced civilizations in a galaxy. This might be pointed out.

Benford is a professor of physics at the University of California at Irvine and helped to design the message that flew on the 1997 Cassini mission to Saturn. He has also worked on the long-term marking of US nuclear-waste sites. So the book is worth reading for its insider's account of the design of markers that tell the story of humanity, and of the Earth, for the benefit of future cosmic travellers. It is also useful for the details it gives of the plans to keep alive our biodiversity, and for its discussion of the storage of nuclear waste. □

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Explosion of interest

Melting the Earth: The History of Ideas on Volcanic Eruptions
by Haraldur Sigurdsson
Oxford University Press: 1999. 260 pp. $30, £18.50 (pbk)

Martin Rudwick

Volcanoes can hardly be ignored, least of all by those who live near them, and their often violent eruptions have duly been recorded throughout literate human history. One of the earliest to be described in some detail was the eruption of Vesuvius in AD 79, which destroyed the towns of Pompeii and Herculaneum. Yet, by preserving the buildings and their contents, that eruption has also given historians and archaeologists an almost unique insight into the everyday life of a Roman province. Twenty years ago, the volcanologist Haraldur Sigurdsson became intrigued by what the volcanic debris that had buried the towns could reveal about the eruption itself. That scientific research, aided by Pliny's famous eye-witness account, led to this historical survey of ideas about volcanic eruptions from antiquity to the present day.

Although Sigurdsson writes as a scientist rather than as an historian, he is familiar with some of the historical literature and, more importantly, has read for himself many of the historical sources that he quotes or summarizes. His account is illustrated with many contemporary pictures of eruptions, some of which will be unfamiliar even to historians of the Earth sciences. He also has the inestimable advantage of having grown up in the volcanic landscapes of Iceland.

Sigurdsson's account combines two distinct kinds of history. The first, which predominates in the earlier chapters, is a history of the eruptions themselves and their human impact. He summarizes the long-running debate about the relation between the catastrophic eruption of Thera in the Aegean in the seventeenth century BC, and the nearly contemporary collapse of the Bronze Age Minoan civilization. He also gives a fascinating reconstruction of the complex eruption of Vesuvius in AD 79.

The second kind of history, which almost takes over in the later part of the book, is an account of the ideas of savants (who in more recent times can properly be called scientists) about the causes of volcanic activity. Here Sigurdsson wants to shift historical attention away from those, such as Nicolas Desmarest in eighteenth-century France, who first recognized extinct volcanoes in regions far from active ones, and thereby showed that volcanism was no mere minor or local phenomenon. Instead, he highlights those he regards as the "true heroes" of his story, nineteenth-century geophysicists, such as William Hopkins.

This is fair enough, but Sigurdsson fails to recognize that his own interest in the causes of volcanic activity was, for savants of earlier generations, only one of many features of volcanoes that deserved close scientific study. For them, the descriptive and classificatory 'natural history' of eruptions was just as important as any 'natural philosophy' or causal theorizing about them. And the former often had greater prestige precisely because it could be more rigorous and not as speculative as the latter.

Furthermore, even within the tradition of causal theorizing, there were many other problems besides the one that Sigurdsson, from his modern perspective, regards as the most fundamental and uses for his title. The mechanism by which rocks are melted within the Earth, to form the magma that reaches the surface as volcanic lava, was indeed a long-standing puzzle. But so, for example, was the very fluidity of lavas and the origin of their generally crystalline structure, and the reasons for the striking variations in the behaviour of different volcanoes.

Sigurdsson does in fact deal well with the history of some of these problems, and he also gives a reliable account of the fortunes of various ideas about the ultimate source of the heat that locally melts the Earth into magma. He takes the story through the discovery of radioactivity a century ago, which provided a previously unsuspected source of heat, and through the development of plate-tectonic theory in the 1960s. And he ends in the age of space exploration with a brief allusion to the extraterrestrial volcanoes discovered recently on Jupiter's satellite Io.

All in all, Sigurdsson has provided an attractive and readable account of the history of ideas about volcanoes, and it should do much to curb what he describes as scientists' frequent dismissal of their own past, "an arrogance that is built on ignorance". □

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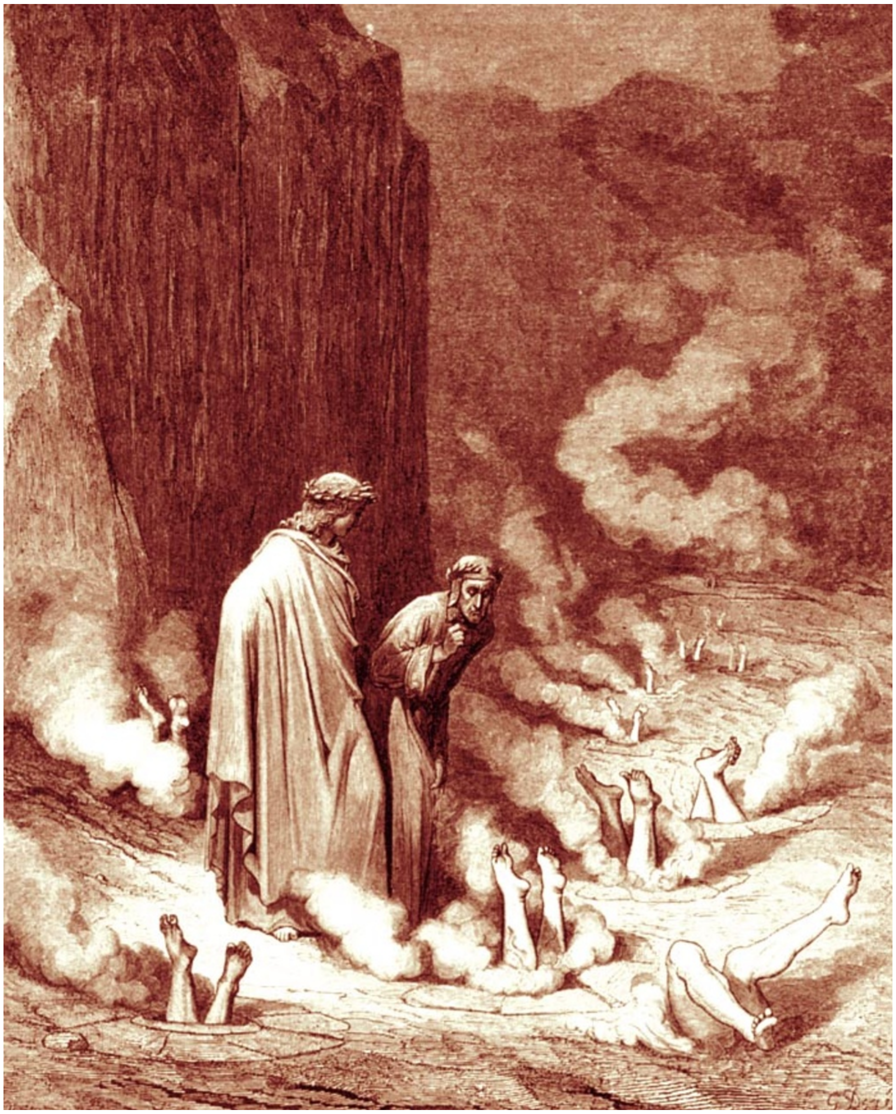

Hell on Earth: Virgil in Dante's Inferno, inspired by bubbling mud pits in a volcanic region near Naples.

From tulips to electric cars

Arbres de Pierre: La Croissance Fractale de la Matière
by Vincent Fleury
Flammarion: 1999. 334 pp. FF170

Patrick Tabeling

The beauty and complexity of the forms found in nature have always intrigued and challenged physicists. Where do they come from? Are there general, underlying, perhaps simple, mechanisms that lead to the formation of a snowflake or a tulip? These questions form the theme of Vincent Fleury's *Arbres de Pierre*, which describes morphogenesis from historical, physical and aesthetic perspectives.

The first chapters give a well-documented historical background to the subject. We read how René-Antoine Réaumur, inventor of the thermometric scale that bears his name and a pioneer in the days before morphogenesis was recognized as a subject, was concerned by the inability at the time to explain the origin of the shapes of stones. We learn how Johannes Kepler proposed a mechanism for the formation of snowflakes, taking into account their sixfold symmetry. We wander through previous centuries,