From Santorini to Armageddon

North American tree-ring data confirm that volcanic eruptions can cause climatic change. So would nuclear war, but to a degree not yet calculable.

THE general concern with cataclysmic happenings on the surface of the Earth requires no special explanation. In a more or less orderly world, people are naturally disquieted by the notion that their lives may be disrupted (or even ended) by events over which they have no control. For if the collision of the Earth with an asteroid at the end of the Cretaceous may have extinguished the dinosaurs and many other kinds of species, may not less spectacular but more probable events abruptly change the course of history without warning, breaking the comfortable expectation of continuity with the future that we now enjoy?

That, no doubt, is part of the reason why there is such widespread alarm about the risk of nuclear war. The same applies to the more recent general preoccupation with the results of purported recalculations of the long-term consequences of a nuclear war, those for example represented by the summary of a calculation now published by Professor Carl Sagan and a group of associates (*Science* **222**, 1283; 1983). They assert that after a nuclear war, the Earth's atmosphere would be so laden with dust that solar insolation of the surface would be drastically reduced, thus also reducing surface temperatures and perhaps even reducing the rate of photosynthesis to below that required for survival.

The issue is not as academic as it might be made to seem by the remark "We'll all be too dead to care". That might be true of the populations of the principal combatants and their neighbours, but populations in the other hemisphere, while damaged by fall-out, would still have a vital interest in the feasibility of survival. So if there are long-term climatic consequences of nuclear war, it is important to know what they are. Those wishing to follow the argument might prudently begin not with the article by Sagan *et al.* but with that of Lamarche and Hirschboek from the University of Arizona in this issue of *Nature* (page 121).

That rich tale, fascinating in its own right, also has a bearing on the question raised by Sagan *et al.* What Lamarche and Hirschboek have done is to correlate with the known occurrences of major volcanoes the occurrences of frost damage rings in bristlecone pines, the long-lived species by means of which dendrochronology in eastern California has been extended back for nearly 5,500 years. The results are striking. Frost-rings in bristlecone pines do indeed correlate well in time with the occurrence of major volcanoes, among which Krakatoa (1883) is, so to speak, the type-specimen.

Within the past century, during which historical records approach in accuracy the tree-ring calendar, the data show that frost-rings follow eruptions more frequently than if the two kinds of events were independent. But during this period, there were summer cold snaps in the western United States not attributable to eruptions (1941 and 1886 for example) and, in the earlier period, many major eruptions that appear not to have caused frost damage.

That is what would be expected. The veil of dust from a volcanic eruption is only one of many causes of climatic variation, while eruptions differ markedly in character, some yielding only short-lived dust clouds.

Several features of the study now described are nevertheless especially pleasing. First, the notion that major eruptions can cause detectable climatic events is modestly confirmed. Second, the work further supports the view that one of the meteorological consequences of volcanic dust in the atmosphere is (in the Northern Hemisphere) an expansion of the circumpolar vortex in the mid-troposphere and a tendency for the pattern of the stratospheric jet-stream to consist of a more exaggerated sequence of lunges towards low latitudes. That should enhance the confidence of model-builders and support those who have been suggesting that the cold spring and autumn in the Rocky Mountains last year (1983) may indeed have been a consequence of the El Chicón eruption in 1982. Finally, a valuable bonus, there is an objective date (1626 BC) for the volcanic explosion of virtually all of the island of Santorini (then called Thera), one of the traumatic events of late Minoan history.

The bearing of this careful study on the question raised by Sagan *et al.* is only indirect. It does, however, qualitatively confirm one of the chief predictions of the consequences of nuclear war — that dust in the atmosphere can have long-term climatic consequencs. But many of the events suggested by the tree-ring study seem to have been exceedingly short-lived. Thus the frost-rings found in California, Utah and Nevada in 1884, the year after the eruption at Krakatoa, seem to correspond with a southerly incursion of cold air from Canada on 9 and 10 September (after a summer that had admittedly been unusually cool).

By contrast, Sagan *et al.* predict much lowered temperatures — on some pictures of the course of a nuclear war, perhaps 20 per cent below normal for 3–6 months afterwards. The chief reason for this huge discrepancy between the consequences of a nuclear war and a volcanic eruption stems from the assumptions made about the quantities of dust carried into the stratosphere by the different events. But everybody, Sagan *et al.* included, agrees that this field is shot through with uncertainty.

The assumptions made about nuclear dust appear, however, to be chiefly responsible for the differences between the new and earlier calculations, that of the 1975 report from the National Academy of Sciences for example. In what is called the "baseline scenario" of a nuclear war (10,000 nuclear explosions with a total yield of 5,000 megatonnes), it is supposed that 1,000 million tonnes of dust would be created, that 80 per cent of that would find its way into the stratosphere and that 8.6 per cent of that would consist of particles smaller than 1 micrometre radius. These assumptions would load the atmosphere with more fine dust than previous calculations have assumed. The new assumptions (and the use made of the one-dimensional model for predicting the attenuation of the obscuring effects of stratospheric dust) are, unfortunately, to be discussed only in a paper still "in preparation". Until that appears, those familiar with the well documented difficulties of measuring the composition and the size distribution of dust even from well studied volcanoes such as Mount St Helens (see for example Brazier, S. *et al. Nature* **301**, 115; 1983) will be wondering where the apparently much more precise data about nuclear dust has come from.

None of this implies that such calculations should wait on accurate parameters for all possible variables. It would probably also be common ground between the authors of the latest calculation and their more quizzical readers that the use of one-dimensional models is likely to yield upper limits for the effects calculated. What might, however, reasonably be asked of the authors is that their conclusions, derived as they are from necessarily crude models and uncertain data, should be plainly stamped with the label QUALITATIVE for fear that their apparent precision may prove spurious.

John Maddox

0028-0836/84/020107-01$01.00