

# Too little, too late

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*Nuclear Explosions and Earthquakes: The Parted Veil.* By Bruce A. Bolt. Pp. xxi+309. (Freeman: San Francisco and Reading, March 1976.) £6.

AFTER the Soviets had unexpectedly broken the moratorium on nuclear tests in 1961, the distinguished owner of this journal (Harold Macmillan) was said to have asked his advisors to show cause why his Government should continue to support seismological research for a test ban; after all was not the UK also free of serious earthquakes? Happily the advice was convincing, the work continued and, according to Professor Bolt, to some effect in a country which had lost its impetus for experimental seismology after John Milne and his contemporaries.

I was reminded of this anecdote by the author's surprise that seismology in aseismic Sweden should be so well supported. It is good that it is because, like the Shields which are seismologically exploited by the Commonwealth countries, Sweden is as near perfect a receptor for seismic waves as one could hope to find—Uppsala was well known for its overestimates of the seismic yields of underground explosions—and in spite of such sites the technical reason why there is no ban on nuclear tests is because the threshold of seismic detection is still rather too high to deter cheating. The fact that places where the seismic transmission properties and ambient noise might be good enough for seismic monitoring of a comprehensive ban on tests are unlikely to be found is not made too clear by Professor Bolt. This means that as long as the possibility of secret tests is a cause for concern, previously unacceptable threshold treaties, like that of the new Soviet-American agreement, must suffice. The author concludes: "the veil across the future of history of civilisation has not been parted".

Nonetheless, seismologists were given every encouragement and opportunity to make a significant contribution to the unveiling; and in describing how they failed this new book by Professor Bolt gives the lay reader a broad and well balanced insight on a many-sided problem.

The basic mechanisms and effects of nuclear explosions and earthquakes, the

way in which the Earth's interior structure and the seismograph modifies the relatively simple seismic wave radiations from these sources, are explained in the first four chapters. We are given an inkling of the confusion which is to follow, but at first all seemed straightforward to the geophysicists from East and West who gathered in Geneva in the summer of 1958 to examine the possibility of monitoring compliance with a treaty to ban nuclear tests. Ironically, the weapon tests which were to deny some of their predictions had already been planned for the autumn; only a month or two after the publication of their report describing how 5 kton or more could be reliably monitored, American seismologists experimentally demonstrated that there would be a great deal of doubt about underground explosions of as much as 20 kton and a few months after that, American physicists showed (theoretically) how to convert a megaton to a few seismic kilotons by detonating in a large enough hole in the ground. That it had to be an unbelievably large hole was irrelevant; the damage was done, in the next three years the opportunity to change the course of affairs (whether for good is another question) passed and the ensuing decade has been devoted to the founding of forensic seismology.

In the end it has turned out that the 1958 experts were not so far wrong, on average, in their 'guesstimate' of 5 kton; seismic waves from yields of this order (as reported by the Soviets) have been recorded on western seismographs with disarming clarity. The trouble is that signals from Nevada are not so well received and it is on Nevada Test Site experience that the Earth is calibrated in terms of seismic magnitude to kilotons of explosive. Geophysicists have been slow to accept that the property of the upper mantle to absorb seismic wave energy varies widely according to the tectonic history of the region. For policing a test ban, it is the behaviour of explosions in regions of high attenuation which determines the threshold at which compliance with a test ban can be guaranteed.

Together with an overestimate in the number of earthquakes of a given size to be expected each year (an error which was rectified in a little remembered US Atomic Energy Commission announcement in July 1962), the existence of unknown, highly attenuating structures was the fundamental source of the early confusion. Professor Bolt takes the next three chapters to describe the results, in the course of which he outlines the contributions of the USA, the Soviet Union and the UK, and of Australia, Canada, China,

France, Japan and Sweden. The Berkner Panel Report outlined the needs in the USA and a curiosity of this report is that its principal contributor was John Gerrard, a product of Professor Bullard's Cambridge department which was to play a useful role in the UK's own contribution.

At the time Bolt completed his book, the prime importance of lateral variations in the upper mantle had not been established, nor had seismogram modelling and the refined aspects of broad band seismology been confirmed as techniques for discriminating between seismic sources and for revealing some methods for testing in secrecy; it says much for the still vigorous development of forensic seismology that Professor Bolt's book is already out of date.

The last three chapters are devoted to accounts of spin-off from the development of nuclear weapons. These include: nuclear engineering for which Professor Bolt is an enthusiast in the face of counter arguments that it is not realistic to seek test bans and non-proliferation of nuclear weapons with, at the same time, freedom to engineer with nuclear explosions; the environmental consequences on people, animals and on earthquakes, the controversies about which were initiated by the megaton sized tests in Nevada and Amchitka Island and, finally, the discoveries about the interior of the Earth which have been made possible because the hypocentre, origin time and size (all unknown quantities for earthquakes) can be measured with great accuracy for nuclear explosions. These discoveries are grouped in the chapter on seismology and nuclear politics on the dubious grounds that politics prevents the free exploitation of large explosions in the interests of seismology.

The book is equipped with appendices giving incomplete lists of nuclear tests by the USA, the Soviet Union, the UK, France and China, and the full text of the 1963 Test Ban Treaty. It is prefaced by a helpful chronology on the principal nuclear and seismological events beginning with Trinity (the first test of all) and ending with the first underground test by France in the south-west Pacific. To students of the test ban problem this French test may represent another gain for the 1963 treaty in spite of non-adherence to it by France. Professor Bolt uses boxes to enclose the more technical sidelines and thereby neatly maintains the well written flow of the text without interruption. □

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