mine wide band system lies between m_b 5 and m_b 5·3 at a distance of 3,500 km.

H. I. S. THIRLAWAY

UKAEA, Blacknest,
Brimpton, Reading RG7 4RS,
Berkshire.

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[1] Molnar, P., Savino, J., Sykes, L. R., Liebermann, R. C., Hade, G., and Pomeroy, P. W., *Nature*, **224**, 1268 (1969).

[2] Liebermann, R. C., and Pomeroy, P. W., *J. Geophys. Res.*, **74**, 1575 (1969).

Reply to Thirlaway

WE apologize to Thirlaway and his colleagues for stating categorically that the shape of the surface wave spectra for discriminating between earthquakes and explosions was suggested prior to our work[1] but not tested. The two figures presented by him in the SIPRI report[2] certainly suggest such spectral differences for explosions and earthquakes. For his data, however, it is not possible to attribute these differences unambiguously to the two kinds of sources because earthquake and explosion data were not shown for the same region. Because Liebermann and Pomeroy[3] and others demonstrate large regional differences in M_S–m_b populations, sceptics could question the interpretation of these differences. Also, the two figures are presented with practically no discussion; we strongly urge publication of the results through established journals. His explosion data do not extend to periods greater than 25 s for two events and about 33 s for the third.

Our explosion and earthquake data[1], however, were obtained for nearly identical source regions and propagation paths, and they extend to periods of about 50 s. Thus we can unambiguously state that differences in the source spectra for the set of explosions and earthquakes that we studied must be attributed largely to differences in the two different types of source time functions and not to differences in focal depth, propagation path, radiation pattern or source dimensions.

We agree that it remains to be seen whether instruments (particularly long period horizontal seismometers) in near-surface vaults will give results comparable with those obtained in the New Jersey mine. Nevertheless, we are optimistic that this can be done. Our location in an active zinc mine is, in fact, quite noisy for long period pressure fluctuations. We successfully eliminated pressure changes as a major contributor to the seismic background noise. Amplitudes of microseismic noise for periods near 20 s in the mine are comparable with those reported[2] for high-quality sites on the surface. Because our instruments are limited by microseismic noise with periods near 20 s, detection capability is not sacrificed by broadening the recording band in comparison with existing narrow band instruments peaked near 20 s.

We stated[1] that we did not have adequate data for m_b (USCGS) less than 5·0 to identify the lower threshold for detection and discrimination of explosions and earthquakes. Also, we noted that body-wave magnitude, m_b, as determined by the USCGS for events in western North America, tends to be larger than determinations made at great distance (which form the basis for most comparisons of detection and discrimination levels[2]). Thus Thirlaway's assessment of our detection threshold probably is a pessimistic interpretation of our results.

In our analysis, a comparison of 50 s Rayleigh waves with m_b seems to be the best discriminant for underground explosions and earthquakes. The amplitudes of 50 s waves for the smallest explosions detected (m_b 5·3) are about twenty times smaller than those for earthquakes of the same m_b. The near parallelism of the explosion and earthquake populations makes us optimistic that the discrimination threshold can be lowered by similar study of additional earthquakes and explosions with $4{\cdot}0 < m_b < 5{\cdot}0$ and by more sophisticated data processing.

PETER MOLNAR
JOHN SAVINO
LYNN R. SYKES
ROBERT C. LIEBERMANN
GEORGE HADE

Lamont-Doherty Geological Observatory of
Columbia University,
Palisades, New York 10964.

PAUL W. POMEROY

Seismological Observatory,
University of Michigan,
Ann Arbor, Michigan 48104.

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[1] Molnar, P., Savino, J., Sykes, L. R., Liebermann, R. C., Hade, G., and Pomeroy, P. W., *Nature*, **224**, 1268 (1969).

[2] *Seismic Methods for Monitoring Underground Nuclear Explosions—An Assessment of the Status and Outlook* (International Institute for Peace and Conflict Research (SIPRI), Stockholm, 1968).

[3] Liebermann, R. C., and Pomeroy, P. W., *J. Geophys. Res.*, **74**, 1575 (1969).

Measurements on Cloud Chamber Tracks

RECENT work reported from Sydney[1–5], on tracks in cloud chamber photographs of particles near the axis of extensive air showers, might be interpreted in terms of particles of subunit charge. It is important, however, to examine the conditions in which normal tracks might possess the reported features. This report draws attention to some specific effects.

If the images counted in this work are indeed drops, data reported by Ghosh, Jones and Wilson[6], from a study of the logarithmic rise of ionization with increasing energy for muons, are relevant. These include two distributions of actual measurements for segments, of 1 cm and about 15 cm respectively, of drops from field-separated tracks near the minimum of ionization in the fully condensed positive ion column. They refer to oxygen at standard pressure and exclude ion clusters arising from energy transfers of about 1 keV upwards. The actual number of drops condensed on the ions of an unseparated plateau track in the Sydney work probably lies in the range 100–160 drops per centimetre, according to the completeness of condensation and the criterion adopted for the exclusion of large energy transfers (delta-rays). Accordingly, this implies that, if condensation were complete, the reported drop counts refer to those in about 1·5 cm of track and the fluctuations would be comparable with those in about two centimetres of the tracks measured by Ghosh *et al.* These fluctuations would therefore be more like those of Fig. 2 than of Fig. 3 of that paper. If condensation were incomplete, the counts would refer to a greater length of track, but an additional fluctuation, caused by actual condensation taking place would be introduced. In either case, the extreme fluctuations would certainly be large and the reported measurements would fall near to them.

Fluctuations of numbers of single drops, although these must occur, are most unlikely to represent the whole situation correctly. The workers in Sydney have sent me direct contact prints of their negatives (from and onto 35 mm film), and it seems that the number of objects counted per centimetre of track is of the order of 30 40 and certainly nothing like 100–160. The Sydney tracks are said to be about 0·17 cm wide, and the magnification for the plane of the tracks is likely to be about 1/13. The smallest objects counted were about 20 μm in diameter, and objects larger than this may be irregular. They do not cover more than about one-fifth of the whole track area. The most likely interpretation is that detect-