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YIELD INDEPENDENT m(M) DISCRIMINANTS FROM NETWORKS

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ABSTRACT

Linear approximations of the relationship between the logarithm of the yield of nuclear explosions in certain areas and the surface and body wave magnitudes at individual seismometric stations in certain regions were used to determine station corrections and to make minimum variance estimates of network magnitudes. The linear approximations apply only to the particular source area/network location. The surface and body wave magnitudes were then linearly combined to make discriminants which are independent of the explosion yield, and normalized to have zero mean values. The explosion yields ranged from about thousand down to about five kilotons. When such discriminants were calculated from magnitudes measured by the same stations but for shallow earthquakes occurring in restricted source areas, their average value was positive, as expected. However, it was also observed that the discriminants were nearly independent of the surface wave magnitudes or the equivalent yields of these earthquakes. The earthquake data ranged from about twenty thousand kilotons down to about twenty kilotons. The m(M) discriminants designed by the author appear to be free from strength dependent convergences between the earthquake and explosion populations and do thus provide for yield independent discrimination. Other simplifications follow from the fact that the distributions of the measured discriminants do not differ significantly from normal distributions.

YIELD INDEPENDENT m(M) DISCRIMINANTS FROM NETWORKS

The relationship between the logarithm of the yield W of nuclear explosions in the Pahute Mesa in the Nevada Test Site and the surface and body wave magnitudes M and m at individual seismometric stations in a Canadian network were approximated by linear relationships between the m or M and the log W. The magnitude versus log W slopes were found to be essentially the same for all stations but different for body wave magnitudes compared to surface wave magnitudes. Station variances and corrections for observed magnitudes were determined and found to be large. Introducing station corrections and weighing the corrected magnitudes in inverse proportion to the variances, gives network values for the surface and body wave magnitudes, which have minimum variance and therefore maximum discrimination sharpness. The network magnitudes thus obtained are proportional to some power of the yield. For the Canadian network (CAN) of 19 stations and explosions in the Pahute Mesa (PAH) in the Nevada Test Site the relations obtained were

$$M_{CAN} = 2.67 + 1.19 \log W \pm 0.19$$

$$m_{CAN} = 3.49 + 0.93 \log W \pm 0.30$$

where W is yield in kilotons. Applications to other source/site combinations than PAH/CAN can be found in other publications by the author (Ericsson, 1971 a, b). Yield independent linear combinations of such network magnitudes are easily calculated. For the Canadian network

$$D_{CAN} = 1.40 + 0.78\, M_{CAN} - m_{CAN}$$

was chosen. The parameter D_{CAN} is designed to be zero, when averaged over several explosions in the Pahute Mesa and to increase with M_{CAN}. The author has shown (Ericsson, 1971 c) that close approximations of the parameter D can be obtained also in cases where no yield calibration of the stations is available, by Kummel-York fitting of a straight line to the available m;M observations.

In the present paper the author briefly describes some results from a recent investigation (Ericsson, 1971 d) of how the parameter D behaves when calculated from m and M from the same stations that recorded the explosions but now generated by shallow earthquakes in certain restricted areas, like the western US and northern Mexico (CALMEX) or the Kuriles-Kamchatka arc (KURKAM). It was found that the parameter D, when obtained from specific source-network combinations, is independent or nearly independent of the earthquake strengths, as measured by the network surface wave magnitude or their corresponding equivalent yield. The results were obtained by statistical tests for independence (see Ericsson, 1971 d). The definition of equivalent yields is also described in another report by the author (Ericsson, 1971 b). Some examples of the results obtained with altogether four different networks and 24 different source/site combinations are shown in Fig 1-4. In one case, described in Fig 1, the data go down to about five kilotons. There the D_{CAN} parameter is given for the network CAN, which comprises 19 stations in Canada. The explosions occur in the Yucca Flat (YUCCA) in the Nevada test site and the earthquakes in the US and Mexico west of the longitude 115^{o}W. The figure also shows data from the explosions Pile Driver, Gasbuggy, Rulison and Faultless, outside the Yucca Flat. Fig 2 shows D_{LASA} obtained from m and M measured by the Montana array LASA as generated by explosions in eastern Kazakh (KAR) and by earthquakes in Kurile-Kamchatka arc (KURKAM) and in the Aleutians (ALEUT). A Smirnow-Kolmogoroff test shows that the latter are only insignificantly different.

Fig 3 shows D_{HFS} obtained by the Hagfors (HFS) observatory in Sweden for explosions in the Nevada test site (NTS) and for earthquakes in California and Mexico. Fig 4 shows D_{HIST} values obtained from a network of four short period array stations in Canada, Scotland, India and Australia and four long period WWSSS stations in Iran, Pakistan and India. The HIST-data are not suitable for a demonstration of yield independence. They do, however, show the best explosion earthquake separation hitherto obtained. The matter of effective separation and discrimination of earthquakes and explosions is outside the scope of the present paper but has been dealt with in earlier publications by the author (1970, 1971 d) and is also topic of a companion paper to the present one, Ericsson (1972). The lack of yield dependent convergences or divergences between the earthquake and explosion populations of the D (m,M) employed here simplifies the problems considerably by making discrimination by the parameter D independent of the event strength. Other simplifications follow from the result that

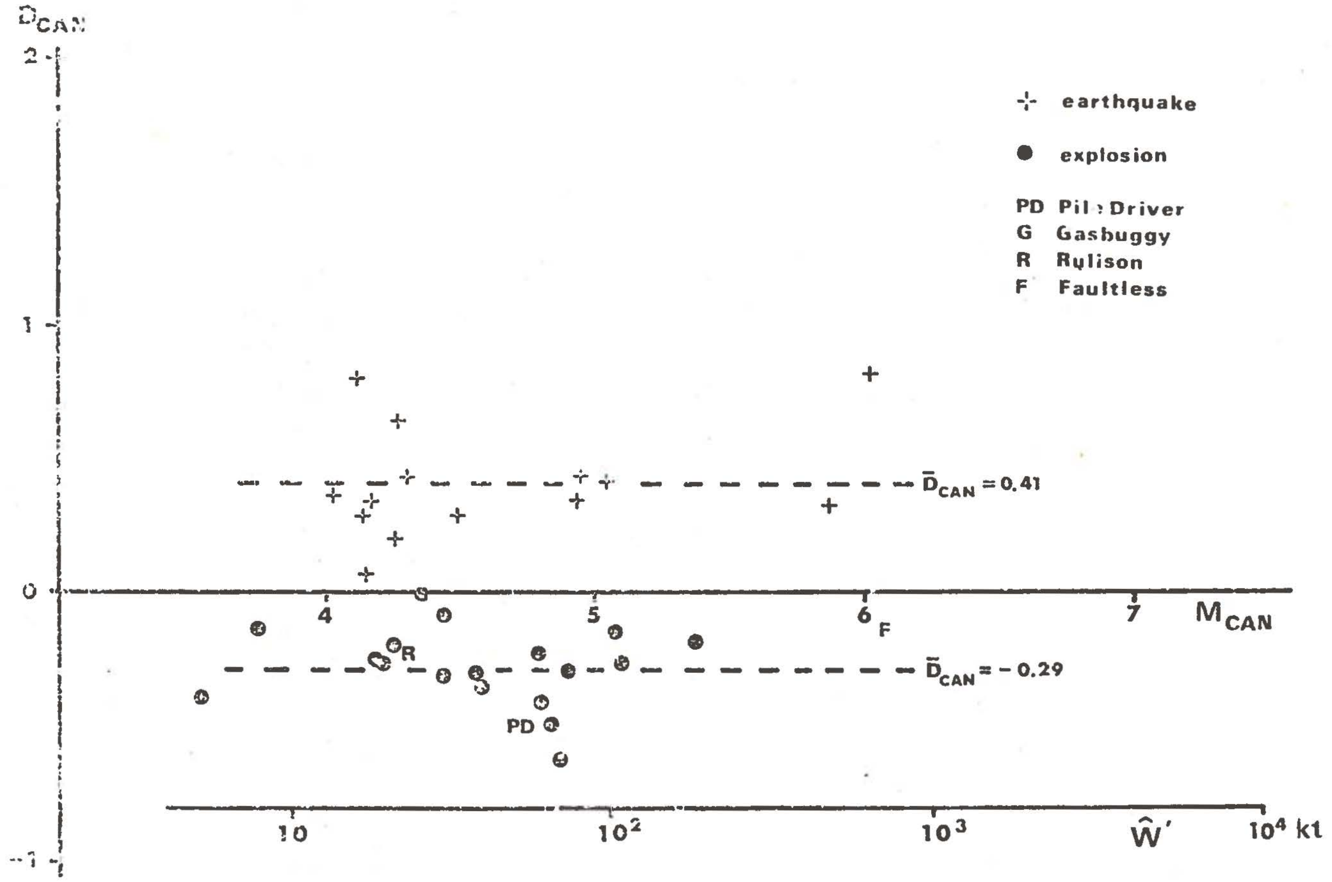

Fig 1. The yield independent discriminant $D_{CAN} = 1.40 + 0.78\ M_{CAN} - m_{CAN}$ for explosions under the Yucca Flat (YUCCA) at the Nevada Test Site and elsewhere in the US and for earthquakes west of 115°W in the US and Mexico (W 115°W).

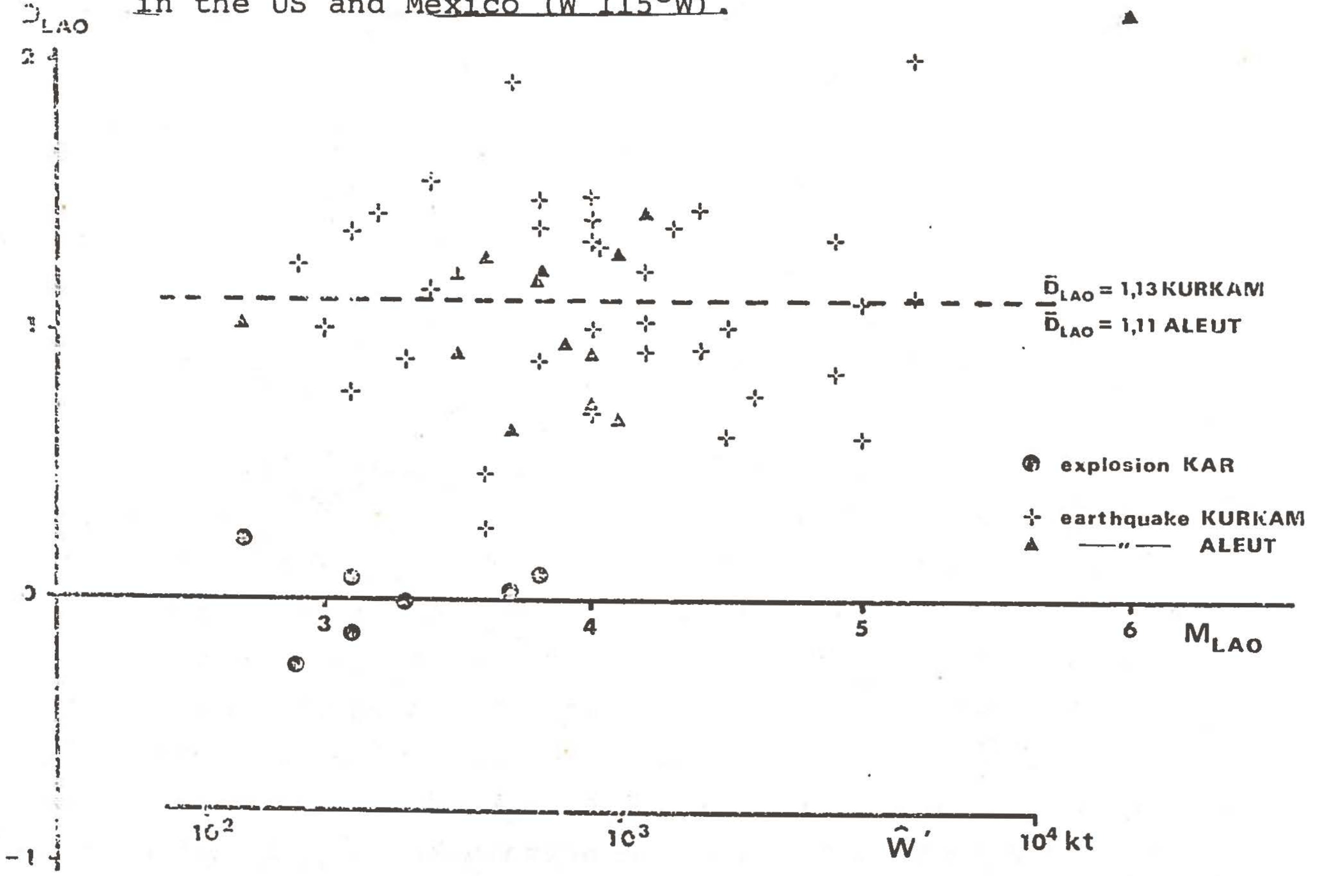

Fig 2. Yield independent discriminant $D_{LAO} = 3.91 + 0.60\ M_{LAO} - m_{LAO}$ for explosions (KAR) in eastern Kazachstan in the USSR and for earthquakes in the Kurile Islands and Kamchatka (KURKAM) in the USSR and in the Aleutian Islands (ALEUT) in the US.

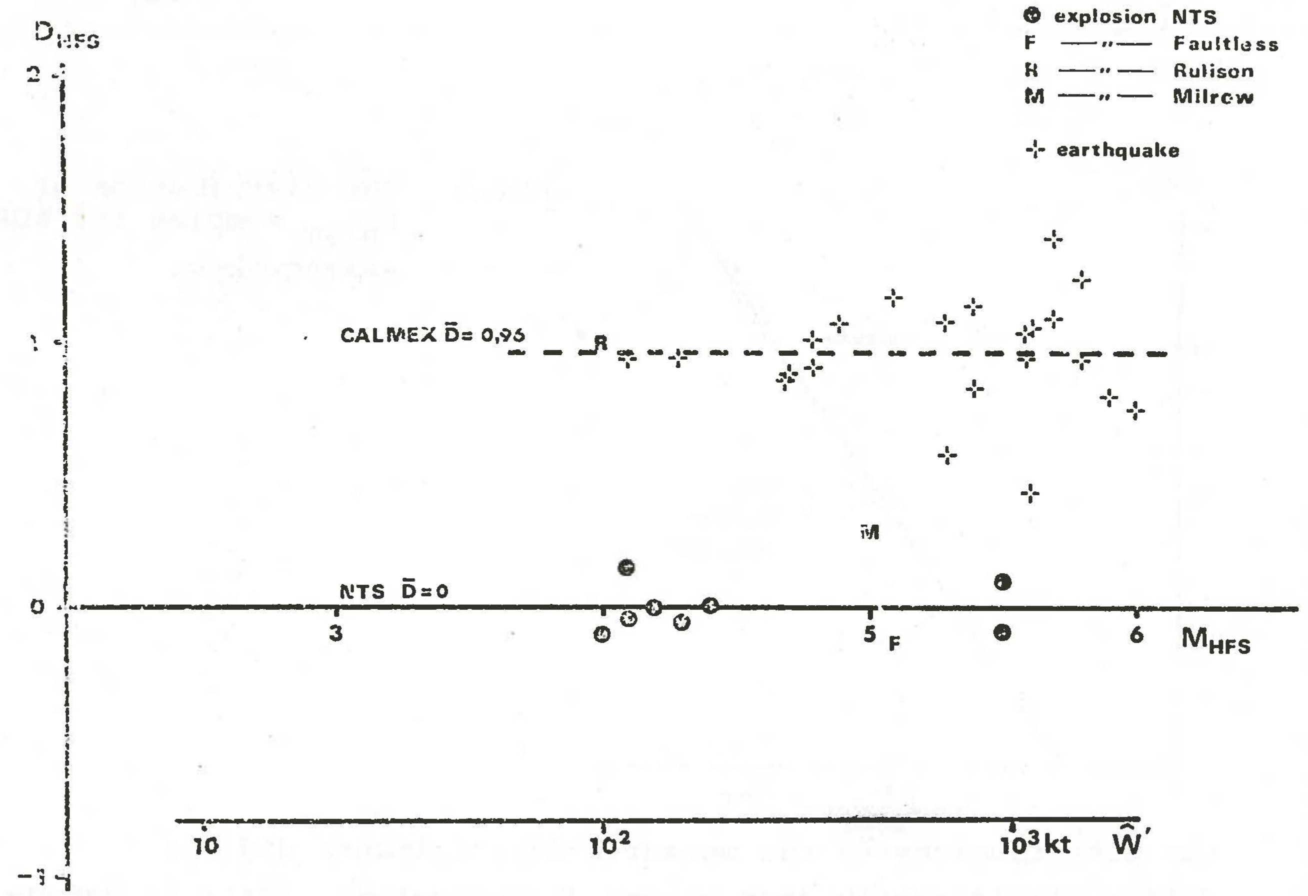

Fig 3. The yield independent discriminant $D_{HFS} = 3.57 + 0.53\ M_{HFS} - m_{HFS}$ for explosions at the Nevada Test Site (NTS) and elsewhere in the US and for earthquakes in California and Mexico (CALMEX).

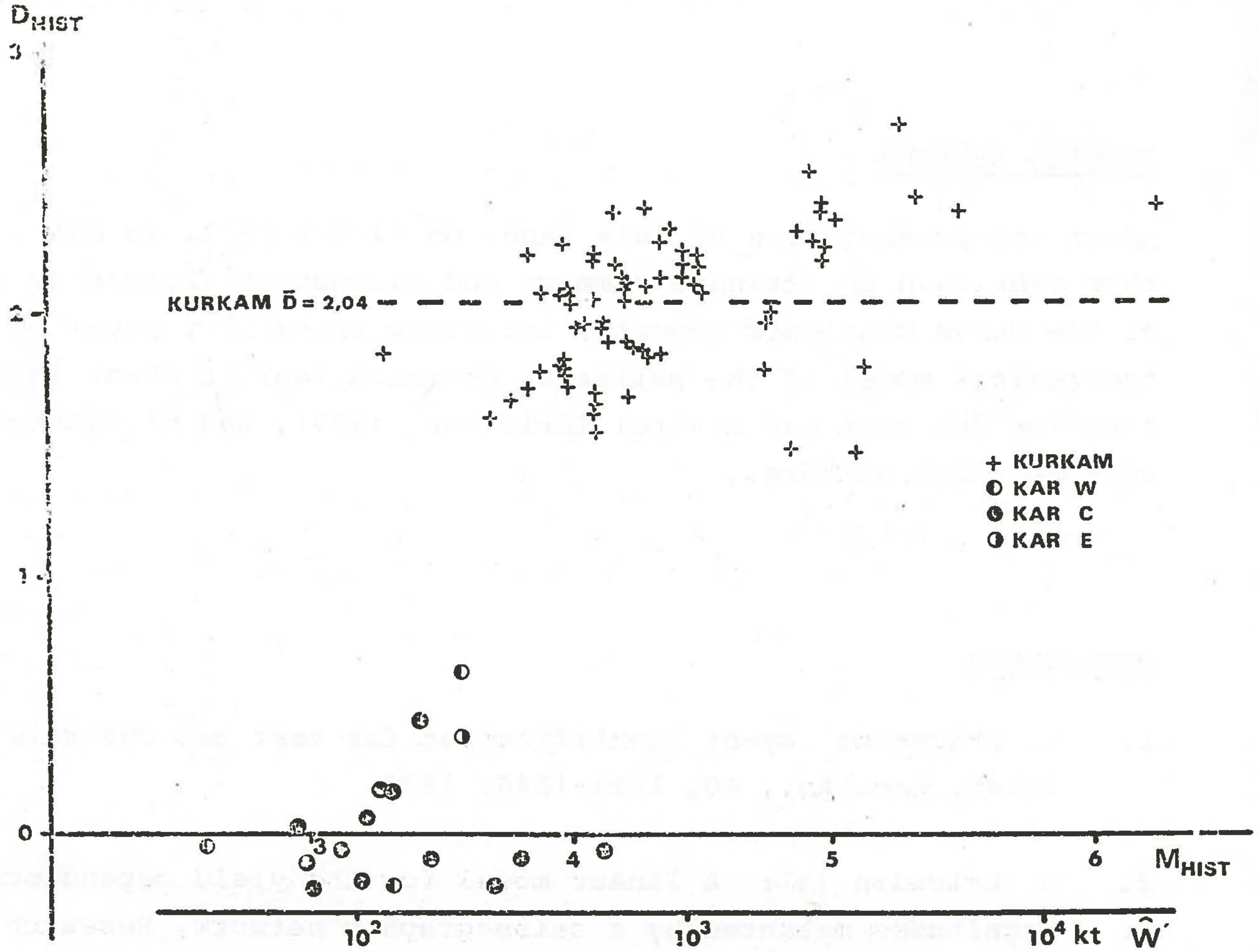

Fig 4. The discriminant $D_{HIST} = 3.28 + 0.73\ M_{HIST} - m_{HIST}$ for explosions in three subareas of the testside (KAR) in eastern Kazachstan in the USSR (KARW, KARC, KARE) and for earthquakes in the Kurile Islands and Kamchatka in the USSR (KURKAM).

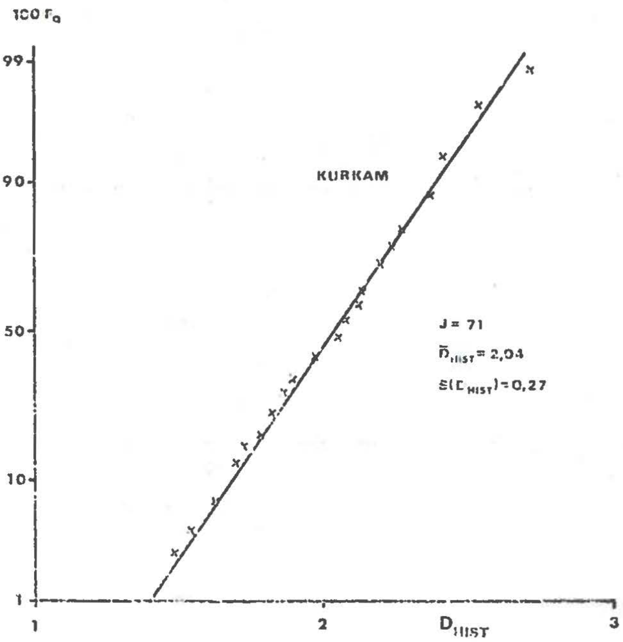

Fig 5. The distribution of D_{HIST} samples for KURKAM earthquakes.

the distributions of the measured discriminants did not differ significantly from normal distributions. This is demonstrated in Fig 5 and further details are given by Ericsson (1971 d).

CLOSING REMARKS

After the presentation of this paper on 24 Nov 1971, in Oslo, the author published an extended summary and discussion (Ericsson, 1971 e) of the above mentioned reports, including an earlier paper on a theoretical model of the political decision task in event identification for test ban control (Ericsson, 1970), and of related work by other authors.

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