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D. Rieber-Mohn (ed.)

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VI.3 Magnitude Studies

Seismic event magnitude represents one of the most important parameters in the context of seismic discrimination due to the versatility of the m_b:M_s discriminant. A novel approach to the estimation of magnitude was introduced by Ringdal (1976), who pointed out the advantages of using truncated distribution theory in estimating network magnitudes of small events. This topic has been further elaborated by Christoffersson (1978), who developed a unified model for estimating magnitudes and detection thresholds. This approach has now been extended to estimate simultaneously M_s-m_b relation of earthquakes, the scattering in these observations together with detection thresholds for the arrays and individual seismograph stations used to form the data base. In the present study, we have adapted the maximum likelihood technique to assess the linearity or lack of such of the m_b:M_s relationship - a problem critical for seismic source identification. Only preliminary results based on rather limited observational data have been obtained so far, and examples of the observed (m_b,M_s) relations are shown in Figs. VI.3.1 and VI.3.2. These results are based on M_s-values as reported by Uppsala, although we have also experimented with corresponding NOAA and NORSAR observations. In the latter cases, the results are similar to those displayed in Fig. VI.3.1 and VI.3.2. It should be noted here that Uppsala appears to be the only seismological station which consistently reports the M_s-parameter and also has done so over a very extensive period of time. Of course, other seismological agencies like ISC (International Seismological Centre), NOAA (National Oceanic and Atmospheric Administration, USA), Moscow World Data Center and also the Berkeley (BKS) seismographic station often report M_s-magnitudes, but their observations constitute the average for a set of stations, while for BKS the reported M_s is the average of the truly observed M_s and the linearly transformed m_b-to-M_s values.

An illustration of Christoffersson's method applied to m_b data from two stations is shown in Fig. VI.3.3, and it is seen that the apparent deviation from the expected slope of 1.00 can be satisfactorily explained by detectability considerations.

Our studies so far have verified the commonly observed appearance of M_s:m_b scatter plots: at high magnitudes, the M_s:m_b slope is significantly greater than 1.00 (typically around 2), while at lower magnitudes (below $m_b \sim 6.0$) there is apparently a distinct curvature in the relationship between M_s and m_b. However, our results show that this behavior may be explained as a result of bias effects in the plots at low magnitude caused by detectability problems. Thus the hypothesis of an intrinsically linear m_b-M_s relationship with a slope greater than 1.00 even at low magnitudes cannot be rejected on the basis of these and other similar observations. The work reported above will be continued, and future plans include greatly extending the data base so as to allow more specific conclusions about the slope of the M_s-m_b relationship.

A. Christoffersson, Dept. of Statistics, Uppsala
F. Ringdal
C. Bjørck, Dept. of Statistics, Uppsala
E.S. Husebye

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Ringdal, F., E.S. Husebye and J. Fyen (1977): Earthquake detectability estimates for 478 globally distributed seismograph stations. Phys. Earth Planet. Inter., 15, P24-P32.

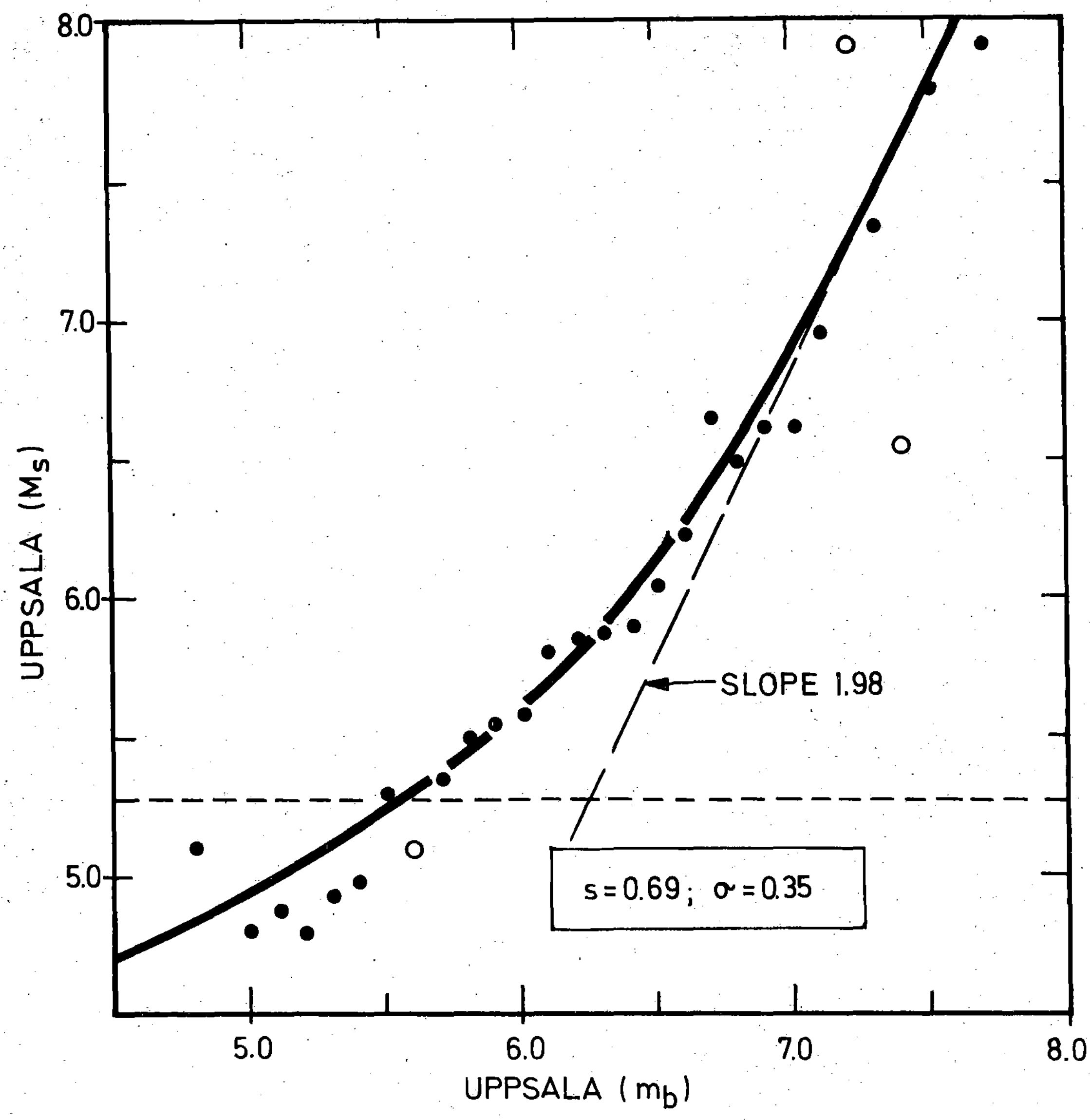

Fig. VI.3.1 Average M_s for given m_b values (both M_s and m_b reported by Uppsala for a reference data set of 412 earthquakes. The solid, curved line is a model fit based upon an assumed linear M_s-m_b relation (slope as indicated) modified by an estimated M_s detectability curve. The parameters (μ,σ) of the detectability curve (Ringdal et al, 1977) are indicated (μ is shown by a stippled horizontal line). The standard deviation S of the inherent M_s-m_b scatter is also estimated. The open circles are data points outside two standard deviations from the model.

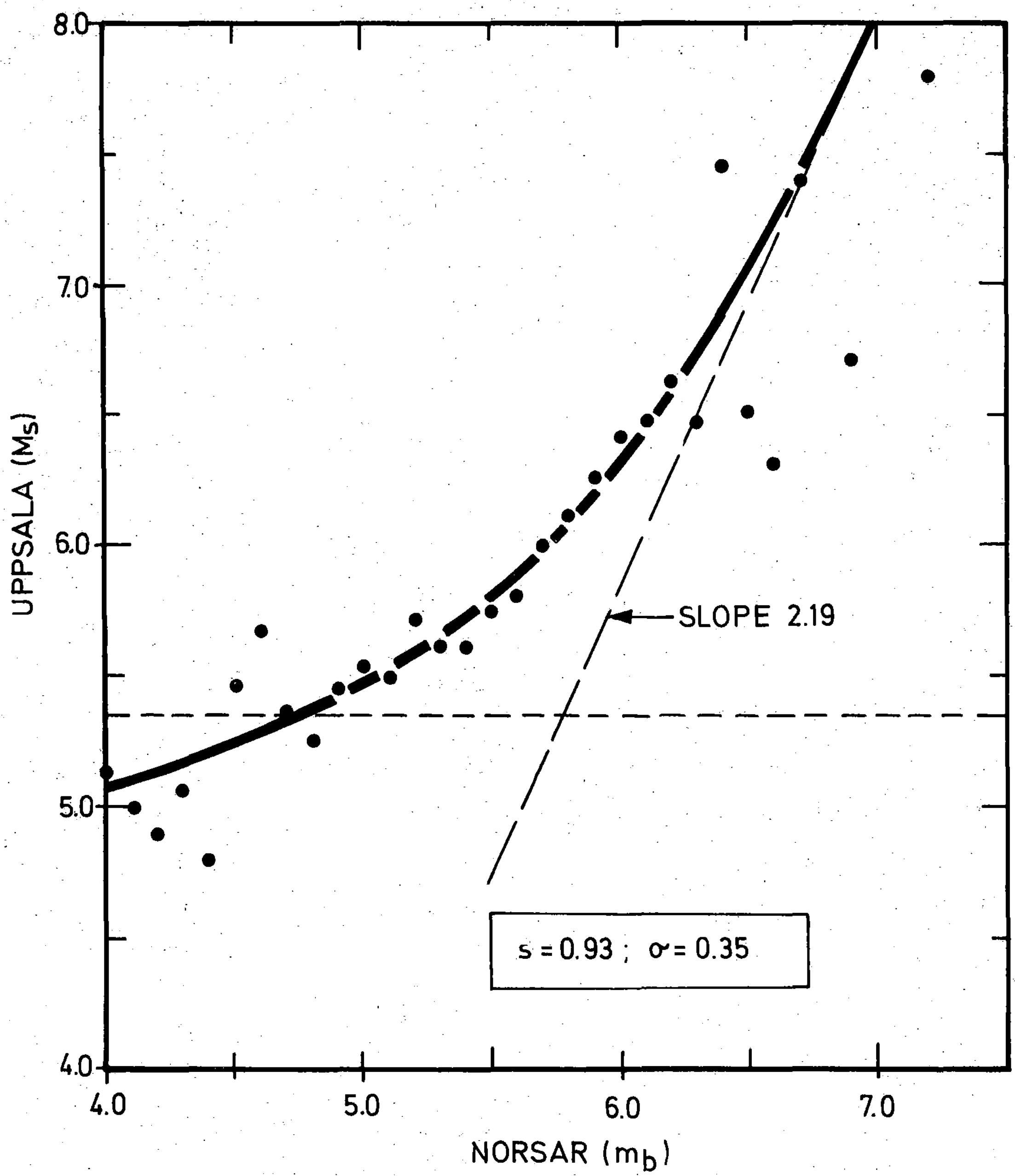

Fig. VI.3.2 Same as Fig. VI.3.1, but with m_b as reported by NORSAR, M_s by Uppsala and the data set containing 403 earthquakes.

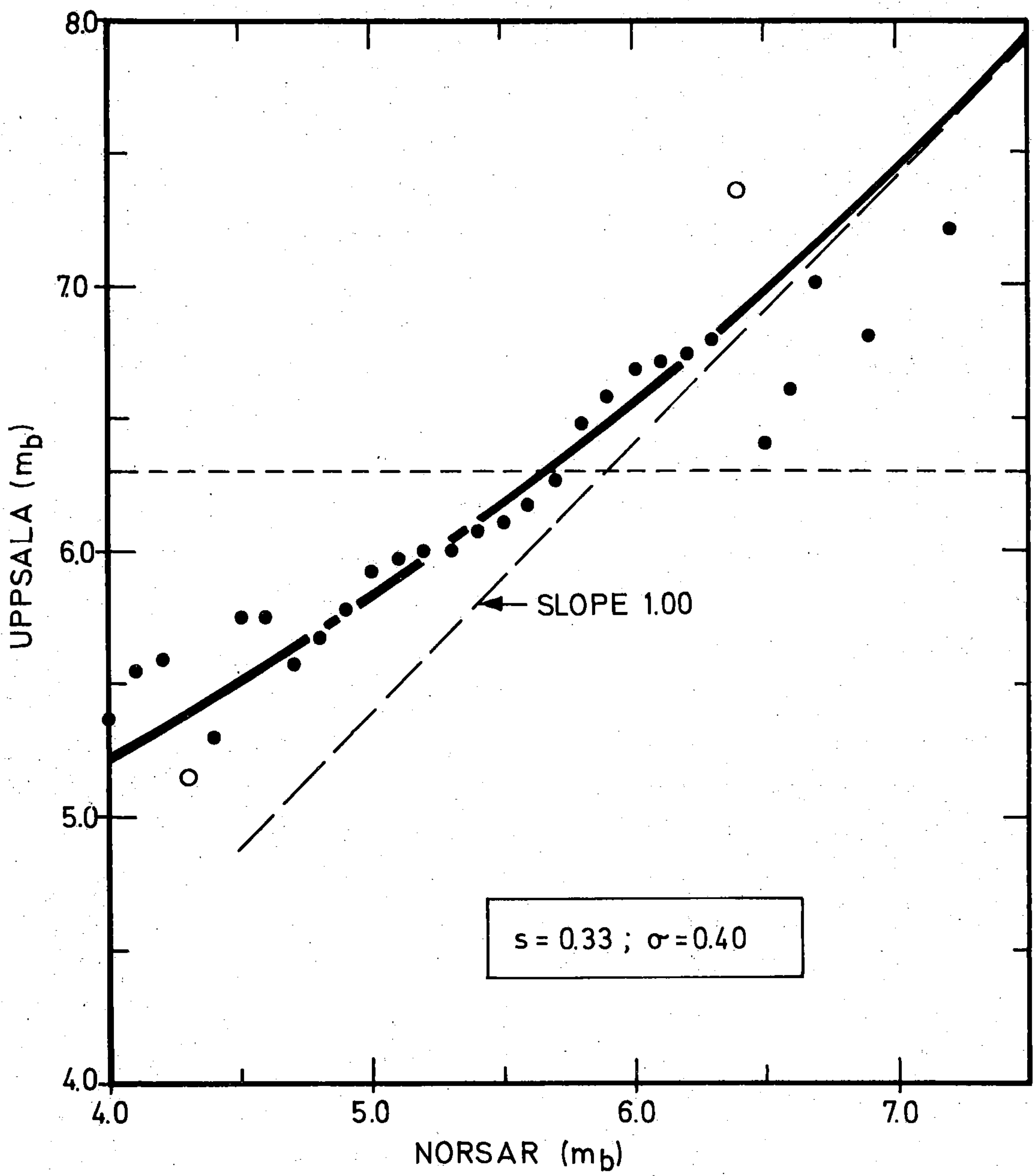

Fig. VI.3.3 Illustration of the model in Fig. VI.3.1 and VI.3.2 applied to estimate the relationship between m_b (NORSAR) and m_b (UPPSALA) (data base 386 earthquakes). The expected slope of 1.00 does not appear to fit the observed data. However, if one takes the effect of detection thresholds into account, while fixing the slope at 1.00, one arrives at the solid, curved line which is a much better fit.