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VII.4 Surface topographic effects at NORESS and ARCESS

In a previous Semiannual Technical Summary Report we analyzed slowness solutions of regional P waves at NORESS from a suite of mining explosions near Leningrad (Ødegaard and Doornbos, 1988). The differences between 3-component slowness solutions at the 3-component sites within the array imply that local structure significantly perturbs the surface particle motion. A synthesis of particle motion based on a multiple scattering method (Doornbos, 1988) explains about half of the observed anomalies by surface scattering, and also explains the observed frequency dependence. Here we report on the results of a similar analysis of teleseismic P waves from Eastern Kazakh nulcear explosions recorded both at NORESS and ARCESS. The P wave spectra from all events are similar at NORESS; a sample of 3 events is shown in Fig. VII.4.1. At ARCESS we can distinguish two groups of events. The spectra within a group are similar, but there are significant differences between the two groups, as illustrated in Fig. VII.4.2 (a and b). The spectral difference requires further investigation, but at this stage we analyze the two groups separately. Average slowness solutions for the events are plotted in Figs. VII.4.3 and VII.4.4. The array slowness solution is based on measured phase differences between all vertical component records within the array and is labeled ALLV; the 3-component slowness solutions are based on relative amplitudes of the 3 components and are labeled by the site identification number. Standard deviations are plotted only for site A0, but the other sites give similar results. There is a slight difference between the array slowness solutions at ARCESS for the two groups, but there is a large difference between the 3-component slowness solutions for the two groups. There are striking differences also between the different sites for each group. A difference between ARCESS and NORESS is that 3-component slowness solutions at ARCESS are relatively high (compared to the array solution), whereas the 3-component solutions at NORESS are relatively low.

We have digitized the surface topography both at NORESS and at ARCESS; elevation maps are shown in Figs. VII.4.5 and VII.4.6. Topography in

the NORESS area is slightly higher, but ARCESS is situated right on top of a hill which is presumably associated with a gabbro intrusion. Topographic effects at ARCESS are therefore not necessarily smaller than at NORESS, but they can be calculated with somewhat higher precision. Calculation of the surface response is done in the frequency domain, and the response is then integrated over frequency in accordance with the observed spectrum. Integration limits were 0.9-2.5 Hz for the events at NORESS and for group A at ARCESS, and 0.9-1.6 Hz for group B at ARCESS. The calculated slowness solutions are plotted (in frames) with the observations in Figs. VII.4.3 and VII.4.4. The figures demonstrate that surface topography explains about half of the observed anomalies. Further they demonstrate that surface topography can produce not only azimuthal anomalies, but also deviations in absolute slowness. Finally, it is remarkable that the low-frequency group of events at ARCESS (group B) produces larger anomalies than the high-frequency group A. Clearly 3-component slowness solutions depend both on surface topography and on the incident signal spectra.

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References

Doornbos, D.J. (1988): Multiple scattering by topographic relief with application to the core-mantle boundary. Geophys. J., 92, 465-478.

Ødegaard, E. and D.J. Doornbos (1988): Surface topographic effects on arrays and three-component stations. NORSAR Semiann. Tech. Summ., 1 Apr - 30 Sep 1988, Kjeller, Norway.

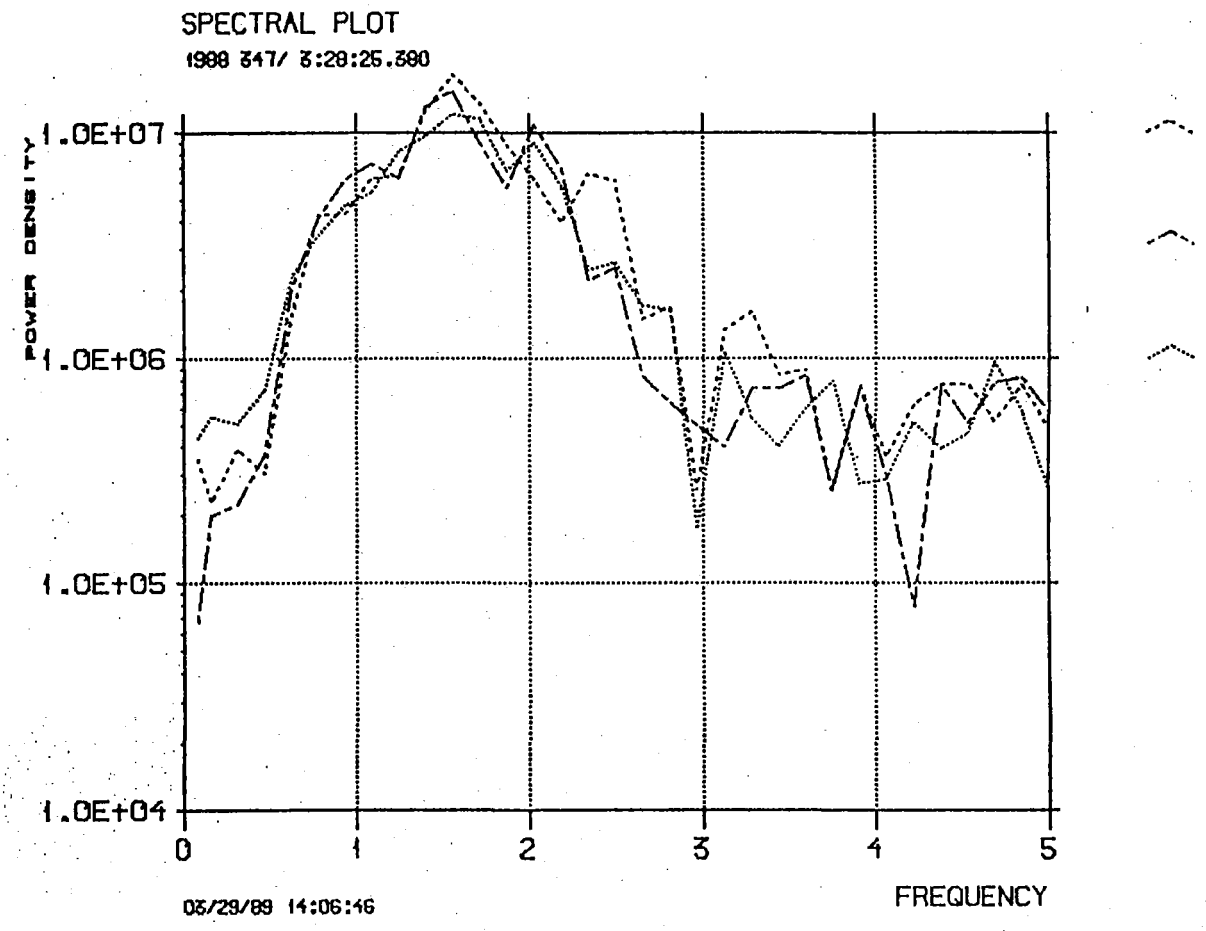


Fig. VII.4.1. P wave signal spectra at NORESS from 3 nuclear explosions in Eastern Kazakh.

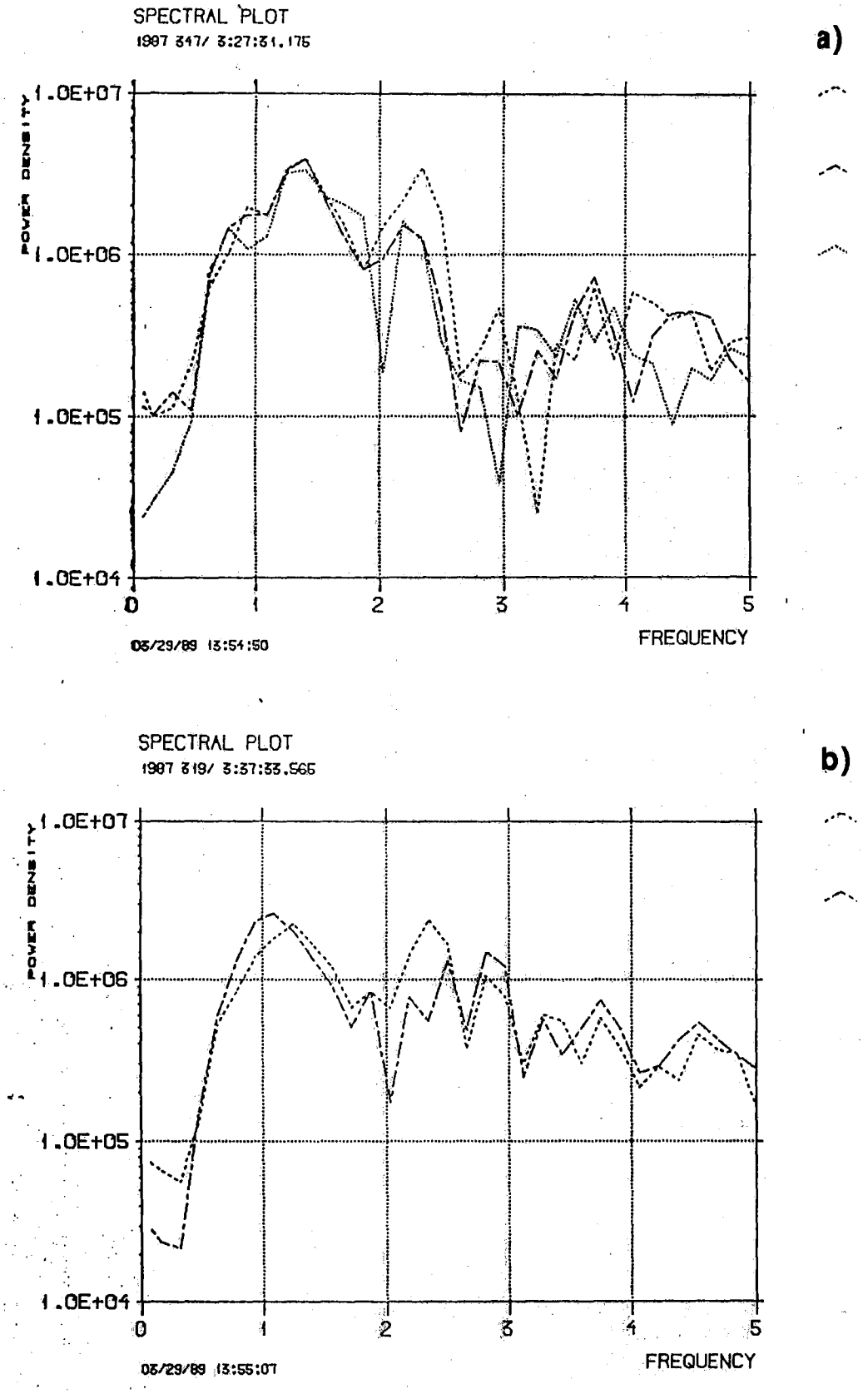


Fig. VII.4.2. P wave signal spectra at ARCESS from nuclear explosions in Eastern Kazakh.
a. 3 events from group A (high-frequency signals)
b. 2 events from group B (low-frequency signals).

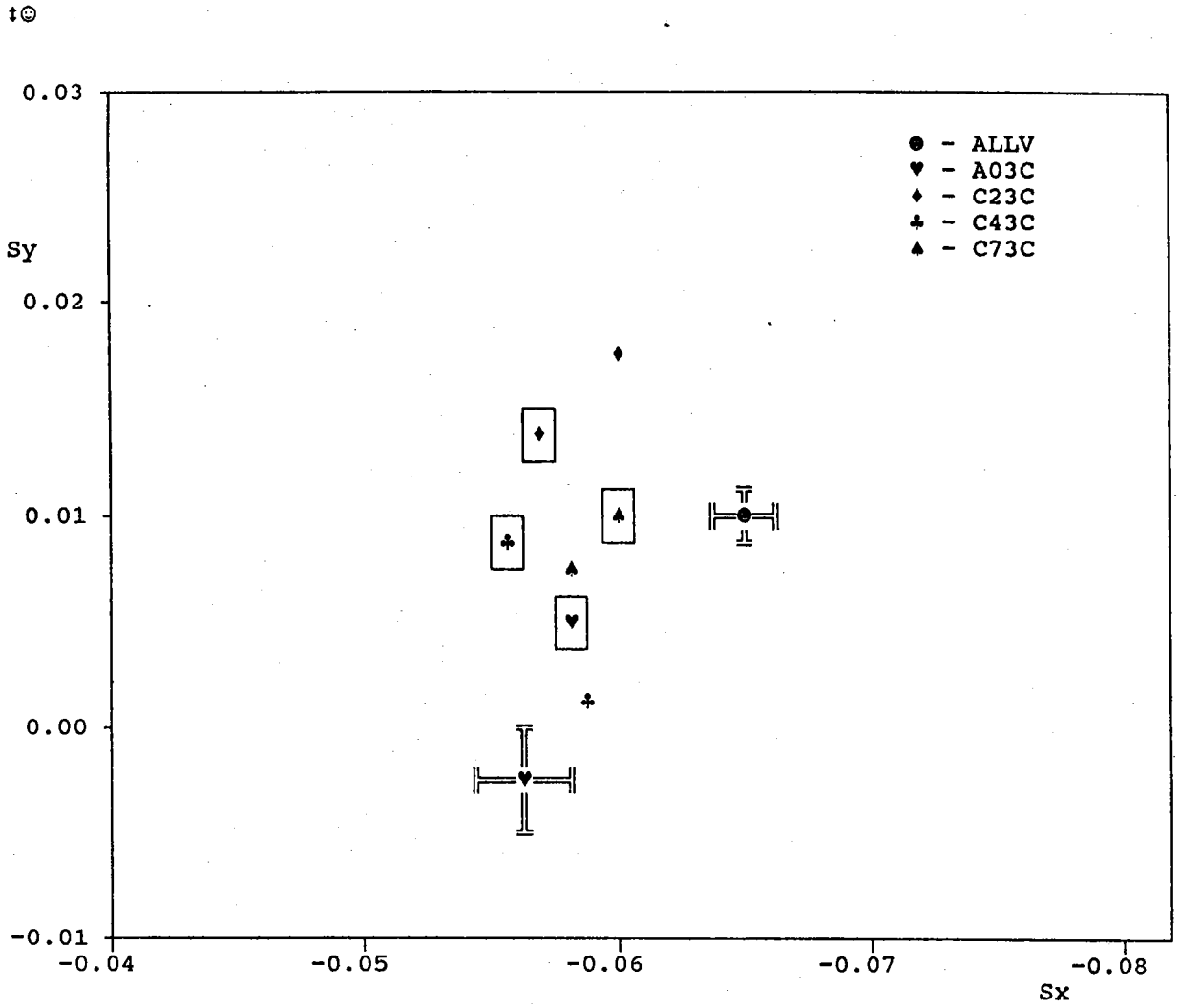


Fig. VII.4.3. Slowness solutions at NORESS. Average over P from 14 events in Eastern Kazakh. Array solution (ALLV) with standard error bars. Three-component solutions at the indicated sites, with standard error bars for site A0. Calculated solutions including response to surface topography are framed.

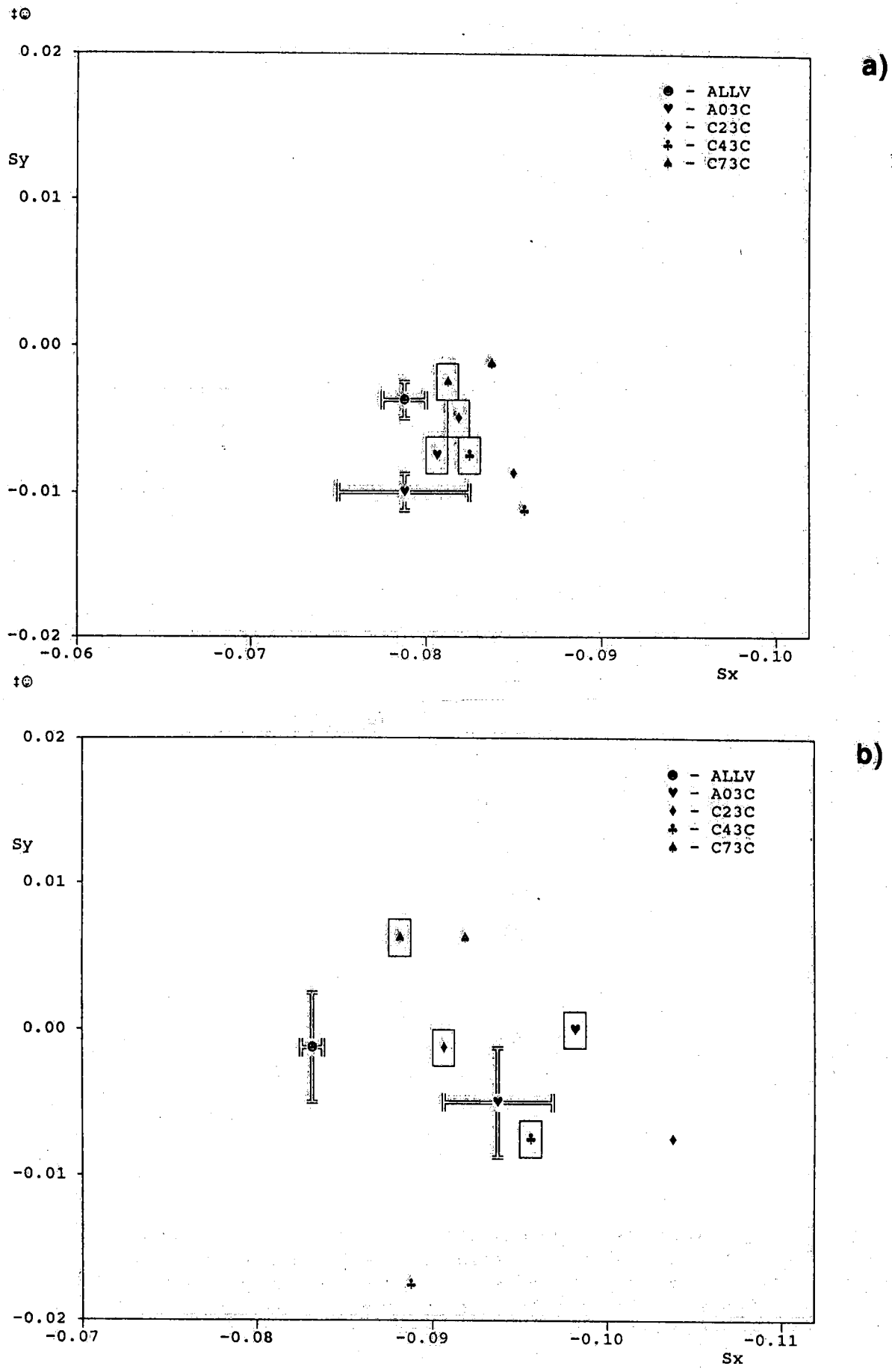
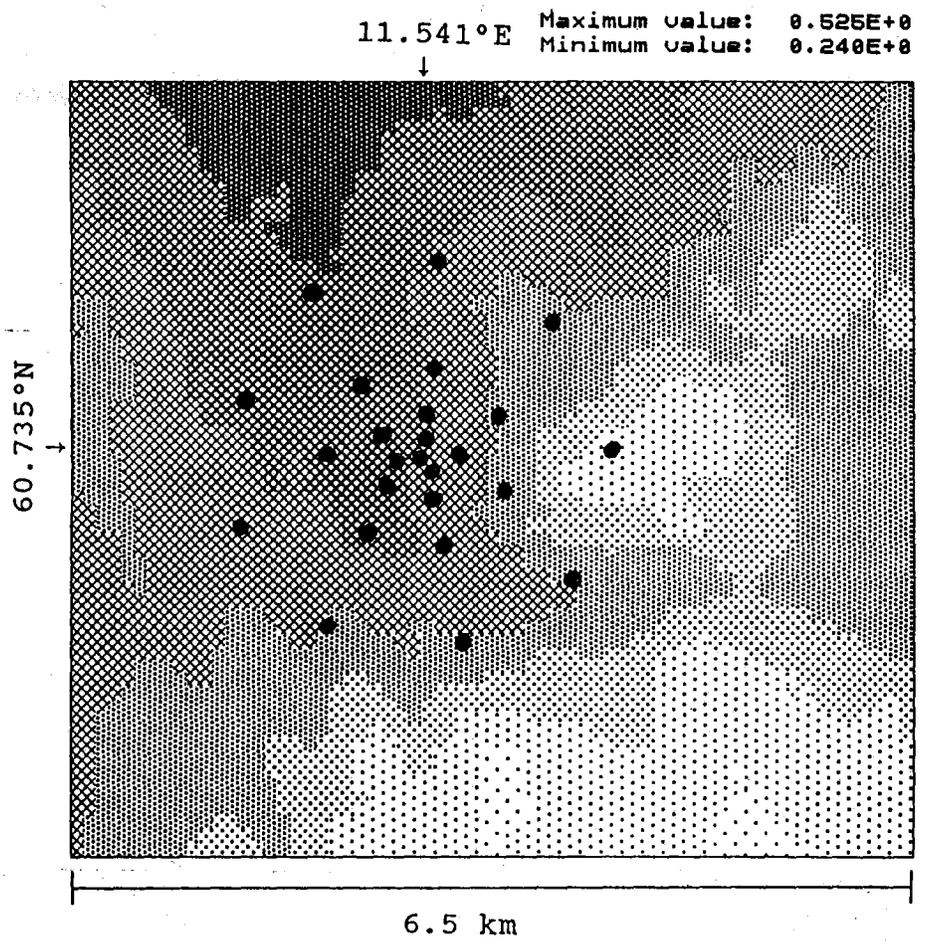


Fig. VII.4.4. Slowness solutions at ARCESS. Details as in Fig. VII.4.3.

a. Average over 4 events from group A.

b. Average over 5 events from group B.



Topographic height in meters

501 -		311 - 359	
454 - 501		264 - 311	
406 - 454		- 264	
359 - 406			

Fig. VII.4.5. Elevation map for the NORESS array area.

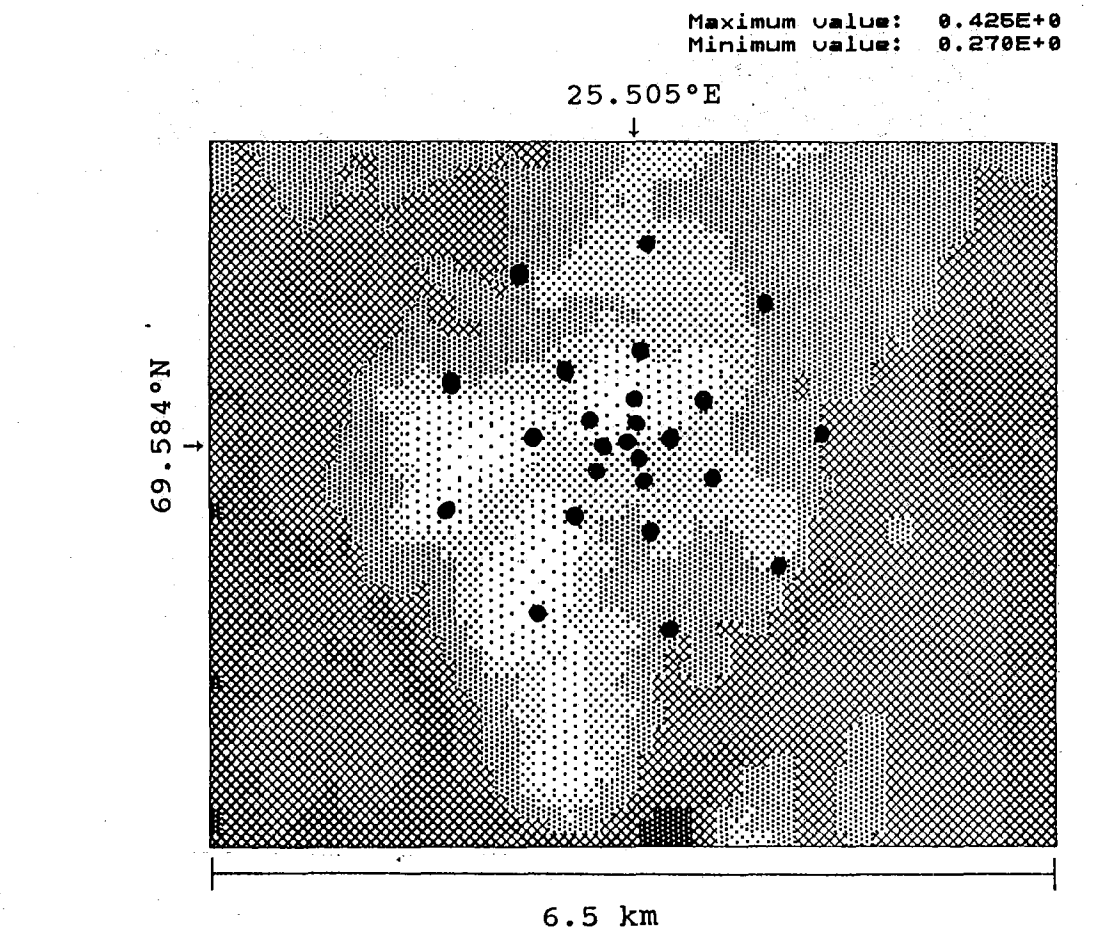


Fig. VII.4.6. Elevation map for the ARCESS array area.