ers hired before 1940, which conflicts with the period of known use of crocidolite yarn (in very small quantities—see Appendix A) in the plant after 1950. This raises the possibility that some amphibole formed part of the exposure mix in this cohort in an early period. Green *et al.* (1997) show that the levels of amphibole are higher in Carolina workers than in local controls (2-fold difference in geometric mean, $P=0.031$) but much less strikingly than 'for chrysotile (5-fold, $P<0.0001$) or tremolite (14-fold, $P<0.0001$). They also report that amphibole at levels >1.0 f/μg (all fibre lengths) were found in only one of the ten lung cancer cases for whom this datum was available. This last observation limits the extent to which amphibole exposure—perhaps unrecognised—might play a role in this cohort. Whatever mechanism is in play does not appear to apply—to the same extent, at least—to the other two textile cohorts reviewed. As already pointed out, the Pennsylvania and Rochdale cohorts (*with mixed fibre exposures*) both give substantially lower estimates of R_L.

If it is accepted that some such feature of the processing in the Carolina cohort has genuinely produced a much higher risk than seen in other chrysotile cohorts the question can be asked how typical these features are of the bulk of applications? Looked at in the wider context of cohorts with mixed fibre exposure, the R_L value for Carolina looks untypically high. Setting aside the possibility that amphibole presents a higher risk of lung cancer, the observations of R_L from mixed fibre cohorts can be taken as informative of the R_L level for chrysotile. This suggests that in typical applications (including other textile processes) R_L for chrysotile is generally lower than the value derived from the Carolina cohort. The median R_L for the 16 cohorts with some chrysotile exposure is 0.5, compared to 4.5 for Carolina men and 6.7 for Carolina women. All but two of the mixed fibre cohorts give an R_L estimate less than 1, and of the two exceptions one (Albin) has a confidence limit including zero, and the other (Ontario) shows features suggestive of significant exposure to crocidolite (see below, Fig. 4 and related text).

To the extent that amphibole fibres make a disproportionate contribution to the lung cancer risk in the mixed exposure cohorts—and the evidence presented here suggests that they do—the typical risk of lung cancer from chrysotile exposure would be even lower. In most circumstances a value of 0.5% per f/ml.yr *should probably be regarded as an upper limit* to the lung cancer risk from pure (commercial) chrysotile. The mean R_L estimate for mixed fibre cohorts excluding the three with particular interpretational difficulties is 0.32% per f/ml.yr with an upper 95% confidence limit of 0.50.

It should be noted that a value of 0.5% per f/ml.yr is not as far out of line with the Carolina observations as it might seem. The 'cohort average' risk estimate from this cohort (6.7 for women, 4.7 for men) prob-

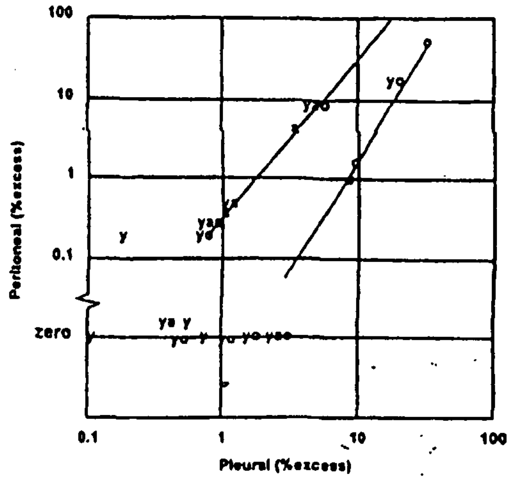

Fig. 4. Comparison of excess mortality from pleural and peritoneal mesothelioma, showing fibre type.

ably overestimates the risk, which from internal analysis is 1 for women and 3 for men (Dement *et al.*, 1994, p. 439). The exposure response regressions on this cohort give an intercept close to zero excess risk at zero dose, and there is thus no reason to suspect serious error in the reference rates (with consequential doubts about interpreting the slope). There is also the possibility of inaccuracies in the conversion of particle counts to fibre counts. One early report on this cohort (McDonald *et al.*, 1983a) suggested that the average conversion factor should be about 6 f/ml to 1 mppcf. If this were true, the risk per f/ml.yr would be halved.

A 'best estimate' of the lung cancer risk would be lower than 0.5% per f/ml.yr. Noting that the mean risk of the mixed fibre cohorts (excluding the three mentioned above) is 0.32% per f/ml.yr, and that the amphibole risk is over 10 times higher, it is possible that virtually all the observed risk could be explained by rather less than 10% of amphibole in the mixed exposures. However there is no direct evidence on which an estimate of the risk of 'pure' chrysotile could be based. Apart from the Balangero cohort, all the chrysotile evidence considered here effectively relates to Canadian chrysotile, since this was the dominant source of fibre for the other chrysotile cohorts. The risk of 'commercial' chrysotile as estimated from the mining cohorts is 0.06% per f/ml.yr. Given that the processing of chrysotile may produce some additional risk, *the best estimate should be set* higher than the mines level, say at 0.1% per f/ml.yr. The overall risk, of a mixture of 96% chrysotile with a risk of 0.1, and 4% amphibole with a risk of 5.1 would be 0.3% per f/ml.yr.

EXTRAPOLATION TO LOW EXPOSURES

All these cohort observations reflect the effect of exposure to high levels of asbestos. The main interest