RAPPORT FRA USA-REISE

18.-28.JUNI 1978

BJØRN GYLSETH

HD nr.777/78

I. INNLEDNING

Programmet for turen til USA var som følger:

18.juni ankomst New York.

19/20 juni besøk ved Mount Sinai School of Medicine.

21/22/23.juni kurs: Health effects of asbestos exposure.

23.juni (etter 12) Workshop Zeolites.

23.juni (kveld) Åpning Conference:
International Conference on Health
Hazards of Asbestos Exposure.

24/25.juni Asbestos Conference.

26.juni Workshop. 1,Demonstration,Identification and Quantification of Asbestos in Tissues. 2.Significance of Aspects Ratio in Regulation of Asbestos Fiber Exposure.

27.juni Asbestos Conference.

28.juni Besøk ved New York University Medical Center,Dept. Environmental Medicine.

28.juni (kveld) Hjemreise.

Jeg vil i det følgende fortløpende referere de inntrykk som av meg ble oppfattet som interessante og derved nedtegnet. En stor del av forelesningene var sterkt medisinsk preget, dog på et forståelig nivå for en ikke-medisiner. Endel av de medisinske data vil bli referert, og jeg ber om overbærenhet mot eventuelle feiltolkninger. Hoveddelen av de medisinske presentasjonene var basert på case reports med et utall av røntgenbilder, bilder av tynnsnitt, generelle funn etc. som er meget vanskelig å referere. Det er klart at utbyttet for YHI hadde vært større dersom en medisiner kunne deltatt og tatt seg av rapporteringen av de medisinske data. På grunn av at stoffmengden som ble gjennomgått (spesielt på kurset) var meget stor, ble det et enormt tempo og tidspress over forelesningene, noe som medførte at en rekke presentasjoner ble kuttet, andre sterkt beskåret. Dette vil tildels prege rapporteringen.

Deltakelsen ved asbestkurset var ca. 100, herav 2 svensker, 1 finne og 1 nordmann (u.t.).

Deltakelsen ved asbestkonferansen var ca.800-900, hvorav 15 svensker, 5 finner og 1 nordmann.

Til tross for tempo syntes utbyttet størst ved kurs og workshop, delvis på grunn av lavere deltakerantall + ikke fullt så mange dominerende personligheter tilstede.

I forbindelse med kursene/workshopene/besøkene ble det innsamlet en god del materiale, stiftet kontakter etc. Dette materiale kan lånes av meg dersom ønskelig.

II. KAPITTEL 1: KURS VED MOUNT SINAI

Besøket startet ved Mount Sinai School of Medicine Environmental Science Laboratory hvor ingen av de ansvarlige forskerne var tilstede som avtalt. Jeg ble vist rundt av en av teknikerne ved labben.

Utstyret besto av 2 transmisjonsmikroskoper, 1 scanning mikroskop, røntgendiffraksjon, lavtemperaturforaskingsovn, IR,GC, AAS etc.

Laboratoriet har spesialisert seg på analyse av uorganisk partikulært materiale og instrumentparken preges av dette. Det samme gjelder personalsammensettingen. Forskningsområdene er sammenfattet i prosjektrapport for 1975-76, denne kan sees hos u.t., og gir en langt bedre oversikt enn det jeg vil kunne rapportere ut fra mitt korte besøk.

Kurset ble introdusert av "Selikoff himself" som belyste de enorme problemer (kostnader) man står overfor i USA på grunn av den enorme utbredelse av asbestbruken i 1940-1960 årene. Som eksempel nevnte han en barneskole, hvor det ble benyttet asbest i tak og vegger. 3/4 mill. dollar ble brukt før miljøet var trygt. Hver eneste bok i biblioteket måtte støvsuges. Videre berørte han problemene med andre fibrøse mineraler som zeolittene og kom derved inn på forekomsten av mesoteliom i Tyrkia. Dette vil jeg komme tilbake til i et senere avsnitt. Disse andre fibrøse materialene har fått meget bred anvendelse, og dersom vi skal tro Stantons cancerteori for fibre, så kan dette ha meget alvorlige følger i fremtiden.

I det neste foredraget ga dr.Langer en generell oversikt over geologien og mineralogien til asbestmineralene uten å bringe noe revolusjonerende nytt. Han dvelte ved definisjonen av asbest som rent mineralogisk kan sammenfattes som følger:

Asbest er en kollektiv mineralogisk term som inkluderer "asbestiform" varianter av forskjellige silikat-mineraler og hvor "asbestiform" refererer til en spesiell type fiberegenskaper, hvor fibrene har ekstreme lengde/bredde forhold, er lett separerbare,fleksible, høy tensil styrke (strekkfasthet) etc. I biologisk terminologi er asbest fiberformede mineraler med kjent biologisk aktivitet.

Videre ga dr. Rohl en forelesning om asbestkontaminering i talkprodukter. De vanligste asbestsortene en fant i talkum er tremolitt,krysotil og antofylitt. Kosmetiske talkumprodukter inneholder også fibre, men ofte av elektronmikroskopisk størrelse.

6 prøver som ble undersøkt inneholdt 5 stk. 2 -12% tremolit. 3 prøver inneholdt også krysotil. Videre blir talkum brukt til polering av ris, og ut fra de mengder en har funnet i enkelte prøver har en beregnet at 600 mg asbest pr. uke pr. individ for typiske ris-spisere ikke er urimelig, og dette gir visse perspektiver for GI-cancer hyppigheten (gi=gastrointestinal). Talkumprodukter brukes også i modellerleirer, og dette gir en potensiell eksponeringskilde for barn. Erstatningsstoffer for asbest, henholdsvis talkum ble også berørt og i denne sammenhengen ble vermikulitt nevnt. Vermikulitt er et komplisert Mg,Ca,Fe,Al-silikat som brukes som isolasjonsmateriale.Vermikulitt finnes i serpentinbergarter og både tremolit og krysotil finnes som forurensninger i dette mineralet. Ved større forbruk av slike materialer bør systematiske analyser foretas for å klarlegge eventuell risiko.

I neste foredrag av dr.Langer ble funn av "asbestos bodies" i humant vev behandlet. Første gang disse fibrene ble oppdaget ble de kalt curious bodies, deretter asbestosis bodies, deretter asbestos bodies og til slutt ferruginious bodies på grunn av påleiringen av jernholdige proteiner. Disse partiklene kan finnes i spytt, bulk vev, histologiske snitt, utstryk etc. Foraskning av større vevsbiter er den sikreste metoden for påvisning av disse fibrene. En rekke faktorer må tas i betraktning ved søkning etter asbestos bodies.

En vil kunne finne variasjoner innenfor forskjellige populasjoner, hvilken fibertype som foreligger, fiberkjernens spesifitet, prepareringsteknikk, og ikke minst instrumentell analysemetode. I et vevsmateriale fra 808 personer fra årene 1927-1929 kunne de påvise asbestos bodies hos 37% av females og 36.4% av males. Tilsvarende materiale fra perioden 1966-1968 viste henholdsvis 40% og 52% med asbestos bodies. Forskjellen ble forklart ved den økning i mengden av asbest brukt i perioden 1930-1970.

Foraskningsteknikker som kan brukes for vevstyper er:

Tørrforaskning:
1) høytemperaturforaskning $t > 450^{\circ}$
2) lavtemperaturforaskning $t < 200^{\circ}$

Våtforaskning: KOH, NaOH, HCI, CH_3COOH, formamide natriumhypoklorit etc.

Harry Heimann ga et historisk overblikk over asbest relaterte sykdommer .

1907 1.rapport om enkeltkasus som beskrev asbest i sammenheng med lungesykdom.

1927 Cook beskriver asbestose 1. gang.

1930-1935 Lynch & Smith første rapport om sammenheng mellom cancer og asbest, første tilfeller av bronch. cancer rapportert.

1943 Første rapporter om pleura fortykkelser, kalsifisering og plaques.

1953 Rapport om 3 tilfeller av mesotelioma i Tyskland.

1960 120 tilfeller av mesotelioma rapportert av Wagner.

1963 Konstantering av sammenheng mellom asbesteksponering og pleuraforandringer, lungecancer, mesotelioma etc. av Selikoff.

1965 Første rapport om familiekontakt - mesotelioma.

1968 Selikoff vurderer dette tidspunktet som vendepunktet for forståelse av asbestrelaterte sykdommer.

Det opplyses i denne sammenheng at 3-5 millioner amerikanere har hatt en eller annen form for eksponering for asbest i amerikanske skipsverft i perioden 1940-45. Resultatene av denne eksponeringen ventes først å tre frem etterhvert.

I neste foredrag gjennomgikk dr.Lilis typiske kliniske funn ved asbestose. Jeg vil i denne sammenheng ikke gå i detalj inn på de diagnostiske kriterier. For de som er interessert så er disse nedtegnet.

Gjennom generelle kommentarer til dette foredraget ble det stadfestet at asbestose ofte forekommer etter svært høye eksponeringer,pleural fibrose synes å komme etter lave eksponeringer selv over kort tid, mens mesotelioma kan forekomme ved lave eksponeringer, men ofte med meget lang latenstid (> 30 år).

Pleural fibrose og/eller kalsifisering er av prognostisk viktighet vedrørende økt insidens av lungecancer og mesotelioma.

Kliniske funn ved mesotelioma kan summeres som følger:
(på engelsk)

PLEURAL MESOTHELIOMA:

- chest pain (unilateral)
- weight loss
- loss of appetite
- rapidly progress of shortness of breath
- pleural effusion
- recurring "
- mediastenum pulled to one side
- cyanosis
- tachypnea
- tachycardia
- tumor growth through chest wall (pleural aspitation,thoracotomy)
- local spread to bones,lymph nodes, pericardium,mediastenum
- cardiac tamponade.

Det ble påpekt av Selikoff at det ikke er påvist et eneste tilfelle av primær mesoteliom i pericard i USA.
Det er omtrent 50/50 fordeling mellom pleura og peritoneum.
En for meg ukjent person hevdet å ha funnet 2 tilfeller av mesoteliom i pericard, det ble her diskusjon/spørsmål om nøyaktighet av diagnose (primær tumor).

Det ble videre stadfestet at chronic bronchitis ikke automatisk er en følge av kraftig asbesteksponering. Videre er det ennå ikke påvist mesotelioma hos MMMF-produksjonsarbeidere.

Selikoff har ikke påvist tilfeller av mesotelioma med mindre enn 11 års latenstid. Korteste latenstid i Sør-Afrika er 18 år.

Yngste tilfelle av familiemedlemmer med mesotelioma er 30 år (død). Diagnosen ble stilt i en alder av 26 år. Denne ukjente personen hevdet igjen å ha funnet et tilfelle av mesotelioma hos en 13 år gammel jente. Selikoff hadde vondt for å godta disse fakta. Helbredelsesmulighetene for mesotelioma anses tilnærmet lik null. Den lengste overlevelsestid observert er 7 år fra diagnose. Denne person lever fortsatt, men tumor infiltrerer nå halsen.

Selikoff berørte forsiktig tankene om andre årsaker for mesoteliom. Han viste likeledes at det blant lavt eksponerte forekommer flere tilfeller av mesoteliom enn blant høyt eksponerte. Dette ble forklart ut fra følgende teorier:

1) Ved høy eksponering dør personene av bronchial cancer og/eller asbestose før mesotelioma utvikles.

2) Asbestose/fiberdannelse i lungeparenchymet forhindrer fibertransport til pleura og peritoneum. Imidlertid viser et fransk arbeide (Bignon) at det finnes krysotilfibre i pleura selv ved langt fremskreden asbestose, så en helte sterkest til den 1. teorien.

I det neste foredraget fikk vi en utmerket gjennomgåelse av patologien ved talkose, silikose og asbestose av dr.Kannerstein Det ble vist bilder av en rekke tynnsnitt, og det er derfor vanskelig å gi et konkret referat. For å skille mellom de tre typene ble bl.a. asbestos bodies brukt som kriterium, med det ble kommentert at en finner asbest i talkum. Som talkose eksempel ble en kondompudrer trukket frem. Under denne patologiseksjonen ble det videre hevdet at en finner asbestfibre i nyre,lever,thyreoidea,milt, men uten at disse fibrene syntes å forårsake noen spesifikk skade på disse organene.

I det neste foredraget tok Selikoff for seg viktigheten av å ha en nøyaktig yrkesanamnese (occupational history). Av 2270 døde i hans isolatørgruppe, var det nevnt asbest på 845 av dødssertifikatene (rapport,asbest ?). Han viste videre at de fleste lungecancer tilfellene overveiende forekom i nedre lungelapp, mens det for røkere er funnet et flertall med primærtumor i øvre lungelapp. Videre diskuterte han mulighetene for feildiagnoser ved bruk av X-ray og viste eksempler hvor pleura-plaques var blitt oppfattet som lungetumorer. I henhold til ILO-klassifiseringen ble det vist at blant ca. 300 røntgenbilder klassifisert av Mount Sinai, samt et annet hospital i USA, viste kun små forskjeller med hensyn til grad av fibrose (lungefunn).

Det ble reist spørsmål om hva man gjør med personer med forandring o/1 i henhold til ILO, og som utsettes for støv (asbest Konklusjonen på det var at arbeidsplassen bedres først før man eventuelt remplasserer personen.

Det ble videre gitt et foredrag av dr. Miller om bruk av lungefunksjonsmålinger som diagnostisk hjelpemiddel ved asbestrelaterte sykdommer. Foredraget kan summeres som følger:

I. Tidlige fysiologiske forandringer
A. Small airway obstruction
B. Regional inhomogenity
C. Reducing D_LCO - normal lung volume
D. Restrictive VC

II. Sene fysiologiske forandringer:
A. Combined obstruction-restriction
B. Pulm.hypertention → Cor pulmonale
C. Alveolar hypoventilation.

Det ble videre diskutert kriteriene for"disability-inability to do one's job". Det var enighet om at i USA var kriteriene altfor strenge, idet VC,PO_2, D_LCO verdiene var satt til 1/3 av normalverdiene ut fra alder, høyde og vekt. Det ble hevdet at ved slike verdier behøvde en ikke å måle, resultatet var ofte innlysende.

Det ble nå presentert endel med asbestrelatert sykdom for å illustrere hvor vanskelig diagnosen ofte kan være. Spesielt ble det vist eksempler på hvordan pleura plaques kunne tolkes som tumorer. Biopsi ble nevnt som et sikkert hjelpemiddel, men ble dog frarådet av Selikoff,idet de hadde hatt 3 dødsfall i forbindelse med lungebiopsier (langt fremskredne). Et av disse tilfellene som ble presentert hadde meget kort eksponeringstid, og Selikoff kom i den sammenheng inn på hvor lang eksponering som skal til for å kunne fremkalle asbestsykdom (f.eks. fibrose,pleura plaques). Selvfølgelig er dette avhengig av graden av eksponering, men 2-4 uker var han sikker på var nok for å gi reaksjon på et senere tidspunkt. Han var ikke sikker på om 2-4 dager var nok? Det ble videre stadfestet at selv om personer tilsynelatende har høye stillinger når de får en slik sykdom, så skal en ikke forledes av dette, idet det ofte er arbeidere som har gått gradene gjennom et langt liv. Dette ble kalt "directors sickness".

Dr.Susan Daum ga oss et bilde av Caplan's syndrom i forbindelse med asbesteksponering. Dette er utartede arthroser som kan forekomme som rheumatiske noduler i lever, nyre, lunge eller som rheumatonic arthritis i knær og albuer. Symptomene ses bare ved langt fremskredne tilfeller av asbestoser og fremtrer ofte sent og etter lang/høy eksponering.

Neste foredrag omhandlet godartet pleural effusjon relatert til asbesteksponering og ble gitt av dr.Edwin Holstein. Det ble presentert 1 kasus.

> 52 årig person, 30 års eksponering, dyspnea,bryst-smerter,blod i pleuravæske,væskeansamling skifter side i løpet av 1 år, høyt antall hvite blodceller, pleural fortykkelse. Spørsmålet var om det forelå lungecancer eller mesotelioma. Eneste muligheten i dette tilfellet var å vente eller bruke biopsi som hjelpemiddel.

Denne gruppen har studert 60 tilfeller med pleural effusjon. Denne undersøkelsen sier ingenting om at denne gruppen er ved høy risiko for mesotelioma eller lungecancer. 6-7 av disse tilfellene har endt med cancer. Det ble stadfestet at det ble funnet fibre i pleura og mesotelialvæsken hos disse personene. Videre at celleanalyse i pleuralvæsken ga få holdepunkter for en sikker diagnose.

Professor John Last ga oss en kort innføring i epidemiologi. Han beskrev kort de forskjellige metoder (cohort, case-control etc.) samt retrospektive henholdsvis prospektive studier uten å bringe noe revolusjonerende nytt.

Selikoff himself holdt en glimrende forelesning om lunge-cancer blant røkere/ ikke røkere kombinert med asbesteksponering. For å kunne tolke dataene riktig viste han til at salget av sigaretter i USA først viste økning rundt 1925, mens forbruket av asbest var som følger (USA):

1879-1909 ~ 700.000 tonn
1910-1929 ~ 4.100.000 "
1960-1969 ~ 7.100.000 " .

Dette er endel av forklaringen for at en ser den voldsomme økningen i lungecancer hos disse persongrupper fra 1950 årene og fram til idag. Blant 2066 ikkerøkere i isolatørgruppen var det funnet 8 lungecancere i perioden 1967-1977, mot forventet ca. 12 tilfeller.

632 N.Y.-N.J. røkere isolatører observert i perioden 1/1.1943-1/1.1977 viste følgende resultat:

	Ex (forventet)	Obs.
Totalt døde	329	479
" cancer	56	210
Lunge "	13	93
pleural mesoteliom	-	11
peritoneal "	-	27
gastrointestinal cancer	15	43

Konklusjonen var at ved kombinasjon av røyking og asbesteksponering vil en kunne forvente økt risk for en rekke typer cancer (lunge, mesotelium, gastrointestinal trakt, nyre lever,milt etc.)

Eks. 17.800 isolatører 1967-1975.

	Ex.	Obs.
Cancer buccal cavity/pharynx	7	17
" larynx	4	9
" nyre	7	17
" hud	6	10
" prostata	18	26.

Dersom en ser på fordelingen av lungecancer i relasjon til lengden av eksponering får en følgende relasjon:

Tid eksponering	Lunge cancer Ex.	Obs.
< 1 måned	1.3	3
1 måned	1.4	5
2 "	1.3	8
1 år	1.5	12
+ 2 år	1.5	10.5

Grovt ble dette skissert som følgende med hensyn til latenstid. Disse personene har arbeidet mest med amosite:

Eksponeringstid	Latenstid
< 1 måned	> 30 år
+ 2 år	>15 år.

Videre ble det vist til forskjellige grupperinger blant isolatører.

283 ikke-røkere observert 1963-1967,
24 tilfeller av lungecancer, mot forventet 3.
En mindre gruppe på 48 (N.Y.insul.) ikke-røkere undersøkt pr. 1/1.1977.
Resultat 0 lungecancer.

Blant 17.800 isolatører:

	Lunge cancer Ex.	Obs.	
2066 ikke-røkere	14	8	pr. 1/1.1977
9500 røkere	60	235	

Blant 12.051 av disse isolatørene hvor en hadde sikre opplysninger om røkevanene, kom en fram til følgende fordeling:

	Ex.	Obs.
Lunge cancer	80	449
Ikke røkere/asbesteksponert	-	8
bare asbesteksponert	-	53
bare røyking	-	72
kombinasjon røyk/asbest	-	315

Det ble videre fremlagt data som viste at for den generelle befolkning som har sluttet å røyke, synker risikoen for lungecancer til det samme som for ikke-røkere 10 år etter de har sluttet. For asbesteksponerte personer som røyker ble følgende data presentert.

	Lunge cancer	
	Ex.	Obs.
Nåværende røkere asbesteksp.	15	171
Personer som har stoppet i 10 år.	4	15

Disse tallene viser at dersom en slutter å røyke så synker risikoen for lungecancer betydelig. Det ble tilslutt stadfestet at det ikke var funnet noen sammenheng mellom forkomst/risiko for mesotelioma og røyking.

Etter dette maraton-foredraget hvor lysbildefremviseren var på sammenbruddets rand etter Selikoffs tempo/behandling, fikk vi et noe roligere sammendrag av lunge cancer -patologi av dr.Jacob Churg. Det ble igjen stadfestet at asbest-relatert lunge cancer forekom hyppigst i nedre lungelapp, mens røyke-relatert lunge cancer forekommer i øvre lunge-lapp. Hos røkere ble det tidligere påvist squamous cell carcino dette har i den senere tid utjevnet seg med omtrent lik fordeling mellom adeno- squamos- , og oat cell carcinom.

	Amerik.studie		Engelsk studie	
	Adenocarc.	Squamous	Adenocarc.	Squamous
Asbesteksponerte	11	11	34	22
Kontrollgruppe	9	12	27	17

	Adenocarc.	Squamous	Oat cell
Med ingen-mild asbestose	25	29	25
Med moderat-kronisk asbestose	38	19	28

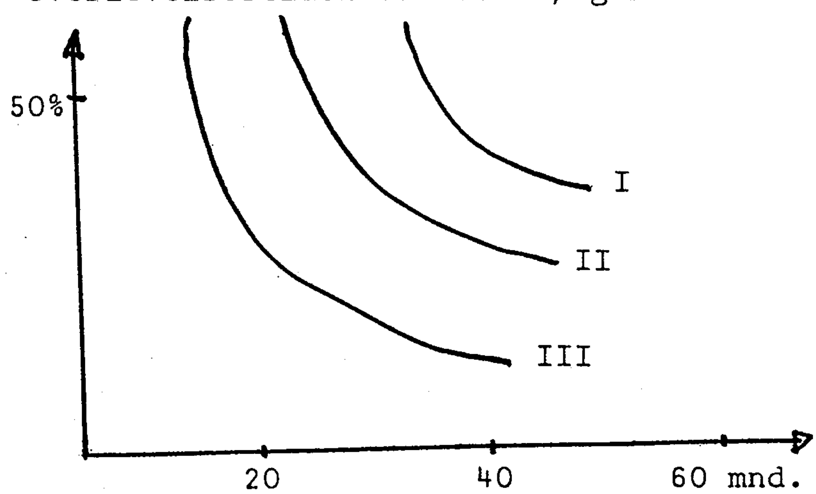
Churg hadde videre undersøkt en eventuell sammenheng mellom grad av fibrose og hyppighet av spesielle typer carcinom uten å finne statistisk signifikante resultater.

Årsaken til at hyppigheten av squamous-, henholdsvis adeno-carcinom nå synes å ha utjevnet seg kan ha sammenheng med bruken av filtersigaretter. Filteret vil filtrere fra en god del tjære samt grove partikler.

I neste foredrag ga dr.Chahinian et overblikk over mulighetene for behandling av lunge cancer. Primært skilte han mellom 3 stadier:

I : tumor < 3 cm
II : " > 3 cm (uten infilt)
III: " invaderer mediastenum

Grov skisse av overlevelsestiden var som følger:



Videre tok han for seg hvilke metoder som ble benyttet under behandlingen. Kombinasjon av cytostatika og strålebehandling syntes å gi størst objektiv respons/forlenging av levetid. Det ble gitt en rekke eksempler på kombinasjonsbehandlinger med cytostatika (MTX,ADR,CYT,CCNU) i forskjellige doser og sammenhengen med responsprosent samt overlevelsestiden.

For 166 tilfeller av mesotelioma i perioden 1959-1973 hadde de en overlevelsestid i gjennomsnitt 2- 55 mnd (median 7 mnd). Det ble videre gitt mortalitetsdata i forbindelse med pleurectomy,pleurpneumoectomy, palliatative kirurgi av mesoteliomtilfeller.

Dr. Lilis tok for seg radiologiske og kliniske funn ved lunge cancer og pleural mesotelioma.

<u>Lungecancer</u>:

1) peripheral
2) lower lobe
3) multiple primary tumors
4) early pleural spread

<u>Pleural mesotelioma</u>:

1) pleural effusion
2) nodular pleural thickening
3) mediastenum deviated
4) fissures often infiltrated
5) possible spread to the other side
6) possible pericardial involvment
7) possible peritoneal involvment.

Ved mesoteliom bøyes brystet oftest mot lesjonen.

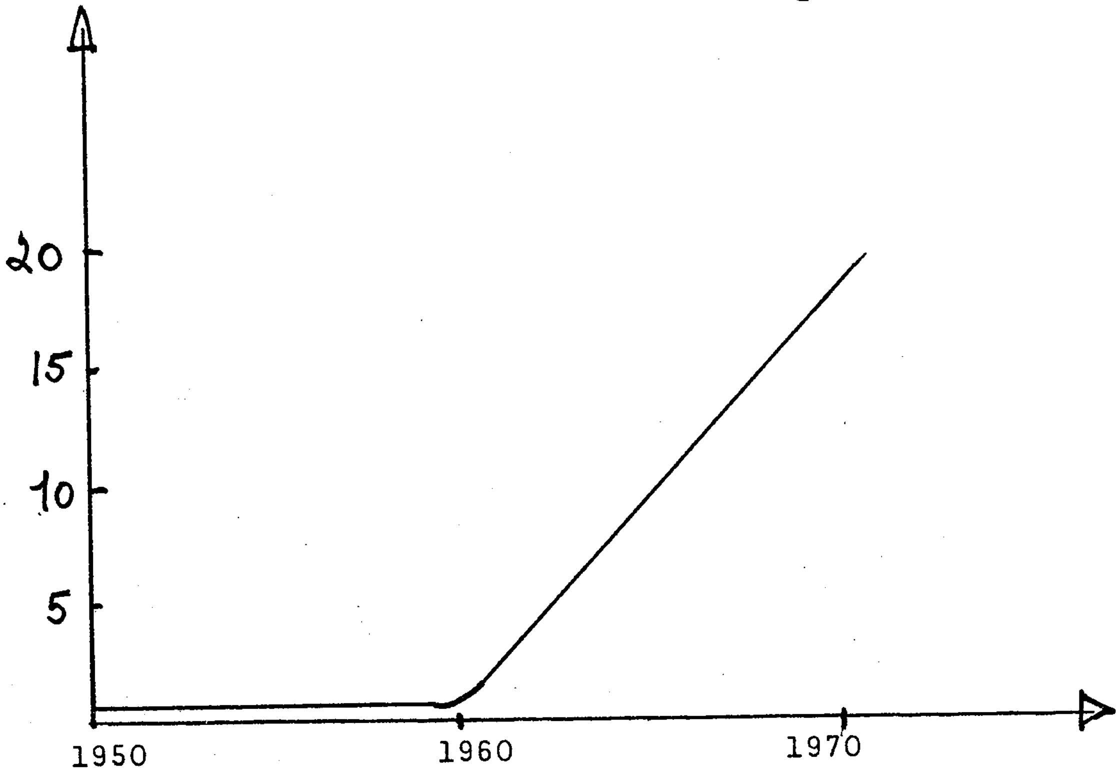
Ved å gjennomgå 48 tilfeller av pleural mesotelioma på nytt, fant en at 33 var riktig diagnostisert. Av 60 peritoneal mesoteliom var 30 rett diagnostisert. De resterende ble diagnostisert som lunge cancer, pleural fortykning, pericarditis og tb. etc. Det ble påpekt at det ved Mount Sinai School of Medicine (MSM) var funnet hovedsaklig amosite og krysotil i lungene til disse mesoteliom-pasientene.

Dr. Alf Fischbein rapporterte om familiekontakteksponering (asbest). En 35 årig kvinne går til vanlig X-ray sjekking, og en finner pleural mesoteliom i mars 1977. Kvinnen lever pr. idag. Faren dør av bronchial cancer/asbestose i mai 1977. Ved å sjekke bakover finner er at moren er død av malign pleural mesotelioma i 1967. I juni 1977 blir søsteren til denne kvinnen tatt til nøyaktig undersøkelse ved MSM og en finner pleurale abnormaliteter på X-ray. Det nevnes at faren var "pipefitter" på et skipsverft under krigen.

Dr. Nicholson ga så et "review" over funnene av mesotelioma ved asbesteksponering. I amerikansk litteratur ble 1.tilfelle beskrevet i 1953. Wagner rapporterte i British J.Ind.Med.17: 260,1960 om 47 tilfeller i perioden 1956-1960 (S.Afrika) 1931-1960 3 tilfeller rapportert av Selikoff-Rabin. 1910-1965 76 tilfeller rapportert av Newhouse-Thompson hvorav 31 var sikkert eksponerte og 9 var familiemedlemmer av eksponerte. Endelig Selikoffs 175 tilfeller av mesoteliom blant 17.800 isolatører i USA og Canada.

Dokumentasjonen over mesoteliom-asbest er idag enorm. Antall tilfeller mesoteliom stiger sterkt fra 1960 og utover. Dette har sin klare sammenheng med at skipsbygningen fikk en enorm oppsving i perioden 1930-1945.

Antall mesoteliomtilfeller i Glasgow.



Av 66 tilfeller diagnostisert ved MSM av pleural mesoteliom var 49 riktige, 7 var lunge cancer, 5 var andre tumorer, resten etc. Av 48 pancreascancer var det 15 peritoneal mesotelioma.

Dr.Kammerstein/Suzuki foreleste om patologi og histopatologi og elektronmikroskopi ved mesoteliomstudier. Konklusjonen på dette foredraget var at det finnes individuelle mesoteliomceller. Ved elektronmikroskopi kan en fra tynnsnitt skille mellom mesoteliom og lunge cancer.

Dr. Susan Daum beskrev såkalt "Neighbourhood exposure".
9 tilfeller av mesoteliom i Sør-Afrika er beskrevet der en med sikkerhet kan fastslå at 0-eksponering foreligger.
146 tilfeller av pleura plaques er rapportert i Finnland i nærheten av antofyllitgruvene. To tilfeller fra statene ble rapportert. Begge hadde bodd vegg i vegg med skipsverft. Det synes imidlertid som om fortynningseffektene ved lufttransport fra en punktkilde er så store at en vil finne svært få fibre 500-1000 m fra kilden, selvfølgelig avhengig av utslippets størrelse.

I USA har en undersøkt tak på eldre hus i nærheten av de aktuelle punktkilder, uten å finne unormale fiber-forekomster. Konklusjonen fra Selikoff var at det kun er personer som 0-5 kvartaler unna punktkilder som kan være ved høyere risiko, men vi har pr. idag ikke bevis for at den generelle befolkningen nær punktkilder er en høyere risikogruppe enn befolkningen lengere unna.

Det nevnes at de tilfellene som var referert fra Sør-Afrika (Wagner) kunne ha sin årsak i at veiene i Cape-provinsen (SA) tildels hadde dekke av krokidolit. Idag har disse veiene fått nytt dekke.

En ny risikogruppe som ble trukket frem av dr.Lorimer, var gruppen bremsemekanikere. 93 U.S.-mekanikere undersøkt hvorav 9 hadde pleural fortykkelse. Selikoff er nå i ferd med å konstruere en kohort på 1000 mann som skal følges. Videre skal tollkontrollører, politimenn, bruvakter osv. kontrolleres på et senere tidspunkt.

En annen risikogruppe som ble trukket frem var "drywall construction workers". Denne type arbeide startet i USA i 1946. Av 15 "taping/sparckling compounds" var det bare 2 som ikke inneholdt asbest. Konsentrasjoner på 0.7-59 fibre/ml var registrert i forbindelse med denne type arbeide. Av 114 snekkere/tapetserere som var undersøkt, fant en 45 med unormal X-ray (parenchymale endringer).

9 med pleurale abnormaliteter (alle med lang eksponering), og 1 tilfelle av lunge cancer. Såkalte "do-it-yourself household users" kan være en risikogruppe. For vårt vedkommende vil malere/tapetserere og håndverkere av denne kategori være en risikogruppe.

I siste foredraget i denne seksjonen tok dr. Paul Kolin for seg sputum cytologi ved maligne lungetumorer. I utgangspunktet påpekte han at dette kunne være vanskelig, idet i det området hvor gass-skiftet foregår forekommer få cancere, samt at spyttproduksjonen her er relativt liten.

Gradering   1 ——————→ 6
    lett forandring   svær forandring
    1 presumption   6 consecutive

9 tilfeller ved Johns -Manvill Co med "presumptive - consecutive sputum atypic cells",hvorav samtlige med negativ røntgen, ble cancer diagnostisert ved bronchoscopy. Kan en se endringer i sputum celler før X-ray, og hvis en deretter kan lokalisere hvor i bronchialtreet cellene kommer fra, da har en funnet et verdifullt hjelpemiddel for tidlig diagnose av cancer. Tilsvarende løsninger kan tenkes ved urincytologi også.

III: Kapittel 2: WORKSHOP ON ZEOLITES VED NEW YORK ACADEMY OF SCIENCE (se eget program)

Zeolitter er en mineralgruppe som forekommer hyppig i jordskorpen, og er i litteraturen omtalt som en egen gruppe under tektosilikatene. Den generelle formelen for zeolittene kan skrives

$$W_m Z_r O_{2r} \cdot s\, H_2O$$

hvor W= Na, Ca, K, Ba, Sr og
Z= Si, Al

Eksempler:

Heulandite:	$Ca\,Al_2\,Si_7\,O_{18} \cdot 6H_2O$
Laumontite:	$Ca\,Al_2\,Si_4\,O_{12} \cdot 4H_2O$

Zeolittene er vanligvis av sedimentær opprinnelse, men finnes også ofte i kaviteter i vulkanske bergarter.

Det finnes 41 forskjellige zeolittmineraler hvorav 9 er såkalt fibrøse (danner tynne fibre)
De viktigste er:

Analcime	$Na_{16}\,(Al_{16}\,Si_{32}\,O_{96}) \cdot 16\,H_2O$
Chabazite	Na Ca_6
Clinoptiolotite	Na K
Erionite	$Na_1\,K_1$ Ca
Heulandite	Ca
Laumontite	Ca
Faujasite	Na
Ferrierite	Na, Mg
Mordenite	Na
Natrolite	Na
Phillipsite	Na, K
Wairakite	–

Zeolittene har på grunn av karakteristiske egenskaper (gode) etterhvert fått nokså bred industriell anvendelse. I det følgende vil jeg kort referere de to viktigste anvendelsesområdene for denne typen mineraler i dag.

1. Zeolitter som molecular sieve eller ionebyttere. I dag har I dag har zeolittene fått bred anvendelse som ionebyttere både for anioner og kationer. De har en rekke fordeler foran andre ionebyttere på grunn av følgende faktorer:

   1. Spesifikk ioneselektivitet
   2. Thermal stabilitet
   3. Motstandsdyktig mot ionestråling
   4. Vanskelig å oksydere
   5. Veldefinert dimensjonell struktur
   6. Motstandsdyktig mot større osmotiske endringer

Etterhvert har zeolittene fått anvendelse innen områdene ved fjerning/gjenvinning av NH_4^+, Cd, Zn, Cu, Co, Ni fra vannkilder for en rekke områder. Videre brukes zeolittene for lagring av radioaktivt Cs og Sr.

Imidlertid det absolutt største anvendelsesområdet finner en innen katalyse. Tidligere brukte en platinakatalysatorer ved "cracking" av råolje. I USA brukes det idag kun aktiverte zeolittkatalysatorer.

Prosess		USA-forbruk tonn
cracking	5-30% faujasite	150.000
hydrocracking	80% mordenite	1.000
isomerization	+ 80% mordenite	$<$ 100
alkylation	+ 80 faujasite	$<$ 100

I Europa er det ca. 50 % av raffineriene som benytter zeolitt-katalysatorer.

Ved 1400 - 1600° F bryter zeolittene sammen til et amorft materiale.

Grunnen til at det ble holdt gruppemøte over dette emnet er at zeolittene kan danne fibre og derved er en potensiell helserisiko ved eksponering, dersom en legger Stantons teori om at det er fiberformen som den effektive agens til grunn. I det følgende ble det vist resultater fra undersøkelser gjort med zeolitter. Det er vist at zeolitter (enkelte) er hemolytisk aktive.

2 tilfeller av pneumoconiose (diagnose ved biopsi) ble rapportert der eksponeringen hadde bestått av katalysator fra et raffineri. Men det mest interesante i denne sammenhengen er de funn som er gjort i Tyrkia av professor Baris. Hans epidemiologiske studier viser at kalsifisert pleura plaques, kronisk fibrotisk pleuritis og malign pleural mesoteliomas er endemisk i noen Tyrkiske landsbyer. I enkelte landsbyer har dr. Baris observert at opptil 30 % av dødsfallene skyldtes mesotelioma. Han har hittil rapportert 140 tilfeller hvorav de fleste var bønder, (92 menn og 56 kvinner). Levealderen for menn varierte fra 15 - 71 med middel på 45 år og for kvinner 12 - 69 med 50 år som midlere levealder.

Det synes å være en omtrent lik fordeling mellom pleural og peritoneal mesotelioma og diagnosene er etterprøvet ved MRC i Cardiff og funnet riktige i de aller fleste tilfellene. Hva kan så være årsaken til at en finner en slik overhyppighet av denne sykdommen i akkurat disse områdene? Lungevevet ble analysert (vanskelig med autopsi p.g.a. religion som forbyr obduksjon) i England (Pooley) og en fant alle typer asbest i vevsprøvene. Mere vev ble undersøkt og det viste seg at mineralet (fibre) zeolitt forekom i store mengder. Fibrene fra lungevevet hadde følgende størrelsesfordeling(TEM):

75 % tynnere enn 0,25 µm
70 % kortere enn 2 - 3 µm

Det ble påvist at hovedmengden av fibre bestod av erionit og chabasit. Ved analyse av steinprøver fra disse landsbyene ble det påvist de samme mineralene (prøver fra fjellet, veier, hus, etc). Etter dette har en rekke geologiske ekspedisjoner vært i Tyrkia og sett på forholdene. Det er påvist store forekomster av zeolitt i områdene rundt disse landsbyene. Videre er det påvist kontaminering av asbest (tremolitt) i enkelte områder. For tiden pågår det målinger av fiberkonsentrasjonen i luften på disse stedene. En har sterk mistanke om at disse pleurale abnormalitetene som er funnet i dette distriktet skyldes daglig eksponering for fibre av zeolitt-type med mulig kontaminering av asbest. Spørsmålet reises hvorvidt også andre fibre kan forårsake mesotelioma og at Stantons teori om fiberdimensjon istedenfor fibertype er den viktigste årsak til eventuell vev-reaksjon (sykelig). "program" for workshop side 25 og 26.

WORKSHOP ON ZEOLITES

TIME: Friday, June 23, 1978, 8:30 a.m. to 6:00 p.m.

PLACE: New York Academy of Sciences, 2 East 63rd Street, New York, New York 10021

Welcome to the New York Academy of Sciences' SCIENCE WEEK and to the WORKSHOP ON ZEOLITES. The Workshop has been organized to bring together members of the scientific and medical communities who are knowledgeable about the properties, uses, and formation of natural and synthetic zeolites and/or who have been concerned with the biological reactivity of these materials and their possible association with human disease. The Academy expresses its appreciation to the following invited participants who have agreed to take part in the Workshop:

Dr. Y. I. Baris - Hacettepe University, Ankara, Turkey

Dr. D. W. Breck - Union Carbide Corporation, Tarrytown, New York (Co-Chairman)

Dr. W. J. Campbell - U.S. Bureau of Mines, College Park, Maryland

Dr. P. C. Elmes - MRC Pneumoconiosis Unit, Pernarth, Wales

Dr. G. T. Kerr- Mobil Research & Development Corporation, Princeton, New Jersey

Dr. A. M. Langer - Mount Sinai Medical Center, New York, New York

Dr. F. A. Mumpton - State University College, Brockport, New York (Chairman)

Dr. F. D. Pooley - University College, Cardiff, Wales

Dr. A. N. Rohl - Mount Sinai Medical Center, New York, New York

Dr. Malcolm Ross - U.S. Geological Survey, Reston, Virginia

Dr. R. J. Schnitzer - Mount Sinai Medical Center, New York, New York

Dr. I. J. Selikoff - Mount Sinai Medical Center, New York, New York

Dr. J. V. Smith - University of Chicago, Chicago, Illinois

Dr. R. C. Surdam - University of Wyoming, Laramie, Wyoming

Dr. D. E. W. Vaughan - W. R. Grace, Inc., Columbia, Maryland

The following format has been developed for the Workshop, consisting of a morning session devoted to talks on the distribution, formation, properties, and applications of zeolite materials, followed by an afternoon session wherein data on the biological activity of these materials would be presented and discussed. All invited participants in the Workshop are urged to attend both sessions. Speakers in the afternoon session will give 15 to 20 minute presentations of their recent findings, to be followed by a 10 to 15 minute discussion period. A general discussion period has been set aside at the conclusion of the Workshop. The chair will entertain first questions to the speakers by other Workshop participants and then by attending observers, time permitting. To assist the official Workshop rapporteur, all presentations and discussions will be tape recorded.

Eksponeringsgradering:

Very Low - Low - Moderate - Severe (>20 f/ml)

Low

	ex	ob	SMR
døde	118	118	100
cancer lunge/pleura	17	17	154
gastrointestinal cancer	9	10	81

LOW - MODERATE	ex	ob
cancer lunge/pleura	9	16

SEVERE<2 ÅR	ex	ob
Alle tilfeller	123	162
Cancer lung/pleura	13	31
gastrointestrial cancer	10	20

SEVERE>2 ÅR		
Cancer lunge/pleura	10	56
gastrointestinal cancer	8	19

Røkevaner - lunge cancer

Menn	ex	ob
aldri røkt	0.06	1
ex/current	12.6	20

Kvinner	ex	ob
aldri røkt	0.10	1
ex/current	0.97	6

AGENDA

8:30 - 8:45	Introduction - F. A. Mumpton, Chairman
8:45 - 9:15	Zeolites - F. A. Mumpton
9:15 - 9:45	Zeolite Structures - J. V. Smith
9:45 - 10:00	Coffee Break
10:00 - 10:30	Zeolite Synthesis and Reactivity - G. T. Kerr
10:30 - 11:00	Zeolite Adsorption and Ion Exchange - D. W. Breck
11:00 - 11:30	Zeolite Catalysis - D. E. W. Vaughan
11:30 - 12:00	Zeolite Distribution in Nature - R. C. Surdam
12:00 - 1:30	Lunch
1:30 - 1:40	Brief Comment on Zeolites and Health - I. J. Selikoff
1:40 - 2:10	*Hemolytic Activity of Zeolites - R. J. Schnitzer and A. M. Langer
2:10 - 2:40	*Zeolite Pneumoconiosis - A. N. Rohl
2:40 - 3:10	*Mesothelioma in Turkey - Y. I. Baris
3:10 - 3:40	*Turkish Mesothelioma and Zeolites - F. D. Pooley
3:40 - 4:10	*Zeolite Distribution in Turkish Mesothelioma Areas - F. A. Mumpton
4:10 - 5:00	Open discussion

*Scheduled for 15-20 minute presentations, followed by 10-15 minute discussion.

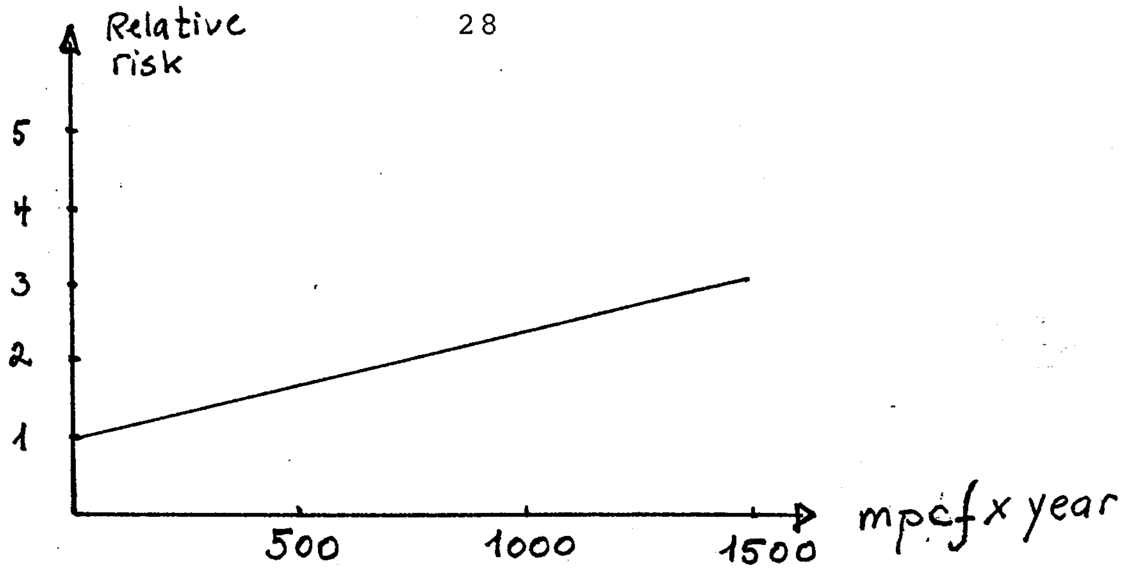
IV: Kapittel 3: CONFERENCE ON HEALTH EFFECTS OF ASBESTOS EXPOSURE

Asbestkonferansen ble et maraton-foretagende med nær tusen deltagere, og typisk for slike konferanser er at utbyttet stort sett er omvendt proporsjonalt med antall deltagere. Som vanlig ble det vist liten respekt for overholdelse av tidsskjema, de fleste slides kunne knapt sees fra første benk, og en rekke aggresive og dominerende personligheter ødela diskusjonene med stort sett irrelevante og uinteressante kommentarer og spørsmål. Så langt gikk alt normalt for en slik maratonkonferanse. En får være glad for at "proceedings" utgis til våren (1979), dog skal jeg idet følgende forsøke å gi et referat fra de mest givende foredrag. Til å begynne med hadde en lagt opp til å behandle dose-respons forholdet for asbest-cancer, og første foredrag ble gitt av dr. Mc Donald som refererte resultatene fra kohort-studien fra krysotilgruvene i Qubec, Canada.

År	1966	1969	1973	1975	
Antall	11788	11572	11391	11379	
Døde	2450	3270	4110	4547	(mortalitet)

Alle disse er født 1891 - 1920, ansatt 1 måned eller mer og har vært fulgt i 12 år. Av 4463 menn som er døde siden 1910, hvor 3 549 forekom i perioden 1951 - 1975 og hvor 3 291 hadde mer enn 20 års eksponering fant en 227 tilfeller av lungecancer fler enn forventet fra standard data.

Ut fra disse dataene, samt de støvmålinger som er foretatt, samt estimater om tidligere års eksponeringer har en konstruert følgende dose-respons sammenheng:



En kunne vanskelig angi en eksakt omregningsfaktor fra mpcf til fibre ml men en faktor på 1,5 - 2 ble antydet. I denne kanadiske gruppen ble det funnet 12 mesoteliom-tilfeller.

Dr. Nicholson rapporterte resultatene fra en kohort fra Thetford mines i Kanada. Kohorten bestod av 544 personer og ble observert fra 1961 - 1977. En kunne bare gi estimater av eksponeringen i denne gruppen, mortaliteten var som følger:

	Ex	Ob
Totalt	159	178
Cancer	36	49
Lunge cancer	11	28
Mesotelioma	–	1

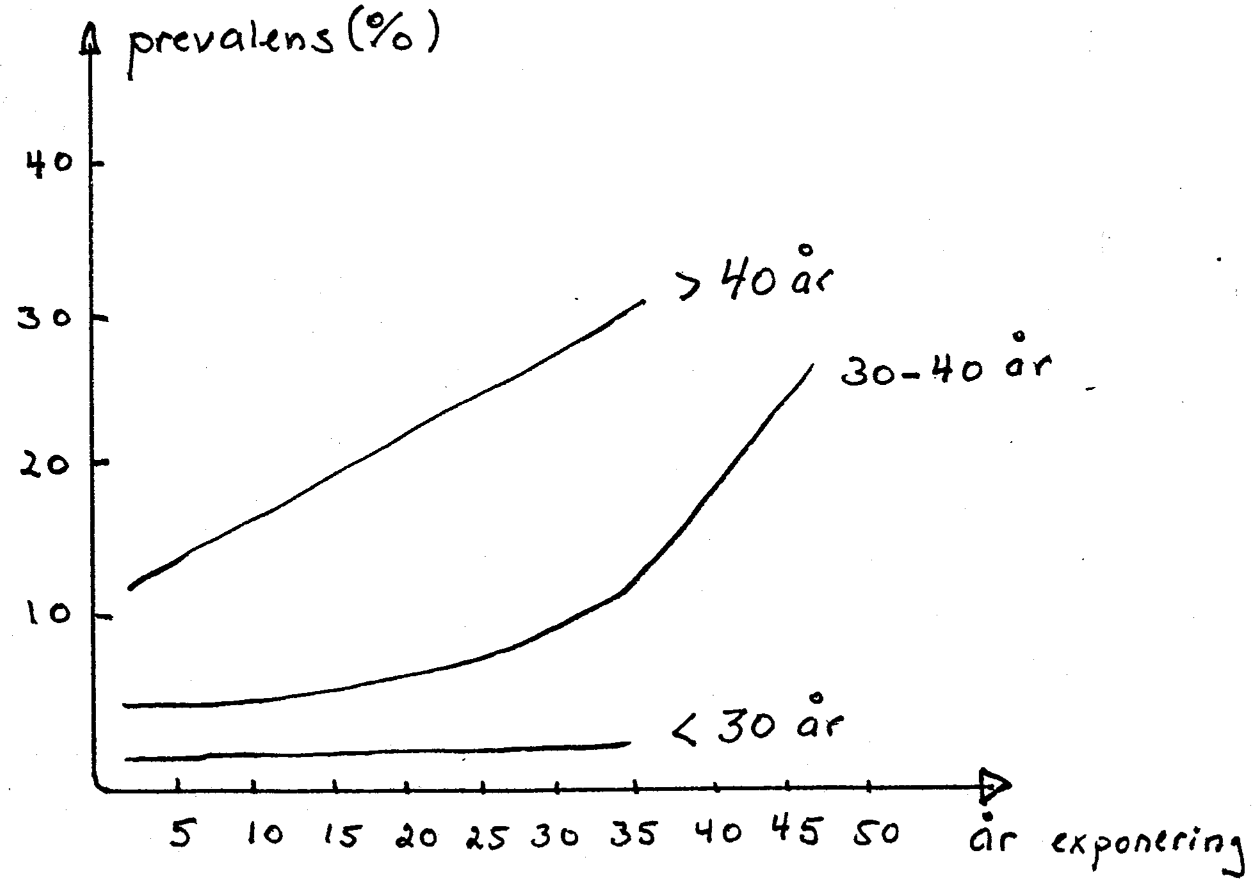
Dr. Kiviluoto gav en oversikt over funn av pleura plaques og neoplasia i Finnland. I et område i Finnland ble det funnet 700 tilfeller av kalsifisert pleura plaques. Denne kokorten ble fulgt fra 1962 - 1977 med hensyn til hyppighet av lunge cancer

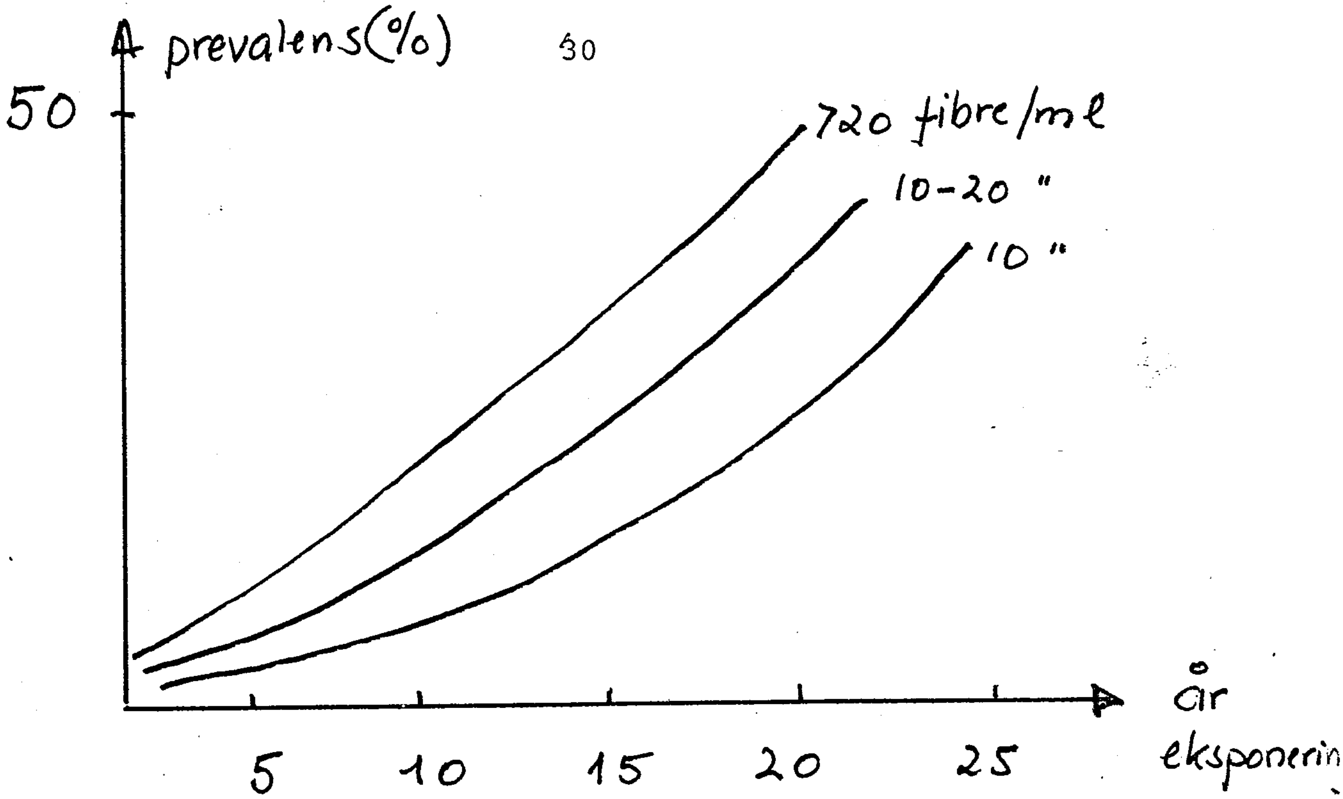
	700 med pleura plaques	700 kontroller
Cancer 1962-1977	60	53
Lung cancer "	13	14

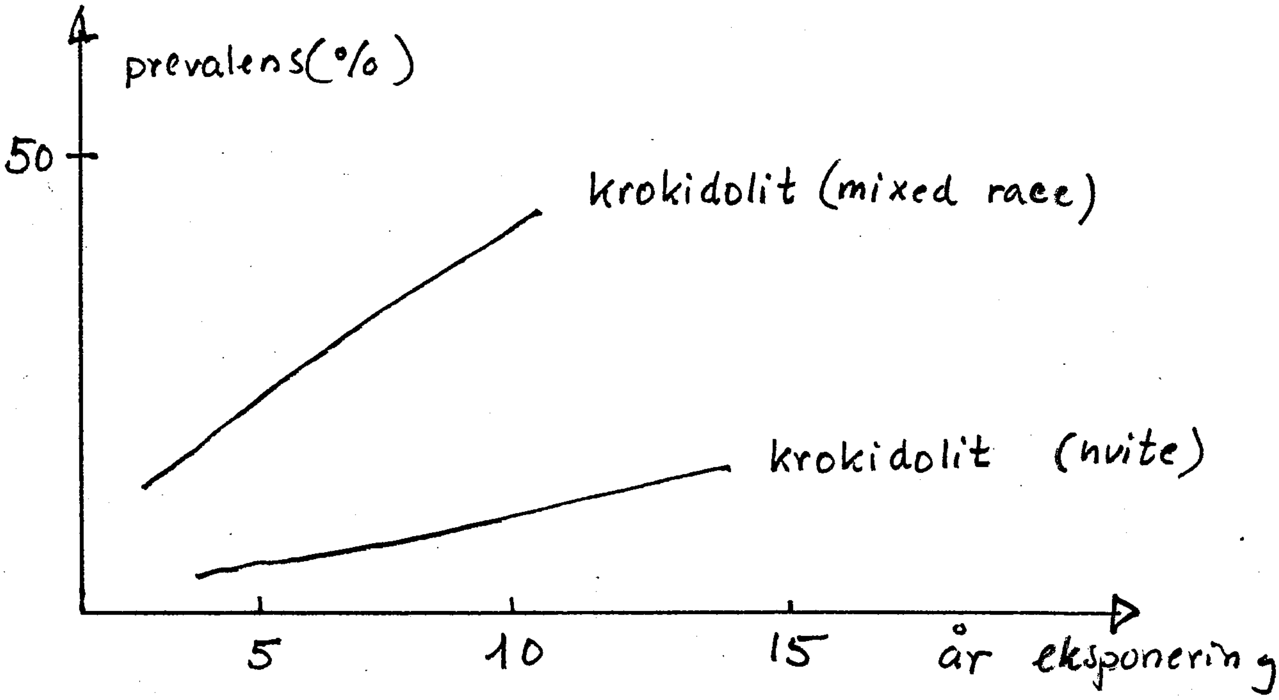
Konklusjonen var at det synes ikke å være noen sammenheng mellom pleura plaques og lunge-cancer i Finnland (i dette området).

Disse personene med plaques hadde bodd i nærheten av antofyllit-gruvene i Finnland, og derved fått en viss eksponering. Det kan tyde på at lav eksponering medfører pleura plaques, mens høy eksponering gir plaques/fibrose/cancer. 85 tilfeller av mesoteliom er observert i Finnland herav kun 1 tilfelle med sikker asbest relasjon.

Dr. Irwig foredro om risikoen for asbestose i krokidolitt og amositt gruver i Sør-Afrika. Ifølge ILO klassifikasjon med lunge forandring 1/0 eller større ble det funnet 7,3 %, 4,5 % med pleural fortykkelse og 3,1 % med "costo-phrenic angle oliberation" og 1,6 % med pleural kalsifisering. Prevalensen var selvsagt høyest hos de som hadde vært eksponert lengst.







En var ikke direkte villig til å erkjenne at de fargede har hatt de dårligste jobbene og derved høyest prevalens. En studerer fortsatt raseforskjeller i så måte.

Dr. Newhouse har studert en kohort av krysotilsyere og vevere og kunne presentere følgende data:

Eksponeringsgradering:

Very Low - Low - Moderate - Severe (>20 f/ml)

Low

	ex	ob	SMR
døde	118	118	100
cancer lunge/pleura	17	17	154
gastrointestinal cancer	9	10	81

LOW - MODERATE

	ex	ob
cancer lunge/pleura	9	16

SEVERE <2 ÅR

	ex	ob
Alle tilfeller	123	162
Cancer lung/pleura	13	31
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SEVERE >2 ÅR

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Røkevaner - lunge cancer

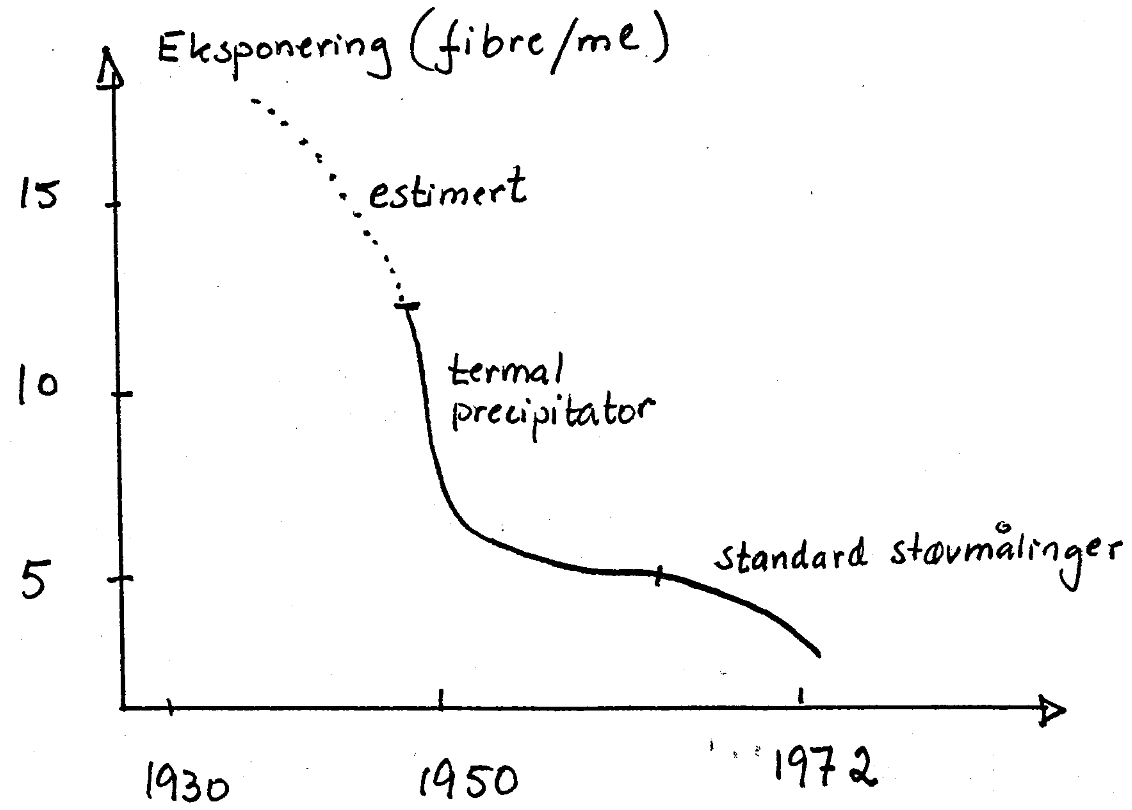
Menn	ex	ob
aldri røkt	0.06	1
ex/current	12.6	20

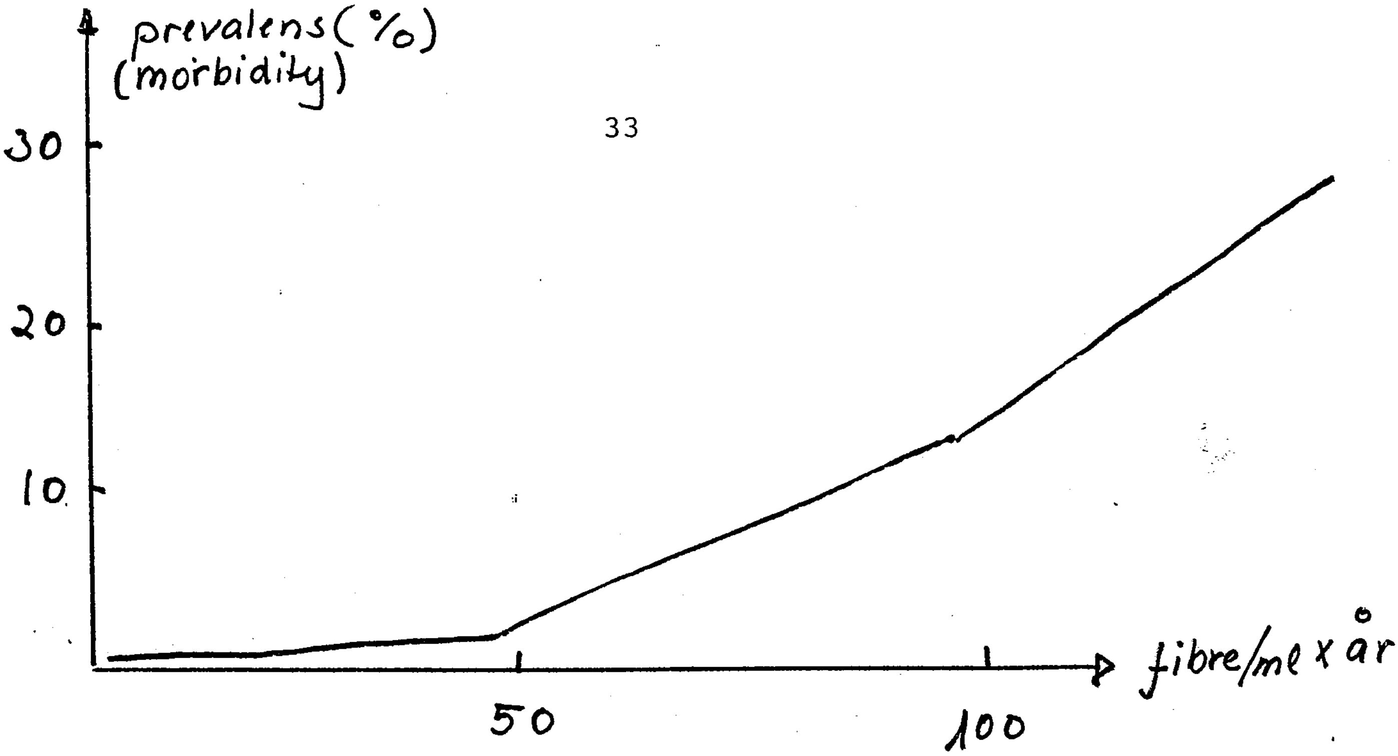
Kvinner	ex	ob
aldri røkt	0.10	1
ex/current	0.97	6

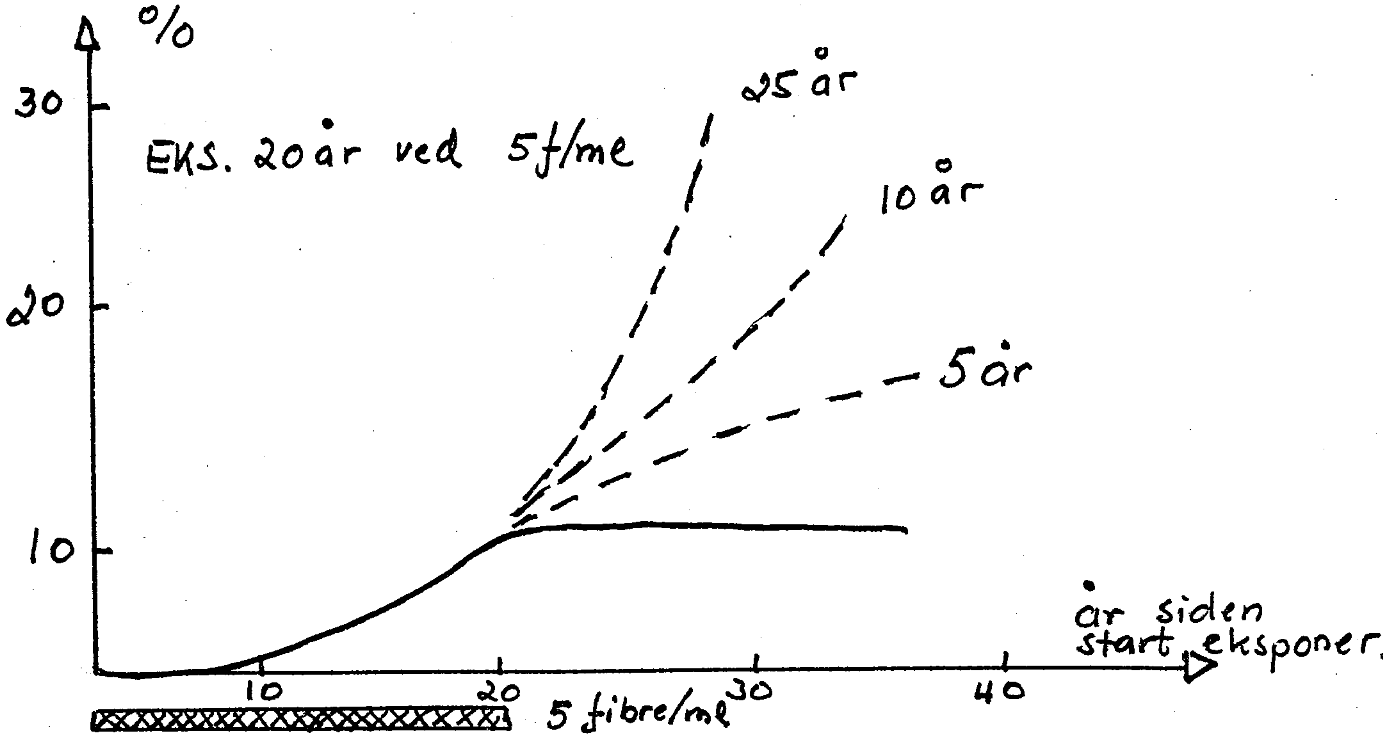
Dr. Lilis trakk frem en ny "høyrisikogruppe som hun kalte "maintenance workers in chemical industry" (vedlikeholdsarbeidere). Hun hadde studert en gruppe på 144 arbeidere hvorav 65 % hadde normal røntgen. 35 % hadde forandringer 1 - 4 i følge ILO-klassifisering hvorav 62 % hadde over 20 års ansettelsestid. 53 av personene hadde hatt direkte asbesteksponering. I 91 av tilfellene kunne en ikke påvise noen direkte eksponering. 22 % fikk diagnosen chronic bronchitis hvor det var jevn fordeling mellom ikke, ex., og nåværende røkere. Kohorten følges videre.

Dr. Bignon i Frankrike har studert en tilsvarende gruppe på 55 personer med midlere ansettelsestid på 24 år. I denne gruppen fant han 4 asbestoser, 1 lungecancer.

Dr. Berry fra MRC i Cardiff gav et utmerket foredrag om dose-respons sammenhengen for asbestrelatert sykdom. Ansatte ved en asbest tekstilfabrikk (ansatt minst 10 år) er studert. Fra 1968 var det blitt benyttet både krysotil og krokidolitt asbest. I denne studien ble lungeforandringer og lungefunksjon benyttet som responskriterium. Problemet er å angi nøyaktige støvkonsentrasjoner. Målingen var foretatt siden 1950.







Ut fra disse dataene hadde en estimert at ved 2 fibre/ml vil en kunne forvente en prevalens på 2 - 24 % avhengig av antall år eksponert.

Dr. Julian Peto viste en analyse av samme tallmateriale med hensyn på mortalitet av bronchial cancer, mesotelioma og/eller asbestose hvor han kommer frem til ved visse estimasjoner at ca. 10 % av disse arbeiderne (679) . sitat :

"10 % of workers would under certain assumtions eventually die of asbestos-induced disease after likelong exposure at 2 fibres/ml, the current English standard."

Disse resultatene antyder at 2 fibre/ml ikke er så sikker grense som en opprinnelig gikk ut fra.

Preliminære resultater fra et studie av mesoteliom-insidensen hos 24 000 arbeidere med hovedsaklig kort eksponering støtter antagelsen om en lineær dose-respons sammenheng, i det minste for denne sykdommen, og det indikerer videre at risikoen ved tilfeldig ikke-yrkesmessig eksponering er sannsynligvis neglisjerbar. Undersøkelsen viser videre at peritoneal mesotelioma er sjelden eller aldri forårsaket av krysotileksponering.

En halv dag ble benyttet til dokumentasjon av det såkalte "The vexing shipyard problem". Det ble fremlagt en enorm dokumentasjon som viste forskjellige grader av overhyppighet av asbestrelaterte sykdommer blant skipsverftansatte. Jeg vil i det følgende kun trekke ut interesante konklusjoner av disse foredragene. Undersøkelsen ved Devonport shipyard viser at pleura plaques ikke indikerer hyppig forekomst av bronch. cancer, mens det synes å være indikasjoner for at pleura plaques kan indikere mesoteliom-risiko.

Selikoff skisserte problemet som følgende (I USA):

1. 1911 første dieselmotor
2. 1924 første undervannsbåt
3. 1940 1 undervannsbåt hver 14. dag
4. 1955 Nautilus sjøsettes
5. 1974 Trident konstrueres

Her kan en forvente asbestrelaterte sykdommer enda noen 10-år blant ansatte ved disse verftene. Av 1.000 verftsarbeidere undersøkt av Selikoffs gruppe fant en 459 med unormal x-ray.

Stumphius i Nederland rapporterte 21 tilfeller av mesotelioma fra 1962-68 blant 3.102 skipsverftarbeidere. 15 med sikker eksponering. 1968-1974 finner han 20 nye tilfeller. 1974-1978 ytterligere 15 tilfeller (SUM 56). Dr. Lajartre rapporterte 70 mesoteliomas fra Bretagn-kysten, 1956-1978 54 diagnostisert ved thoractomy, 9 ved necropsy og 10 ved biopsi. Det var 67 menn og 3 kvinner. 15 tilfeller var mixed mesoteliomas, 55 var epitel mesoteliomas. 51 av tilfellene hadde sikker eksponering.

Dr. Anderson har studert en gruppe på 776 "HOUSEHOLD CONTACTS". 91 av disse ble ekskludert p.g.a. mulig eksponering. 146 hadde pleural fortykkelse, 66 kalsifisert pleura og 61 pleura plaques. 126 hadde pleural abnormalitetes, 53 hadde pleural/parenchymal abnorm.

Dr. Cuyler-Hammond refererte fra en undersøkelse foretatt blant nabobefolkningen til en asbestfabrikk. En fant ikke statistisk signifikante forskjeller sammenlignet med en kontrollgruppe m.h.t. lunge cancer.

V: Kapittel 4: WORKSHOP ON ASBESTOS

Demonstration, identification and quantification of asbestos in tissue

Denne "workshopen" var meget dårlig organisert av de fire store innen området, nemlig: dr. Bignon, dr. Cook, dr. Heppleston og dr. Pooley. Av denne grunn varte denne bare ca 2 timer mot programmert 8.

Det kan kort summeres at det som synes å være nytt i denne sammenheng er at en forsøker å angi innholdet av fibre i vev i vektenheter (µg) istedenfor antall. Pooley og Bignon som samarbeider med Langer i USA bruker våtforaskning (NaOCe)av vev som metode for fjerning av organisk materiale. Dr. Rüttner kunne imidlertid til stor glede for alle andre vise resultater som dokumenterte tap av fibre ved bruk av denne metoden. Videre vil magnesium lakes ut av krystilfibre. Det synes som om tørrforaskningsteknikkene (lav temp. foraskning) er den best egnede metoden. Ellers syntes den såkalte "carbon extraction" metoden å være anvendelig ved TEM. Metoden går i korthet ut på at en7 µm tykt vevsnitt foraskes og overføres til en TEM-grid.

Det ble stadfestet at fibre finnes i lever, nyre, milt, pankreas hos eksponerte individer, mens for gastro-intestinalvev synes det å herske tvil. I Duluth hvor en har meget høyt asbestinnhold i drikkevannet har en påvist fibre i urin hos mennesker.

Det ble videre vist eksempler på fiberinnhold i lungevev hos eksponerte individer. I selve lungevevet kunne en ikke påvise særlig store variasjoner med hensyn til fiberinnhold, men i pleura var variasjonene store. Dr. Bignon har utført forsøk med rotter (injeksjonsforsøk), og kunne påvise asbest i omtrent samtlige organer 90 dager etter injeksjon. Høyeste konsentrasjoner ble påvist i lymfeknutene. Krokidolitt og tynne glassfibre syntes å lagres i større grad enn krysotil i lymfeknutene.

Det ble hevdet at det ikke er noen korrelasjon mellom grad av fibrose og fiberantall, mens det foreligger korrelasjon mellom fiberantall og tid og grad av eksponering.

SIGNIFICANCE OF ASPECT RATIO IN REGULATION OF ASBESTOS FIBRE EXPOSURE

På denne "workshopen" som var langt bedre organisert ble det fremlagt abstracts eller komplette foredrag. Jeg vedlegger disse. Det ble presentert et arbeide hvor en hadde injisert intraplurالt fibre med eksakt diameter/lengde forhold. Glass- og asbestfibre tynnere enn 0,4 µm men lenger enn 20 µm syntes å være de mest aktive m.h.p. carcinogenese.

Appendix 1. Definition of asbestos-ralated mineralogical terms

" 2. Identification of fibrous and non-fibrous amphiboles in the EM.

" 3. The effect of aspect ratio on fibre counts, A preliminary study

" 4. A comparison of asbestos fibres and whiskers

" 5. History of asbestos-associated disease

" 6. Neighbourhood pleural calcifications

" 7. Neighbourhood mesothelioma

Appendix 1.

WORKSHOP No. 1. June 26, 1978 New York

DEFINITION OF ASBESTOS-RELATED MINERALOGICAL TERMS

MINERALS are naturally occuring crystalline and inorganic elements and compounds.

A MINERAL is defined by its distinct crystal structure and chemical composition and is identified by a name, which usually ends with "-ite".

Some variation in the chemical composition in a mineral is accepted without changing the name of the mineral. If an element, not normally present in a mineral, is present in significantly larger than trace quantity the mineral may be given a new name or the name (or the chemical symbol) may be added to the mineral's name as a prefix. The latter is the currently preferred practice. For example, in Mn-Cummingtonite about 12% of the iron and magnesium is replaced by manganese. Consequently, Mn-Cummingtonite is considered as a distinct mineral.

Minerals in a MINERAL SERIES have the same crystal structure and essentially the same chemical composition, except for the variable ratios of two (or more) similar cations occupying the same structural sites. End members of the series containing only one of these cations (or maximum known or permissible ratios) have distinct mineral names. Others in the series are identified by the quotation of the ratios of these cations.

In the past names were given to minerals in certain ranges of the variable cation ratios. Some minerals may also have special names. For example, plagioclase is the name of a mineral series in which the variable cations are Na, Ca, Si, and Al. The two end members are albite and anorthite containing only Na or Ca, and 3:1 or 1:1 ratios of Si:Al, respectively. Minerals in this series are identified today by the percentage of Na and Ca they contain. $Ab_{80}An_{20}$, for example, is a plagioclase containing 80% Na and 20% Ca. Minerals within certain ranges of Na/Ca ratios used to have names, like oligoclase andesine, labradorite, and bytownite. Although these minerals names are still valid they are rarely used today.

Some mineral series have no special names and may be referred to by the hyphenated names of the two end members, or by the name of only one end member. An example is the cummingtonite-grunerite series. Members of this series are identified by their Mg/Fe ratios (or Mg/Mg,Fe,Mn).Cummingtonite is the Mg and grunerite the Fe end member. Minerals in these series are frequently referred to simply as cummingtonite and for further identification the Fe/Mg ratio is given.

Mineral names and mineralogical terms are remnants of the history of the mineralogical discipline. This occasionally may lead to some inconsistency in nomenclature. In the actinolite-tremolite series, for example, the tremolite is the pure Mg end member while the other end member, actinolite, contains 80% Fe and 20% Mg. As more iron-rich minerals were found in this series they were given the name of ferro-actinolite. Most mineralogists, however, prefer a simplified nomenclature and consider actinolite as the pure iron end member of this series.

A MINERAL GROUP contains a number of minerals which have identical or very similar crystal structures but have different cations in secondary structural sites.

Most mineral groups have special names, an example for that is the amphiboles, which have a characteristic crystal structure containing parallel double chains of tetrahedrally coordinated silicon (occasionally with some aluminum substitution) and bands of octahedrally coordinated cations. The difference between the various members of the amphibole group have different symmetry and/or different composition. Some members are mineral series (e.g., cummingtonite-grunerite) and others are single minerals (e.g., anthophyllite).

Under different physical conditions a mineral may crystallize in different HABITS. Habits include characteristic shapes of crystals or crystalline aggregates, or different colors due to impurities, imperfection, trace element substitutions or radiation damages, or other variations in appearance or properties.

Some of the different habits of a mineral may be considered as VARIETIES and may have distinct names. These variety names may have historical, mining, or gemological significance; they should not be confused with mineral names, however.

The different habits are identified by descriptive terms. Like prismatic, equidimensional, acicular, filiform, asbestiform, platy and tabular for single crystals; columnar, radiating, granular, massive, lamellar, foliated and drusy for crystalline aggregates. These two categories of terms may be used in pairs (one from each category), like acicular actinolite crystals may grow in radiating aggregation.

The physical (and to a much lesser degree the chemical) properties of a mineral may be constant in different habits but may also be significantly different. The properties of acicular and prismatic crystals of actinolite have identical properties, for all practical purposes. However, asbestiform, microcrystalline and massive, and reticulated habits of actinolite have conspicuously different properties. For that reason these different habits of actinolite were considered to be distinct minerals and were given different names in the past. Some of these names are still used today as variety names. The massive microcrystalline variety of actinolite is known as nephrite and is one of the two types of jade, and is one of the toughest known natural substances. The asbestiform variety, at earliest times, was believed to be a distinct mineral and was named asbestos. The flexible reticulated variety is called mountain leather and the stiff fibrous variety is called byssolite.

Some minerals under pressure will FRACTURE into various shapes of fragments. Some will always and readily CLEAVE along certain regular planes, which are weakness planes in the crystal structure. A few minerals will break along PARTING planes which are somewhat similar to cleavage planes but are not present in all specimens of the same minerals and are limited to certain parts of a crystal.

Some minerals have no cleavage; some have only one cleavage plane, like the micas. This cleavage is so good in micas that thin plates of micas can be removed from a crystal like pages in a book. Some minerals have two or three different cleavage planes and according to the inclination of these planes, they will create characteristic and regular geometric fragments. Amphiboles, for example, have two cleavage planes inclined to each other at near 60° and 120° angles. When amphibole crystals are attempted to be broken they will cleave along these two cleavage planes into prismatic fragments which have an approximately 120° rhombus cross-section. Since amphiboles have no third cleavage plane perpendicular, or inclined to the two cleavage planes it requires much more stress to break the crystals across the prismatic axis than to cleave them along the prismatic faces. Consequently the prismatic cleavage fragments of amphiboles tend to be greatly elongated. This cleavage pattern of the amphiboles dominates the shape of all fragments, even at submicroscopic scales. Consequently, all amphibole fragments at all sizes will resemble acicular crystals and in the electronmicroscope they can easily be mistaken for asbestos fibers.

While cleavage is a constant property of a mineral, parting is an accidental one, caused by oriented imperfections or impurities in the crystal structure.

Some minerals have tendency to develop parting in specific crystallographic planes. Some amphiboles, for example, are known to develop parting in the (001) plane which is perpendicular to the long axis of the cleavage fragments. In these amphiboles the fragments will be shorter than in other amphiboles.

A FIBER is an acicular single crystal, or a similarly elongated polycrystalline aggregate, which displays some resemblance to organic fibers. Examples for criteria of "resemblance" to organic fibers" are: circular cross section, flexibility, silky surface luster, axial lineation, threaded appearance, high aspect ratio, etc. Most of these fiber characteristics cannot be observed at microscopic scale. Consequently, any needle-like particle displaying parallel edges may be referred to as a fiber. In other words, at microscopic levels it may not be possible to distinguish between asbestiform fibers, acicular crystals or needle-like cleavage fragments.

The descriptive term FIBROUS used for a mineral which is composed of parallel, radiating or interlaced aggregates of fibers, from which the fibers are usually separable. That is, the crystalline aggregate may be referred to as fibrous even if it is not composed of separable fibers, but has that distinct appearance.

The term ASBESTIFORM refers to a special type of fibrous habit in which the fibers have extreme aspect ratios, are easily separable, are flexible, and possess higher tensile strength than crystals in other habits of the same mineral. Increased flexibility and higher tensile strength appear to be the most distinct qualities of asbestiform fibers. These properties are undoubtedly due to certain structural variations and can justifiably be included in the definition.

ASBESTOS is a collective mineralogical term which includes the asbestiform varieties of various silicate minerals. The justification for restricting asbestos to silicate minerals may be questionable from the mineralogical point of view, as non-silicate minerals may also crystallize in fibrous habit and some of the fibers may possess asbestiform properties. However, these properties are expected to be different in magnitude from those of the asbestiform silicates and, therefore, from the health study's point of view, are justifiably excluded from the category of asbestos.

Tibor Zoltai and Ann G. Wylie

For comparable definitions and illustrations see U.S.Bureau of Mines, Information Circular No. 8571 (1977).

For presentation in Workshop No.1 of the International Conference on: The Scientific Basis for the Public Control of Environmental Health Hazards, June 26, 1978, New York, N.Y. Sponsored by the N.Y. Academy of Sciences and the U.S. Bureau of Mines.

Appendix 2

Identification of Fibrous and Non-Fibrous Amphiboles in the Electron Microscope

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Abstract

The extensive and systematic epidemiological and other studies of Dr. Selikoff and his associates at Mt. Sinai Hospital have aroused public recognition of adverse health effects due to exposure to asbestos dust, especially among insulation workers and others in the asbestos "trades."[1,2] In these cases, monitoring the airborne fibrous dust concentration in the work environment by phase contrast optical microscopy has been quite satisfactory. However, the suggestion that acicular fragments of non-fibrous amphiboles below the limit of optical microscopy may pose similar hazards has prompted almost exclusive reliance on electron microscopy for identifying and counting particles in air and water samples.[3]

Until the complexity of differentiating between the numerous mineral species which could be present was recognized, an apparent aspect ratio of 3:1 and the resemblance of a possibly incomplete selected area electron diffraction pattern to that from a standard sample seemed sufficient criteria for identification.[3] However, a large number of silicate minerals have prismatic cleavage and unit cells similar to the commercial asbestos mineral varieties.[4,5] Furthermore, the aspect ratio of fine particles produced by spontaneous or imposed comminution is a manifestation of anisotropy in crystallographic and physical characteristics. Thus, differences in macroscopic attributes, especially fibrosity and optical properties readily observed between hand samples of fibrous and non-fibrous mineral varieties[6] reflect differences in crystallization history and resulting microstructure at the fibril and crystal layer sequence levels. It is also evident that the surface properties and presumably the carcenogenic potency of asbestos fibers will be closely related to the particular crystal faces that predominate.[7]

Reliable techniques for positive identification of unknown particles in ambient air or water samples by combined scanning and high voltage electron microscopy have been developed.[8,9] Extension of these methods through the use of automatic image analysis in the SEM and concepts borrowed from quality control applications permit statistically significant characterization of particulate samples

for environmental monitoring purposes. Single crystal electron diffraction analysis has also permitted differences in the preferred orientation of asbestiform and non-fibrous amphibole particles to be determined in the electron microscope on a quantitative basis. Evidence that particle face orientations are related to crystal growth form has been developed by direct examination of transverse sections of several mineral varieties.

It is highly desirable that electron optical characterization of mineral dusts used for health effects studies include determination of crystal face orientations as well as the distribution of particle sizes and aspect ratios and the identity of the various minerals present. Such detailed information will be required in order that exposure to the particulate matter found in air samples from ambient or occupational environments can be distinguished from the known health hazard caused by asbestos or any other mineral species which may be suspect in the future.

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Appendix 3

Energy, Mines and Resources Canada — Énergie, Mines et Ressources Canada

CANMET
Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

THE EFFECT OF ASPECT RATIO ON FIBER COUNTS; A PRELIMINARY STUDY

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THE EFFECT OF ASPECT RATIO ON FIBER COUNTS; A PRELIMINARY STUDY

by

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- - -

ABSTRACT

The results of a study of the inter-laboratory precision obtained by the NIOSH counting method are reported. Three different aspect ratios including (a) 3:1, (b) 5:1, and (c) 10:1, were applied as fiber counting criteria. Likewise, maximum and minimum lengths covering the following ranges were also applied as criteria for the choice of particles to be counted: (a) 5 to 10 µm (b) 10 to 50 µm (c) >50 µm (d) >10 µm. Twelve laboratories (6 industry, 3 government and 3 research) counted two samples from each of 6 plants (1 asbestos-cement, 1 brake linings, 2 ore treating mills, 2 textiles).

Results obtained are summarized hereunder:

Counting Criteria Aspect Ratio	Min. Length	Mean Count %	Coefficient of Variation
3:1	5 µm	100	0.43
5:1	5 µm	80	0.38
10:1	5 µm	53	0.54
3:1	10 µm	38	0.49

It appears that a 5:1 aspect ratio is better than 3:1 and 5 µm leads to better precision than 10 µm minimum length. However, a parallel study at one laboratory (ORF) of the same samples at high resolution indicated that correlation was excellent between TEM fibre count vs. visual microscope for the count using fibres >5 µm in length. In addition, most of the non asbestos particles are thereby eliminated. The majority of fibres are classed as >10:1 aspect ratio, a much smaller amount are in the >5:1<10:1 aspect ratio; the number of fibres with aspect ratio less than 5:1 aspect ratio are insignificant.

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INTRODUCTION

The "naturally occurring inorganic fibre task group" in ASTM Committee E34 (Occupational Health and Safety) have been developing an ASTM standard for these fibres which include asbestos. The method of counting fibres, the NIOSH technique, was determined to have a high degree of variance and this was confirmed at a recent workshop of the National Bureau of Standards. The method however is the best available for the purpose at this time. It has a number of advantages; it is relatively simple and can be easily learned. If the precision of the method were to be increased and simultaneously if the "fibres" counted were truly asbestos then the disadvantages of this relatively simple method would be overcome to a large degree.

The NIOSH technique has adopted the criteria of a 3:1 aspect ratio and greater than 5 µm in length for identifying and counting of fibres. Those familiar with grinding techniques had shown, that with some minerals, particulates of 3:1 aspect ratio could be created. As well, non asbestos fibrous materials were known to occur in association with asbestos materials, e.g., niemalite and brucite with chrysotile.

These suggestions are supported by electron microscopic studies by the U.S. Bureau of Mines, which showed that non-asbestiform varieties such as anthophyllite, tremolite and hornblende produced cleavage fragments of which 95 per cent had an aspect ratio smaller than 10:1 and 70 per cent smaller than 3:1. On the other hand, the majority of commercial milled chrysotile asbestos had an aspect ratio greater than 10:1. This would suggest than an increase of the aspect ratio from 3:1, to say, 10:1 could significantly improve the discrimination between true fibres and non-fibrous particulates for counting purposes.

In order to overcome these problems the thought of increasing the aspect ratio was suggested. This would allow, it was hoped, greater discrimination between true fibres and non fibrous particulates thus increasing precision as well as being more certain that only asbestos fibres were counted.

A round robin series was begun to test this hypothesis. Objectives of the initial round robin were: to indicate problem areas and also to point the way to a more refined round robin series that would be statistically designed and allow for an analysis of variance. A parallel study of fibre count and identification on the same samples, was included in this initial series.

Twelve laboratories consisting of 3 government, 3 research and 6 industrial laboratories, participated in this initial study.

COUNTING CRITERIA AND EXPERIMENTAL METHOD

The technique for counting generally followed the NIOSH method using a membrane filter. Two samples from each of six plants were obtained on membrane filters. The type of plants are shown in Table 1. The two filters were taken near different machines.

TABLE 1

Origin of Filter Samples by Industry

1.	Asbestos-Cement	7.	Mining (mill)
2.	Asbestos-Cement	8.	Mining (mill)
3.	Brake linings (carding)	9.	Textile (twister)
4.	Brake linings (press 0416)	10.	Textile (twister)
5.	Mining (mill)	11.	Textile (blender)
6.	Mining (mill)	12.	Textile (blender)

Each filter was complete or had had one or two 1/8th wedges removed from it. One 1/8th wedge from each of the twelve membrane filters was sent to each of 5 participating laboratories and the sixth wedge was counted by all six mining laboratories. Each laboratory mounted and counted the sample, using its standard technique and criteria, except in so far as it was asked to count "respirable" fibres, that is less than 3 μm diameter, and to allocate them to the seven regions given on Table 2, (defined by both length and aspect ratio). Each laboratory was asked to count each sample with two counters. The laboratory microscopes are described in Table 3.

TABLE 2

<u>Group Classifications</u>

Length \ Aspect ratio	1:3 1:5	1:5 1:10	> 1:10	Total
5 - 10 µm	1	2	3	8
10 - 50 µm	4	5	6	9
> - 50 µm			7	7
Total	10	11	12	13

TABLE 3

<u>Microscope Type and Related Data Used in Counting</u>

Counter Code [1]	Microscope	Magnification	Graticule type	Graticule size µm²	Diameters Defined
I A1	Bausch & Lomb	400	Porton	3000	-
B2, 3	"	400	"	3000	
C4, 5	"	400	"	3000	
D6, 7	"	430	"	2500	
E8	"	400	"	3000	
F9	"	430	"	2500	
G G10, 11, 12	Petro Zeiss	500	Circular	45000	
H13, 14	Olympus		Porton	3310	
I15, 16, 17	Dynascope 70	400X	Porton	4030	
R J18		400X		5500	as mean at midpoint
19	Zeiss	500X	Patterson	3440	
K20	Leitz	500X	Porton	3310	

<u>Footnote</u>:

I Industry, Government, R Research - Labs A to K - Counters 1-20.

One group of samples similar to those used for the optical microscope count, was also sent to the Ontario Research Foundation. The particulates were counted and identified by electron microscope (TEM) and compared to the count obtained by phase contrast optical measurement.

RESULTS AND DISCUSSION

A. Fibre Count by Phase Contrast Microscopy

The results were received with fibres classified into the first 7 groups (Table 4) as well as a field count. Also shown is a summary of the results on all 12 slides as means and standard deviations expressed as per cent of total count. The variations (as standard deviations) on fibre/unit area is about 50 per cent greater than on fibres as parts per total; this is presumably due to variations in fibre density and/or visual acuity of counters.

Effect of Length

The analysis of fibres into groups by length is shown in Table 5.

TABLE 4

Summary of Results

mean as % of total count from analysis of fibre/sq mm.

Aspect ratio / Length	3:1 5:1	5:1 10:1	> 10:1	Total
5-10 µm	13.8	18.7	24.1	56.6
10-50 µm	2.9	7.9	26.6	37.4
> 50 µm			5.9	5.9
Totals	16.7	26.6	56.7	100.0
		83.3		

standard deviation as % of total count from analysis of fibres/sq mm.

Aspect ratio / Length	3:1 5:1	5:1 10:1	> 10:1	Total
5-10 µm	14.4	11.3	19.2	24.6
10-50 µm	7.7	9.8	19.2	18.3
≥50 µm			6.0	6.0
Totals	20.8	16.5	34.0	34.3
		33.7		

TABLE 5

Analysis of Length

	Fibres by % of Total Length		
	5-10 μm	10-50 μm	>50 μm
Analysis by proportion of total			
Mean Overall	61.6	34.0	4.4
Standard Deviation	10.8	10.7	3.3
S.D./Mean	0.17	0.31	0.75
Analysis by Fibres/Unit Area			
Mean Overall	56.6	37.4	5.9
Standard Deviation	24.6	18.3	6.0
S.D/Mean	0.47	0.49	1.0
Range of Slide Means	28-77	21-51	1-12

Effect on Aspect Ratio

The analysis of fibres into groups by aspect ratio is shown in Table 6.

TABLE 6

Analysis of Aspect Ratios

	Fibres by % of Total Aspect Ratio				
	3:1 5:1	5:1 10:1	> 10:1	> 5:1	Total
Analysis by Proportion of Total					
Mean Overall	18.2	27.4	54.4	81.8	100
Standard Deviation	16.5	11.2	22.1	16.5	100
S.D/Mean	0.91	0.41	0.41	.20	0
Analysis by Fibres/Unit Area					
Mean Overall	16.7	26.6	56.7	83.3	100
Standard Deviation	20.8	16.5	34.0	33.7	34.3
S.D./Mean	1.25	0.62	0.60	.40	.34
Range of Slide Means	9-37	21-34	38-68	63-91	

It can be seen that the variability of the aspect ratio groups is much greater than the length groups (Table 5).

The interpretation of the results are discussed for each length region below:

(a) Long fibres: >50 μm

All fibres less than 3 μm diameter and longer than 50 μm had an aspect ratio greater than 10:1 so that there was only one group, No. 7, in this study. On average 1 to 2 per cent of the fibres were longer than 50 μm on the mining and asbestos cement samples and up to 12 per cent on the textile mill slides. Nearly all the single fibres seen on the slides had a diameter of less than 3 μm, although some of the bundles had apparent diameters greater than this.

(b) Medium length fibres: 10-50 μm

The fibres in this region formed 20 to 30 per cent of the total number for the mining and asbestos cement slides and 40 to 50 per cent for the brake linings and textile slides. Overall the average was 34 per cent.

The counters disagreed considerably on the allocation of fibres across the three aspect ratio regions.

(c) Short fibres: 5-10 μm

The fibres in this region formed 70 to 76 per cent of the total number for the mining and asbestos cement slides and 28 to 58 per cent for the brake linings and textile slides. The overall mean was 62 per cent with a standard deviation of 11 per cent.

Some difficulties were encountered by the counters. These comments are important in ascertaining that the new major study avoid some of the ambiguities and problems encountered in this preliminary study. The comments are listed below:

a) Assigning aspect ratios for fibres 500 10 µm in length where the fibre diameter is small.

b) Some of the slides were too dense (i.e., too many fibres/ unit area) and some too light.

c) Many of the particulates in 3:1 and 5:1 aspect ratio groups were not chrysotile based on their prismatic appearance.

It was found to be much more difficult to judge the aspect ratio of a fibre than its length. The major problem in judging length was the failure to adjust the dimensions of the marks on the graticule to the exact length required. This can lead to a bias dependent on both counter and microscope. The difficulty of judging and the effect of the aspect ratio appears to depend on the length range.

IDENFITICATION AND COUNTING BY TRANSMISSION ELECTRON MICROSCOPY (TEM)

Problems were encountered with the slides from which the solvent had evaporated. This problem was overcome.

Up to 10 grid squares were counted, if required, to locate a total of 100 fibres. Chrysotile was identified by morphology (tubular structure) and occassional checks were made by selected area electron diffraction and energy dispersive X-ray analysis of the fibres. Other mineral fibres greater than 3:1 aspect ratio were also counted. Fibres longer than 5 µm were counted and tabulated separately.

RESULTS AND DISCUSSION

A summary of the optical fibre count data are shown in Table 7 and a summary of the relevant fibre counts and identification are shown in Table 8.

Practically all the fibres (Table 8) were chrysotile and therefore, the other fibres will not be considered further in this discussion.

It is interesting to note, that in the higher size ranges, large variations occurred between the different samples.

The larger fibres, >5 μm, which had been counted separately produced the results shown in Table 9. A comparison of the fibre count by optical microscope vs. that by TEM is graphically shown in Figure 1. A relationship definitely appears to exist between the two methods. The correlation coefficient of 0.978 is highly significant.

No such relationship exists between the two methods for fibres less than 5 μm in length, Figure 2. This is partially attributed to the origin of the samples, some fibres being more dispersed than others because of their industrial origin.

The vast majority of fibres counted by TEM have an aspect ratio exceeding 10:1. The results of fibre count analysis for two samples are shown in Tables 10 and 11, 2K326 and CCM16-02 respectively. Each table contains a total count of approximately 100 fibres. In Table 11, there are about 55 per cent fibres greater than 10:1 aspect ratio, 41 per cent between 5:1 and 10:1 aspect ratio and 4 per cent less than 5:1 aspect ratio. In

TABLE 7

Summary of Optical Fibre Count Data

Sample	Fibres Counted	Fields Scanned	Area Scanned, mm^2	Fibre Density, Fibres/mm^2
Asbest 1	208	155	0.513	405
Asbest 2	45	350	1.159	39
Lake 3CP	225	350	1.159	194
Lake 2FF	194	350	1.159	167
2K258 (T1)	204	26	0.086	2372
2K215 (T2)	202	52	0.172	1174
2K326 (T2)	214	40	0.132	1621
CCM 16.0.2	200	155	0.513	390
CCM 16.0.3	203	69	0.228	890
Atlas 1	207	193	0.639	324
Atlas 2	119	350	1.159	103

TABLE 8

Summary of Routine Fibre Counts for All Fibres

Sample	** Fibre Concentration (Fibres/ml)		Estimated Mass Concentration (Nanograms/m^3)	Concentration Equivalent to 1 fibre detected (Fibres/ml)	Fibre Type *
	Mean	95% Confidence Interval			
Asbest 1	230 <1.4	160 - 300	3800	1.37 1.37	C OF
Asbest 2	150 1.4	110 - 190	4700	1.40 1.40	C OF
Lake 3CP	320 9.4	240 - 390	45000	1.57 1.57	C OF
Lake 2FF	200 1.3	130 - 270	2700	1.29 1.29	C OF
2K258 (T1)	937 <7.4	780 - 1100	22000	7.38 7.38	C OF
2K215 (T2)	860 7.7	510 - 1200	36000	7.72 7.72	C OF
2K326 (T2)	870 17	500 - 1200	20000	8.28 8.28	C OF
CCM 16.0.2	750 <7.3	660 - 840	26000	7.25 7.25	C OF
CCM 16.0.3	840 <7.7	380 - 1300	18000	7.63 7.63	C OF
Atlas 1	150 <1.3	100 - 190	16000	1.28 1.28	C OF
Atlas 2	96 <0.98	57 - 130	1000	0.98 0.98	C OF

** Concentration assuming 1 m^3 sampling volume and 1/6th filter supplied.

* C = Chrysotile, OF = Other Fibres (Mineral particulate >3:1 aspect ratio).

TABLE 9

Comparative Summary of Fibre Counts

Sample	Fibre Count in Fibres/mm² on Original Membrane Filter			
	Optical >5 μm	TEM >5 μm *	TEM all Fibres	TEM all Fibres, 95% Confidence
Asbest 1	405	2.4×10^4	3.8×10^5	$(2.70 - 5.00) \times 10^5$
Asbest 2	39	9.7×10^3	2.5×10^5	$(1.80 - 3.20) \times 10^5$
Lake 3CP	194	6.9×10^3	5.3×10^5	$(4.00 - 6.50) \times 10^5$
Lake 2FF	167	9.5×10^3	3.3×10^5	$(2.20 - 4.50) \times 10^5$
2K258 (T1)	2372	2.0×10^5	1.6×10^6	$(1.33 - 1.83) \times 10^5$
2K215 (T2)	1174	7.9×10^4	1.4×10^6	$(0.85 - 2.00) \times 10^6$
2K326 (T2)	1621	9.4×10^4	1.5×10^6	$(0.86 - 2.06) \times 10^5$
CCM 16.0.2	390	1.8×10^4	1.3×10^6	$(1.14 - 1.45) \times 10^6$
CCM 16.0.3	890	3.5×10^4	1.4×10^6	$(0.63 - 2.20) \times 10^6$
Atlas 1	324	3.8×10^3	2.5×10^5	$(1.70 - 3.20) \times 10^5$
Atlas 2	103	2.3×10^3	1.6×10^5	$(0.95 - 2.20) \times 10^5$

* Large area of grid separately scanned for fibres >5 μm only, in order to increa: statistical validity.

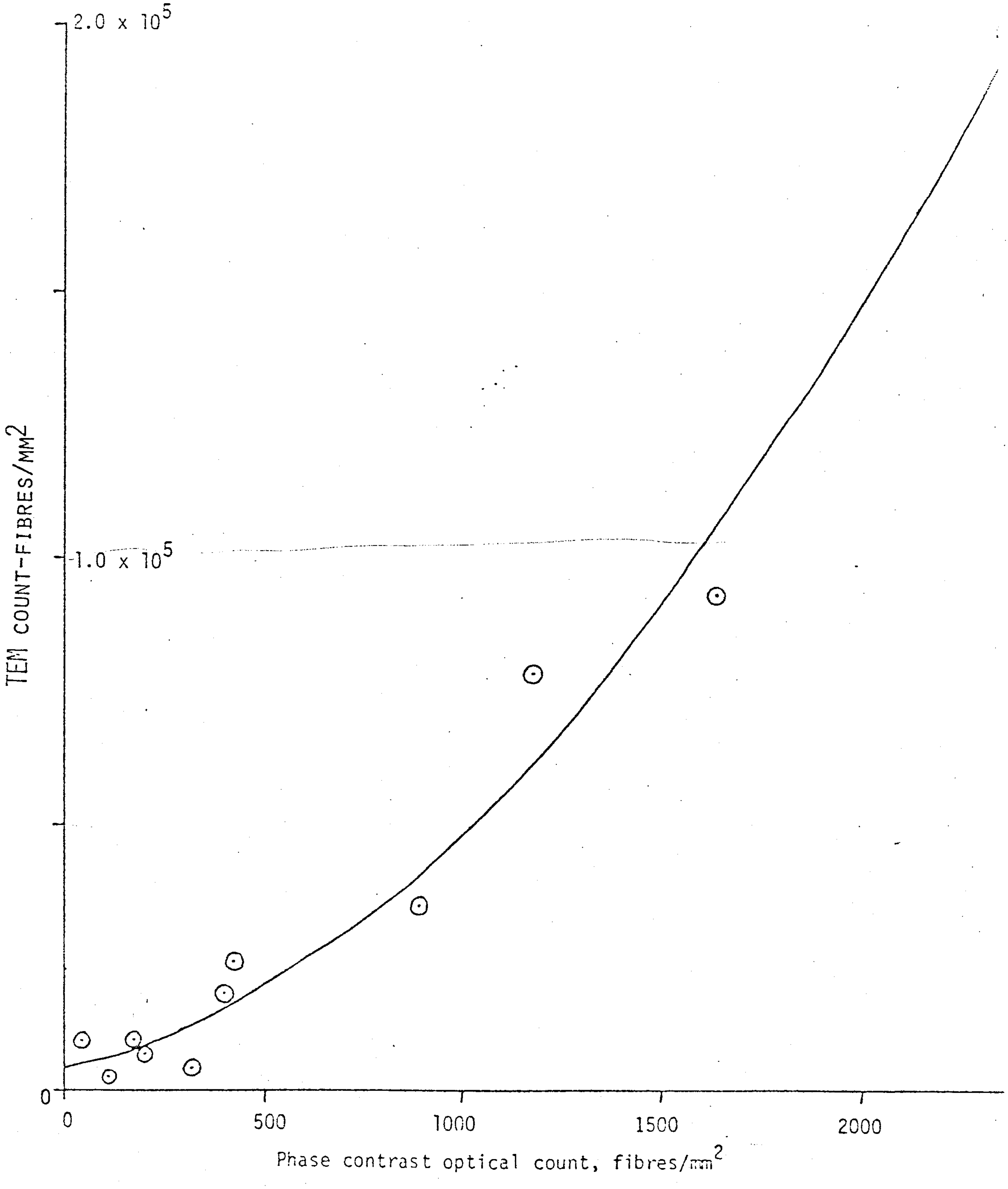

FIGURE 1. RELATIONSHIP BETWEEN TEM COUNT AND PHASE CONTRAST OPTICAL COUNT FOR FIBRES LONGER THAN 5 μM

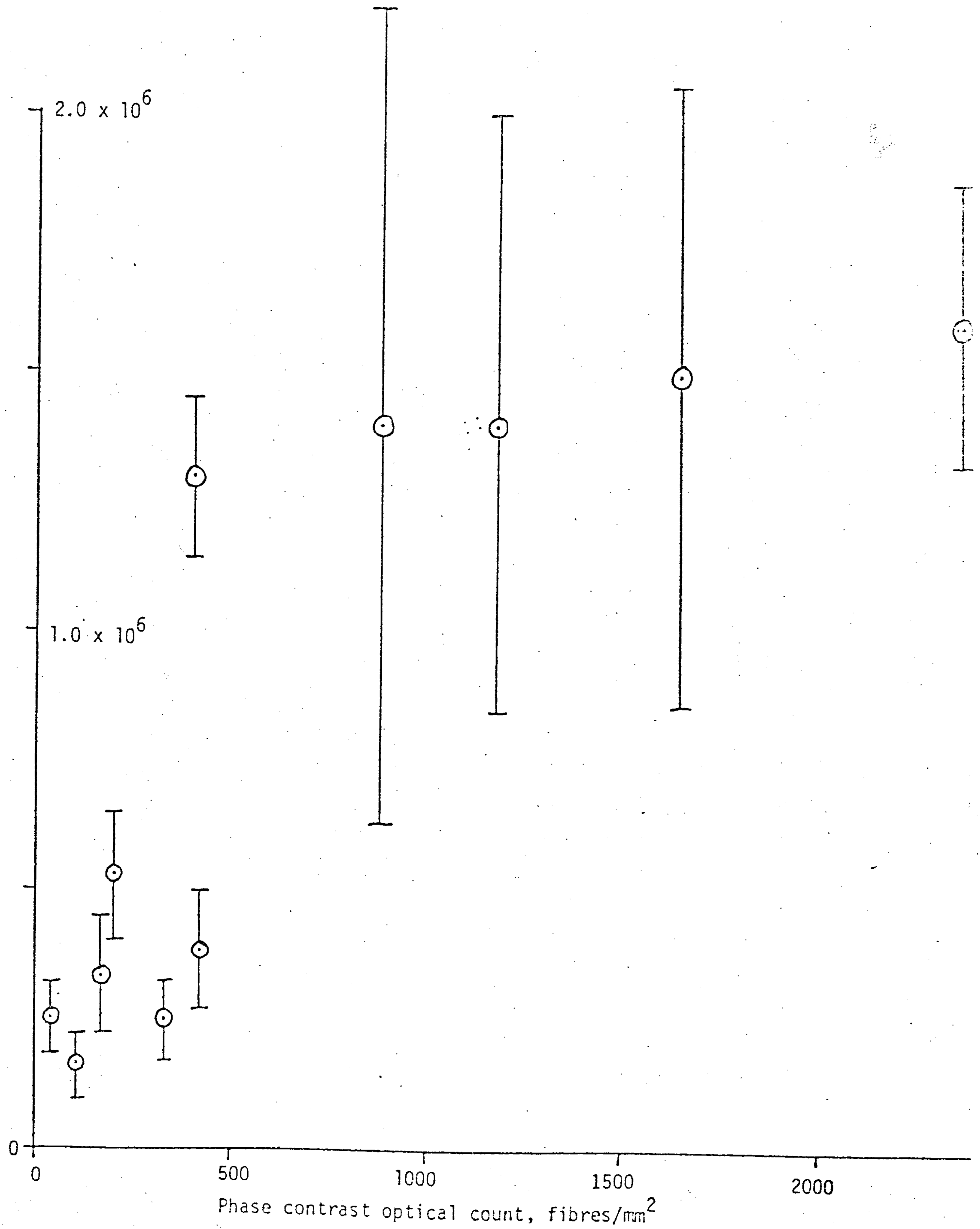

FIGURE 2. RELATIONSHIP BETWEEN TEM COUNT OF ALL FIBRE LENGTHS AND OPTICAL FIBRE COUNT

Table 10, fibres greater than 10:1 aspect ratio amount to about 76 per cent of the total fibres, between 10:1 and 5:1 aspect ratio the percentage fibres amounts to about 24 per cent and there is less than one per cent fibres with an aspect ratio of less than 5:1.

TABLE 10

Asbestos Fibre Count Analysis: Chrysotile Raw Sizing Data

SAMPLE: 2K326 (T2)

Length um	Width um	Aspect Ratio	Length um	Width um	Aspect Ratio	Length um	Width um	Aspect Ratio
0.82	0.045	18.0	1.41	0.136	10.3	0.59	0.091	6.5
0.27	0.045	6.0	0.36	0.045	8.0	1.18	0.091	13.0
2.09	0.136	15.3	2.68	0.136	19.7	0.73	0.045	16.0
2.50	0.045	55.0	0.68	0.045	15.0	0.50	0.045	11.0
0.41	0.045	9.0	0.55	0.045	12.0	1.14	0.091	12.5
1.18	0.136	8.7	0.95	0.091	10.5	0.55	0.045	12.0
3.27	0.045	72.0	1.05	0.273	3.8	0.95	0.045	21.0
1.41	0.136	10.3	0.73	0.045	16.0	0.45	0.091	5.0
1.86	0.091	20.5	2.86	0.045	63.0	0.27	0.045	6.0
1.45	0.136	10.7	0.45	0.045	10.0	0.32	0.045	7.0
2.77	0.136	20.3	0.27	0.045	6.0	0.73	0.045	16.0
1.18	0.045	26.0	1.86	0.045	41.0	1.59	0.182	8.7
2.05	0.136	15.0	3.27	0.091	36.0	1.18	0.045	26.0
2.09	0.136	15.3	1.32	0.045	29.0	1.45	0.045	32.0
0.59	0.045	13.0	5.59	0.045	123.0	6.23	0.045	137.0
5.73	0.091	63.0	6.23	0.136	45.7	4.64	0.091	51.0
1.45	0.045	32.0	1.64	0.045	36.0	2.95	0.045	65.0
0.73	0.091	8.0	0.73	0.045	16.0	2.05	0.091	22.5
20.55	0.045	452.0	0.55	0.045	12.0	0.27	0.045	6.0
0.95	0.045	21.0	0.36	0.045	8.0	0.32	0.045	7.0
1.64	0.091	18.0	7.36	0.045	162.0	2.91	0.045	64.0
0.73	0.045	16.0	0.91	0.045	20.0	18.18	0.045	400.0
0.32	0.045	7.0	1.00	0.045	22.0	0.73	0.045	16.0
0.36	0.045	8.0	0.73	0.045	16.0	1.14	0.136	8.3
4.14	0.045	91.0	2.09	0.045	46.0	0.64	0.091	7.0
1.18	0.182	6.5	1.36	0.091	15.0	0.32	0.045	7.0
0.73	0.045	16.0	7.45	0.045	164.0	0.59	0.091	6.5
1.18	0.045	26.0	5.64	0.045	124.0	1.41	0.136	10.3
0.64	0.045	14.0	0.32	0.045	7.0	0.73	0.045	16.0
0.55	0.045	12.0	0.36	0.045	8.0	1.00	0.091	11.0
0.36	0.045	8.0	1.23	0.045	27.0	1.50	0.045	33.0
1.00	0.091	11.0	0.82	0.045	18.0	1.09	0.045	24.0
2.09	0.045	46.0	1.59	0.045	35.0	0.91	0.045	20.0
0.59	0.045	13.0	0.27	0.045	6.0	4.82	0.091	53.0
0.59	0.045	13.0	0.95	0.136	7.0	1.27	0.045	28.0

TABLE 11

Asbestos Fibre Count Analysis:
Chrysotile Raw Sizing Data

SAMPLE: CCM 16.0.2

Length um	Width um	Aspect Ratio	Length um	Width um	Aspect Ratio	Length um	Width um	Aspect Ratio
1.68	0.045	37.0	0.95	0.091	10.5	1.41	0.091	15.5
2.73	0.045	60.0	0.91	0.045	20.0	0.27	0.045	6.0
0.23	0.045	5.0	0.59	0.045	13.0	1.36	0.091	15.0
0.41	0.091	4.5	0.59	0.091	6.5	0.41	0.091	4.5
5.50	0.045	121.0	0.55	0.045	12.0	0.23	0.045	5.0
1.55	0.045	34.0	0.36	0.045	8.0	0.50	0.045	11.0
0.59	0.091	6.5	0.73	0.091	8.0	1.41	0.091	15.5
1.05	0.182	5.7	0.41	0.045	9.0	3.00	0.273	11.0
0.41	0.045	9.0	2.59	0.045	57.0	3.95	0.045	87.0
0.59	0.045	13.0	0.86	0.091	9.5	0.36	0.045	8.0
1.05	0.136	7.7	1.09	0.227	4.8	0.73	0.091	8.0
0.32	0.045	7.0	0.32	0.045	7.0	0.64	0.182	3.5
0.86	0.091	9.5	0.41	0.091	4.5	0.50	0.045	11.0
0.73	0.045	16.0	0.27	0.045	6.0	1.23	0.045	27.0
0.23	0.045	5.0	0.64	0.045	14.0	0.86	0.045	19.0
0.64	0.045	14.0	8.05	0.045	177.0	0.41	0.045	9.0
0.50	0.045	11.0	0.36	0.045	8.0	0.73	0.091	8.0
1.14	0.091	12.5	1.68	0.045	37.0	0.73	0.091	8.0
0.36	0.045	8.0	3.09	0.273	11.3	0.86	0.091	9.5
0.50	0.045	11.0	0.95	0.091	10.5	0.64	0.045	14.0
0.77	0.045	17.0	0.36	0.045	8.0	0.68	0.091	7.5
0.68	0.045	15.0	0.36	0.045	8.0	2.82	0.045	62.0
0.41	0.045	9.0	1.86	0.091	20.5	1.32	0.045	29.0
3.23	0.136	23.7	0.23	0.045	5.0	1.82	0.045	40.0
0.41	0.045	9.0	0.27	0.045	6.0	0.64	0.045	14.0
0.50	0.045	11.0	0.59	0.091	6.5	0.68	0.091	7.5
0.32	0.045	7.0	1.27	0.045	28.0	0.64	0.045	14.0
2.41	0.045	53.0	1.77	0.136	13.0	1.18	0.091	13.0
0.50	0.045	11.0	0.50	0.045	11.0	1.45	0.182	8.0
0.68	0.091	7.5	2.09	0.136	15.3	1.77	0.045	39.0
0.32	0.045	7.0	1.00	0.091	11.0	0.64	0.045	14.0
0.32	0.045	7.0	3.50	0.409	8.6	0.45	0.045	10.0
0.32	0.045	7.0	0.55	0.045	12.0	2.77	0.182	15.2
1.05	0.091	11.5	1.14	0.045	25.0	1.45	0.136	10.7
0.41	0.045	9.0						

CONCLUDING REMARKS

Results, of this initial and preliminary aspect ratio round robin involving twelve participating laboratories, indicate that fibre count precision using the optical microscope, phase contrast technique is increased when a 10:1 aspect ratio is used instead of 3:1. The relative error decreased from 93 per cent to 42 per cent although the number of fibres counted decreased by approximately 45 per cent.

It was previously recognized that the optical microscope did not allow all fibres to be counted particularly in the very small lengths, i.e., <5 μm. Using a TEM, a relationship was found to exist, for fibres >5 μm in length, between the count of fibres for optical microscope phase contrast technique and that by TEM. The ratio of fibres counted is about 1:50 respectively. No such relationship exists for fibres in the range less than 5 μm in length, however in these very short lengths an average fibre ratio of 1:1,000 (average) was found.

The vast majority of fibres counted by TEM, >5 μm long, had aspect ratios greater than 10:1. This was true for all samples, ranging from about 60 per cent to over 80 per cent of the total fibres counted in each sample. It would appear that increasing the aspect ratio to greater than 5:1 should increase the precision of the fibre count by the phase contrast microscope technique, particularly because of the relationship found between the TEM and optical microscope methods. This can be verified in the next round robin series. This second series, which will hopefully avoid some of the problems encountered in the present study, is now being statistically designed.

ACKNOWLEDGEMENTS

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Appendix 4.

A COMPARISON OF ASBESTOS FIBERS AND "WHISKERS"

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Whiskers are metallic and ceramic filamentary single crystals, like asbestos in appearance, that have ultrahigh tensile strengths and occur in micron sized widths. The strength of whiskers can be ten to twenty fold greater than that of regular crystals of the same material. For this reason, whiskers have been subjects of intense study by metallurgists and ceramicists in recent years because of the possibilities for exploiting these properties in development of high strength whisker reinforced composites.

The high strength of whiskers is attributed to their crystalline perfection and small dimensions which minimize the occurrence of defects that are responsible for the much lower strength of materials when in non-whisker form. Certain types of internal defects, such as stacking faults and dislocations, can in some cases enhance the strength of crystals. Surface defects, on the other hand have the opposite effect. It has been demonstrated that the low frequency of surface defects is responsible for the high strength of whiskers. Whiskers of a given type have quite variable strengths. Smallest whiskers have the highest strength; tensile strength increases exponentially as a function of decreasing surface area. This function has been closely approximated theoretically by treating surface flows as Griffith cracks, and calculating the resulting stress concentration. Electron microscrope studies have confirmed that the strongest whiskers have the fewest surface features.

In comparing the properties of whiskers with those of asbestos fibers, it seems that whiskers can be considered to be synthetic analogs. It has long been apparent that asbestiform varieties of minerals have tensile strengths considerably greater than the non asbestiform crystals. Good quality amphibole asbestos has tensile strength approaching 30,000 kg/cm^2 (the theoretical strength of such chain silicates is about 115,000 kg/cm^2). No comparable data are available for non-asbestiform amphiboles, but tensile strength of silicates in general ranges from about 1,000 to 3,000 kg/cm^2. We conducted some crude, exploratory tensile strength measurements on non-asbestiform amphiboles and obtained values around 1,000 kg/cm^2.

In addition to the difference in strength between the two habits, limited data suggests that the strengths of asbestos fibers increase as fiber size decreases. Also, the surfaces of asbestos fibers are notably regular. These similarities suggest that as with whiskers, the strength of asbestos is governed by surface defects. The analogy between asbestos fibers and whiskers can be extended to include conditions of crystallization. Whiskers can be grown in one dimensional stress fields, the same conditions under which asbestos fibers grow in geological environments.

It is suggested that a detailed comparison of asbestos fibers and their mineralogically equivalent acicular crystals with whiskers and their corresponding regular crystals can lead to a more fundamental understanding of the asbestiform habit of minerals.

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INFLUENCE OF FIBROUS NATURE OF MINERALS ON IN VITRO CYTOTOXICITY

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The health hazards caused by exposure to commercial asbestos particles are well known. The question, however, still remains whether the nonasbestiform equivalents of these minerals, to which people may be exposed in mining, quarrying and other activities can also have adverse effect on human health. To this date very little is known about the biological activities of these non-asbestos particles. We all agree that more research is needed to understand the physical and biological activities of these non-asbestos particles. We all agree that more research is needed to understand the physical and biological characteristics of these minerals in their different crystallization habits. Furthermore, research should be extended to include other common minerals and their varieties. Unfortunately, the direct study of the physical, chemical and biological properties of all these minerals and their varieties would be an extremely extensive and time-consuming project. A more practical approach is to define the physical and chemical properties of minerals and their varieties in categories and test them simultaneously in selected biological systems. Such a project has been initiated under EPA sponsorship. It is hoped that an extrapolation can be made to relate specific mineralogical properties to specific biological activity.

For an initial study in this program we have selected four samples of the cummingtonite-grunerite series: asbestiform grunerite, acicular grunerite, semi-asbestiform cummingtonite and acicular cummingtonite. In preparation for the biological studies these minerals were ground to obtain samples of various particle sizes. All samples were characterized for chemical composition, size distribution, surface area and surface charge. The biological activities of the samples were determined by measurement of cell lysis of sheet erythrocytes and cytotoxicity to Chinese hemster ovary cells.

A comparison of the biological activities was made between the four samples of similar surface area (2.80 to 4.13 m^2/mg). The results indicated that the asbestiform variety of grunerite (Fe/Mg=83/17) was the most and acicular grunerite (Fe/Mg=91/9) the least hemolytic and cytotoxic. The hemolytic activity and cytotoxicity of both cummingtonite samples (Fe/Mg=70/30) were found to be between that of asbestiform and acicular grunerite. It was also observed that if the acicular grunerite was ground finer to obtain higher surface area it can produce cellular damage. Both hemolytic activity and cytotoxicity were found to be proportional to surface area each of the four mineral samples. However, the same size fractions of the same mineral, when the mineral is crystallized in different habits, do not demonstrate the same biological properties.

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MINERAL FIBER* INVESTIGATION OF THE REGIONAL COPPER-NICKEL STUDY IN NE MINNESOTA

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The Regional Copper-Nickel Environmental Impact Study is a comprehensive examination of the potential cumulative environmental, social, and economic impacts of copper-nickel mineral development in northeastern Minnesota. This study is being conducted for the Minnesota Legislature and state Executive Branch agencies under the direction of the Minnesota Environmental Quality Board and with the funding, review, and concurrence of the Legislative Commission on Minnesota Resources. The Study will not make or propose state policy pertaining to copper-nickel development.

The Regional Study includes investigations of the problem of generation of mineral fibers during processing of copper-nickel ores from the gabbroic rocks at the base of the Duluth Complex in NE Minnesota. In addition to the Regional Study staff, the Minnesota Department of Health (MDH), the Minnesota Department of Natural Resources (MDNR), the Mineral Resource Research Center (MRRC), and the Minnesota Geological Survey (MGS) have all cooperated in this study.

The study is based on selected samples from 225 kg splits of nine different occurrences of mineralized gabbro. Thin section modes on an average of 35 thin sections per sample show that the amount of amphibole present varies from below detectable limits to approximately 13 volume percent with an average of 2.3 volume percent. The amphibole present in the samples include hornblende, actinolite, and cummingtonite-grunerite. Although no obvious asbestiform habit was found in the nine process samples, an unusual actinolite with asbestiform habit was found in gabbroic rocks adjacent to one of the samples. Other major minerals present in the samples include plagioclase, olivine, pyroxene, chlorite, biotite, copper-nickel sulfides, and iron-titanium oxides.

Using the nine samples, MRRC conducted bench-scale ore concentration tests. Samples of tailing slurries were agitated and then sampled using a standard sedimentation sizing technique with an Andreasen pipette to exclude fragments larger than 37 µm. Samples of the water with its suspended particles were then sent to MDH for fiber analysis. The particles were collected on Nuclepore filters at MDH and were prepared for transmission electron microscopy using the Jaffe-Wick method. The MDH Hitachi model HU12A TEM with tilting stage and attached x-ray energy dispersive analysis system was used for fiber counting. Other samples analyzed for fiber content include: ground feed, concentrate, tailings generated from a different grinding system and a series of sedimentation sizing samples derived from one tailing slurry by sampling at various time intervals up to 48 hours after agitation.

Results of the fiber analysis show a good (r=0.998) linear fit to a plot of amphibole content by volume from thin section work versus the number of fibers present per liter following processing. A coarser grinding system produced a fair (r=0.739) linear fit. Additional results, although preliminary, indicate a poor linear fit for plagioclase fibers versus plagioclase in the rock samples. Other preliminary work indicates the average aspect ratio for 176 amphibole fibers is 9.18, whereas the average for 110 plagioclase fibers is 7.47. The ranges for the number of amphibole fibers per liter in tailing samples is 1.64×10^{8} to 3.54×10^{10}.

*The term fiber is used here in reference to any mineral particle with an aspect ratio greater than three to one.

THE EFFECT OF ASPECT RATIO ON FIBER COUNTS; A PRELIMINARY STUDY

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The results of a study of the inter-laboratory precision obtained by the NIOSH counting method are reported. Three different aspect ratios including (a) 3:1, (b) 5:1, and (c) 10:1, were applied as fiber counting criteria. Likewise, maximum and minimum lengths covering the following ranges were also applied as criteria for the choice of particles to be counted: (a) 5 to 10 μm (b) 10 to 50 μm (c) >50 μm (d) >10 μm. Twelve laboratories (6 industry, 3 government and 3 research) counted two samples from each of 6 plants (1 asbestos-cement, 1 brake linings, 2 ore treating mills, 2 textiles).

Results obtained are summarized hereunder

Counting criteria		Mean count	Coefficient of
Aspect ratio	Min. Length	%	variation
3:1	5 μm	100	0.43
5:1	5 μm	80	0.38
10:1	5 μm	53	0.54
3:1	10 μm	38	0.49

It appears that a 5:1 aspect ratio is better than 3:1 and 5 μm leads to better precision than 10 μm minimum length. However, a parallel study at one laboratory (ORF) of the same samples at high resolution indicated that correlation was excellent between total fibre count, and the count using the 10:1 and 10 μm criteria. In addition, most of the non-asbestos particles are thereby eliminated.

OPTICAL PROPERTIES OF FIBROUS AMPHIBOLES

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Fibrous monoclinic amphiboles may be assigned to one of two groups according to their optical properties: type 1, those which exhibit parallel extinction in all orientations, and type 2, those which commonly show parallel extinction but which will always show oblique extinction in some orientation. Single crystal X-ray diffraction Weissenberg photographs show that the parallel extinction characteristic of type 1 arises from random to semi-random orientation around a common fiber (c crystallographic) axis of fibrils, single crystals of approximately 1000 Å width. All samples of amosite and crocidolite examined are type 1 amphiboles. Asbestiform actinolite and asbestiform potassium richterite with type 1 characteristics have also been identified. Chrysotile, although not an amphibole, also has type 1 characteristics. Type 2 fibrous monoclinic amphiboles are typified by the variety called byssolite although some samples of tremolite to which the adjective asbestiform has been applied also fall in this category. The prevalence of parallel extinction is due to 100 parting, probably the result of twinning. Optically resolvable fibers are single crystals and are composed of fibrils. By contrast, more common acicular fragments of monoclinic amphiboles generally show oblique extinction since they are commonly bounded by 110 cleavage surfaces.

FIBER LENGTH AND ASPECT RATIO OF SOME SELECTED ASBESTOS SAMPLES

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Four samples of aabestos; 'short-fiber' chrysotile, 'long fiber' chrysotile, amosite and crocidolite, have been characterized by particle size and shape distribution. Characterization of these samples was done by SEM and/or TEM and is presented as particle size distribution by both number of particles as well as by volume (weight) percentages. The data show aspect ratios characteristic of asbestos. Aspect ratios are low for the very short fibers and increase as fiber length increases due to the relatively constant mean width of the unit fibril.

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ASBESTIFORM AND ACICULAR MINERAL FRAGMENTS

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Some of the physical and chemical properties of a mineral may be grossly modified according to the secondary structural variations required by specific crystallization habits. One of the most extreme examples of that is the difference between the properties of asbestiform fibers and acicular crystals of the same mineral. The properties of asbestiform amphiboles are so distinct from that of the common amphibole crystals that for a long time they were considered to be different minerals. Recent biological and epidemiological studies support the anticipitated extension of these physical differences to include differences in biological properties and in degrees of potential health hazards. Consequently, it should be clear by now that the shape and the mineralogical identity of the particles is not sufficient in the evaluation of their environmental significance. The identification of the crystallization habit is equally necessary. In case of asbestos that may even be the more important criterion. It is conceivable and highly probable that the primary agent responsible for the carcenogenic character of asbestos is in the realm of the peculiar properties of asbestiform fibers and the mineralogical identity of the asbestos particles may be only of secondary significance.

The definition of "asbestos minerals" in environmental legislation and regulation is an arbitrary one based on a commercial argument. That is, only those minerals are considered to be "asbestos" which are known to occur in concentrated deposits and can be exploited for financial gains. This definition is adequate for industrial use but is not scientific and does not serve the purpose of environmental research and regulations. A more appropriate definition would be to consider those specimens of a mineral asbestos which are crystallized in the asbestiform habit and thus have the properties of asbestos. The current definition recognizes only five "asbestos minerals" (chrysotile, actinolite-tremolite, anthophyllite, cummingtonite-grunerite, and riebeckite) which belong to two mineral groups: the serpentines and the amphiboles. The fact is, however, that a much larger number of minerals may, on occasions, crystallize in that habit and some may have comparable properties to that of chrysotile and asbestiform amphiboles. The crystal structures of the layered silicates are similar to the structure of serpentines. Consequently, it is possible that asbestiform clays, micas and chlorites may have the same combination of asbestos properties. There are many chain silicates besides amphiboles and there are no theoretical reasons why they would not crystallize in the asbestiform habit. There are also many non-silicate minerals which are known to crystallize in asbestiform-like habit. It would be dangerous and unjustified to conclude that all asbestiform fibers are, by definition, carcenogenic and that all acicular, but not asbestiform particles are relatively harmless. Some fibrous and acicular minerals may be extremely dangerous in one instance and much less harmful in others. Fibrous zeolites, for example, are not known to occur in asbestiform habit yet they have the potential to be as harmful as asbestos. The strong and relatively inert silica frame of the zeolites contains large, open channels and pockets in which an extensive number of chemicals can be stored, including toxic compounds. That is, the biological potential of fibrous zeolites is variable.

Limiting our attention to only five "asbestos minerals" and disregarding the significance of their state of crystallization is an erroneous oversimplification and can lead us to tragic mistakes. The proper evaluation of the health affects of mineral particles in air and water is infinitely more complicated and its understanding calls for extensive and coordinated research in several scientific disciplines.

Appendix 5.

History of Asbestosis-Associated Disease

Reference List

A. Pulmonary Parenchymal Disease

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Appendix 6

NEIGHBORHOOD PLEURAL CALCIFICATIONS

Finland:

Kiviluoto	From among the x-rays in the Central Hospital of Northern Karelia, 126 cases showing calcified pleural plaques were found. They had no evidence of tuberculosis, and had never worked in an asbestos mine. In a sub-group of 60, it was found that 50% lived within a 10 km. radius of an asbestos mine. There was one autopsy. Asbestos bodies were not found, but anthophyllite fibers were. A cow living near the mine had similar findings. 6,312 residents of the mine district were surveyed radiologically. 499 (12.6%) had pleural plaques with no other obvious cause. Pulmonary fibrosis was present in 24%.
Raunio 1965	Mass minature roentgenological investigation comprising of most of the population of Finland. In two mining communes of Tuusniemi and Kuusjaervi, pleural calcification occurred in 9 and 6.4% respectively. Other rural communes had less than 0.01% prevalence of this finding.
Meurman 1966	Among 438 autopsies from 3 Finnish hospital districts during 1963-4, and on people older than 15 years, 255 were from the asbestos mining region. None were mine workers. Pleural plaques were found in 39.3%. A second region with no asbestos mine had a similar incidence of plaques. Asbestos bodies were found in the lungs of 85% of those with plaques and 40% of those with no plaques.
Navratil 1972	The prevalence of pleural plaques in populations living in vicinity of an asbestos plant, or in the same district as an asbestos plant was 5.8%.

Czechoslovakia

Hromek 1962	67% of the population of the Pacov region (the western part of the former Jihlava region) were x-rayed. Of 9,871 x-rays, 273 (2.79%) had pleural calcifications, a finding which had been familiar to local doctors since the 1930's. The abnormalities are bilateral in 98.3% of the cases. All but two of the cases were in agricultural workers or retired agricultural workers. There was none with occupational exposure to asbestos, and there was none with occupational exposure to asbestos, and there are no known asbestos minerals in the area. Calcification was often found in members of the same family. It is not present in those less than 40 years old and increases each decade. It is present in 17.9% and 19.5% of those in the 8th and 9th decades respectively.
Marsova 1964	241 cases of pleural calcification among 44,549 chest x-rays (0.5%) were found among asymptomatic agricultural workers.

Rous
1970

79% of the population of the Pelhrimov district were x-rayed. Among 9,760 x-rays, pleural calcifications were found in 664 (6.6%) with the highest prevalence among those age 66-70. There was no associated illness. 9.7% had a history of a pleural effusion. Familial occurrence was common. If two generations had the abnormality, 100% of the older generation was affected. When farmhouses had changed owners, both the first and second group of occupants had developed the abnormality.

No evidence of asbestos minerals in the area has been found.

Germany

Anspach
1965

Among 429 cases of pleural calcification in the Dresden area 35.9% were from neighborhood exposure. Pulmonary fibrosis was rarely seen in this group.

Bulgaria

Zolov
1967

92% of the residents of the Avren region of Southern Bulgaria who lived within 10 km of an asbestos mine, were x-rayed. 132 (25%) cases of pleural calcification occurred, all among people who had never worked in the 22 year old mine. Most of those with pleural abnormalities were in the 6th decade or older.

Burlikoff
1970

X-ray examination 3,826 persons in the Kolarovo district of Bulgaria revealed 11 (0.3%) with pleural calcification. The abnormalities were found only among inhabitants of 4 villages. The affected individuals were between the ages of 62 and 92. The abnormalities were found to be confined to farms with high soil asbestos-mineral content, or in farms with outcroppings of asbestos containing rock, which were used in household and farm construction. The minerals later identified were anthophyollite, tremolite and the fibrous mineral sepiolite, the most common amphibole mineral in the area.

Appendix 7

NEIGHBORHOOD MESOTHELIOMA

Wagner 1960 South Africa	33 cases of Mesothelioma occuring in the North Western Cape Province of South Africa. 9 apparently had only neighborhood exposure: playing on asbestos dumps, living near a mine or on the transport routes. Lapse period was noted. The period of time from the first exposure to the onset of the tumor was 20 to 40 years.
Anspach 1965 Dresden	35 cases of Mesothelioma which were found in the Silicosis Register between 1950 and 1954. 9 had a "neighborhood exposure." They worked in the vicinity of an asbestos factory. There was no relation of mesothelioma to the presence or absence of pulmonary fibrosis in the lung tissue.
Newhouse 1965 London	Of 85 confirmed mesotheliomas reported at the London Hospital over a 50 year period, 36 had a neighborhood exposure: living within 1/2 mile of an asbestos material plant. A case control study showed that 11 (30.6%) of those in the series with no occupational exposure to asbestos lived within 1/2 mile of an asbestos factory, compared to 7.6% of the in-patient controls.
Lieben 1967 Pennsylvania	Mesotheliomas were collected from the voluntary reports of 152 cooperating hospitals in South Eastern Pennsylvania. Of 42 confirmed cases, 8 were due to neighborhood exposure encountered either at home or at work.
Bolig 1968 Germany	Referrals of mesotheliomas. An unspecified number of their referrals were found, through interviews, to have no occupational or domestic exposure. They lived within the neighborhood of an asbestos using industrial facility.
McEwen 1970 Scotland	Mesotheliomas were collected from all the hospitals in Scotland for the period 1950-1967. 5 women with only neighborhood exposure to asbestos are found in the series of 80 cases. (Interviews of relatives and neighbors were used to obtain exposure history.)
Borow 1972 Manville, N.J.	72 mesotheliomas occuring in local hospitals are found. Two (2) women patients had only environmental exposure.
Webster 1973 South Africa	232 Mesotheliomas were referred to the Tumor Reference Panel. 76 (37%) were considered to be of environmental origin.
Viana 1978 New York State	52 mesotheliomas were collected through a registry. 1 case in which no occupational or domestic exposure could be elicited from relatives and neighbors was found.