A Further Study of China Biscuit Placers in Stoke-on-Trent

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Powdered alumina has been used in the china industry of Stoke-on-Trent for first or 'biscuit' placing for about 30 years. An investigation of 169 placers and oven oddmen, more than half of whom had been working with alumina for more than 15 years, revealed no cases of radiologically manifest pneumoconiosis which could be related to the inhalation of alumina.

The results of the indirect maximum breathing capacity measured in 166 men were perhaps less convincing than the radiological evidence due to the different age structures of the groups examined. However, there was no evidence that the inhalation of alumina used in pottery manufacture causes pulmonary dysfunction.

The bedding or placing of fine china ware into powdered flint during first or 'biscuit' firing used to be the most serious respiratory hazard in the North Staffordshire Pottery Industry and led to the substitution of alumina for flint in the 1930s. A comprehensive account of the events leading to this major contribution in the prevention of silicosis in this country was given in a Milroy lecture by Meiklejohn, published in this journal (1963).

About 15 years after all china factories in Stoke-on-Trent had substituted alumina for flint as a bedding medium and eight years after the use of flint for such purposes had been officially prohibited by the Pottery (Health) Special Regulations of 1947, King, Harrison, Mohanty, and Nagelschmidt (1955) reported that certain types of alumina could produce severe fibrosis in the lungs of rats. Consequently, an immediate radiological examination of the china placers and oddmen working at the china biscuit kilns was initiated by Meiklejohn and Posner (1957). No cases of pneumoconiosis were detected in men who had been exposed to alumina only. The findings seemed to be reassuring, but at the time of the investigation only a few workers had been exposed to alumina for more than 15 years. The investigators therefore suggested that the problem 'should be kept under further vigilant observation'.

By the winter of 1964, more than half of the china biscuit placers and oddmen in the area had been exposed to alumina dust for more than 15 years. Furthermore, one large factory had lately introduced

a new method—profile placing—which dispensed with the use of powdered bedding media altogether. This method is likely to be adopted by most other firms in coming years. Thus the time seemed ripe for a review and possibly final re-assessment of the situation. In addition, the establishment of a respiratory physiology department in Stoke-on-Trent enabled us to add objective function tests to the radiological investigations and an enquiry into respiratory symptoms.

Present Investigation

The survey was carried out during the autumn and winter of 1964/65. Since the previous investigations in 1956, the china industry in Stoke-on-Trent had been the subject of extensive reorganization and amalgamation of factories with the result that only 19 factories had to be visited compared with 25 at the preceding survey. Unlike in 1956, no attempt was made to restrict the investigation to men who had been exposed to alumina only. Experience had shown that the films of workers with exposure to other dusts, such as coal or flint, were useful in avoiding bias in the interpretation of chest radiographs which were read without knowledge of employment histories.

The manufacturers were asked to provide lists of all male china biscuit placers and oddmen in their employment. Altogether 186 men were invited by a personal letter to complete a questionnaire on a precise occupational history since leaving school, on respiratory symptoms, smoking habits, and clinical histories.

One hundred and sixty-nine men presented themselves for radiography and completed the questionnaire, a response of 90.8%, which was higher than in 1956 (84.6%). For various extraneous reasons, three men were unable to complete the respiratory function test. All three had worked with other dusts in addition to alumina, but their radiographs showed no evidence of pneumoconiosis.

One of us (E.P.) checked, completed, and, if necessary, corrected the men's questionnaires at the time of their attendance. This was followed by simple spirometry when four consistent expiratory spirometry were obtained using a 'Vitalograph'. Finally a full-sized chest film (12 × 15 or 14 × 17 in.) was taken.

Results

Age Structure The age structure of the population examined is shown in Table I. As would be expected, the proportion of younger men was

TABLE I

AGE DISTRIBUTION OF 169 CHINA BISCUIT PLACERS

Age (yrs.)	Alumina Only		Alumina and Other Dusts	
	No.	% of Total	No.	% of Total
<25	15	26	5	4.5
25-34	11	19	5	4.5
35-44	24	41	20	18
45-54	5	9	40	36
55-64	3	5	38	34
65+	—	—	3	3
Total	58	100	111	100

TABLE II

TIME WORKED WITH ALUMINA BY 169 CHINA BISCUIT PLACERS AND ODDMEN

Time Worked with Alumina (yrs.)				Workmen	
				No.	% of Total
Less than 5	..	..	..	29	17
5-9	..	..	..	18	11
10-14	..	..	..	29	17
15+	..	..	..	93	55
Total	..	..	..	169	100

considerably higher in the group exposed to alumina only. A considerable number in this group had started to work as china placers after the substitution of flint by alumina and had, therefore, not been exposed to 'other dusts'. Of the 81 men above the age of 45 years who had been exposed to alumina and other dusts, 55% had been working with flint as china placers, the remainder were either ex-miners or potters who had been working in other departments of the ceramic industry. Table II summarizes the length of time the 169 china biscuit placers and oddmen had worked with alumina.

Radiological Investigation Each of us read all the films independently without knowledge of the occupational or clinical history of the men and classified the radiographs according to the ILO-Geneva classification (1959) with the aid of the appropriate Standard Films. We encountered considerable difficulties with regard to 'Z' shadows (increased lung markings) and 'L' shadows (numerous linear or reticular opacities). A combined reading session, however, resulted in agreement about 161 radiographs and disagreement over eight. No agreement was reached with regard to the presence or absence of pneumoconiosis in four and with regard to the stage of pneumoconiosis in another four instances. We sent these eight films to Dr. W. W. Jones, senior member of the Pneumoconiosis Panel in Birmingham, and accepted his readings for our analysis. It should be mentioned that none of these eight films was of a man who had worked with alumina only.

Pneumoconiosis Present Pneumoconiosis was suspected or diagnosed in 32 men (Table III) all of whom had been exposed to dusts other than alumina for varying periods. Twenty-four men had been using flint in addition to alumina, and in five men the length of exposure to flint was less than five years. However, as has been pointed out elsewhere, this is not an uncommon experience (Meiklejohn and Posner, 1957). The other men were either ex-miners or had worked in other departments of the pottery industry where there are recognized hazards from dust. Some had a very mixed history.

Pneumoconiosis Absent The radiographs of 137 men showed no evidence of pneumoconiosis. There were no cases of active tuberculosis or of neoplasm. Other abnormal findings were as follows: three cases of inactive tuberculosis; two cases of bronchiectasis; two cases of post-inflammatory pleural thickening; and four cases with abnormally translucent lung fields, flattened and low diaphragms, and narrow heart silhouettes, suggesting emphysema.

TABLE III
OCCUPATIONAL HISTORY AND RADIOLOGICAL CATEGORY OF 32 CHINA BISCUIT PLACERS AND ODDMEN
WITH PNEUMOCONIOSIS

No.	Age	Exposure to Industrial Dusts (yrs.)				Radiological Category
		Alumina	Flint	Coal	Others	
1	64	19	21	6	—	m1
2	59	17	12	—	—	m1
3	54	5	—	12	—	m2
4	47	14	—	15	—	m2
5	44	23	4	—	—	Z
6	63	23	19	—	Pottery dipper 1	m3/B
7	59	22	23	—	—	m2
8	62	19	9	9	—	m2/B
9	48	22	6	4	—	p2
10	64	25	25	—	—	m1
11	64	26	24	—	—	m2
12	63	23	23	—	—	m1
13	51	20	8	2	—	m1
14	59	14	2	8	—	p1
15	42	21	4	—	—	m2
16	53	25	8	—	Earthenware placer 3	p1
17	40	19	4	—	—	p1
18	48	18	7	—	Clay manager 4	m1
19	45	20	9	—	—	m2
20	73	25	15	—	Teapot turner 10	m2
21	60	15	20	5	—	L
22	61	23	12	—	Saggarmaker 5	m1
23	52	18	—	14	—	m1
24	42	14	—	15	—	L
25	59	15	—	10	—	Z
26	53	13	—	—	Blunger charger 15	L
27	60	14	—	—	Earthenware turner 30	m2
28	51	16	5	—	Earthenware dipper 8	p1
29	63	24	20	—	—	m2
30	63	3	—	31	—	m1
31	41	15	6	—	—	m1
32	50	25	9	—	—	p1

Cases 1 to 4 are also shown under the corresponding numbers in Table IX.

Respiratory Symptoms The 169 men in this series are not a representative sample of the male population of Stoke-on-Trent nor of the approximately 20,000 men at present employed in the local pottery industry. Comparisons with these populations or with the results of investigations elsewhere were not envisaged at the start of our survey. We attempted, however, a comparison between the three main groups in our series, *i.e.*, men who had worked only with alumina, men who had worked with other dusts but whose radiographs did not show pneumoconiosis, and men who had pneumoconiosis. For this purpose the full range of questions used by Fletcher, Elmes, Fairbairn, and Wood (1959), by Higgins, Cochrane, Gilson, and Wood (1959), and

by other investigators seemed to be unnecessary and too time-consuming. We therefore restricted our enquiries to simple questions which would allow us to define three groups:

1. No symptoms.
2. Simple syndrome of chronic bronchitis or phlegm production, similar to that used by Ferris and Anderson (1962).
3. Complex syndrome (College of General Practitioners, 1961) involving dyspnoea and repeated chest illnesses in addition to persistent phlegm production.

The simple syndrome was diagnosed when positive answers were given to one or both of these questions:

TABLE IV
RESPIRATORY SYMPTOMS OF 169 CHINA PLACERS AND ODDMEN, ACCORDING TO AGE AND EXPOSURE TO DUSTS

Age (yrs.)	Alumina Only			Other Dusts					
	Total No.	Simple Syndrome	Complex Syndrome	No Pneumoconiosis			Pneumoconiosis Present		
				Total No.	Simple Syndrome	Complex Syndrome	Total No.	Simple Syndrome	Complex Syndrome
18-44	50	8 16%	— —	25	7 28%	1 4%	5	2 40%	— —
45+	8	2 25%	2 25%	54	19 35%	14 26%	27	6 22%	14 52%
Total	58	10 17%	2 3%	79	26 33%	15 19%	32	8 25%	14 44%
			21%				52%		

TABLE VI

SMOKING HABITS OF 169 CHINA PLACERS AND ODDMEN, ACCORDING TO AGE AND EXPOSURE TO DUSTS

Age (yrs.)	Alumina Only						Other Dusts											
							No Pneumoconiosis						Pneumoconiosis Present					
	No.	N.S.	Cig. I	Cig. II	Ex-Smokers	Pipe and Mixed	No.	N.S.	Cig. I	Cig. II	Ex-Smokers	Pipe and Mixed	No.	N.S.	Cig. I	Cig. II	Ex-Smokers	Pipe and Mixed
18-44	50	5 10%	22 44%	21 42%	—	2 4%	25	3 12%	14 56%	8 32%	—	—	5	—	2 40%	3 60%	—	—
45+	8	1 12.5%	—	6 75%	—	1 12.5%	54	4 7%	17 32%	28 52%	3 5%	2 4%	27	1 4%	12 44%	11 41%	1 4%	2 7%

N.S. Non-smokers who have never smoked more than an occasional cigarette.

Cig. I Up to 19 cigarettes per day.

Cig. II 20 cigarettes or more per day.

Pipe and mixed smokers These men smoked predominantly pipe tobacco plus occasional cigarettes.

The absence of marked differences in smoking habits between the three sub-groups allowed us to combine all non-smokers and cigarette smokers in Table VII, which shows the relation of smoking habits to respiratory syndromes in the two age groups. The high overall proportion of the complex syndrome in men older than 45 years emphasizes the importance of the age factor and, by implication, the length of time a man had been smoking. On the other hand, we found no significant differences in the prevalence of the complex syndrome in relation to the number of cigarettes smoked. The small number of 14 non-smokers does not allow any valid comparisons with the cigarette smokers.

TABLE VII

SMOKING HABITS AND RESPIRATORY SYMPTOMS OF 158 CHINA PLACERS AND ODDMEN: NON-SMOKERS AND CIGARETTE SMOKERS

Age (yrs.)	Smoking Habit	No.	Simple Syndrome	Complex Syndrome
18-44	Non-smokers	8	— —	— —
	Cig. I	38	5 13%	— —
	Cig. II	32	12 38%	1 3%
45+	Non-smokers	6	3 50%	2 33%
	Cig. I	29	12 41%	12 41%
	Cig. II	45	12 27%	16 36%

Non-smokers Never smoked more than an occasional cigarette

Cig. I Up to 19 cigarettes per day

Cig. II 20 cigarettes or more per day

Respiratory Function Tests The four consistent expiratory spiograms were measured to give the vital capacity (V.C.) and the indirect maximum breathing capacity (I.M.B.C.). The latter was derived from the forced expiratory volume in 0.75 second (F.E.V. 0.75) as described by Kennedy (1953). Both the V.C. and the I.M.B.C. were obtained from the mean of the four consistent spiograms. In Figs. 1 and 2 they were expressed as a percentage of the predicted normal values according to the age and height of each man. We used the nomogram given by Cotes (1965) which is based on the data of Kory, Callahan, Boren, and Syner (1961).

From Figures 1 and 2 it became clear that in many men the I.M.B.C. is impaired more than the V.C. and consequently we confined further analysis to the I.M.B.C. findings, which are generally considered to be a more useful index of pulmonary dysfunction than the V.C. (Gilson and Hugh-Jones, 1949; McKerrow, 1960).

Absolute I.M.B.C. Values by Age and Dust Exposure These are shown in Table VIII. The obvious trend is the fall of the mean I.M.B.C. with age which applies to all three groups. Because of the widely varying numbers of men examined in each sub-group, and the very small number in some of them, comparisons at each age level are obviously difficult. In view of this the slightly higher values for men below the age of 45 who had been exposed to other dusts in addition to alumina (group II), compared with those who had worked with alumina only (group I), seem to be of little significance. In group III (men with pneumoconiosis), the mean I.M.B.C. was generally lower than in the two other

FIG. 1. The individual vital capacities of the 166 china placers and oddmen were expressed as a percentage of the predicted normal, based on the age and height of the individual.

FIG. 2. The individual I.M.B.C.s of the 166 china placers and oddmen were expressed as a percentage of the predicted normal, based on the age and height of the individual.

TABLE VIII

MEAN I.M.B.C. OF 166 CHINA BISCUIT PLACERS, ACCORDING TO AGE, HEIGHT, AND EXPOSURE TO DUST

Age Group (yrs.)	No. in Group	Alumina Only				Alumina and Other Dusts							
						No Pneumoconiosis				Pneumoconiosis Present			
		No.	Mean Age (yrs.)	Mean Height (in.)	Mean I.M.B.C. (l./min.)	No.	Mean Age (yrs.)	Mean Height (in.)	Mean I.M.B.C. (l./min.)	No.	Mean Age (yrs.)	Mean Height (in.)	Mean I.M.B.C. (l./min.)
<25	20	15	19 (17-24)	68 (64-72)	143 (120-179)	5	21 (19-23)	69 (68-70)	158 (140-170)	—	—	—	—
25-34	16	11	31 (25-34)	66 (63-71)	133 (118-154)	5	32 (29-34)	67 (66-71)	145 (129-165)	—	—	—	—
35-44	43	24	39 (35-44)	67 (63-73)	117 (64-163)	14	39 (36-43)	68 (64-73)	132 (85-164)	5	42 (40-44)	68 (65-70)	93 (76-144)
45-54	44	5	47 (45-48)	69 (65-72)	108 (79-126)	28	49 (45-54)	67 (62-71)	100 (55-148)	11	51 (47-54)	67 (62-71)	90 (38-120)
55+	43	3	56 (58-62)	70 (68-72)	95 (93-105)	24	59 (55-65)	67 (61-72)	73 (16-106)	16	62 (59-73)	65 (61-69)	79 (33-109)
Total	166	58	—	—	—	76	—	—	—	32	—	—	—

Figures in brackets indicate the range of measurements.

groups, except for the men above the age of 55, whose values are practically on the same level with those in the corresponding age group who had exposure to other dusts but no evidence of pneumoconiosis.

The rate of decline by age and exposure to dusts is shown in Figure 3. From the age of 35 years onwards it was steeper in men who had been exposed to other dusts in addition to alumina.

I.M.B.C. Expressed as Percentage of Predicted

Normal Figure 2 shows the proportions of men with I.M.B.C. values less than 70% of the predicted normal according to age and dust exposure. The first two columns represent men who had only been exposed to alumina. The third column refers to 24 men below the age of 45 years who had exposure to other dusts in addition to alumina, but no radiological evidence of pneumoconiosis. The proportion of men in these three columns who showed an I.M.B.C. of less than 70% of the predicted normal was approximately 20% (exact values in each

FIG. 3. The individual I.M.B.C. of the 166 china placers and oddmen were expressed as a percentage of the predicted normal, based on the age and height of the individual.

column being 16%, 25%, and 17%). Only four of the men in the third column had been exposed to flint dusts (one, two, four, and five years respectively) and one of them had also one year's exposure to earthenware dust. The remainder were either examiners with exposures ranging from one to 12 years (14 men) or men who had worked in other pottery departments between one and 10 years (six men).

The proportions of men with an I.M.B.C. of less than 70% of the predicted normal in columns IV, V and VI were considerably higher (50%, 80%, and 41% respectively) than columns I, II and III. Column IV relates to men over 45 years of age with no pneumoconiosis but who had been exposed to alumina and other dusts. Columns V and VI relate to men with pneumoconiosis exposed to alumina and other dusts. Four of the five men less than 45 years of age (column V) had been exposed to flint for four to six years and the fifth man had been a coal miner for 15 years.

Figure 2 suggests, therefore, that the proportion of men with an I.M.B.C. of less than 70% of the predicted normal value was higher in workmen who had been exposed to other industrial dusts in addition to alumina. These findings must be seen in the light of the absolute values in Table VIII and the limitations applicable to comparisons with normal

values predicted from other sources. However, it seems safe to conclude that alumina does not cause as much respiratory impairment as some other dusts occurring in the pottery and coalmining industries.

Men with I.M.B.C. Values of less than 50% of Predicted Normal Those men with an I.M.B.C. less than 50% of the predicted normal value are listed in Table IX. All these men had been exposed to potentially hazardous dusts as well as to alumina with the exception of two workers who had worked with alumina only. These two men were only moderate smokers, had no respiratory symptoms, and had normal radiographs. The reason for the great reduction in their I.M.B.C. is not clear.

Of the remainder, four men had radiological changes suggestive of emphysema, and it is interesting that their I.M.B.C. values are among the lowest recorded. Two men had radiological evidence of bronchiectasis and their I.M.B.C. was only 30% and 35% of the predicted normal. There were six cases with no radiological abnormalities, two with simple pneumoconiosis only, and one case with healed tuberculosis.

In view of the surprising inconsistencies in some cases between the low I.M.B.C. values, clinical histories, and radiographic findings, this group of

TABLE IX

ANALYSIS OF AGE, OCCUPATIONAL EXPOSURE, SMOKING HABITS, RESPIRATORY SYNDROME, AND RADIOLOGICAL APPEARANCES OF 15 MEN WITH I.M.B.C. BELOW 50% OF EXPECTED VALUE

No.	Age	Exposure to Industrial Dusts (years)				Smoking Habits	Respiratory Syndrome	Radiological Appearance	I.M.B.C. Percentage
		Alumina	Flint	Coal	Others				
1	64	19	21	6	—	Cig. I	Complex	Pneumoconiosis (m1) and Bronchiectasis	35
2	59	17	12	—	—	Cig. I	Nil	Pneumoconiosis (m1)	49
3	54	5	—	12	—	Cig. I	Nil	Pneumoconiosis (m2) and emphysema	28
4	47	14	—	15	—	Cig. II	Complex	Pneumoconiosis (m2)	48
5	65	17	18	8	—	Cig. II	Complex	Emphysema	18
6	56	24	11	—	—	Cig. I	Nil	Emphysema	38
7	59	25	14	—	—	Ex-smoker (Cig. II)	Complex	Emphysema	12
8	64	24	21	2	—	Cig. II	Complex	Bronchiectasis	30
9	58	24	8	—	—	Cig. II	Complex	Inactive tuberculosis	46
10	39	2	—	—	—	Cig. I	Nil	Normal	48
11	41	22	—	—	—	Cig. I	Nil	Normal	35
12	55	16	—	25	—	Cig. I	Complex	Normal	47
13	55	17	—	—	Earthenware biscuit placer 24	Cig. II	Simple	Normal	42
14	48	6	—	25	—	Cig. II	Simple	Normal	45
15	64	14	—	12	—	Cig. II	Simple	Normal	40

Cig. I up to 19 cigarettes per day; Cig. II 20 cigarettes or more per day.

Note: Cases 1 to 4 are also shown under the corresponding numbers in Table III.

FIG. 4. The individual I.M.B.C.s of the 166 china placers and oddmen were expressed as a percentage of the predicted normal, based on the age and height of the individual.

15 men will be further investigated as regards other parameters of lung function and will be reported later.

The relationship between respiratory symptoms and the I.M.B.C. is illustrated in Figure 4. There were 79 men aged 18 to 44 years and 87 men over 45 years of age.

Of the men aged 18 to 44 years, there were 61 with no symptoms, 17 with the simple syndrome, and only one with the complex syndrome. It can be seen from the histograms in Fig. 4 that there is no striking difference in the I.M.B.C. findings between those men with no symptoms and those men with the simple syndrome.

Of the men over 45 years of age, 32 had no symptoms, 26 had the simple syndrome, and 29 the complex syndrome. Again in this age group there was very little difference in the I.M.B.C. figures of those men with a simple syndrome and those men with no symptoms. However, the I.M.B.C. values of the men with the complex syndrome are, in general, considerably lower than those with no symptoms or the simple syndrome.

In all, there were 15 men with I.M.B.C. values less than 50% of the predicted normal, five of whom claimed to have no symptoms; three were classified as having the simple syndrome and seven as having the complex syndrome (Table IX).

Discussion

The most important result of the present investigation was the complete absence of radiologically manifest pneumoconiosis in workmen who had been exposed to alumina only. Furthermore we found no evidence that the I.M.B.C. of men who were 'pure alumina workers' was lower than that of those who had been exposed to other dusts as well (*e.g.*, coal, flint, or composite ceramic dusts). In fact, in terms of 'percentage of predicted values' of I.M.B.C. the evidence points the other way.

The situation in the British pottery industry seems therefore to be quite different from that in other industries where serious chest disease has been reported as the result of inhalation of pure metallic aluminium (Goralewski, 1947, 1950; Mitchell, 1959; Mitchell, Manning, Molyneux, and Lane, 1961) or of mixed bauxite fumes (Shaver and Riddell, 1947; Shaver, 1948).

On the other hand, our results are in accordance with the experience of Kennedy (1956) who found no evidence of physiological or radiological changes as the result of prolonged inhalation of aluminium oxide dust in the course of therapeutic trials. In this context, a personal communication by the late Professor E. J. King, quoted in the report of the preceding survey (Meiklejohn and Posner, 1957), is of

some interest. In this, King suggested that alumina as used in pottery manufacture is thoroughly dehydrated and its fibrogenicity thereby greatly reduced.

Nearly 30 years ago, in 1937, alumina was substituted for flint as a bedding medium in the pottery industry. The prediction by Plant (1939) that this event would prove to be an *annus mirabilis* for the industry seems to have withstood the test of time and follow-up studies.

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