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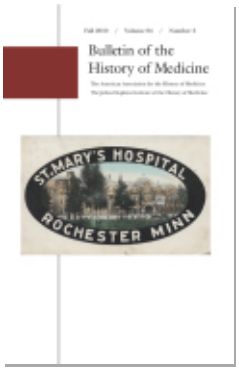

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Beyond a Shadow of a Doubt? Experts, Lay Knowledge, and the Role of Radiography in the Diagnosis of Silicosis in Britain, c. 1919–1945

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SUMMARY: The history of silicosis provides an important chapter in the history of occupational and environmental health. Recent historical scholarship has drawn attention to the importance of patient attitudes, popular protests, and compensation claims in the formation of a "lay epidemiology" of such a disease, frequently challenging the scientific orthodoxies devised by large corporations and medical specialists. Surprisingly little research has been undertaken on the United Kingdom, which provided much of the early expertise and medical research in respiratory diseases among industrial workers. This article examines the introduction of a particular technique, x-radiography, and its use by radiologists and others in debates on the causes and consequences of silica inhalation by the laboring population in Britain during the early decades of the twentieth century. In contrast to some recent interpretations, and also to the narrative of progress that practitioner historians have developed since the 1940s, this article suggests that the use of this technology was contested for much of this period and the interpretation of X-rays remained disputed and uncertain into the 1950s. The article also questions recent accounts of lay epidemiology as an adequate model for understanding the progress of such innovations in medical history.

KEYWORDS: silicosis, fibrosis, anthracosis, pneumoconiosis, X-rays, coal miners' lung, workers' compensation

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Introduction: The Spectacle of Silicosis

In June 1929 Edgar King, a coal miner from southwest England, was sent to Bath Hospital for a radiographic examination. According to the radiologist who photographed the sick miner's chest, the X-ray exposures provided "quite sufficient" evidence that King suffered from silicosis.[1] Silicosis was by then well known as a pulmonary disease afflicting workers in dusty occupations where prolonged inhalation of fine particles of "free" silica (quartzite) led to a progressive fibrosis of the lungs.[2] Such particles could be found wherever granites, sandstones, and similar rocks were drilled, cut, blasted, crushed, and polished. They arose also when silica-rich stones were used for grinding or sharpening objects, such as metal edge tools and cutlery, serious lung damage being again most evident among workers employed in confined spaces for prolonged periods. Miners of coal as well as metal ore cut into rock strata to access seams and make roadways, though at the beginning of the twentieth century colliers were rarely suspected of having severe respiratory illness resulting from their work.

By the time Edgar King was diagnosed, doctors were ready to recognize industrial bronchitis as well as silicosis as coalfield illnesses. King was typical of many British miners in that he spent his working life on the same coalfield, with the exception of a few short months before 1914 spent cutting "headings" in the silica-rich grey sandstone rock that underlay the Somerset seams. This proved a lethal excursion: by the end of 1926 breathing problems forced King off the coal face, and two years later he was permanently disabled. Certified as silicotic in the autumn of 1929, King collapsed and died in July 1930. He was forty-five. The inquest on King proved a turning point in the recognition of the disease, finding

1. Bristol University Library, Somerset Miners Association Papers, DM 443 (hereafter SMA), box 6, Edgar King to Fred Swift, June 11, 1929, and November 30, 1929. King was anxious that Swift (a local union official) would not think he was "taking up your time with trivialities."

2. Wellcome Library, Donald Hunter Papers (hereafter Hunter Papers), PP/HUN/C 1/56, cases from Oldchurch Hospital, Romford, Ward E4, June 28, 1934, for sandblaster includes X-ray report: "The radiographic appearances are those of a silicosis. The radiogram made 13 March 1933 shows a partial left pneumothorax. (GRMC)." Hunter diagnosed William Norris, a billiard table maker with "slate pneumoconiosis" October 15, 1931, noting "Rubs on sand with iron float. Dusty job." Radiogram examination suggested advanced silicosis, and sputum test October 15, 1931, revealed no tuberculosis but "dense masses of pneumococci present."

death caused by heart failure due to silicosis and "anthracosis." The autopsy painted a vivid portrait of his internal health.

> The lungs were almost black in structure. . . . They were hard and heavy and deeply puckered and shrunk in certain areas. Some portions were of almost stoney [*sic*] hardness on section, the colour was black and the lung substance devoid of air spaces. On pressure a black offensive thick liquid exuded of the character of thin putty. On cutting with a knife the resistance was of hard black putty.[3]

The conclusion that no tuberculosis was present also contributed to contemporary debate on the reciprocal contribution of coal dust and tubercular infection to the death of miners. Accusations flew at King's inquest that the hopeless penury of his last years would have been relieved if retrospective compensation had been provided for sufferers of "miners' lung" (or even silicosis) by 1929.[4] Local union officials such as Fred Swift of the Somerset Miners' Association (SMA), conducted stubborn and often lonely campaigns to secure redress for sick miners. Swift denounced King's working conditions as "barbarous," attracting the attention of eminent medical figures such as John Scott Haldane and former Medical Inspector of Factories Sir Thomas Legge to workers' illnesses in such neglected coalfields. Not only were radiographs of King and his colleagues examined by senior physicians but sections of the dead miner's lung were dissected in detail by a foremost authority, the results presented to the main Advisory Committee of the Mines Department.[5]

3. SMA, box 6, Godfrey Carter, "Autopsy of Edgar Frank King, July 15 1930."

4. Mark Bufton and Joseph Melling, "A Mere Matter of Rock': Organised Labour, Scientific Evidence and British Government Schemes for Compensating Silicosis and Pneumoconiosis among Coalminers, c. 1926–1940," *Med. Hist.* 49 (2005): 155–78.

5. SMA, box 6. A. J. Cook to Swift, July 21, 1930; *Somerset Standard* cutting, July 18, 1930. Thomas Legge had already visited the area in the previous year. Also SMA, box 6, for his "Silicosis: Report on Thirty Miners Engaged off and on 'Branching' in the Somersetshire Coal Field," June 1929, which discusses King's X-ray and the "large patches of dense fibrosis in both lungs" that it revealed. For Health Advisory Committee of King's case, NA POWE 8/139, Minutes of the 40th Meeting of Health Advisory Committee (HAC) of Mines Department, 1931, Sir Kenneth Goadby told the Committee that 'this [King's] lung showed in a remarkable manner how previously existent silicotic fibrosis retards the elimination of inhaled coal dust…'. King's radiographs were presented to the following Committee meeting. NA POWE 8/157 for Minutes of 41st Meeting of HAC. For union responses, Modern Record Centre, Warwick, Trades Union Congress Papers (hereafter TUC Papers), 292/144.341/8, press cuttings July 14, 1930; Jenny P. Ford, "Writhlington and Fred Swift," and "Fred Swift: One Case Victory," *Five Arches: Radstock, Midsomer Norton & District Museum Society* 24 (Autumn 1995): 8–9**;** and National Library of Scotland, J. S. Haldane Papers (hereafter Haldane Papers), reference 10306, unlisted materials: typescript of "Notes on radiograms of four Somerset miners" Memorandum XL (F) pencil dated February 10, 1931.

The King inquest was clearly pivotal not only in legal deliberation on disease compensation in Britain's collieries but also in scientific discussions of pulmonary illness during the 1930s. A leading member of the Advisory Committee which received news of King's inquest, J.S. Haldane, later noted Swift's campaigning work in a lecture to the Institute of Mining Engineers in 1930, acknowledging the force of the evidence in compelling him to revise earlier claims that bronchitis among coal miners was rare and due to factors other than underground dust.[6] The famous physiologist continued to insist that coal dust itself did not cause silicosis, even rejecting conclusions reached at Johannesburg's international conference organized under the auspices of the International Labor Office (ILO) in 1930 that the risk of silicosis was proportionate to the amount of free silica in the atmosphere. Haldane likewise criticized reliance on dubious X-ray evidence in compensation cases.[7] Listening to Haldane, Dr. Sydney Fisher (first permanent Medical Inspector of Mines), questioned his conclusions in offering inquest evidence on forty-nine fatalities among colliers similar to Edgar King.[8]

The exchanges between Legge and Swift are also revealing. Appointed as the first Medical Inspector of Factories at the Home Office in 1898, Legge became Britain's foremost international authority on occupational diseases before resigning in protest at his government's refusal to honour an ILO prohibition of lead paint. Subsequently appointed the first medical adviser to Britain's Trades Union Congress (TUC), Legge confirmed to Swift that his personal examination of King a year before his death showed the miner "so advanced a case" that his death came as no surprise. As early as 1925 Swift had sent the Mines Department the X-rays of Somerset miners when the Department's Health Advisory Committee

6. J. S. Haldane, "Silicosis and Coal-Mining," *Trans. Inst. Mining Engin.* 80 (1930–31): 415–51 (including discussion).

7. Ibid., 417, 422. A number of speakers referred also to the Empire Mining and Metallurgical Congress in South Africa, which discussed silicosis (e.g., Arthur Mort, 429, in discussion). Haldane noted, "I want to make a strong protest against the practice of diagnosing silicosis on mere X-ray examination without knowledge of the man's history and of the kind of dust he breathes. One is apt to get into the hands of X-ray specialists who diagnose silicosis in all sorts of cases," 423.

8. National Archives (NA), Ministry of Mines records POWE 8/81 shows fifty-five applications for post although Sydney W. Fisher, aged thirty-nine and in colliery practice since 1919, was the only applicant with specialist knowledge of silicosis (and also a law student of Lincoln's Inn), having completed an M.D. thesis on the subject as well as having served on the Refractories Industries Medical Board. Haldane, "Silicosis and Coal-Mining" (n. 6), 431–42, Fisher in discussion. Detailed pathologies were listed for deceased colliers, several of whom died from heart failure due to fibrosis attributed to silicosis.

undertook a study of Somerset rock drillers, and it was these that Legge and Fisher reviewed following King's inquest, finding that all but one of the colliers showed "very considerable silicosis," with two also presenting symptoms of tuberculosis.[9]

Not as hostile as Haldane to revisionist ideas on lung disease, Legge and Fisher in 1930 still shared some of his reluctance to revive Victorian suspicions of coal dust. Coroners might record "anthracosis" due to coal dust as a contributory cause of death, though even sympathetic medical experts remained uncertain about the precise relationship between different mine minerals, "miners' phthisis," and tuberculosis, even after a clear typology was agreed upon at another ILO conference in 1938.[10] Scientists were more confident about the distinctive damage caused by silica particles, including the combined attack of fibrosis and tuberculosis, detecting a distinctive signature left by silica particles where "nodules" were formed as a colloidal defensive response when microscopic quartz dust invaded the drainage channels of the lung. Fisher offered a simple description of these characteristic formations in 1932.

> These dots, which can be felt when handling a [postmortem] lung specimen grow in number and merge, a more or less large, hard, rubber-like area resulting which replaces normal lung. When a lung becomes silicotic it loses its elasticity, and in most cases the fine double covering-layer which enables it to move smoothly (the pleura) becomes thickened and causes the lung to stick to the

9. SMA, box 6, Legge to Swift, July 14, 1930, and Legge to Swift, July 21, 1930. Legge later examined the films with Sydney Fisher. Four survivors from the group were invited for further radiographic examination. SMA, box 6, Mines Department to Swift, October 20, 1930. Fisher reported to the Health Advisory Committee on King's recent inquest as a miner who had been one of those investigated by the Committee in 1925 and the need for re-examination. NA POWE 8/139, Minutes of 37th Meeting of the HAC. In 1936 Fisher told the Royal Commission on Safety in Mines that the 1925 study of twelve Somerset rock drillers had revealed that all these men "but one were found definitely to be suffering from silicosis, the one case being doubtful." Fisher's Memorandum submitted prior to his oral evidence to the Royal Commission, paragraph 9. Copy in NA POWE 8/199. Fisher possibly elided earlier and later examinations as he was himself only appointed as the first permanent medical inspector of mines in November 1927, long after the study was completed, though it seems the Mines Department were fully aware of the lethal consequences of rock drilling in collieries as early as 1925. The Health Advisory Committee approved Fisher's memorandum, see HAC 1937, POWE 8/200.

10. Gillian Burke and Peter Richardson, "The Profits of Death: A Comparative Study of Miners' Phthisis in Cornwall and the Transvaal, 1876–1918,' *J. S. Afr. Stud.* 4, no. 2 (1978): 147–71, 152, for L. G. Irvine's classification for the second Silicosis Conference at Geneva in 1938, which followed the more famous South African event of 1930.

> chest wall. . . . [T]he lung tissue becoming gradually destroyed and replaced [in fibrosis cases] by the united efforts of tubercle and silica.[11]

While Fisher again noted the complicating impact of tuberculosis, he did not discuss the effect of other dusts on the diseased lungs of industrial workers. By the time of his writing, the scientific orthodoxy on the unique hazard presented by silica was being questioned, and within a decade it was to be overturned.

This article considers the progress of debates on dust-related lung disease among British workers and, more particularly, the contribution of roentgen exposures (X-rays) to the diagnosis and treatment of this industrial illness. There has been remarkably little research into silicosis in Britain, though the United Kingdom played a vital role in the international understanding of this and other dust-related diseases before 1939. The new technology of X-rays formed an important tool for investigating lung disease, though the scope for subjective interpretation of the radiographic images contributed to the vigorous debates on the etiology of pulmonary illness before international standards for applying the technology were finally agreed upon in the 1950s.[12] There were also marked variations in the use made of this technology by medical scientists and governments concerned with limiting the impact of mineral dusts on workers. The application of X-rays to screen workers and diagnose and prevent silicosis in mining centers such as South Africa accelerated research on "phthisis" among mineworkers but also confined scientific attention to quartzite particles. A distinctive strand of research was undertaken on lung disease in coal districts, finally prompting a major investigation by Britain's Medical Research Council (MRC) into south Wales's anthracite and bituminous coal mining communities during 1938–41. The MRC study involved mass X-ray examinations of colliers and led to a fundamental, if belated, shift in the clinical orthodoxy on occupational lung disease and the reclassification of silicosis as one form of "pneumoconiosis" that affects people working in dusty occupations.[13]

11. NA, POWE 8/167, "Confidential Memo on Silicosis among Workers in Coal Mines, by Medical Inspector of Mines Dr. Sydney W. Fisher." One official commented on the cover sheet, "Medically speaking, it is to be regretted that the note may not be published. . . ." Also Fisher, *Memorandum on the Industrial Diseases of Silicosis and Asbestosis* (London: HMSO, 1932).

12. Stanley Joel Reiser, *Medicine and the Reign of Technology* (Cambridge: Cambridge University Press, 1978), esp. 58–67, 189–91, 214.

13. NA, FD 1/2885, E. L. Middleton, Secretary, Medical Research Council Committee on Industrial Pulmonary Disease to South Wales Miners' Federation, July 3, 1937. Cutting, *Western Mail*, "Miners and Health Investigation: Alleged Sabotage of Inquiry by Doctors: Protest

This article locates the progress of technology within a larger political economy of industrial disease, tracing the circumstances in which lung disease became a subject of serious policy concern.[14] The stuttering pace of intellectual and legislative reform in Britain during the first half of the century has been attributed to many things, including the continued inconsistencies in technical standards and in agreed-upon methods of interpretation. In recent years historians have argued that fresh action in recognizing and treating workers' diseases depended not on the introduction of medical technologies or even on the resources invested in diagnostic services, but rather the capacity of laboring communities to articulate a collective experience of industrial maladies and mobilize political support for this popular epidemiology of illness. This interpretation of communal welfare and public health politics emerging from grass-roots campaigns and fusing practical experience, technical understanding, and ethical protest would provide a persuasive narrative in which to understand the heroic efforts of radical champions such as Fred Swift in Somerset (Swift being a notable activist in the Labour Party) as well as the celebrated campaigns of his union counterparts in south Wales.

Authoritative though these narratives of class struggle and communal intervention appear to be, they give only a partial, and in some cases misleading, understanding of the way in which expertise is formed and communicated within the scientific community and also of the complex influences that experts exerted on the progress of debate and policy. The political activists who orchestrated a movement for compensation reform in the years 1926–43 constructed a particular interpretation of disease and promoted a vision of unified policies needed to address working-class health problems, though even they did not pursue a single consistent goal in regard to dust diseases. In exaggerating the unity and influence of labor organizations we may obscure the contributions of distinctive campaigns outside and even inside workers' communities as activists struggled to change public understanding of lung disease. British evidence suggests rather the importance of links forged among general practitioners, local

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to Home Office," November 4, 1937. Historians know rather less about the experience of silicosis and respiratory disorders in such workplaces as iron and steel foundries, including those attached to automobile plants.

14. Randall M. Packard, *White Plague, Black Labor: Tuberculosis and the Political Economy of Health and Disease in South Africa* (Berkeley: University of California Press, 1989): "The political economy of disease literature has, in fact, been stronger on political economy than on the linkages between political economy and specific disease patterns," 20.

tuberculosis officers, expert researchers, and campaigning bodies concerned with public as well as occupational health in these decades.[15]

The culmination of research and campaigning by medical and scientific groups, labor activists, and legal advocates eventually forced scientific bodies such as the MRC to confront what they had previously avoided as a political issue: namely, the rationale for monetary compensation. One consequence of this reorientation was to extend the boundaries and scope of occupational studies to include broader investigations of environmental conditions and communal health standards that enlarged the clinical understanding of workplace hazards. In this intellectual transition, X-rays were given a strategic role by researchers and medical personnel employed in mass screening of Welsh miners. The political limits of this disciplinary stretch also need to be acknowledged. The legislative and institutional reforms of the 1940s did not deliver the comprehensive and integrated system of industrial and public health for which many reformers hoped before the inauguration of a National Health Service in 1948. Far from being a triumphant consolidation of citizens' rights at work and in society, health care continued to be divided along institutional and legal lines that were drawn in the early years of the century.

This analysis of the medical understanding of silicosis and popular politics is developed in a brief review of recent literature on dust diseases.

Knowing Silicosis: Narratives of Expertise and Technology

The application of roentgen rays to the examination of respiratory organs began in a period of intense technological change. New power tools were transforming the working environment of industries around the world. The introduction of heavy drills to hard rock metal mining in the United States, Europe, South Africa, and Australia in the last three decades of the nineteenth century also generated unprecedented amounts of dust underground.[16] Human capital was wasted at a remarkable rate as migrant

15. Hunter Papers, PP/HUN/C 1/56, file 48, William Norris case (see n. 2) includes correspondence of Dr. Touissant from the Public Health Dispensary, Bermondsey, to London Hospital and the reply from Hunter to Touissant, October 30, 1931, regarding presence of tuberculosis and Hunter's note that patient's bronchitis in the lung damaged by pneumoconiosis, confirmed by radiograms, "shows a coarse diffuse mottling." Touissant commented to Hunter on November 3, 1931, that Norris's first X-ray at Guy's in March 1927 revealed "dense opacities throughout both lungs" but had never had positive sputum and was removed from the tuberculosis register after Hunter's correspondence.

16. Larry D. Lankton, "The Machine under the Garden: Rock Drills Arrive at Lake Superior Copper Mines, 1868–1883," *Technol. & Cult.* 24, no. 1 (1983): 1–37, esp. 29–31; Mark

labor was supplied from Europe's metal mining regions, particularly Cornwall, which had suffered a sharp decline in mineral prices from the 1870s.[17] Severe respiratory and related diseases faced by workers returning from employment in the new mining frontiers, including South Africa's goldfields, prompted research such as Haldane's classic study of Cornish miners in 1903–4. Fast, dry drilling in the deep metal ore mines of South Africa, Australia, the United States, and other countries had, by the early years of the twentieth century, threatened an epidemic of dust-induced lung disease. It was at this critical juncture that fine particles (five microns or less) of quartz rocks, created by power tools and inhaled into the alveoli of the lungs, were identified as a lethal hazard faced by mining populations. Haldane's findings on the hazards posed by the silica-rich dust of Transvaal's Rand mines were known when the British government began compensating industrial diseases in 1906–7.[18] Larger numbers of workers were affected by less fatal respiratory problems caused by dust in the global coal mining industry, though the threat of anthracosis was thought to be limited and diminishing after 1900.[19]

Michael Bloor, among others, has emphasized the capacity of such mining communities to develop a critical "lay epidemiology" of illness, describing a mode of popular knowledge that enabled Welsh coal miners to force scientific experts and governments to recognize the dangers of coal dust by the 1930s.[20] The contribution of labor unions to the fight

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Wyman, "Industrial Revolution in the West: Hard-Rock Miners and the New Technology," *Western Hist. Quart.* 5, no. 1 (1974): 39–57, esp. 44–45; Brian Shovers, "The Perils of Working in the Butte Underground: Industrial Fatalities in the Copper Mines, 1880–1920," *Montana: Mag. of Western Hist.* 37, no. 2 (1987): 26–39, esp. 28, 36–37; and James C. Foster, "Western Miners and Silicosis: 'The Scourge of the Underground Toiler,' 1890–1943," *Industr. & Labor Rel. Rev.* 37, no. 3 (1984): 371–85, esp. 372–74.

17. Migration of skilled, trained, and well-paid labor remained a significant feature of the global mining industry throughout the twentieth century. Hunter Papers, PP/HUN/C 1/56, file 49, Charles Stewart aged fifty-five, mining engineer, diagnosed as suffering from "quartz pneumoonokoniosis" after X-ray August 24, 1932. Stewart worked in Germany, Canada, Australia, Spain, and Sudan. Spanish mines enjoyed "really a bad reputation for quartz dust," Hunter to Howells, August 31, 1932.

18. "Report of the Departmental Committee on Compensation for Industrial Diseases, Minutes of Evidence" (hereafter Samuel Committee Evidence), Cd. 3496, 1907.

19. Alan Derickson, *Black Lung: Anatomy of a Public Health Disaster* (Ithaca, N.Y.: Cornell University Press, 1998) 1–21, provides an excellent summary of early medical debates from a radical perspective. Nancy J. Krokosky, "Black Lung and Silicosis," *Amer. J. Nursing* 85, no. 8 (1985): 883–86.

20. Michael Bloor, "The South Wales Miners Federation, Miners' Lung and the Instrumental Use of Expertise, 1900–1950," *Soc. Stud. Sci.* 30, no. 1 (2000): 125–40, esp. 126–29. Drawing on Davey Smith and others in explaining lay epidemiology, Bloor acknowledges divided sentiments among British experts faced with X-ray evidence of silicosis and pneumoconiosis.

against silicosis is also a salient feature of Angela Vergara's recent study of copper mining in Chile during the mid-twentieth century. Vergara draws on David Rosner and Gerald Markowitz's pioneering study of silicosis in the United States and Randall Packard's account of lung disease in South Africa to develop her powerful analysis of class exploitation and health mobilization in a postcolonial society.[21] For Vergara the physical environment of hazard and disease in Chile's copper industry sharpened communal consciousness and fomented class struggle against shared dangers.[22] Rosner and Markowitz suggest that the radical epidemiology of silicosis developed in the early twentieth century was succeeded by apolitical science pursued by an expert elite insisting on "objectivity" divorced from critical or ethical analysis of the political context for labor exploitation.[23] In contrast, Vergara stresses the role of medical scientists in a Republican reform movement that construed silicosis as a public health issue in both military and civilian regimes.[24]

One clue to understanding decision-making in occupational health may be found in the distinct ways in which medical technologies are developed and applied in countries with different class structures and contrasting political constitutions. The evidence suggests that industrial populations do not always consolidate their understanding of hazards as they move between regions and areas where medical facilities may be unevenly distributed. Studies of silicosis reveal distinctive national patterns of detection and regulation in the decades when scientific knowledge was increasingly the province of both national and international

21. Angela Vergara, "The Recognition of Silicosis: Labor Unions and Physicians in the Chilean Copper Industry, 1930s–1960s," *Bull. Hist. Med.* 79, no. 4, (2005): 723–48, esp. 726–27; David Rosner and Gerald Markowitz, *Deadly Dust: Silicosis and the On-Going Struggle to Protect Workers' Health* (Ann Arbor: University of Michigan Press, 2006). In their important work on the United States, Rosner and Markowitz found that industrialists, medical personnel, and insurance officials advocated the appointment of expert medical panels that would monitor disease and recommend compensation awards in accordance with a coherent, scientific rationale of silicosis, thereby taking the issue out of the political arena and away from state interference.

22. Vergara, "Recognition of Silicosis" (n. 21), 725, on the formative importance of workplace disease experience in shaping miners' collective identity.

23. Rosner and Markowitz, *Deadly Dust* (n. 21), 7–8.

24. Vergara, "Recognition of Silicosis" (n. 21), 724–26. Cf. Rosner and Markowitz, *Deadly Dust* (n. 21). Chile's legislative program was influenced by military leaders, radical (Popular Front and Radical Party) politicians, medical notables, as well as labor unions and campaigning newspapers, to a degree that would have startled and alarmed most observers of American, European, and colonial reform during the early and middle decades of the twentieth century. Rosner and Markowitz provide a pessimistic account of professional self-interest, conservative political values, and institutional resistance to workers' grievances.

communities of experts. Screening by X-rays figured prominently in the case of southern Africa. Gillian Burke and Peter Richardson, Elaine Katz, Randall Packard, and others have detailed that the range of respiratory disorders that were studied in the years before the second Johannesburg silicosis conference in 1938 (following the famous 1930 conference) provided a tripartite distinction of pure silicosis, tuberculosis, and phthisis.[25] The refinement of scientific expertise was not necessarily a conservative enterprise or a barrier to social justice. Rosner and Markowitz suggest that American scientists became absorbed with precise dust measurements and X-ray evidence in an effort to demonstrate their scientific objectivity, though clinical examination and patient testimony remained fundamental elements in most compensation cases.[26] The introduction and application of X-rays also provoked tensions as scientific opinion divided experts on radiological standards of exposure until the 1950s.[27]

These divisions registered more than struggles between scientists and lay activists espousing popular understanding but reflected also the distinct practical cultures of different societies and the distribution of social power. Technology historians have often noted that mechanical inventions and technical innovations result from the strategic demands of state as well as private enterprise.[28] Scientific and industrial technologies histori-

25. Burke and Richardson, "Profits of Death" (n. 10), 152, for L. G. Irvine's classification for the second Silicosis Conference at Geneva in 1938. Elaine Katz, *The White Death: Silicosis on the Witwatersrand Gold Mines, 1886–1910* (Johannesburg: Witwatersrand University Press, 1994), 13–28; and Packard, *White Plague, Black Labor* (n. 14) both provide valuable radical analyses of Rand capitalism.

26. Rosner and Markowitz, *Deadly Dust* (n. 21), 184–86, for authorities such as Leroy Gardner of the Trudeau Foundation and Theodore Hatch of the Industrial Hygiene Foundation, including Hatch's doubts about using X-rays as a diagnostic tool.

27. Jock McCulloch and Geoffrey Tweedale, *Defending the Indefensible: The Global Asbestos Industry and Its Fight for Survival* (Oxford: Oxford University Press, 2008), esp. 67–69, for concerns about the reliability of radiological evidence and the quality of patient testimonies.

28. Jennifer Stanton, "Introduction: On Theory and Practice," in *Innovations in Health and Medicine: Diffusion and Resistance in the Twentieth Century,* ed. Stanton (London: Routledge, 2002), 1–18, esp. 2–3; John V. Pickstone, *Ways of Knowing: A New History of Science, Technology and Medicine* (Manchester: Manchester University Press, 2000), esp. 19, 37–53, 146–51; James A. Secord, *Victorian Sensation: The Extraordinary Publication, Reception, and Secret Authorship of* Vestiges of the Natural History of Creation (Chicago: University of Chicago Press, 2000) esp. 518–32; Robert B. Gordon, "Who Turned the Mechanical Ideal into Mechanical Reality?" *Technol. & Cult.* 29, no. 4 (1988): 744–78; John K. Brown, "Design Plans, Working Drawings, National Styles: Engineering Practice in Great Britain and the United States, 1775–1945," *Technol. & Cult.* 41, no. 3 (2000), 195–238; and Barton Hacker, "Engineering a New Order: Military Institutions, Technical Education, and the Rise of the Industrial State," *Technol. & Cult.* 34, no. 1 (1993): 1–27.

cally form a terrain on which different interests—government and civic institutions, capitalist, and distinct occupational or professional bodies—struggled for control of the instruments of knowledge.[29] The introduction of X-rays presented a challenge to existing modes of medical investigation and verification, as a growing crowd of radiology practitioners assembled at the gates of medical academies. The pace of technological progress remains a matter of some debate. Allard E. Dembe notes the unrealistic enthusiasm in regard to the new technology among physicians in many countries.[30] E. H. Burrows claims that British clinicians were among the earliest users of the new technology, signaled by the foundation in Britain of the world's first radiology journal in 1896.[31] Stanley Reiser found that the use of X-ray technology in Britain increased steadily after 1920, with numbers doubling every five years until 1950.[32] Other scholars emphasize the lethargic and uneven embrace of the new technology in Britain. Chris Lawrence argues that the comparatively slow adoption of diagnostic radiology was due to conservative medical authorities clinging to traditional views of "clinical art" and defending the clinical capacities of individual physicians.[33] Bernard Pasveer agrees that radiology worked "in the shadows" as diagnosis depended on clinical examination rather than on fine distinctions within the monochrome images of the X-ray.[34] Steven Cherry contrasts the ready adoption of laboratory and surgical aids—such as instrument sterilization, rubber gloves, and gauze facemasks—with the more gradual utilization of X-ray techniques after 1900.[35]

Restrictions on the use of X-ray technology were not peculiar to Britain; Rosner and Markowitz note disagreements over X-ray evidence and respiratory volume in the United States during the 1930s.[36] In many respects,

29. See, e.g., Christine Macleod, "James Watt, Heroic Invention, and the Idea of the Industrial Revolution," in *Technological Revolutions in Europe: Historical Perspectives,* ed. Maxine Berg and Kristine Bruland (Northamption, Mass.: Elgar, 1998), 96–116.

30. Allard E. Dembe, *Occupation and Disease: How Social Factors Affect the Conception of Work-Related Disorders* (London: Yale University Press, 1996), 134–35.

31. E. H. Burrows, *Pioneers and Early Years: A History of British Radiology* (Aldernay, Channel Islands, UK: Colophon, 1964), 144. The journal was *Archives of Clinical Skiagraphy.*

32. Reiser, *Medicine* (n. 12), 160.

33. Chris Lawrence, "Incommunicable Knowledge: Science, Technology and the Clinical Art in Britain 1850–1914," *J. Contemp. Hist.* 20, no. 4 (1985): 503–20, esp. 514.

34. Bernard Pasveer, "Knowledge in the Shadows: The Introduction of X-ray Images in Medicine," *Sociol. Health & Illness* 11, no. 4 (1989): 360–81.

35. Steven Cherry, *Medical Services and the Hospitals in Britain, 1860–1939* (Cambridge: Cambridge University Press, 1996), 19.

36. David Rosner and Gerald Markowitz, *Deadly Dust: Silicosis and the Politics of Occupational Disease in Twentieth-Century America* (Princeton: Princeton University Press, 1991), 32, 86, 185–98, 202; and Gerald Markowitz and David Rosner, "The Illusion of Medical Certainty:

Britain continued to be regarded as a model of disease regulation at work by many, including American authorities such as Alice Hamilton.[37] There could be little question of the high caliber of silicosis specialists among its factory inspectorate, such as Edward Middleton, whose research background in south Wales's mining communities helped establish his international reputation by the 1920s. A comparison with the work of South Africa's Miners' Phthisis Commission, created in South Africa during 1911–12, offers a less flattering reference point. This commission pioneered the use of X-ray techniques in the examination of three hundred Rand miners (one-tenth of the number examined by the survey) and introduced a legislative and medical program to control silicosis, providing a model that was closely monitored in Britain before the introduction of its own, more limited, industrial silicosis schemes in 1919.[38] Australia's New South Wales Board of Trade and Queensland's Labour government similarly established enquiries (including X-ray techniques to investigate chest diseases) among workers at locations such as Broken Hill in 1911–19.[39] The technical proficiency of the South African dust experts is indicated in British invitations to its mines inspectors to examine dust levels in Somerset and south Wales collieries as early as 1926.[40]

Silicosis and The Politics Of Industrial Disability, 1930–1960," *Millbank Quart.* 67, no. 2, pt. 1 (1989): 228–53, 233.

37. Alice Hamilton Papers, Ratcliffe College Library, Harvard University, A 22 (series 22), 22/29, 30, 31, for discussion of lead poisoning and comparative standards of the United Kingdom and the United States, including the paper "Hygiene in Industry," December 7, 1910. Hamilton also controversially criticized the grinding of granite gravestones as a source of silicosis for American workers.

38. Henry K. Pancoast and Eugene P. Pendergrass, "The Roentgen Classification of Pneumoconiosis, Based Upon Roentgen Appearances, with and without a Coexisting Tuberculosis Process and the Differential Diagnosis," *J. Industr. Hygiene* 16, no. 6 (1934): 327–45, esp. 327; R. R. Sayers and Anthony J. Lanza, "History of Silicosis and Asbestosis," in *Silicosis and Asbestosis,* ed. Lanza (London: Oxford University Press, 1938), 7; and L. G. Irvine, A. Mavrogordato, and H. Pirow, "A Review of the History of Silicosis on the Witwatersrand Goldfields," in *Silicosis: Records of the International Conference Held at Johannesburg 13–27 August 1930,* no. 13 (Geneva: International Labour Office, 1930), 188. By 1916 South Africa's Miners' Phthisis Prevention Committee claimed that "radiographic appearances in cases of silicosis afford the most reliable single piece of evidence in establishing the existence and the actual stage of the disease in any particular case." Quoted in Andrew Meiklejohn, "The Development of Compensation for Occupational Diseases of the Lungs," *Brit. J. Industr. Med.* 11 (1954): 198–212, on 200.

39. K. R. Moore, "Silicosis in Australia," in *Silicosis: Records* (n. 38), 298; Bradley Bowden and Beris Penrose, "Dust, Contractors, Politics and Silicosis: Conflicting Narratives and the Queensland Royal Commission into Miners' Phthisis, 1911" *Australian Hist. Stud.* 37 (2006): 69–107.

40. NA, POWE 8/112/1, "Report on dust investigations in mines in the United Kingdom," by H. Pirow, October 21, 1926, 2–4.

Historians may differ on the pace with which British medical authorities embraced X-rays, but it is clear that some countries were more advanced in utilizing this technology. Institutional structures and cultural practices played a part in the uneven and peculiar uses made of radiography to detect and prevent respiratory illnesses at work. Recognizing the institutional nexus in which medical technologies develop underlines Dembe's argument that awareness of disease generally increases in periods of rapid technological, industrial, and military change, such as the scientific management era of the early twentieth century.[41] Explanations of illness were adapted to contemporary models of engineering and technical processes, compressing diverse and uncertain origins of disease into linear etiologies to meet the demands of industrialists, insurers, medical providers, governments, and others for clear and demonstrable explanations of toxic impact on the workers' bodies. Radiological techniques were developed and utilized after 1895 by scientists in response to desires of employers, insurers, and courts to exclude unjustified "malingerers" from compensation. Responsible physicians were exposed to the pressure of novel and formidable expectations as they were given the unenviable, if influential, role of gatekeeper in the progress of compensation claims, carrying the burden of forensic proof for dust-related illnesses that remained difficult to diagnose with precision.[42]

It was continuing uncertainty about the relative costs and benefits of British compensation schemes, rather than the stuttering recognition of the silica threat, that explains the fragmentary evolution of financial redress for workers in different industries from 1919. These highly specific and partial schemes so frustrated the British labor movement that the TUC periodically pressed for a comprehensive public health reform and radical review of workmen's compensation for diseases (including dust-related respiratory disorders), though they were dissuaded by Legge in the early 1930s from abandoning existing models of industrial compensation.[43] Concerns continued that hard scientific proof ruled out vague pathological results and meant that X-ray test results were more seldom interrogated than patient case histories and geological samples, as defence lawyers demanded specific proof of links between the etiol-

41. Dembe, *Occupation and Disease* (n. 30), 229, 232–34, 243–44, 254–55.

42. Ibid., 135–36, 141–42. Dembe's interpretation usefully points to the significance of statutory compensation in determining the investment of resources and time in different medical technologies, though his analysis is only partly appropriate to the British case since his argument underplays the impact of medical orthodoxy and professional divisions in restricting the scope of X-ray usage.

43. TUC Papers, 292/143.82/4, Legge to J. L. Smyth, June 25, 1928; and 292/143.82/15, TUC Workmen's Compensation and Factories Committee, Minutes, February 16, 1933.

ogy of occupational disease and industrial—rather than domestic or communal—conditions.[44]

It was the contemplation of the manifold sources of ill health that troubled the boundary between work and the communal life of the employee. The association of fibrotic degeneration in the lung and the incidence of tubercular infection puzzled and divided activists as well as researchers in the early decades of the twentieth century as tuberculosis, bronchitis, and pneumonia stubbornly persisted in crowded neighborhoods.[45] Crisp legal niceties in distinguishing workplace and environmental health problems had already been practically challenged by tuberculosis agencies, supplementing the research on silicosis and various forms of infection undertaken by E. H. Kettle, W. E. Gye, and others in the 1920s.[46] These organizations and local tuberculosis officers, frequently in alliance with community and colliery practitioners, made a significant, if neglected, contribution to the transformation of political as well as medical opinion on lung diseases among working communities, including south Wales. One reason they were able to do so was their control of, and familiarity with, the largest amount of radiographic equipment available before the outbreak of war in 1939.

Historical studies have not always registered the degree of dispute about dust-related illnesses that persisted within a diverse and unequal research community. In recognizing such differences we are able to reassess the argument that the medical understanding of lung disease was decisively reshaped by popular epidemiology and the instrumental use of scientific expertise by organized labor. Leadership was not seized by the kind of republicanist medical professionals seen in Chile, nor did researchers slide into abstruse issues of measurement seen in the United

44. Bufton and Melling, "'Mere Matter of Rock'" (n. 4).

45. Linda Bryder, *Below the Magic Mountain: A Social History of Tuberculosis in Twentieth-Century Britain* (Oxford: Clarendon Press, 1988), 2–6. For the South African mining district, see Packard, *White Plague, Black Labor* (n. 14), 259–73.

46. "Silica and Tuberculosis," *Tubercle* 2 (1921), 562–63, refers to both Gye's and Edgar Collis's work. Patrick Heffernan, "The Colloidal Theory of Silicosis," *Tubercle* 11 (1929-30), 61–63; James A. Murray, "Edgar Hartley Kettle, 1882–1936," *Obit. Notices Roy. Soc.* 2, no. 6, (1938): 301–5, esp. 302–4; C. H. Andrewes, "William Ewart Gye, 1884–1952," *Obit. Notices* 8, no. 22 (1953), 418–30, 421. Kettle and Gye were pathologists closely involved in cancer research (Kettle headed Cardiff University's Pathology Department for three years as well as the Medical Research Council's Radiology and Industrial Pulmonary Disease Committees), though their research on silicosis demonstrated the impact of collagen in thickening tissues and leading to fibrosis as well as the intrusion of tubercular infection. For a discussion of research in tuberculosis (including the statistical work of MRC and views of D'Arcy Hart) see Bryder, *Below the Magic Mountain* (n. 45), 99–102.

States. Industrial disease did attract younger researchers radicalized by political engagements in the 1930s, though their influence was more apparent after 1945. The sources of this transformation can rather be found in a reorientation of scientific, governmental, and campaigning thinking about the supposedly unique hazard presented by "free silica."

Radiology made a notable, but not a decisive, contribution to this revision. Nor should we exaggerate the impact of this renaissance of thinking about pneumoconiosis. The reform of the research agenda did not lead to the radical reconstruction of policies for the prevention of dust and the compensation of sufferers, but rather to a substantial enlargement of existing diagnostic and institutional practices within the United Kingdom. The remainder of this article develops this interpretation in a discussion of the contribution of X-rays to British research on silicosis in the early decades of the twentieth century.

Through a Glass Darkly: Silicosis, Science, and X-ray Technology, 1918–45

Edgar King's was not the first death in southwest England to draw the attention of the national press to the chest problems of British miners. In the early years of the twentieth century, severe respiratory illness among Cornwall's metal mining communities attracted comment from government officials as well as medical practitioners concerned with the growing evidence of blood and breathing problems in an industry where workforce numbers declined severely after the collapse of copper prices during the 1870s. Concern about the dusty conditions faced by British miners had already been registered when the Kinnaird Commission heard evidence from 1862, but this and subsequent enquiries made limited progress in determining the proximate and precise causes of "miners' phthisis" (or "miners' asthma") before the first reliable X-rays were taken in 1905.[47] Blood disorders among Cornish miners and diverse complaints of impure air featured in discussions of high death rates among these workers, along with investigations of gases, temperature, exertion, diet, alcoholism, hereditary predisposition, climate, and domestic habitations.

47. Catherine Mills, "The Pitfalls of Cause and Effect Correlations: Nineteenth Century Health Reforms—Silicosis and the Case of the Cornish Miners" paper, (International Conference on the History of Dust Diseases, University of Exeter, 2004), 3–4. Mills supports R. A. Williams, Peter Bartrip, and others in rejecting the claims of Gillian Burke and Peter Richardson's argument that mining companies and mines inspectors colluded in not enforcing ventilation regulations in periods of falling copper prices, published in their "Profits of Death" (n. 10).

John Scott Haldane's epidemiological study of Cornish mining conditions in 1903–4 discovered ankylostomiasis infection (spread by parasitic worm in feces) but also found dangerous mine dust created by powered drills, particularly affecting miners who had returned from working in South Africa.[48] Suggesting that rock drills fitted with water suppressants would be more effective than mine ventilation, he continued to play a significant, complex role in promoting and sustaining orthodoxy on the silica hazard.[49] An expert on the carbon content of mine air and its affect on blood hemoglobin (oxygen capacity), Haldane's analysis of the alveoli suggested to him the fundamental importance of air quality and bodily, as well as environmental, temperature in the respiratory health of the underground worker.[50] Haldane's research into Cornish miners' diseases did not end the debate on mineral dust. The etiological uncertainties as well as the risks to individual employment that continued to surround "miners' phthisis" and the distinctive contributions of silica and tuberculosis to lung disease was apparent in evidence to the Samuel Committee on the Compensation of Industrial Diseases during 1906–7.[51] John F. Arlidge, leading authority on industrial phthisis in the potteries, maintained a clear distinction in terminology between hereditary tuberculosis and dust-related lung disease but offered little clarity in isolating pathological symptoms.[52] Thomas Oliver similarly acknowledged that the relationship between fibrosis caused by dust and tubercular infection was not a consistent one, the two diseases often complicating illness and causing earlier death.[53] Workers in dusty trades such as slate mining and milling appeared particularly liable to contracting pneumonia and tuberculosis, which local doctors attributed to dust fibrosis weakening the

48. Steven Waite Sturdy, "A Co-ordinated Whole: The Life and Work of John Scott Haldane" (Ph.D. thesis, University of Edinburgh, 1987), 164–68.

49. Ibid., 169–71.

50. C. G. Douglas, "John Scott Haldane, 1860–1936," *Obit. Notices* 2, no. 5, (1936): 115–39, 117–23.

51. Samuel Committee Evidence, Cd. 3496, 1907, Evidence of Dr. Arthur Hall of Sheffield on November 16, 1906, Q1734-35. See evidence of Professor Robert Muir, January 16, 1907, for silica and coal dust discussion, Q4750-54.

52. Samuel Committee Evidence, J. F. Arlidge, February 18, 1907, Q6709-6732 for discussion of "potters' asthma" and difficulties of distinguishing the use of terms as well as symptoms of phthisis, consumption, tuberculosis, bronchitis, asthma and similar dust-induced diseases, including Q6716: "I do not like the term dust phthisis because it is difficult to deal with." Q6720: "Would dust consumption do as a term? Yes. I want to keep clear of the word tubercle because that is hereditary."

53. Samuel Committee Evidence, Dr. Thomas Oliver, April 22, 1907, Q10664-10668.

lung.[54] Industrial tuberculosis remained a subject of active debate in the interwar period even as X-rays were widely used in communal screening for the disease.[55]

The Samuel Committee of 1907 acknowledged the pernicious effects of silica dust in causing lung fibrosis, but emphasized the capacity of laborers displaying early, milder symptoms to continue active employment for many years. Early diagnosis would deny such workers any prospect of compensation and also exclude them from the industry, confirming union fears that regular medical inspections, including X-ray screening, offered employers an opportunity to dismiss those presenting secondary symptoms rather than risk their deterioration. The refusal of Legge and his committee colleagues to schedule silicosis for claims under Britain's 1906 Workmen's Compensation Act can be contrasted with the approach adopted in contemporary South Africa. Pioneering X-ray surveys were undertaken in the Rand goldfields and reviewed by London government officials before the first British silicosis legislation was drafted in 1917–18.[56] Edgar Collis had confirmed in the Milroy Lectures of 1915 that "free" silica presented the primary, if not unique, threat to lungs of industrial workers and the paucity of statistical evidence that coal dust in modern mines led to serious respiratory illness.[57]

After 1919 the British factory inspectorate (housed in the Home Office) repaired some of the British research deficit in a series of studies of industrial lung disease, including Edward Middleton and E. L. Macklin's important investigation in 1923–24 of Sheffield's notoriously unhealthy

54. Samuel Committee Evidence, Dr. Richard Jones, February 25, 1907, Q7438-7444. Cf. evidence of J. G. Ashmore, a slate quarry manager of Blaenau Ffestiniog, Q9764, 9771, who attributed phthisis and other diseases of respiratory organs prevalent throughout his district to climatic, rather than industrial, conditions. Linda Bryder, "Tuberculosis, Silicosis, and the Slate Industry in North Wales, 1927–1939," in *The Social History of Occupational Health,* ed. Paul Weindling (London: Croom Helm, 1983), 108–26, 120–21, argues that the local medical profession retained highly conservative sociological explanations of tuberculosis.

55. "Industrial Tuberculosis," *Lancet* 200 (1921): 1260, for discussion in which Lyle Cummins participated; and "Tuberculosis and Employment" (report of Royal Institute of Public Health, annual congress), *Lancet* 208 (1925): 1258–59. Bryder, *Below the Magic Mountain* (n. 45), 105, suggests that the "widespread use of X-rays by the 1930s did not necessarily make diagnosis more accurate."

56. South African progress was also regularly noted in British medical journals. See, e.g., "South Africa: Miners' Phthisis," *Lancet* (April 1914): 1147.

57. E. L. Middleton, "The Aetiology of Silicosis," *Tubercle* 1 (1919–20): 257–62. For E. L. Collis see Joseph Melling and Christopher Sellers, "Objective Collectives? Transnationalism and 'Invisible Colleges' in Occupational and Environmental Health from Collis to Selikoff," in *From Dangerous Trades to Trading Dangers: Towards a Industrial Hazard History of the Present,* ed. Melling and Sellers (Philadelphia: Temple University Press, 2011), forthcoming.

grinding trades, in which they used X-ray techniques. Three years later Charles L. Sutherland, subsequently chief officer of the Silicosis Medical Board (SMB), completed a parallel study of pottery workers with S. Bryson, again utilizing X-ray technology.[58] These studies foreshadowed the seminal study of south Wales coal miners undertaken in 1938–42.[59] Radiographic evidence was not, however, considered a secure basis for forensic analysis of the disease or sufficient proof for compensation, even in a case such as King's. The limited reliance on X-ray evidence can be attributed to the complex network of institutional and legal rules that were developed to compensate silicosis sufferers from 1919. Radiological expertise was not readily accepted by doctors trained in clinical examination, who relied on stethoscopes to detect uneven rhythms or "railes" in the breathing of patients.

The correct reading of the exposure and the competence and consistency of the radiographer were often questioned in discussions of lung disease, though such reservations would have assumed less importance had they not been reinforced by the concern of key government departments to maintaining a working relationship with employers. British governments depended on the cooperation of industrial firms for which the Home Office as well as the Treasury continued to resist any move to state underwriting of compensation risks in hazardous trades.[60] Ludwig Teleky hailed the pioneering use of X-ray techniques in research studies of cutlery grinding and potteries during the mid-1920s, though he did not point out that such investigations failed to persuade the manufacturers of the serious risks posed by sandstone or the need for confidential exami-

58. *Report on the incidence of Silicosis in the Pottery Industry,* Dr. C. L. Sutherland and Dr. S. Bryson (London: HMSO, 1926), 51. NA, PIN 12/23, "Report by E. L. Macklin on regulations for grinding," August 23, 1923, for background to the study. Staub-Oetiker of Zurich had applied X-ray techniques when investigating metal grinders' lung disorders in 1916 while Böhme used the technology in examining Ruhr coal miners in the 1920s.

59. Three MRC reports were responsible for the definitive classification of chronic pulmonary disease caused by coal dust inhalation. *Chronic Pulmonary Disease in South Wales Coalminers: I—Medical Studies* (London: HMSO, 1942); *Chronic Pulmonary Disease in South Wales Coalminers: II—Environmental Studies* (London: HMSO, 1943); and *Chronic Pulmonary Disease in South Wales Coalminers: III—Experimental Studies* (London: HMSO, 1943).

60. NA, PIN 11/1, WM note for Gladstone, November 23, 1906, regarding "blackmailing of individual firms" and WSC (unknown) marginal comments, November 24, 1906; PIN 12/11, "Refractories Industries (Silicosis) Scheme, 1919," R. R. Bannatyne notes April 25, 1917, on Report on Ganister Mining prepared by E. L. Collis, medical inspector of factories at Sheffield including comments of Collis, April 20, 1917, on a voluntary wage-based industrial scheme; and comments of Brace at conference with workers' representatives, July 17, 1917.

nation of their workers.[61] Recalcitrant industrialists could delay and even derail medical arrangements for the examination and compensation of their workforces, by, for example, sustaining challenges to radiographic evidence that depended on clinical interpretation.[62] An infuriated but largely impotent Conservative Home Secretary threatened the Sheffield metal grinding firms in 1926 with the prospect of damaging legal claims, while the pottery firms resigned from the government inquiry into silicosis in the potteries before it could issue its report two years later.[63] Edward Middleton was a particular target for criticism in the latter investigation, the Committee acknowledging that radiographic examination could not provide the only basis for diagnosing silicosis. Medical arrangements for the potteries were finally agreed to only on the eve of the Second World War.[64]

Progress could also be tortuous in the various metal and coal mining industries: it was here that official government preferences, scientific expertise, and business attitudes combined to sustain the silicosis orthodoxy. Experts and civil servants were often divided by professional cultures and institutional cultures within their own ranks as they struggled to find a practical consensus, as well as being frequently frustrated at the intransigence or ignorance of employers with whom they dealt. Mines inspectors reported in 1926 that management at Mells Colliery (which employed Edgar King) resisted official direction to improve ventilation and introduce water-suppressants in rock drilling, though existing arrangements were in clear breach of the 1911 Coal Mines Act.[65] The inspectors them-

61. Ludwig Teleky, *History of Factory and Mine Hygiene* (New York: Columbia University Press, 1948), 204.

62. Compensation provisions were made on an industrial basis with the creation of mutual insurance funds by firms engaged in production using silica. Schemes were designed to meet the conditions and risks found in different industries, beginning with the refractories industries scheme in 1919–20. When industrialists united in refusing to participate in setting up, funding, and administering a mutual scheme, the Home Office and even politicians found they could make little progress.

63. *Report of the Departmental Committee on Compensation for Silicosis Dealing with the Pottery Industry* (London: HMSO, 1928); draft copy in NA, PIN 12/26, 11–14.

64. NA, PIN 12/23, William J. Hicks, September 14, 1926: "[T]he position is becoming a public scandal & as they decline to play the game I must bring in a bill to include silicosis . . . under the W.C. Acts." PIN 12/26, Draft Report on Silicosis in the Pottery Industry, July 27, 1928, Appendix II; T 161/806, *Report on the Incidence of Silicosis in the Pottery Industry*, Dr. C. L. Sutherland and Dr. S. Bryson (London: HMSO, 1926), 51; PIN 12/82, Silicosis and Asbestosis (Medical Arrangements) Scheme. Pottery Industry, Conference at Home Office with British Pottery Manufacturers' Federation, May 2, 1939.

65. NA, POWE 8/112, 89374, H. A. Abbot (Divisional Inspector) to Chief Inspector of Mines, March 1, 1926, citing the "difficult position financially" of the Colliery; and Chief

selves were divided on the extent of the silicosis hazard and scope for medical examination. When the South African expert, Dr. Hans Pirow, reported again in 1925 on mine dust in Somerset and south Wales, many divisional officials stressed the limited presence of silica in their districts, and the Welsh inspectors emphasized the continuing hostility of workers to medical examination enforced by statutory regulation.[66] Mines Department officials had earlier noted, however, that the reluctance of both miners and owners to recognize the hazards they faced provided some rationale for compensation to compel managers to take a more serious attitude to safety.[67]

Underlying the hesitancy and inconsistency expressed in official memoranda at the Mines Department was a distinctive research culture that had been nurtured between officials, employers, and scientific experts over decades of regulation before dust disease and compensation emerged. This shared culture had grown when the greatest threat of dust had been one of combustion, igniting explosions that could kill hundreds of colliers in dusty and "gassy" mines. Trained officials as well as managers tended toward mechanical, engineering solutions to dust control, whether by suppression at source or by ventilation. Scientists specializing in mining research, such as Haldane, learned early in their careers that the management culture of the extractive industries gauged the value of scientific work in terms of its "practical" understanding of mining and that a good working relationship with owners depended on an appreciation of hard economic as well

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Inspector of Mines to Abbot, April 16, 1926 noting that preventive measures proposed were not satisfactory, since "There is no room for doubt that the conditions at Mells are dangerous; and . . . adequate preventive measures must therefore be pressed to the limit." In another comment, E. J. M (unknown) noted of Mells that workmen denied serious dust dangers and "stubbornly resist measures which fuss them in their work, such as water drills, respirators, special dust extraction devices and the like. . . . POWE 8/112, Memorandum note dated March 16, 1926.

66. NA, POWE 8/112, 89374, W. J. Charlton (Swansea) to H. Walker, Chief Inspector of Mines, November 2, 1925; Carly (?) Cardiff to H. Walker, November 4, 1925, supporting proposal for medical examination of "some old experienced sinkers," and February 19, 1926, emphasizing absence of rock in steam coal measures and wetness of such rock in other seams "as to tender any risk of silicosis remote." Cf. Davies (Newcastle) to Walker, December 11, 1925: "It appears to me that the first thing to do would be to subject the drill operations to xray [*sic*] examination, and if it be found that phthisis exists, then remedial measures ought to be taken." Pirow undertook the study of machine drilling in 1925 in association with Captain Hay, designer of the widely-used canvas dust-trap for machine drillers.

67. NA, POWE 8/112, 68086, "Silicosis in Coal Mines: Remedial Measures," Note by S. H. F (?), March 18, 1926, possibly for the Home Secretary: "If Silicosis is made the subject of compensation, the management may perhaps take a greater interest in the matter than at present."

as welfare concerns.[68] Such ties of mutual dependence were strengthened by technical arrangements for examining industrial safety. British governments developed few centralized research or laboratory facilities in this field and continued to rely on professional, charitable, and private voluntary associations to undertake key investigations into lung diseases.[69]

For these and other reasons Haldane remained a key figure, directing the British Coal Owners' Research Association research laboratory at Birmingham and collaborating with Cardiff mining engineer Thomas D. Jones in research for the Safety in Mines Research Board.[70] Haldane had earlier joined senior medical figures Kenneth Goadby and Walter Fletcher in the Metal Mines Health Advisory Committee (MMHAC) at the Mines Department, later the Health Advisory Committee (HAC), sponsoring studies such as Goadby's X-ray investigation of diseases among metalliferous miners.[71] From its earliest days this committee considered evidence of lung disease related to coal mine working and dusts, including claims for silicosis and bronchitis, for which no compensation was paid.[72] Yet, these scientists were more concerned with determining the physical properties

68. Haldane Papers, MS 20510/286, William Galloway of Cardiff to Haldane, April 4, 1907. Galloway stressed that "mining men" were "not permeated by the scientific spirit" and would accept mine-based, rather than laboratory, results.

69. Henry K. Pancoast and Eugene P. Pendergrass, "The Roentgenological Aspects of Pneumoconiosis and its Medico-Legal Importance," *J. Industr. Hygiene* 15, no. 3 (May 1933): 117–35. Pancoast and Pendergrass noted that "the roentgenological examination is of so much importance in establishing the status of the claimant as to disability from pneumoconiosis, the roentgenologist plays an important part in the conflicting expert testimony," 131.

70. Haldane Papers, 20514/193, Reports to the BCORA from Mining Research Laboratory, 20514/194, April 1, 1932; and 20514/195 Interim Report April 1, 1933. Haldane also drew a salary from the association.

71. The advisory committee for the Metalliferous Mining Industry Committee on Occupational Disease had its first meeting on November 29, 1922, at which Edgar Collis was present, as well as E. A. Gowers, Goadby, Fletcher, and Haldane, at which the last was elected chairman. See NA, POWE 8/76.

72. NA, POWE 8/83. At its second meeting on February 26, 1923, MMHAC considered the Challends case at Brodsworth Main Colliery, certified as silicosis by a certifying surgeon, which was appealed to a medical referee on the grounds that silicosis was (in the words of the employer) "not a disease for which compensation is payable as far as the Coal Mining Industry is concerned," quoting letter of September 2, 1923, from Colliery Company. The following meeting considered four cases from Lanarkshire, including that of James Lennox, who claimed compensation for inhalation of gas and coal dust. See NA, POWE 8/84, May 28, 1923. In the latter case Dr. Logan's strong opinion was quoted: "[B]y far the most important factor in the production of pulmonary diseases in coal mines is not the exposure to coal dust, no matter how high the siliceous content may be, but the repeated exposure to impure air . . . ."

of sandstone and harder rocks found alongside ores, and with technological scope for suppressing and eliminating dusts at source, rather than their pathological impact on miners.[73] This research did raise questions about the quality and correlation of X-ray photographs, as Goadby proposed research into different dusts represented on radiographs and Edgar Collis praised South African research and scholarship; however, the MMHAC was bound by its accountability to the Mines Department for metal working rather than being concerned with collieries.[74]

The relatively slow pace with which X-ray surveys were introduced to detect and combat industrial lung disease cannot be wholly explained in terms of the resistance of British industrialists, the conservatism of leading scientists, or the uneven introduction of compensation provisions for industries affected by silica dust. It is true that collieries were not included in Various Industries' compensation schemes until 1928 and even this partial victory was not related to fresh research on coal dust. At important moments the government itself appeared reluctant to promote X-ray technology, even where the numbers of cases and expected claims were fairly modest, particularly where the technology figured in the deliberation of awards. In March 1924 the directors of the Refractories Industries Compensation Fund (RIFC), concerned with fireclay miners, suggested extending X-ray usage to verify claims that were too readily accepted by its compensation committees. Home Office officials stressed the lengthy period needed to recoup the increased cost of examinations by radiographic equipment even if compensation awards were reduced.[75] Evidence from the more relaxed regime of the 1930s indicates that the actual costs involved in refractories and sandstone workers' X-ray examinations remained very moderate, as indicated by Table 1.

Official caution about the introduction of X-ray examinations was undoubtedly sustained by continuing professional skepticism about the utility of X-rays. Collis noted in 1928 that the radiographic skills needed to provide robust and reliable exposures remained scarce and similar shadows could be detected in photographs found among both silicotic and nonsilicotic iron miners.[76] Sydney Fisher agreed in 1932 that the

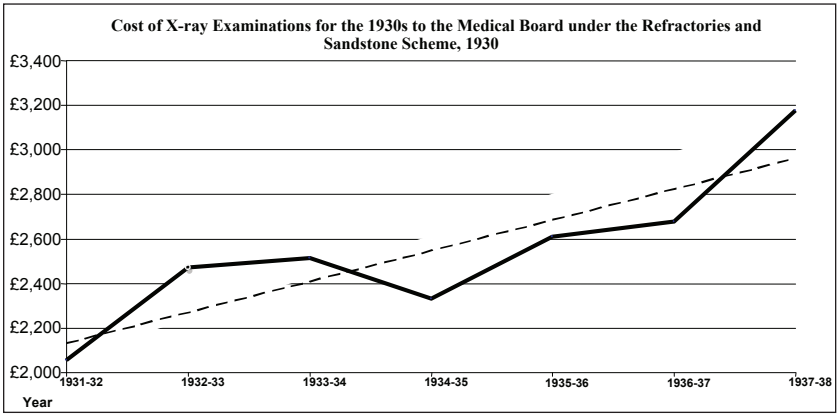
73. NA, POWE 8/112, "Silicosis and use of rock drills. Approval of [Captain] Hay Dust Trap" by Chief Inspector of Mines, July 7, 1925, referring to Piron [Pirow?] enquiry, e.g.

74. POWE 8/85, MMHAC Fourth Meeting Minutes, June 25, 1923. Stuart's monograph on South Africa was noted.

75. NA, PIN 12/22, the Refractories Industries Compensation Fund: Notes by the Directors of the Fund Regarding Recommendations by the Departmental Committee as to Amendment of Scheme, March 1924. To RICF, April 7, 1924.

76. NA, POWE 8/84, "Report by Dr. E. L. Collis on his visit on 3rd September, 1928, to Cumberland Iron-Ore Mines"; and NA, POWE 8/112.

Table 1.



uniformity of technique rather than quality of exposure presented the major obstacle to advances in radiological understanding of lung diseases among coal miners.[77] Edward Middleton acknowledged deficiencies in X-ray facilities across Britain and that exposures of "a certain technical standard" were vital to enable radiologists and others to accurately interpret evidence of respiratory disease.[78] It was not merely the technical limitations in radiological techniques and training that justified the continued emphasis on expert clinical examination. Medical experts and civil servants appeared anxious that the discretionary control exercised by senior medical referees—and their primary capacity for reading radiographic and other evidence in combination with clinical examination of patients and a reading of the patient's career—should not be challenged by tuberculosis officers and other medical personnel. Such anxieties help to explain the creation of the Silicosis Medical Board (SMB) in 1931, which consisted of four regional panels under a senior coordinator whose members reached a decision after clinical examination of claimants (or their bodies after postmortem), usually with radiographic films. An SMB member, Andrew Meiklejohn, later explained that it was these

77. Fisher, "Confidential Memo on Silicosis among Workers in Coal Mines" by Medical Inspector of Mines Sydney W. Fisher. NA, POWE 8/167, "it is practically useless to compare one set of films with another set taken by a different person." Fisher also noted the inability of Dr. Sutherland to find microscopic evidence of silicosis after three local physicians agreed on the diagnosis at a postmortem.

78. NA, PIN 12/29, "Report on the Occurrence of Silicosis Amongst Sandstone Workers: Introduction Memorandum by Dr. E. L. Middleton, one of H M Medical Inspector of Factories," by E. L. Middleton, November 7, 1928.

specialists rather than individual radiologists who assumed responsibility for interpreting X-ray evidence in compensation claims.[79] The criteria of assessment remained in the hands of elite experts who played the key role in assessing the cases brought forward for compensation under the different schemes.

Between 1920 and 1935 almost two thousand cases covering industrial diseases were referred by different industries to such specialist referees, roughly half gaining approval for compensation.[80] In 1932 Haldane, as member of HAC, was vociferous in his criticism of the SMB and its medical advisers for issuing compensation certificates to miners in areas such as south Wales where fibrosis could be rarely attributed to silica.[81] In fact, X-rays appear to have been used relatively rarely in the initial examinations of suspected cases undertaken at regional centers of the SMB even during the 1930s, as Tables 2 and 3 indicate.

More advanced examinations were undertaken by specialists at the SMB, combining clinical observations and patient testimony with radiographic exposure. Although X-rays were rarely acknowledged as the primary tool in decision-making, it was the reading of such films and the attendant vocabulary of visual shapes, in terms of well-defined "nodules" versus less-pronounced reticular patterns of silica deposits, that provided the board with its rationale for judgment. Nodules remained the agreed, recognizable signature of the disease. As the director of the board explained in 1935, half of the disablement applications were rejected where X-rays revealed a "fine reticulation" but only "doubtful nodulation."[82] Sources suggest that the board rejected an increasing proportion of claims during the 1930s when total numbers of applications, particularly from colliery workers, climbed sharply, an unspecified portion also revealing symptoms of tuberculosis. Table 4 indicates the broad trend and also the spectacular rise in coal mining cases during pre–WWII years.

79. Andrew Meiklejohn, "Some Medico-Legal Aspects of Silicosis," *Med.-Leg. & Crim. Rev.* 10, (April 1942): pt. II, 78–86.

80. NA, PIN 12/131, Evidence of Kenneth Goadby to Departmental Committee on Workmen's Compensation. Goadby estimated that of 1972 cases, 927 were allowed, 941 dismissed, and 104 made the subject of a special reference.

81. NA, POWE 8/181, HAC Meeting October 17, 1934. See also POWE 8/189, "Various Industries (Silicosis) Amendment No. 2 Scheme 1934 Extension of Silicosis Compensation to Hematite Iron Ore Miners," Field to Fudge, January 31, 1935, concerning Haldane's refusal to accept that iron ore miners were suffering from silicosis. Haldane had complained that no one "knew the grounds on which the Boards diagnose cases." Collis, Goadby, and Fisher were generally more conciliatory.

82. NA, FD 1/2880, C. L. Sutherland to Middleton, December 20, 1935.

Table 2. Silicosis Medical Board: Initial Examinations at Regional Centers for Four Industries, 1933

	Bristol	Stoke	Sheffield	Manchester	Total
Refactories Industries					
Total by Medical Board	30	72	45	0	147
Total referred by AMOs	1	0	0	2	3
Total by AMOs	32	4	0	53	89
Total X-rayed	2	0	1	0	3
Total Certificates F	2	8	5	0	15
Total Certificates C	0	0	0	0	0
Sandstone Industries					
Total by Medical Board	112	40	58	158	368
Total referred by AMOs	1*	0	4	5	9
Total by AMOs	49	2	97	83	231
Total X-rayed	11	8	8	21	48
Total Certificates F	6	1	8	7	22
Total Certificates C	3	5	5	10	23
Pottery Industry					
Total by Medical Board	6	276	0	0	282
Total referred to Medical Board	0	0	0	2	2
Total by AMOs	1	0	0	35	36
Total X-rayed	2	18	0	0	20
Total Certificates F	1	26	0	2	29
Total Certificates B	0	1	0	0	1
Total Certificates C	2	3	0	0	5

Continued on p. 450

Table 2 *(continued)*. Silicosis Medical Board: Initial Examinations at Regional Centers for Four Industries, 1933

	Bristol	Stoke	Sheffield	Manchester	Total
Asbestos Industry					
Total by Medical Board	1	6	17	104	128
Total referred by AMOs	1	0	2	1	4
Total by AMOs	50	1	54	25	130
Total X-rayed	0	0	2	0	2
Total Certificates F	0	1	2	7	10
Total Certificates C	0	0	0	0	0

AMO = Assistant Medical Officers * +1 examined in 1932 and referred to Medical Board in 1933
Source: Annual Reports of Silicosis Medical Board.

Table 3: Silicosis Medical Board: Initial Examinations at Regional Centers for Four Industries, 1937

	Bristol	Stoke	Sheffield	Manchester	Total
Refractories Industries					
Total by Medical Board	144	52	196	137	529
Total referred by AMOs	7	0	0	2	9
Total by AMOs	64	0	9	88	161
Total X-rayed	1	0	28	2	31
Total Certificates F	6	0	14	12	32
Total Certificates C	0	0	2	0	2

Table 3 *(continued)*. Silicosis Medical Board: Initial Examinations at Regional Centers for Four Industries, 1937

Sandstone Industries					
Total by Medical Board	99	102	165	149	515
Total referred by AMOs	3	0	3	3	9
Total by AMOs	46	0	158	102	306
Total X-rayed	5	8	23	8	44
Total Certificates F	5	5	28	8	46
Total Certificates C	0	1	4	0	5
Total Certificates E	0	0	1	0	1
Pottery Industry					
Total by Medical Board	2	266	2	2	272
Total referred by AMOs	0	0	4	1	5
Total by AMOs	9	0	44	32	85
Total X-rayed	0	2	0	0	2
Total Certificates F	0	8	3	0	11
Asbestos Industry					
Total by Medical Board	13	100	44	513	670
Total referred by AMOs	10	0	0	5	15
Total by AMOs	73	0	65	40	178
Total X-rayed	0	6	3	1	10
Total Certificates F	7	0	0	22	29
Total Certificates B	0	0	0	0	0
Total Certificates E	1	0	0	0	1

Source: Annual Reports of Silicosis Medical Board.

Table 4. Examinations by Silicosis Medical Board in Pursuance of Application for Death and Disablement Certificates, 1933 and 1937

1933	Disablement		Death	
Industry or Occupation	No. men examined	No. CSS/A with TB*	No. applications	No. CCS/A with TB**
Refractory Industry	4	2	9	6
Sandstone Industry	69	53	38	32
Pottery Industry	143	70	40	31
Asbestos Industry	16	6	3	1
Coal Mining Industry	282	199	43	31
Masons and stone dressers	99	72	39	31
Metal Grinding Industries	24	13	8	6
Other Industries	29	20	14	12
Total	666	435	194	150

1937	Disablement		Death	
Industry or Occupation	No. men examined	No. CSS/A with TB*	No. applications	No. CCS/A with TB**
Refractory Industry	8	1	7	6
Sandstone Industry	35	26	24	15
Pottery Industry	89	41	48	42
Asbestos Industry	7	3	0	0
Coal Mining Industry	604	256	99	72
Masons and stone dressers	81	56	43	26
Metal Grinding Industries	10	8	6	2

Table 4 *(continued)*. Examinations by Silicosis Medical Board in Pursuance of Application for Death and Disablement Certificates, 1933 and 1937

Other Industries	85	33	27	24
Total	919	424	254	187

* Number certified to be suffering from silicosis or asbestos or either of these diseases accompanied by tuberculosis
** Number certified to be caused by silicosis or asbestos or either of these diseases accompanied by tuberculosis
Source: National Archives, PIN12/67.

Coal mining became the focus for debates on silicosis in the early 1930s as the "Five Fatal Valleys" of the anthracite district in southwest Wales attracted scientific as well as political and legal attention.[83] The contribution of "lay knowledge" and community solidarity to this campaign has been well documented in recent studies.[84] Campaigns by the South Wales Miners Federation (SWMF) and the Anthracite Miners' Association (AMA) in particular found a voice in James Griffiths, president of "the Fed" from 1934, and Member for Parliament for Llanelli. In 1936 Griffiths forced Home Office acknowledgment of the limitations of the medical research into pneumoconiosis.[85] As we saw, union officials such as Fred Swift maintained contacts with a range of medical practitioners, officers, and researchers including those engaged in X-ray work.[86] From 1932 even the HAC became convinced that fresh investigation was needed into the hazards of coal dust.[87]

A less well-known, and yet undoubtedly significant, pressure for fresh research before the 1928 Silicosis Act was passed can be traced to the work of the antituberculosis movement in Wales and other regions of Britain. The leadership of the tuberculosis campaigners was assumed by the Welsh National Memorial Association (WNMA), which administered sanatoriums throughout the Principality and generated detailed radiographic

83. The five valleys of Swansea, Neath, Dulais, Amman, and Gwendraeth in southwest Wales where miners "galloped to death" were depicted by the *News Chronicle*. Swansea University, National Union of Mineworkers (NUM) collection, SWCC MNA/NUM/3/5/20, cuttings.

84. Michael Bloor, "No Longer Dying for a Living: Collective Responses to Injury Risks in South Wales Mining Communities, 1900–1947," *Sociology* 36, no. 1 (2002), 89–105, esp. 95–96, 102.

85. House of Commons, *Hansard*, May 7, 1936, cols., 1853–1854; James Griffiths, *Pages From Memory* (London: J. M. Dent & Sons, 1969), p. 55; and NA, FD 1/2890, Middleton to A. Landsborough Thomson of MRC, July 8, 1941, regarding Griffiths.

86. Swift had carefully compiled the names of men dying from lung disease since at least 1923. SMA Papers, box 6, Swift to Frank Hodges, April 11, 1923, and June 7, 1923; Notes of Dr. P. Jones to Swift, April 17, 1923. Swift claimed six living miners were suffering from "fibroid phthisis or silicosis" by June 1923. The first of four cases listed by Swift in a letter to Hodges of June 7, 1923, was Edwin Plummer, who died from "fibroid phthisis" in January 1919, according to his doctor. This physician believed another patient had similarly died in April 1916.

87. NA, POWE 8/176, *Eleventh Annual Report of The Safety in Mines Research Board: Including a Report of Matters Dealt with by the Health Advisory Committee of the Mines Department: 1932* (London: HMSO, 1933): "[P]athological and radiological studies not only widen our knowledge of the disease itself and of the best means of treating sufferers from it, but by determining the kinds of dust that are liable to injure the human lung and in what concentrations these dusts are dangerous, they also indicate the directions in which preventive measures can most usefully be taken," 111.

profiles of thousands of patients.[88] The WNMA cooperated with local government Medical Officers of Health in providing a basic screening service for children, adolescents, and adults suspected of suffering from tuberculosis. Their capacity for examining suspected silicosis sufferers in the industry led one Home Office official to suggest, as early as 1923, the appointment of silicosis and tuberculosis officers in each industrial district, assisted by radiologists specializing in different industries. This proposal was firmly resisted by senior civil servants on the grounds that local physicians lacked the complex skills required.[89]

Whitehall's desire to retain central control over technical expertise and its suspicion, if not disdain, of local tuberculosis officers did not prevent a number of them from cultivating connections with leading silicosis experts.[90] The WMNA was itself instrumental in funding key research in the field of miners' lung problems, particularly when S. Lyle Cummins (professor of tubercular medicine at Cardiff's Welsh National School of Medicine) became director of research. Major contributions included Norman Tattersall's 1926 study of silicosis among miners cutting "hard headings" of rock strata, known as "branching" in Edgar King's coalfield.[91] WMNA's radiological study of hewers in 1929 concluded that anthracite

88. G. R. Jones, "The King Edward VII Welsh National Memorial Association 1912–1948," in *Wales and Medicine: an Historical Survey,* ed. John Cule (London: British Society for the History of Medicine, 1975), 30–31, 35; and David Egan, *Coal Society: A History of the South Wales Mining Valleys 1840–1980* (London: HMSO, 1987), 108.

89. NA, 12/127, F. J. H. Coutts to Sir W. Kinnear, October 11, 1923. The writer expressed astonishment that "the use of x rays in assistance of diagnosis had been so largely neglected," arguing that only where certifying officers or medical personnel secured X-ray proof would appeals for or against a refusal of certification be considered. His proposal would "secure that every case had the opinion of two medical men, one an expert in the routine dealing with ordinary tuberculosis, and the other a special expert in Silicosis, with the further advantage of the x-ray photograph." E. L. Middleton, Observations on Coutts Letter to Sir W. Kinnear, October 11, 1923.

90. Patrick Heffernan, tuberculosis officer for Derbyshire, was one of the most prolific correspondents and contributors, strongly supporting Haldane's views. Haldane Papers, reference 10306, unlisted materials, letter from Heffernan to Haldane, December 28, 1929, enclosing article "Colloidal Silicosis" from *Tubercle*; letter from Fletcher at MRC to Haldane, clearing the lines as to whether it was acceptable for Haynes to work with Kettle, who was working on silicosis, March 27, 1930. Fletcher noted that the active centers besides Barts Hospital were Cardiff under Cummins, working on silicosis and anthracosis, and Leeds, where Matthew Stewart was working. At Manchester, Bramwell of MRC and Henry of the Home Office were studying card room dust. See also "Some Aspects of Silicosis," *Tubercle* 11 (1929–30): 481–89.

91. Norman Tattersall, "The Occurrence of Clinical Manifestations of Silicosis Among Hard Ground Workers in Coal Mines," *J. Industr. Hygiene & Toxicology* 8 (1926): 466–80.

miners retained coal dust in their lungs, while a larger investigation in 1931 linked long service with lung fibrosis in older colliers.[92] Cummins and the WMNA subsequently challenged Haldane's explanation of "infective silicosis" and mine temperatures, reinstating an earlier link of coal dust to anthracosis and pneumoconiosis.[93] In 1932 E. H. Kettle published his "Observations on the Pneumoconioses," which reaffirmed silicosis as a paradigmatic form of the larger family of lung diseases but emphasized the significance of asbestos and other deleterious dusts, just as Lyle Cummins reclaimed "anthracosis" for the pathological vocabulary.[94] The steady accumulation of research, alongside pressure from tuberculosis and labor organizations, led to an erosion of the orthodox view that silicosis presented a unique hazard.

These research initiatives not only revived debates on the hazards of coal and other industrial dusts, but also weakened the diagnostic boundaries between the social and industrial causes of respiratory illness that doctors and lawyers had carefully constructed in the early twentieth century.[95] As Haldane acknowledged in 1930, there were unmistakeable signs of bronchitis among coal miners, even if he continued to insist that silicosis did not prevail among "any class of coal-miners" whether cutting, conveying, or road making for coal, also rejecting the Johannesburg consensus that silicosis risks were proportionate to the environmental prevalence of free silica.[96] In giving the coal industry a clean bill of health,

92. Anthracite collieries were mainly located in the west and far west of the south Wales coalfield. David Egan, *Coal Society: A History of the South Wales Mining Valleys 1840–1980* (London: HMSO, 1987), 5–6; "Investigation into the Radiological Appearance of the Chests in Coal-Miners," *King Edward VII WNMA Annual Report* 17 (1929): 129–31; and '"Coal Miners Lung': A Radiological Study of Certain Groups of 'Industrially Healthy' South Wales Coal-Miners," *King Edward VII WNMA Annual Report* 18 (1931): 158–81, reprinted with alterations in *J. Industr. Hygiene* 13 (1931): 19–26.

93. Haldane Papers, box 10306, Welsh Memorial Report for March 31, 1933, from Director of Research regarding "'Curious' bodies in the lungs of colliers, coal-trimmers and others." NA, FD 1/2875, Middleton to Mellanby, February 8, 1935, regarding Sen's research; and S. Lyle Cummins and A. F. Sladden, response to Haldane correspondence, *Brit. Med. J.* (1934): 554.

94. E. H. Kettle, "Observations on the Pneumoconioses," *Brit. Med. J.* 2 (1932): 281–83; also S. Lyle Cummins, "Pneumoconiois with Special Reference to the Silico-anthracosis of Coal Miners," *Brit. Med. J.* (1935): 287–90.

95. NA, POWE 8/188, Health Advisory Committee recommendations in regard to MRC investigation into mortality from respiratory disease. Fisher review noted that during 1931–34, the SMB had issued silicosis certificates in 95 cases of death, 305 cases of totally disabled, and 129 cases of partially disabled, with about ninety percent in south Wales.

96. Haldane, "Silicosis and Coal-Mining" (n. 6), 416, 417, 422. Haldane claimed to have noted bronchitis as early as 1910–11, while acknowledging Tatersall's work on south Wales in the *Journal of Industrial Hygiene* in 1926. Arthur Mort referred also to the Empire Mining and Metallurgical Congress in South Africa distinct from ILO affiliation, 429.

Haldane appeared more complacent than some anthracite mine owners who funded his research as he stressed the difficulties of relying on X-ray evidence to ascertain the presence of silicosis and other lung diseases.[97]

Coal was not the only story heard in Wales. One of the most noted studies by a tuberculosis doctor was concerned not with Welsh coal districts but its northern slate quarries and mines. The work of J. W. Morris, T. W. Davies, and others on slate quarry miners (again sponsored by Memorial Association funds), was to be widely acknowledged after 1938.[98] Trade unionists in south Wales and across Britain contributed to the intellectual and political ferment of the 1930s, persuading Manny Shinwell, mines secretary in the MacDonald Labour Government in 1931, to direct the MRC to review the coal dust question.[99] Bradford Hill's statistical analysis of cases concluded that fresh clinical research was required, though the leading anthracite firm made it clear that they would not cooperate with the WNMA.[100] The company involved attracted further attention in 1934 when research using X-rays of Ammanford anthracite miners was published in the *British Medical Journal*.[101] Anthracite collieries in south Wales employed relatively small numbers of miners, though they claimed the bulk of new silicosis cases, along with Welsh bituminous mines, as Table 5 shows.

97. Haldane, "Silicosis and Coal-Mining" (n. 6), 417–19. Haldane added, "even if no dust-inhalation accompanied coal-mining, the bronchitis mortality would still be almost as high," 420. He bitterly complained about "the practice of diagnosing silicosis on mere X-ray examination without knowledge of the man's history and of the kind of dust he breathes. One is apt to get into the hands of X-ray specialists who diagnose silicosis in all sorts of cases." See 423–25 for discussion.

98. NA, POWE 8/229, "Silicosis: Investigation Concerning . . . Workers at Slate Mines and Quarries in Merionethshire," detailing evidence of Dr. J. W. Morris, March 10, 1938; Clement Davies to Captain H. Crookshank of Mines Department, September 2, 1938, discussing the tuberculosis question; and T. W. Davies, "Silicosis in Slate Quarry Miners," *Tubercle* 19 (1937–38): 289–306. Davies had been employed in Montgomery and Merioneth prior to his move to Swansea. Dr. Wade had suggested a link between silicosis and tuberculosis in 1926; Sutherland and Bryson examined more than a hundred slate workers (though only half by X-ray) in 1929 and cast doubt on this conclusion, while Chalke's report of 1933 was noncommittal. Clement Davies chaired a committee of investigation in 1937–39 staffed by Davies and Morris, which again strongly linked silicosis and tuberculosis as noted by Edward Middleton. See Bryder, "Tuberculosis, silicosis" (n. 54), 113–14.

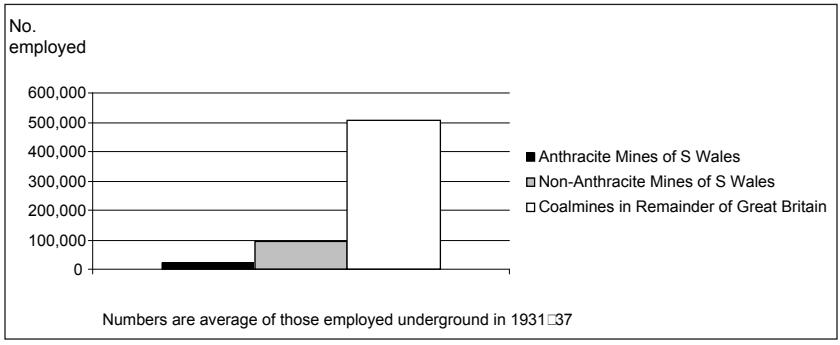
99. NA, FD 1/2873, Memo from E. Fudge of Mines Department to David Munro of the Industrial Pulmonary Diseases Committee of the Medical Research Council, December 17, 1930; and Cummins to Munro, November 12, 1931.

100. NA, FD 1/2873, Amalgamated Anthracite Collieries to A. Bradford Hill, July 10, 1931, noting of the tuberculosis organization, miners' chest complaints had "nothing whatever to do with this disease."

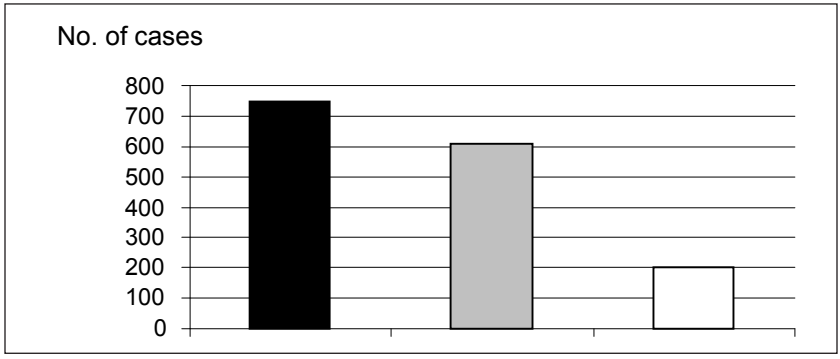
101. Andrew Harper, "Silicosis in South Wales Colliers," *Brit. Med. J.* 19 (May 1934) *I*: 920–21. See Hunter, *Diseases* (n. 13), 1017, for the pioneering roles of Tattersall and Harper.

Table 5.

Numbers of Coal Miners Employed Underground in UK, 1931–37



Coalmining: New Certified Silicosis Cases in South Wales and Rest of UK, 1931–37



In the year in which he died (1936), Haldane and such collaborators as T. D. Jones sought funding from the government for further research into mine dusts and lung disease. Faced with mounting pressure from researchers as well as labor organizations and government, MRC's Industrial Pulmonary Diseases Committee (IPRC) proposed to undertake a comprehensive medical and radiological examination of miners at six south Wales collieries. This scheme was rejected in favor of a more detailed examination of a small number of miners whose disability "resembled Silicosis without conforming to the accepted definition of Silicosis, with the object of characterising the condition as clearly as possible."[102] Radiologi-

102. NA, POWE 8/200, Health Advisory Committee, January 5, 1937, which protested that medical boards already possessed the essential clinical and radiological data of certified cases.

cal and clinical examination of 560 men precipitated a fresh calibration of the X-ray vocabulary, including terms such as "reticulation," "nodular with coalescence," and "massive with fluffed shadows."[103] Research uncovered many miners presenting pulmonary disease symptoms that did not conform to the classical or "nodular" patterns of diagnosis.[104] By 1937 Middleton, secretary of the IPRC, sought cooperation from the South Wales Miners' Federation in new research encompassing "medical and radiological examination" of most or all the workers in specific collieries, while emphasizing that his committee was "concerned solely with the scientific aspect of the question of pulmonary disease."[105]

Philip D'Arcy Hart and Edward Aslett undertook detailed clinical investigations in 1938–39, work that was disrupted by the outbreak of war and withdrawal of X-ray apparatus, provoking fierce protests from SWMF.[106] Further threats from the federation forced the reintroduction of X-ray equipment to complete the survey and enable miners to present compensation claims. When the key reports from D'Arcy Hart and Aslett were finally drafted in late 1942, Middleton insisted the authors boldly emphasize the scientific advances rather than insert caveats around their research finding.[107] The new epidemiology thereby sustained a contemporary campaign resulting in fundamental pneumoconiosis compensation reforms by 1943. Older battles between medical researchers and the mining engineers who had supported Haldane continued after the publication of the reports and the subsequent foundation by the MRC of a Pneumoconiosis Research Unit in south Wales under Charles Fletcher to consolidate and extend occupational research into the fresh field of social epidemiology.[108]

103. NA POWE 8/216, Health Advisory Committee minutes of the 52nd Meeting, March 14, 1938.

104. NA, FD1, "Medical Research Council: Pulmonary Disease Among Coal Miners: Statement of the Problem," November 24, 1936.

105. NA, FD1 /2885, E.L. Middleton to Secretary of SWMF, July 3, 1937.

106. NA, FD1 /2888, "Investigation into Chronic Pulmonary Disease in the South Wales Coal-Field," June 15, 1939; and FD1 /2889, Harris to Middleton, September 4, 1939.

107. NA, FD 1/2895, Middleton to D'Arcy Hart, January 28, 1943.

108. NA, FD 1/2896 T. D. Jones of Cardiff threatened legal action for the misrepresentation of his views. FD 1/2904, Departmental Committee on Pneumoconiosis, C. M. Fletcher to Edward Mellanby, August 5, 1947. Hunter Papers, manuscript diary notes [most undated] HUN D 1/1, 1947: "Fletcher says that T. D. Jones was an unscrupulous fellow. Not only did he insist that the lung diseases of the South Wales mines is bronchitis derived from exposure in the Spakes [carriages] . . . but he wished to prejudice the MRC effort. 'I've got the best dust lab in the world. Come to me and do all your dust counts there.'"

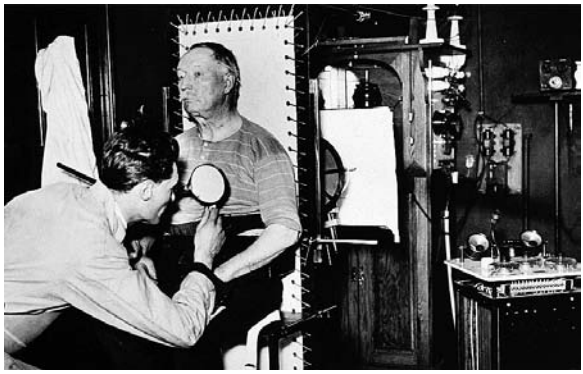


Figure 1. A seated man is attached to equipment by a technician to have an X-ray taken. Photograph c. 1925. Wellcome Library, London.

Conclusions

Medical historians have explored in depth the lethal history of dangerous trades, including those that threatened the environment of particular communities as much as those employed in hazardous production. Minerals such as silica are the most commonplace of earth's substances, posing a serious threat to the human body only when eroded or ground to sizes that permit absorption into sensitive organs, usually in confined spaces and for prolonged periods. Even as the frontiers of industrial capitalism advanced across the globe in the past century, pulmonary disorders such as pneumonia, bronchitis, and tuberculosis remained much more prevalent in urbanized societies than lung diseases connected to workplace dust. The sound of coughing and labored breathing must have been commonplace among migrant populations and the settled poor who crowded into cramped domestic spaces. Nor were the mature industrial economies necessarily the most affected by dust, for South African mining demonstrated that developing, as well as advanced, economies harbored dangerous dusts where communities became nodal points in the extraction of mineral and other natural resources using powered tools.[109] Migration itself represented one feature of the movement of production factors as labor was purchased across national boundaries when the booms and busts of market forces drew armies of mineworkers from depressed Cornwall and rural Africa to Transvaal and Australia, dispatching many back home with savings and congested lungs to die in their homelands.

109. Packard, *White Plague, Black Labor* (n. 14), 5–19. McCulloch and Tweedale, *Defending the Indefensible* (n. 27), 325, provides a critical survey.

Recent research in the history of occupational disease and environmental hazards has highlighted the agency of victims of toxic poisoning, labor activists, and communal associations in forming a critical response to the corporate power of business enterprise. Drawing on practical understanding of everyday risks and the collective impact of hazards on the lives of local communities, workers and others forged "lay" epidemiology in active resistance to scientific orthodoxy that so often underwrote existing production systems. Michael Bloor's interpretation of pneumoconiosis campaigns of the 1930s offers a model of class mobilization and collective ethics that, in part, inspired radical public health reforms in the 1940s. Similarly, David Rosner and Gerald Markowitz's work on America and Angela Vergara's on Chile show how popular movements were essential in transforming the political understanding of workplace dangers at a period when some scientists promoted an amoral standard of scientific objectivity which uncoupled intellectual responsibility from political engagement.

This scholarship provides a compelling interpretation of workers' agency in struggles for health and highlights the neglected contribution of activists such as Fred Swift in revising scientific orthodoxy that had privileged silica as uniquely hazardous. Such accounts are necessarily composed to retrieve and accentuate particular moments in the development of intelligence about different diseases, and they frequently form part of a larger heroic narrative of class struggle in which victims of negligent management and of corrupt or dilatory officials succeed in bringing industrial hazards to public attention. Although historians sometimes suggest a sharp disjuncture between the world of popular and scientific expertise, it is noticeable that scientists have also contributed to this radical vision of the battle against dust. The personalities involved in the MRC study achieved some celebrity in the 1940s and again in the 1990s when the scientific community that gathered around the famous Llandough Unit reassembled to commemorate their historic mission. The role of X-ray technology was placed alongside an engagement with local populations by D'Arcy Hart in a significant commentary on the original MRC study that employed a vocabulary familiar to Marxisant social historians of the post–War era.

> I am going to try to rescue from threatened oblivion the initiative of the MRC some fifty years ago . . . at Ammanford . . . [there] was no x-ray setup there, we used a mobile van, Portable X-rays Limited, which trundled around the valleys, and it is amazing what beautiful x-rays they took for the period. . . . Anyway that was a great success. Also our history taking was very important and a great success. This was due to the remarkable memories of the miners.[110]

110. Philip D'Arcy Hart, "Chronic Pulmonary Disease in South Wales Coal Mines: An Eye-Witness Account of the MRC Surveys (1937–1942)," *Soc. Hist. Med.* 11 (1998): 459–68, quotation on 462.

The generation that had been responsible for identifying silica (including Haldane, Collis, and Legge) had a keen sense of their place in the history of occupational health. Within a decade a new group of researchers, including Fletcher, D'Arcy Hart, and Cochrane, was revising that history as well as the terms of the diagnoses for pneumoconiosis as they struggled to establish a new institutional base for their research in south Wales

It has been argued in this article that collective alliances as well as historical narratives reflect the concerns of different people at distinct moments and that their construction should be understood as strategic testimonies in which competing moral imperatives are evoked by the activists who articulate the concerns of their constituents. They do not represent a consistent or predetermined response of classes to the experience of production. For communal relationships and political consciousness in Somerset and north Wales slate districts were quite different from those seen in the "Five Fatal Valleys" of south Wales, but their contribution was significant, as was the work of tuberculosis campaigners across Wales and Britain.

The introduction and use of different technologies are also presented in heroic narrative forms, as historians of science and technology often remind us. One senior physician at the London hospital where much pioneering work on occupational diseases was undertaken claimed as early as 1941 that the application of radiological method to the study of the lungs some thirty years before led to precise diagnoses rather than intelligent guesswork.[111] Such assessments exaggerated both the pace of change and the significance of this technology, which was not employed on a scale comparable to South Africa until at least the 1940s. Britain served as a cradle for scientific intelligence on dangerous dusts as well as industrial technologies, Haldane's Cornish research distinguishing the impact of "bad air," bacteriological agents (including ankylostomiasis), and mineral dust which had so often confounded investigations of miners' illnesses. It remains a puzzle that the United Kingdom should have trained so many colonial luminaries who later figured in research on workplace dust without engaging in the mass radiological surveys which enabled southern Africa to gain international recognition for the analysis and classification of silicosis by the 1930s. Even then, inconsistencies of technique and interpretation are indicated by Sydney Fisher's call as

111. Arthur J. Amor, *An X-Ray Atlas of Silicosis* (Bristol: John Wright & Sons and Simpkin Marshall, 1941), xi–xii. Wilson Jameson was dean of the London School of Hygiene and Tropical Medicine.

late as 1950 for a standardization of X-ray photographic and assessment techniques.[112]

Even more fundamental than problems of technical standards was the difficulty of securing resources for major X-ray programs in industries that were declining and marginal (such as metal mining, refractories, and even slate), or facing intense competition and steady contraction as new investment failed in aging industrial regions (as in coalmining and potteries). Employers' resistance to participation in industrial schemes of examination and compensation could cripple even urgent initiatives, though their stubborn resistance drew sustenance from the scepticism of scientists such as Haldane. It has been argued in this article that the application of X-ray techniques to the investigation, diagnosis, and treatment of pulmonary disease among Britain's industrial workers can be usefully located within a larger context of economic change and institutional bias. Roentgen rays were introduced in an era of rapid technological and organizational change within the capitalist economies that introduced rock drills which opened up the Rand goldfields and laboratory science permitting precise measurements of human respiration undertaken by physiologists such as Haldane. The appearance of techniques such as radiography and the growth of radiological investigation challenged existing divisions of labor within medical science at a time when pneumatic tools were disrupting artisan methods of working in mining and other sectors. The dense network of professional and occupational relations were affected by innovation, extending from the manual workface to expert committee rooms where technical details were decided and courts where forensic evidence was disputed. One reason for Haldane's remarkable influence in the dust debates was his ability to bestride the terrain of theoretical physiology and the "practical" world of mine engineering, communicating across disciplinary frontiers that often witnessed bitter hostilities between embattled groups of rival scientists.

Conflicts over the uses of X-ray technology alert us to the importance of interest groups and the institutions which sustained their influence. Those handling the new technology, the radiographers who exposed patients to roentgen rays and the radiologists who examined the expo-

112. Kenneth M. A. Perry, "Diseases of the Lung Resulting From Occupational Dusts Other Than Silica," *Thorax* 2, no. 2 (June 1947): 91–119, esp. 104; NA, POWE 8/199, "Minutes of Evidence: Taken Before the Royal Commission on Safety in Coal Mines: Monday 2 November 1938," for Fisher's reference to views expressed at the Johannesburg conference of 1930; Anon., "Recommendations for the Standardisation of Radiographs in Industrial Pulmonary Diseases: A Memorandum Prepared by the Radiological Sub-Committee," *Brit. J. Radiol.* 23 (August 1950): 272, 500–503, and Reiser, *Medicine* (n. 12), 190–92.

sures were particularly useful in delineating the distinctive fibrotic nodules which silica dioxide gradually inscribed on lung tissues attempting (by colloidal action) to seal off the toxic invasion. Far greater use of X-ray equipment was made by contemporary clinicians and others seeking to detect the onset of tuberculosis, or the resurgence of tubercular lesions who had contained the bacillus at an earlier point. Technical difficulties in establishing consistent standards of exposure and reliable interpretation of radiographic images remained a significant problem into the 1940s, more particularly when the vexed question of the relationship of tuberculosis to dust-related fibrosis was considered and symptoms which ranged from bronchitis to emphysema were discussed by doctors. Tracing the evidence of coal dust and explaining the literal "black spot" of serious fibrosis among anthracite miners in Wales, presented serious challenges even after the MRC began its comprehensive research survey of specific south Wales mining areas in 1937.

The institutional reform that gave fresh urgency to the dust problem and greatly complicated the discussion of relative risk was the introduction of workmen's compensation for industrial diseases in 1906 and the belated arrival of silicosis benefits from 1919. Legal claims in an adversarial system were initially confined to small groups of workers in unimportant trades, coupled with a contributory system of benefits funded by tariffs on employers in each trade. The scope of the compensation law was extended to colliery mine workers after 1928, though the system of medical refereeing was confined to a relatively small group of medical experts (later directed by Sutherland in the SMB), who examined the pathological evidence, collating testimony and ruling within the tight parameters of statutory schemes and legal requirements. The King case highlighted the difficulties of diagnosis even at postmortem, as well as the limited attention paid to earlier X-ray evidence of the Somerset miners. Compensation provisions were was framed around the principle that the worker's history should involve a measurable, physical proximity to silica-rich (more than fifty percent quartz) rock, rather than medical pathology or X-ray exposures which could be disputed and medical specialists realised that geologists were more likely than radiologists to appear as expert witnesses in such cases.[113]

The aim of this article is not to disregard the major contributions made by popular movements and key groups of medical professionals in

113. TUC Papers, 292/144.341/8, "Report of Meeting between Sir Thomas Legge and Miners' Federation on 13th March [1930], Re Miners' Silicosis"; also 292/144/34.1, W. C. Hancock to Legge, December 8, 1931.

the field of modern occupational health. The purpose is rather to locate these rival narratives and their heroic protagonists in a cultural history of silicosis that encompasses the struggles for the control of technologies in medical diagnosis as well as workplace production. The evidence presented here suggests not a stark polarity between scientific expertise and popular epidemiology but rather a dense, often heated, conversation about respiratory illnesses conducted in a crowded space by a diverse range of groups jostling to be heard. As we have seen, Haldane commended Fred Swift in August 1930 for first drawing attention to fatalities from silicosis in British collieries, visiting him as assiduously as Legge and Fisher.[114] In dispatching X-rays of diseased miners to civil servants in London Swift exposed the iniquities of a compensation system that denied them equal treatment with similar workers in other trades, though he took some risks in depending on the support of senior scientists such as Haldane whose own libertarian values led him to resist state regulation in favour of a "practical" rationale that embraced an orthodoxy viewing silica as uniquely dangerous.

Swift represented a coalfield that received far less attention from contemporary writers and historians who portrayed the tragic plight of Welsh valleys and the stubborn efforts of famous Labour personalities in the winning of pneumoconiosis reform and forging a new welfare politics in the 1940s. The disputes over dust diseases and the efficacy of X-ray techniques in detecting and conquering those shows how complex and varied were the disciplinary and cultural, as well as sectional and political, divisions around the compensation question. These struggles extended to the British research community and the imprint of sectional as well as solidarity battles may be found in the restrictions placed on the use of radiographic and radiological expertise at this time, as diagnostic verdicts were made by a group of specialists who were empowered to determining the precise etiology of occupational illness. The assumption that particular dusts might be fixed in space and time, microbes as well as minerals and manpower obeying simple rules of movement, were an essential fiction if liability was to be demonstrated. Radiography remained in the shadows partly because it illustrated in its own opaque products the difficulties and

114. SMA, box 6, Haldane to Swift, August 24, 1930. He added that the "investigation which we [the Health Advisory Board] caused to be made through official sources confirmed your reports." Haldane, "Silicosis and Coal Mining" (n. 6), 417, is based on this meeting. Miners Federation of Great Britain Annual Conference, July 11, 1932, *Annual Volume of Proceedings for the Year 1932* (London, 1933), 113, for Swift's speech; SMA, Council Minutes, Book 10, May 20, 1930 and June 10, 1930; SMA, box 6, Legge to Swift, July 30, 1930; SMA, box 6, Haldane to Swift, October 24, 1934; and SMA, Council Minutes, Book 11, June 1936.

subjective discretion required to read illness into delicate films. Deciphering coal dust stigmata was even more problematic though by the time the MRC Report was published, both the intellectual and political landscape had changed decisively in favour of extending compensation provision. In assessing the contribution of activists such as Swift to this transformation we need understand the critical and strategic choices made by the different groups with whom they negotiated, as well as commemorating the heroic quality of their selfless efforts to change history.

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