

# Introduction

During the late eighteenth and early nineteenth centuries, technological advance and industrial expansion introduced new challenges to the workplace. Within these changes, the emergence of dangerous and unhealthy conditions were perhaps some of the most immediate and threatening, and a ‘secret successful war’ was waged on the working population that brought ‘infirmity, sickness and death’, but nowhere were the perils more plentiful and oppressive than in mining.<sup>1</sup>

Underground labour was by its very nature dangerous and unhealthy. Miners risked death, injury and disease from a wide variety of hazards.<sup>2</sup> They performed repetitive and arduous movements in cramped conditions, and were exposed to rising water, unstable rock, uneven floors, vertical ladders and unprotected shafts in poorly illuminated, damp and unsanitary conditions. Mine air was vitiated with naturally occurring toxic and explosive gases, dust, smoke from oil lamps, tallow candles and tobacco, and often lacked sufficient oxygen to sustain hard physical activity. The small scale of early operations generally protected against major disasters.<sup>3</sup> Movement between occupations enabled the workforce to recover their strength and vitality, and isolated fatalities and sporadic injuries were largely accepted as incidental to the nature of mining labour.<sup>4</sup>

From the late eighteenth century, the exhaustion of shallow surface deposits, rising demand for fuel and raw materials and the application of gunpowder to rock removal and steam power to pumping and winding, all encouraged the mine owners to expand both the depth and scale of their operations. This ‘new era of deep, large scale extraction’ both exacerbated the hazards inherent in underground labour, and introduced new dangers of working with heavy machinery and chemical explosives.<sup>5</sup> Expansion of the workforce and the shift towards regular and more disciplined employment increased the numbers of workers at risk, and introduced lengthier and more sustained exposure to the hostile working environment. By the mid nineteenth century the life expectancy for a metalliferous miner was roughly 29 years, seven years less than the estimated 36 years for a collier. These figures

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<sup>1</sup> J. Rule, *The Experience of Labour in the Eighteenth Century* (London, 1981), p. 84.

<sup>2</sup> See G. Rosen, *The History of Miners’ Diseases: A Medical and Social Interpretation* (New York, 1943).

<sup>3</sup> M. Flinn with the assistance of D. Stoker, *The History of the British Coal Industry: Vol. II, The Industrial Revolution 1700–1830* (Oxford, 1984), p. 214.

<sup>4</sup> R. Burt, *The British Lead Mining Industry* (Redruth, 1987), p. 184.

<sup>5</sup> R. Burt, *A Short History of British Metal Mining Technology in the Eighteenth and Nineteenth Centuries* (Netherlands, 1982), p. 14.

compared unfavourably with mortality amongst agricultural labourers who lived for approximately 62 years.<sup>6</sup>

To address the problems of industrialized society the function and structure of government changed profoundly, and the early to mid nineteenth century witnessed increasing state regulation of labour in the textile and coal mining industries.<sup>7</sup> The aim of these early Acts of Parliament was the protection of women and children from unwholesome conditions, largely by their removal from the workplace.<sup>8</sup> As yet there was no regulation of the dangerous and unhealthy working environment, no government inspection of the workplace and no official record of occupational morbidity and mortality in either the metalliferous or coal mining sectors. The mine owners looked to the protection of their property and the adult male labour force was left ultimately responsible for both their occupational health and safety. In 1850, government intervened and a new era of safety regulation began.

The 1850 Act for Inspection of Coal Mines in Great Britain made provision for the appointment of executive officers and defined their duties, which were limited to an authority to inspect, draw attention to dangerous practices and conditions and suggest rather than enforce their prohibition.<sup>9</sup> It was a temporary measure of five years duration and, as the title of the Act suggested, it applied solely to coal mining and emphasized ventilation and the prevention of accumulations of methane. A code of general safe working practice and penalties for contravention followed in 1855 and, in 1860, jurisdiction of the law was extended to embrace ironstone wrought in conjunction with coal. By the 1870s, legislation had extended beyond the coal sector and the code of safe working practice had been comprehensively expanded. By the 1890s, all underground extractive industries, including quarrying, were subjected to varying degrees of regulation and control, and the Inspectorate had greatly expanded in numbers, experience and authority. Best managerial practice had been established and responsibility for the safety of the men was no longer implied, but clarified in law. In the opening decade of the twentieth century provisions to improve mine hygiene were incorporated into best practice in both sectors. On the eve of the First World War in 1914, the law operated in line with advances in science, technology and medicine, and the foundations of current health and safety law had been established.

During the first 20 years of regulation, the numbers of fatal injuries amongst colliers were held at a steady rate of roughly 1,000 accidents per year. This was a

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<sup>6</sup> Data sourced from the *Report of the Commissioners Appointed to Inquire into the Condition of All Mines in Great Britain to Which the Provisions of the Act 23 & 24 Vict. c. 151 Do Not Apply*, British Parliamentary Papers, 1864 (3389) (hereafter BPP *Kinnaird Commission*), Pt. II, Appendix B, III, 'Statistics and Evidence', pp. 154–6.

<sup>7</sup> O. MacDonagh, 'The Nineteenth Century Revolution in Government: A Reappraisal', *Historical Journal*, 1, 1 (1958), pp. 52–67 at 52–3.

<sup>8</sup> B. Hutchins and A. Harrison, *A History of Factory Legislation* (London, 1911).

<sup>9</sup> 14 & 14 Vict. c.100, An Act for Inspection of Coal Mines in Great Britain, 14 August 1850.

significant achievement considering that production and manpower doubled during the period.<sup>10</sup> Although there was marked regional variation, from 1872 onwards the overall trend in frequency of fatality was one of decline. The average rate of accident mortality fell from roughly 2.3 per 1,000 men employed underground per annum to 1.0 per 1,000 in 1914.<sup>11</sup> In contrast, the trend of decline was much less marked in metalliferous mining. Accident mortality fell from 2.4 per 1,000 men employed underground per annum to 1.6 per 1,000.<sup>12</sup> In terms of ill health, the Registrar General recorded that deaths from respiratory diseases affected colliers roughly one-fifth greater than in the wider labouring population, however, incidence of ‘constitutional diseases’ were less widespread, and it was claimed that the men were immune to tuberculosis.<sup>13</sup> Whereas in the metalliferous sectors, incidence of occupational respiratory disease continued to rise and the average working life of men drilling into hard rock was estimated at roughly eight years.<sup>14</sup>

Historical studies of government intervention in the welfare interests of labour have largely focussed upon the regulation of manufacturing in the late nineteenth and early twentieth centuries.<sup>15</sup> A second strand of analysis has concentrated on compensation policy initiatives, particularly in coal mining and the asbestos trades in the twentieth century.<sup>16</sup> More recently Ronnie Johnston and Arthur McIvor, using oral testimony, have placed coal miners’ bodies central to the study of

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<sup>10</sup> B. Job, ‘The British Mines Inspectorate: The Early Years 1850–1872’, *Mining Engineer* (April 1986), pp. 426–31 at 430–431.

<sup>11</sup> Data sourced from *Annual Reports of the Inspectors of Mines, 1872–1914*, British Parliamentary Papers (hereafter BPP *Inspectors of Mines*).

<sup>12</sup> *Ibid.*

<sup>13</sup> A. Bryan, *The Evolution of Health and Safety in Mines* (London, 1975), p. 110.

<sup>14</sup> *Report to the Secretary of State for the Home Department on the Health of Cornish Miners*, British Parliamentary Papers, 1904, Cd.2091 (hereafter BPP *Cornish Miners*), p. 18.

<sup>15</sup> For example see P. Bartrip, *The Home Office and the Dangerous Trades, Regulating Occupational Disease in Victorian and Edwardian Britain* (Amsterdam, 2002); B. Harrison, *Not Only the Dangerous Trades: Women’s Work and Health in Britain 1880–1914* (London, 1996); and C. Malone, *Women’s Bodies and the Dangerous Trades in England 1880–1914* (Woodbridge, 2003).

<sup>16</sup> See P. Bartrip, *The Way from Dusty Death, Turner and Newell and the Regulation of Occupation Health in the British Asbestos Industry 1890s–1970* (London, 2001); J. L. Bronstein, *Caught in the Machinery, Workplace Accidents and Injured Workers in Nineteenth Century Britain* (Stanford, 2008); M. Bufton and J. Melling, ‘“A Mere Matter of Rock”: Organized Labour, Scientific Evidence and British Government Schemes for Compensation of Silicosis and Pneumoconiosis amongst Coalminers, 1926–1940’, *Medical History*, 49 (2005), pp. 155–78; J. McCulloch, *Asbestos Blues: Labour, Capital, Physicians and the State in South Africa* (Oxford, 2002); and G. Tweedale, *Magic Mineral to Killer Dust: Turner and Newell and the Asbestos Hazard* (Oxford, 2000).

occupational respiratory diseases.<sup>17</sup> Although the 1842 Mines and Collieries Act, which prohibited female and regulated child labour underground has provided the backdrop for study of women as gendered subjects in the workplace,<sup>18</sup> the history of health and safety regulation of the British mining industry is a much-neglected field of academic research and current knowledge is sparse.<sup>19</sup> The introduction, development and operation of law have generally been discussed as part of the wider history of the coal industry, with little reference to either mine hygiene or the regulation of the metalliferous mining sectors.<sup>20</sup> Moreover, there has been no significant attempt to explain the piecemeal pattern and chronology of development, why government appeared to prioritize the safety of the collier until the early twentieth century, and why regulation appeared to have had a much greater impact on rates of occupational mortality amongst colliers than metalliferous miners. Existing studies of mining reform largely provide limited chronological narratives that simply emphasize modernization as an explanation for historical events.<sup>21</sup>

The origins of Victorian social reform have been broadly interpreted as Tory, motivated by an ethic of social responsibility, or radical, and as Dicey first argued in 1905, essentially a Benthamite inspired response.<sup>22</sup> In contrast, Oliver MacDonagh has asserted that the adoption of new responsibilities by the state was an independent historical process and impervious to both human agency and

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<sup>17</sup> R. Johnston and A. McIvor, *Miners' Lung: A History of Dust Disease in British Coal Mining* (Aldershot, 2007).

<sup>18</sup> A. V. John, *By the Sweat of their Brow: Women Workers at Victorian Coal Mines* (London, 1984); J. Humphries, 'Protective Legislation, the Capitalist State and Working Class Men: The Case of the 1842 Mines Regulation Act', in R. E. Pahl (ed.), *On Work: Historical, Comparative and Theoretical Approaches* (Oxford, 1988), pp. 95–124; and B. Job, 'Women Workers at the British Collieries and the Mines Inspectors', *British Mining*, 59 (1997), pp. 14–31.

<sup>19</sup> Bartrip, *Dangerous Trades*, p. 1.

<sup>20</sup> R. Nelson Boyd, *Coal Mines Inspection: Its History and Results* (London, 1879); Bryan, *Health and Safety*; O. MacDonagh, 'Coal Mining Regulation: The First Decade 1842–1852', in R. Robson (ed.), *Ideas and Institutions of Victorian Britain: Essays in Honour of George Kitsen Clark* (London, 1967), pp. 58–86; D. Morrah, 'A Historical Outline of Coal Mining Legislation', in *A Historical Review of Coal Mining* (London, 1947), pp. 301–20; and L. Telkey, *The History of Factory and Mine Legislation* (London, 1948).

<sup>21</sup> See, for example, Boyd, *Coal Mines Inspection*; Bryan, *Health and Safety*.

<sup>22</sup> A. V. Dicey, 'The Debt of Collectivism to Benthamism', *Lectures on the Relation between Law and Public Opinion in England during the Nineteenth Century* (London, 1905). This line of thinking was further developed by J. B. Brebner, in 'Laissez Faire and State Intervention in Nineteenth Century Britain', *Journal of Economic History*, VIII (1948). Also see J. W. Aydelotte, 'Conservative and Radical Interpretations of Early Victorian Social Legislation', *Victorian Studies* (December 1967), pp. 223–36, at 227; and V. Cromwell, 'Interpretations of Nineteenth-century Administration: An Analysis', *Victorian Studies* (March 1966), pp. 245–55.

contemporary political and ideological philosophies.<sup>23</sup> Adopting a phased model, he suggested that government intervened only when it was obliged to do so by exposure of events or circumstances that were intolerable to society, such as the condition of underground female and child labour. Once government proposed a legislative remedy, endangered interests brought their political influence to bear and forced a compromise that culminated in an emasculated law that was insufficient to remove the original abuse, but with potential for widening state regulation.<sup>24</sup> This released a 'runaway train' of accumulative expansion. The key step was the appointment of executive officers, followed by additional statutory controls based both upon their day-to-day practical experience of upholding an inefficient law and their burgeoning knowledge and authority. Finally an awareness was reached that a 'grand piece of legislation' would not offer a satisfactory remedy, and regulation had to be understood as a dynamic process of 'closing the loopholes', 'tightening the screw ring by ring' and steadily extending the jurisdiction of the law.<sup>25</sup>

The model, according to MacDonagh, offered a convenient description that would provide perspective, stimulate thought and further the understanding of government growth.<sup>26</sup> Nonetheless, it attracted substantial debate and criticism, most notably the question of 'intolerability' and the notion of history as a process.<sup>27</sup> In 2002, Peter Bartrip briefly revisited MacDonagh's theory suggesting that the regulation of the dangerous trades in Victorian and Edwardian Britain was part of a 'process of factory regulation' and in that sense paralleled the model.<sup>28</sup> The emphasis that MacDonagh placed on the significance of the exposure of intolerable circumstances, the importance of inspection in preparing the ground for subsequent interventions and the ad hoc piecemeal development of social policy is particularly pertinent to this study of mining reform. Moreover, the model provides a sufficiently adaptable framework for a multi-dimensional approach that exposes and untangles the complex and dynamic forces that determined the chronology of health and safety reform of the mining industry, and subsequently shaped its nature and its historical development. The result is an interesting revision on the notion of linear progress that penetrates far beyond the surface of modernization as a force of change, that reveals continuities with current themes in twentieth-century histories of occupational health that owe their origins to the changing nature and frequency of risk that followed in the wake of industrialization.

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<sup>23</sup> MacDonagh, 'Revolution in Government', pp. 52–67.

<sup>24</sup> *Ibid.*, p. 58.

<sup>25</sup> *Ibid.*, p. 60.

<sup>26</sup> *Ibid.*, pp. 61 and 67.

<sup>27</sup> For examples see H. Paris, 'The Nineteenth-Century Revolution in Government: A Reappraisal Reappraised', in P. Stansky (ed.), *The Victorian Revolution: Government and Society in Victoria's Britain* (New York, 1973); and J. Hart, 'Nineteenth Century Social Reform: A Tory Interpretation', *Past and Present* (July 1965), pp. 39–61.

<sup>28</sup> Bartrip, *Dangerous Trades*, p. 286.

This study both revisits and revises the familiar story of colliery reform and draws upon both a wide range of rich source material relating to both mine hygiene and the regulation of the metalliferous sectors, including Parliamentary Papers and the largely untapped Annual Reports of the Mines Inspectors, to offer a comprehensive account of the historical development and operation of health and safety law in the nineteenth and early twentieth centuries. A mix of chronological narrative and analysis of industry, government and labour interests reveal the competing socio-economic, environmental, medical, technical and cultural tensions from which policy initiatives emerged, developed and operated. The emphasis on metalliferous mining, in particular the Cornish non-ferrous sector, provides a unique opportunity to illustrate the effects of sustained labour in hard siliceous rock, and facilitates exploration of the impact of industrial decline and traditions of independent working on the implementation, operation and development of the law.

The extent to which industry and the state were culpable for bodily damage resulting from exposure to hazardous working conditions has attracted vigorous debate amongst scholars researching occupational health histories of labour. On the one hand historians, such as Geoffrey Tweedale, and Gillian Burke and Peter Richardson, suggest that health was knowingly sacrificed for profit.<sup>29</sup> On the other hand, Bartrip, in particular, has argued that given the scope of industrial medicine at the time little more could have been done to protect the workforce.<sup>30</sup> This study largely adopts the middle ground. It is suggested that intervention was not a simple response to high occupational mortality, but influenced by a variety of factors, such as visibility of risk and the extent of understanding and acceptance of medical knowledge, as argued for by Bartrip, and a combination of public sympathy, trade union activism and political responsibility, recently suggested by Bronstein.<sup>31</sup> This study also demonstrates that it is necessary to consider legal precedents, the responses of the workforce and the economic performance of the industry and, challenging MacDonagh's model, contemporary thinking in political economy must be taken into account even above the brief mention it is accorded by Bartrip.<sup>32</sup> Moreover, apportioning blame for damaged bodies is by no means as clear or as straightforward as the literature suggests, and culpability for injury and disease

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<sup>29</sup> For example see S. Bowden and G. Tweedale, 'Mondays without Dread: The Trade Union Response to Byssinosis' in the Lancashire Cotton Industry in the Twentieth Century', *Journal of the Social History of Medicine*, 16, 1 (2003), pp. 79–95; G. Tweedale and P. Hansen, 'Protecting the Workers: The Medical Board and the Asbestos Industry 1930s–1960s', *Medical History*, 42 (1998), pp. 439–57; and G. Burke and P. Richardson, 'The Profits of Death: A Comparative Study of Miners' Phthisis in Cornwall and the Transvaal 1876–1918', *Journal of South African Studies*, 4, 2 (1978), pp. 147–71.

<sup>30</sup> P. Bartrip, 'Too Little too Late? The Home Office and the Asbestos Industry Regulations 1931', *Medical History*, 42 (1998), pp. 421–38.

<sup>31</sup> Bartrip, *Dangerous Trades*, pp. 1–29 and Bronstein, *Caught in the Machinery*, p. 6.

<sup>32</sup> Bartrip, *Dangerous Trades*, p. 249.

often rested not just with the 'gatekeepers' of reform, but with an individualistic and self-sufficient labour force.

The study contains a timeline of major accidents, government inquiries, Bills and Acts of Parliament referred to in the text. The aim is not to provide an exhaustive list but to minimize excessive detail, particularly as some events and circumstances are referred to more than once. The opening chapter 'Industrialization and the Frequency and Perception of Risk' suggests that deep mining and associated technological advances introduced new dangers to the workplace, but also exacerbated the scale and frequency of hazards already inherent in underground labour. No one particular hazard was confined exclusively to either coal or metalliferous mining. Differing working methods and local geological factors, however, produced variations in the scale, frequency and nature of hazards between the two sectors. Unstable strata and particularly methane posed great danger to the collier. Methane occurs naturally, burns readily in air and is explosive in certain critical mixtures.<sup>33</sup> Without warning, the colliery, its machinery and manpower, often across several generations, were destroyed and production was brought to a standstill in a single explosion. In contrast, minor injuries, disability, chronic respiratory disease (a particular problem for the non-ferrous miners men working hard siliceous rock) and isolated deaths in both sectors of the mining industry were overshadowed by the immediacy and drama of colliery explosions. Health and safety reform of the mining industry, as MacDonagh assumed, owes its origins to these changes in the frequency and nature of occupational risk, but also to the marked differences in the visibility of hazard.

Chapter 2 charts the rise of a reforming interest. It establishes who they were and reveals how their early interest in mining safety was motivated by the increase in the frequency and changes in the nature of occupational hazards that followed on from industrialization, and examines their pioneering struggles. Much of their activity revolved around the most dramatic and visible of risks: colliery explosions in the coal mining sector. In contrast to MacDonagh's model, however, 'public intolerability', the pump primer of reform, did not automatically follow on from the public awareness of a social evil and neither was it man's instinctive reaction to seek an immediate legislative solution. It is suggested that demand for government intervention only emerged in strength when practical and voluntary solutions failed, and Lord Ashleigh's successful campaign to regulate underground child and female labour established a legal precedence of government interference in the mining industries in 1842.

Chapter 3 highlights the positive contributions made by organized colliery labour towards securing safety concessions in the workplace, particularly when their role is considered in comparison with the non-ferrous metalliferous miners' independence and 'quietude'. The colliers' brought a sense of urgency, if not legitimacy, to the established campaign for safety, but they also began to challenge the narrow emphasis on ventilation with demands for a more comprehensive code

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<sup>33</sup> The explosive range falls roughly between 5–15 per cent of methane in air.

of safer working practice. Although labour and the reforming interest largely operated independently of each other, by default rather than by design, together they trapped government in a pincer movement and pushed the then Home Secretary, Sir George Grey, to a point of no return. In August 1850 the government Bill for an advisory system of safety inspection became law. Correspondingly, Grey took the opportunity that staunch individualism and self-sufficiency amongst the metalliferous men offered to ignore the deterioration in their occupational mortality; a strategy in which they willingly colluded.

It is suggested in Chapter 4, ‘Intervention in Coal Mining, 1850–1887’, that as weaknesses and deficiencies in the 1850 Act were exposed by its day-to-day operation, the Home Office responded to demands for strengthened and additional intervention either by adopting their familiar defence of information gathering or at best by nominally ‘plugging the gaps’. There was no guarantee that evidence of risk or a recommended means of prevention would result in regulation, particularly if it was likely to result in controversy. Government adopted the line of least resistance, treading a fine line between appeasing labour whilst protecting strategic interests. This somewhat challenges the benign interpretation of Home Office responses argued for by Bartrip,<sup>34</sup> but neither does it sit entirely comfortably with assertions of neglect.<sup>35</sup> Until every occupational hazard, legal loophole and administrative difficulty had been accepted, understood and comprehensively remedied, the law would fail to meet optimistic expectations, tragedies would continue to occur and so the process was repeated. This resulted in a slow ad hoc process of expansion and development of the law, in which labour is again attributed a strong role. Moreover, although the piecemeal expansion and extension of the law broadly parallels MacDonagh’s model, there was no perfect fit with the predicted order.

The regulation of the metalliferous sector is central to the discussion in Chapter 5. It is suggested that the appointment in 1862 of a Royal Commission inquiry into the condition of all mines that were excluded under current colliery law was a response by the Home Office to settle a controversial point raised in debate and represented their established policy of information gathering rather than a commitment to reform. The Commissioners recommended the introduction of safer and healthier working practices that would undoubtedly improve general conditions but they were hindered by limited medical knowledge and swayed by erroneous expert opinion and failed to establish the association between dust and miners’ phthisis (silicosis); the primary cause of high rates of occupational mortality amongst the metalliferous miners. Nevertheless, the Commission exposed the widening gulf in regulation between the two sectors which government struggled to both justify and sustain, and the chairman of the Commission, George Kinnaird, fought a hard and isolated battle against apathy and resistance from not just from

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<sup>34</sup> Bartrip, *Dangerous Trades*, p. 284.

<sup>35</sup> For example see Burke and Richardson, ‘The Profits of Death’; Bowden and Tweedale, ‘Mondays without Dread’; and Tweedale and Hansen, ‘Protecting the Workers’.

the Home Office but also labour and the industry, and in 1872 the metalliferous sectors were finally brought under the expanding umbrella of colliery reform.

Chapter 6 reveals that metalliferous mining regulation both reflected erroneous expert medical opinion and largely resembled current colliery law both with the removal of measures specific to the prevention of major disasters and those the Home Office simply viewed as unwarranted, such as the certification of managerial staff. Although the law would undoubtedly improve working conditions, it would make very little impact on the incidence of miners' phthisis. According to MacDonagh's model of social progress weak and limited intervention provides the foundations for a process of accumulative expansion of the original law as legal loopholes and administrative deficiencies are exposed and remedied.

Reform of the metalliferous sector had largely been driven by institutional expansion in coal mining and not in response to public pressure for intervention, and consequently there was very little expectation of change. Moreover, as industrial decline accelerated, many metalliferous mining companies were simply unable to afford the cost implications of reform. These factors both hindered the effective operation of the law and resulted in an already badly flawed body of legislative controls remaining fundamentally unchanged in the period 1872 to 1914, and subject only to administrative amendments and supplementary Acts that both originated in and were largely driven by the economically dominate coal sector.

Chapter 7, 'Scientific, Technological and Medical Advances', reveals both how reform became more evidence based, and the Home Office more proactive, as the nineteenth century drew to a close. This resulted in a more effective body of legislative regulation and control in both the coal and metalliferous mining sectors and was primarily motivated by dominant concerns in the wider political and economic arenas, suggesting that MacDonagh's notion of a historical process was not as impervious to extraneous influences as he had originally envisaged.

Prominence is given to two key developments; the recognition and acceptance of both the explosive characteristics of coal dust and its role in exacerbating the frequency and magnitude of explosion; and the aetiology and natural progression of miners' phthisis. Although not the most frequent cause of accidental death in the collieries, the reduction of explosive risk was the yardstick by which contemporaries measured success. The new emphasis upon laboratory experiment and fieldwork predictably concentrated on resolving the controversy surrounding coal dust and exploring effective methods of preventing explosion. The discovery that spreading stone dust minimized the risk fed into the growing anxieties surrounding the rising rate of mortality from respiratory disease amongst the non-ferrous miners at home and abroad, and the mining industry capitalized upon recent developments in the field of industrial medicine, particularly in relation to the dusty factory floor.

The final chapter, 'Hazards and Heroics', explores the responses of labour to an increasingly regulated environment. Central to the discussion are the non-ferrous metalliferous miners, the Cornish in particular. The unique method of wage payment and structural organization of the sector entrenched notions of fierce

independence, self-sufficiency and a rigid adherence to tradition that hindered the development of effective reform. Moreover, the individualized nature of hazard in combination with piecework fostered a culture of risk-taking behaviour, and an indifference to danger that ultimately sabotaged the effective operation of the law. Without widespread recognition of the need to challenge workplace attitudes, customs and behaviours, legislative control, however stringent, evidence-based and financially supported by the industry, would only ever be of limited value in ensuring that the non-ferrous men laboured in a safe and healthy working environment.

Behind the assumptions of progress portrayed in the historical literature lie a series of pragmatic and often tardy responses by the state. There was no firm commitment to health and safety reform until the late nineteenth century. Government intervened only when it was obliged to do so in order to meet sustained and persistent demands for remedial action, and protect strategic economic interests. Rousing and sustaining demand for change, and shaping the direction and emphasis of government research and intervention, was the highly visible and dramatic nature of colliery explosions, which broadly parallels the first phase of MacDonagh's model. Where these key determinants of reform were weak or absent and occupational risk less visible, government adopted an attitude of indifference towards the welfare of labour. The invisibility of single fatalities and occupational disease to humanitarian concern leaves MacDonagh's concept of 'public intolerance' intact. The ad hoc process of amendment and consolidation of the law, as deficiencies and legal loopholes were slowly exposed, similarly corresponds, albeit rather loosely, with the final phases of his model.

The social consequences of industrialization may have released a runaway train of social progress, but man steered its course, and determined its final destination. The significant role organized labour played in determining the early chronology and nature of colliery regulation and the subsequent actions of key players, such as George Kinnaird, challenges MacDonagh's dismissal of human agency. Moreover, the shift in emphasis towards a more proactive evidence-based safety regulation and the emergence of mine hygiene initiatives motivated by both anxieties surrounding the longevity of coal supply and the quest for national efficiency disputes the notion of a historical process that was impervious to philosophical and ideological forces.

The effectiveness of government intervention in reducing rates of occupational mortality was determined by the recognition of workplace hazards; the ability of science, technology and medicine to provide an equivocal guide on which to base effective regulation and control; and the ability of the industry to bear the cost implications of reform. Protective labour legislation, however rigorously evidenced-based, was of limited value in ensuring a safe and healthy working environment without the understanding and compliance of management and the men alike.