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Scottish chemistry, classification and the early mineralogical career of the 'ingenious' Rev. Dr John Walker (1746 to 1779)

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Abstract. The Rev. Dr John Walker was the Professor of Natural History at the University of Edinburgh from 1779 to 1803. Although his time in this position has been addressed by several studies,[1] the previous thirty years that he spent 'mineralizing' have been virtually ignored. The situation is similar for many of the well-known mineralogists of the eighteenth century and there is a lack of studies that address how a mineralogist actually became a mineralogist.[2] Using Walker's early career as a guide, this essay seeks to detail the making of an eighteenth-century Scottish mineralogist. The time frame under examination begins with Walker's matriculation at the University of Edinburgh in 1746 and it ends with his being appointed professor in 1779. The first section demonstrates that Walker's early mineralogical education at the Medical School and under William Cullen was closely linked to chemistry. The second section shows how he used chemical characters to classify minerals and to criticize the systems of Linnaeus, Da Costa, Wallerius and Cronstedt. Because Walker needed many 'fossil' samples to test the viability of his chemical mineralogy, the final section details how he used tours, patrons and correspondents to build his mineral collection.

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1 Walker's time in this position has been detailed in M. D. Eddy, 'Merely a natural history of the Earth: geology, mineralogy and time in John Walker's University of Edinburgh Natural History Lectures', *History of Science* (2001), **39**, 95–119; C. W. J. Withers, 'Improvement and enlightenment: agriculture and natural history in the work of the Rev. Dr. John Walker (1731–1803)', in *Philosophy and Science in the Scottish Enlightenment* (ed. Peter Jones), Edinburgh, 1988, 102–16; G. Taylor, 'John Walker, D.D., F.R.S.E. 1731–1803. Notable Scottish naturalist', *Transactions of the Botanical Society of Edinburgh* (1959), **38**, 180–203; John Walker, *Lectures in Geology – Including Hydrography, Mineralogy, and Meteorology with an Introduction to Biology by John Walker* (ed. H. W. Scott), London, 1966.

2 Studies that address the actual practice of seventeenth- and eighteenth-century mineralogy in detail are few. Some of the following sources, however, give a helpful overview: H. Torrens, 'Early collection in the field of geology', in *The Origins of Museums: The Cabinet of Curiosities in Sixteenth- and Seventeenth-Century Europe* (ed. O. Impey and A. MacGregor), Oxford, 1986, 204–13; W. E. Wilson, 'The history of mineral collecting 1530–1799', *Mineralogical Record* (1994), **25**, 1–264; W. C. Smith, 'Early mineralogy in Great Britain and Ireland', *Bulletin of the British Museum (Natural History), Historical Series* (1978), **6**, 49–74; A. Livingstone, *Minerals of Scotland: Past and Present*, Edinburgh, forthcoming 2002.

Educating a 'fossilist' (I): the University of Edinburgh

Walker was born in 1731 and studied at the University of Edinburgh from 1746 to 1749. Although his official course was Divinity, he also studied natural philosophy, chemistry and possibly botany. During this time, the word 'mineral' and 'fossil' were used interchangeably to describe objects that were dug out of the ground. Such a broadly based definition meant that a range of fields like metallurgy, chemistry, georgics and pharmacy influenced mineralogy. As Scotland had no mining academies, mineralogy was actually treated in the *materia medica* and chemistry course offered in the Medical School – particularly in the lectures of Charles Alston,[3] Andrew Plummer and, later, William Cullen. By the mid-1750s, Edinburgh's Medical School had become one of the best places in Britain to learn mineralogy. As many of the professors had studied under Herman Boerhaave at the University of Leiden,[4] they used experimental chemistry to examine biological processes and to develop new pharmaceuticals.[5] The chemical language and characters used in their experiments exerted a strong influence on the practice of botany and mineralogy at the University for the entire century.

Nowhere is the influence of chemistry more clear than in a manuscript written sometime after 1795. Entitled *Systema Fossilium*, it presented Walker's classification of 'fossils' and was based on research that he had conducted over the past fifty years. In its introduction he recounts his early mineralogical education:

> I began to collect Fossils in the Year 1746 when attending the Natural Philosophy Class, and was first led to it, by the Perusal of [Robert] Boyle's Works, and especially his Treatise on Gems … [I] often traversed the Kings Park, the Sea Shores between Crammond & Musselburgh, and visited the Quarries & Coalleries near Edinburgh, but had not Book at the Time, to direct [me] concerning the Species of Fossils, but Woodward's Catalogues. After studying the Works of Boyle, Becker, Stahl, Boerhaave, & some others, I attended Dr. Plummer's Course of Chymistry in the Year 1749, and became still fonder of Mineralogy.[6]

This quotation shows that Walker's first taste of mineralogy was inspired by the natural philosophy course taught by Robert Steuart (1675–1747) in 1746.[7] This led him to read

3 For instance, see Alston's *Lectures on the Materia Medica Containing the Natural History of Drugs, their Virtues and Doses: also Directions for the Study of the Materia Medica; and an Appendix on the Method of Prescribing/Published from the Manuscript of the Late Dr. Charles Alston … by John Hope*, London, 1770.

4 These men are treated in E. A. Underwood, *Boerhaave's Men at Leyden and After*, Edinburgh, 1977.

5 R. G. W. Anderson, 'Chymie to chemistry at Edinburgh', *Royal Society of Chemistry Historical Group Occasional Papers* (2000), **2**, 1–28. The chemical aspects of Edinburgh's pharmacological scene are specifically treated in A. H. Maehle's *Drugs on Trial: Experimental Pharmacology and Therapeutic Innovation in the Eighteenth Century*, Amsterdam, 1999.

6 John Walker, *Systema Fossilium*, Bound MS, Glasgow University Library (subsequently GUL) GB 247, MS Gen 1061 (1795 Watermark), f. 2. The introduction to this manuscript (which contains the above quotation) was republished over twenty years later as 'Notice of mineralogical journeys, and of a mineralogical system, by the late Rev. Dr. John Walker, Professor of Natural History in the University of Edinburgh', *Edinburgh Philosophical Journal* (1822), **6**, 88–95.

7 This is the same Robert Steuart (also spelled Stewart) who taught David Hume and who founded 'The Physiological Library'. See M. Barfoot, 'Hume and the culture of science in the early 18th century', in *Studies in the Philosophy of the Scottish Enlightenment* (ed. M. A. Stewart), Oxford, 1990, 151–90.

Robert Boyle's collected works (which included his treatise on gems),[8] John Woodward's *An Attempt Towards a Natural History of Fossils of England*,[9] John Becher's *Physica Subterranea*,[10] George Stahl's *Philosophical Principles of Universal Chemistry*,[11] and Herman Boerhaave's *Elements of Chemistry*.[12] Save for Woodward, all of these books were written by chemists. Having read these sources, Walker then attended the lectures of Andrew Plummer (d. 1756), the professor of chemistry in the Medical School. In addition to attending Plummer's lectures, it is quite possible that he also attended the *materia medica* course of Charles Alston (1683–1760).[13] Yet, aside from teaching Walker the basics of chemistry and natural philosophy, there is no convincing evidence that Plummer, Alston or Steuart had any significant influence on his early mineralogy.

Based on Walker's comments in his *Systema Fossilium* and on several other extant manuscripts from early in his career (to be discussed in the next section), it can be seen that his initial conception of mineralogy was shaped by what he read in the books written by Boyle, Woodward, Becher, Stahl and, to an extent, Boerhaave. However, the mineralogical classification promoted by these chemists or mineralogists was inconsistent. Since chemical nomenclature and vocabulary were not standardized until the end of the eighteenth century,[14] each of these authors had a slightly different approach to mineralogy. For instance, Stahl based his system on chemical characters, while Woodward only used chemistry when physical characters were not enough. To make matters even more confusing, there were three different approaches to chemical classification being employed: (1) Aristotelian Elements (earth, water, fire and air), (2) Paracelsian *Tria Prima* (sulphur, mercury and salts) and (3) the five-principle system (salts, inflammables, water, earths and metals). Despite these different forms of chemistry, Walker's sources listed above do agree on the general assumption that the concept of an 'earth' is central to any credible mineralogical arrangement.

During Walker's student years, there were generally two different conceptions of the word 'earth' (or *terra*). The first referred to the matter traditionally associated with the word 'soil'. I shall use the lower-case form of 'earth' to connote this meaning. The second conception of earth was more philosophical. It referred to the one of four primary substances that made up all rocks and stones. I shall use an upper-case term – 'Primary

8 Robert Boyle, *The Philosophical Works of the Honourable Robert Boyle Esq.*, 2nd edn. (ed. Peter Shaw), London, 1738.

9 John Woodward, *An Attempt Towards a Natural History of the Fossils of England, in a Catalogue of the English Fossils in the Collection of J. Woodward, M.D.*, London, 1728–9.

10 Johann Joachimi Beccheri, *Physica Subterranea – Profundam Subterraneorum Genesin, E Principiis Hucusque Ignotis, Ostendens … et Specimen Becchariánium, Fundamentorum Documentorum, Experimentorum, Subjunxit Georg Ernestus Stahl*, Lipsiæ, MDCCXXXIIX.

11 Georg Stahl, *Philosophical Principles of Universal Chemistry: or, the Foundation of a Scientifical Manner of Inquiring into and Preparing the Natural and Artificial Bodies for Uses of Life* (tr. Peter Shaw), London, 1730.

12 Herman Boerhaave, *Elements of Chemistry* (tr. Timothy Dallowe), London, 1735.

13 There are four of Alston's books listed in the 1804 posthumous catalogue of Walker's library: Cornelius Elliot, *A Catalogue of the Books in Natural History with a Few Others, which Belonged to the Late Rev. Dr. Walker, Professor of Natural History in the University of Edinburgh*, Edinburgh, published by C. Stewart, 1804. Edinburgh University Special Collections (subsequently EUL) La.III.352/6. See Nos. 61, 58, 66, 220, 562.

14 Maurice P. Crosland, *Historical Studies in the Language of Chemistry*, London, 1962.

Earth(s)' – to represent this definition.[15] (Likewise, I shall use the capitalized version of 'Salt' to connote bodies that 'are sapid, miscible with water, and not inflammable').[16] The idea that one Primary Earth could form the base of all minerals appealed to many mineralogists during the seventeenth and eighteenth centuries. Its intellectual lineage stretched back to Platonic 'forms' and the four Aristotelian elements. During the sixteenth century, chemists held that all matter was somehow born from a Universal Acid and it was this concept that was eventually transformed into the eighteenth century's idea of a 'universal' Primary Earth.[17]

Of the six authors above, only Becher and Stahl place a strong emphasis on the role played by Primary Earths in the classification of minerals. The others are either sceptical or unclear on the matter. For instance Boyle, in his works on earths, minerals and metals, was more concerned with ascertaining practical applications. To achieve this goal, he looked at both physical and chemical characters. Yet, even though he was a chemist, he doubted the existence of a Primary Earth:

> Hence we may reasonably doubt, whether the assertors of elementary earth can shew us any native substance deserving of that name; and, also whether what remains, after chymical analysis, tho' it has all the qualities, judg'd sufficient to denominate a portion of matter earth, may not yet be either a compounded body, or endowed with the qualities which belong not to simple earth.[18]

Woodward shared Boyle's pragmatic view. He concentrated solely on physical characteristics, that is, the 'Nature', 'Properties' and 'Phenomena' of minerals.[19] For every fossil, wherever possible, he observed its placement in the ground and 'the Bulk, the Form, the Texture, the Constitution, the Purity or Mixtures discernible in it'.[20] This being the case, his work offers a vague definition of what he means by the word 'earth'. For him, anything in the ground that was not a mineral or a metal received this title.[21] Likewise, Boerhaave was not interested in strictly defining this term in *Elements* (even if he was, his vacillation between Aristotelian, Paracelsian and five-principle chemistry would have muddled the definition anyway).

Woodward's and Boyle's emphasis upon physical characters proved to be very useful for Walker throughout his entire career. In fact, Woodward remained a reference work that Walker recommended to his students after he became Edinburgh Professor of

15 David Oldroyd treats these two different definitions of earth in 'Some phlogistic mineralogical schemes, illustrative of the evolution of the concept of "Earth" in the 17th and 18th Centuries', *Annals of Science* (1974), **31**, 269–306.

16 This definition was offered countless times in William Cullen's lectures and was even used by William Withering in his translation of Tobern Bergman's *Outlines of Mineralogy*, Birmingham, 1783, §20. See Cullen's discussion of Salts in L. Dobbin, 'A Cullen manuscript of 1753', *Annals of Science* (1936), **1**, 138–56.

17 N. E. Emerton masterfully traces this intellectual lineage from Plato to the eighteenth century in *The Scientific Reinterpretation of Form*, London, 1984. The role of Earths in eighteenth-century chemistry is treated in A. Duncan, *Laws and Order in Eighteenth-Century Chemistry*, Oxford, 1996, 159–68.

18 Boyle, op. cit. (8), 143.

19 Woodward, op. cit. (9), p. x.

20 Woodward, op. cit. (9), pp. x–xi.

21 Woodward, however, does state that he believed that the composition of 'earth' remained relatively constant – even if it was moved about by a flood. John Woodward, *An Essay Toward a Natural History of the Earth: And Terrestrial Bodies, Especially Minerals*, London, 1695, 220, 260–2.

Natural History in 1779. However, the prominent role played by Primary Earths in Walker's *Systema Fossilium* demonstrates that it was Becher and Stahl who laid the conceptual foundations for his chemical approach to the composition of rocks and stones.[22] Becher held that there were three kinds of Earth: Vitrescible, Fatty and Mercurial.[23] Because he was not able to isolate completely each element of this *tria prima*, each remained a philosophical construct similar to a Platonic 'form'. The purest representation of Vitrescible Earth was associated with quartz and was characteristically dry. It was the primary ingredient of stones and minerals and imparted the qualities of fusibility, solidity and opacity.

By the time Walker started attending the University of Edinburgh, the five-principle system of chemistry had become quite influential in the Medical School. By the mid-1750s, Cullen included all of the Primary Earths under the term 'Earth Principle'.[24] In the years that immediately followed his time at the University of Edinburgh, Walker eventually decided that Vitrescible Earth was one of five Primary Earths associated with the Earth Principle. However, he never ceased to believe that it was the oldest of all the Primary Earths. Such a view slightly differed from Becher, who held that there was a foundational Primary Earth (Fatty Earth) which served as the base for all Earths and which conferred colour, taste and odour.[25] Like Becher, Stahl maintained the *tria prima* stance, and it was this conception of 'Earths' that was given the title 'primitive Earths' in Peter Shaw's widely read English translation of Stahl's *Philosophical Principles of Universal Chemistry*.[26] Because Stahl accepted many of Becher's chemical definitions,[27] their works are sometimes collectively called the Becher–Stahl School.[28] The influence of this school upon seventeenth- and eighteenth-century chemical mineralogists was quite significant.[29] In Edinburgh, its influence was felt in the articles printed in *Essays and Observations, Physical and Literary*, the principal journal of the Medical School and Edinburgh Philosophical Society from the 1750s until the 1770s. The Becher–Stahl School also influenced Cullen, Walker's chief mentor. Even after its chemistry was eclipsed at the end of the century, Walker still referred to the phlogiston theory in his geology and mineralogy lectures.[30] He never ceased to maintain that the 'first persons

22 For more on Walker's later conception of Primary Earths, see Eddy, op. cit. (1).

23 Beccheri, op. cit. (10), 49.

24 A discussion of how chemical 'principles' were used in mineralogy at this time can be found in D. R. Oldroyd's 'The doctrine of property-conferring principles in chemistry: origins and antecedents', *Organon* (1976/7), **12/13**, 139–55. For the chemical processes used to analyse Primary Earths, see Oldroyd's 'Some eighteenth-century methods for the chemical analysis of minerals', *Journal of Chemical Education* (1973), **50**, 337–40.

25 Oldroyd, op. cit. (15), 269–305.

26 Stahl, op. cit. (11), 13. At this time, 'Primitive Earth' was used interchangeably with 'Primary Earth'.

27 D. Oldroyd examines some of the philosophical aspects of Stahl's chemistry in 'An examination G. E. Stahl's *Philosophical Principles of Universal Chemistry*', *Ambix* (1973), **20**, 36–52.

28 R. Laudan, *From Mineralogy to Geology: The Foundations of a Science, 1650–1830*, London, 1987, 47–69.

29 Emerton, op. cit. (17), 225–6.

30 For instance, in his 1780s and 1790s geology lectures, Walker cites the following of Becher's works: *Chymisches Laboratorium*, Frankfurt, 1680; *Natur-Kündigung der Metallen*, Frankfurt, 1679; *Parnassi Illustrati … Mineralogia*, Ulm, 1663; *Physica Subterraneae*, Frankfurt, 1703. See Walker, op. cit. (1), 271.

among the moderns that aimed at the proper method of arrangement in the fossil kingdom were Becher and Stahl'.[31]

Educating a 'fossilist' (II): William Cullen and Primary Earths

After Walker finished attending the University of Edinburgh in 1749, he was ordained into the Church of Scotland. Around 1753 or 1754, he made two marl and (mineral) manure collections and submitted them to the Edinburgh Philosophical Society. He was awarded medals for both collections and it was this recognition that first made him known to William Cullen and possibly to Lord Kames. Although Cullen lived in Glasgow until 1755, he had been a member of the Society since 1749 and was 'more and more attached to Mineralogy, which was at that Time indeed, his own favourite Pursuit'.[32] Walker and Cullen struck up a friendship and Walker began to study chemistry with him soon thereafter. A close bond formed between them and Walker's writings from the 1750s demonstrate that he based most of his chemistry upon Cullen's teachings.[33] Influenced by the Becher–Stahl School, Boerhaave and Pierre Joseph Macquer,[34] Cullen employed the five-principle chemical system. During the 1750s, Cullen spent a great deal of time trying to develop a systematic arrangement for Salts. He also performed experiments that allowed him to aver that the Earth Principle was 'not soluble in water, not inflammable, of a dry & solid consistence, either not fusible in the fire or if fusible concreting again in the form of glass'.[35] After reading Johann Heinrich Pott's *Lithogéonosie*[36] sometime during the mid-1750s, Cullen became convinced that there were four genera of Primary Earths:[37]

1. Vitrescible
2. Calcareous
3. Argillaceous
4. Talky

31 Walker, op. cit. (1), 'Mineralogy lecture', 224–5. This edition of Walker's work only includes his introductory lecture on mineralogy. The rest of the manuscript notes taken by students during his mineralogy lectures are housed in EUL.

32 Walker, *Systema Fossilium*, op. cit. (6), f. 4.

33 See M. D. Eddy, 'The doctrine of salts and Rev. John Walker's analysis of a Scottish spa (1749–1761)', *Ambix* (2001), **48**, 137–60.

34 Pierre Joseph Macquer, *Élémens de chymie théorique*, Paris, 1749; *Elémens de chymie-pratique. Contenant la description des opérations fondamentales de la chymie, avec des explications & des remarques sur chaque opération*, Paris, 1751.

35 William Cullen, 'Misc. Lectures Notes, Re: Earths by William Cullen', GUL MS Cullen 795, f. 1. Also treated in ff. 2–8. Compare to Black's 1767/8 definition: '*Terrea sunt solida, sapida, nec aqua pura Simplici Solubilia nec Inflammabilia & nunquam fusibilia quin in Vitrum Abuent.*' Thomas Cochrane, *Notes from Doctor Black's Lectures on Chemistry 1767/8* (ed. Douglas McKie), Wilmslow, 1966, 27.

36 GUL MS Cullen, op. cit. (35), f. 6. Johann Heinrich Pott, *Lithogéognosie ou examen chimique des pierres et des terres en général: et du talc, de la topaze & de la statite en particulier avec une dissertation sur le feu et sur la lumière*, Paris, 1753. The German edition first appeared in 1745. Pott's Earths and their relation to mineralogy are discussed in T. M. Porter, 'The promotion of mining and the advancement of science: the chemical revolution of mineralogy', *Annals of Science* (1981), **38**, 543–70, 556–8.

37 Cullen used the term 'Primitive Earths'. These are clearly stated in the 'Pharmaceuticæ Cullini' section of Black's 1767/8 chemistry lecture notes. Cochrane, op. cit. (35), 26–8.

In the Cullen Collection housed in the University of Glasgow Special Collections Department, there are numerous copies of Cullen's manuscript notes that he used to give as his lectures during the 1750s. Though illegible in several cases, these clearly define his conception of the four Primary Earths. He held that *Vitrescible Earths* quickly changed to glass, became readily transparent with the application of fire, struck fire with steel, were little altered by calcinations and were not dissolved by acids. Because of their glass-like transparency, he often referred to them as 'crystalline'. Within this genus he included gems, flint, calculi, sands, quartz and fusible spar (probably feldspar).[38] *Calcarious Earth* could either be burnt to quicklime or dissolved with effervescence in acid menstruums. It included marble, limestone, chalk, spars, stalactites, shells, marls, magnesia alba, aluminous earth, quicklime and earths that contained animal and vegetable matter.[39] *Argillaceous Earth*, on account of its 'viscidity & fineness', was not dissolvable by acids, could be turned upon a lathe and became harder and more compact when exposed to fire. This genus contained white clay, coloured clays, steatites and ferruginea.[40] *Talky Earth* was less well defined because Cullen could not decide whether or not it included *Gypseous Earth*. This fluctuating genus contained selenicks and gypsum. Upon being burned, these fossils 'changed into a gypsum or Such a kind of Quicklime as is dissolved in kinds of Acids & is the longest resisting vitrification'.[41] Based on Cullen's observations, Joseph Black would later decide that Talky Earth and Gypseous Earth both formed their own separate genus.

Aside from a few physical qualities like transparency and malleability, Cullen's prevailing method for determining Primary Earths was chemical. More specifically, his tests employed 'Fire' and 'Chemical Menstrua'. Cullen's usage of 'Fire' generally meant 'heat'. Or, as he stated, 'the presence of Fire' can vulgarly be judged by the presence of 'Heat & Light'.[42] 'Chemical Menstrua' referred to humid forms of analysis (aqueous solutions) that were governed by the Salt Principle (which Cullen also called the Doctrine of Salts).[43] During his time as Walker's teacher, his use of heat had convinced him that all Primary Earths might be reduced to 'a transparent vitrious body'. Echoing the Becher–Stahl School, Cullen felt that this suggested the 'possibility of the universal clarification of our opaque terrene Globe'.[44] This excited him because such a Primary (Vitrescible) Earth could serve as the base for a standardized mineralogical system. Yet Cullen could not actively argue for the explicit existence of such a Primary Earth because the only way to reduce Calcareous, Gypseous and Argillaceous Earths into a vitrescible

38 For more on Cullen's chemical conception of Vitrescible Earths, see 'Of vitrescent earths and vitrifications … by Cullen', GUL MS Cullen 268/8.

39 The following definition of the four Earths are taken from William Cullen, 'A chemical examination of common simple stones & earths … by William Cullen with Notes [Incomplete] on alkali earths and the Earth's structure', GUL MS Cullen 264, f. 1.

40 Cullen, op. cit. (39), f. 1.

41 GUL MS Cullen, op. cit. (35), f. 1 and f. 5.

42 GUL MS Cullen, op. cit. (35), f. 5.

43 Cullen's saline analysis is discussed in several places in A. L. Donovan's *Philosophical Chemistry: The Doctrines and Discoveries of William Cullen and Joseph Black*, Edinburgh, 1975.

44 GUL MS Cullen, op. cit. (35), f. 1.

state was by adding saline mixtures.[45] The presence of these Salts made it hard to determine whether or not the original Earth under examination was truly vitrifiable. Even so, Cullen's acceptance of the Primary Earths allowed him to hold that all rocks were 'nothing else but Earths baked firmly together'.[46] As such, they could be reduced back to their constituent Earths if pulverized. For this reason, he was more concerned with chemical experiments that tested for the presence of Primary Earths.

In addition to identifying a stone's Primary Earths, Cullen's chemistry lectures also treated another important mineralogical topic: earth. He defined this as 'powdery bodies diffusible in Water'.[47] With this definition, it seems that Cullen was trying to portray earth as a makeshift species that fell between Primary Earths and Salts. However, such a broad definition was not without its problems and Cullen spent a good deal of time trying to iron out the conceptual wrinkles. It seems that Walker was involved in this process because he published an article in the 1757 edition of the *Philosophical Transactions* which addressed the shared characters of saline and terrene mineral water solutions.[48] In general, Cullen held that there were two types of earth. The first was 'of moist surfaces & viscid'. These consisted of marls and of clays. He sometimes placed stipulations on these substances. He held that marls should effervesce in acid and should not harden in fire. Clays should harden in fire and be soluble in acids. The second type of earth was 'of dry surfaces and friable'. These consisted of ochres and 'tripelas'.[49] He sometimes stipulated that the ochres should be 'soft and smooth' and the tripelas should be 'hard and rough'.

Cullen's interest did not stop at Primary Earths and earths. He even offered a basic classification system for stones. He held that they consisted of two types: Powdery and Solid. Powdery Stones, or rather those 'In coarse powder',[50] consisted of sand, grit and earth fragments. Solid Stones, or those 'In larger Masses',[51] consisted of two general divisions: Simple and Structured. Since Cullen thought that stones were composed of a mixture of Primary Earths and earths, his classifications are quite rough and sometimes overlap. Simple Stones included gypseous stone, freestone, limestone, rockstone and (curiously) granite. The description he offers for 'Structured' stones in his manuscript notes is vague and seems to be directed at the concreted matter surrounding rocks. He offers four types: Determined, Milky, Coloured and Clear. Sprinkled throughout his entire classification of stones are also chemical characters which are usually determined by experiments involving acid. Thus Cullen oscillates between physical and chemical

45 Saline experimentation was arguably a leading form of humid analysis in both Scotland and France during the early to mid-eighteenth century. For the French scene, see Frederic L. Holmes, 'Analysis by fire and solvent extractions: the metamorphosis of a tradition', *Isis* (1971), **62**, 129–48.

46 Cullen, op. cit. (35), f. 1.

47 Cullen, op. cit. (39), f. 7.

48 John Walker, 'An account of a new medicinal well, lately discovered near *Moffat*, in *Annandale*, in the county of *Dumfries*. By Mr. *John Walker*, of *Borgue*-House, near *Kirkcudbright*, in Scotland', *Philosophical Transactions of the Royal Society of London* (1757), **50**, 117–47. The chemical content of this article is treated in Eddy, op. cit. (33).

49 Tripela is Cullen's word for 'tripoli', which is 'A fine earth used as a polishing-powder, consisting mainly of decomposed siliceous matter, esp. that formed of the shells of diatoms; called also infusorial earth or rotten-stone'. *OED*.

50 Cullen, op. cit. (39), f. 7.

51 Cullen, op. cit. (39), f. 7.

characters for this classification. The physical characters that he particularly liked were softness, hardness, smoothness, colour and stratigraphical alignment.

In addition to mineralogy, Cullen's chemistry was relevant to both medicine and natural history. Such a link was not new in Britain. For instance, in addition to emphasizing the value of applying chemistry to all the kingdoms of nature, Boyle's comments on the actual practice of natural history served as a guide for many naturalists.[52] Likewise, Cullen's lectures make the link between natural history and chemistry quite clear:

> Natural History is what acquaints with the native place[,] & the Sev[l] appearances of all the Subjects of Art or Commerce[,] it must appear to deserve particular attention & that it is Chemistry that teaches the various manufacture of these for the purposes of Life[.] Both together may be considered as important to Society[.] They are necessarily connected together[.] The chemist will often blunder if He cannot distinguish Natural Productions & at the same time The Naturalist will not be able properly to distinguish the Sev[l] Similar productions of Nature without the Assistance of Chemical Exp[ts] [.][53]

Based on this rationale, Cullen kept his own mineralogical collection, which Walker purchased for the Edinburgh Natural History Museum in the 1790s.[54] Cullen also encouraged his other students to do the same, as can be seen by the fact that Black was also interested in collecting minerals.[55] Cullen's above lecture on this topic goes on to direct his students to examine minerals because the

> Earth of every Country contains in its Bowels a variety of Valuable Matters that are neglected & undiscerned[.] Arts are often at a loss for matter[ial]s & we often import[.] This Country has been so little examined that probably many treasures are reserved to the discovery of Skilfull persons[.]

He then proceeds to give a long list of minerals worth investigating in Scotland. Walker took this list quite seriously because he made it a point to examine many of its items during the next two decades.[56] This allowed him to acquire the specimens that eventually became part of the University of Edinburgh's Natural History Museum.[57] In this manner, chemistry and mineralogy were mutually dependant. Chemistry provided characters by

52 Robert Boyle, *General Heads for the Natural History of a Country Great or Small*, London, 1692. For an example of his application of chemistry to natural history, see Robert Boyle, *Short Memoirs for the Natural Experimental History of Mineral Waters*, London, 1684.

53 William Cullen, 'Fragments of a lecture by Cullen concluding and summarising the first part of the course; natural history and its productions', GUL MS Cullen 258, ff. 2–3.

54 Walker, *Systema Fossilium*, op. cit. (6), f. 16.

55 R. G. W. Anderson, *The Playfair Collection and the Teaching of Chemistry at the University of Edinburgh 1713–1858*, Edinburgh, 1978, 58.

56 Walker went on to write similar lists for his students: 'A memorandum given by Dr. Walker, professor of natural history, Edinburgh, to a young gentleman going to India, with some additions', *The Bee* (1793), **17**, 330–3. Likewise, Robert Jameson, Walker's student and successor, went on to do the same: 'Literary and scientific intelligence', *The Edinburgh Magazine and Literary Miscellany; A New Series of the Scots Magazine* (1817), **1**, 367–9.

57 For Walker's later involvement with the University of Edinburgh Natural History Museum, see C. D. Waterston, *Collections in Context: The Museum of the Royal Society of Edinburgh and the Inception of a National Museum of Scotland*, Edinburgh, 1997, 1–41.

which rocks could be classified – first into genera based on Primary Earths and then into classes. These characters were not only used for arranging minerals. They were also employed in the making of pharmaceuticals and in the purification of mineral ores. The latter was linked to mining and could therefore be used to obtain patronage. This is why Walker's contemporary Black analysed box after box of minerals sent to him by Lord Hopetoun and other naturalists during the 1770s.[58] In addition to analysing mineral ores, chemistry was incorporated into the larger utilitarian enterprise of agricultural improvement. This is why the Philosophical Society was interested in Walker's 1753 to 1754 marl collections. Following this pattern, Walker continued to promote the interaction of chemistry and natural history throughout his career and,[59] like Cullen, gave a public lecture on the topic in 1788.[60]

Chemistry and classification (I): Walker's early attempts at arrangement

Cullen's combination of chemistry and natural history had a profound effect on Walker. The first printed indication of this effect was in his 1757 *Philosophical Transactions* article on mineral water.[61] Walker maintained his interest in chemistry over the next ten years as he toured Scotland. As these travels were extensive, they will be treated in the next section. The main goal of the present section is to detail his nascent classification system. The manuscript sources on this topic for the period between 1757 and 1766 are few. Of those that are extant, there is no clear indication as to which mineralogical classification influenced Walker's early investigations. Even though the 1761 index of his library shows what he was reading,[62] it does not indicate his personal definition of a Primary Earth, nor does it specifically identify his classificatory preference. His index also does not list several books that were published before 1761, but that proved to be quite influential to Walker's mineralogy in the mid-1760s – a good example being Linnaeus's *Systema Naturæ*. The 1771 report that he compiled for his 1764 Hebrides and Highlands tour offers a similarly murky picture. Since it is quite likely that he interpolated several authors into the text, it is difficult to determine which books he was actually using in 1764.[63]

58 EUL Black MS 873–5. John Hope [second Earl of Hopetoun] to Joseph Black, 19 May 1770, ff. 28–30. John Hope to Joseph Black, 9 June 1770, f. 31. A. J. Alexander [from Bracelot, Grenada] to Joseph Black, 31 April 1773, ff. 58–62. John Graham [from Cumberland] to Joseph Black, n.d., ff. 76–7.

59 As Professor of Natural History, Walker was the academic patron (along with Joseph Black) of the Natural History Society of Edinburgh organized by students during the 1780s and during this time chemistry played a prominent role in the papers that were given. D. E. Allen, 'James Edward Smith and the Natural History Society of Edinburgh', *Journal of the Society for the Bibliography of Natural History*, 8 (1978), 483–93. See especially page 489.

60 John Walker, 'Public Lecture, Anno 1788, on the Utility and Progress of Natural History and Manner of Philosophising', *Essays on Natural History and Rural Economy* (ed. Charles Stewart), Edinburgh, 1808, 323–47.

61 Walker, op. cit. (48).

62 John Walker, *Index Librorium (1761)*, Bound MS, EUL, Dc.2.38. This not only lists the books that were in Walker's possession, it also offers a methodological commentary of some of them.

63 Originally compiled into a report and named the *Kings MS*, this work was published in 1980 as *The Rev. Dr. John Walker's Report on the Hebrides of 1764 and 1771* (ed. Margaret M. McKay), Edinburgh, 1980.

The first clear indication as to which classification system was guiding his initial mineralogical activity is found in a notebook of natural history commonplaces entitled *Adversaria*.[64] Kept from 1766 to around 1772, it is a collection of aphorisms, observations and thoughts drawn from personal observation, books, articles and conversations.[65] Much of this information would eventually be included in the natural history lectures and articles that he wrote after he became a professor in 1779. Since the first entry is numbered '300', it is likely that *Adversaria* is the only remaining example of a set of several notebooks. Even though it contains observations on all three kingdoms of nature, it focuses chiefly upon mineralogy and botany. The mineralogical entries are helpful for two reasons. First, they include the half dozen or so authors who most influenced Walker at this time (sometimes specific books and page numbers are cited). Second, there are several lists of minerals that were either collected by him or by other naturalists. In entry 335, he lists general directions on how a beginner might group newly collected Fossils:

- α. Gems. Crystals. Agates. Pebbles. Jaspers. Granites. Porphyries. Free stone. Whetstone. Touchstone.
- β. Marbles. Limestone. Flints. Spars. Chalk. Alabaster. Stalactites. Petrifactions.
- γ. Talc. Slate. Asbestos.
- δ. Salts. Vitriols. Selenites.
- ε. Amber. Ambergrease. Bitumens. Coal. Pyrites. Sulphurs. Arsenic. Pumice. Lava.
- ζ. Loams. Marls. Clays. Sands. Boles. Ochres.
- η. Ores of all the Metals & semi-metals.
- θ. Petrified Wood, Plants, leaves, Fruits, Shells, Bones.
- ι. Figured fossils, as Entrochi, Belemnites, Asteno, Cornua Ammonites. Glossopetra.
- κ. Superficial Delineations of Herbs, Trees, Ruins &tc. upon Stones.[66]

It is hard to know if Walker based this list on something that he read (either in a book or in a letter) or if it was of his own creation. No matter where he got it, the list demonstrates the direct influence of Cullen and chemical mineralogy. Not only is it based on the five-principle system propounded by Cullen and many of his colleagues in Edinburgh's Medical School (Salts, Inflammables, Metals, Earths and Water),[67] but its first four categories are directly based on the fourfold division of Primary Earths (vitrescible, calcareous, argillaceous and talcy) that Cullen took from Pott. The α group contains stones that are indurated and composed of a high percentage of vitrescible Earth. The β group is generally made of calcareous Earth and is semi-hard. The γ group

Augmentations of the sections on Jura and Iona were eventually published in Walker's *Essays*, op. cit. (60), as 'History of the Island of Icolumbkil', 111–99 and 'History of the Island of Jura', 219–81.

64 John Walker, *Adversaria* (1766–72), Bound MS, GUL MS Murray 27.

65 *Adversaria*'s semi-aphoristic style in parts is similar to the approach taken by Linnaeus in *Philosophica Botanica*, Stockholm, 1751. Joseph Black was also interested in such a type of personal notation. See Thomas Thomson, *The History of Chemistry Vol. I*, London, 1830, 315.

66 Walker, op. cit. (64), f. 157. The Greek characters are Walker's. The 'Asteno' fossil in the ι class might possibly be 'Asteria'.

67 This was also the system used by Black (Cullen's former student) during the 1760s; the only difference was that he added the sixth category of 'Airs'. See Cochrane, op. cit. (35).

Earth	**Salt**	**Inflammables**
α group (vitrescible)	δ group	ε group
β group (calcareous)		
γ group (talcy)	**Metals**	**Organic**
ζ group (argillaceous)	η group	θ, ι, κ groups

Figure 1. Walker's Rudimentary Mineralogical Classification, late 1760s.

is soft and contains talcy Earth. The fossils in the ζ group are composed of various ingredients characteristic of argillaceous Earth. Walker used Salts, Inflammables and Metals to form his next categories. The δ group contains Salts or minerals like fluors that had qualities that Walker would have understood to be saline.[68] Those placed in the ε group are either inflammable themselves or are a naturally occurring product of inflammables. Finally, the η group was based on Metals.

Once Walker had used chemical principles to group metals and minerals, he then grouped the remains of animals or plants found in the ground. Here he moves beyond the realm of rocks and stones. Since this limited his ability to use chemical characters, he relies more on the physical characters to group such organic 'Productions' (groups θ, ι, κ). However, despite such a physically based classification, the chemical properties of these productions were still a topic addressed by eighteenth-century chemists. Joseph Black devoted a whole section to the productions of animals and vegetables in his 1767–8 lectures[69] and many of the chemical mineralogists mentioned in Walker's *Adversaria* and his 1761 library index included similar categories.[70] Thus all of Walker's early classifications were based upon the chemistry of the day. The only chemical element that is not included in his classification is Water. Technically, however, it was not a fossil and this is probably why it is omitted. Walker did believe that Water was important for mineral studies – as can be seen in his 1757 *Philosophical Transactions* article on Hartfell Spa.[71]

Chemistry and classification (II): systematic mineralogy sources

Of the half dozen or so authors mentioned in *Adversaria*, only Emanuel Mendes Da Costa's *A Natural History of Fossils*[72] and Linnaeus's *Systema Naturæ* receive a notable amount of attention. Even though each of them based their system on physical characters, both used chemistry at some point in their classification. However, their systems

68 Elsewhere in *Adversaria*, op. cit. (64), Walker held that fluors were '"compound Bodies, consisting of a Salt and an Earth". And that therefore, they should be strictly ranked among the Salia, having no Title [title] to the Character of simple primitive Earths, which have been given them'. Walker, op. cit. (64), f. 145.

69 Cochrane, op. cit. (35), 173–90.

70 For instance, see the 'petrification' classes in Johan Gottschalk Wallerius, *Minéralogie, ou description générale des substances du règne minéral. Par Jean Gotschalk Wallerius, Professeur Royal de Chymie, de Métallurgie & Pharmacie dans l'Université d'Upsal, de l'Académie Impériale de Curieux de la Nature*, Paris, 1753 and in Fredrick Augusti Cartheusar, *Elementa mineralogie*, Frankfurt, 1755.

71 Walker was fascinated with mineral water for his entire career. In addition to his 1757 article, op. cit. (48), and the mineral water works in his 1761 *Index*, there are several manuscript notes from the 1780s that address the topic. See EUL Dc.1.58 f. 2, f. 40, and ff. 90–92.

72 Emanuel Mendes Da Costa, *A Natural History of Fossils*, London, 1757.

were different. Da Costa took issue with Linnaeus's method[73] and had created his own classification which ran in the following order: *series*, *chapter*, *genus*, *section* and *member*. As he did not finish his system, there are only two series: Earths and Stones. The chapter, genus and section are formed on physical features (colour, texture and so on) and the members are differentiated based on their reactions to acids and alkalis. Likewise, Linnaeus resorted to chemistry as a final option to be used after physical characters were exhausted: 'The student has three modes of investigating this [Mineral] Kingdom: *Physical*, which descends through the obscure generation of minerals: *Natural*, which considers their superficial and visible structure: *Chemical*, which ascend through their destructive analysis.'[74] For the last, Linnaeus employed fire and acids. He also used several other characters that fell within the realm of eighteenth-century humid analysis: concretion, cementation, calcination, putrefaction and crystallization.[75] It can be seen that chemistry was used in Da Costa and Linnaeus, but it was relegated to a minor role.

Walker's early classification clearly demonstrates that he did not follow such an approach. His many references to these authors show his life-long proclivity to cite works that were ordered by taxonomies (or even an epistemology) that he himself did not support. He had no problem with extracting examples from one book and then inserting them into a system (usually his own) that seemed more reasonable. He began this practice early in his career with his use of Becher, Stahl and Woodward and he continued it in his geology lectures where he cites theorists like Buffon and Maupertuis.[76] This process of extracting and inserting natural history commonplaces was common during the Enlightenment. In mineralogy's case, the sea of sources produced a canon of works from which examples were most often taken.[77] Da Costa, Linnaeus,[78] John Hill and Woodward were the standard works cited by British mineralogists.[79] However, the difference between citing them and actually agreeing with them was sometimes quite vast.

As Walker's work demonstrates, it was quite common to praise these canonical authors in one sentence and then criticize them in the next. In general, the preface of almost every systematic mineralogy book was full of attacks upon the shortcomings of previous authors. Da Costa's *History* was no exception: 'I have attentively examined

73 G. S. Rousseau and D. Haycock, 'The jew of Crane Court: Emanuel Mendes da Costa (1717–91) natural history and natural excess', *History of Science* (2000), **38**, 139–42.

74 Charles Linné, *A General System of Nature, through the Three Grand Kingdoms of Animals, Vegetables, and Minerals: Systematically Divided into their Several Classes, Orders, Genera, Species, and Varieties – Vol. VII* (tr. William Turton), Swansea, 1804, 9. Also see Caroli a Linné, *Systema Naturæ per Regnatria Naturæ, Secundum Classes, Ordines, Genera, Species, cum Characteribus & Differentiis. Tomus III. Cum Privilegio Siæ Riæ Mitis Sveciæ, & Electoris Saxon*, Homiæ, 1768, 11.

75 See Linné *General System*, op. cit. (74), 3–9; Linné *Systema Naturæ*, op. cit. (74), 3–11.

76 See Eddy, op. cit. (33), 101–2.

77 Roy Porter, *The Making of Geology: Earth Science in Britain 1660–1815*, Cambridge, 1977, 112–18.

78 Linnaeus's conceptual framework was hard for most chemical mineralogists to escape, even in his native Sweden. See Hjalmar Fors, 'Chemistry and the mining industry in eighteenth-century Sweden', unpublished manuscript.

79 Some of the others were John Hill's *A General Natural History: Or, New and Accurate Descriptions of the Animals, Vegetables, and Minerals of the Different Parts of the World …*, London, 1748–52 and Woodward's *An Attempt Towards a Natural History of the Fossils of England; In a Catalogue*, op. cit. (9).

the Woodwardian and Wallerian systems, and, finding them defective, have presumed to form a new one from the principles of both.'[80] Yet Da Costa was criticized in the same manner by later mineralogists, one of them being Walker himself: 'Mr. Da Costa has from Germany the same red micaceous Fossile, which is found at Dalswinton. He considers it as an Ore of Iron, as Linnaeus likewise does, tho' probably I think with some impropriety. It is the Ferrum intractable nitens micaceum. Lin.[naeus].'[81] Sometimes these criticisms became rather pointed and this caused tempers to flare. However, in Walker's case, his fruitful correspondence with Da Costa during the 1760s suggests that he took issue with the system and not with the man.

Walker's disagreement with Da Costa and Linnaeus over the classification of the ferrous/micaceous mineral in the quotation above is significant because it touches on two important issues presented by *Adversaria*. First, it demonstrates Walker's emerging proclivity to use chemical analysis as a means for disagreeing with well-known mineralogical authorities. No doubt his contention with Da Costa and Linnaeus on this point was informed by the 'iron principle' experiments that he performed on Hartfell Spa in 1757. Second, in the course of his mineralogical observations, Walker cites Johan Gottschalk Wallerius (1709–85), the eminent professor of chemistry at the University of Uppsala (1750–67).[82] During the mid-eighteenth century, Wallerius wrote about a number of chemically related disciplines, but his most influential mineralogical work in Britain was *Minéralogie, ou Description Générale des Substances du Règne Minéral* (1747).[83] Citing this work to clarify the classification of *ferrum intractable nitens micaceum*, Walker writes, 'Of this Species Wallerius has 2 Varieties.'[84] This reference to Wallerius is notable because it links Walker to Swedish chemical mineralogy at a very early date.

Not only does he make several references to Wallerius, but Walker also mentions Wallerius's disciples Jacques-Christophe Valmont de Bomare (1731–1807) and Axel Fredrik Cronstedt (1722–65). Bomare was then 'Démonstateur d'Histoire Naturelle, Membre de la Société Litteraire de Clermont-Ferrand, de l'Académie royal des Belles-Lettres de Caën, de l'Académie royale des Sciences, Belles'Lettres & Beaux-Arts de Rouen' and was the author of *Minéralogie, ou Nouvelle Exposition du Règne Minéral* (1762).[85] Cronstedt's work on mineralogy had been written in 1758, but had gained a wider audience when it was translated into German during 1760.[86] The mineralogies of

80 Da Costa, op. cit. (72), p. iv.

81 Walker, op. cit. (64), f. 152.

82 J. R. Partington, *A History of Chemistry, Vol. III*, London, 1962, 169–72.

83 Johan Gottschalk Wallerius, op. cit. (70). The original was published in Swedish (Stockholm, 1747 and 1750). The French edition was based upon the German translation (Berlin, 1750).

84 Walker, op. cit. (64), f. 152.

85 Jacques-Christophe Valmont de Bomare, *Minéralogie, ou nouvelle exposition du regne minéral. Ouvrage dans lequel on a tâché de ranger dans l'ordre le plus natural les individus de regène, & où l'on expose leurs propriétés & usages méchaniques; avec un dictionnaire nomenclateur et des tables synoptiques*, Paris, 1762. Quotation taken from the frontispiece.

86 Cronstedt's first chemical mineralogy system was published in Swedish as *Försök Till Mineralogie*, Stockholm, 1758; however it was its 1760 German translation that brought it to the attention of mineralogists in the German-, French- and English-speaking countries. See Cronsted's entry in the *Dictionary of Scientific Biography*; D. R. Oldroyd, 'A note on the status of A. F. Cronstedt's simple earths and his analytical

Wallerius, Bomare and Cronstedt all based their systems upon Primary Earths just like Walker, Cullen and Black. In fact, it was Cullen himself who had first introduced Walker to Cronstedt in 1764:

> Not long before I set out [for the Hebrides], Dr. Cullen had received the first German Edition of Cronstedt's Essay, of which he was so fond, that he carried it for several Weeks in his Pocket. He translated to me the leading Characters of Cronstedt's new & peculiar Classes. He was particularly anxious about the Zeolite. And it was in consequence of this, that I first observed it, among the Basaltick Rocks at the Giants Causeway, though afterwards, in greater Plenty & Variety in many of the Islands.[87]

By 1766 Walker was discussing Cronstedt's chemical mineralogy with the German naturalist F. W. P. Fabricius.[88] In *Adversaria*, Walker takes care to note Cronstedt's comments on Zeolite, particularly because of its relation to talc: 'He [Fabricius] says our whole Canna Fluor is not a Talc, but the Zeolite of Cronstedt, who has found it in the same Genus with the Lapis Lazuli, because both have this remarkable Property, that with Aqua fortis they dissolve into Gelly.'[89] Walker's connection to Swedish chemical mineralogy was even further solidified by the fact that Da Costa (Walker's primary mineral supplier) traded minerals with Wallerius and eventually edited the first English edition of Cronstedt's *Mineralogy*.[90] Additionally, several of the minerals in Walker's collection came from Sweden and Norway. Thus, both directly and indirectly, Walker was able to remain informed on Scandinavian chemical mineralogy.[91]

Building a collection (I): the mineralogy of travel

One of the distinguishing marks of the professors who lectured in Edinburgh's Medical School was that they understood the pedagogical effectiveness of passing around natural history specimens. Students were also encouraged to build their own collection of mineralogical and botanical simples and this contributed to an *in situ* form of naturalism

methods', *Isis* (1974), **65**, 506–12; Porter, op. cit. (36), 558–60. Interestingly, James Hutton also used Cronstedt's work. See J. Jones, 'The geological collection of James Hutton', *Annals of Science* (1984), **41**, 223–44, 239.

87 Walker, *Systema Fossilium*, op. cit. (6), f. 7; Walker, 'Notice of mineralogical journeys', op. cit. (6), 90.

88 Fabricius had received his medical doctorate from the University of Edinburgh in 1767. His thesis was entitled *Tentamen Medicum Inaugurale, de Emetatrophia. Quod, Annuente Summo Numine, Ex Auctoritate Reverendi admodum Viri, Gulielmi Robertson, S.S.T.P.*, Edinburghi, 1767.

89 Walker, op. cit. (64), f. 212.

90 Axel Fredric Cronstedt, *An Essay Towards a System of Mineralogy: by Axel Frederic Cronstedt. Translated from the Original Swedish, with Notes, by Gustav von Engestrom. To which is Added, a Treatise on the Pocket-Library, Containing an Easy Method, Used by the Author, for Trying Mineral Bodies, Written by the Translator. The Whole Revised and Corrected, with some Additional Notes by Emanuel Mendes Da Costa*, London, 1770.

91 It is worth noting here that Walker does not seem to have been influenced by Werner at any point in his career – even after his student Robert Jameson went to Saxony to study with him during the 1790s. This is most likely because Werner's classification was based on physical characters. See Scott's introduction in op. cit. (1), pp. xxiv–xxv, xxxvii; J. M. Sweet and C. D. Waterston, 'Robert Jameson's approach to the Wernerian Theory of the Earth, 1796', *Annals of Science* (1967), **23**, 81–96, 81–3. Walker also does not seem to have utilized crystallographic criteria.

that lasted well into the nineteenth century.[92] Apart from building curiosity collections, this seems to have been the leading motivation for collecting minerals in Scotland during the mid-eighteenth century.[93] As Walker's biography demonstrates, one of the most common ways of locating useful minerals in Scotland was travel. During his student years, Walker first explored the Edinburgh area with his friends Edward and Alexander Wight. He visited quarries, collieries, the King's Park and the Firth of Forth's shoreline. Even though he mentions these and many other trips in his *Systema Fossilium*, it is sometimes difficult to trace his exact steps because he visited several places more than once and because he did not leave behind any personal diaries. However, his trips can be divided into two overarching categories: short and long tours. Walker used short tours to explore almost the entire mainland of Scotland. They could last from a few days to a few months. In his early travels (1753 to 1762), he explored areas in Midlothian and South Lothian, Tweeddale, Moffat and Annandale. From 1753 to 1757 he lived in Galloway where he toured its moors and dales as well as the Stewartry of Kirkcudbright. During these trips he collected the marl and manure samples that attracted the attention of Cullen and the Philosophical Society. In 1758 Walker went to live in Glencorse (also spelled Glencross) and also travelled with Cullen to Breadalbane. During the next three years he toured Fife, the shores of the Tay, Kinnoul Hill, Clackan, Annanshire, the silver and cobalt mines of Alva and the copper mine of 'Aithoy'.

In 1762 Walker moved to Moffat and lived there for the next twenty years. These Moffat travels (1762 to 1782) were even more extensive. As he would later state, 'During my long Residence in Moffat, I collected in a Number of short tours, all the remarkable Fossils in Dumfriesshire, the Forest of Selkirk, Teviotdale, Ayrshire, and Clydesdale.'[94] Additionally, he visited the lead mines of Machrymore, Leadhills and Wanlock, the copper mines of Covend and the antimony mines of Eskdale. He made over thirty trips to Leadhills and Wanlock on account of their close proximity to Moffat. There, between 1761 and 1764, he observed many minerals (strontite and zeolite in particular) that had not been previously seen in Britain. Walker would later state these 'new' minerals to be: 'the Ore, and the Ochre of Nickel; the Plumbum pellucidum of Linnæus; the Plumbum decahedrum and cyaneum, both undescribed; the Saxum metalliferum of the Germans; the Ponderosa aërata of Bergman; and the Morettum, which afterwards appeared to be a sort of Zeolite'.[95] As his comments on Fabricius and Cronstedt indicate, his interest in

92 The practice of a physician traversing the woods and fields to find *materia medica* simples reaches back to Hippocrates. In 1683 the Scottish geographer Sir Robert Sibbald stated, 'As for the Practice of *Medicine*, *Hippocrates* hath abundantly proven, that a Physician must, who would practise alright, first know the place.' *An Account of the Scotish Atlas, or the Description of Scotland Ancient and Modern*, Edinburgh, 1683, 1–2. The link between local naturalism and *materia medica* in modern times has been treated by D. E. Allen in 'Walking the swards: medical education and the rise and spread of the botanical field class', in D. E. Allen (ed.), *Naturalists and Society: The Culture of Natural History in Britain, 1700–1900*, Aldershot, 2001, Part I. Also see Chapters 1 and 2 in his *The Naturalist in Britain: A Social History*, London, 1976.

93 This seems to shed some light on Hugh Torrens's statement that the 'question of how minerals were found in the first place, prior to their being uncovered and mined, has been strangely neglected'. 'Some thoughts on the complex and forgotten history of mineral exploration', *Journal of the Open University Geological Society* (1997), **17**, 1–12.

94 Walker, *Systema Fossilium*, op. cit. (6), f. 5.

95 Walker, *Systema Fossilium*, op. cit. (6), ff. 5–6; Walker, 'Notice of mineralogical journeys', op. cit. (6), 89.

zeolite was originally related to talc, that is, a potential Primary Earth. Furthermore, his research on strontitic 'earth' led to its later chemical classification.[96] Other short travels during this Moffat period include a 1765 journey to London[97] and his 1778 trips to Stirlingshire, Perthshire, Forfarshire, the Mearns and Aberdeenshire. Walker moved to Colinton (near Edinburgh) in 1782 and remained there until he died in 1803. During this time, he was first busy with lecturing and then slowly began to lose his eyesight. As a result, his short trips were limited and he depended more upon the observations of students and correspondents.[98]

In addition to his short tours, Walker took two long tours to the Highlands and Hebrides. The first was in 1764 and the second was in 1771. The 1764 tour covered most of the Inner and Outer Hebrides and was more extensive. Both of these trips were dually supported by the General Assembly of the Church of Scotland and the Board of Annexed Estates. For his scientific and his ecclesiastical observations, he was awarded both an honorary MD and DD in 1765.[99] Whenever observing minerals, he was keen to record '1. The Qualities, local Uses, & indigenous Names to be marked' and '2. The most common Productions generally neglected'.[100] He also noted and/or collected the following:

1. [The general chemical divisions of fossils.][101]
2. Specimens of a large Size necessary.
3. The Want of sufficient Specimens, on Cause of the Imperfection of the natural History of Fossils.
4. Valuable Ores long considered as useless.
5. To collect the most common Rocks, Stones and Earths, especially those which prevail over a Country, or any considerable Tract.
6. The Walls of Vein, the Earths, Ochres & Fluors, as well as the Ores it contains.
7. To mark the Circumstances of their native Situation.
8. Whether the Fossile is in the Place where it has been generated.
9. Proportion of Metal in the Ore – Size of Disposition of the Veins – Manner of working the Mines & smelting the Ores.

Even though Walker states these directions to be more useful for a neophyte traveller, his later writings demonstrate that he followed a similar system when he traversed the wilds of Scotland. Like his chemical divisions of minerals, these instructions were probably not original to Walker. In fact, they bear a strong resemblance to the instructions given

96 '[T]o Dr. Walker the merit is due of having determined mineralogically that Strontites was a new mineral species. Dr. Hope afterwards, by the *discovery* of the strontitic earth, added to the interest of the determination of Dr. Walker, and proved that strontites was also a new chemical species.' Walker, 'Notice of mineralogical journeys', op. cit. (6), 91, f. '*'.

97 John Walker, 'Mineralogical journal from Edinburgh to London', op. cit. (60), 395–402.

98 In addition to all the short trips listed above, Walker also toured the western side of England from Carlisle to Bristol. See Walker, *Systema Fossilium*, op. cit. (6), f. 10 or Walker, 'Notice of mineralogical journeys', op. cit. (6), 91. At some point, he also visited Preswick and Cunningham. See Walker, op. cit. (64), ff. 222–3 and ff. 216–19.

99 The MD was awarded by the University of Glasgow and the DD was awarded by the University of Edinburgh.

100 Walker, op. cit. (64), f. 156.

101 As discussed in the previous section of this paper.

by Boyle, Woodward and Cullen. Concerning the preservation of samples, Walker recommended the following tools and precautions:

10. Each Specimen to be put up separately & tallied with a Catalogue.
11. Tender Fossils to be put up in Cotton in Chip Boxes, & these again well wrapt & tied up in paper, because the Glue of the Boxes, sometimes gives way. Gems, fine Spars & Crystals, Stalactites, Asbestos, Crystals of Salts & Vitriols, Superficial Delineations, figured or lucid Ores, & most sorts of Petrifactions & figured Fossils require this Precaution.
12. The several Parcels to be packed up in Barrels or strong Boxes, with plenty of Paper, Cotton, Tow or some such soft Substance.
13. Iron Cron. Pocket Spade. Hammers. Chip Boxes. Paper of different kinds. Pack Thread. Cotton. Canvass Bags.[102]

Using these directions, Walker made observations and collected a wide variety of samples that allowed him to write a detailed report on the Hebrides for King George III. This report is now known as the *King's MS*. It was based on his 1764 journey and took him seven years to write. The preface of the *King's MS* is addressed 'TO HIS MAJESTIES COMMISSIONERS AT THE BOARD OF ANNEXED ESTATES'[103] and it states, 'The following History of the western Islands, undertaken at your Desire and executed under your patronage, I have endeavoured as much as possible to render subservient to your excellent and Patriotic Designs.'[104] As a representative of the Crown's improving landlords, it was his duty to identify minerals that were of economic value – lead, coal, marble and metals being the most notable.[105]

At first glance, the plethora of physical observations in the *King's MS* might suggest that Walker had forgotten his chemical mineralogy. However, this was not the case. He cited chemical mineralogists like Wallerius and Cronstedt because many of the minerals he mentions would have been of great interest to Scottish chemists.[106] An excellent example of this is in the section of the report on the Isle of Skye. Here Walker mentions that he has found a Talcy Earth similar to that used for making China in Cornwall. 'I have as little doubt, that this Talc of Sky, is superior to the Soap Rock. It is of a most

102 Walker, op. cit. (64), ff. 157–8.

103 The Board of Annexed Estates was set up to oversee the lands that had been confiscated by the Crown after the 1745 Jacobite Rebellion. Governed by a council of nobles, it was to this body that Walker addressed his report. One of the goals of the Board was to determine whether or not the land could be economically improved and whether or not there was still a strong Catholic presence.

104 See McKay's introduction to Walker, op. cit. (63), 1–30. Also see Anon., 'Dr. John Walker's report to the assembly 1–65, concerning the state of the highlands and the islands', *Scots Magazine* (1766), **28**, 680–9; Anon., 'Dr. Walker's report concerning the state of the Highlands and Islands, to the General Assembly 1772', *Scots Magazine* (1772), **34**, 288–93.

105 Walker, op. cit. (63), 33. He specifically comments about the coal deposits on the islands of Gigha, Rhum and Eigg. Coal's role in the development of eighteenth-century mineralogy is briefly treated in Hugh Torrens, 'The history of coal prospecting in Britain 1650–1900', in 11th Symposium of the International Co-operation in the History of Technology Committee (ed.), *Energie in der Geschichte*, Düsseldorf, 1984, 88–95.

106 In addition to citing Wallerius and Cronstedt in the *King's MS*, he also mentions the mineralogical works of John Ray, Hans Sloan, Linnaeus, (Louis?) Esteve, James Balfour and Robert Sibbald. See Walker, op. cit. (63), 143, 163, 189–91, 198–9 and 215–19.

pure and impalpable Substance, of itself, *the most unalterable in the fire* perhaps, of any Fossile, Gold only excepted.'[107] This test upon Talcy Earth served two important chemical goals. First, it would have aided Black and Cullen in their deliberations about Talc's status as a Primary Earth. These deliberations were closely related to several other experiments Black had conducted over the past decade to determine whether or not other substances like alum and magnesia alba were products of calcareous earth. These types of experiment had been initiated by Andreas Marggraf and Johann Pott at the Berlin Academy a decade earlier.[108] Second, since the 1750s Cullen had been searching for a Scottish clay that could be used to make porcelain (this was why he had originally consulted Pott). It was for this reason that Walker used his fire experiment to argue that the Talc from the Isle of Skye was just as suited for manufacturing china as the 'apyrous' clay (kaolin) used from Stourbridge and other places in the English Midlands.

In all of his travels from the 1750s to the 1770s, Walker's chemistry played an important role in how he actually gathered mineralogical samples. The only way that he could determine whether or not the manure from Kirkcudbright or the Talc from Skye were relevant to other chemical mineralogists was to perform preliminary tests in the field or at home that would reveal whether or not certain minerals were worth sending to Edinburgh for further analysis. This would not have been hard since the two main tests (fire and acids) did not involve elaborate apparatus[109] (however, it is worth saying that Walker does not mention Cronstedt's blowpipe technique).[110] Once the samples were in Edinburgh, this allowed him and others to conduct more experiments upon them. Moreover, it was these private specimens that would eventually form the core of the 'public' mineralogical collection of Edinburgh University's Natural History Museum.[111] Over the next thirty years, the chemical characters obtained from such fossils played a key role in the classification system that he taught his natural history students during the 1780s and 1790s.[112] Since his classification was based on Primary Earths, the very categories created by each genus and species led him to investigate specific chemical

107 Emphasis added. Walker, op. cit. (63), 218.

108 For Alum, the question was whether or not it was an alkaline Calcareous Earth. See Frederic Lawrence Holmes, *Eighteenth-Century Chemistry as an Investigative Enterprise*, Berkeley, 1989, 49–55.

109 Sometimes an acid test could be performed by simply tasting the object under consideration. For instance see his treatment of the South Uist's *polygonum amphibium*. Walker, op. cit. (63), 76.

110 This could be because Cullen only gave Walker a partial translation of Cronstedt's classification, thereby possibly preventing Walker from knowing about Cronstedt's blowpipe. The fact that Walker does not mention the field use of this test confirms (at present) Staffan Müller-Wille's belief that the instrument was generally confined to laboratory usage. See Müller-Wille's paper given at the History of Science Society Annual Meeting at Denver, Colorado, Session 'The creation of order: scientific classifications in the eighteenth and nineteenth centuries', November 10, 2001.

111 Walker's keepership formed a unique private–public situation. See Charles W. J. Withers, '"Both useful and ornamental": John Walker's Keepership of Edinburgh University's Natural History Museum, 1770–1803', *Journal of the History of Collections* (1993), **5**, 65–77; Anderson, op. cit. (5), 22; Waterston, op. cit. (57), 11. The transfer from private to public collections during this time is also treated in E. P. Hamm, 'Unpacking Goethe's collections: the public and private in natural history collecting', *BJHS* (2001), **34**, 275–300.

112 See the mineralogy sections of David Pollock's 1797 notes from Walker's lectures: *Epitome of Natural History*, Vols. 4–9. EUL Gen. 706.D-711.D.

characters of select fossils – Talc, once again, being a good example of this specialized interest.

Building a collection (II): correspondents, patrons and collecting fossils

Whether or not Walker was observing the chemical or physical characters of Scottish minerals, he still needed samples from home and abroad that could function as a source of comparison. In addition to the minerals that he collected on his personal travels in Scotland, the specimens that he acquired during the 1750s and 1760s came from two other sources: correspondents and patrons. Although he had been in contact with Linnaeus since 1762, it was Walker's 1765 trip to London that enhanced his correspondence network. He was received by English naturalists, like John Ellis, who were familiar with his name because of his Linnaean credentials and his *Philosophical Transactions* article.[113] Scottish naturalists living in London would have also known of him on account of his travels and connections in their home country. This connection back to Scotland was important because the political situation of the mid-eighteenth century had created a closely knit Scots community in London. Overseeing this network were two political magnates: Lord Bute and his brother James Stuart Mackenzie. It seems that Walker was received into this community on account of his intent to publish a natural history of Scotland[114] and because he knew Bute. He used this visit to obtain correspondents who were willing to trade not only minerals but also botanical and zoological specimens.[115]

While in London, Walker was also put into contact with one of the best-known fossil traders in Britain – 'Mr. da Costa, author of the History of Fossils, and then Librarian to the Royal Society'.[116] During the 1760s, Da Costa provided Walker with a wide variety of minerals. He sent him thirty-one 'Articles' in 1765 and twenty-nine in 1769.[117] How Walker paid for these is not certain. He most probably received them in exchange for sending Da Costa samples from the Highlands and Hebrides. Da Costa would have been particularly keen on obtaining Scottish minerals on account of England's rising interest in the natural history of 'North Britain'.[118] The Da Costan fossils came from England,

113 John Ellis to Linnaeus, 29 October 1765, in James E. Smith (ed.), *A Selection of the Correspondence of Linnaeus and Other Naturalists*, New York, 1978, 180.

114 William Walison to Richard Pulteney, 29 October 1765, National Library of Scotland (subsequently NLS) Acc. 9533, No. 314.

115 The most fruitful botanical connection Walker made was Dr Richard Pulteney, with whom he exchanged both plants and seeds. See Walker to Dr Pulteney, 3 June 1768 and Dr Pulteney to Walker, October 1768, Linnean Society Manuscripts No. 238. Facsimilies housed in NLS Acc. 9533, No. 314.

116 Walker, *Systema Fossilium*, op. cit. (6), f. 10.

117 Here it is worth noting that Walker's entire list of mineralogical suppliers (which is included in the original MS of *Systema Fossilium*, op. cit. (6), ff. 10–18) is omitted from the 1820 printing of *Systema Fossilium*'s preface. There is also a curious list of 'Prices of some fossils & shells sold at an auction in London. Jan^{r} 1766' in Walker's *Adversaria* that might have been sent by Da Costa. Walker, op. cit. (64), ff. 136–7.

118 This interest was soon confirmed by the popularity of Thomas Pennant's tours (1769 and 1772) and by Johnson and Boswell's 1773 tour. See Pennant's *A Tour in Scotland 1769*, Edinburgh, 2000 and *A Tour in Scotland and Voyage to the Hebrides 1772*, Edinburgh, 1998; Samuel Johnson, *Johnson's Journey to the Western Islands of Scotland and Boswell's Journal of a Tour to the Hebrides with Samuel Johnson, LL.D*, London, 1930.

Brazil, Hungary, Florence, Russia, Sweden, Norway, Pennsylvania, Peru, Bohemia, France and several German principalities (including Saxony).[119] In between these two shipments from Da Costa, Walker also obtained a 'Collection of other Fossils brought from Italy by Mr. John Sivewright of Southhouse'. Sivewright had recently died and Walker obtained sixty-nine specimens via the deceased's sister during 1768.[120] Over the next thirty years, Walker continued to collect minerals in such a manner. He also began to hire lapidaries[121] to find specific fossils. As he became part of the British mineralogical trade, his own network expanded and this placed him in contact with other willing suppliers and traders. For instance, his *System Fossilium* states that in 1772 he received fossils from 'Mr. George Wilson, Surgeon in London' and 'Miss Blackburn from Orford'.[122] A key point to note about these fossils is that, like the samples he collected himself, Walker subjected many of the specimens to chemical analysis – as can be seen by the *ferrum intractable nitens micaceum* debate already detailed above.

Walker's other mineralogical source during the 1760s was aristocratic patrons. His initial contact with the aristocracy was through William Cullen. It was Cullen's chemical knowledge that had originally allowed him to make his own contacts among the nobility.[123] During the 1750s Cullen was involved in introducing Walker to Lord Kames and to the Clerk family of Pennicuik.[124] Walker's travels in the mid-1760s furthered his reputation as Cullen's protégé and placed him in contact with aristocrats like the Earl of Loudan (on whose land Walker sketched coal strata).[125] These tours and his connection with Lord Kames promoted Walker as a credible naturalist and led the Board of Annexed Estates to select him for the 1764 tour of the Hebrides and Highlands.[126] In addition to establishing contacts with Baron Mure, Baron Cathcart, Lord Queensbury and Lord Hopetoun, the 1764 tour allowed Walker to befriend Lord Bute. Over the next ten years, Walker functioned as a scientific advisor to all four of these men.

Most Scottish landowners were interested in mineralogy and chemistry because of their close links to mining and land improvement. It was for this reason that Walker was

119 Walker, op. cit. (64), ff. 144–52; 174–5. The Pennsylvanian minerals could have possibly come from Benjamin Franklin, whom Walker lists in his *Systema Fossilium* as a source for his mineralogy collection, op. cit. (6), f. 18.

120 Walker, *Systema Fossilium*, op. cit. (6), f. 10.

121 Walker uses the term 'Lapidary' to describe a person who buys or trades minerals.

122 Walker, *Systema Fossilium*, op. cit. (6), f. 12.

123 Cullen had first met the Duke of Argyll on account of His Grace's desire to obtain chemistry apparatus. By 1751 Cullen was discussing chemistry with Argyll via correspondence. See 'Drafts of four letters from William Cullen to the Duke of Argyll on the subjects of fossil alkali and salt production', GUL, GB 247, MS Cullen 60. Cullen also had strong links to the Duke of Hamilton and his family. Douglas Guthrie, 'William Cullen and his times', in *An Eighteenth Lectureship in Chemistry: Essays and Bicentenary Addresses Relating to the Chemistry Department (1747) of Glasgow University* (ed. J. W. Cook), Glasgow, 1950, 50–1.

124 It is also likely that Cullen introduced Joseph Black to the Pennicuik family, a relationship that blossomed in the 1770s. See Thomson, op. cit. (65), 328–9.

125 Walker, op. cit. (64), ff. 213–15.

126 Cullen was also busy promoting Walker to other naturalists like Thomas Pennant: 'I take the liberty of recommending to Mr. Walker a thorough Attention to the Zoology of the Western Isles.' Thomas Pennant to William Cullen, 21 April 1764, EUL La.III.352/1 ff. 9–10.

keen to copy down Cullen's (*circa*) 1766 *Lectures on Agriculture*[127] and to offer colliery observations (like those he made for the Earl of Loudan). Walker was not the only one to use chemical mineralogy to obtain patronage. Black, Cullen's other protégé, followed the same pattern.[128] In addition to questions of land improvement, members of the landed class also consulted men like Walker, Black and Cullen because they were interested in writing their own treatises on georgics – Kames's *Gentleman Farmer* (1779) being a good example.[129] Quite often, such agricultural and mineralogical advice paved the way for political connections and preferential access to large tracts of land. For instance, it was Hopetoun's Wanlock and Leadhills mines that afforded Walker the most detailed view of underground minerals and his mineral well (Hartfell Spa, outside of Moffat) that allowed Walker to publish his first article.[130] Acquiring these minerals also led to their analysis, both for reasons of science and patronage.[131]

This symbiotic relationship between land improvement and natural history was one of the main factors that propelled Walker's career, especially when the town council appointed him to be the professor of natural history in 1779.[132] Moreover, based on the careers of Walker, Cullen and Black (and others like professors Alston and Francis Home), it seems that mid-eighteenth-century Scottish mineralogy thrived on a reciprocal relationship that existed between improvement-minded patrons and naturalists that were either employed in or trained by the medical schools. If one looks at the chemical experiments being performed on minerals by Edinburgh's Medical School professors who taught chemistry or *materia medica*,[133] it becomes apparent that many of their experiments were directly applicable to mineralogical and chemical classification. In this sense the Medical School provided a key service that was characteristically associated with mining academies in Europe.[134]

127 John Walker (transcriber), *Abstract from Dr. Cullen's Lectures on Agriculture* (*c.* 1766), EUL Dc.3.70. John Thomson sets the date of these lectures to be around 1766 in his *An Account of the Life, Lectures, and Writings of William Cullen Vol. I.*, Edinburgh, 1859, 64. For more information on these lectures, see C. W. J. Withers, 'Improvement and Enlightenment: agriculture and natural history in the work of the Rev. Dr. John Walker (1731–1803)', in *Philosophy and Science in the Scottish Enlightenment* (ed. P. Jones), Edinburgh, 1988, 102–16; 'A neglected Scottish agriculturalist: the "Georgical Lectures" and agricultural writings of the Rev. Dr. John Walker (1731–1803)', *Agriculture History Review* (1985), **33**, 132–43.

128 As demonstrated by the mineralogy letters exchanged between Black and Lord Hopetoun, op. cit. (58).

129 Also see C. W. J. Withers, 'On georgics and geology: James Hutton's "elements of agriculture" and agricultural science in eighteenth-century Scotland', *Agricultural History Review* (1994), **42**, 38–48.

130 Several other naturalists visited these mines throughout the seventeenth and eighteenth centuries. See T. C. Smouth, *Report on the Lead-Mining Paper at Hopetoun House, West Lothian, 1625–1799*, Edinburgh, 1962 and M. D. Eddy, *New DNB* (forthcoming, 2004).

131 Porter argues that 'From 1700 until 1775 ... most mineralogists felt that their chief task was to integrate mineralogy and chemistry, for the benefit of mineralogy.' T. Porter, op. cit. (36), 548.

132 See S. Shapin, 'Property, patronage, and the politics of science: the founding of the Royal Society of Edinburgh', *BJHS* (1974), **7**, 1–41.

133 J. Black, op. cit. (58). Aside from the mineralogical sections on Cullen's chemistry lectures discussed in the first section of this essay, see Joseph Black's sections on 'earths', op. cit. (35) and the entries on mineralogical simples contained in the *material medica* lecture notes of Alston and Home that are housed in the Royal College of Physicians of Edinburgh. See especially Alston's *Lectures on materia medica*, 12 vols. [Edinburgh, *c.* 1740] and Home's *Lectures on materia medica*, 2 vols. [Edinburgh, *c.* 1768].

134 For a general introduction to the role of mining academies see M. Guntau, 'The natural history of the Earth', in *Cultures of Natural History* (ed. N. Jardine, J. A. Secord and E. C. Spary), Cambridge, 1996, 211–29;

Walker's most significant aristocratic patron was Lord Bute. Like Kames, Bute's interest in natural history went beyond simple land improvement. In addition to its economic value, natural history was Bute's favourite hobby.[135] He had taken his degree from the University of Leiden in 1732 and, like many naturalists, he was not content with the Linnaean classification system.[136] This led him to construct his own.[137] In 1765 Bute gave Walker access to his London library[138] and by 1767 it is highly likely that Bute was supplying specimens to 'the ingenious Doctor Walker of Moffat'.[139] Bute must have thought highly of Walker's abilities because he discussed his alternative classification with him. Walker specifically recorded Bute's thoughts on the classifications of gems and flowers in his *Adversaria*.[140] To help develop his system, Bute had amassed a large collection of minerals and plants from Britain and abroad. Wilson has suggested that his mineralogical collection was well over a hundred thousand specimens. If this is true, Bute's collection was possibly the largest in Europe at the end of the eighteenth century.[141] Bute allowed Walker to see part of his 'fossil' catalogue sometime during the late 1760s. In the notes that Walker took on the collection, he states that Bute had purchased some of the minerals from a Mr Maine for the sum of £300. Walker was able to view '1833 Numbers of Fossils, many of which, are English & Foreign'. Of these, Walker copied down sixty Scottish specimens and twenty 'Foreign Fossils, chiefly German' – the latter being mostly metals.[142] Walker continued to maintain his relationship with Bute into the 1770s. He visited the Isle of Bute during his 1771 tour and in 1772 Bute sent Baron Mure two letters enquiring about a box of books that he had bought for Walker in London.[143]

Bute and Walker's other patrons placed him in contact with their natural history network at home and abroad. In Britain, Walker's ties with Bute advanced his standing

D. Brianta, 'Education and training in the mining industry, 1750–1860: European models and the Italian case', *Annals of Science* (2000), **57**, 267–300. Unfortunately, Brianta's analysis conflates 'Britain' with 'England' (thereby ignoring trends in Scotland). See pages 280–1.

135 D. P. Miller, '"My favourite studdys": Lord Bute as naturalist', in *Lord Bute: Essays in Re-interpretation* (ed. Karl W. Schweizer), Leicester, 1988, 213–39. Also see Anonymous, *A Catalogue of the Capital Collection of Optical, Mathematical, and Philosophical Instruments and Machines: Late the Property of The Right Hon. the Earl of Bute* ..., London, 1793. One of the only known copies of this is housed in Imperial College's Science Museum Library. Furthermore, the 'Walker' listed as buying lots 79, 211, 227 and 233 just might have been John Walker – not Adam Walker as G. L'E. Turner has proposed in 'The auction sales of the Earl of Bute's instruments, 1793', *Annals of Science* (1967), **23**, 213–42, 221 and 227.

136 John Hill (1716–75) for example. F. A. Staflau, *Linnaeus and the Linnaeans: The Spread of Their Ideas in Systematic Botany, 1735–1789*, Utrecht, 1971, 207–10, 231.

137 Eventually published as *Botanical Tables, Containing the Different Families of British Plants Distinguished by a Few Obvious Parts of Fructification Rang'd in a Synoptical Method*, London, 1784. Also see Ray Desmond, *Kew: The History of the Royal Botanic Gardens*, London, 1995, 92.

138 Walker, op. cit. (64), f. 200.

139 D. S. Erskine to Bute, 23 March 1767, Cardiff, MSS, Bundle 2. Also quoted in Miller op. cit. (135), 238.

140 Walker, op. cit. (64), f. 194–5.

141 Wilson, op. cit. (2), 69–70.

142 Walker, op. cit. (64), ff. 178–86.

143 Lord Bute to Baron Mure, 25 March 1772, NLS, Mure of Caldwell Correspondence, MS 4945; Lord Bute to Baron Mure, 14 August 1772, NLS, Mure of Caldwell Correspondence, MS 4945. Part of the former letter states, 'I have taken the liberty to send a box of books for Dr Walker; to [?] address that I beg you would forward him.'

with the natural history community in London, especially after he had corresponded with the famous naturalist Sir Joseph Banks.[144] Walker's ties with Kames brought him into contact with several of the Judge Advocate's scientific advisors – two examples being Sir John Nasmyth (*c.* 1704–79)[145] and Sir John Pringle (1707–82).[146] The fact that Walker had been trusted by the nobles who sat on the Board of Annexed Estates most likely gained him an introduction to the Duke of Northumberland in 1765.[147] However, Walker's contact with Northumberland may have been encouraged by Bute.[148] Walker's notes and letters from the 1750s through the 1770s further indicate that he was in contact with several landed families[149] as well as several of Edinburgh's judge advocates.[150] Since many of these landowners actively maintained natural history contacts abroad, Walker benefited from their extended network. The best example of this situation is a letter written from Dr John Rogerson to John Clerk, the seventh son of Sir John Clerk of Pennicuik.[151] Rogerson was a former student of Cullen. He was the personal physician to Catherine the Great and several other members of the Russian court in St Petersburg. The letter states,

> I wrote Dr. Walker last Autumn and sent at his requisition upwards of an hundred specimens of Russian and Siberian Ores which I hope he has received safe – I think they were addressed to the Care of the Jamiesons of Leith. Dr. Pallas Professor in our Academy and a Man of first rate mint and knowledge furnished me with almost all of them. I should be glad to open correspondence

144 Walker to Joseph Banks, 28 March 1767 and Walker to Joseph Banks, 23 January 1772, in *The Banks Letters: A Calendar of the Manuscript Correspondence of Sir Joseph Banks, Preserved in the British Museum, the British Museum (Natural History) and other Collections in Great Britain* (ed. W. R. Dawson), London, 1958, 849. Both letters are on this page.

145 Walker, op. cit. (64), ff. 224, 227, 228–9. Naysmyth studied with Linnaeus in Sweden and was elected fellow of the Royal Society in 1767. See G. E. Cokayne, *Complete Baronetage, Vol. IV*, Gloucester, 1983, 441.

146 John Pringle to Walker, 19 February 1778. The letter is lost, but is referred to in Walker's 28 February 1788 letter to Lord Hailes, NLS, MS 25303, ff. 5–6. Pringle was Scottish, and was made physician to the queen (1761) and then to the king (1764). He was elected President of the Royal Society in 1772 and was directly involving in editing the 1774 edition of the *Edinburgh Pharmacopoeia*. For the latter see D. L. Cowen, *Pharmacopoeias and Related Literature in Britain and America, 1618–1847*, Aldershot, 2001, 38–40.

147 Walker visited him during his 1765 trip to London. It seems that the Duke of Northumberland and Walker even had several detailed conversations about the differences between Scottish fir and pine trees. Walker, op. cit. (64), ff. 128–31.

148 Northumberland and Bute were discussing natural history as early as the 1750s. It was Northumberland who had introduced John Hill to Bute. Miller, op. cit. (135), 219.

149 Most were Scottish nobles: (1) John Boyle, Earl of Glasgow (1714–75). (2) David Stuart Erskine, Earl of Buchan (1742–1826). (3) George Macartney (1737–1818), whom Walker calls 'Lord Auchinleck', was knighted in 1764, sent as Britain's Envoy to Russia (1764–7) and made Baron in 1776. (4) Sir William Maxwell (*c.* 1715–71). (5) George Clerk (1715–84), second son of Sir John of Pennicuik. Styled Sir George Clerk-Maxwell (1782), he served as Scottish Commissioner of Customs (1763–84). Walker was also in contact with the Englishman Sir John Hussey Delavel (1728–1808) of Ford, Northumberland. Delavel was also a keen mineralogist. See *DNB*.

150 (1) The aforementioned Henry Home, Lord Kames. (2) Sir David Dalrymple, (1726–92), styled 'Lord Hailes' when he was made a judge advocate for the Scottish Court of Session in 1766. (3) Francis Garden (1721–93), styled 'Lord Gardenstone' when raised to the bench in 1764.

151 The stratigraphical drawings of John (the younger) were originally supposed to be included in Hutton's *Theory of the Earth*. See John Clerk (ed.), *James Hutton's Theory of the Earth: Reproductions of Drawings, Mostly by John Clerk of Eldin*, Edinburgh, 1978.

between Dr. Walker and him – he writes and speaks English so it would be perfectly easy for both and might be mutually usefull to each other.[152]

Rogerson was part of a larger network of Scottish physicians who lived on the Baltic and who helped supply mineralogical specimens. Many of them were associated with port cities that contained large British trading communities. They collected a wide variety of minerals and sent them back to British naturalists and landowners seeking to compare their ores, minerals and metals to those from abroad.[153] During the 1760s this network flourished under the patronage of Baron Charles Cathcart, the British Ambassador to Russia. Walker was included in this network because he had formed close links to the Cathcart and Hopetoun families. As the above excerpt indicates, the mineralogical rewards of such a network would have no doubt provided more specimens that would eventually help him write his own mineralogical system.

Conclusion

This article has detailed the early mineralogical career of Rev. Dr John Walker, with specific focus on how he analysed, arranged and acquired 'fossils'. It began by showing that chemistry was one of the main forms of analysis used for ascertaining mineral characters in eighteenth-century Scotland. Although he was familiar with other theories, Walker was most influenced by five-principle chemistry. He was introduced to this when studying at the University of Edinburgh and via his mentor William Cullen. This form of chemistry favoured the Becher–Stahl School's concept of a 'Primary Earth' that chemically analysed stones and then classified them based on which Primary Earth they contained. With the help of Cullen and Kames, Walker entered into the Scottish natural history scene during the 1750s and continued to use chemistry to ascertain the chemical characters of minerals. Although the Swedes, Germans and French promoted chemical mineralogy at this time, it was the Swedish authors that had the most profound effect on the mineralogy practised by Walker and several of his contemporaries. He first used Wallerius and Cronstedt in the 1760s and then went on to use Bergman in the 1770s. The influence of Swedish mineralogy remained strong when he began to give his mineralogy lectures in the 1780s and he continued to cite these authors up until he died in 1803. The fact that he taught chemical mineralogy to seven hundred or more students during his time as a professor suggests that this form of analysis (and the sources that he cited) deserve a closer look – especially since many of these students were members of the Royal

152 Dr John Rogerson to John Clerk, 23 August 1772, National Archives of Scotland, GD 18/5121/3. The letter is dated St Petersburg. It also mentions Dr Hope and seed specimens that were collected for Catherine the Great by Professor Laxman. The connection with Pallas would eventually find fruition in 1783 when he sent Walker 129 fossils from Siberia for Edinburgh's Natural History Museum. Whithers, op. cit. (111), 70.

153 See J. H. Appleby, 'A survey of some Anglo-Russian medicinal and natural history material in British archives, from the seventeenth century to the beginning of the nineteenth century', in *The Study of Russian History from British Archival Sources* (ed. Janet M. Hartley), London, 1986, 107–31; A. G. Cross, 'Articus and *The Bee* (1790–94): an episode in Anglo-Russian cultural relations', in *Oxford Slavonic Papers, New Series, Vol. II*, Oxford, 1969, 62–76. L. Koerner also treats various aspects of the Baltic mineralogy in 'Daedalus Hyperboreus: Baltic natural history and mineralogy in the Enlightenment', in *The Sciences in Enlightened Europe* (ed. W. Clark, J. Golinski and S. Shaffer), 389–422.

Society of Edinburgh during the years when the different versions of James Hutton's *Theory of the Earth* were debated and published. Indeed, Hutton's original 1785 monograph treats the sea as if it were one gigantic flask in which 'loose materials had formed into solid masses'.[154] Even though this process involved heat, the older professors of the Medical School like Walker, Black and Cullen would have used saline chemical vocabulary to describe many of processes implied in Hutton's account of the 'globe'.[155]

Walker's career demonstrates that acquiring and analysing minerals in eighteenth-century Scotland was a symbiotic relationship. The best example of this situation was Walker's involvement with the Hope family. There is no doubt that his 1757 *Philosophical Transactions* paper would have pleased John Hope, the second Lord Hopetoun, because Hartfell Spa (the medicinal well under examination) was on his land. It should therefore come as no surprise to see that Walker was appointed to be the minister of Moffat in 1762 – a town in which the Hope family exerted a considerable amount of influence (indeed, they donated the land on which the town's present church is built). Living in Moffat placed several of the Hopetoun mines within a day's walking distance. Even though it is not certain as to what extent Walker was involved in guiding the family's view on ore or coal prospecting, it is clear that he made himself available to give advice on the minerals being dug out of their mines.[156] The links that he made with the Hope family early in his career became very useful later in his life. During the late 1770s, the second Lord Hopetoun helped Walker secure his professorship and gave him access to mineral specimens that he had acquired while travelling abroad.[157] After the second Lord Hopetoun died in 1781, James Hope, the third Lord Hopetoun, continued to supply the Natural History Museum with specimens[158] and politically supported Walker's involvement in the creation of the Royal Society of Edinburgh in 1783.[159] To this day several of the marble slabs given by the Hopes to the Natural History Museum still bear Walker's handwriting on their labels – a memorial to the strong bonds that existed between eighteenth-century mineralogy and patronage.[160]

154 James Hutton, *Abstract of a Dissertation Read in the Royal Society of Edinburgh, upon the Eleventh of March, and Fourth of April, M,DCC, LXXXV, Concerning the System of the Earth, its Duration and Stability*, Edinburgh, 1785, 8.

155 This situation becomes particularly interesting when one considers that it took some time before the new nomenclature was accepted in Edinburgh. This is treated in A. Lundgren and B. Bensaude-Vincent (eds), *Communicating Chemistry: Textbooks and their Audiences, 1789–1939*, Canton, MA, 2000. See A. Donovan's two articles on this context: 'Scottish responses to the new chemistry of Lavoisier', *Studies in Eighteenth-Century Culture* (1979), **9**, 237–49; and 'Chemistry and philosophy in the Scottish Enlightenment', *Studies on Voltaire and the Eighteenth Century* (1976), **152**, 587–605. The delayed reception of the new nomenclature in light of national contexts is treated in B. Bensaude-Vincent and F. Abbri, *Lavoisier in European Context: Negotiating a New Language for Chemistry*, Canton, MA, 1995.

156 In addition to Walker, the Hopetoun mines were also visited by Thomas Pennant and R. E. Raspe. See M. D. Eddy, 'James Hope Johnstone, third Earl of Hopetoun (1741–1816)', *New DNB* (forthcoming, 2004).

157 Waterston, op. cit. (57), 22.

158 Lord Hopetoun is also listed as a patron of the museum in a report written by Walker around 1786. EUL La.III.352/5 f. 1.

159 Shapin treats this in op. cit. (132).

160 There were over one hundred of these marble specimens, many of which are housed in the National Museum of Scotland, reference number G1993.34.

In addition to the Hope family, Walker was able to procure his specimens from a variety of other sources. The most immediate was his own backyard. Since this was a time when physicians and apothecaries still had to scour the countryside for pharmacological simples, his training at Edinburgh's Medical School and with Cullen proved to be very useful because it had taught him how to utilize the specimens that existed in his own locality. Since his career demonstrates that lapidaries and savant suppliers existed in healthy numbers in Scotland and London, more research needs to be done to see just who 'Mr. John Sivewright' and 'Mr. George Wilson' actually were and what sorts of network they used to procure and sell 'fossils'. Walker's list of mineralogical suppliers would be an excellent place to start for such research because it shows that Baltic sources were just as important as those that came from the Mediterranean and, to a lesser extent, the Americas. Such a wide variety of locations also suggests that Scottish mineralogy, like botany, benefited from Britain's central position in eighteenth-century trade and colonization. The emphasis placed upon mineralogical topics in the Medical School led many of the physicians and surgeons assigned to naval or diplomatic posts to be on the lookout for foreign fossils. A good example of this practice is Dr John Rogerson and the samples that he sent to Walker from St Petersburg. The efforts of such mineralizing physicians were often reinforced by the patronage of Scottish ambassadors who owned mines and who wanted to compare their ores to those of foreign countries. It was probably for this reason that Lord Cathcart, the British ambassador to Russia, collected ores and gave patronage to physicians like Rogerson. Another diplomat interested in mineralogy was Robert Liston, the ambassador to Spain. He used his influence to acquire and send Walker several different types of ore during the 1780s. The motivations for supplying foreign minerals were therefore complex and the cases of these physicians and diplomats, or even that of Da Costa and Walker, force the researcher to consider the motivations of those who participated in the mineralogical trade. Were minerals simply collected because of their novelty, or were they initially selected to be compared chemically to indigenous ores and pharmaceutical simples that could be commodified?

To answer this question, more work will have to be done on the eighteenth-century mineralogical scene in Britain, not just for Scotland, but also for England, Ireland and Wales. Not only do the practising mineralogists need to be more clearly identified, but the sources that were used as field guides and in university medical courses also need to be surveyed. Since many medical professors still read Latin, books in this language also will also have to be considered. Additionally, local chorographies, statistical surveys and even mining records should also be consulted. For example, the mineralogical content of Highland and Hebrides tour reports,[161] *The Statistical Account of Scotland* (1791–9),[162] and accounts written in other European languages need to be

161 Walker's *Kings MS*, op. cit. (63), would be included in this category. See also D. M. Henderson and J. H. Dickson (eds.), *A Naturalist in the Highlands. James Robertson, His Life and Travels in Scotland, 1767–1771*, Edinburgh, 1994.

162 John Sinclair (ed.), *The Statistical Account of Scotland. Drawn up from the Ministers of the Different Parishes, Vols. I–XI*, Edinburgh, 1791–9. Walker made two contributions to this work. John Walker, 'Number XXVII. Parish of Colington, County of Edinburgh, Synod of Lothian and Tweeddale, Presbytery of Edinburgh', in *A Statistical Account of Scotland … Vol. 19*, Edinburgh, 1799, 579–91; William Torrence and John Walker,

considered.[163] Historians of geology have done some preliminary work in ferreting out pre-1800 British mineralogy sources.[164] However, mineralogy's centrality to medicine and the natural history enterprise necessitates that it be treated as a subject in its own right and not as a preamble to geology. Indeed, a serious historical treatment of mineralogists on the scale of Ray Desmond's edition of the *Dictionary of British and Irish Botanists* has yet to be written. No matter which path is taken, the world of eighteenth-century mineralogy will remain an intriguing field for those wishing to investigate the many faces of eighteenth-century chemistry and natural history.

'Number XXI. Parish of Glenncross, Presbytery of Dalkeith, Synod of Lothian and Tweeddale, and County of Mid-Lothian', in John Sinclair, *A Statistical Account of Scotland … Vol. 15*, Edinburgh, 1799, 435–46.

163 As Walker's *Adversaria* indicates, F. W. P. Fabricius had travelled into the highlands. However, like many travellers, his observations were not committed to print. There are several eighteenth-century French and German travel works that address Scotland's mines and minerals, but these have not yet been treated in relation to their contribution to the history of mineralogy. Some helpful French sources from the late eighteenth century are Gabriel Jar, *Voyages métallurgiques, ou, Recherches et observations sur les mines et forges de fer … faites depuis l'année 1757 jusques & compris 1769, en Allemagne, Suéde, Norwege, Angleterre & Ecosse …*, Lyon, 1774–81; Paul Henri Mallet (ed.), *Voyages aux montagnes d'Ecosse et aux isles Hébrides, de Scilly, d'Anglesey, &c. …*, Paris, 1785; Barthélemy Faujas de Saint-Fond, *Voyage en Angleterre, en Ecosse et aux îles Hébrides: ayant pour objet les sciences, les arts, l'histoire naturelle et les moeurs; avec la description minéralogique du pays de Newcastle des montagnes du Derbyshire, des environs d'Edinburgh, de Glasgow, de Perth, de S.-Andrews, du duche d'Inverary et de les grotte de Fingal …*, Paris, 1797 (translated into English in 1799).

164 The most encompassing project being W. A. S. Sarjeant, *Geologists and the History of Geology: An International Bibliography from the Origins to 1978 Vols. I–V*, London, 1980.