HMSNEWS
Historical Metallurgy Society

42 Autumn 1999

Forthcoming Events

HMS Annual Conference 10th to 12th September on The Iron Industry of Furness at Ambleside. Fully Booked.

The Association of German Iron and Steel Makers. Lectures on Technical history with excursions in Duisburg from 14th to 16th October 1999 (64th gathering of the historical section of the Ass. of German Iron and Steel Makers) **Innovation then and now**. Insights into the history of iron, steel and coal in the Ruhr. Visits include: Technical education centre at Hambom (Thyssen Krupp Stahl AG) Thyssen Krupp Steel Works, Duisburg and tour of harbour. Schalker Verein Tube Works, Gelisenkirchen. Mining and Coke Works Essen. Villa Huegel and historical archives — Krupp. Landsberg Palace. Industry Museums in Hattingen and Oberhausen. Park Landscape — Meiderich Blast Furnaces etc in Duisburg. Before the conference on the 13th Oct. there will be the chance to visit the underground workings of the Walsum coal mine of the German Coal Company Ltd (maximum 20 able bodied people!)

For full details please contact :- Mr M Toncourt, Verein Deutscher Eizenhuetten Centre, P.O. Box 10 5145, D40042 Duesseldorf. Tel 0211/6707-460 Fax 0211/6707-452. E-Mail man-fred.toncourt@vdeh.de.

Experimental and educational aspects of bronze metallurgy
18–22 October 1999 from the bronze age to the middle ages. Experimental part 18-20 October Educational part 20-22 October To be held at Buitencentrum K. Wilhelminalaan 24 8384 GH Wilhelminaoord Netherlands Contact: Ernest Molsfax 0031-521382050 fam.mols@wxs.nl.

Experimental archaeologists will carry out their own experiments and in the Educational part they will act as teachers. They're invited to present papers. A proceedings of the conference will follow later that year, beginning next year. The costs are 200 guilders for experimental archaeologists (including workshop, sleep arrangements, food, proceedings) For participants in the educational part it is 350 guilders. (Because of funding the prices are kept as low as possible) There is a homepage:
http: //users.castel.nl/~molse01 or
website:www.dekker-auto.org.

Study Tour to Mexico
The Society is planning to go ahead with the Mexican Study Tour in conjunction with Atalaya Tours. The tour is planned to take about a fortnight, starting on 21st May 2000, directly following the end of the Archaeometry Conference. It will be based on Mexico City, Zacatecas, Pachuca, Taxco, and probably either Guanajuato or Real de Catorce. The tour will concentrate on ore processing, smelting and silverworking sites from the 16th century to the present, but will include pre-Columbian metal and obsidian mining, some of the major pre-Columbian archaeological sites, and time in the colonial-Spanish cities. Accommodation will be in comfortable hotels, and air travel (including flight from the UK) are likely to be around £1300; the tour will be open to non- HMS members, but we will get a discount. Members who returned David Cranstone's flier in the Winter newsletter will be hearing direct from Atalaya Tours in the near future — anyone else interested should contact Jamie Thorburn, Atalaya Tours Ltd, Ceinionfa, Capel Dewi, Aberystwyth, SY23 3 HR, UK.

1999 Annual General Meeting

Twenty nine members and their guests attended the AGM and Spring Meeting at our Registered Office, the headquarters of the Institute of Materials in Carlton House Terrace. At the AGM a new Chairman, Eddie Birch, was appointed and three new Council Members, Peter Claughton, Vanessa Fell and Thilo Rehren.

Spring Meeting 1999

We had hoped that the Programme Secretary of the Institute would have told us about the Institute and the building but regrettably she was unable to attend. Paul Cort, Chairman of our Programme Committee presented her script instead.

The Institute of Materials is a result of the merger of the Institute of Metals, The Institute of Ceramics, the Plastics ad Rubber Institute and the British Composites Society. This is the latest in a series of mergers that have taken place since the second World War.

In 1869 the British ironmasters banded together to form the Iron and Steel Institute. It's original purpose was protectionist but it soon realised that the exchange of information would benefit the Industry and it became one of the leading learned societies of the day. JISI was a well known and respected journal. In 1899 the Institute was granted a Royal Charter by Queen Victoria. Soon after this the non-ferrous metals industry formed the Institute of Metals as a learned society covering all non-ferrous metals. Again it was soon recognised as a leading learned society though its journal, JIM. Both held conferences and seminars which were particularly useful when many of the producers were relatively small.

After the first World War the need for qualified scientists lead to the formation of a number of professional bodies which awarded qualifications by examination and relevant experience but it was not until 1945 that the Institution of Metallurgists was formed. The Institution was granted a Royal Charter in 1975. By 1985 all the metallurgical institutions had merged to form the second Institute of Metals.

Other materials societies had followed a parallel path and in the late 1980s it became clear that their interests overlapped. The British Composites Society was formed because the composites community could not see that any of the existing societies could represent their interests. Discussions took place between the various bodies and the members, who were not easily convinced, were consulted. In 1991 the merger was agreed and the new Institute of Materials was formed in January 1993.

The Institute now has about 18,000 members from all over the world. The range of interests is very wide covering all aspects of extraction, production, processing and end use of all kinds of materials.

1 Carlton House Terrace.

The house was built in 1830 by Decimus Burton to a design by Nash for Carlton House Terrace. This was a redevelopment of Carlton House, once the home of the Prince Regent.. Tenants of the building have included the US Ambassador (1900–5) and George Nathaniel, Marquess of Kedleston who lived there from 1905–1925. After his second marriage in 1917 it became a social centre and most of the prominent people of the day must have been entertained there. After his death it was empty for eleven years until it became the headquarters of the Savage Club. In 1940 a bomb destroyed the Council Room and the Library of the Savage club below it. The damage was repaired in 1949 but the damage caused by the bomb, exposure to the weather, and perhaps the period when it was empty, was worse than had been realised and rot and decay set in. In 1963 the Savage Club moved out. In 1969 the Crown Estate offered the lease to the Iron and Steel Institute on the basis that they would renovate the shell. They moved in 1972.

The principal rooms have been restored to the designs of J P Candy-Deering and are designated as preserved historic features. The Council Room was Curzon's sitting room and the Library was the dining room. The Bessemer Room on the ground floor was the Library. The rooms hold a collection of historic pictures. On the landing are the original Bessemer patents and in the Bessemer room the Institute keep the casket which held the scroll conferring the Freedom of the City of London on Sir Henry.

As affiliated members of the IoM HMS members can use some of the facilities provided by the Institute. Ask if you are interested. After the introduction we were allowed to visit the public rooms in an interesting building.

After an excellent buffet lunch in the Library (and out on the terrace) we had hoped to visit a disused part of the Underground system. The Victorian metallurgy that had been employed in building it would have been of interest. Unfortunately London Transport were unable to accommodate a large party and a visit to the Transport Museum had been substituted. This has a very wide range of public transport vehicles and other items from the track and signalling system. Unfortunately much of what in the real underground is cast iron had been simulated in plastic. Nevertheless I thought most people enjoyed the alternative visit.

Peter Hutchison

The Council after the 1999 AGM is

President	Dr Colin Phillips
Chairman	Mr M.E. Birch
Hon General Secretary	Mr. Peter Hutchison
Hon Treasurer	Mr. Mike Cowell
Hon Joint Editor	Dr Justine Bayley
Hon Joint Editor	Mr. David Crossley
Hon Joint Editor	Dr. Sam Murphy
Member	Dr Tim Smith
Member	Mr Peter Claughton
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Member	Dr. Thilo Rehren
Member	Dr Richard Smith
Member	Dr. Gill Juleff
Member	Mr Duncan Hook
Member	Mr. David Cranstone
Member	Col Paul Cort
Member	Dr Katherine Eremin
Member	Dr. J.P. Northover
Member	Dr. Alan Williams
IoM representative	Dr. C. Corti
Membership Secretary	Mrs Lesley Cowell
Newsletter Editor	Miss Amina Chatwin
Archaeology Chairman	Dr. J.P. Northover
Programme Chairman	Col Paul Cort
Publications Chairman	Dr Justine Bayley

Help wanted

The Secretary has received the following queries

From Hubert Jacobi of Eschweiler, Germany. Information about Samuel Dobbs who worked from 1817 to 1850 in several places in Europe and died in Vienna.

From: Olle Andersson

I am an archaeologist, blacksmith and a curator at an industrial heritage museum in Sweden. Although I have both practical and theoretical knowledge concerning the forging of gunbarrels by the old methods (both damascus and plain steel) I would very much like to find someone who has more experience in these matters. Do you know of any such person and where they could be contacted? (I know they are out there since I've seen pictures of newly made barrels, but the makers elude me.) Could you help me?

Please send any offers of help to the Hon Gen Secretary
PeteHutch@compuserve.corn
Mr. Peter Hutchison
22, Easterfield Drive
Southgate
Swansea,
SA3 2DB

Archaeometallurgy

A shorter contribution this issue due to the editor's move from English Heritage to the Royal Armouries Museum in Leeds. I hope to be able continue compiling the Archaeometallurgy column. However, as my links with archaeological community have become more tenuous, I'm now more reliant on readers contacting me with contributions (or suggestions for them). I look forward to hearing from you!

David Starley had intended to use here an article on Romano-British iron smelting furnaces at Laxton, Northants but this has now appeared in the last HMS Journal Vol 32 Number 2 which you will recently have received. Editor

Metal from Heaven — A Bolt from the blue

Contribution from Paul Craddock

Mike Baillie is an infuriating fellow — just when he had (more or less) convinced us that some of the more dramatic short term global climatic deteriorations over the past few thousand years could be attributed to volcanic eruptions (Bailie 1995), he now tells us that extra terrestrial bombardment was the more likely culprit (Baillie 1999). The present author remains firmly sceptical by the evidence presented, but would point out that if one does invoke the heavens then there is interesting supportive metallurgical evidence that Baillie has overlooked.

Professor Baillie is a distinguished dendro-chronologist who has worked at Belfast University for many years, amongst other things establishing

the tree ring record back through prehistory. Put very simply, trees put down an outer growth layer each year, and the thickness of this layer varies according to the weather during the growing season. Thus a characteristic pattern of rings, species and region specific builds up over the years. This pattern once dated can then be recognised in other wood, enabling it to be dated with great precision. Baillie's work on Irish bog oak, dating back through many thousands of years, as well as establishing the chronological sequence also revealed much information on the palaeoclimate. His work, and that of others around the world, showed that very occasionally there had been isolated years in which, globally, little or no growth had taken place at all. The particular years that Baillie and others identified as experiencing especially severe climatic conditions were 2354–2345BC, 1628BC, 1159BC, 207BC, 44BC and 540AD. This much is beyond doubt, and in these years something awful, in every sense of the word, must have taken place — but what?

The true global nature of these events in the climate indicated by tree rings everywhere, and then confirmed by the ice cores taken from Greenland, became apparent in the late 1960's and 1970's. This was around the time that the Mount St. Helens and other major eruptions had poured enormous quantities of dust and gas into the upper atmosphere. At much the same time archaeologists established that the now peaceful Aegean island of Santorini must have erupted catastrophically some time in the mid second millennium BC destroying the thriving Minoan settlement on the island, and, it was further postulated, Minoan civilisation generally. Baillie and others sought to establish a link between the 1628BC tree ring event and the Santorini eruption, which was dated with much less precision by radiocarbon to within 1670 to 1530 Cal BC at a 95% confidence level.

However, for the last few years volcanoes have been rather quiet, but after the poor showing of Halley's Comet in 1986, which nevertheless generated great interest and a new popular literature on comets generally, there have been the much more impressive cometary events, with Hale-Bopp clearly visible in 1997 and the spectacular end of comet Shoemaker/Levy 9 as it plunged into Jupiter, dramatically recorded by the Hubble telescope in 1994, revealing to all the awesome destructive power of a cometary impact. Comets are, so to speak, in the air.

Baillie has reexamined the tree and ice core evidence and now seeks to establish that the real cause of the sudden and short lived climatic deteriorations was extra-terrestrial. The main part of the book is taken up with an examination of the (very) diverse contemporary historical evidence for such catastrophes. For the events of the late first millennium BC and later, there are some surviving records that do hint, albeit obliquely, at something happening in the sky. But for the events in the third and second millennia BC the evidence is much more tenuous and there are major problems linking the tree ring evidence to any historical date. Baillie seems to have to rely variously on the very precise dating of Biblical events worked out by Bishop Usher in the 17th century (he famously dated the Creation to 4004 BC), extrapolation of the Medieval Irish Annals back to the Early Bronze Age, and the totally discredited Immanuel Velikovsky.

However, there is more tangible evidence, at least for meteoritic bombardment in the second millennium BC. Meteorites, originating in the asteroid belt, are made up of planetary debris, and many are of iron (Buchwald 1980). They have very distinct structures and compositions, with a nickel content typically of between 6% and 15%, but always above 5%. quite different from any telluric or early smelted iron. This distinctive composition has allowed a very few artefacts fashioned from meteoritic iron to be recognised (Waldbaum 1980, Craddock 1995, p. 110), reaching back to Pre-Dynastic Egypt, but what was this metal. called?

Both the Egyptians and the Mesopotamians had words that translate literally as 'metal from heaven' (see Newton Friend 1926, p.38-41 for a general discussion of these terms). This, surely, was the meteoritic iron. However there are problems, in the pre- sent world of our every day experience we would not associate a lump of metal in the ground with shooting stars- occasions of experiencing meteoritic falls and finding the meteors are just too rare. After all it was not until the early 19th century that the European scientific community was finally persuaded to believe in meteorites at all, following the spectacular and well recorded fall of stony meteorites at L'Aigie in France. But we are asked to believe that people across the Middle East knew this back in the 3rd and 4th millennium BC, and moreover gave the distinctive name to the metal, although strangely, they gave no name to the meteorites themselves.

The real situation is much more suggestive. The original Egyptian word ‘bia’, in use from the third millennium BC, meant just metal, only in the mid second millennium BC did the term ‘bia n pet’ ‘metal from heaven’ come to be used (Barakat 1998, Craddock 1995, p. 106–7). Also in the early second millennium BC the term ‘AN BAR’ — metal from heaven, appears in the Hittite trade accounts (Waldbaum 1980), and other occurrences of the term, also in the early second millennium BC are discussed by Bjorkmann (1973). As noted above objects of meteoritic iron had already been made for thousands of years previously, why was it only in the early second millennium BC that its heavenly origin was recognised? Could it be that there had been massive falls of meteorites, so prolific that no-one was left in any doubt from where the metal was coming? Supporting material evidence from the eastern Mediterranean comes in the form of the meteorite from the Minoan palace of Hagia Triada on Crete. This is a stony meteorite (Varoufakis 1982) — presumably the iron meteorites were used to make artifacts. Thus perhaps we should be looking for more material evidence in the surviving metalwork. The problem here is that iron corrodes and is either lost altogether, or, if meteoric, preferentially loses its nickel content, a fact that has caused more than one piece of ancient corroded meteoric iron to be misidentified as being of smelted metal: Another problem is that from the late second millennium BC smelted iron rapidly became quite common throughout the Middle East, and thus it would be difficult to recognise iron of meteoritic origin amongst the rest.

Such a problem does not exist further to the east in China where smelted iron began only in about the eighth century BC. There, many hundreds of bronze artefacts have been examined belonging to the Shang culture of the first part of the second millennium BC, but no artefacts of iron. In the few centuries from the end of the Shang period in the 14th century BC up to the inception of iron smelting many artefacts made from meteoritic iron have now been recognised(Han 1998).

Other evidence could be given from around the world, for example on Sri Lanka the freshly smelted bloom of iron was known as a meteorite (Juleff pers. comm.).

Taken together these strands may make a story, but there are problems. The evidence from the later historic events would suggest a cometary close approach or impact, but comets do not contain iron; also analysis of the ice cores indicates enhanced sulphur which suggests that there really was volcanic activity after all associated with some of the events. Baillie counters this by suggesting that the extra-terrestrial impact could have triggered volcanic activity. It all becomes rather involved. . .

This is not to say that iron did not cause dramatic changes in the ancient world, helping to bring down the great trading nations such as the Mycenaeans. It did, but it was not the iron that fell from heaven but rather that which came from the furnace. Ore for the new metal was readily available all around the Middle East and this broke the dependency on long distance supplies of copper and tin and thereby rendered long and well established trade routes superfluous. Correctly treated the new metal was also far superior to any other synthetic material previously known. Smelted iron was to have a far more dramatic and permanent effect on human affairs than the few recorded meteoritic impacts have had to date.

But do read Mike Baillie’s fascinating and entertaining book before we all get taken out by the big one!

References

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Waldbaum, J.C., 1980 The First Archaeological Evidence for Iron and the Transition to the Iron Age, in *The Coming of the Age of Iron*, eds. T.A. Wertime and J.D. Muhly Yale. New Haven, pp.69-98.

Paul T. Craddock, Dept. of Scientific Research, The British Museum, London WC1B 3DG.

Many thanks to the contributors for the above items. Any archaeometallurgy contributions for the Winter 1999 issue, by 29 October to: David Starley, Royal Armouries, Armouries Drive, Leeds LS10 1LT. Tel. (0113) 220 1919 Fax. (0113) 220 1917 email: david.starley@armouries.org.uk

Two programmes appeared on TV Channel 4 on July 27th and Aug 3rd with the rather lurid title Secrets of the Dead sub-titled Catastrophe: How the World Changed ,in which historian David Keys investigates the far-reaching consequences of the volcanic eruption in AD 535. Members may like to look out for a repeat. Editor.

Gads of Steel

John Harris of the Worshipful Company of Ironmongers is anxious to find out as much as possible about *Gads* which appear on their coat of arms. He writes:

"I have convinced myself that *Gads of Steel* in our coat of arms means pieces of steel plate, flat or slightly curved, approximately rectangular, of no particular size and for no particular use. They are analogous to *blocks of wood*.

O.E.D. gives a gad as meaning a sharp spike (on the back of a gauntlet), a bar (or iron), a spear a pointed stick (cattle goad), a stout stick or fishing rod, and a measuring rod. They give some quotations:-

1387 "Smiths strike and temper great gadded of iron"

1430 "On his body lay gaddes read brenning" (no clue what 'read brenning' means)

1686 "they cut it (steel) into narrower bars about half an inch over, then into short pieces of an inch or two inches long called gaddes"

1703 "Flemish steel is made some in bars some in gaddes"

1741 ". . . quenching in this liquor a gad of steel about eight or ten inches long"

1841 ". . . the de'il be in me, but I put this bright gad down her throat" (This is from Scott's Waverley ch. xxx, and is an angry blacksmith saying what he would like to do to a woman who is berating him)

BOOKS ON HERALDRY

Gough and Parker "Glossary", "Gad, a plate of steel for hammering upon, curved and square".

Franklyn, "Encyclopaedia and Dictionary", ". . . of unknown origin and use: Ironmongers' is not a pike. Possibly a bolster plate, or conventional representation of overlapping scales sewn into a leather base to form articulated joints in plate armour".

Rothery "Concise Encyclopaedia", "Oblong figures like a billet with thickness shewn in perspective".

Boutell (Revised Brooke Taylor) "Spike on gauntlets".

Friar "A new Dictionary" ". . . a billet".

Bromley and Child, "Armorial Bearings", "Ironmongers' 1455. Pieces of steel of various shape". (They give two illustrations of two dimensional pieces of plate, one pear shaped and one barrel shaped)

Have members any other, perhaps more definite, or conclusive definitions.?

Institute of Archaeology, University College London, 31–34 Gordon Square, London WC1H OPY Tel. 0171-387-7050 ext. 4721 http://www.ucl.ac.uk/iams.

I recently spoke to Dr. J. Merkel and he tells me that IAMS the booklet put out at intervals is now, owing to funding, issued free of charge. The Winter No 20

contained most interesting articles on **Chalcolithic, 5th Millennium BC, Copper Smelting at Timna**, with new radio carbon evidence for Timna Site 39. by Professor Beno Rothenberg and Dr J. Merkel. **Expedition to Atika, A Western Iberian Cassiterite Survey 1992–96, High-Tin Mirrors of Kerala, South India, etc**. The next copy is in preparation for next Winter. *Editor*

BOOKS

Brian Read writes that while moving spare Journals from the Science Museum to the new membership secretary's house half a dozen copies of **Metals and the Sea**, and eleven copies of the two part reprint of **Percy Vol 3 on Lead**, were discovered. These few remaining copies are available from Brian Read at 22 Windley Crescent, Darley Abbey, Derby, Derbys. DE22 1BZ. The price is *Metals and the Sea* £10 including postage (whole world) *Percy Vol 3* £33 including postage UK and Europe, £34 surface mail (rest of the world) £38 airmail (rest of the world).

The Merton Press send a list which includes The **Iron Industry of the Weald** by Henry Cleere and David Crossley. 2nd Edition 1995 xvi+425pp ISBN 898937 04 4 £24.95 **British Blast Furnace Statistics** by Philip Riden and John G Owen 1995 304pp ISBN 1 898937 05 2 £35. Order from Merton Priory Press, 67 Merthyr Road, Whitchurch, Cardiff CF14 1DD (Credit card orders may be phoned to 01222 521956 or faxed to 01222623599) There is no charge for postage in the UK; overseas postage charged at cost.

The Alchemy of Sculpture

by Tony Birks.

The often dramatic and sometimes alarming processes through which a sculptor's original must pass before it emerges as a permanent form in bronze are true alchemy. Until now there has been no classic intelligible text explaining the techniques of this 6000 year old craft. With hands-on experience in the giant Pangolin art foundry in Gloucestershire, Tony Birks has produced a book which describes in detail the alternative routes via lost wax or sand moulding to the finished patinated form, with illustrations of all stages of production, and of many significant finished works, ranging in scale from the tiny to the gigantic. Fully illustrated in colour throughout. Hardback 160 pages £35.00 plus £4.00 towards postage. ISBN 1 899296 07 7 Published by Marston House/Pangolin Editions, Unit 9, Chalford Industrial Estate, Chalford, Glos. GL6 8NT. Tel. 01453 886527.

Preparing a Statue for Casting.

Correspondence

Dr. Tim Smith replies to the letter by Peter King in the HMSNews No 41.

Thank you for your letter commenting on the report of my presentation on Rockley Furnace to the HMS annual conference.

I am afraid the report has an incorrect date (1632 instead of 1652) and also misses my point regarding the later date of the surviving furnace. The reference to Philip Riden was a passing one as the 1652 date is used in his Gazetteer of charcoal blast furnaces, and

credit should have been given to David Crossley whose excavation of the site provided the basis for my talk.

The confusion over the furnace date arises as there were two blast furnaces at Rockley, Low Furnace which is the one that survives as a ruin, and Furnace Hill about 500 m to the west. No remains survive for Furnace Hill above ground level.

Since my main interest is in the structure of early furnaces, I have not carried out original research on the origins but base my information on David Crossley's report of his excavation. (*The Archaeological Journal* 152 1995 p 381–421). According to this, *Furnace Hill* was built by Lionel Copley in 1652 and *Low Furnace* in about 1700 by John Spencer in partnership with Stanthorpe. There was also an earlier water powered bloomery and smithy to the east.

Regarding the casting pit, I note your suggestion that it may have been used for casting heads and anvils for helve hammers, but it is unnecessarily deep for this, extending to 2.2m. Its construction is very similar to the gun pits that we find on the Weald, but as you rightly say, despite local legend, there is no record that cannon were cast there. I agree the evidence that rollers were cast for crushing sugar cane is circumstantial, but this was a product of Stavely iron-works who later owned the furnace. The casting pit was, incidentally, a later edition.

The Editor apologizes for the incorrect date, and other shortcomings of the report., which were entirely her own errors.

The Hon. Editor Amina Chatwin, The Coach House, Parabola Road, Cheltenham GL 50 SAN Tel. (01242 525086) welcomes contributions for the HMSNews, by the end of February, June 11th, and November 5th. If possible on Apple Mac, or Ascii.

NEW MEMBERSHIP SECRETARY
Mrs Lesley Cowell, 17a Thorncliff Road, Northill, Beds. SG18 9AQ or e-mail (marked for her attention) mcowell@british-museum.ac.uk.

One of our members has suggested that the following table of elements, from "A History of Metallurgy" by Prof. R.F. Tylecote would be a more useful aid to reading the Journal that the shorter version I put in HMSNews No 40.

APPENDIX 3: TABLE OF ELEMENTS

Element	Symbol	Specific Gravity	Melting Point °C
Aluminium	Al	2.70	659.7
Antimony	Sb	6.62	630.5
Arsenic	As	5.73	
Beryllium	Be	1.8	1278±5
Bismuth	Bi	9.75	271.3
Boron	B	3.33	
Cadmium	Cd	8.65	320.9
Calcium	Ca	1.54	
Carbon	C	3.52	
Cerium	Ce	6.79	640
Chlorine	Cl		
Chromium	Cr	6.73	1890
Cobalt	Co	8.71	1495
Copper	Cu	8.95	1083
Fluorine	F		
Germanium	Ge	5.46	958.5
Gold	Au	19.3	1063
Hydrogen	H		
Indium	In	7.28	156.1
Iron	Fe	7.88	1535
Lead	Pb	11.34	327.4
Lithium	Li	0.53	186
Magnesium	Mg	1.74	651
Manganese	Mn	7.42	1260
Mercury	Hg	13.60	-38.9
Molybdenum	Mo	9.01	2620±10
Nickel	Ni	8.9	1455
Niobium	Nb	8.4	1950
Nitrogen	N		
Oxygen	O		
Phosphorus	P	1.83	44.1
Platinum	Pt	21.37	1773.5
Potassium	K	0.87	62.3
Selenium	Se	4.8	217
Silicon	Si	2.42	1420
Silver	Ag	10.53	960.8
Sodium	Na	0.97	97.5
Sulphur	S	2.1	112.8
Tellurium	Te	6.25	452
Thallium	Tl	11.86	303.5
Tin	Sn	7.29	231.9
Titanium	Ti	4.5	1800
Tungsten	W	19.1	3370
Vanadium	V	5.69	1710
Zinc	Zn	7.16	419.5
Zirconium	Zr	6.44	1900