ERES NEWSLETTER

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EDITORIAL

This first issue of the year 2001 Newsletter is very late and we apologize for this. It is mainly devoted to the third and last part of a series on rare-earth history and we thank Prof. L. Niinistö for having taken the time to write these very interesting articles on the discovery of rare-earth elements.

4th GENERAL COUNCIL Madrid, Sept. 21, 2000

As announced in the last issue of the newsletter, we had not enough space to print the prize regulations which were adopted by the general council. Here are they.

LeCoq de Boisbaudran Award

1. The LeCoq de Boisbaudran award, subsidised by Rhodia Rare Earths is in principle bestowed every three years during the ERES-sponsored International Conference on f-Elements (ICFE).
2. The awardee may be of any nationality and may be located in an academic, governmental, or industrial institution, or elsewhere.
3. The award is given for outstanding and long-lasting contribution to the science and/or technology of the f-elements. Major contributions to other areas of science or technology should not be part of the decision. On the other hand, other factors may be considered in the evaluation of the candidates, such as contributions to (i) teaching or graduate training in f-elements, (ii) professional societies, (iii) publications related to f-elements (editorships, etc.).
4. The call for nominations is published in the ERES Newsletter and on the web site of the association. Nominations can be proposed by any scientist or industry people active in the field of f-elements; they should be accompanied by a full curriculum vitae of the proposed candidate and, whenever possible, they should be backed by seconding letters covering information complementary to the nominating letter.
5. The nomination committee is comprised of the ERES executive committee enlarged by one Rhodia representative, by the chair of the ICFE conference and, depending on the candidates proposed, by experts in the relevant fields, appointed by the executive committee.

(Approved by the General council, Madrid, September 21, 2000).

Junior Award

1. The Junior award, subsidised by ERES is in principle bestowed every three years during the ERES-sponsored International Conference on f-Elements (ICFE). It amounts to 1000 Euros.
2. The awardee may be of any nationality and may be located in an academic, governmental or industrial institution, or elsewhere. He/she should ideally be under 35.
3. The award is given for an innovative contribution to the science and/or technology of the f-elements. Contributions to other areas of science or technology should not be part of the decision. On the other hand, the potential of the candidate in the field of research and/or technology should be a major consideration in the decision.
4. The call for nominations is published in the ERES Newsletter and on the web site of the association. Nominations can be proposed by any scientist or industry people active in the field of f-elements; they should be accompanied by a full curriculum vitae of the proposed candidate and, whenever possible, they should be backed by seconding letters covering information complementary to the nominating letter.
5. The nomination committee is comprised of the ERES executive committee enlarged by the chair of the ICFE conference and, depending on the candidates proposed, by experts in the relevant fields, appointed by the executive committee.

(Approved by the General council, Madrid, September 21, 2000).

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SWEDISH CONTRIBUTIONS TO THE DISCOVERY OF F-ELEMENTS.

Part 3*: The Work of Mosander, Cleve and Nilson

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During a five-year period around 1840, C.G. Mosander carried out investigations in Stockholm which first led to the discovery of lanthanum and finally to the separation of impure terbium and erbium. At the University of Uppsala, L.F. Nilson found scandium in 1878 to be followed next year by the discovery of P.T. Cleve who separated thulium and holmium. The names of these elements reflect the places of discovery, viz. Ytterby, Stockholm, and Scandinavia.

The discovery of 4 f-elements including scandium and yttrium can be divided into three periods. After the initial discoveries of yttria and ceria around 1800 it took almost 40 years before new discoveries were made thanks to the persistent work of Carl Gustav Mosander (1797—1858). Another four decennia elapsed before the last period of discoveries (1878—1907) was initiated, but this time several chemists in various countries were involved, among them the Swedes Lars Frederik Nilson (1840—1899) and Per Theodor Cleve (1840—1905). While Gadolin, Berzelius and Mosander had worked by chemical methods only, the newly discovered spectral analysis was guiding (and sometimes misleading) the researchers of the last period. Meanwhile also the periodic system of elements was established in 1869—70 by D.I. Mendeleev and independently by L. Mayer which helped the scientists to predict the missing elements and continue the search.

The discoveries of Mosander

Fig. 1. Carl Gustav Mosander (1797-1858), professor of chemistry and mineralogy at the Caroline Institute in Stockholm.

C.G. Mosander had become in 1832 at the age of 35 the successor of Berzelius and professor at the Karolinska Medico-Chirurgical Institute in Stockholm where Berzelius had given up his post in favour of full-time work at the Academy of Sciences as its permanent secretary. Berzelius and Mosander continued to work and live in the same house which was the newly erected building of the Academy at Drottninggatan in the centre of Stockholm. The daily contacts with Berzelius were essential in guiding Mosander and spreading the news of his discoveries. Mosander was not a prolific writer but quite the opposite who during his whole career published only five papers in pure chemistry.

Berzelius had already in 1825 asked Mosander to prepare cerium sulfide and it was during the course of this work that Mosander became convinced that cerium oxide contained another metal oxide. Ten years later he took up the separations again, now using more than a kilogram of cerite raw material. The existence of a new element became established in November 1838 and early next year the discovery was made more widely known by Berzelius through his letters to Pelouze in France and Poggendorff in Germany and a detailed account in the Annual Report (Årsberättelse). The Annual Reports by Berzelius were originally published in Swedish but translated into German by Wöhler and thus reached a wide audience. The name of the new element *lanthon* was derived from the Greek word meaning "hidden" as suggested by Berzelius.

Fig. 2. Jöns Jacob Berzelius (1779-1848) is commemorated by several Swedish and foreign stamps; here one of them published in 1939.

The separation of lanthanum from cerium oxide had demonstrated Mosander's skills and persistence as an inorganic chemist. In the course of fractional precipitation and crystallization of the sulfates involving tens of steps, Mosander became also convinced that there exists a third, less alkaline element in ceria. Its amethyst colour was distinctly different from the white and yellow colors of pure lanthanum and cerium salts, respectively. Mosander was unwilling to prematurely announce his discovery but news of Theodor Scheerer (1813—1875) working in Norway and using gadolinite as starting mineral finally led Mosander to

* Previous parts: ERES Newsletter, Vol. 9, No. 2 (1998), Vol. 10, No. 1 (1999).

describe his experiments and observations at the Scandinavian Meeting of Natural Scientists in Stockholm in July 1842. In fact, Scheerer presented the results of his analyses at the same meeting but only vaguely suggested that yttria might contain another element.

Mosander suggested the new element the name didymium (Greek didymos = twins) because it closely resembled lanthanum and had been discovered in conjunction with it. Wöhler, who was a good friend of both Berzelius and Mosander, objected the name and thought it had been given because Mosander had four children, all born as twins. The name didymium survived Wöhler but for much longer as such. In 1885 the Austrian scientist Carl Auer von Welsbach (1858—1929) separated didymium into two elements: neodymium (new twin) and praseodymium (green twin), but when naming the new elements retained part of the original name.

Now Mosander turned his attention to yttria and in autumn of 1842 was sure that yttria contained other rare earths as Scheerer had suggested. Berzelius was again eager to announce the discovery and in his Annual Report for 1842, which was published in April 1843, we can read the first description of two new rare earths: terbium and erbium. The names were derived from the Ytterby quarry where the gadolinite mineral was originally found in 1787. This is the only example in the Periodic Table where names of several elements (four in the case of Ytterby) have been coined from a single word. Internationally Mosander's discovery became known as an addendum to his Stockholm paper which was translated into English and presented by his brother-in-law at Cork during the meeting of the British Association for the Advancement of Science and later published by all leading chemical journals in Europe.

The Work of Cleve and Nilson

During the forty years following Mosander's work, chemistry in general had vastly progressed. However, the analytical separations of closely related elements and compounds still remained tedious requiring factional crystallization and precipitation often involving tens or even hundreds of steps. In the case of the still undiscovered rare earths another problem was that often large amounts of raw material were needed. A breakthrough was witnessed at the end of 1870s when six new elements were discovered in just three years. Ytterbium and gadolinium were separated and named by J.C. Marignac (1817—1894) working in Geneva and samarium by P.E. Lecoq de Boisbaudran (1838—1912) in France. In Sweden the centre for rare earth research had meanwhile moved from Stockholm to some 70 km north to Uppsala, a university town with great chemical traditions dating back to J.G. Wallerius (1709—1785) and T.O. Bergman (1735—1784) who were the first chemistry professors there during the previous century.

Fig. 3. Lars Fredrik Nilson (1840-1899), professor of analytical chemistry at the University of Uppsala.

The discovery of scandium required kilogram quantities of raw materials. Originally euxenite, a complex niobate mineral, was used as starting material but later also gadolinite was employed. As the concentration of scandium is quite low, 4 kg of gadolinite was needed to separate just 0.8 g of Sc_2O_3. Since the element was first discovered in minerals euxenite and gadolinite, which had not yet been found anywhere except in Scandinavia, Nilson named the new element scandium.

Nilson was professor of analytical chemistry at the University of Uppsala. His colleague, P.T. Cleve, was the first one to point out that the properties of scandium closely corresponded to those of eka-boron predicted by Mendeleev. Together with the discovery of gallium by Le Coq de Boisbaudran three years earlier, the separation of scandium greatly contributed to the general acceptance of Mendeleev's periodic system.

Fig. 4. Per Teodor Cleve (1840-1905), professor of chemistry at the University of Uppsala.

Cleve's fame rests mainly, however, on his separation of two new elements from erbia: holmium and thulium. This took place a year after Nilson's discovery of scandium and the names honour Stockholm (Holmia in Latin) and Scandinavia (Thule)

Selected literature

A. General Reviews

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2. Weeks, M.E., *Discovery of the Elements*, 7th Ed., Journal of Chemical Education, Easton, PA 1968, pp. 667—699.
3. Szabadvary, F., In: *Handbook on the Physics and Chemistry of Rare Earths*, K.A. Gschneidner, Jr. and L. Eyring (Eds.), Vol. 11, Elsevier, Amsterdam 1988, pp. 33—80.
4. Evans, C.H. (Ed.), *Episodes from the History of the Rare Earth Elements*, Kluwer, Amsterdam 1996 (Chapters 1—5 by P. Pyykkö & O. Orama, J. Trofast, L. Tansjö, F. Szabadvary & C. Evans, H. Kragh).
5. Niinistö, L., In: *Rare Earths*, R. Sáez and P.A. Caro (Eds.), Editorial Complutense, Madrid 1998, pp. 25—42.

B. Biographies

6. Hjelt, E. and Tigerstedt, R., *Johan Gadolin 1760—1852 in Memoriam, Wissenschaffliche Abhandlungen Johan Gadolins im Auswahl*, Soc. Sci. Fenn., Helsinki and S. Hirzel, Leipzig 1910.
7. Jorpes, J.E., *Jac. Berzelius, His Life and Work*, Almqvist & Wiksell, Stockholm 1970.
8. Jorpes, J.E., *Acta Chem. Scand*. 14 (1960) 1681—83. (Mosander)
9. Partington, J.R., *A History of Chemistry*, Vol. 4, Reprint Edition, Martino Publishing, New York 1996, pp. 142, 898, 908 (Berzelius, Nilson, Cleve).
10. *Dictionary of Scientific Biogra-phy*, Vols. 2, 3, 9, 10, Scribners, New York. 1970-1980 (Berzelius, Cleve, Mosander, Nilson).

BOOKS

Handbook, Vols 29 & 30

The 29th volume of the *Handbook on the Physics and Chemistry of Rare Earths* is devoted to the role of rare earths in catalysis and contains six chapters: "The metal and alloys in catalysis" (V. Paul-Boncour, L. Hilaire, A. Percheron-Guégan), "The metal and alloys in catalysis II" (H. Imamura), "The mixed oxides" (M.A. Ulla, E.A. Lombardo), "Ceria-containing three-way catalysts" (J. Kaspar, M. Graziani, P. Fornasiero), "The use of rare-earth-containing zeolite catalysts" (A. Corma, J.M. Lopez Nieto) and "Triflates" (S. Kobayashi).

Volume 30 is the first of two volumes devoted to high temperature superconductors and contains eight chapters: "High-temperature superconductivity in layered cuprates: overview" (B. Maple), "Crystal chemistry of superconducting rare-earth cuprates" (B Raveau, C. Michel, M. Hervieu), "Single-crystal growth for science and technology" (Y. Shiohara, E. A. Goodilin), "Phase diagrams and thermodynamic properties" (P. Karen, A. Kjekshus), "Electron paramagnetic resonance in cuprate superconductors and in parent compounds" (B. Elschner, A. Loidl), "Positron annihilation in high-temperature superconductors" (A.A. Manuel), "$Rba_2Cu_3O_7$ compounds: electron theory and physical properties" (W.E. Pickett, I.I. Mazin) and "Electron 4f state splittings in cuprates" (U. Staub, L. Soderholm).

A second volume on high temperature superconductors (Vol. 32) containing ten more chapters on the subject is in press and should appear soon.

Volumes 29 and 30 appeared in 2000 and are published by Elsevier Science B.V., Amsterdam. ISBN 0 444 50472 9 and 0 444 50528 8.

AGENDA

MAJOR CONFERENCES

Rare Earths 2001 Sept. 2001

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OTHER EVENTS

ACTINIDE 2001 Nov. 4-9, 2001

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