

REFERENCES

1. BISWAS, A.K. & DAVENPORT W.G. 1980. *Extractive metallurgy of copper*, second edition, Pergamon Press.
2. BRUWER J.S., 1996, *Experimental investigation of the phase relations in the system Cu-Ni-S in the temperature ranges 1200 °C to 1700 °C*, MSc thesis, University of Pretoria.
3. CELMER, R.S. 1987. *The distribution of minor elements in the nickel matte smelting*, PhD thesis, University of Toronto.
4. CHEN X.J., KHOR K.A., CHAN S.H. and YU L.G. 2003. *Preparation yttria-stabilized zirconia electrolyte by spark-plasma sintering*, Materials Science and Engineering A341, pp 43-48.
5. COCOCCIONI M., CORSO A., and GIRONCOLI S. 2003. *Structural, electronic, and magnetic properties of Fe₂SiO₄ fayalite: comparison of LDA and GGA results*, Physical review B67, and pp 0941061-7.
6. COLE S. and FERRON C.J. 2002. *A review of the beneficiation and extractive metallurgy of the Platinum-Group Elements, highlighting recent process innovations*, Canadian Institute of Mining, Metallurgy and Petroleum, Montreal, L.J. Cabri(ed.), special volume 54, The Geology, Geochemistry, Mineralogy and Mineral Beneficiation of PGE, pp 811-844.
7. CRAMER, L.A., October 2001. *The extractive metallurgy of South Africa's platinum ores*, JOM, pp 14-18.
8. DARKEN, L.S. & GURRY R.W. 1946, *Iron-oxygen equilibria involving liquid oxide*, Contribution to the research laboratory, volume 68, pp 798-816.

9. DAVENPORT W.G, KING M., SCHEILESINGER M. & BISWAS A.K. 2002, *Extractive metallurgy of copper*, Pergamon, 4th edition.
10. DE VILLIERS, J.P.R. & KLEYENSTUBER A.S.E. 1984, *The partitioning of chromium between sulphide and silicate melts at controlled partial pressures of oxygen and sulphur*, Mintek report.
11. DEGTEROV, S.A. & PELTON A.D. 1998, *A thermodynamic database for copper smelting and converting*, Metallurgical and Materials Transactions B, volume 30B, pp 661-669.
12. ELLIOT J.F. 1976. *Phase relationships in the pyrometallurgy of copper*, Metallurgical Transactions B, volume 7B, pp 17-33.
13. FLOYD J.M. 2000. *Research and development of Ausmelt technology*, The Brimacombe Memorial Symposium, Metallurgical Society of CIM, pp 173-191.
14. FONT J.M., HINO M. & ITAGAKI K., 1998. *Minor elements distribution between iron-silicate base slag and Ni_3S_2 -FeS matte under high partial pressures of SO_2* , Materials Transactions, JIM, volume 39, pp 834-840.
15. FONT J.M., HINO M. & ITAGAKI K., 2000. *Phase equilibrium and minor-element distribution between Ni_3S_2 -FeS matte and calcium ferrite slag under high partial pressures of SO_2* , Metallurgical and Materials Transactions B, volume 31B, pp 1231-1239.
16. FONT M., HINO M., & ITAGAKI K., 1999. *Phase equilibrium and minor elements distribution between iron-silicate base slag and nickel-copper-iron matte at 1573K under high partial pressures of SO_2* , Materials Transactions, JIM, volume 40, number 1, pp 20-26

17. FONT, M., TAKEDA, Y.& ITAGAKI, K. 1998. *Phase equilibrium between iron-silicate base slag and nickel-iron matte at 1573K under high partial pressures of SO₂*, Materials Transactions, JIM, volume 39, number 6, pp 652-657
18. FREDRIKSSON P. and SUNDMAN BO. 2001. *A thermodynamic assessment of the Fe-Pt system*. Calphad, volume 25, No 4, pp 535-548.
19. FUKUYAMA H., DONALD J.R., and TOGURI J. 1997. *Wetting behaviour between fayalite-type slags and solid magnesia*, Journal of the American Ceramic Society volume 80, pp 2229-2236.
20. FUSHEN LI, YUHUA TANG & LIFEN LI. 1996. *Distribution of oxygen potential in ZrO₂-based solid electrolyte and selection of reference electrode of oxygen sensor*, Solid State Ionics volume 86-88, pp 1027-1031.
21. GASKELL D.R. 1981. *Introduction to metallurgical thermodynamics*. McGraw-Hill, pp 433-459.
22. GEORGALLI G.A., EKSTEEN J.J., and REUTER M.A. 2002. *An integrated thermochemical-systems approach to the prediction of matte composition dynamics in an Ausmelt nickel-copper matte converter*, Minerals Engineering volume 15, pp 908-917.
23. GELDENHUIS J.M.A. 1991. *Development of electrochemical sensing techniques for the determination of activity-composition relations in liquid alloys and slags at 1873K*, PhD thesis, University of Pretoria.
24. GELDENHUIS J.M.A., D. MILLER, B. VAN BEEK, J. NDLOVU, and K.T. HARA. 2004. *Development of alternative techniques for matte level measurements in sulphide smelting furnaces*, International Platinum Conference 'Platinum Adding Value', The South African Institute of Mining and Metallurgy, pp 25-35.

25. GELDENHUIS J.M.A and DIPPENAAR R.J. 1991. *A reassessment of the activity of chromium in the Fe-Cr-O system at 1873K*, Metallurgical Transactions B, volume 22B, pp 915-918.
26. GISBY J.A., DINSDALE A.T., BARTON-JONES I., GIBBON A. & TASKINEN P.A., 2002. *Predicting phase equilibria in oxide and sulphide systems*, The Minerals, Metals & Materials Society Annual Meeting, Seattle, pp 533-545
27. HELLWEGE K.H., MADELUNG O., 1985. *Numerical Data and Functional Relationships in Science and Technology*, Springer Londolt-Bornstein, volume 15, Metals: electronic transport phenomena, pp 48-63
28. HINO M., PAGADOR R.U. & ITAGAKI K., 1999. *Distribution of minor elements between saturated FeO_x-MgO-SiO₂ or FeO_x-CaO-MgO-SiO₂ slag and nickel alloy*, materials transactions, JIM, volume 40, pp 225-232.
29. HINO M., ROGHANI G. & ITAGAKI K., 1997. *Phase equilibrium and minor elements distribution between SiO₂-CaO-FeO_x-MgO slag and copper matte at 1573K under high partial pressures of SO₂*, Material Transactions, JIM, volume 38, pp 707-713.
30. ILUNGA M., 1996. Cours de metallurgy des metaux non-ferreux. Universite de Lubumbashi.
31. International Platinum Association. 2002. *Mining and production*. [Online]. Available <http://www.platinuminfo.net/minpro.html>
32. Internet .2005: *Title of web page*.
http://www.outokumpu.com/pages/Page_8086.aspx. Visited on 15 March 2005
www.angloplatinum.com. Visited on 15 March 2005
1. <http://www.halwachs.de/pgmref.html>. Visited on 15 March 2005

2. <http://www.nationmaster.com/encyclopedia/Zirconia>. Visited on 28 July 2005
33. IMANAKA N., OGURA A., KAMIKAWA M. and ADACHI G. 2001. *CO₂ gas sensor with the combination of tetravalent zirconium cation and divalent oxide anion conducting solids with water-insoluble oxycarbonate electrode*, Electrochemistry Communications volume 3, pp 451-454.
34. IWASE M., 1992. *Developments in zirconia sensors during the 1980's-laboratory and in-plant applications in iron and steelmaking*, proceedings of the 1st International Chromium Steel and Alloys Congress, The South African Institute of Mining and Metallurgy, volume 2, pp 49-61.
35. IWASE M., MCLEAN A, KATOJI K., KIKUCHI Y. and WAKIMOTO K. 2004. *Evaluation and control of iron and steelmaking slags through electrochemical FeO sensors*, VII International Conference on Molten Slags Fluxes and Salts, The South African Institute of Mining and Metallurgy, pp 787-796
36. IWASE M., YAMANDA N, NISHIDA K and ICHISE E. 1984. *A thermodynamic study of CaO+CaF₂+Fe_xO fluxes used for the external dephosphorisation of hot metal*, ISS Transactions, volume 4, pp 47-53.
37. IWASE M., YAMANDA N, NISHIDA K and ICHISE E. 1984. *A rapid determination of the activities in CaO-Fe_xO liquid slags by disposable electrochemical oxygen probes*, ISS Transactions, volume 4, pp 69-75.
38. JANKE D. 1977a. *Physico-chemical properties of solid oxide electrolytes at steelmaking temperatures*, Arch. Eisenhüttenwes. Volume 48, pp 255-260.
39. JANKE D. 1977b. *Thermal and mechanical properties of solid oxide electrolytes at steelmaking temperatures*, Arch. Eisenhüttenwes. Volume 48, pp 467-474.

40. JANKE D. 1977c. *Electrical properties of solid oxide electrolytes at steelmaking temperatures*, Arch. Eisenhüttenwes. Volume 48, pp 311-318.
41. JANKE D. 1982. *Oxygen probes based on calcia-doped hafnia or calcium zirconate for use in metallic melts*, Metallurgical Transactions B, volume 13B, pp 227-235.
42. JONES, R.T. 1999. *Platinum smelting in South Africa*. South Africa Journal of Science volume 95, pp 525-534.
43. KONGOLI F., DESSUREAULT Y. and PELTON A.D. 1998. *Thermodynamic modelling of liquid Fe-Ni-Cu-Co-S mattes*, Metallurgical and Materials Transactions B, volume 29B, pp 591-601
44. KYLLO A.K. and RICHARDS G.G. 1990. *A mathematical model of the nickel converter: Part I. Model development and verification*, Metallurgical Transactions B, volume 22B, pp 153-161.
45. KURCHANIA R. and KALE M. 2001. *Measurement of oxygen potentials in Ag-Pb system employing oxygen sensor*, Metallurgical and Materials Transactions B, volume 32B, pp 417-421.
46. LAIURA G.H., WATANABE K., and YAZAWA A. 1980. *The behaviour of lead in silica-saturated, copper smelting systems*, Canadian Metallurgical Quarterly, volume 19, pp 191-200.
47. LEVIN E., ROBBINS C. and McMURDIE H. 1964. *Phase diagrams for ceramists*, The American Ceramic Society, Inc, p 59.
48. LIAO L. and FRUEHAN R.J. 1990. *Thermodynamics of Ti, Al and inclusion formation in stainless steel and nickel alloys*, ISS Transactions, volume 11, pp 105-111.
49. MACKEY P.J. 1982. *The physical chemistry of copper smelting slags-a review*, Canadian Metallurgical Quarterly, volume 21, No.3, pp 221-260.

50. MAJUMDAR R., SARKAR P., RAY U., and MUKHOPADHYAY. 1999. *Secondary catalytic reactions during thermal decomposition of oxalates of zinc, nickel and iron (II)*, Thermochemica Acta 335, pp 43-53.
51. MARTIN P.L., PHAM A.Q. and GLASS R.S.2003. *Effect of Cr₂O₃ electrode morphology on the nitric oxide response of a stabilised zirconia sensor*, Sensor and Actuators B 96, pp 53-60.
52. MATTHEY J., 2005.[Online].
<http://www.platinum.matthey.com/production/africa.php>. Visited on 14 March 2005.
53. MERKLE R.K.W. and McKENZE A.D. 2002. *The mining and beneficiation of South African PGE ores-an overview*, The Geology, Geochemistry, Mineralogy and Mineral Beneficiation of Platinum-Group Elements, Edited by L.J. Cabri , Canadian Institute of Mining, Metallurgy and Petroleum, special volume 54, pp 793-809.
54. MERUVA R.K. and MEYERHOFF M.E. 1997. *Potentiometric oxygen sensor based on mixed potential of cobalt wire electrode*, Analytica Chemica Acta volume 341, pp 187-194.
55. MORTIMER A.G., and REED G.P. 1995. *Development of a robust electrochemical oxygen sensor*, Sensors and Actuators B volume 24-25, pp 328-335.
56. MOSTERT J.C. & ROBERTS P.N. 1973. *Electric smelting at Rustenberg Platinum Mines Limited of nickel-copper concentrates containing platinum-group metals*. Journal of the South African Institute of mining and Metallurgy, pp 290-299.
57. NAGAMORI M., 1974. *Sulfidic and oxidic dissolution of copper in fayalite slag from low-grade matte*, Metallurgical Transactions, volume 5, pp 531-538
58. NAGAMORI M. and MACKEY P.J. 1978. *Thermodynamics of copper matte converting: Part I. Fundamentals of the Noranda process*. Metallurgical Transactions B, volume 9B, pp 255-265.

59. NAGAMORI M., ERRINGTON W.J., MACKEY P.J. and POGGI D., 1994. *Thermodynamic simulation model of the Isasmelt process for copper matte*, Metallurgical and Materials Transactions B, vol 25B, pp 839-853.
60. NALDRETT A.J. 1969. *A portion of the system Fe-S-O between 900 and 1080°C and its application to sulfide ore magmas*, Journal of Petrology, volume 10, part 2, pp 171-201.
61. NALLICHERI, N.V. 1988. *Behaviour of oxygen and sulphur in mattes containing nickel*, MSc thesis, M.I.T.
62. NAUDE, N. 2003. *Ferro-alloys technology IV. Course*. Tshwane university of Technology.
63. NELL J. 2004. *Melting of platinum group metal concentrates in South Africa*, The Journal of the South African Institute of mining and Metallurgy, volume 104, pp 423-428
64. NELSON G.O. 1992. *Gas mixtures: preparation and control*, Lewis Publishers, pp 26-235
65. NEWMAN, M.A., 1972. *Platinum*, Transactions of the Institute of Mining and Metallurgy, pp A52-A68.
66. PENGFU TAN & NEUSCHUTZ D., 2001. *A thermodynamic model of nickel smelting and direct high-grade nickel matte smelting process: part I. Model development and validation*, Metallurgical and Materials Transactions B, volume 32, pp 341-351.
67. PERT E., CARMEL Y., BIONOMIC A., OLORUNYOLEMI T., GERSHON D., CALAME J., LLOYD I.K., and WILSON O.C. Jr. 1984. *Temperature measurements*

- during microwave processing: the significance of thermocouple effects.* Journal of the American Ceramic Society. Pp 1981-1986
68. PISTORIUS, PC. 2003. *Pyrometallurgical Process Analysis*. Pretoria: University of Pretoria.
69. PREIDEL W., RAO J.R., MUND K, SCHUNCK O., and DAVID E. 1995. *A new principle for an electrochemical oxygen sensor*, Sensors and Actuators B volume 28, pp 71-74.
70. RAO, YK.1985. *Stoichiometry and thermodynamics of metallurgical processes*, Cambridge University Press, pp 692-820.
71. REDDY R.G. and BLANDER M. 1987. *Modeling of sulfide capacities of silicate melts*, Metallurgical Transactions B, volume 18B, pp 591-596.
72. *Refining of platinum group metals / principle flow sheet*. [Online]. Available www.halwachs.de/pgm-refining.htm
73. ROSENQVIST T., 1978. *Phase equilibria in the pyrometallurgy of sulphide ores*, Metallurgical Transactions B, volume 9B, pp 337-351
74. RUPARD R.G. and GALLAGHER P.K. 1996. *The thermal decomposition of coprecipitates and physical mixtures of magnesium-iron oxalates*, Thermochemica Acta 272, pp 11-26.
75. SOLTANIEH M., TOGURI J.M., SRIDHAR R. & TAKASU T., 2000. *The thermodynamics of the Ni-Co-S ternary system*, Metallurgical and Materials Transactions B, volume 31B, pp 121-128.
76. SOMSIRI C. and GASKELL D.R.1995. *The activities of sulphide and oxide components and solubility of oxygen-iron-sulphur-oxygen mattes at 1300°C*, Metallurgical and Materials Transactions B, volume 26B, pp 1157-1164.

77. SOTIROPOULOS S. and WALLGREN K. 1999. *Solid-state microelectrode oxygen sensors*. Analytica Chemica Acta volume 388, pp 51-62
78. STOFKO M., SCHMIEDL and ROSENQUIST T. 1974. *Thermodynamics of iron-sulphur-oxygen melts at 1200°C*, Scandinavian Journal of Metallurgy volume 3, pp 113-118.
79. TASKINEN P., 1984. *Thermodynamics of liquid copper alloys at 1065-1450°C*, Scandinavian Journal of Metallurgy, volume 13, pp 75-82.
80. TASKINEN P., SEPPALA K., LAULUMAA J. & POIJARVI J., 2001. *Oxygen pressure in the Outokumpu flash smelting furnace-part 1 and 2: copper flash smelting settler*, Transactions of the Institution of Mining and Metallurgy, volume 110, pp C94-C108.
81. TURKDOGAN E.T., 1980. *Physical chemistry of high temperature technology*, Academic Press, pp 5-24.
82. UECKERMANN, H. 2002. *Partitioning of platinum-group elements between metal and sulphide melt in the Cu-S and Ni-S systems*, MSc thesis, University of Pretoria.
83. ULMER, G.N. 1971. *Research techniques for high pressure and high temperature*. Springer-Verlag.
84. VAN WIJNGAARDEN M.J.U.T., GELDENHUIS J.M.A. & DIPPENAAR R.J., 1988, *Determination of the electrical characteristics of a commercially available yttria-stabilized zirconia electrolyte used in the high-temperature thermodynamic studies*, Journal of South African Institute of Mining and Metallurgy, volume 88, pp 265-271.
85. VAN WIJNGAARDEN, M.J.U.T. & DIPEENAAR, R.J. 1986. *The use of zirconia-based solid electrolytes for the rapid determination of iron oxide activities in iron and steel making slags*, journal of the South Africa institute of mining and metallurgy, November, volume 86, pp 443-453.

86. VAN WIJNGAARDEN, M.J.U.T., DIPPENAAR R.J. & VAN DEN HEEVER P.M.1987. *An evaluation of the electrochemical oxygen probes used in steelmaking*, journal of the South Africa institute of mining and metallurgy, September, volume 87, pp 269-278.
87. VAN WIJNGAARDEN, M.J.U.T. & DIPPENAAR, R.J. 1988. *The activity of iron oxide in (CaO+CaF₂+ SiO₂+ Fe_xO) slags*, Iron and Steelmaker, volume15, no. 2, pp 49-55.
88. VAN WIJNGAARDEN, M.J.U.T. & DIPPENAAR, R.J. 1988. *A thermodynamic study of lime-based slags used for the external refining of hot metal*, 71st Steelmaking Conference Proceedings, volume 71, pp 395-403.
89. VILJOEN, W.2001. *Phase relations in the system Cu-Fe-Ni-S and their application to the slow cooling of PGE matte*, PhD thesis, University of Pretoria.
90. WRIGHT S., JAHANSHAHI S. and SUN S.2004. *Activities of Cu, Fe and Ni in Cu-Fe-Ni-S mattes*, VII International Conference on Molten Slags Fluxes and Salts, The South African Institute of Mining and Metallurgy, pp 277-284.
91. XIA C. and al. 2003. *Composite cathode based on yttria stabilized bismuth oxide for low-temperature solid oxide fuel cells*, Applied Physics Letters, American Institute of Physics, volume 82, pp 901-903.
92. YANNOPOULOS, JC.1976. *Extractive metallurgy of copper*, The Metallurgical Society of AIME, volume 1.
93. YAZAWA A. 1974. *Thermodynamic considerations of copper smelting*, Canadian Metallurgical Quarterly, volume 13 number 3, pp 443-453.