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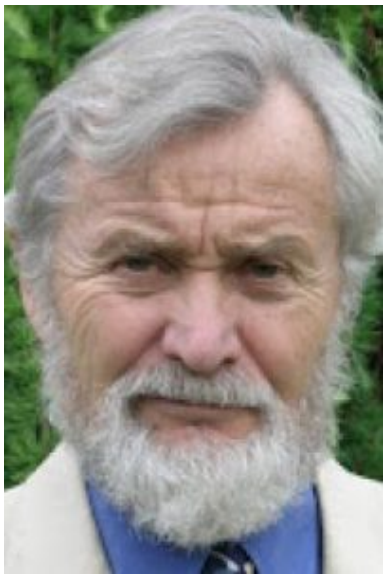
Honorary note: Janusz S. Laskowski – 60 years of scientific work and 82nd birthday



Professor Janusz S. Laskowski, FCIM, currently President of Laskowski Research Inc. and Professor Emeritus of Mineral Processing at the University of British Columbia, in Vancouver, Canada.

He graduated with a B.Sc. in Chemistry from the Silesian University of Technology in 1956, obtained his M.Sc. degree in Chemical Engineering in 1958, and his Ph.D. degree in Mineral Processing in 1963. In 1961/62, Laskowski spent a year as a postgraduate student at the Department of Colloid Chemistry (under Prof. P.A. Rehbinder) at Lomonosov University, Moscow, where he was involved in research under the supervision of Professor V.I. Klassen at the Mining Institute of the USSR Academy of Sciences in Moscow. In 1966, Laskowski translated Klassen's monograph on "*Coal Flotation*" (V.I. Klassen, Coal Flotation, Wyd. Slask, Katowice, 1966; Polish text). In 1967, Dr. Laskowski obtained a Leverhulme Trust Post-Doctoral Fellowship and spent the following year with Dr. J.A. Kitchener at the Department of Mineral Technology at the Imperial College, London. After Dr. Kitchener retired, Dr. Laskowski and Prof. John Ralston edited the volume "*Colloid Chemistry in Mineral Processing*" in his honor, which was published by Elsevier in 1992.

Professor Laskowski was an associate professor of mineral processing at the Silesian University of Technology until 1973, when he was appointed Professor of Mineral Processing at the Wroclaw Technical University in Wroclaw, Poland. In 1971/72, he taught several courses at the University of Chile in Santiago as a visiting professor. During this time, he was invited by Professor Fernando Concha to spend one month with the University of Concepcion, where Prof. Laskowski updated his book, *Fundamentos Fisicoquimios de la Mineralurgia*. Prof. Laskowski's book was then translated into Spanish and published by the University of Concepcion in 1974.

As a member of the International Committee, Prof. Laskowski has been in charge of International Mineral Processing Congresses since 1970. He chaired the 13th International Mineral Processing Congress in Warsaw in 1979 and edited two-volume proceedings (J.S. Laskowski (editor), *Mineral Processing – Proc. 13th Int. Mineral Processing Congress*, Elsevier, 1980), as well as three volumes of round-table seminars. In 1981, he was invited by Professor Douglas W. Fuerstenau to join him as a visiting professor for one year with the University of California, Berkeley. The following year, he was appointed Professor of Mineral Processing in the Department of Mining and Mineral Process Engineering at the University of British Columbia in Vancouver, Canada. When Professor Jan Leja retired after 20 years with the University of British Columbia, Laskowski edited a volume titled "*Frothing in Flotation*" in his honor (published by Gordon and Breach in 1989). This book turned out to be the first volume in a series of publications: "*Frothing in Flotation II*", edited jointly with E.T. Woodburn, was published by Gordon and Breach in 1998; and "*Frothing in Flotation III*", edited jointly with C.T. O'Connor and J.P. Franzidis, appeared as a special issue of the *International Journal of Mineral Processing*, Vol. 64, Issues 2-3, in 2002.

In 1966, Professor Laskowski started a series of Polish National Symposia, "*Physicochemical Problems of Mineral Processing*," serving as chairman of the Organizing Committee until 1980. When he left the country, the Symposia were taken over by his former Ph.D. students and research associates (Dr. J.

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Lekki, Dr. A. Luszczkiewicz, Dr. J. Drzymala, Dr. Z. Sadowski), and since then he has been a member of the Editorial Board of the *Physicochemical Problems of Mineral Processing* journal. In 1984, Professor Laskowski founded the international journal "*Coal Preparation*," for which he was editor-in-chief until 2004.

Professor Laskowski took two sabbatical leaves from the University of British Columbia, which he spent with Prof. Jean Cases's Surface Chemistry Group at Ecole Nationale Superieure de Geologie in Nancy, France in 1987/88, and with the Department of Chemical Engineering of the University of Cape Town, South Africa, in 1996.

In 1995, Professor Laskowski initiated a new series of UBC-McGill international symposia on the Fundamentals of Mineral Processing and chaired the first Symposium on the "*Processing of Hydrophobic Minerals and Fine Coal*" in Vancouver, BC, in August 1995. The proceedings volume, "*Processing of Hydrophobic Minerals and Fine Coal,*" was edited by J.S. Laskowksi and G.W. Poling and published by the CIM Metallurgical Society in 1995.

Professor Laskowski chaired the 3rd Symposium on "*Polymers in Mineral Processing*" in Quebec City, Canada, in 1999, for which he edited the proceedings volume appearing under the same title. He chaired the 5th Symposium, "*Particle Size Enlargement in Mineral Processing*", which was held in Hamilton, Canada, in August of 2004, and edited the Symposium Proceedings. In 2006, the Metallurgical Society of the Canadian Institution of Mining organized the 6th UBC-McGill-University of Alberta international symposium on "*Interfacial Phenomena in Fine Particle Technology*" in honour of Professor Janusz Laskowski, followed by the publication of a special issue of *Canadian Metallurgical Quarterly*, Vol. 46, No. 3, 2007. The UBC-McGill-UofA symposia continue to be held every 2 years.

With Professor David Boger, Prof. Laskowski co-chaired the Engineering Foundation Conference on "*Rheology in the Mineral Industry*" in San Diego in February, 1997. The papers presented at this conference appeared in a special issue of *Mineral Processing and Extractive Metallurgy Review* (Vol. 20, Issues 1-3, 1999), edited by D.V. Boger and J.S. Laskowski, and in a special issue of *Coal Preparation* (Vol. 18, Issues 3-4, 1997) edited by J.S. Laskowski and H. Usui. Dr. Laskowski co-chaired the 2nd Engineering Foundation Conference on "*Rheology in the Mineral Industry*" in Hawaii in March, 1999.

Professor Laskowski co-chaired the Symposium "*Apparent and Microscopic Contact Angles*" led by Dr. J. Drelich held in conjunction with the 216th National American Chemical Society Meeting, Boston, August 24-27, 1998, and jointly with J. Drelich and K.J. Mittal edited the volume "*Apparent and Microscopic Contact Angles*" published by VSP in 2000. The same year, he won the Arthur F. Taggart Award from the Society of Mining Engineering. Professor Laskowski's monograph on "*Coal Flotation and Fine Coal Utilization*" was published by Elsevier in 2001 and it is one of the most comprehensive books published in the area of coal processing.

In 2008, at the *24th International Mineral Processing Congress* in Beijing, he was awarded the mineral processing's highest award, the Lifetime Achievement Award of the International Mineral Processing Council. He is also a recipient of the 2010 Antoine Gaudin Award.

He supervised over 20 Ph.D. theses and published over 300 papers in refereed journals and conference proceedings. Professor Laskowski retired from the University of British Columbia in 2001, but still continues doing research with a group of graduate students. He also still collaborates with the University of Concepcion (Chile), Helsinki University of Technology (currently Aalto University), Universidad Autonoma de San Luis Potosi (Mexico) and with CSIRO in Melbourne. In 2002 he incorporated his own research company, Laskowski Research Inc.

Professor Laskowski conducted research in many countries such as: Poland, Russia, Chile, France, USA, Canada, South Africa and Finland. He contributed to the training of students, academics and researchers around the world and left the legacy of solid work and strong convictions that scientists need to be accountable their work beyond their own academic environments. Many of his former graduate students became professors and known scientists in the area of flotation and surface chemistry, perhaps leaving the greatest legacy of his contributions to the mineral processing science.

Prof. Janusz Laskowski's the most significant contributions:

(i) Flotation thermodynamics and kinetics

His well-known publication with J.A. Kitchener (*J. Coll. Interf. Sci.*, 29, 670-679, 1969) in which methylated silica was used to show that hydrophobic solids interact with water only through London-

Van der Waals forces, and that all solids would be hydrophobic if they did not carry polar or ionic groups. This paper is considered to be the first to provide evidence that there may be an attractive force that is responsible for the rupture of wetting films which was not considered in the DLVO theory (R.H. Yoon and L. Mao, *J. Coll. Interf. Sci.*, 181, 613-626, 1996). Because fundamental flotation studies need the system in which both surface wettability and electrical charge can be independently varied, the methylated silica system was used to study the relationship between hydrophobicity and floatability (J.S. Laskowski, in "*Advances in Mineral Processing* (P. Somasundaran, ed.), SME, 1986, pp. 189-208). This was followed by finding a correlation between the flotation rate and energy barrier opposing particle-bubble attachment (J.S. Laskowski et al., Energy barrier in particles-to-bubble attachment and its effect on flotation kinetics. 17th *Int. Mineral Processing Congress*, Dresden, 1991, Vol. 2, pp. 237-249).

(ii) Magnetite dense medium rheology

Between 1985 and 1995, Prof. Laskowski obtained several research grants provided by Craigmont Mines, an industrial partner. This research resulted in a series of original contributions on dense medium separation. First, the rheoviscometer was developed, which could be used to study rheological properties of magnetite suspensions, which are highly unstable and their settling characteristics (B. Klein, J.S. Laskowski and S.J. Partridge, *J. Rheol.*, 39, 827-840, 1995). The rheological studies that followed led to a series of original contributions.

The Casson model was found to be very effective in describing the flow curves in a broad range of magnetite particle sizes (from $d_{63.2}$ = 30 μm resembling commercial magnetite) and over the solid content range from 5 to 25% (which covers the entire solid content range for dense medium separation) (Y. He and J.S. Laskowski, *Mineral Proc. & Extractive Metal. Review*, 20, 167-182, 1999). The Casson yield stress was found to be a dominant factor that determines the apparent viscosity of such media. Thus, in the empirical equation proposed by Napier-Munn to describe the influence of medium rheology on dense medium cyclone separation $E_p = \phi d_n$ (where E_p is probable error (separation efficiency) and ϕ is a function of apparent viscosity and cyclone, geometry) for the fine magnetite the medium apparent viscosity can be replaced by the yield stress (Y.B. He, J.S. Laskowski and B. Klein, *Chem. Eng. Sci.*, 56, 2991-2998, 2001).

(iii) Weak electrolyte type flotation collectors

In most publications, flotation collectors are classified into ionic and non-ionic. This entirely overlooks a very important group of flotation collectors, the weak electrolyte-type collectors that include important compounds such as primary amines and fatty acids.

The series of publications initiated by a joint paper with Sergio Castro (S.H. Castro, R.M. Vurdela and J.S. Laskowski, *Colloids & Surfaces*, 21, 87-100, 1986) addressed this topic. The domain diagrams introduced for weak-electrolyte collectors, depending on the surfactant concentration and pH, define ranges in which precipitating species may appear: in alkaline solutions in the case of alkyl amines, and in acidic solutions in the case of fatty acids. These colloidal species were found to have well defined iso-electric-points around pH 10.6-11 for C12-C14 aliphatic amines, and around pH 2.5-3 for fatty acids. The species were found to easily accumulate on the surface of bubbles, making the electrokinetic charge of such bubbles identical to the charge of the precipitating collector (J.S. Laskowski, in "*Advances in Flotation Technolopgy*" (B.K. Parekh and J.D. Miller, eds.), SME, 1999, pp. 59-82). It was shown that at concentrations exceeding solubility, flotation properties of the weak-electrolyte type collectors, and especially the pH flotation limits, are determined by the precipitation of the molecular forms of these collectors (J.S. Laskowski, R.M. Vurdela and Q. Liu, The colloid chemistry of weak-electrolyte collectors flotation. Proc. 16th Int. Mineral Processing Congress, Elsevier. 1988, Part A, pp. 703-715). Finding that high electrolyte concentration affects the Krafft point of long chain primary amines (J.S. Laskowski, M. Pawlik and A. Ansari, *Can. Met. Quart.*, 46, 295-300, 2007) allowed the development of a complete potash ore flotation theory (J.S. Laskowski, *Miner. Eng.*, 45, 170-179, 2013).

(iv) Flotation frothers

Introduction of the concept of critical coalescence concentration (CCC), the number that characterizes frother ability to reduce bubble size (Y.S. Cho and J.S. Laskowski, *Int. J. Min. Proc.*, 64, 69-80 (2002); *Canadian J. Chem. Eng.*, 80, 299-305, 2002; J.S. Laskowski, *Physicochem. Probl. Min. Proc.*, 38, 13-22, 2004) entirely revolutionized research in the area of froth and frothing agents.

(v) Flotation in highly concentrated electrolyte solutions/seawater

In the early stages of his professional carrier, inspired by Professor V.I. Klassen, Prof. Laskowski selected the coal salt flotation as a topic for his Ph.D. Thesis. Currently, Prof, Laskowski has been again involved full time in research in this area. However, the driving force now is not coal, it is a shortage of fresh water. In the areas such as, for instance, the Atacama Desert in Chile, this shortage is especially inconvenient.

With a team of researchers at the Universidad de Concepcion in Chile (headed by Professor Sergio Castro) he became involved in studying why some minerals, for example molybdenite, are depressed when flotation is carried out in sea water. The discovery that this depression is caused by magnesium ions, which hydrolyze and form hydro-complexes and magnesium hydroxide when pH is raised above 9.5 with lime to depress pyrite, allowed for new flotation technologies that do not require sea water desalination (S. Castro, P. Rioseco and J.S. Laskowski, Depression of molybdenite in seawater. Proc. 26th *Int. Mineral Proc. Congress*, New Delhi, 2012, paper No. 741; S. Castro, A. Lopez-Valdivieso and J.S. Laskowski, *Int. J. Min. Proc.*, 148, 48-58, 2016; J.S. Laskowski, S. Castro and L. Gutierrez, Flotation in highly concentrated electrolyte solutions/seawater. Proc. 29th *Int. Mineral Procesing Congress*, Moscow, 2018, Paper 162).

Prof. Janusz Laskowski has always been an avid outdoorsman enjoying hiking, camping, swimming, skiing and tennis and in recent years he has enjoyed artistic painting. According to his wife Barbara, he is always helping her with keeping up their beautiful garden in Richmond, BC where they both reside. An immigrant himself, he always welcomed all his students, many of them from abroad to join him for delightful dinner parties at his home during the family holidays like Thanksgiving and Christmas.

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