Interview with Dr. Ahmad Ghahreman
"The Role of Electrochemistry in Hydrometallurgical Processes"

I am A. Deniz Bas, 2017 MetSoc Emerging Professional in Hydrometallurgy Technical Section. I regularly do short interviews with eminent scientist and professors on mining and metal extraction processes around the world. I am pleased to submit my most recent interview with Assistant Professor Ahmad Ghahreman of Queen's University on the role of electrochemistry in hydrometallurgy. I believe that this interview would be useful and will especially encourage the undergraduate students who look forward to study metallurgy or related fields.

Ahmet Deniz Bas (Deniz): You are a well-known professor in hydrometallurgy and electrochemistry around the world. You teach hydrometallurgy and leading a very active hydrometallurgy research group at Queens' University. Dr. Ghahreman, What would you like to say briefly about your work and academic life? How did you choose to start a career in hydrometallurgy? What was the main reason behind that?

- **Ahmad Ghahreman (Ahmad):** Hi Deniz. What would i say about my work and academic life? My response would be that I love what I do! Everyday I tell myself that I have the opportunity to make a difference today, and that truly is what I try to do. I have to say work and life balance is a bit difficult, particularly because of the travels and long work hours involved in mining business, but when you like what you do you never get tired.

Assistant Professor Ahmad Ghahreman

The very first time I was introduced to extractive metallurgy was long time ago when as a high school student I had the opportunity to visit a copper plant tank house. I was amazed that how one can make metals out of solution. Being so confused, I asked my teacher about the phenomena and he told me: "It is electrochemistry, and is explained in your science book". I checked my high school science book several time that night; it wasn't. But that stayed with me until I got the opportunity to learn electrochemistry at university.

The role of electrochemistry in the hydrometallurgy research is very undervalued. About 90% of the reactions we deal in hydrometallurgical processes, including most leaching operations, oxidative crystallization and impurity removal, to some extent solvent extraction and definitely electrowinning and sometime other precipitation methods, all involve reactions which are electrochemical in nature. Thus, a good hydrometallurgist is an expert in electrochemistry and knows chemistry very well. I enjoy chemistry and electrochemistry and I always look at the processes from chemistry and engineering point of view.

Deniz: What are your thoughts about the recent developments in hydrometallurgy in the world and in Canada? Nowadays everybody is talking about innovation. Do you see a different innovation strategy in various countries?

- **Ahmad:** We definitely need innovative low cost and environmentally sound processes that are easily scalable. The rate of innovative processes development has gone slower in Canada, Australia and the US, and main reason is that most mining companies are shutting down their research and technology centres. Only very few mining companies in western world has their research centres. Nonetheless, we are still innovative; the very first Calcium Thiosulfate process that is being operated in Nevada by Barrick Gold, and many other innovative processes around. We definitely need to do more on innovation side; the industry has recognized the need for more innovation and major Canadian companies have started to look into the innovation a bit deeper now. Future looks better than the past 2 decades.

Deniz: Why is the application of electrochemical methods in metal extraction so important? Does it really bring solutions to overcome the problems in extraction processes?

- Ahmad: Well, as I explained above, the role of electrochemistry is two folded: one is that electrochemistry will help us to understand the reactions and develop processes that have higher efficiencies. For instance, by understanding the arsenic oxidation process, which is an electrochemical process, we were able to develop a catalytic process that doesn't require any expensive oxidant such as H_2O_2; or in another example, by understanding the electrochemical oxidation mechanism of pyrite we were able to modify

the reaction such that the atmospheric oxidation of pyrite produces more elemental sulfur than sulfuric acid. Secondly, electrochemical processes also are becoming more acceptable in the industry; I expect that the electrochemical processes will have more applications in the future of metals and mining industry, especially waste water treatment.

Deniz: Do you think that electrochemical methods are sufficiently (and properly) used in hydrometallurgy researches? Why electrochemistry does not have the profile of hydrometallurgy? Should the researchers benefit more from these methods in their studies?

- Ahmad: I think there is a disconnection between the electrochemical experiments in the laboratory and leaching studies, and that is that in electrochemistry we control the potential of the minerals (i.e. electrodes) while in the hydrometallurgical leaching we control the potential of solution (i.e. reduction oxidation potential or ORP). Thus, the electrochemical studies on bulk minerals somehow are disconnected from the observations of the hydrometallurgists. This of course is a problem in the way we apply electrochemistry in our studies. At Queen's University, we have developed an electrochemical station that looks into the electrochemistry of the slurries, and we have been producing more meaningful results on gold electrochemistry. My hope is to make a shift in the way we usually do electrochemical studies for hydrometallurgical systems, thus the results of the research we do are agreeable with those of actual leaching tests. We are planning to publish largely on this and assist other researchers with newer techniques for electrochemical measurements.

Deniz: If you compare the past and present situation concerning the use of electrochemical methods in hydrometallurgy, What would you like to tell us? How do you see its future?

- Ahmad: I think I answered this question above. With the electricity cost expected to become lower in the future, and power generation to be more sustainable (less reliance of fossil fuels), we will rely more applications of the electrical resources for metals extraction and this will open up a large area for the electrochemical process developments in metallurgical applications.

Deniz: What would you like to advice to the students wishing to do graduate studies in hydrometallurgy-electrochemistry?

- Ahmad: A great hydrometallurgist is a very good chemist with solid electrochemistry background and strong engineering mind-set; additionally I would like to see that the students have/gain a good understanding of the economics of the mining and metallurgical processes.

Deniz: May I ask you, please rank your three favourite topics/subjects that you like much in your field/area?

- **Ahmad:** I enjoy flowsheet design, economic analysis of the flowsheets, and fundamental chemistry studies to understand reactions better and improve the processes. In respect to metals, I have strong interest in gold, lithium and base metals.

Dr. Ghahreman with his students at COM 2017 in Vancouver

Deniz: I am quite sure that many people, especially the young ones, will enjoy reading this interview. Would you like to add anything else?

- **Ahmad:** Hydrometallurgy, and in general extractive metallurgy, is a great field to be in now. Our society will need more and more metals and we will need to design and develop more efficient and cleaner extraction processes. I would suggest students spend more time on understanding the design criteria for better flowsheets, chemistry of the processes, and to appreciate economic side of the studies as well.

Deniz: Thank you so much for kindly accepting my invitation and for this enjoyable and impressive interview.

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