Studies on direct solvent leaching of uranium from gattar grade ores

Ahmed El Sayed Mady Husein

Several uranium occurrences have been discovered by the Nuclear Materials Authority in various locations in the Egyptians terrains. These occurrences belong mineral to two principal mineralization types, viz those associated with the younger granite plutons in the Eastern Desert and those associated with the Sedimentary Carboniferous rocks of Um Bagua Formation in west central Sinai Gabal Gattar younger granite pluton, situated at about 40 km NW Hurghada City, is actually one of the promising uranium prospects in Egypt where several occurrences are found. The latter have been enumerated from GI to GVIII except that GV occurrence which is hosted in El Hammamat sediments that occur at the north eastern contact of G. Gattar granite pluton. The GV occurrence is indeed greatly interesting due to the presence of a relatively important assay of REEs associated with uraniumMineralogically G. Gattar younger granite is mainly composed of quartz, potash feldspar, plagioclase and a minor amount of biotite while El Hammamat sediments are essentially composed conglorenates, siltstones and greywackes. These sediments are also interbedded with volcanic rocks (Dokhan volcanics) and are intruded by the younger granites. Beside being affected by the mineralizing both rock types have actually been subjected by different hydrothermal alteration processes. On the other hand, it is work mentioning that beside uranite, different discrete secondary uranium minerals have been identified I the different G. Gattar occurrences including namely uranophane, no REEs minerals have been identified in any of these occurrences.The present work is mainly concerned with the potentiality of applying the solvent leaching procedure as a non-conventional leaching technique for the recovery of uranium from Gattar granite GII composite sample as well as both uranium and REEs from El Hammamat sediment GV composite sample. Justification of using this procedure in values essentially the relatively low grade of Gabal Gattar uranium occurrences besides their presently limited extensions as their possible reserves have not yet been defined. Accordingly, the chosen processing techniques should be of low cost expenditures. In the solvent leaching technique a proper organic solvent is applied to an ore material after its prior proper treatment in the solid state for converting its metal values into suitable extractable forms. To realize the objectives of the present work, two composite samples have been collected from the Gabal Gattar occurrences GII and GV. In the latter, it was found that uranium assays 2040 ppm in GII composite sample whereas it assays 2840 in GV composite sample besides a relatively

important amount of the REEs, viz, 1520 ppm.To achieve successful application the different relevant solvent leaching parameters have been studied in detail using the acid extractant di-2-ethyl hexyl phosphoric (DEHPA) as a suitable cation exchanger for uranium as well as for the REEs associated with uranium in El Hammamat sediment GV occurrence. The studied factors involved the major acid pugging factors; namely the effects of the curing temperature, the curing time and the acid amount besides those controlling the solvent leaching process it self; viz, the solvent concentration and the solvent flow rate. In addition, the relevant stripping factors of uranium as well as of REEs and uranium from properly loaded DEHPA phase prepared from Gattar GII and GV composite samples respectively have been studied.In case of Gattar granite GII composite sample, the attained optimum conditions for uranium extraction (> 98%) involved pugging the ore size fraction -5 +60 mesh with 90 kg/t sulfuric acid and a curing time of 2 h, at room temperature using 0.15 M DEHPA concentration at a flow rate of 2 ml/min. To study the uranium stripping factors, a properly loaded solvent, sample assaying 2.14 gU/l was prepared and sodium carbonate was chosen as the strip solution. The studied factors involved sodium carbonate concentration, the shaking time and the aqueous/organic phase ratio. About 96% of uranium was successfully stripped from the loaded solvent sample by using 0.5 M sodium carbonate for 2 min shaking time with an A/O phase ratio of 1/1. the corresponding McCabe-Thiele stripping diagram was constructed and from which it was revealed that 2 theoretical stages would be required in a counter current system using an O/A flow of 1.3 as deduced from the slope of the operation line.The solvent leaching procedure was then applied to El Hammamat sediment GV composite sample for studying the recovery of both uranium and the REEs using the same solvent used for GII namely; DEHPA from the obtained results, it was found that El Hammamat GV sample could be solvent leached by using an ore grained size fraction of -5 +60 mesh pugged with 90 kg H_2SO_4 and cured for 2 h at 50 ◦C curing temperature for > 98% uranium recovery or for 3 to 4 h for the recovery of about 62-67 % of the REEs. For these recovery data, the solvent concentration should be 0.15 M DEHPA and its flow rate 2 ml/min.To study the stripping characteristic of both uranium and REEs from the study DEHPA solvent a loaded sample was properly prepared. The assay of uranium and the REEs in the latter was found attain 4.36 and 3.20 g/l respectively. It was thus revealed that 98.5% of the loaded REEs (in addition to about 25% of the loaded uranium) could be striped from the prepared solvent sample by 1M sulfuric acid while about 93% of the remaining uranium could be stripped by using 10M sulfuric acid. There stripping data have obtained at an O/A ratio of 1/1 and using a shaking time of 5min.On the other hand, using the determined acidity of I and 10M of H_2SO_4 the two corresponding McCabe-Thiele diagrams were properly constructed. Thus at 1M, it was found that two theoretical stages would required in a counter current system with a flow rate (O/A) of 3 slope of the applied operating line. In the second stripping circuit, using 10M H_2SO_4 for stripping the remaining uranium the constructed McCabe-Thiele stripping diagram indicated three theoretical stages are required in a counter current system with a flow rate (O/A) of 3 (slope of the applied operating line). Accordingly, the resultant strip liquor of either the first and the second stripping circuit would assay about 9 g/l of U or REEs respectively. Due to

the relatively low percent recovery of the REEs (~67%) through the solvent leaching procedure it was decided to study a conventional solvent extraction procedure for uranium and REEs separation from the acid leach liquor of El Hammamat sediment GV sample prepared by agitation leaching. Accordingly, a stock leach liquor solution of GV sample was prepared by applying the optimum leaching conditions previously obtained by Mahfous(148). The latter involved 30 kg/t sulfuric acid, 1/1 solid/liquid ratio, -35 mesh size and a leaching time of 4h at room temperature. The uranium and REEs assay of the obtained leach liquor (pH 1.1) attained 3.20 and 3.42 g/l respectively besides 46.0 g/l SO4--.For the separate recovery of uranium and REEs from the prepared leach liquor of El Hammamat GV sample, two extraction circuits were applied using trioctylamine (TOA) for prior uranium extraction while the REEs, left behind in the leach liquor, would subsequently be recovered using di(2-ethylhexyl) phosphoric acid (DEHPA). In either circuit, the corresponding relevant extraction and stripping factors have been studied. Accordingly, from the obtained extraction data it was found that about 98% of uranium could be extracted by using 0.11M TOA for 5min shaking time at pH of 1.1 with an O/A phase ratio of 1/1. from the corresponding McCabe-Thiele extraction diagram, it was found that three theoretical stages would be required in a counter current system using a flow rate (A/O) of about 3.75 which (slope of the operating line). On the other hand, the studied stripping factors indicated that it would be possible to strip about 96% of the loaded uranium by 5M sulfuric acid for 5 min shaking time and 1/1 phase ratio. The corresponding McCabe-Thiele stripping diagram was reveled that two theoretical stages would be required in a counter current system with a flow rate of about 0.3 (slope of the operating line).For the REEs recovery, DEHPA was used for treating the uranium-free leach liquor in a second extraction circuit. Many factors affecting the extractability of REEs from the uranium-free leach liquor namely; DEHPA solvent concentration, shaking time and O/A phase ratio were studied. from the obtained extraction data, it was found that about 98% of REEs could be extracted by 0.15M DEHPA concentration for 5 min shaking time and using O/A phase ratio of 1/1. The corresponding McCabe-Thiele extraction diagram reveled that three theoretical stages would be required in a counter current system with a flow rate(O/A) of about 2.33 (slope of the operating line). On the other hand, the studied stripping factors indicated that about 98% of the loaded REEs could be stripped by 1M sulfuric acid for 5 min shaking time and 1/1 phase ratio. In the meantime from the constructed McCabe-Thiele stripping diagram, it was found that two theoretical stages would be required in a counter current system with a flow rate (O/A) of about 0.33 (slope of the operating line).from the above mentioned data, it has been possible to formulate three integrated flowsheets for the processing of the two studied Gattar uranium occurrences; viz:1- Solvent leaching flowsheet for uranium from Gattar granite GII composite sample (Fig. 56)2- Solvent leaching flowsheet for uranium and rare earth elements from EL Hammamat sediment GV composite sample (Fig. 57)3- Conventional solvent extraction flowsheet for uranium and rare earth elements from El Hammamat sediment GV composite sample (Fig. 58)