A novel pumping scheme to enhance mining of metals and minerals and effective groundwater treatment

Traditionally, pumping for so-called subsurface intervention (in situ groundwater remediation, geothermal energy or in situ mining) involves a set of static placed wells to inject and extract fluids from underground. Stephen Varghese investigated a relatively new pumping method that uses a circular array of wells and regularly switches to different pairs of wells. This can improve the performance of targeted delivery of fluids (for mining) or subsurface confinement of fluids (for groundwater remediation).

In situ groundwater remediation involves pumping treatment solution directly into the underground layer of water via injector wells to neutralize contaminants. The performance can be improved by proper confinement of fluids to enable effective treatment. In situ mining similarly employs injector wells to deliver treatment (leaching) solutions in a targeted manner into ore-rich zones, thereby dissolving metals which is then extracted via extraction wells. Injector-extractor wells are also used in geothermal systems to recover heat from underground hot dry rocks, by circulating production fluids, the effective distribution of which can boost heat recovery.

In 2008 a new pumping method was introduced that in principle accomplishes efficient distribution of production fluid or its confinement and targeted delivery. In practice it means having a circular array of wells separated by a certain angle. The effect of reorientation can then be achieved by periodically turning off the current pair and turning on another pair after a certain time. Compared to a steady flow of fluids in the traditional static pumping systems (“base flow”), now there is a novel time-periodic flow (“RPM flow”).

The analyses of Varghese reveal that RPM flows entrap heat within the reservoir domain, thereby leading to reduced heat extraction when compared to the base flow. This implies that base flow outperforms RPM flows for heat recovery in geothermal systems. The entrapment, on the other hand, is very effective for the other two transport goals. Entrapment of the contaminated water enables its effective treatment within the established central island, which represents the reaction zone, as well as along its boundary, which may act as reaction front. Such entrapment however cannot be realized using the base flow.

Similarly, RPM flows enable targeted delivery of the scalar quantity enabling its application in in situ mining. RPM flows can therefore in principle be used for enhanced mineral recovery from reservoirs with spatially dispersed ore-rich zones, without the need for providing direct physical access to the mineral rich zones via wells, while at the same time conserving the usage of leaching solution. The base flow again fails in such targeted delivery of leaching solution.

Furthermore, Varghese investigated the optimal reorientation frequency and the requirement of implementing an odd or even pair of wells constituting the circular array, for both the confinement (groundwater remediation) and targeted delivery (mining) of fluids. He also characterized how the exchanging of heat between the distribution fluid and the solid porous
media through which the fluid flows can impact the effectivity of RPM flows.

The new pumping method need not necessarily be cheaper since it may involve drilling of additional wells. But RPM flows enable targeted delivery and confinement while base flow cannot. For example with increasing environmental concerns related to open pit mining and depleting metal resources, RPM can potentially be employed to mine unsafe or not easy to reach ore-regions, while minimizing environmental risks. Additionally many of the reservoirs already use multiple wells, but such a well configuration (RPM) is not used, and therefore in this case the costs may not be much different.

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