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Is Iran running out of yellowcake?

By David Albright, Jacqueline Shire and Paul Brannan

Rev. 1

Iran could be close to exhausting its supply of uranium oxide while lacking the adequate resources to sustain indigenous commercial-scale uranium processing and enrichment. Our conclusion, echoed in a recent report by Mark Hibbs in *Nuclear Fuel*,[1] is based on an examination of Iran's uranium reserves, its stocks of yellowcake (uranium oxide) acquired from overseas sources and, the requirements to sustain a commercial nuclear power program. The absence of activity at one of Iran's two uranium mines casts further doubt on its claims that it can establish independence in the fuel cycle required for a civil nuclear energy program.

How much uranium does Iran have?

In the mid-1970s, Iran acquired 600 tons of yellowcake from South Africa. We are unaware of any significant additional acquisitions by Iran, which as noted below are reportable to the IAEA under its safeguards agreement. At the time of the purchase, Iran's Shah, with U.S. support, had embarked on an ambitions plan to build as many as twenty power reactors in Iran and signed a contract with Germany's Kraftwerk Union (now Siemens) to build the first power reactors at Bushehr.

Reporting obligations: Under its safeguards agreement with the IAEA, Iran is obligated to report all imports of materials containing uranium: "When any material containing uranium or thorium which has not reached the stage of the nuclear fuel cycle … is directly or indirectly

[1] Mark Hibbs, "All of Iran's UF6 centrifuge feed now indigenously mined, milled," *Nuclear Fuel*, December 15, 2008. **Note**: This publication is available only to subscribers, but content can be accessed via Lexis-Nexis approximately three weeks following publication.

exported to a non-nuclear weapon State, the **State shall inform the Agency of its quantity, composition and destination**…." The safeguards agreement also states that "**safeguards shall not apply there under to material in mining or ore processing activities.**" Under the IAEA's Additional Protocol, to which Iran is not an adherent, countries are obligated to provide the "location, operational status and the estimated annual production capacity of uranium mines and concentration plants…."

Uranium imports banned: United Nations Security Council resolutions ban exports to Iran of all "items, materials, equipment, goods and technology" that could contribute to its enrichment activities, including uranium ore. In addition, transfers of uranium ore in quantities greater than 500 kilograms annually are subject to the export control guidelines of the Nuclear Suppliers Group. **These restrictions effectively close the door on legal imports by Iran of significant quantities of uranium ore**.

Saghand mine: Iran currently has two uranium mines, one in southern Iran near the Persian Gulf, at Gchine, and the second in central Iran at Saghand. By its own admission, the Saghand mine contains a low-grade ore body, of 553 parts per million uranium. (The image below is part of a presentation by the Atomic Energy Organization of Iran, which can be found here). High-grade ore-bodies can contain as much as 20 percent Uranium. Low-grade bodies generally contain 0.1 percent U, or 1,000 ppm. A Canadian mining exploration company notes that concentrations under 0.075% (750 ppm) are generally considered uneconomical to mine.

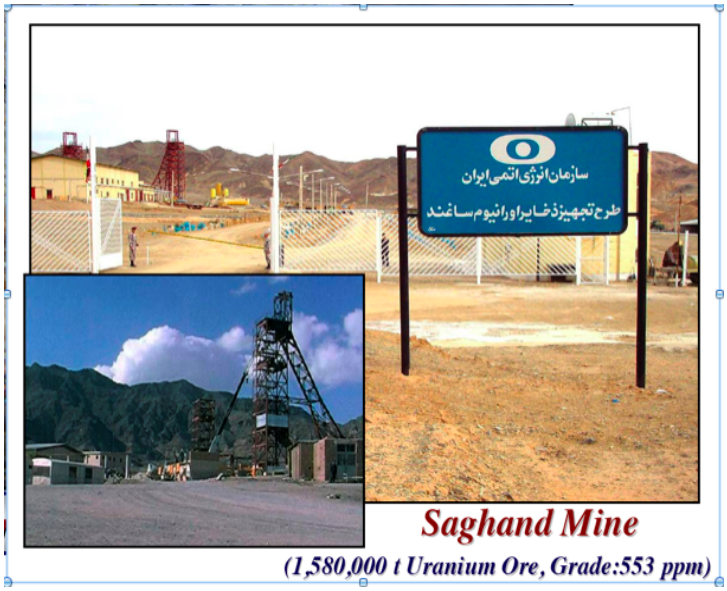

Figure 2. Ground photographs of the Saghand mine site.

Iranian officials informed the IAEA that they turned to Chinese experts to assess the quality of the Saghand mine in 1989 and entered into a contract with a Russian company to build a uranium ore processing plant in 1995. In 2004, the IAEA reported that the mine's infrastructure was essentially complete; tunneling toward the ore bodies had begun and that ore production would begin in 2006 with the goal of producing 50 tons annually. Once mined, the ore would be processed at a nearby mill at Ardakan.

A November 18, 2008 presentation at the James Martin Center for Nonproliferation Studies (CNS)(available on YouTube), reported that there has been no substantial mining activity at Saghand. The annotation of the imagery below draws upon this presentation.

In the first image, taken on August 24, 2004, there is no indication of mining activity or the presence of ore prepared for shipment for further processing:

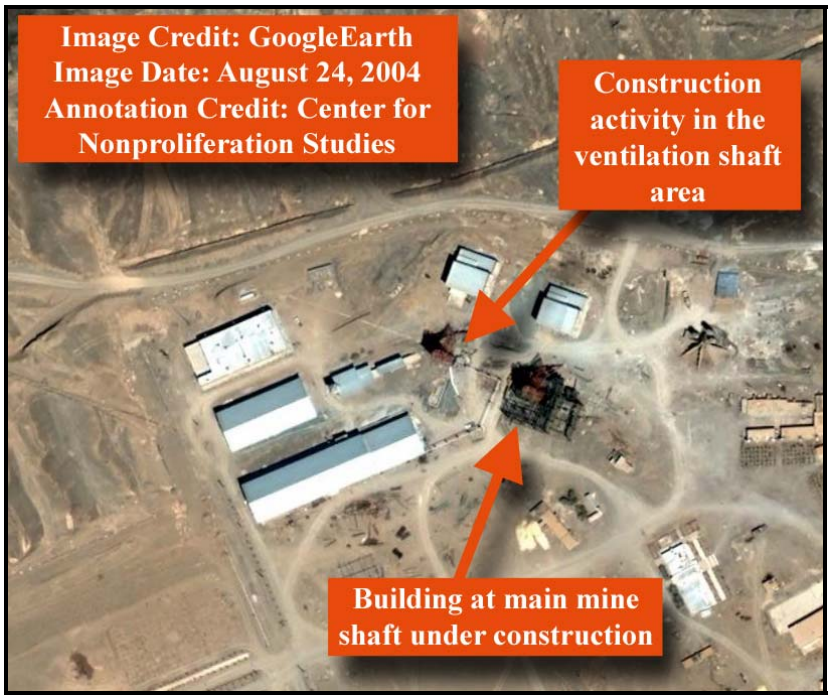

Figure 3. August 24, 2004 GoogleEarth image of the Saghand mine site.

Similarly, in this DigitalGlobe image from October 21, 2008, there is still no evidence of mining activity:

Figure 4. October 21, 2008 DigitalGlobe image of the Saghand mine site. There is no mining activity apparent in the main mine shaft area

The IAEA reports that the mining at Saghand takes place underground. Thus, it is not possible to determine from imagery when the mine might begin to operate. Further evidence that Iran's ore production at Saghand is virtually nonexistent can be seen in the 2004 and 2008 images of Ardakan, Saghand's ore processing facility located approximately 120 km away (see figures 5 and 6). Comparing the August 24, 2004 image to the December 28, 2008 image shows further construction of buildings on site but no evidence of ore processing activity. In 2008, Hossein Faghihian, the deputy head of Iran's Atomic Energy Organization claimed that the Ardakan facility would open by March 2009.

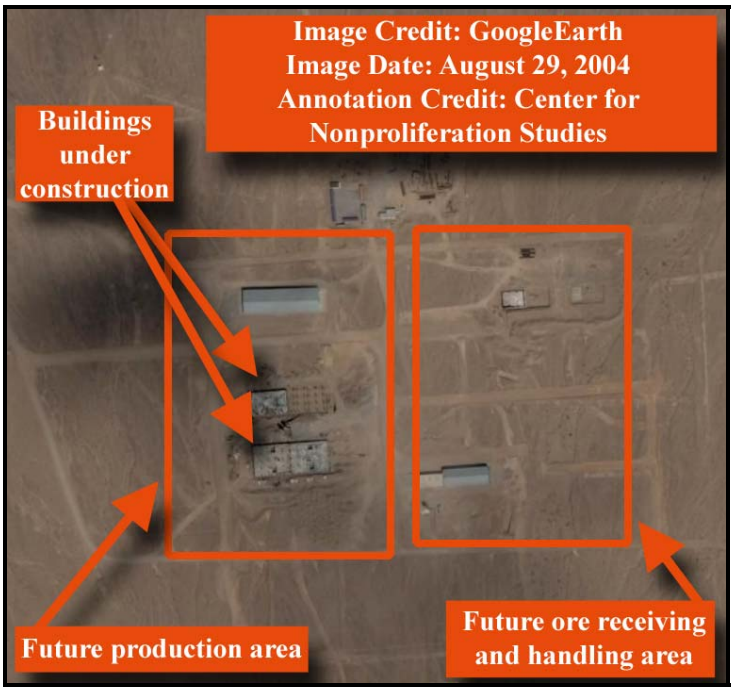

Figure 5. August 29, 2004 GoogleEarth image of the Ardakan Yellow Cake Production Plant

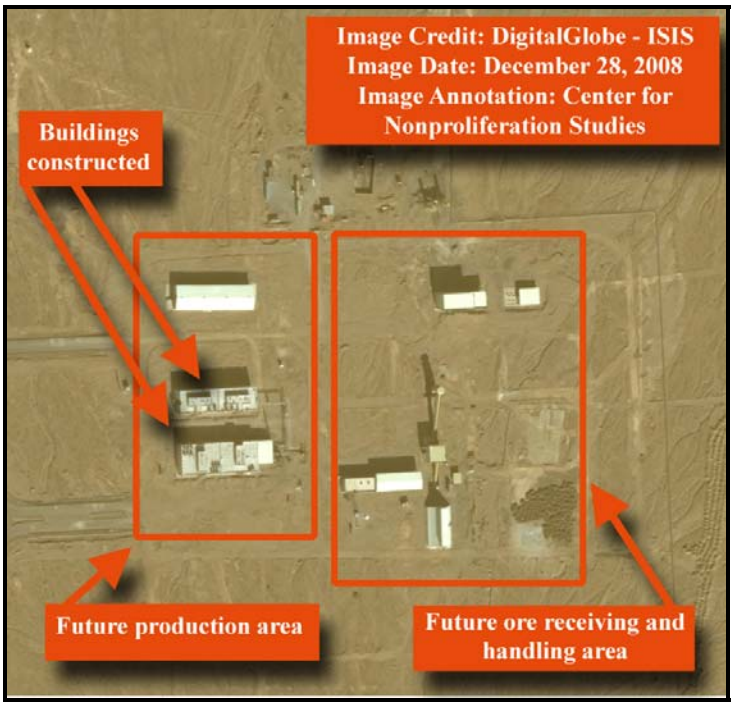

Figure 6. December 28, 2008 DigitalGlobe image of the Ardakan Yellow Cake Production Plant

The Gchine (Gachine) mine and mill: The IAEA reported in 2004 that the Gchine mine and co-located mill had begun production and would eventually produce 21 tons of uranium per year. The uranium, which contains "low but variable grade uranium ore," is located in near surface deposits that are open-pit mined.

This facility is controversial for two reasons. Iran appears not to have disclosed it to the IAEA in 2003 when Iran initially reported its fuel cycle activities to the IAEA (the November 2003 report contains a detailed list of facilities and sites associate with the nuclear fuel cycle in Iran, but makes no mention of Gchine, or the Bandar Abbas site, as

it was identified by an Iranian opposition group in 2004).[2] Second, the mine was developed by Kimia Maadan, a private company linked to the so-called alleged studies documents revealing possible nuclear weapons-related research and development.

A DigitalGlobe image from August 22, 2002 in the CNS presentation shows the original unlined[3] waste tailings pond used for initial uranium ore processing circa mid-2004. Imagery from June 2005 (figure 7) shows that this original waste tailings pond had been back-filled, with a new pond being prepared.[4] A March 3, 2006 DigitalGlobe image from the CNS presentation shows the newly lined waste tailings pond with some liquid.[5] The November 2008 DigitalGlobe image (figure 8) shows the new pond with waste tailings and illustrates the current operational state of the mill:

Figure 7. June 16, 2005 GoogleEarth image of the Gchine mill. New waste tailings pond being excavated to replace shallow unlined original

Figure 8. November 25, 2008 DigitalGlobe image of the Gchine mill shows waste tailings in the new pond.

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[2] Iran counters this criticism by claiming that it declared the Gchine facility in a well known biannual nuclear industry publication, colloquially known as the "Red Book." However, a check by an expert in the field of uranium mining and milling of the 2001 and 2003 Red Books, the latter being the last one before the IAEA revealed this site in 2004, contains no entries for the Gchine area or its province Hormozgan, although uranium in other areas was listed. There is a general reference to uranium deposits being near Gchine and in the province Hormozgan in the National Geoscience Database of Iran. In these Red Books, no mention is made of active mining or of a mill operating either at the present Gchine site or nearby. The Red Book is published jointly by the IAEA and Nuclear Energy Agency of the OECD. A description of the 2007 Red Book can be found here.

[3] *Evidence from Imagery: The Iran and Syrian Nuclear Programs – An Open and Shut Case?* James Martin Center for Nonproliferation Studies, November 18, 2008. CNS presentation

[4] Ibid.

[5] Ibid.

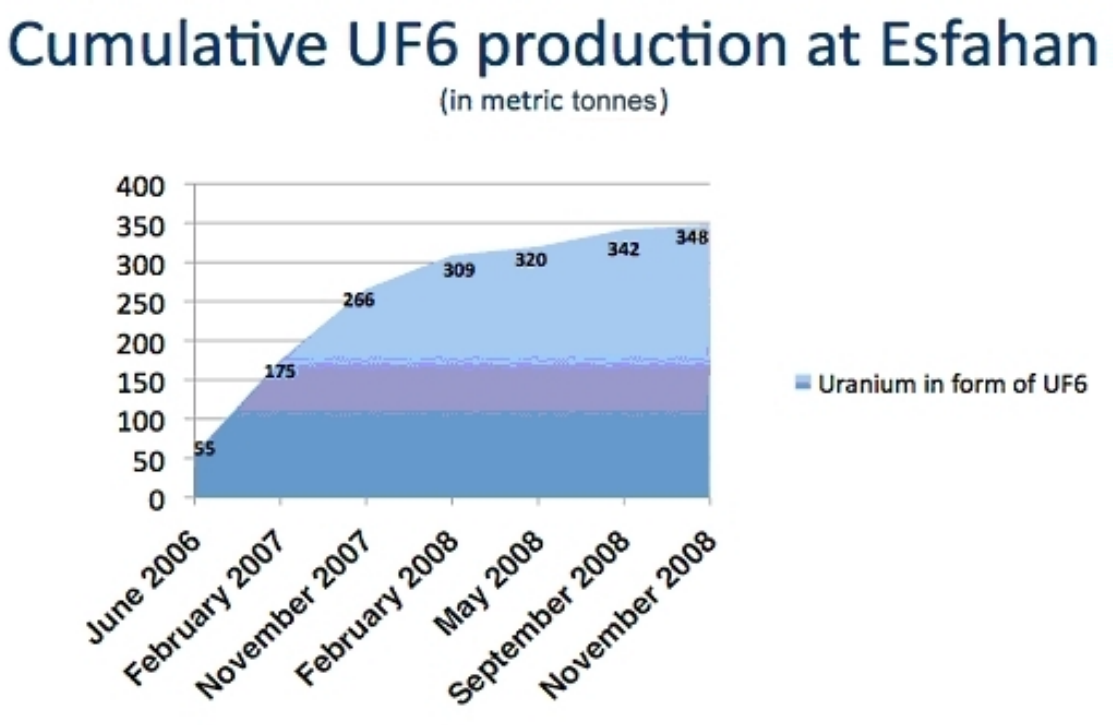
How much is 21 tons of uranium? The output of the Gchine mine is inadequate to meet the refueling requirements of a single 1,000 MW electric power reactor, which would require approximately 250 tonnes of uranium to yield approximately 25 tonnes of low enriched uranium, enough for a single reloading of the reactor's fuel (the initial fueling would require four times as much). Further, Gchine produces only a fraction of the uranium needed to keep Esfahan operating at both current and projected levels.

How much South African uranium is left? How long will it last?

Six hundred tonnes of uranium oxide (U3O8) is the equivalent of approximately 500 tonnes of uranium. If all of that material were converted to uranium hexafluoride, the feed gas for centrifuges, Iran would yield approximately 750 tonnes of uranium hexafluoride. In November 2008, the IAEA reported that Iran had produced 348 tonnes of uranium in the form of uranium hexafluoride (the equivalent of approximately 515 tonnes of uranium hexafluoride). This would indicate that Iran has exhausted just less than three-fourths of its original supply of South African uranium.

It also is important to note that Iran is likely to reserve at least some of its uranium stock, perhaps as much as 100 tonnes, for the Arak heavy water reactor currently under construction, which will be fueled with natural uranium.

The chart below illustrates the slowing pace of uranium hexafluoride conversion at Esfahan. The November 2008 IAEA report further notes that the facility was shut down for maintenance between August and October 2008.



Conclusion:

The next six months stand to be revealing: Will Iran slow operations at Esfahan in order to conserve a dwindling supply of uranium or even shut down the facility? Will it begin to use its limited supply of domestically mined uranium, which is of unknown quality and could lead to inferior grade uranium hexafluoride? Or will Iran try to find foreign suppliers, as suggested by recent reports, in defiance of sanctions imposed by the United Nations Security Council? A further possibility is that Iran manages to maintain operations at Esfahan well into 2010, raising the possibility that it succeeded in acquiring uranium ore from other sources

The current uranium ore shortfall illustrates a fundamental inconsistency between Iran's stated intentions—a commercially viable, indigenously fueled, civil nuclear power industry, and its capabilities. If Iran's objective is a latent nuclear weapons capability, it need not invest resources in the further development of its mining industry. But if it wants to meet the requirements of even a single Bushehr-type reactor, it will need to do much more to develop its own indigenous mining capabilities, or settle its differences with the international community so that it can import sufficient quantities of uranium. In fact, it could then import enough low enriched uranium fuel to make domestic mining and production of uranium hexafluoride unnecessary.