

The Process Designing of Gold Extraction from Placers of Passu to Shimshal (Hunza Valley) Gilgit-Baltistan by Mercury Amalgamation and Cyanidation Leached Method

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Abstract: Gold wash through panning or washing in the fluvial sediments or sands is done on the river banks in Skardu, Hunza and other places. The method of gold washing is very crude, primitive and most of the gold is washed away back into the river. The current study mainly focused on extraction of placer gold deposits. Pneumatic machines from Passu to Shimshal (Hunza valley) Gilgit-Baltistan. The mercury amalgamation and cyanide leached methods have been used for placer gold deposits extraction from the concentrate obtained from shaking table. The amount of gold recovered from amalgamation method with mercury was 30.9%. The alloyed gold with other metals, gold dust, and fine gold was recovered by chemical process. The reagent consumption, i.e. 1.4 kg/ton of NACN and 6 Kg / ton of CaO were used for extraction of placer gold deposits. The extracted gold is 10.24 g /t and silver 22 g /t and the remaining gold like the amalgamation residue, tailings and middlings are extracted by cyanidation leached method. The extraction of gold by cyanidation process was compared graphically, and study results revealed that extraction of gold using cyanidation leached method was 91.40% and silver 100%, respectively.

Keywords: Shaking table, amalgamation, cyanidation, recovery.

Introduction

In history of extraction of placer gold deposits, extract in various regions of Gilgit-Baltistan (GB) along Indus river basin, most of the gold is collected from the placers of these areas and fed to the market in Gilgit-Baltistan (Alam et al., 2018). Minerals like metals (gold), dimension stones (marble, granite, gemstones) play a vital role in the economy of GB. Thousands of families are involved in this industry and contribute a major portion to the economy of Gilgit-Baltistan, Pakistan. Gold extraction is a common practice, gemstones are mined from different localities, marble and granite industry is also developing day by day in GB. The heavy metals present in the gold concentrate may also be recovered by using modern methods on small scale, usually which are thrown into the river amalgamated with mercury, which affects the environment.

Austromineral carried out studies during 1975-76 with the objective of proving the feasibility of at least one economic gold placer deposit, having a daily output of 5000 tons of alluvial gravel/sand, assaying about 0.3 grams of gold per ton. The method of mercury amalgamation used for gold extraction from placer gold deposit is a common practice worldwide (Veiga et al., 2006). The alternates of placer gold are Chlorination, Bromine leaching, Thiourea leaching, Thiocyanate leaching and Selenic acid (Bamzai and Shukla, 1999). The mercury-free techniques are environmentally friendly but are highly expensive (Hylender, 2001). The processing of placer gold is

suitable by gravity separation and followed by mercury amalgamation (Shah, 2004). This method is effective for gold extraction of larger particle size, while cyanidation is effective for the recovery of finer particles, dissolved and alloyed gold. It is reported that shaking table is the most appropriate gravity separator for the recovery of fine-grained gold on the basis of specific gravity (Mitchell, 1997). The main objective of the study was to design a process for the extraction of gold from the placers along the Shimshal river from Passu to Shimshal.

Study Area

The study area widely extended from northern part of Pakistan and situated in between the great Karakorum Mountain Range of (GB) bordering with China and Afghanistan. Geological units exposed in this area are Passu slates, Kilik Formation, Gircha Formation, Gojal dolomite, and Karakorum batholith. GB is situated in the northern part of Pakistan extreme north of Pakistan bordering with China, India, and Afghanistan covering an area of 72,496 km² (27,799 square miles) with elevation varying between 1000 m and 8,611 m ASL. In this region land uses included glaciers (28.7%, n=72496 km²), agricultural land (1.36 %), forests (3.2 %), rangelands (grasses, shrubs etc.) (32 %), barren lands i.e., rocks, clips and bare soils (34.4 %) and others including streams and rivers (0.43 %) of total area (Khan, 2013).

Geology of the Study Area

Shimshal valley is famous for gold recovery from

fluvial sediments by local gold washers for a long time. Even nuggets of native gold are reported from

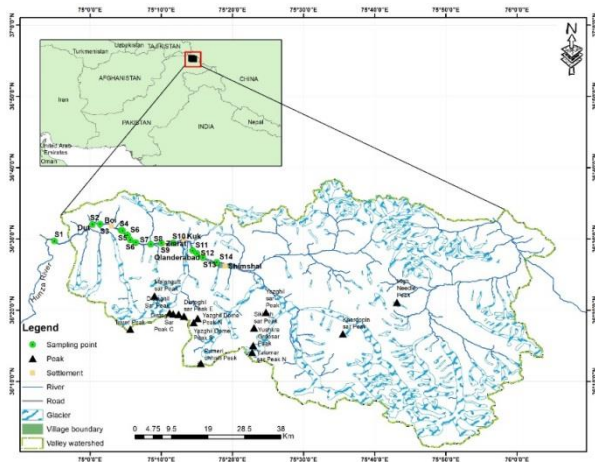


Fig. 1 Map of study area with sampling points along Hunza river (between Passu to Shimshal), Hunza valley.

the study area. During this study a small nugget of gold from Dut Nalah was also found in the area, which comprised of Passu slates, Kilik and Gircha formation, Gojal dolomite and Karakoram batholith. The Passu slates are light to dark grey in colour, thin to medium bedded. Intrusions of granite, diorite, aplite and vein

quartz are common. The weathered product is splintery in nature. Passu slates are intruded by Karakoram batholith and their contact is faulted. (Tahirkheli, 1990). The Kilik Formation contains metasediments, argillites, meta sandstone, quartzite, marble, low grade limestone and dolomite. The fresh colour of the rock is creamish to medium grey and weathered colour is rusty brown (Gaetani et al., 1990). The sequence is medium to thickly bedded and contains exposed to chemical weathering. The name of Gircha Formation was assigned by Desio and Martina (1979). The formation consists of argillaceous rocks like semi to medium crystalline limestone and quartzite sandstone. The limestone is yellowish in colour and thin bedded in nature. The sandstone is light colored and flaggy in nature. These rock units are intruded by diorite, granite, aplite and vein quartz. This sequence has tectonic slices of Gojal dolomite and Pak China Friendship Formation. Tahirkieli et al., (1990) reported this formation which was assigned Lower Permian (Fig. 2).

The Gojal dolomite consists of semi crystalline argillaceous limestone, semi to medium crystalline arenaceous dolomitic limestone, dolomite and semi to medium crystalline arenaceous dolomitic limestone. The limestone and dolomitic are thick to thin bedded. These are fine to medium grained in nature and colour

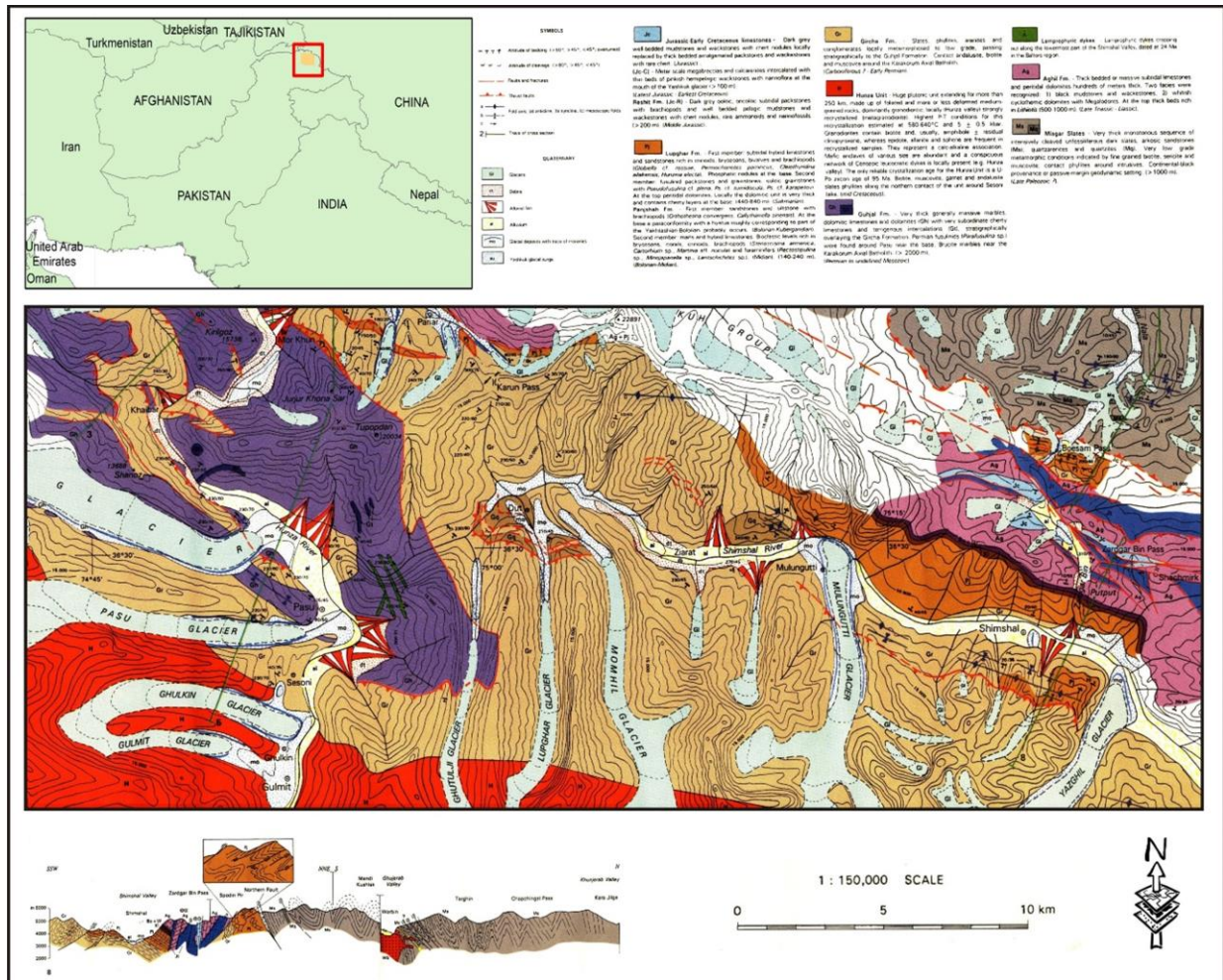


Fig. 2 Geological map of study area (Zanchi et al., 1994).

is light grey to yellowish brown. At some places it is folded and faulted. On the basis of fossil shells found in Gojal dolomite, the age was determined as Permo-Triassic (Tahirkieli et., al. 1990). The Karakorum axial batholith comprised of porphyritic biotite granodiorite and hornblende granodiorite, which are intruded by granites, pegmatite, aplites, vein quartz are foliated. A fault is also found in the batholith located in south and north respectively (Fig. 2).

Materials and Methods

An estimated 0.885 tons of concentrate was collected from 220 tons of processed material from 20 points of the study area. GPS locations were recorded from where the samples were collected using standard sampling method (ASTM D-6883). The samples were collected by pitting at various depths as well as benching along the river banks at different locations and collecting material, which was fed into the pneumatic machine and concentrate was weighed. About 885kg of prepared material, which was separated from 220 tons was sent to the laboratory for analysis.

One kg sample taken from the separated material was collected and riffled out, and the representative sample was sent for mineralogical / ore microscopic and chemical analysis. The rest of the material was treated by physical process to recover coarse gold. The concentrate / coarse gold material passed through various methods including grinding / thumbing to remove any oxide present in the gold and then amalgamated, to recover coarse crude gold. The amalgamated mercury was recovered for repeated reuse. The Cyanidation samples were sent for laboratory test and carried out on the tail as well as on the middling and residue material after recovery of coarse gold for determination and extraction of gold and silver if present in the samples.

The concentrate obtained from shaking table was fed to the flotation machine in the presence of water. Lime as well as mercury was added to the concentrate to expose the surface of the coarse gold and rolling continued in the bottle rolling mill for 30 minutes. The pregnant mercury containing gold was recovered from the concentrated sample by panning and the amalgamated mercury was recovered by cast iron retort. The amalgamated mercury was heated upto 700° C in the retort furnace to separate from the concentrated gold. The mercury separated from crude gold by condensing in the suction vessel in the presence of water for re-use. To determine any gold or silver in the residue amalgamated material is processed by cyanidation method.

To make a uniform bulk sample, the residue of the mercury amalgamation process of each container and the middling of the gravity separation are mixed. One kg representative portion from the bulk sample was taken for each agitation or cyanidation leaching test

and for bottle rolling cyanidation test. Both the samples were converted into pulp by adding water and quantity of lime was added to increase the pH up to 10.5%. The NaCN (sodium cyanide)) is added at 0.1% of the solid solution. During the cyanidation process, representative samples of each solution were collected from agitation cyanidation and also from bottle cyanidation after 2, 18 and 24 hours, respectively. The atomic absorption method was used to determine the gold and the silver recovered contents. On the completion of cyanidation test, the pulp was filtered, and the residue was thoroughly washed to ensure the transference of all gold and silver into the pregnant solution. The fire assay technique was used to extract any remaining gold form the residue after drying the sample. The time period was determined for the extraction of maximum gold and silver as well as reagent consumption for the cyanidation test experiments. The comparison of the two processes (agitation and cyanidation) for the extraction of gold and silver were carried out for the suitability of the method for gold extraction from placer gold.

Results and Discussion

The extraction of gold from placers along the Gilgit river from Passu to Shimshal (Hunza) shows that the coarse crude gold may be recovered by mercury amalgamation method, while gold dust, fine, ultra-fine and dissolved gold may be recovered by agitation/cyanidation method. The recovery of gold by mercury amalgamation method was 30.9 % and by agitation /cyanidation were 91.40 for gold with 100% recovery for silver respectively. Similarly, the recovery mercury which was used for mercury amalgamation method is 89%. From the chemical analysis of the original head sample and shaking table elements found 7.3 gm/ton and 3.0gm/ton of Au and Ag, respectively (Table 1). While Table 2 represented laboratory experiments results of shaking table with feed material of 48kg, out of which 1.85kg of concentrate with recovery of 3.8% produced 0.00 gm/ton Au, 5.3 kg middling with recovery of 30.9% produced 0.6gm/ton Au and 41.95kg of tail with recovery of 66% produced 0.5g/ton Au respectively.

Table 1. Chemical analysis of original head sample.

Chemical analyses of head sample	
Au	7.3 gm/ton
Ag	3.0 gm/ton

Table 2. Laboratory experiments of shaking table.

Product	weight	% Recovery	Au g/t	
48 kg	concentrate	1.85 kg	3.8	-----
	Middling	5.3 kg	30.9	0.6
	Tail	41.95 kg	66	0.5

The shaking table processed a total of 48 kg feed material. The details of concentrate, middling and tailing were shown in Table 2. Column C represented the extraction of physical gold by amalgamation process. The crude coarse gold (unrefined gold; mixture of copper) recovered by mercury amalgamation method from the sample was 15 gm. Hence, coarse gold present in the original concentrate material is 16gms/ton. During recovery of this crude coarse gold about 31gms of mercury was used. The mercury recovered is about 89%, while losses of

was only 30.9% for gold extraction. Extraction of gold (88%), copper (83%) and mercury (63%) increased rapidly up to 5 hours in the practice of bottle rolling mill method. After 5 hours there was a gradual increase in extraction up to 24 hours which reached 100% for Au and Ag, respectively. Extraction of gold is maximum after 24 hours. Furthermore, the maximum Au and Ag were extracted using bottle roll cyanidation method through the processing of fine ultra-fine and dissolved gold and silver particles.

Table 3 Agitation cyanide leaching test.

Time (Hr)	Contents and Additions				Solutions				Cal. Extrac			
	Solid	Water	NaCN	CaO	NaCN	pH	pH	Au	Ag	Au	Ag	
	(g)	(g)	(g)	(g)	%	Pre	Post	g/ton	g/ton	%	%	
0	1000	1000	1	4	0.1	7.3	10.55	-	-			
2	-	-	0.9	2	.01	9.73	10.50	7.28	4	68.76	19.14	
18	-	-	0.13	-	.087	10.40	10.40	10.24	691.40		27.13	
24	-	-	0.90	-	.01	10.21	10.01	4.03	2236.16		100	

mercury during this process is 10 to 11%. Similarly, the agitation/cyanidation for recovery of fine, ultrafine and dissolved gold are given in Tables 3, 4, respectively.

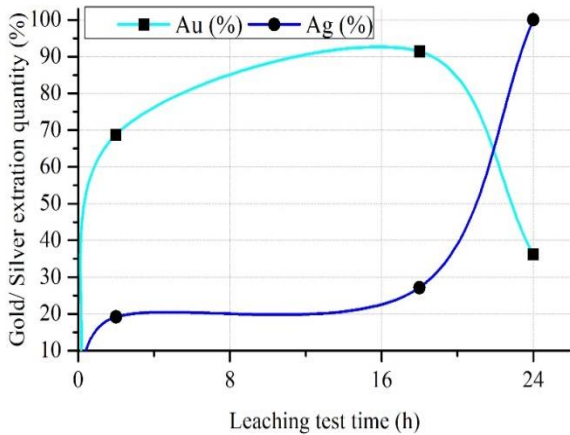


Fig. 3 Extraction of gold by agitation cyanide leaching test method and its relationship with time.

It was observed that the recovery of gold increased sharply with increase in time. The maximum recovery of gold was 29.8 % after 24 hours. It was also observed that the difference in recovery of Au, Ag, and Cu increased with increasing time. Better separation of Ag was observed in agitation method, but the recovery of gold is minimum. The agitation cyanidation method showed a sharp separation between Au, Ag and Cu with a relatively low extraction.

Figure 3 represented the extraction of gold from placer deposit with agitation/ cyanidation leaching method. About 91.40% gold and 100% silver were extracted from processed samples, respectively as compared to the mercury amalgamation process technique, which

Conclusion

The study examines the gold extraction from placer deposits along the river banks from Passu to Shimshal (Hunza district) GB with two different methods namely mercury amalgamation and agitation/cyanidation methods.

1. It is concluded that the study area contains visible, fine, ultrafine and dissolved gold and silver. The mineralogy and assay of the sample indicates that there is free as well as combined gold present.
2. The silver in the study area is easily extractable by chemical process. Mercury amalgamation method is suitable for the recovery of the coarse crude gold.
3. The fine, ultrafine and dissolved gold as confirmed on laboratory scale studies is possible to be recovered by agitation/cyanidation process.
4. The reagent consumption i.e. 1.4 kg/ton of NACN and 6 kg/ton of CaO is calculated on the basis of laboratory experiments.
5. The extracted gold is 10.24g/ton and 22gm/ton silver.

The successful recycling technique developed for reuse of mercury has protected the environment including surface as well as underground water. Air, human resources which poses a great threat of an environmental hazard by the local gold washers face.

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