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Reconnaissance Investigation of the Alluvial Gold Deposits in the North Takhar Area of Interest, Takhar Province, Afghanistan

By Peter G. Chirico, Katherine C. Malpeli, and Thomas W. Moran

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Conversion Factors

Multiply	By	To obtain
Length		
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
Mass		
gram (g)	0.03527	ounce (oz)
kilogram (kg)	2.205	pound (lb)
Area		
square kilometer (km ²)	0.3861	square mile (mi ²)
Volume		
cubic meter (m ³)	35.31	cubic foot (ft ³)

Reconnaissance Investigation of the Alluvial Gold Deposits in the North Takhar Area of Interest, Takhar Province, Afghanistan

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Introduction

Purpose

From 1958 to 1977, Soviet geologists collaborated with the Afghan Geological Survey (AGS) to conduct a nationwide assessment of Afghanistan's physical geography and natural resources. In partnership with the Department of Geology and Mines of the Afghanistan Ministry of Mines (MoM), Soviet geologists of the state-owned company, Technoexport, and scientists with the Soviet Geological Mission produced hundreds of reports documenting the country's vast mineral resources. These reports provide in situ and derived data of existing mineral deposits, as well as valuable topographic, geologic, and hydrographic data.

The previously published data on placers in Takhar Province were collected prior to the development of satellite-based remote-sensing platforms and new methods of geomorphic mapping involving digital terrain models (DTM) and geographic information system (GIS) processing techniques. This study integrates these new technologies and techniques with previously collected borehole sampling data and geomorphologic interpretations to reassess the alluvial gold placer deposits in Takhar Province. Through a combination of historical borehole and cross-section data of the sampled placer deposits of Samti, Nooraba-Khasar-Anjir, and Kocha as well as terrain modeling and satellite imagery analysis, these placer deposits were reassessed, resulting in higher resolution estimates of gold placer targets and their potential for artisanal and industrial mining in this region.

Study Area

Takhar Province is located in northeastern Afghanistan (fig. 1) and shares its northern border with Tajikistan, defined by the Panj River (fig. 2). The topography of the region is characterized by rough mountainous terrain dissected by numerous alluvial valleys, with elevations commonly ranging from 400 meters (m) in the valleys to over 2,800 m on the ridges. Rain-fed agriculture dominates the flat alluvial valley bottoms and gently sloping terrains, while the higher elevations are dominated by rangeland and shrubland (Afghanistan Information Management Service, 2002). The province is host to reserves of coal and gold, which are mined artisanally, as well as fine salt and construction materials such as loam, sand, and gravel (GRM International, 2006).



Figure 1. Map showing the location of Takhar Province, Afghanistan. The North Takhar Area of Interest is outlined in red, and is shown in more detail in figure 2.

This project selected three previously sampled placer gold deposits within Takhar Province on which to focus. These deposits, located in the northern part of the province, are the Samti, Nooraba-Khasar-Anjir, and Kocha placers. The general study area, the North Takhar Area of Interest (AOI), is bounded to the east by long 70°10' E., to the west by long 69°22' E., to the south by lat 36°51' N., and to the north by the Panj River (fig. 2). The Samti deposit lies at the northern edge of the study area within the middle Panj River valley, while the Nooraba-Khasar-Anjir deposit lies south of Samti, within the lower reaches of tributaries of the Panj River. The Kocha deposits are located in the southwestern part of the study area along the Kocha River, a tributary of the Amu Darya River. Rather than conducting the analysis for the entire length of the Kocha River, earlier workers examined in detail only those segments of the Kocha River known to be auriferous. These segments are located near the mouth and along the lower, middle, and upper reaches of the Kocha River.

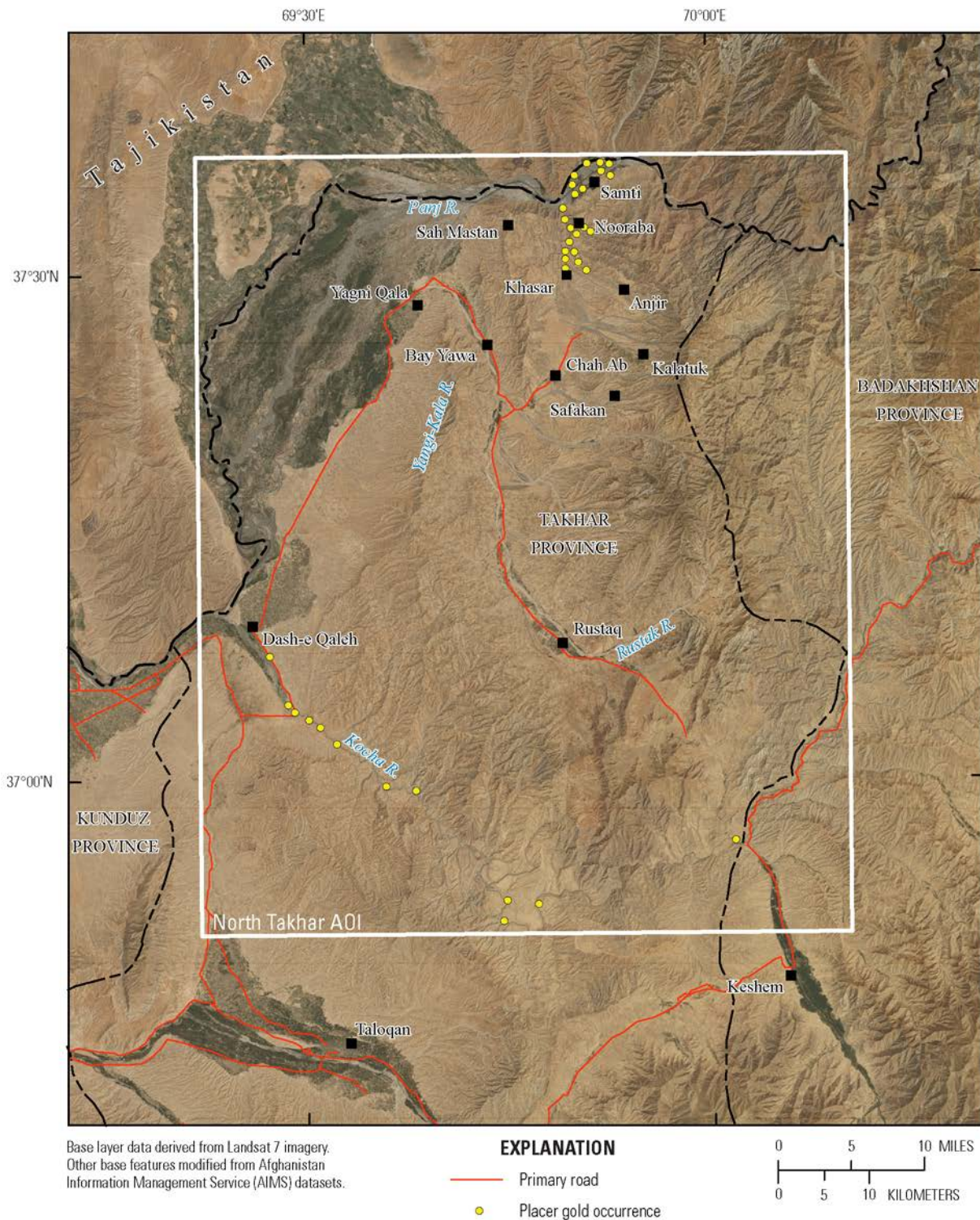


Figure 2. Map showing locations of the Samti, Nooraba-Khasar-Anjir, and Kocha placer deposits within the North Takhar Area of Interest (AOI).

Geology

Placer Gold Deposits in Afghanistan

The largest known placer gold deposits in Afghanistan are located in north Takhar Province near the border with western Badakhshan Province. These deposits are known as the Samti and Nooraba-Khasar-Anjir placers, and are worked by artisanal miners. Conglomerates of early Pliocene age, known as the Karnack Formation, are identified as a primary source of detrital gold for the Samti and Nooraba-Khasar-Anjir commercial placers and for the permissive deposits of the lower Kocha River. A third known deposit, Zarkashan, is located in southern Ghazni Province, upstream from the Zarkashan-Anguri copper and lode gold deposits.

The Samti, Nooraba-Khasar-Anjir, and Kocha Placer Deposits

On the basis of estimates of alluvial gold resources made by previous researchers, a series of commercial placer deposits, non-commercial deposits, and permissive areas have been identified in the North Takhar AOI. The Samti and Nooraba-Khasar-Anjir deposits were the focus of numerous prospecting expeditions by Soviet geologists and are considered to be commercial in nature, while the Kocha deposits, not as heavily sampled and less mineralized, are considered to be permissive.

The Samti placer deposit lies along the middle span of the Panj River (fig. 3) and is situated in the Panj Valley between the mouth of the Varichi stream and Khasar River valleys. It is about 8 kilometers (km) in length and varies from 900 m to 1.7 km in width (Galchenko, 1972). Previous estimates of gold resources throughout Samti were calculated to be 30,062 kilograms (kg), with the average content throughout the entire mass of alluvium calculated to be 408 milligrams per cubic meter (mg/m^3) and the average depth of the mineralized alluvium calculated to be 31.5 m (Galchenko, 1975a). Potential gold resources can also be found in high terraces extending 40 m above the Panj River valley and in alluvial fans of the Panj River tributaries located above the alluvial plain.

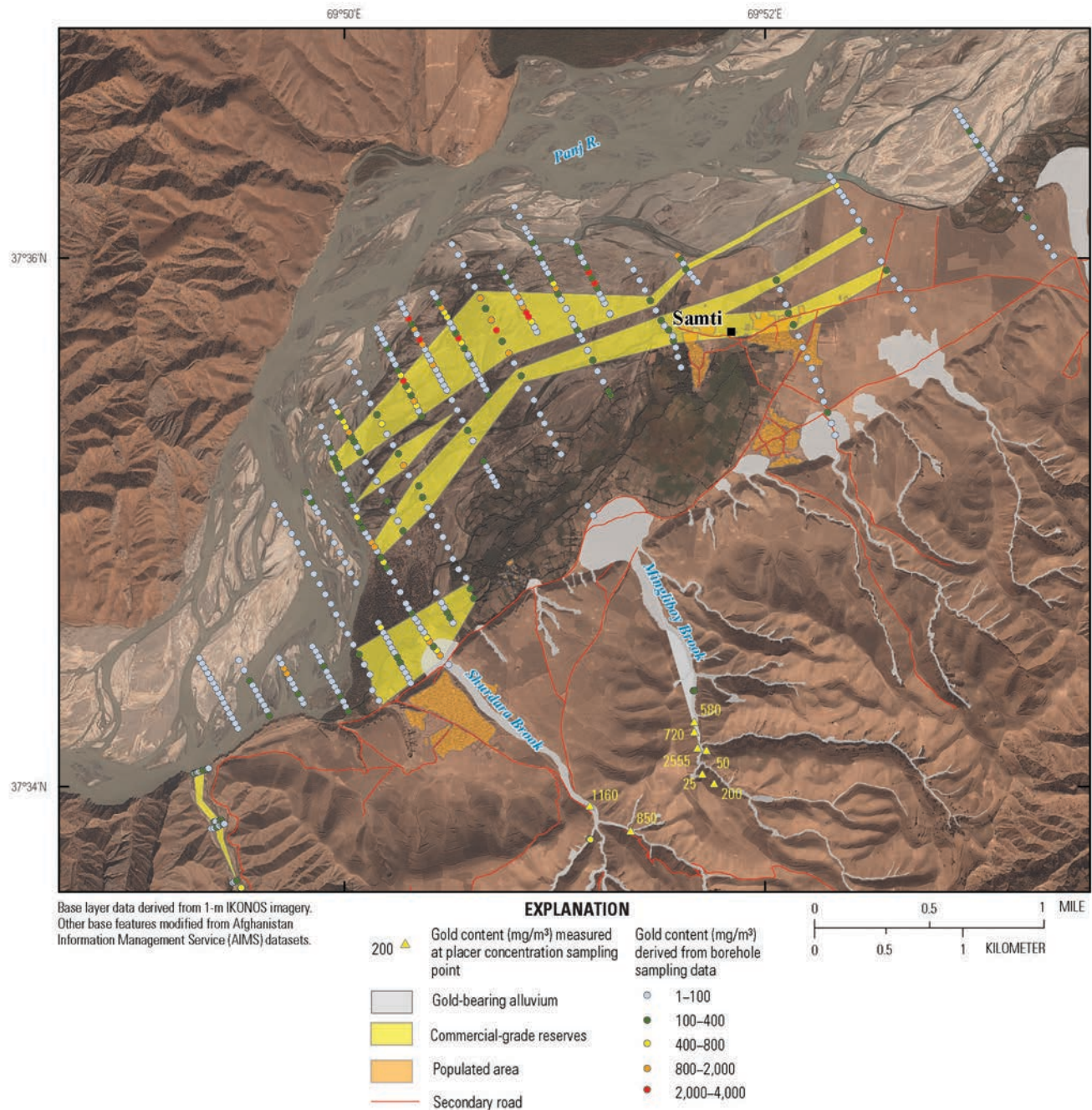


Figure 3. Map showing the Samti placer deposit and the locations of previous sampling investigations.

Alluvial deposits are noted to be 50 to 100 m wide in the valley flat of the Nooraba River, 80 to 120 m wide in the Khasar River valley, and 50 to 150 m wide in the Anjir Brook valley (Galchenko, 1975b) (figs. 4, 5). These deposits commonly range from 7 to 14 m in thickness. The Nooraba placer deposit is 3.8 km long and varies from 10 to 50 m in width, the Khasar River placer is 4.6 km long and 30 to 100 m wide, and the Anjir placer deposit is 2.3 km long and 20 to 70 m wide (Galchenko, 1975b). The concentrations of gold in the auriferous beds are not uniform, varying from as little as 90 to 100 mg/m³ to as much as 19 grams per cubic meter (g/m³). The overburden is also auriferous but not

economical for mining; its gold concentrations range from several milligrams per cubic meter to 300 mg/m³ (Galchenko, 1975b). In the Nooraba placer, the auriferous bed varies from 1 to 3 m in thickness and has a gold content that ranges from 100 to 760 mg/m³. In the Anjir Brook valley the auriferous bed is 1 to 2.5 m thick and contains between 123 and 2,716 mg/m³ of gold. The gold reserves were estimated by the previous researchers to be 437 kg in the Khasar placer, 210 kg in the Nooraba placer, and 155 kg in the Anjir placer, for a total of 802 kg within the Nooraba-Khasar-Anjir deposit (Popenko and Teplych, 1970; Galchenko, 1975a,b).

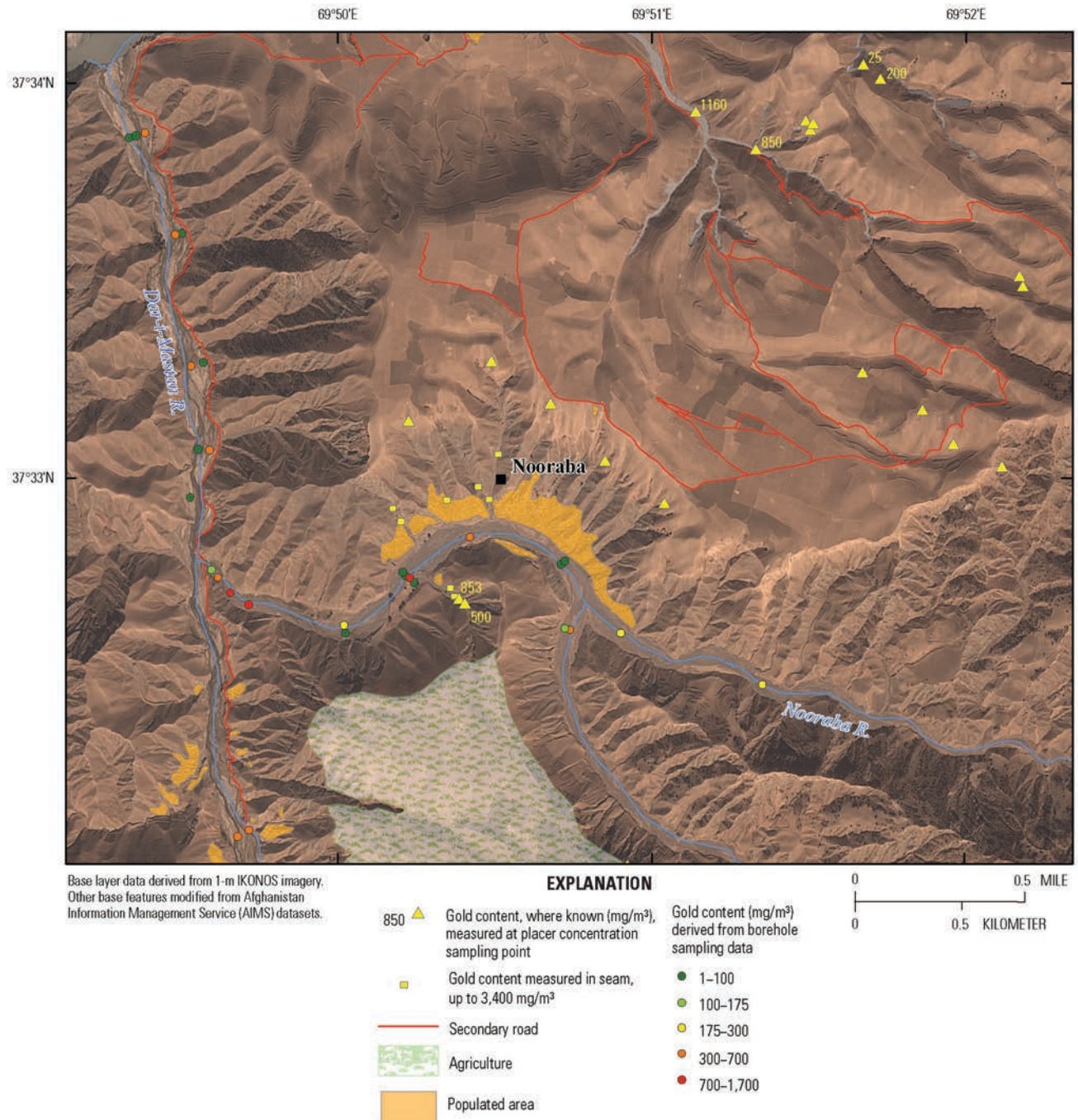


Figure 4. Map showing the Nooraba placer deposit and the locations of previous sampling investigations.

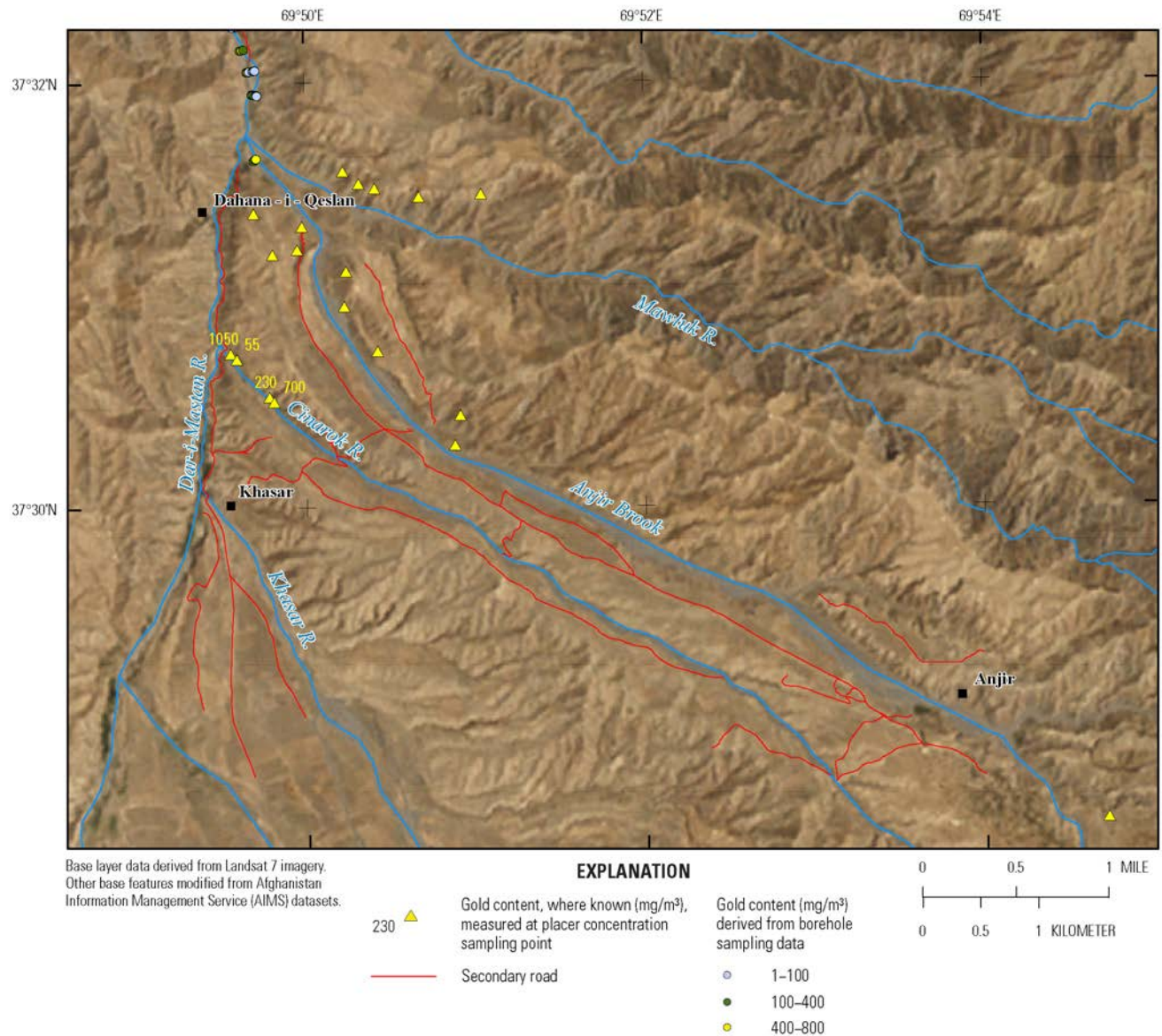


Figure 5. Map showing the Khasar-Anjir placer deposit and the locations of previous sampling investigations.

The Kocha placer deposits comprise several permissive areas. The first area measures 300 square kilometers (km²) and is confined to alluvium derived from Archean metamorphic rocks and Lower Carboniferous volcanic and sedimentary rocks. Thirty-nine samples out of 104 showed single grains of gold per sample, and seven yielded 0.04 to 0.50 g/m³. Subsequent sampling along the right bank of the Kocha River and along the headwaters of the right tributary of the Yaftal River found a permissive area (14 km²) underlain by Pliocene conglomerate. Ten or more grains of gold were found in each of four samples (Semionov and others, 1967). In a third area, 25 km² in size and underlain by Pliocene conglomerate and Early Carboniferous plagiogranite, gold was found in five samples in amounts varying from single grains to 0.17 g/m³ (Semionov and others, 1967). No previous reserve estimates exist for the Kocha deposits.

Methodology

In order to assess the resource potential of the Samti, Nooraba-Khasar-Anjir, and Kocha placer deposits, it was first necessary to develop a GIS database containing all available borehole sampling data and concentration sampling data acquired during the Soviet geologic investigations. During those investigations, a total of 447 samples were collected at the Samti deposit, 117 were collected at the Nooraba-Khasar-Anjir deposit, and 21 were collected from the Kocha deposits. For each sample location the depth, thickness of overburden, grade of gold-bearing alluvium, and any additional available information were recorded within the database.

A geomorphic model characterizing the alluvial, terrace, and colluvial zones was then derived using the sampling data and a DTM developed using a digital elevation model (DEM) and the hydrologic network (fig. 6). The 30-m Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model (GDEM) dataset was used to create the geomorphic model. First, the Strahler stream-order method was used to define watershed boundaries and derive streamflow paths for the study area, using the ASTER GDEM dataset. Because it is unlikely that an entire watershed is uniformly endowed with gold, only subbasins having a recorded gold occurrence were included in the analysis. Gold-bearing subbasins were modeled for the Samti deposit, the Nooraba-Khasar-Anjir deposit, and the Kocha deposits. The ASTER GDEM dataset was then used to create a relative DEM (elevation above base stream flow). The relative DEM was reclassified into four geomorphic zones, consisting of alluvial and low terrace deposits (alluvium 1), more recent alluvial flat deposits (alluvium 2), terraces, and colluvium derived from local underlying bedrock.

Data on gravel thicknesses and grade from the borehole and concentration sample datasets were integrated into the geomorphic model, producing a minimum, maximum, and mean grade for each of the four geomorphic zones (table 1).

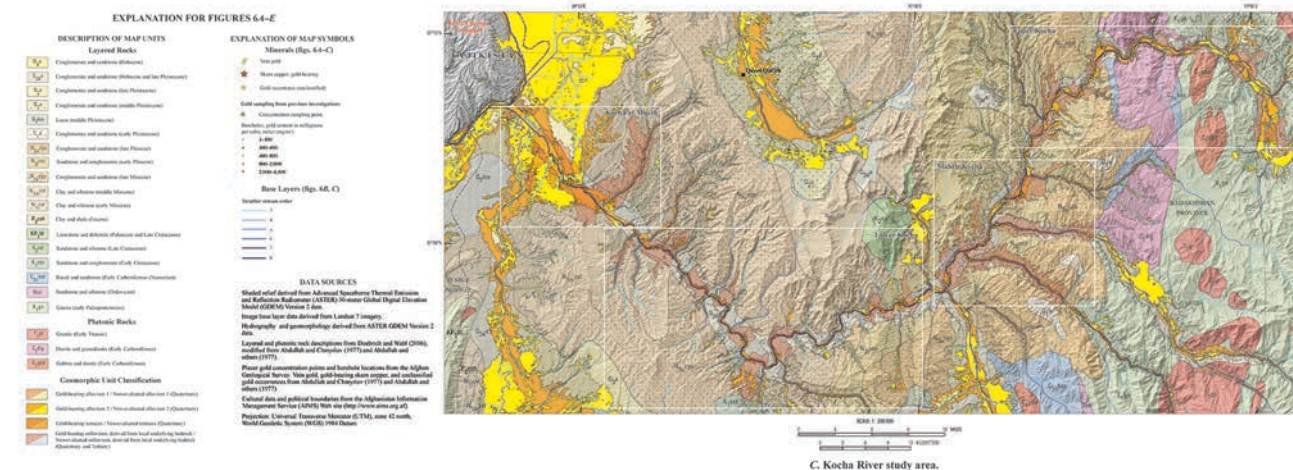
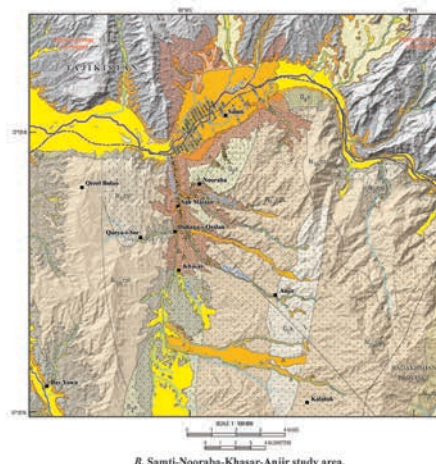
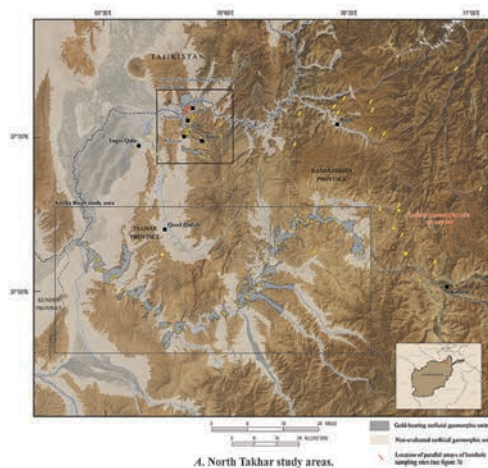


Figure 6. Maps and photographs showing the geologic and geomorphic units of the placer gold deposits in the North Takhar Area of Interest.

After completion of the geomorphic model, the resource potential was calculated using the volume and grade methodological approach (Chirico and others, 2010). This approach can be expressed mathematically as $P = (VG)$, where P is the estimated resource potential, V is the volume of the deposit, and G is the mean gravel grade of the deposit. The volume of the deposit was calculated by multiplying the surface area of each of the geomorphic zones (alluvium 1, alluvium 2, terraces, and colluvium) by their respective gravel thicknesses. A minimum, maximum, and mean gravel grade were then developed for each geomorphic zone based on the available sampling data. The volume of each zone was then multiplied by the minimum, maximum, and mean grades to arrive at a minimum, maximum, and mean resource potential for each geomorphic zone within the Samti, Nooraba-Khasar-Anjir, Kocha at mouth, lower Kocha, middle Kocha, and upper Kocha deposit areas.

Table 1. Integration of data into the geomorphic model.

[mg/m³, milligram per cubic meter; m², square meter; m, meter; m³, cubic meter; -, none]

Location	Geomorphic zone	Number of samples	Minimum grade (mg/m ³)	Maximum grade (mg/m ³)	Mean grade (mg/m ³)	Area (m ²)	Gravel thickness (m)	Volume of gravel (m ³)
Samti	Alluvium 1	9	4	178	65.44	2,801,228.26	1.5	4,201,842.39
	Alluvium 2	419	1	3,701	201.76	23,816,033.90	1.904	45,345,728.54
	Terraces	7	11	107	50.57	5,536,755.54	1.0975	6,076,589.21
	Colluvium	12	43	5,900	858.58	20,699,084.91	0.63	13,040,423.49
Total		447						
Nooraba/Khasar/Anjir	Alluvium 1	6	4	806	175.33	329,457.68	0.6	197,674.61
	Alluvium 2	102	2	3,154	304.18	17,062,057.31	0.903933	15,422,956.65
	Terraces	1	1,050	1,050	1,050	1,735,683.88	-	-
	Colluvium	8	55	853	348.25	16,655,767.64	0.5	8,327,883.82
Total		117						
Kocha (Mouth)	Alluvium 1	0	-	-	-	5,790,279.98	0.7	4,053,195.98
	Alluvium 2	2	5	5	5	21,395,233.12	0.8	17,116,186.50
	Terraces	1	5	5	5	24,616,817.49	0.6	14,770,090.49
	Colluvium	0	-	-	-	33,520,094.92	0.5	16,760,047.46
Total		3						
Kocha (Lower)	Alluvium 1	0	-	-	-	977,182.50	0.7	684,027.75
	Alluvium 2	1	24	24	24	9,518,855.94	0.8	7,615,084.75
	Terraces	4	26	44	34	7,245,041.67	0.6	4,347,025.00
	Colluvium	3	4	42	27	53,049,963.70	0.5	26,524,981.85
Total		8						

Table 1. Integration of data into the geomorphic model.—Continued

[mg/m³, milligram per cubic meter; m², square meter; m, meter; m³, cubic meter; -, none]

Location	Geomorphic zone	Number of samples	Minimum grade (mg/m ³)	Maximum grade (mg/m ³)	Mean grade (mg/m ³)	Area (m ²)	Gravel thickness (m)	Volume of gravel (m ³)
Kocha (Middle)	Alluvium 1	0	-	-	-	3,419,370.17	0.55	1,880,653.59
	Alluvium 2	1	8	8	8	11,281,553.51	0.6	6,768,932.11
	Terraces	2	4	12	8	14,663,072.75	0.5	7,331,536.38
	Colluvium	0	-	-	-	88,452,396.48	0.4	35,380,958.59
Total		3						
Kocha (Upper)	Alluvium 1	1	43	43	43	3,506,563.63	0.45	1,577,953.64
	Alluvium 2	6	3	16	6	33,466,925.83	0.5	16,733,462.92
	Terraces	0	-	-	-	9,554,624.05	0.4	3,821,849.62
	Colluvium	0	-	-	-	55,139,073.08	0.3	16,541,721.92
Total		7						

Results

The results of the volume and grade approach are displayed in table 2. Based on the mean grades, the resource estimates for the placer gold deposits are as follows: 20,927 kg for Samti, 7,626 kg for Nooraba-Khasar-Anjir, 160 kg for the mouth of the Kocha, 1,047 kg for the lower Kocha, 113 kg for the middle Kocha, and 168 kg for the upper Kocha. Separate resource estimates were calculated for each geomorphic zone, within each of the deposits. Within the Samti deposit, the colluvium zone was shown to have the largest reserves, followed by the alluvium 2 zone. Meanwhile, within the Nooraba-Khasar-Anjir deposit, the alluvium 2 zone shows the greatest reserves, followed by the colluvium zone. For the mouth of the Kocha, lower Kocha, middle Kocha, and upper Kocha, sample data were not available for all of the geomorphic zones; therefore, resource estimates could be calculated only for particular zones within the Kocha deposit areas. For the mouth of the Kocha, data were available only for the alluvium 2 and terrace zones. Upon examination of the resource estimates based on the mean grade at the mouth of the Kocha, the alluvium 2 is slightly more endowed than the terraces, while at the lower Kocha the colluvium is approximately five times more endowed than the terraces, and four times more endowed than the alluvium 2. At the middle Kocha, the alluvium 2 and terrace zones are nearly equally endowed. Along the upper Kocha, samples were available only within the alluvium zones, and showed that the alluvium 2 zone is slightly more endowed than the alluvium 1 zone.

Table 2. Comparison of the results of the resource estimates from this study with the Soviet resource estimates.

[kg, kilogram; -, none]

Location	Geomorphic zone	Resource estimate (minimum grade) (kg)	Resource estimate (maximum grade) (kg)	Resource estimate (mean grade) (kg)	Soviet resource estimate (kg)
Samti	Alluvium 1	17	748	275	-
	Alluvium 2	45	167,825	9,149	-
	Terraces	67	650	307	-
	Colluvium	561	76,938	11,196	-
Total		690	246,161	20,927	30,062
Nooraba/Khasar/Anjir	Alluvium 1	1	159	35	-
	Alluvium 2	31	48,644	4,691	-
	Terraces	-	-	-	-
	Colluvium	458	7,104	2,900	-
Total		490	55,907	7,626	802
Kocha (Mouth)	Alluvium 1	-	-	-	-
	Alluvium 2	86	86	86	-
	Terraces	74	74	74	-
	Colluvium	-	-	-	-
Total		160	160	160	-

Table 2. Comparison of the results of the resource estimates from this study with the Soviet resource estimates.— Continued

[kg, kilogram; -, none]

Location	Geomorphic zone	Resource estimate (minimum grade) (kg)	Resource estimate (maximum grade) (kg)	Resource estimate (mean grade) (kg)	Soviet resource estimate (kg)
Kocha (Lower)	Alluvium 1	-	-	-	-
	Alluvium 2	183	183	183	-
	Terraces	113	191	148	-
	Colluvium	106	1,114	716	-
Total		402	1,488	1,047	-
Kocha (Middle)	Alluvium 1	-	-	-	-
	Alluvium 2	54	54	54	-
	Terraces	29	88	59	-
	Colluvium	-	-	-	-
Total		83	142	113	-
Kocha (Upper)	Alluvium 1	68	68	68	-
	Alluvium 2	50	268	100	-
	Terraces	-	-	-	-
	Colluvium	-	-	-	-
Total		118	336	168	-

Conclusion

Previous resource estimates were conducted by the Soviets for the Samti and Nooraba-Khasar-Anjir deposits. The Samti deposit was estimated to contain 30,062 kg of gold, while the Nooraba-Khasar-Anjir deposit was estimated to contain a much lower 802 kg of gold (table 2). No previous resource estimate has been done to date for the Kocha deposits. For the Samti deposit, the resource estimate based on the mean grade calculated in this study reports approximately 9,000 kg less gold than the Soviet estimate. Meanwhile, in the Nooraba-Khasar-Anjir deposit, the resource estimate based on the mean grade calculated in this study reports nearly 7,000 kg more gold than the Soviet estimate. The difference between the new estimates and previous estimates results from the higher resolution geomorphic model and the interpretation of areas outside of the initial work zone studied by Soviet and Afghan geologists.

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