The Discovery of the Yanacocha Gold Deposit

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Introduction

The Yanacocha gold deposit has been studied in considerable detail since production commenced in 1993 (Harvey et. al. 1999; Turner, 1999). Knowledge of its geology has advanced well beyond that at the time of discovery. Accordingly, this paper does not attempt to add to the geological understanding of the deposit, but rather deals with the events and factors leading to its discovery. As such is as much historical as it is technical. Much of the information presented is derived from a presentation made by the writer at a Newmont exploration meeting in 1994 (Paverd 1994).

In 1980 Newmont Mining Corporation formed a new overseas exploration division and the writer was appointed its manager. The division had no staff, a limited budget and no exploration properties. Its vision was the discovery of base and precious metal deposits in areas new to Newmont.

At the time Newmont had little experience in undertaking exploration outside of the 'English speaking' world and office and field based studies were considered a prerequisite to acquiring the necessary expertise to allow country selection. After some two years of work including field visits and establishing contacts with many companies the choice in South America was narrowed to Chile and Peru. In late 1982 the writer recommended that exploration be initiated in Peru, and Newmont opened an office in Lima in March 1983.

Peru was selected over Chile for three main reasons:

1. The geology of Peru was considered to be more favorable for discovery. Research and extensive visits to the countries had convinced the writer that Peru had greater potential for base and precious metal discoveries. While, Chile had potential for porphyry copper and high level gold deposits, Peru had the potential for the discovery of copper/zinc and silver/zinc skarns, MVT zinc deposits, VHMS copper/zinc deposits, copper, zinc and silver replacement deposits, in addition to porphyry copper and epithermal precious metal deposits
2. There was less competition in Peru. There were over twenty large mining companies undertaking exploration in Chile in the early 1980's. Competition for ground was intense and acquisition costs were high. In contrast there were probably only three operating in Peru and ground acquisition costs were reasonable; an important consideration given Newmont's modest budget
3. Chile had received far more exploration in the preceding fifteen years than Peru and this probably meant that the more obvious deposits had been found.

The Yanacocha Joint Venture

Study of the mining industry in Peru suggested that the best approach would be to farm in on existing exploration projects rather than to attempt to locate claims. The reason for this was twofold: Firstly, many small to moderate size mining companies were operative in Peru and therefore much of the better ground was probably already owned. Secondly, having access to local political, technical and logistic expertise through a partner was considered important. Newmont therefore actively solicited joint ventures.

As part of the country selection process the writer met with Dr. José Miguel Morales of Estudio Garcia Sayan to obtain information on the mining environment in Peru. In addition to providing legal and administrative advice he offered to introduce Newmont a number of local companies. One of these was Compania Minas de Buenaventura, where the writer met Alberto Benavides.

Newmont had first established contact with the BRGM in January of 1983 in Orleans and several projects were evaluated, but it was not until one day in August of 1983 when Alberto Benavides mentioned that CEDIMIN, which was at that time 35% owned by Buenaventura, might be interested in finding a partner for Yanacocha that the Yanacocha project came to Newmont's attention. Later the same day Alberto Benavides and the writer were joined by Jacques Boulanger of the BRGM at a luncheon at the El Suizo restaurant, where he confirmed the BRGM's interest in a joint venture on Yanacocha and a due diligence visit was arranged.

Anthony Bowerman, the NPL exploration manager visited Yanacocha in September of 1983. He was impressed by mineralization and the extent of the mineralized system and recommended further work. Negotiations between Newmont and the BRGM began the same month.

Consistent with the policy of involving local companies, and to avoid the problems associated with a 50/50 joint venture between a French government body and a North American company, Compania de Minas Buenaventura was invited to join the proposed joint venture in November 1983.

A letter of intent was signed between the three parties in May 1984. In terms of the agreement Newmont and Buenaventura were to fund the exploration to earn a 40% and 20% equity in the joint venture respectively. Work began immediately, but a definitive agreement was not signed until September 1985. Newmont was appointed operator reporting to a joint venture committee, which met every quarter. In addition to governing the routine matters of the joint venture, these meetings became an important forum for the exchange of ideas and contributed greatly to the ventures ultimate success.

Background

Based on the existence of old workings in the Carachugo area it is possible that the Yanacocha gold deposits were first exploited by the Incas in pre-colonial times. There is no evidence that they were worked by the Spanish.

Victor Hollister recognized that the area had potential for base and precious metal deposits as early as 1962, but no work was undertaken until 1969 when anomalous silver and lead was detected in stream sediments during a survey undertaken by a British technical aid mission.
Nippon Mining undertook a diamond drilling program in the area in 1970, which was directed at the discovery of porphyry copper deposits. No core and no data survive, and apart from the physical location of drill holes in the field, no information is available.

In 1980 based on the results of the British stream sediment survey CEDIMIN, the Peruvian branch of the Bureau de Recherches Geologiques et Minieres (BRGM), applied for the Chaupiloma 'denuncios' totaling some 10,700 hectares over an area which now includes most of the Yanacocha deposits.

Work began in 1981and continued through 1983. It consisted of 1:2,500 topographical surveys, a 1:10,000 photo-geological survey over an area of 40,000 hectares, and a soil geochemical survey on a 100m by 100m grid over 17,000 hectares. Samples were assayed for silver, lead, zinc, and copper, and six silver anomalies were delineated. The anomalies were labeled A through F and mapped a scale of 1:2,500.

The anomalous areas were further investigated by more detailed mapping and a 50m by 50m soil geochemical grid. Shallow, hand-excavated, trenches were placed over the better silver soil anomalies and the values confirmed by rock chip sampling. Some Induced Polarization and Resistivity work was also undertaken. Silver values varied from less than 30 g/t Ag to 1,000 g/t Ag. The silver was accompanied by some gold mineralization; generally less than 0.3 g/t Au, but with spot highs of up to 5 g/t Au.

One of the better trench values was 6m at 250 g/t Ag and 2.5 g/t Au from a silicified breccia (trench 350N/400E), but most trenches yielded between 30 g/t Ag to 90 g/t Ag with around 0.3 g/t Au.

Mapping and rock chip sampling also delineated a number of narrow, siliceous and gossanous structures, which contained gold in the area known as anomaly B. Values were generally in the order of 1 g/t Au, but one assay of 14 g/t Au was recorded.

Examination of the results suggested that Yanacocha constituted an epithermal, bulk silver target. The silver mineralization appeared to be near stratiform, localized along a shallowly dipping contact between a water lain tuff and dacite. The zone containing the mineralization was up to six meters thick and covered an area of some four square kilometers.

Exploration

1984 Exploration Program

As the nature and distribution of the silver mineralization at Yanacocha was imperfectly understood it was decided to confine the exploration for 1984 to

obtaining more information by geological mapping and trenching, prior to possible drilling.

The program accordingly took the form of geological mapping and trenching over a 100-hectare area encompassing anomalies A (north east of Yanacocha Norte), B (north of Yanacocha Norte), and C (Yanacocha Oeste) (Figure 1) as well as reconnaissance mapping and sampling in what later became known as the Carachugo and San Jose areas.

At area A trenching in silicified and argillized tuffs resulted in the delineation of a two hectare area averaging 68 g/t silver. At area C trenching delimited a silicified breccia with an aerial extent of 70 square meters with values of up to 2.5 g/t gold and 260 g/t silver.

Mapping and trenching at area B defined two highly siliceous, near vertical, vein-type structures, an eastern and a western, containing alunite and pyrite within argillized tuffs. The structures were generally less than 5 meters thick, contained between 1g/t and 7 g/t gold, and could be traced intermittently for 400 meters.

Work in the Carachugo and San Jose areas gave disappointing results. Some of the old dumps in the area yielded up to 1 g/t gold, but these values could not be replicated in rock chip sampling.

The results were considered sufficiently encouraging to warrant a drilling program.

1985 Exploration Program

The 1985 exploration program comprised 21 RC drill holes at anomaly A, two diamond drill holes and 4 RC holes at anomaly C, and six diamond drill holes at anomaly B in addition to mapping at anomalies D, E, and F.

The RC drilling at anomaly A defined a 3 million ton, silver deposit containing 87 g/t silver and 0.4 g/t gold, whereas the drilling at anomaly C yielded only minor amounts of silver and gold (Figure 1). These were disappointing results and it was apparent to the partners that little potential existed for an economically viable, bulk silver deposit.

Drilling results over the gold bearing structures in the anomaly B area were not much better. The three drill holes (1,3 and 6) completed over the western structure gave poor results. They defined a narrow vein system of 0.9 m to 2.0 m in true thickness with grades of between 0.9 g/t and 2.5 g/t gold. Holes 2 and 5 on the eastern structure were no better. Only hole 4 at the southern end of the structure gave an intersection of some interest, namely 7 meters true thickness at a grade of 9.6 g/t gold (Figure 1).

The gold mineralization in drill hole 4 was contained within a highly silicified, vein-like structure containing alunite and pyrite, within argillized volcanics. The structure was open at depth, but thinned to the north and could not be traced in outcrop to the south. The future of the project appeared bleak. The

silver mineralization did not constitute a bulk target and the gold mineralization appeared to be restricted to narrow epithermal veins.

Despite the good outcrop in the Yanacocha area, mapping had not proved easy. A thin veneer of lichen, giving all outcrops a uniform gray appearance, covers all exposures in the area. Detailed mapping therefore required almost continuous rock-chip channels. This was very time consuming and of course not practical for the large scale mapping done up until that time.

The spectacular exposures of mineralized and altered rock visible today are due entirely to exposure by mining. It is noteworthy that despite the fact that the alteration at Yanacocha has a strike length of more than 17 kilometers it is not visible on TM imagery.

Mapping during the 1984 season had demonstrated that a large, irregularly shaped zone of siliceous rock occurred to the south of area B (Figure 1). This material was interpreted as an intensely silicified tuff, overlying the argillized and silicified tuff carrying the silver mineralization. Random rock-chip sampling of this material had yielded little of interest, but no systematic sampling or in depth geological mapping had been attempted.

Acid sulfate gold systems had only recently been recognized as a new class of gold deposit, but our understanding of the Yanacocha geology was rudimentary and while we recognized that we were dealing with an epithermal system we really had no idea at that time that Yanacocha was representative of the class. Our approach to our work was therefore very pragmatic. Rather than trying to explain the model we tried to explain the anomaly.

The area immediately south of anomaly B was a geological anomaly. The results we had obtained there simply did not agree with those that had been obtained in area B. It was accordingly decided to map and sample the area immediately south of drill hole 4 in much greater detail than previously, before abandoning the project. In late 1985 the area was remapped and systematically sampled on a 200m by 20m grid.

The results of this work were exceptional. The rock chip sampling outlined a NNW striking, mineralized zone containing > 0.5 g/t Au at surface over a strike length of more than 500m. The detailed mapping clearly demonstrated that several types of silica alteration were present and that the gold was associated with only one of these.

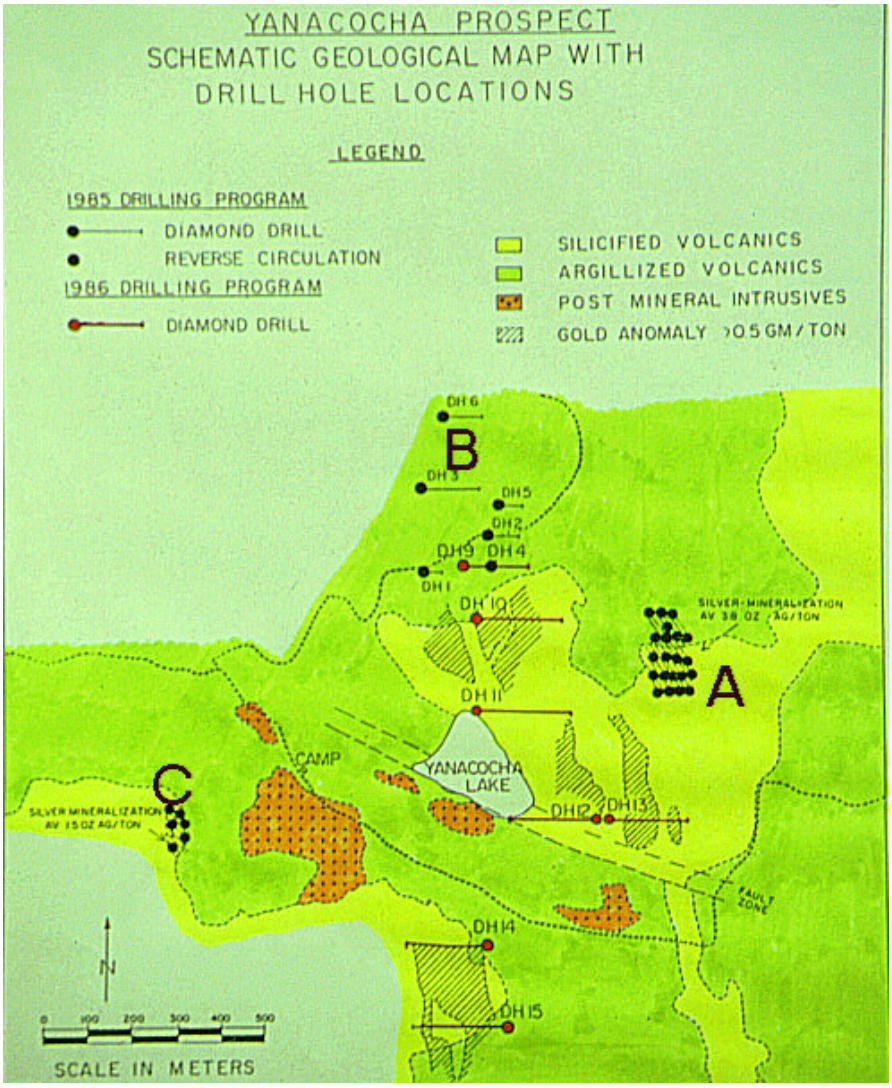
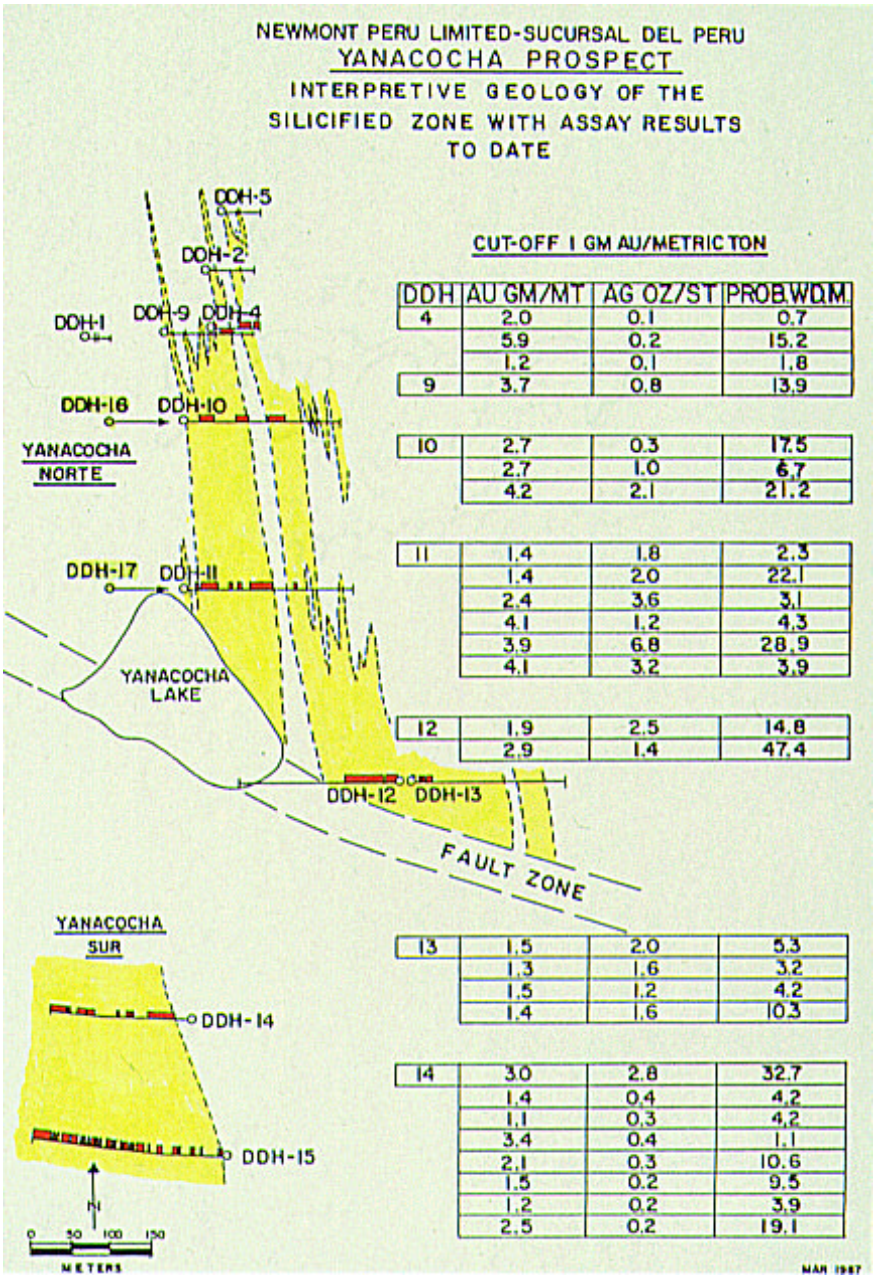


Figure 1. Original illustration produced in 1986

1986 Exploration Program

The 1986 program consisted of seven diamond drill holes (Hole 9 through 15 Figure 1) to follow up on the rock chip sample results at what is today known as Yanacocha Norte and Yanacocha Sur. Because we now knew that the siliceous zones were more complex than we had previously believed detailed sampling and mapping of other areas of siliceous rocks was undertaken as well. These included the areas now known as Carachugo, San Jose and Maqui Maqui.

The results of the diamond drilling were uniformly positive, good mineralized intersections were obtained in all but drill hole 13, as summarized in Figure 2.



DDH	AU GM/MT	AG OZ/ST	PROB.WDM.
4	2.0	0.1	0.7
	5.9	0.2	15.2
	1.2	0.1	1.8
9	3.7	0.8	13.9
10	2.7	0.3	17.5
	2.7	1.0	6.7
	4.2	2.1	21.2
11	1.4	1.8	2.3
	1.4	2.0	22.1
	2.4	3.6	3.1
	4.1	1.2	4.3
	3.9	6.8	28.9
	4.1	3.2	3.9
12	1.9	2.5	14.8
	2.9	1.4	47.4
13	1.5	2.0	5.3
	1.3	1.6	3.2
	1.5	1.2	4.2
	1.4	1.6	10.3
14	3.0	2.8	32.7
	1.4	0.4	4.2
	1.1	0.3	4.2
	3.4	0.4	1.1
	2.1	0.3	10.6
	1.5	0.2	9.5
	1.2	0.2	3.9
	2.5	0.2	19.1

Figure 2. Original illustration produced in March 1987.

These results required a complete revision of the geological model. The mineralization was not contained within veins or a lithologic unit, but within broad, crosscutting, near vertical, structurally confined zones of intense silicification, all contained within a wide halo of intensely argillized volcanic rocks. The gold mineralization was accompanied by alunite and in places enargite.

The rock chip sampling and mapping of the siliceous zones at Carachugo, San Jose and Maqui Maqui also yielded positive results and outlined in total an area of 60 hectares containing > 0.5 g/t gold (Figure 3).

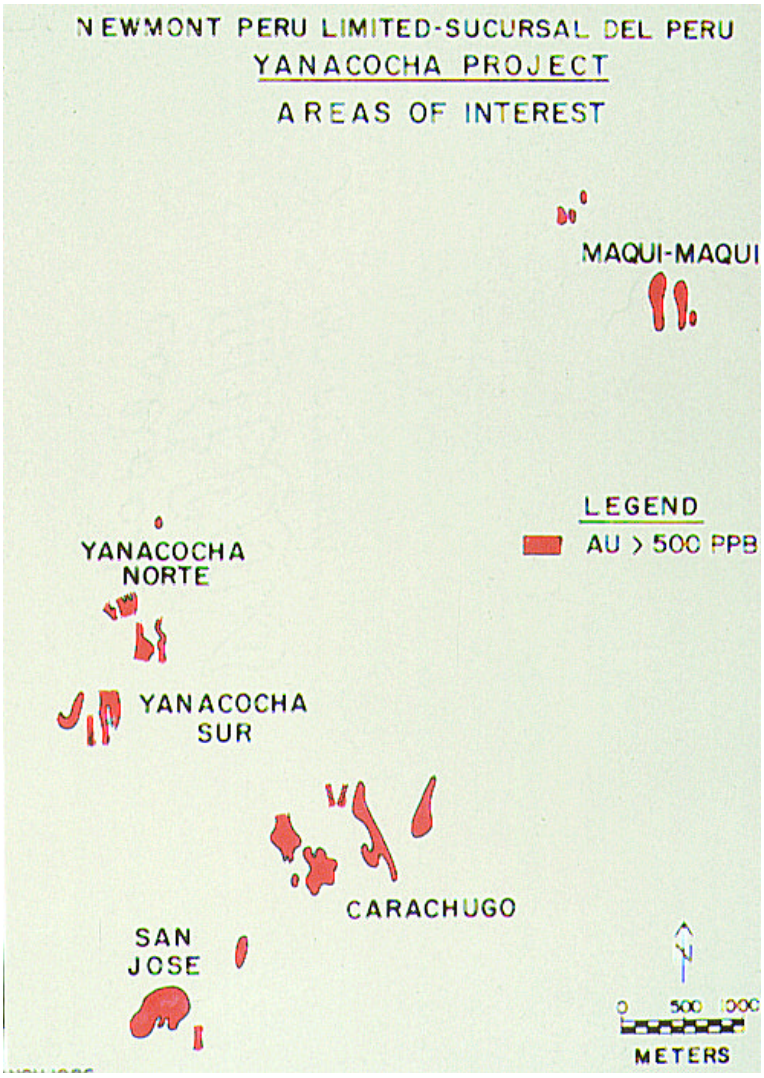


Figure 3 Original image produced November 1986

1987 Exploration Program

Economic and social conditions in Peru had been deteriorating for a number of years. Hyperinflation and terrorism were major problems. When the government raised nationalization of the banking and oil industry much of the foreign investment remaining in Peru fled the country. In 1987 Newmont was the only foreign company exploring in Peru. Not unexpectedly, management while remaining committed to the venture was reluctant to commit large sums of money to it.

The joint venture partners, NPL, CEDIMIN, and CMB, accordingly decided to limit expenditure sufficient only to maintain the 'denuncios' in good standing. Exploration in 1987 was therefore limited to two drill holes (Figure 2, holes 16 and 17) and minor mapping and sampling in the Yanacocha, Carachugo and San Jose areas. Both drill holes returned good results, confirming the continuity of the gold mineralization at depth.

A preliminary resource estimate for Yanacocha Norte and Yanacocha Sur based on the 17 drill holes and the surface sampling gave 10.4 Mt at 4.1 g/t gold and 3.2-oz/t silver. This has turned out to be a very conservative estimate since the known resources of the Yanacocha area today exceed 9 million ounces of gold (Harvey et. al., 1999).

Sufficient encouragement had now been received to warrant scooping metallurgical studies on drill core. The results were disappointing. Gold recoveries were poor and cyanide consumption, because of the presence of soluble copper, were high. It was apparent that higher-grade material would be required if the project was to be viable and it was decided to focus on evaluating the new anomalies at Carachugo, San Jose and Maqui Maqui, rather than continuing to drill out the Yanacocha anomalies

1988 Exploration Program

In 1989 five drill holes were completed in the Carachugo area. The mineralization at Carachugo was found to be quite different to that at Yanacocha. The gold was contained in a highly friable, granular, silica rock, which unlike the Yanacocha mineralization was sub-horizontal and only 50m to 70m thick. Mineralogically the rock consisted almost entirely of silica and leach tests gave better than 80% recovery with acceptable cyanide consumption. Indications were that it would not require crushing and that some of the material could be removed with out the necessity of blasting.

A rough resource estimate, using the five drill holes and the rock chip sampling suggested the presence of 10 Mt to 12 Mt of material at a grade of 1.6 g/t to 2.0 g/t gold. This was an excellent result and marked the turning point for the project

1989 Exploration Program

A total of thirty five drill holes were completed during 1989. A preliminary resource of 10 Mt a grade of 1.4 g/t gold was indicated at the close of the program.

Post 1989

A pre – feasibility study and pilot plant construction were completed in 1990. A full scale feasibility study and construction followed and the first gold was poured on 7 August 1993, almost exactly ten years after the first field inspection by Newmont in September of 1983.

Conclusion

Yanacocha must surely rank as one of the most successful exploration ventures in South America in the last two decades. With production of 1.66 million ounces of gold in 1999 it has grown to become the largest gold producer in South America and one of the largest acid-sulfate gold districts in the world.

Acknowledgements

The success at Yanacocha is due to many factors; management commitment and support, teamwork within the joint venture, diligent and careful work by the team members and as always a reasonable dose of serendipity. Many individuals contributed to the project, but the following require special mention:

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