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QUARTZ VEIN INFILL STRUCTURE MODE IN KENCANA DEPOSIT, GOSOWONG GOLDFIELD, INDONESIA

K.S. Electricia[1], Mega F. Rosana, Euis[1] T. Yuningsih[1], Ildrem Syafri, S.N. Viqnoriva[2]
[1]Geological Engineering Faculty, Padjadjaran University
Jl. Raya Bandung Sumedang Km. 21, Jatinangor, Sumedang 45363, Indonesia
[2]PT.Nusa Halmahera Minerals, Halmahera Island, North Maluku, Indonesia
Email: steamy4380@gmail.com

ABSTRACT

Gosowong province has economic mineralisation which is classified as low sulphidation epithermal veining system containing high-grade of gold and silver. It is characterizes by various veins hosted in Holocene Quaternary volcanic rocks, mineralisation generally occurs in host rock andesite. The Kencana epithermal vein system in Gosowong Au-Ag district hosted by two main sub-parallel North-West trending major fault structures, named Kencana One (K1) and Kencana Two (K2) with strike lenght extend up to 600m. Both structures joined by link structures, appears to be Kencana Link (K-Link) as the thickest link structure. The Kencana One (K1) is the first underground mine in Gosowong district. The nature of underground conditions at Kencana has a high variability of gold grades. Thus due to extremely high grades ore in Kencana, it is need to be precise and thoroughly handling to obtain best results. Primary mineralisation occurs in multistage veins, breccias and stockwork veins as infill structures. This study confirming that there is a strong correlation between quartz vein infill structure mode versus gold grade which classified into (1) 1.01-3.0g/t Au, dominated with wall-rock breccia and stockwork, (2) 3.01-6.0g/t Au, dominated with wall-rock breccia follows by stockwork, (3) 6.01-20.0g/t Au, dominated with wall-rock breccia follows by quartz lode and stockwork, (4) 20.01-80.0g/t Au, dominated by wall-rock breccia follows by vein breccia and quartz lode, (5) >80g/t Au, dominated by wall-rock breccia. In terms of production quartz vein infill mode together and quartz vein texture with gold grade has been used as the main reference for geologist to make a direction in the process of ore drive determination in underground mining operations.

Keywords : Kencana, low sulphidation epithermal, quartz vein infill mode

SARI

Gosowong memiliki mineralisasi ekonomis yang merupakan epitermal sulfida rendah yang mengandung emas dan perak dengan kadar tinggi. Cebakan dicirikan dengan kehadiran urat yang bervariasi dengan batuan vulkanik kuarter sebagai batuan induk berumur Holosen, mineralisasi umumnya terjadi di dalam batuan induk andesit. Kencana berada di dalam area Cebakan Au-Ag Gosowong. Kencana terdiri dari dua struktur besar yang berdampingan, dinamakan Kencana Satu (K1) dan Kencana Dua (K2) dengan arah jurus sepanjang 600m. Keduanya dihubungkan dengan struktur yang dinamakan Kencana Link (K-Link) yang merupakan struktur bukaan yang paling tebal. K1 adalah tambang bawah tanah pertama di Gosowong. Kondisi bawah tanah di Kencana menunjukkan variasi tubuh bijih emas yang mengandung kadar emas yang bervariasi. Dengan adanya kadar emas yang tinggi, maka penangannya harus tepat dan seksama untuk mendapatkan hasil terbaik. Secara umum mineralisasi terjadi secara bertahap dalam urat kuarsa, breksiasi, dan urat stockwork. Penelitian ini menegaskan bahwa terdapat korelasi yang kuat antara tipe struktur urat kuarsa dengan kadar emas yang diklasifikasikan menjadi (1) 1.01-3.0 g/t Au, didominasi oleh breksiasi batuan dinding dan stockwork, (2) 3.01-6.0 g/t Au, didominasi oleh breksiasi batuan dinding diikuti oleh stockwork, (3) 6.01-20.0 g/t Au, didominasi oleh breksiasi batuan dinding diikuti oleh quartz lode dan stockwork (4) 20.01-80.0 g/t Au, didominasi oleh breksiasi batuan dinding diikuti oleh breksiasi urat kuarsa dan quartz lode (5) > 80g/t Au, didominasi oleh breksiasi batuan dinding. Di dalam proses produksi, tipe struktur urat kuarsa dan tekstur urat kuarsa bersama dengan kadar emas menjadi petunjuk untuk geolog dalam menentukan arah penambangan emas di dalam tambang bawah tanah.

***Kata kunci** : epitermal sulfida rendah, Kencana, tipe struktur urat kuarsa*

INTRODUCTION

The Gosowong Au-Ag district located in Halmahera Island, North Maluku Province, Indonesia. Gosowong province are owned and operated by PT. Nusa Halmahera Minerals, a joint venture between PT. Aneka Tambang Tbk (25%) and Newcrest Mining Limited. Detail location is presented in Figure 1. Gosowong district has three deposits namely Gosowong (open pit), Toguraci (open pit and underground) and

Kencana (underground) as appear in Figure 2. Kencana underground gold mine is hosted by two main sub-parallel North-West trending fault structures, named Kencana One (K1) and Kencana Two (K2) with strike lenght up to 600m, with vertical extent of 250m, and dipping 35°- 45° towards the East, true width ranges from 1m to 20m (Coupland et al., 2009). Both structures joined by link structures, appears to be Kencana Link (K-Link) as the thickest link structure (Figure 3).

Underground development of Kencana mine commenced in February 2005 with the first underground ore mined in March 2006. K1 has a multiphase formation history with numerous brecciation and opening events (Clark, 2012). Kencana is a complex deposit with extreme high-grade gold occurences. Gold content can change drastically within a borehole as well as in underground face sampling results. Gold content often different from model interpretation, due to ground condition. This study focus on K1, it has the most complete information as mining process is in progress and underway for a long time.

The goal of this study is to determine correlation between quartz vein infill structures mode towards gold grade content, and to identify the distributions of infill structures mode. Such identification could be an accurate reference to the original conditions in the ground. This approach can guide geologists in the field to determine both drilling direction and mine direction with this study as reference.

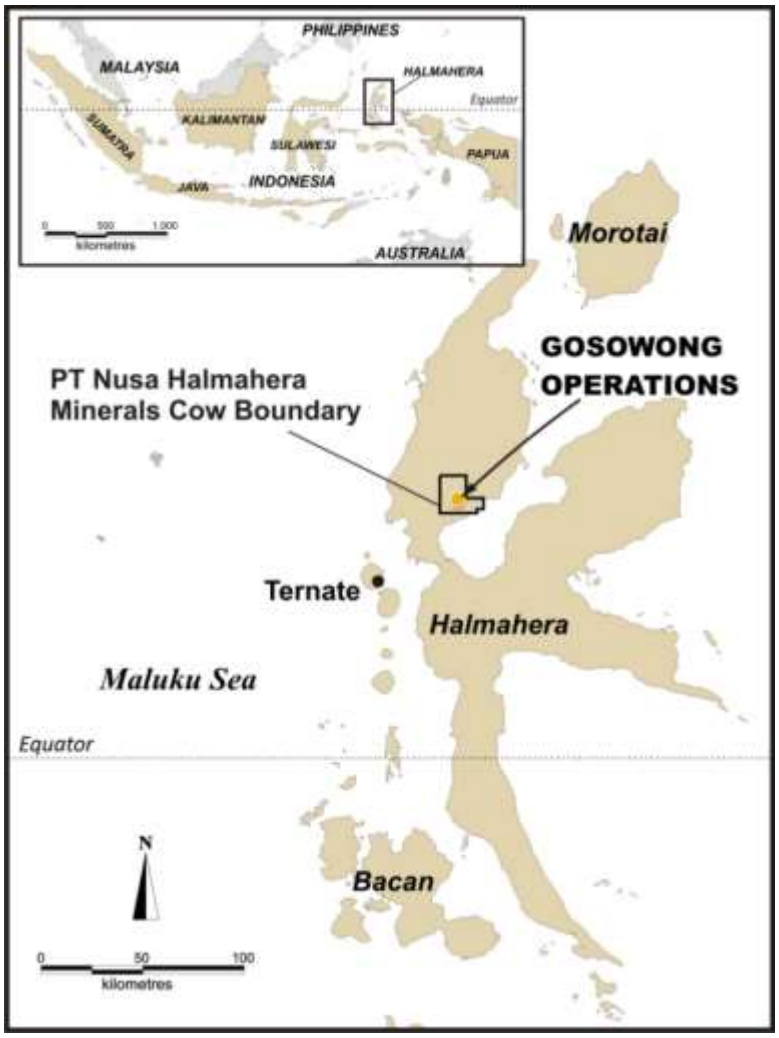

Figure 1. Gosowong Operation location (Modified after Coupland et al., 2009)

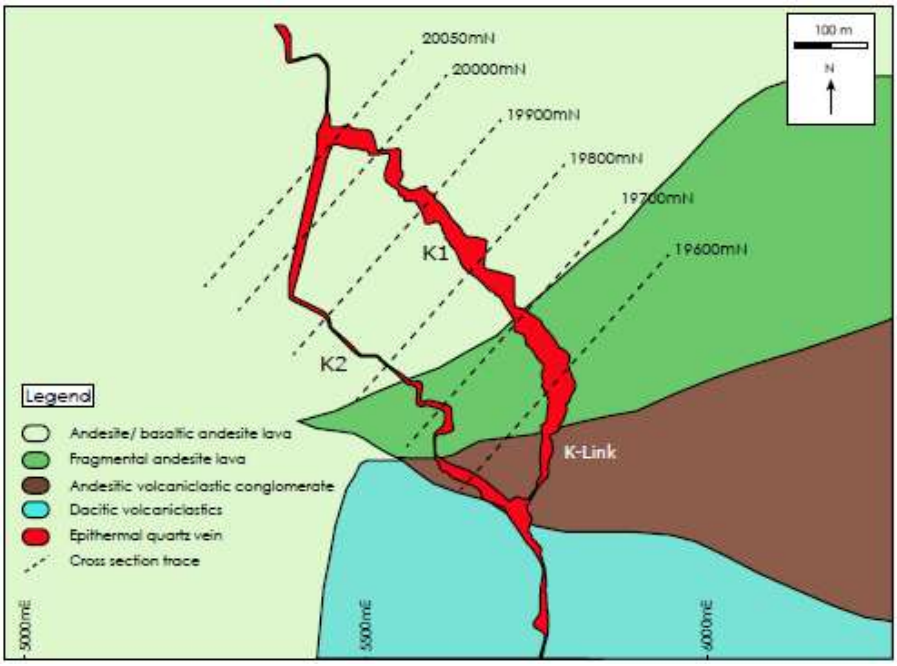

Figure 2. Orientation of geological structure in Kencana (Modified after Clark, 2012)

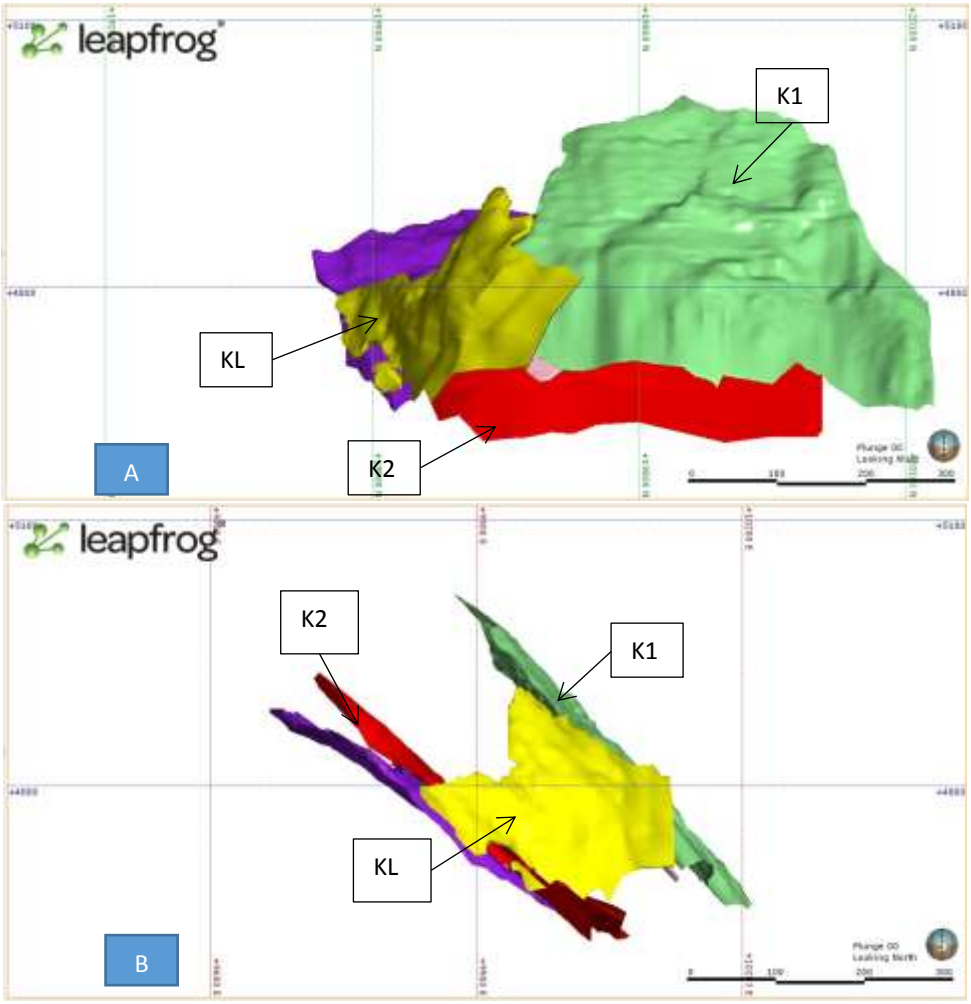

Figure 3. Kencana deposit, (A) looking West, (B) looking North; K1-light green, K2-red, K-Link- yellow (PT.NHM, 2015).

GEOLOGY AND MINERALISATION

Halmahera Island is a part of an active island arc situated to the east of the Molucca Sea Plate, where the opposing Sangihe and Halmahera arcs have been actively converging since the late Pliocene (Richards et al., 2004). Plio-Pleistocene volcano-sedimentary succession occur immediately adjacent to Quaternary or Recent volcanic cover rocks were considered prospective for epithermal deposits (Carlile et al., 1998). At Kencana, epithermal mineralisation occurs at or immediately adjacent to the contact between andesite-dominated and underlying basalt-dominated units of the Gosowong Formation (Fitzpatrick et al., 2015) as seen on Figure 4. The K1 structure strikes in North-West/South-East direction, 315°from North, dipping in 35-45° towards North-East. Kencana's stratigraphy demonstrate the Quaternary late stage, as mineralization took place in andesitic package, predominantly andesite lava, volcaniclastic mudstone on the top of volcaniclastic conglomerates, and diorite as intrusion (Figure 4). Kencana has an extreme high-grade gold occurences at depth, as presented on Table 1 as example. The main mineralization zone characterized by massive to brecciated chalky quartz adularia sulphide banded veining that is locally overprinted by dark green chlorite-sulphide banded veining locally and late stage black sulphide of colloform banding-cockade textures, grading over 80 g/t Au. The sheared zone mineralization characterized by moderate to intense shearing, breccia and clay after adularia, contains wallrock and main zone fragments. It forms mostly at the top of the main zone as hanging wall zone and other location within the package, typically grading 20-80 g/t Au. Stockwork and sheeted mineralization occurs in significant volumes with gold grades typically moderate to low gold grades, 1.0-20 g/t Au.

Table 1. An extreme gold grade content within one drill hole, (PT.NHM, 2015)

Hole ID	From (m)	To (m)	g/t Au
KSU033	71	72	0.08
	72	72.5	799
	72.5	73.3	37.2
	73.3	74	3.07
	74	74.8	4.44
	74.8	75.8	4.23
	75.8	76.6	8.21
	76.6	77.3	6.2
	85	85.6	1.71
	85.6	86.3	0.11
	86.3	87	1.62
	87	87.8	2.62
	87.8	88.5	15.6
	88.5	89.2	3.2
	89.2	89.7	3.45
	89.7	90.4	70.8
	90.4	91.1	31.1
	91.1	91.7	21.1
	91.7	92.2	65.6

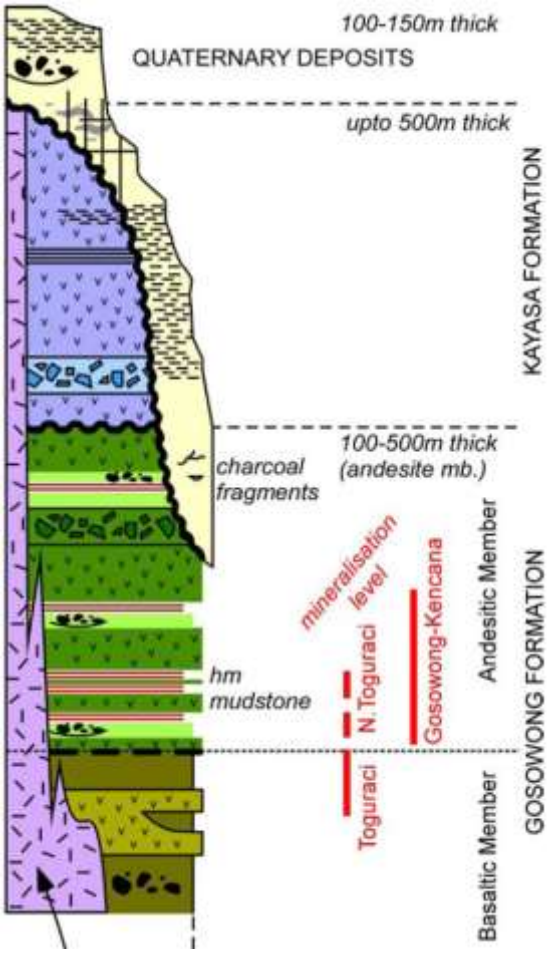

Figure 4. Stratigraphy of Gosowong and surroundings (PT.NHM, 2015).

METHOD

The resource definition process applied at Gosowong is based on systematic diamond drilling with some Reverse Cirulation (RC) drilling used when appropriate. It has been established that shoots drilled spacing of approximately 50x50 metres can generally be classified as Inferred Resource. Drill spacing 25x25 metres can support Indicated Resource classification. Due to the extremely high grades presence at Kencana deposit, it is need to drill with spacing 12.5x12.5 metres or equivalent for grade control purpose. Diamond core is logged and photographed prior to sampling for fire assays. Samples are assayed for gold and silver grades at on site laboratory using screen fire assay method. PT. Intertek Utama Services (ITS) as onsite laboratory conduct screen fire assays for Au-Ag. Final results input directly to database to generate intercept. Intercept represent gold contents at depth within one drill hole (Figure 5). Then, quartz vein description applied on screen running by certain software to determine its characteristic, quartz vein texture and infill structure as well as quartz percentage. Gold contents within quartz vein identification would drives for next drill plan prepared by geologist. A total of 140 drill holes were used in this study consists of exploration, resource definition and grade control holes, 95 drill holes conducted from underground and 45 drill holes drilled from surface. Total of 2938 samples data were extracted from 140 drill holes, are reviewed for this study. All data were sorted by its gold content, and then sorted by its quartz vein structure mode with consider the quartz percentage and quart vein textures, classified into several ore body classification subsequently. With this

method, it will demonstrate dispersion of quartz vein infill structures mode.

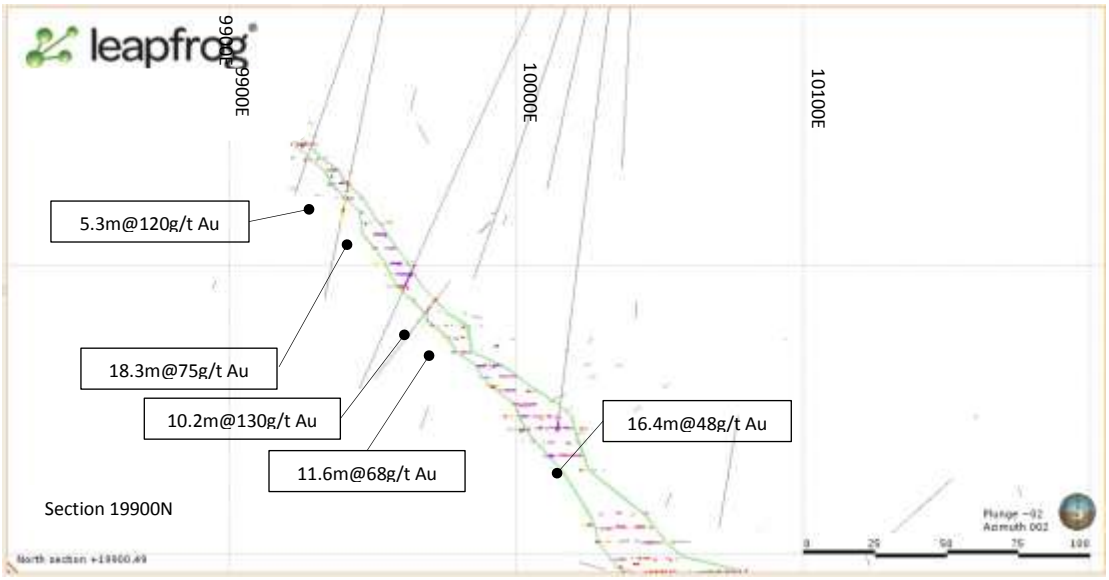

Figure 5. Intercepts generated by drilling result, i.e in section 19900 North. (PT.NHM, 2015)

Data processing steps consist of:

a. Gold content is sorted into several classification based on condition of the ground in terms of production and used for gold grade blending before entering the mill.
b. Each classification sorted by its quartz vein infill structures mode and quartz veins textures subsequently.

RESULTS AND DISCUSSION

Five types of quartz vein infill structure mode recognized in Kencana and surroundings (Figure 6). Quartz vein infill structure mode and quartz vein textures are used for the general physical appearance or character of a rock, including the size and shape of, and the mutual relations among, its component minerals. Quartz vein infill structure is generally used for the larger features of a rock and is determined by the spatial arrangement of its mineral aggregates which differ from one another in shape, size, composition, and texture (Dong et al., 1995).

Ore body were classified into five group, each group respectively exhibit gold grade range as well as infill structures and consists several quartz vein textures. The classification are:

a) Gold grade 1.01-3.0g/t Au, consider as low grade
b) Gold grade 3.01-6.0g/t Au, consider as medium grade
c) Gold grade 6.01-20.0g/t Au, consider as medium grade
d) Gold grade 20.01-80.0g/t Au, consider as high grade
e) Gold grade >80g/t Au, consider as high grade.

There are five major quartz vein infill structure mode recognized in Kencana as below (Figure 6):

1. Q*uartz lode* (QL), has more than 90% quartz material, lower than 10% wall-rock material, identified as source of mineralisation, minor brecciation.
2. Breccia, consists two types: wall-rock breccia characterized by wall-rock as clasts in quartz matrix (BXW), and vein breccia characterized by quartz as both clasts and matrix (BXV).
3. Stockwork (SK), characterized by quartz veins intersect randomly, filling gaps, some of which are found thick.
4. Sheeted (SH), characterized by thin quartz veins that form a parallel pattern filling gaps.
5. Cavity filling (CF), characterized by quartz veins filling narrow cracks and or gaps with erratic form.

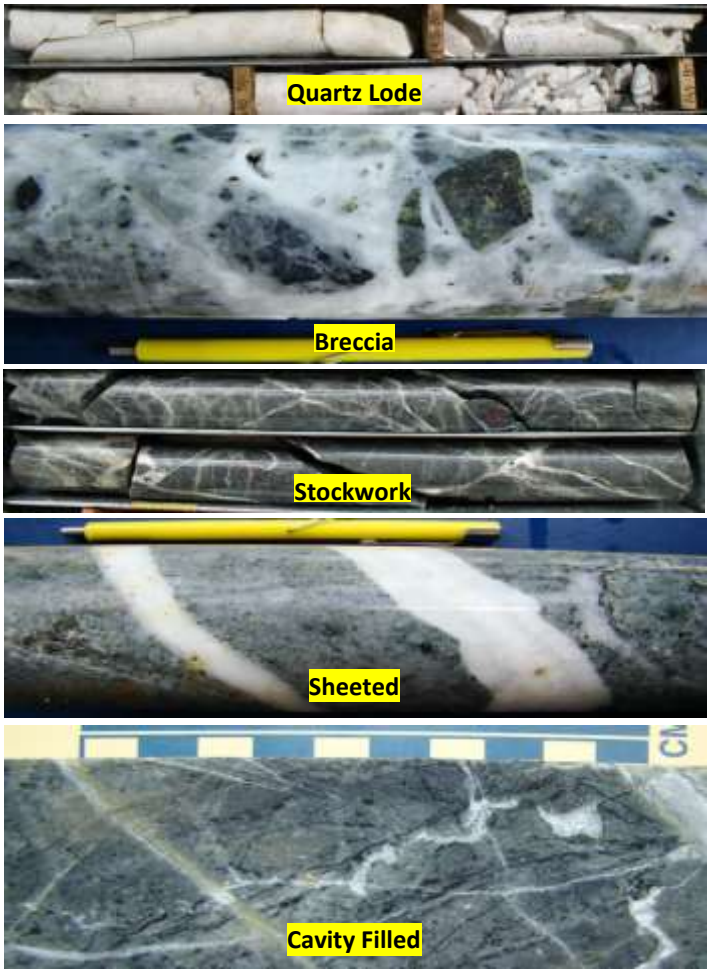

Figure 6. Quartz vein textures in Kencana and its surroundings (PT.NHM, 2009).

Gold content classification associated with quartz vein infill structure mode distribution are presented in Table 2 and Figure 7 are:

1. Gold grade 1.01-3.0g/t Au, predominantly by wall-rock breccia and stockworks, follows by vein breccia, quartz lode and cavity filling veins.
2. Gold grade 3.01-6.0g/t Au, predominantly by wall-rock breccia follows by stockwork veins, follows by quartz lode and cavity filling veins subsequently.
3. Gold grade 6.01-20.0g/t Au, predominantly by wall-rock breccia follows by quartz lode, stockwork-sheeted veins, and vein breccia subsequently,
4. Gold grade 20.01-80.0g/t Au, predominantly by wall-rock breccia follows by quartz lode and vein breccia subsequently,
5. Gold grade >80g/t Au, predominantly by wall-rock breccia which indicating multiphase boiling and mixture events, as the wallrock contains high grade overprinted by late stage fluids.

Table 2. Distribution of quartz vein infill structure mode frequencies in K1 - Kencana

g/t Au	Quartz vein infill structure mode					
	QL	BXV	BXW	SK	SH	CF
1,01-3,0	66	77	477	269	47	69
3,01-6,0	58	28	309	92	25	56
6,01-20,0	93	55	427	95	33	33
20,01-80,0	44	37	339	31	5	11
>80	10	10	135	4	0	3
Number of data	271	207	1687	491	110	172

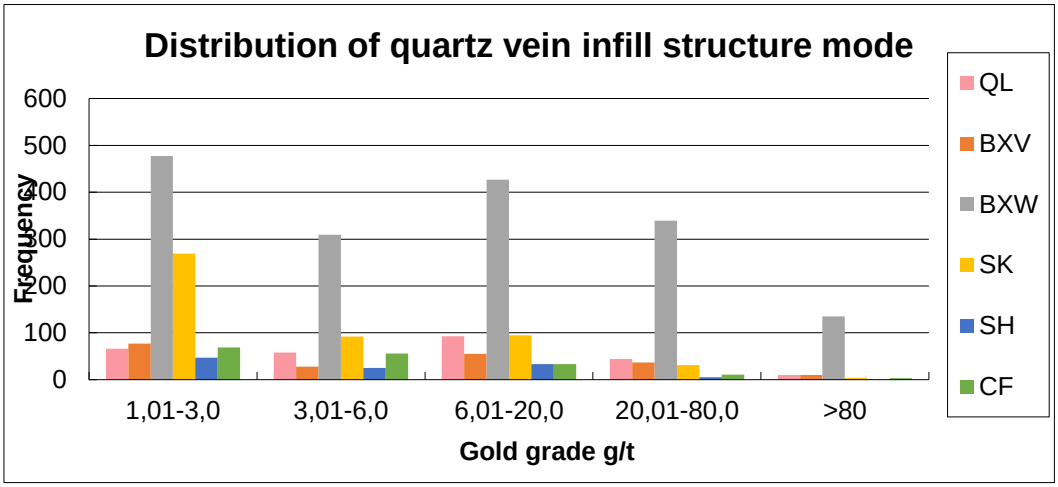

Figure 7. Distribution of quartz vein infill structure mode frequencies in K1 - Kencana.

This study exhibit that wall-rock breccia occurs in all ranges of ore body, nevertheless ore body with high grade gold content dominated by quartz vein wall-rock breccia with sulphide bands content. Stockwork dominated in low grade range, as well as sheeted structure (Figure 7). Open space filling is the characteristic of epithermal vein systems, especially in Kencana they are controlled by geological structure, and appear to fill up the available open space. Evidence of fluid boiling is present in Kencana, as well as hydraulic fracturing that may create breccia filled with vein material (Figure 8). Crack-seal veins appear subsequently in order of millimeters, identified as stockwork and locally cavity filling.

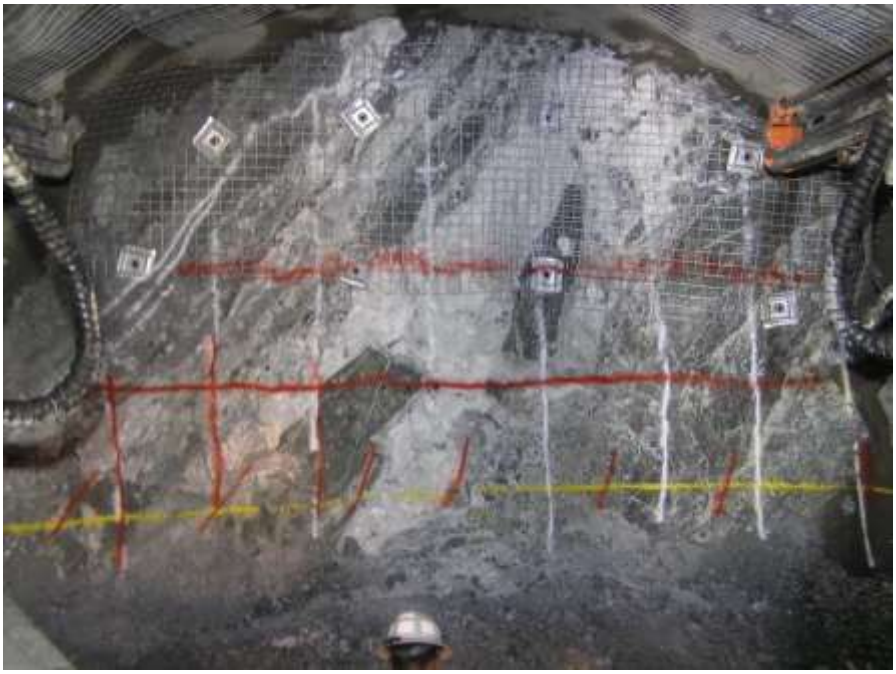

Figure 8. Face of K1 underground mining in Kencana deposit.

Moncada et al (2009) done a study to determine if there is a correlation between gold and silver grades and the presence and abundance of fluid inclusion and mineralogic features characteristics of boiling in order to develop a simple technique that can help explorationists to distinguish between barren and mineralized veins. Whereas this study indicate the infill

structure mode that has best relationship to high Au grades is wall-rock breccia with sulphide bands presence in cockade textures surrounds clasts as feature of boiling system. The relevance can be seen in the distribution of quartz vein infill structure mode frequencies in Figure 7.

CONCLUSIONS AND RECOMMENDATION

Wall-rock breccia with sulphide bands presence dominating in high grade gold content ore body, accompanied by vein breccia as quartz vein infill structure. Medium gold content within ore body dominated by wallrock breccia dominate and stockwork veins subsequently. Low grade gold content within ore body has strong wall-rock breccia and stockwork-sheeted dominating as quartz vein infill structure mode. This study is expected to be a guide in the implementing of underground mining in order to optimize mining practice, these features can be used as reference in field work.

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