INSTITUTO DE INGENIEROS DE MINAS DEL PERÚ

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High Grade Copper-Gold-Silver Hosted in Multiple Tourmaline Breccia Pipes, Soledad Project, Ancash, Peru

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1. Introduction

The Soledad project is located in Ancash province of central Peru, approximately 260 km north-northwest of Lima and 35 km south of Barrick's Pierina mine. The project is part of the Ticapampa-Aija Mining District in the Cordillera Negra, a region with a long history of exploration and mining. Previous exploration identified numerous high-grade quartz-tourmaline-sulfide breccia pipes that crop out at surface. Whereas the mineralization hosted in the breccia pipes is impressive in terms of grade and vertical extent, previous explorers were targeting a blind mineralized porphyry deposit inferred to be the source of the breccia mineralization. Chakana is focused on testing the breccia pipes to determine if they host economic mineralization. To date, fifteen breccia pipes have been confirmed in two clusters, the Soledad cluster and the Compañero cluster (*Figure 1*).

2. Geology

The breccia pipes at Soledad are principally hosted in the Calipuy group volcanic rocks, consisting of andesite flows, tuff and dacite with a composite thickness of over 2,000 m. A secondary host is monzodiorite that intrudes the volcanic rocks. The breccia pipes have dimensions ranging from 25 to 200 m in width at surface with separation between the pipes of 100-500 m. The pipes commonly form prominent outcrops with steep vertical walls (*Figure 2*). The breccia is polymictic and contains clasts reflecting the adjacent host rock, either andesite, tuff or monzodiorite. Clasts of andesite and tuff are generally tabular, or "shingle" in shape, and are strongly altered to quartz-sericite-tourmaline (Fig. 2). Contacts between breccia pipes and wall rock are sharp and generally marked by vertical, sheeted quartz-tourmaline veining. An alteration halo of quartz-tourmaline-sericite-sulfide extends outward from the breccia contact several meters into wall rock. Within the breccia, sulfide mineralization occurs in the matrix and as clast replacement (*Figure 3*). Grades are typically highest on the margins of the breccia bodies where permeability was best developed. Based on initial petrography, the sulfide assemblage includes chalcopyrite, hypogene chalcocite, digenite, pyrite, tetrahedrite, boulangerite, bournonite, and arsenopyrite. Sphalerite and galena are common on the margin of the breccia and in veinlets in the fractured wall rock. Gold occurs as free grains in the 20 um to 2.8 mm size range within pyrite and along sulfide grain boundaries. Mineralogy varies between breccia pipes. For example, arsenopyrite is common in Bx 1, but is generally absent in Bx 5.

3. Surface Exploration

A program of detailed mapping, lithogeochemistry, soil geochemistry and controlled-source/natural-source audio-frequency magnetotellurics (CS/NS-AMT) has been carried out at Soledad. Mapping focused on known breccia occurrences, areas of alteration consisting of sheeted quartz-tourmaline veining, and structures that control alteration. Several areas interpreted to represent alteration

above blind breccia bodies have been identified. Lithogeochemistry is used to identify mineralized breccias, with gold and silver being the most useful pathfinder elements. Copper is typically leached in the near surface.

Soil geochemistry is very effective in delineating known mineralized breccias and identifying exploration targets. Soil results for gold show a strong correlation with the known breccia pipes and further highlight several additional exploration targets (Fig. 4). There is a corridor of anomalous gold extending NNE from Huancarama to Bx 5, an area of approximately 1,400 m by 300 m. Other areas of interest include 1) an anomaly northeast of Bx 1 where mineralized breccia is poorly exposed, 2) anomalies east of breccias Bx 5 and Bx 3W, 3) a continuous anomaly surrounding and extending beyond the Paloma East and West pipes, and 4) a broad area of anomalous gold in soil 400 m by 100 m surrounding the Huancarama Breccia Complex (Figure 4).

A CS/NS-AMT survey was conducted to determine the response from known mineralized breccia pipes and identify exploration targets. The technique was successful in confirming vertical, “pipe-like” bodies of conductivity near known mineralized breccia pipes and identifying similar features in areas with little or no outcrop that are considered to be prime exploration targets.

4. Drill Results

An exploration and resource definition drilling program was initiated in August of 2017 with the goal of defining initial resources on several breccia pipes and testing several targets. Drilling on the first two breccia pipes, Bx 1 and Bx 5, has confirmed high grades for copper, gold, and silver (Table 1). At Bx 1, drilling discovered a blind breccia pipe 40 m north of the main breccia pipe. Mineralization has been intersected to a depth of 389m in the Main Zone and to a depth of 490m in the North Zone and is open at depth. Mineralization at Bx 5 has been drilled to a depth of 410 m and remains open at depth.

5. Genesis of Tourmaline Breccia Pipes

The tourmaline breccia pipes at Soledad are interpreted to be related to a deep, volatile-rich, intermediate intrusion (Kirwin, 2018). During crystallization of the magma, volatiles accumulated in a cupola developed on the intrusion until the volatile pressure overcame the lithostatic pressure, resulting in hydrofracturing in the rock column above the intrusion (*Figure 5*). A catastrophic eruption occurred, creating a column of brecciated rock that tapers with distance above the intrusion. Importantly, the breccia pipes did not breach the paleosurface. Collapsing tabular breccia fragments created the characteristic shingle texture, which often grades into mosaic texture consisting of blocky clasts from more competent wall rock. Breccia clasts also exhibit curvilinear fractures diagnostic of decompressive shock texture (Figure 5) commonly observed in tourmaline breccia pipes worldwide (Kirwin, 2018). After formation of the breccia, a metal-bearing hydrothermal fluid flooded the open space matrix of the breccia, depositing sulfide minerals along with quartz and tourmaline.

6. Conclusions

The Soledad project consists of high-grade copper, gold, and silver breccia pipes in two separate zones, the Soledad and Compañero clusters. Drilling to date has confirmed the breccia pipes to be vertically extensive with the highest grades often associated with the margin of the breccia pipe. Breccia clasts are entirely derived from the wall rock and exhibit a quartz-sericite-tourmaline alteration assemblage. These features suggest that the source intrusion is at greater depths than the current limits of drilling. This does not preclude the presence of a later mineralized intrusion at shallow depths within the project area.

Acknowledgements

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References

Kirwin, Douglas, J. 2018. Characteristics of intrusion-related copper-bearing tourmaline breccia pipes. Abstract with Program. Metals, Minerals, and Society. Society of Economic Geologists. Keystone, Colorado, USA. September 22-25, 2018.(http://www.segabstracts.org/abstract_summary.php?mode=public&abs_id=1033)

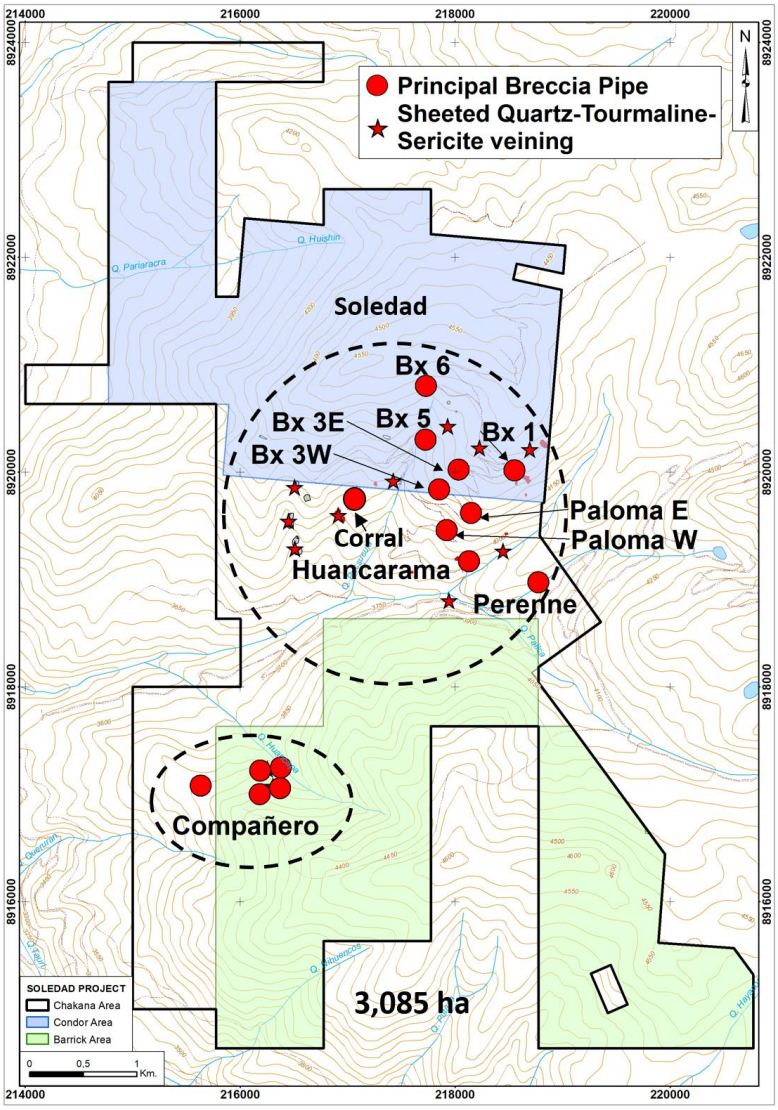

Figure 1. Soledad Project showing known breccia pipes and occurrences.

Table 1. Select Assay Results from Bx 1 and Bx 5.

	DDH#	From(m)	To (m)	Interval	Au (g/t)	Ag(g/t)	Cu%	Cu_eq%*	Au_eq g/t*
Bx 1	**SDH17-018**	0.00	209.00	209.00	2.22	69.6	0.96	3.01	4.60
	including	0.00	40.00	40.00	4.21	18.6			4.45
	including	40.00	114.00	74.00	3.31	65.5	1.11	3.83	5.86
	SDH17-020	0.00	113.00	113.00	3.58	51.5	1.17	3.95	6.04
	including	0.00	43.00	43.00	4.11	31.8			4.53
	including	43.00	113.00	70.00	3.25	63.6	1.87	4.54	6.94
	SDH18-049	76.90	121.00	44.10	8.50	27.1	2.02	7.81	11.94
	including	77.60	97.00	19.40	14.36	26.0	2.70	12.31	18.83
	SDH18-059	0.00	233.00	233.00	1.36	57.2	0.85	2.24	3.42
	including	0.00	46.00	46.00	2.11	26.1			2.45
	including	46.00	233.00	187.00	1.18	64.9	1.05	2.38	3.63
	SDH18-070	0.00	111.55	111.55	3.48	48.4	1.05	3.75	5.73
	including	0.00	40.00	40.00	4.38	20.1			4.65
	including	40.00	111.55	71.55	2.98	64.2	1.63	4.13	6.31
Bx 5	**SDH17-041**	0.00	176.00	176.00	1.81	27.5			2.17
	including	12.00	176.00	164.00	1.68	27.4	0.51	1.84	2.82
	SDH18-080	0.00	264.00	264.00	1.30	24.3	0.71	1.77	2.70
	including	30.00	264.00	234.00	1.30	21.6	0.79	1.82	2.79

* Cu_eq and Au_eq values were calculated using copper, gold, and silver. Metal prices utilized for the calculations are Cu – US$2.90/lb, Au – US$1,300/oz, and Ag – US$17/oz. No adjustments were made for recovery as the project is an early stage exploration project and metallurgical data to allow for estimation of recoveries are not yet available. The formulas utilized to calculate equivalent values are Cu_eq (%) = Cu% + (Au g/t * 0.6556) + (Ag g/t * 0.00857) and Au_eq (g/t) = Au g/t + (Cu% * 1.5296) + (Ag g/t * 0.01307).

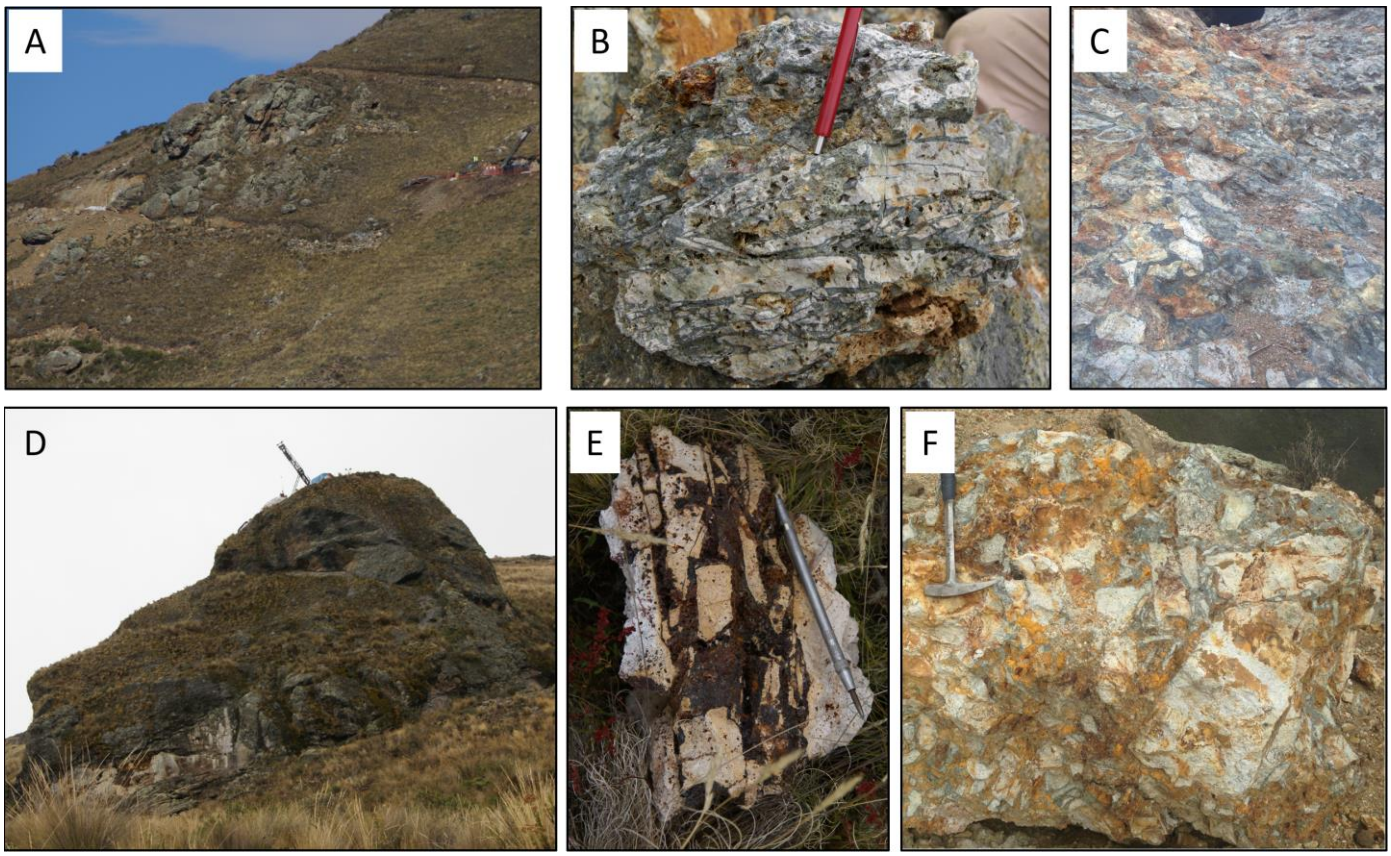

Figure 2. Examples of breccia pipes and breccia textures. A) Bx 1 (note drill rig for scale); B) shingle texture from Bx 1; C) Mosaic breccia from Bx 1; D) Bx 5 (note drill rig for scale); E) shingle breccia with iron oxides in matrix after sulfides; F) Mosaic breccia from Bx 5.

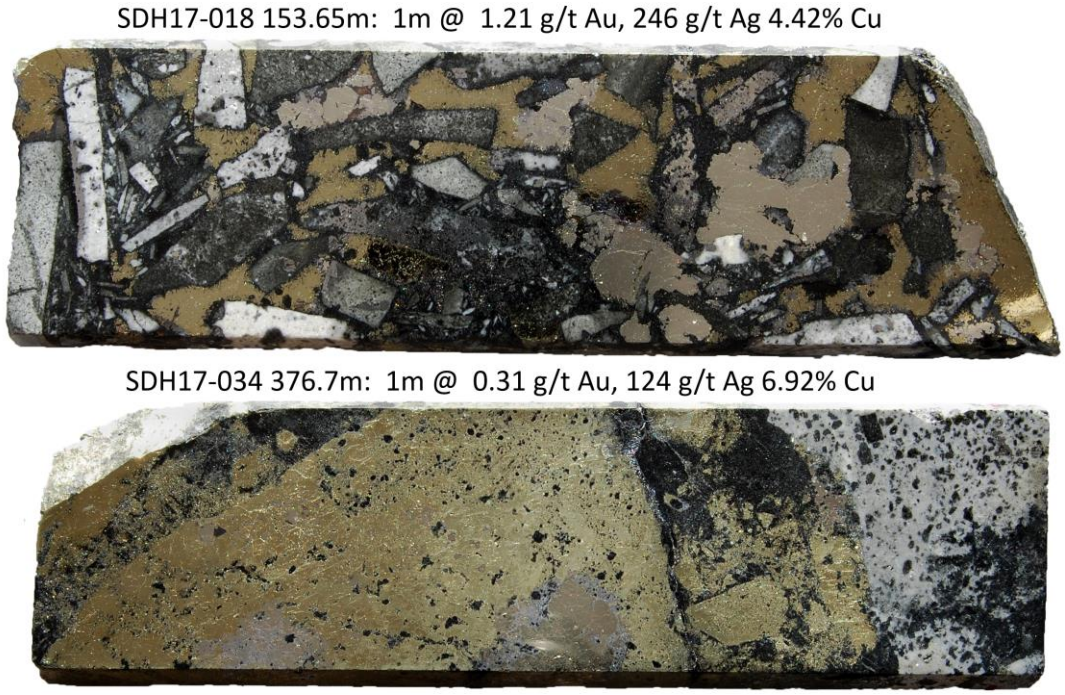

Figure 3. Examples of breccia mineralization in the matrix (upper), and as clast replacement (lower).

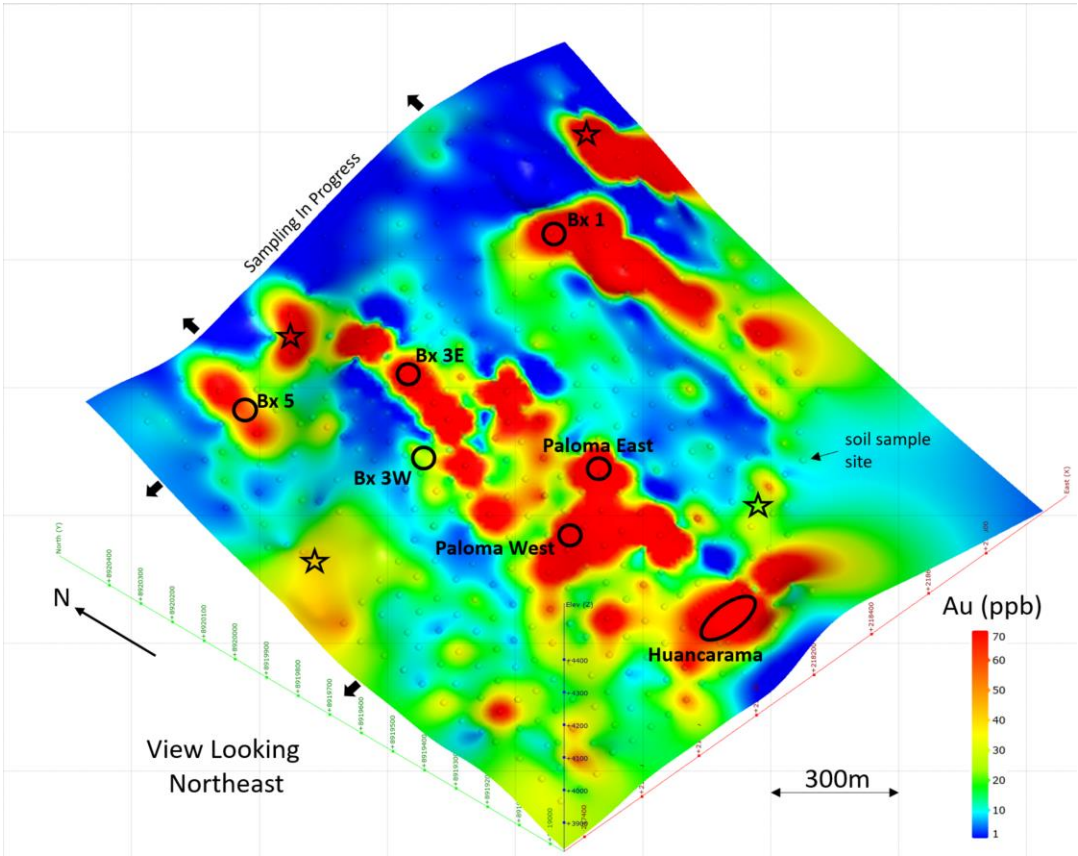

Figure 4. 3D perspective view looking northeast of the main Soledad breccia pipe cluster showing confirmed breccias and occurrences (stars). Color image shows gold in soils collected on 50m centers. Anomalous areas without confirmed breccia pipes or occurrences are considered exploration targets. Gold is determined by Fire Assay on a 30g sample.

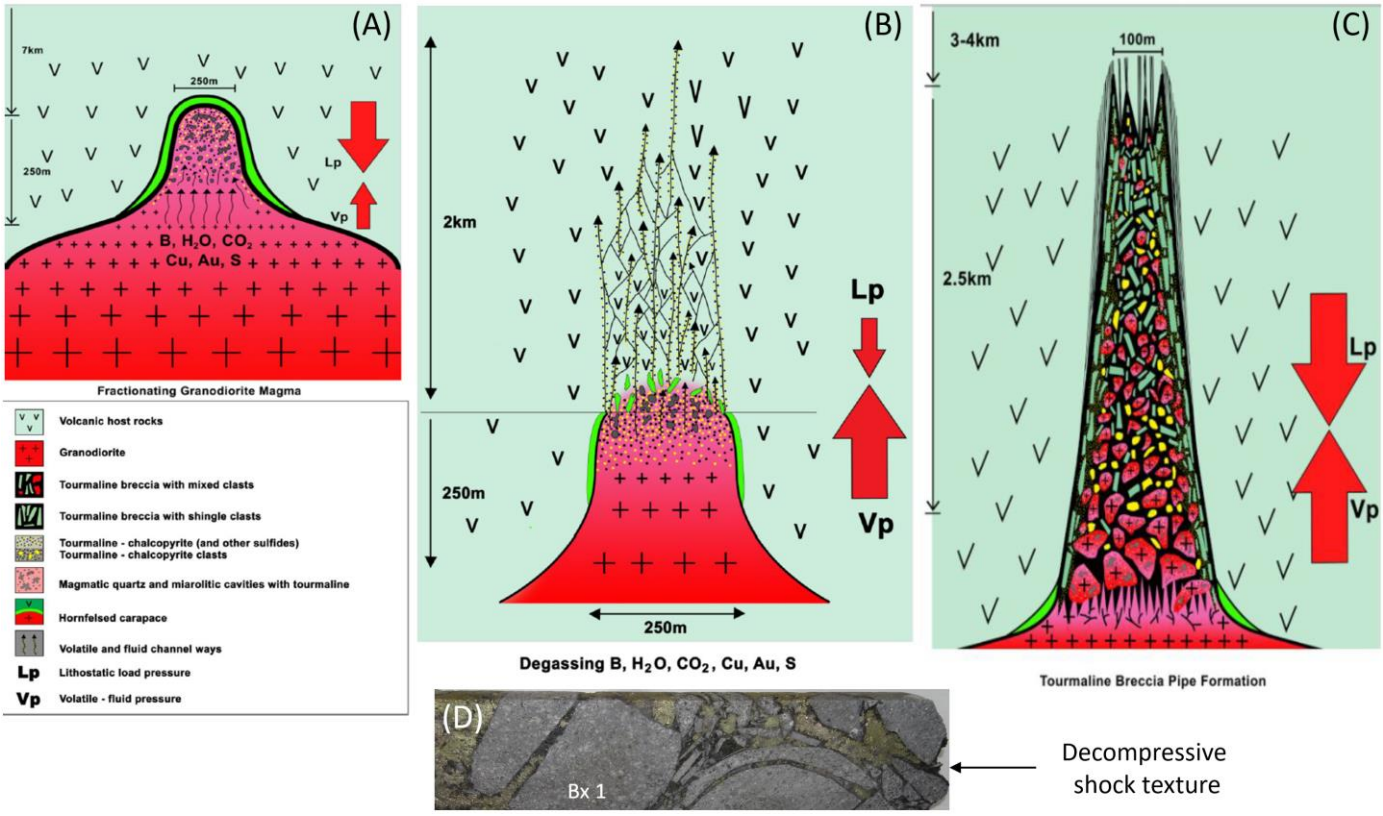

Figure 5. Hypothetical sections showing the three stages of tourmaline breccia pipe formation (A-C), and an example of decompressive shock texture (D).

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