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**PolarX Limited (ASX: PXX)**

Update - July 2019

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**Note:** This report is based on information provided by the company as at July 13, 2019.

Investment Profile	
Share Price - 12 July 2019	A\$0.092
12 Month Low/High	A\$0.051/0.155
Issued Capital:	
Ordinary Shares	415.9 m
Options (Total)	23.45 m
Fully Diluted	439.4 m
Market Capitalisation	A\$38.3 m
Cash - July 5, 2019	A\$7.7 m

Board and Management	
Mr Mark Bojanjac:	Executive Chairman
Dr Frazer Tabearth:	Managing Director
Dr Jason Berton:	Executive Director
Mr Bob Boaz:	Non-Executive Director
Mr Ian Cunningham:	CFO/Company Secretary
Mitchell River Group:	Technical Services
Millrock Resources:	Exploration & Logistic Services

Major Shareholders	
Lundin Mining	12.9%
JP Morgan	8.3%
U.S. Global	8.1%
Ruffer UK	7.5%
Top 20	69%
Board/Management/MRG Team	12%



Mark Gordon - Senior Analyst

The investment opinion in this report is current as at the date of publication. Investors and advisers should be aware that over time the circumstances of the issuer and/or product may change which may affect our investment opinion.

### CASHED UP & SET FOR AN ACTIVE 2019 FIELD SEASON

PolarX Limited ("PolarX" or "the Company") is set for an active 2019 field season over the Alaska Range Project ("the Project"), and is well cashed up with ~A\$8 million in the tin.

A\$4.28 million of this came from a share subscription by the C\$5.3 billion TSX listed Lundin Mining Corporation ("Lundin Mining", TSX:LUN) as part of an exclusive option agreement to enter into an earn-in over the porphyry targets within the Stellar claim package, and will be used to fund the 2019 exploration over these targets. Planned work includes 5,000 m of core drilling over the high priority Saturn (formerly Zackly SE) and possibly Mars targets. Ongoing data interpretation has confirmed the strong potential of these targets for porphyry-style mineralisation, with Saturn interpreted as being the source of mineralising fluids for the Zackly skarn.

The results of the 2019 field work on the porphyry targets will then be used by Lundin Mining in a decision whether to proceed with the earn-in. Should they elect to do so Lundin Mining will have the right to earn 51% of the claims through the staged expenditure of US\$24 million on direct exploration and staged cash payments of US\$20 million to PolarX over three years. Lundin Mining will earn no equity with an early withdrawal, however may choose to accelerate the programmes.

Our view is that this is an excellent structure for an earn-in agreement, and will ensure, by virtue of annual expenditure commitments, that work will be ongoing. We will not see, as is often the case in similar agreements, the larger partner making slow progress, and thus frustrating the junior partner and shareholders.

The Zackly claims have been excised from the Lundin Mining agreement, with much of the work in 2018 involved in extensional drilling of the Zackly skarn, which has an initial Inferred Mineral Resource Estimate ("MRE") of 3.4 Mt @ 1.2% Cu, 2.0 g/t Au and 14 g/t Ag. The 2018 drilling extended the 1,050 m strike of the initial MRE by at least 850 m, with the Resource open along strike and at depth. This is part of a global MRE for the Project (including Caribou Dome) of 6.2 Mt @ 2.0% Cu and 2.0 g/t Au, for 127,000 tonnes of contained copper and 217,000 oz of Au.

The 2018 drilling intersected thick, shallowly dipping and shallow mineralisation in a separate skarn zone at the eastern end of Zackly (850 m east of the MRE), showing the potential for open pit mining and a significant MRE extension. PolarX will concentrate the 2019 Zackly drilling over this zone, with results to be incorporated into an updated MRE. It is also planned to commence a PEA/PFS for Zackly by the end of 2019, with the results of current and upcoming metallurgical testwork also to be incorporated into the study.

### KEY POINTS

**Lundin Mining agreement:** This is a key breakthrough for the Company, and has brought a quality partner into the Project as well as onto the register - this has also ensured funding for 2019, and should the option be exercised, for the foreseeable future.

**Porphyry potential enhanced:** The results of work to date have further enhanced the potential of the Project to host porphyry copper-gold mineralisation, which will be amongst the next drill targets for the Company.

**Upside and open pit potential at Zackly:** The 2018 drilling has added significant size to the Zackly Cu-Au skarn mineralisation, and also highlights the potential for appreciable open cut mineralisation.

**Attractive mining destination:** Alaska is an attractive and well regarded mining destination, ranking 5th globally and 2nd in the United States in the 2018 Fraser Institute survey - the state is home to a number of metal mines, as well as coal and a large oil and gas industry, with the attractiveness of Alaska being highlighted by the 2018 purchase of the high grade (14.7 g/t Au), 4.15 Moz Pogo gold mine by ASX-listed Northern Star Minerals (ASX: NST).

**Close to infrastructure:** The Project is situated close to transport infrastructure, allowing for ready vehicular access, negating the need for all activities to be helicopter supported.

**Strong management and technical team:** The Company has management, technical personnel and partners with extensive experience in the junior resources sector (and in the case of Millrock Resources, extensive Alaskan experience) and a proven history of technical success and delivering value to shareholders; in addition key personnel and related partners hold ~12% of the Company, thus aligning their interests with those of other shareholders.

**Active exploration programmes and news flow:** Given the results of the 2018 work programme, we expect another concerted effort in 2019 (including expected drilling at Zackly, Saturn and Mars), with all indications that this will again bring very positive news.

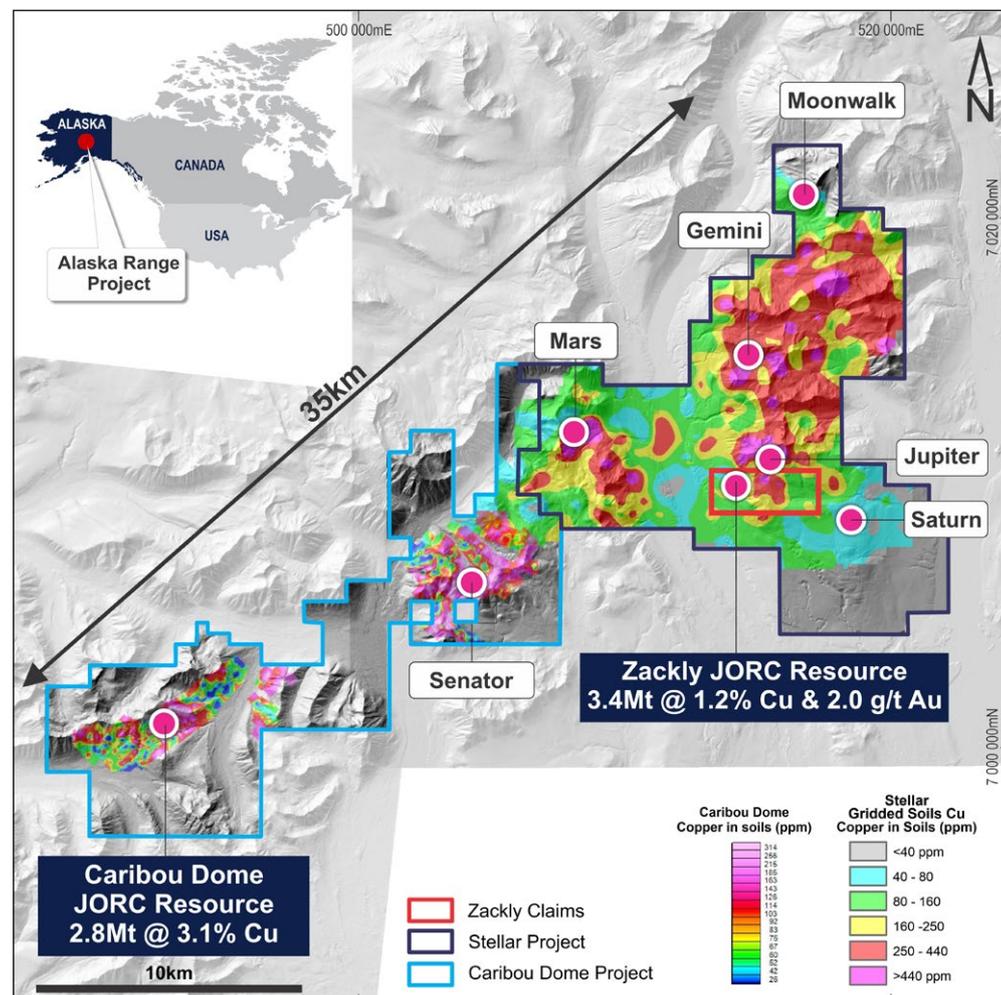
**Leveraged to exploration success:** With an EV of ~A\$30 million, the Company is well leveraged to positive exploration news with the potential to return significant value to shareholders.

## ACTIVITIES UPDATE

### OVERVIEW

- ◆ PolarX's activities are focussed on the 262.1 km<sup>2</sup> Alaska Range Project, which comprises two highly prospective contiguous projects, namely Stellar and Caribou Dome, located in the Central Alaskan Ranges (Figure 1).
- ◆ Activities subsequent to our November 2018 update note include:
  - The signing of an option for an earn-in agreement with Lundin Mining covering the Stellar Project (however with PolarX retaining the Zackly claims),
  - A 1 for 7 rights issue that raised A\$3.46 million - there was a primary take up of 59% under the Entitlement Offer, with an additional 22% issued under a Shortfall Offer,
  - Addition of 30 new claims, taking the Alaska Range Project area from 242.65 km<sup>2</sup> to 262.1 km<sup>2</sup> - the new claims cover the depth extents of an interpreted steeply plunging intrusive cluster at the Saturn prospect, defined by 3D inversion modelling of the detailed magnetics flown in 2018,
  - Ongoing interpretations of project data,
  - Receipt of all assays from the 2018 drilling programme; and,
  - Planning of activities for the 2019 field season.
- ◆ In addition to the recently completed rights issue as mentioned above, the Company received A\$1.26 million from a placement at A\$0.06 per share in December 2018, and also received A\$4.28 million from a placement at A\$0.08/share to Lundin Mining as part of the Lundin Mining earn-in option - the Company has a healthy cash balance of A\$7.7 million going into the 2019 field season.
- ◆ No significant field activities have been undertaken since our last note, given that it has been winter, however an induced polarisation ("IP") survey over Saturn is imminent, and with drilling planned to commence in late July.

Figure 1: Project location map



Source: PolarX

## LUNDIN MINING EARN-IN OPTION AGREEMENT

- ◆ As announced to the market on June 4, 2019, the Company has entered into an earn-in option agreement with TSX-listed Lundin Mining over selected porphyry targets within the Stellar claim group - the Zackly claims are excised from the agreement (Figure 1).
- ◆ This gives Lundin Mining the option to earn up to 51% of the Stellar claims through the staged expenditure of US\$24 million on exploration and staged payments to PolarX of US\$20 million over a three year earn-in period (Table 1), and can terminate at any time as long as the requisite cash payments to that point are up to date.
- ◆ The option included a recently completed US\$3 million (~A\$4.3 million) share subscription in PolarX at A\$0.08/share (with Lundin Mining now being PolarX's largest shareholder), which will be used for exploration over porphyry targets in the 2019 field season - activities for this will be determined by a five person exploration committee, comprising three members from Lundin Mining and two from PolarX.

**Table 1: Lundin Mining earn-in payments US\$m**

Lundin Mining earn-in payments US\$m					
Year	Equity	In-Ground Expenditure	Cash Payment	Total US\$m	Equiv. A\$m (0.69 fx)
Pre Earn-In	\$3 m	\$0 m	\$0 m	\$3 m	\$4.3 m
Earn-In Yr. 1	\$0 m	\$8 m	\$2 m	\$10 m	\$14.5 m
Earn-In Yr. 2	\$0 m	\$8 m	\$3 m	\$11 m	\$15.9 m
Earn-In Yr. 3	\$0 m	\$8 m	\$5 m	\$13 m	\$18.8 m
Exercise Fee			\$10 m	\$10 m	\$14.5 m
<b>TOTALS</b>	<b>\$3 m</b>	<b>\$24 m</b>	<b>\$20 m</b>	<b>\$47 m</b>	<b>\$68.1 m</b>

Source: PolarX

- ◆ Lundin Mining can exercise the option to enter into a 3-year Earn-in Period for a joint venture at any time prior to the Option Exercise Date, which is the latter of the end of a 30-day period to review the results of the 2019 exploration programme or December 31, 2019, with the following earn-in terms:
  - Year 1 - upfront cash payment to PolarX of US\$2M within 30 days of the Option Exercise Date (anticipated to be 30 January 2020) plus a minimum of US\$8M exploration expenditure by the end of Year 1 to earn the right to continue,
  - Year 2 - upfront cash payment to PolarX of US\$3M within 30 days of the first anniversary of the Option Exercise Date (anticipated to be 30 January 2021) plus a minimum of US\$8M exploration expenditure by the end of Year 2 to earn the right to continue,
  - Year 3 - upfront cash payment to PolarX of US\$5M within 30 days of the second anniversary of the Option Exercise Date (anticipated to be 30 January 2022) plus a minimum of US\$8M exploration expenditure by the end of Year 3 to earn the right to then enter into a joint venture; and,
  - Final cash payment of US\$10M to PolarX to exercise the right to form a joint venture initially owned 51% Lundin Mining and 49% PolarX.
- ◆ Lundin Mining can withdraw at any time prior to formation of the JV as long as the required upfront cash payments for said year to PolarX have been made at that point.
- ◆ Lundin Mining may accelerate the earn-in phase by spending the total of \$24M and making the \$20M cash payments in a shorter timeframe at its sole election.
- ◆ Once formed, the JV will be managed by a five-person board (three Lundin Mining appointees, two PolarX appointees). Both parties will be responsible for funding their share of future expenditure, with standard dilution provisions for non-contributing parties.
- ◆ Full details are provided in the Company release of June 4, 2019.

## ZACKLY DRILLING

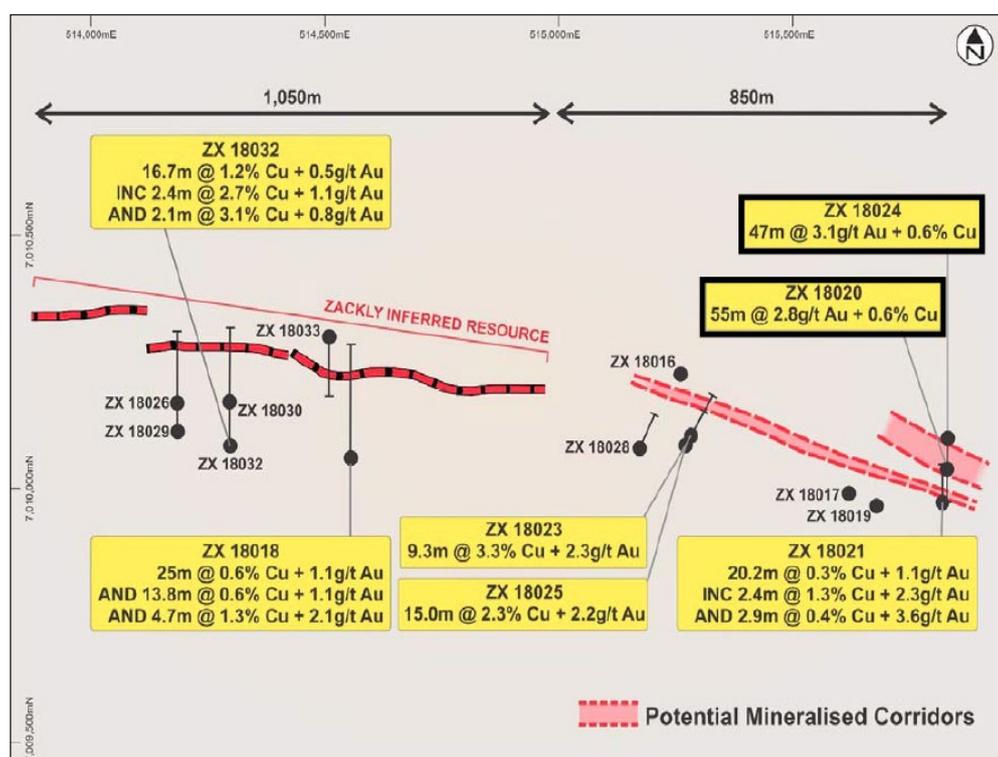
- ◆ The Company completed 18 holes for 3,754.4 m at Zackly during the 2018 field season, with collars shown in Figure 2 - this adds to the 14 holes for 1,888.94 m drilled in 2017.
- ◆ Final assay results were received in late 2019, with all results of the 2018 drilling shown in Table 2.
- ◆ The drilling has confirmed an extra 850 m of strike length at Zackly (which is still open to the west and east), and has also intersected a thick, shallowly dipping zone at the eastern end which is still open along strike and down dip (Figures 2, 3 and 4).

Table 2: Zackly 2018 drilling results

Zackly 2018 drilling results						
Hole_ID	From (m)	To (m)	Width (m)	Cu %	Au g/t	Ag g/t
ZX-18016	No significant intersection					
ZX-18017	No significant intersection					
ZX-18018	261.6	287.1	25.5	0.6	1.1	5.5
including	261.6	266.9	5.3	1.1	1.7	11.3
including	273.5	277.3	3.8	0.8	1.2	6.3
including	285.8	287.2	1.4	3.2	9.3	38.2
and	300.8	314.7	13.9	0.6	1.1	4.7
including	312.0	314.7	2.7	1.3	2.1	10.5
and	326.1	330.8	4.7	1.3	2.1	10.6
including	326.1	328.6	2.5	2.3	3.5	18.5
ZX-18019	No significant intersection					
ZX-18020	2.5	57.1	54.6	0.6	2.8	9.5
including	2.5	14.0	11.5	0.6	5.3	12.0
including	18.3	27.1	8.8	0.5	5.8	5.6
including	32.0	43.3	11.3	0.8	1.8	23.3
including	46.2	57.1	10.9	1.0	1.6	3.9
ZX-18021	8.2	28.4	20.2	0.3	1.1	5.3
including	8.5	10.9	2.4	1.3	2.3	23.6
including	16.0	18.9	2.9	0.4	3.6	7.1
and	45.1	48.9	3.8	0.2	2.4	3.9
and	57.1	59.2	2.1	0.5	1.0	7.4
and	76.6	79.2	2.6	0.1	0.6	1.6
and	83.7	91.0	7.3	0.3	1.0	1.9
ZX-18023	20.8	30.1	9.3	3.3	2.3	19.7
ZX-18024	36.1	82.8	46.7	0.6	3.1	3.3
ZX-18025	84.8	99.8	15.0	2.3	2.2	11.9
ZX-18032	264.1	280.8	16.7	1.2	0.5	6.9
and	288.1	290.2	2.1	3.1	0.8	13.2

Source: PolarX

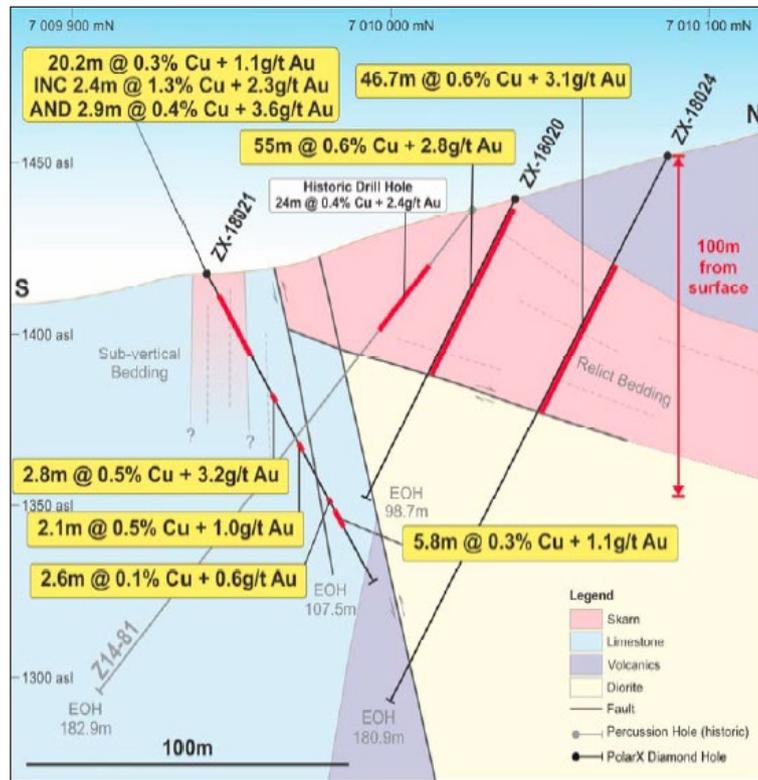
Figure 2: PolarX drilling - Zackly - showing significant results



Source: PolarX

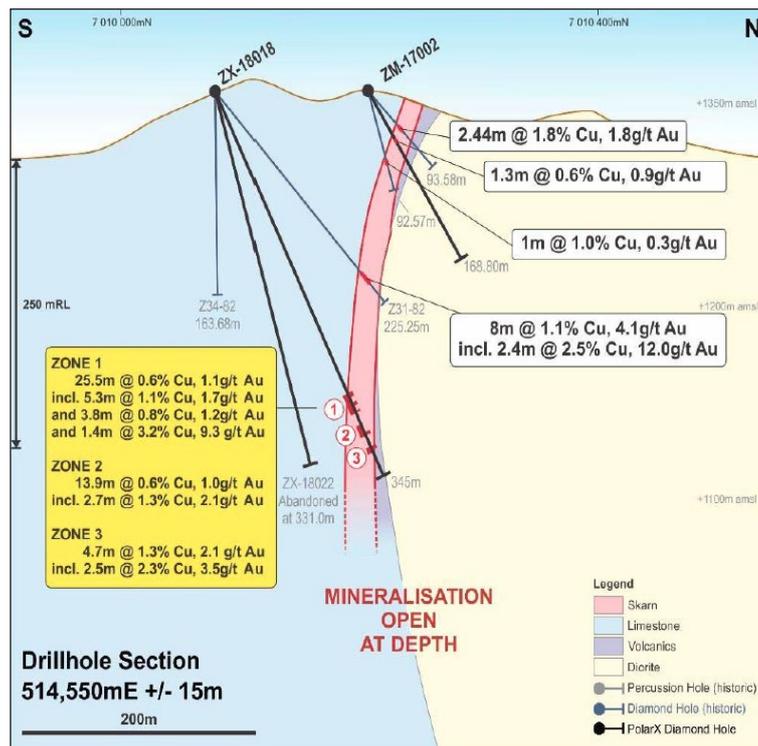
- ◆ This thick, shallow mineralisation at the eastern end highlights the potential for open cut mining, and also contains significant oxide mineralisation - this zone will be the target for drilling in 2019.
- ◆ As is the case for skarns, variable types have been recognised, including magnetite and garnet skarns; in addition visible gold has been noted in places, and quartz-sericite (a typical porphyry vein/alteration assemblage) veining has been recognised, providing an ESE vector to a fluid source and possible porphyry style mineralisation at Saturn, as reinforced by the results of magnetic inversion modelling as discussed below.

Figure 3: Zackly drill section 515,840E, showing flat-lying mineralised skarn



Source: PolarX

Figure 4: Zackly drill section 515,550E, showing vertical skarn and high grade drilling results

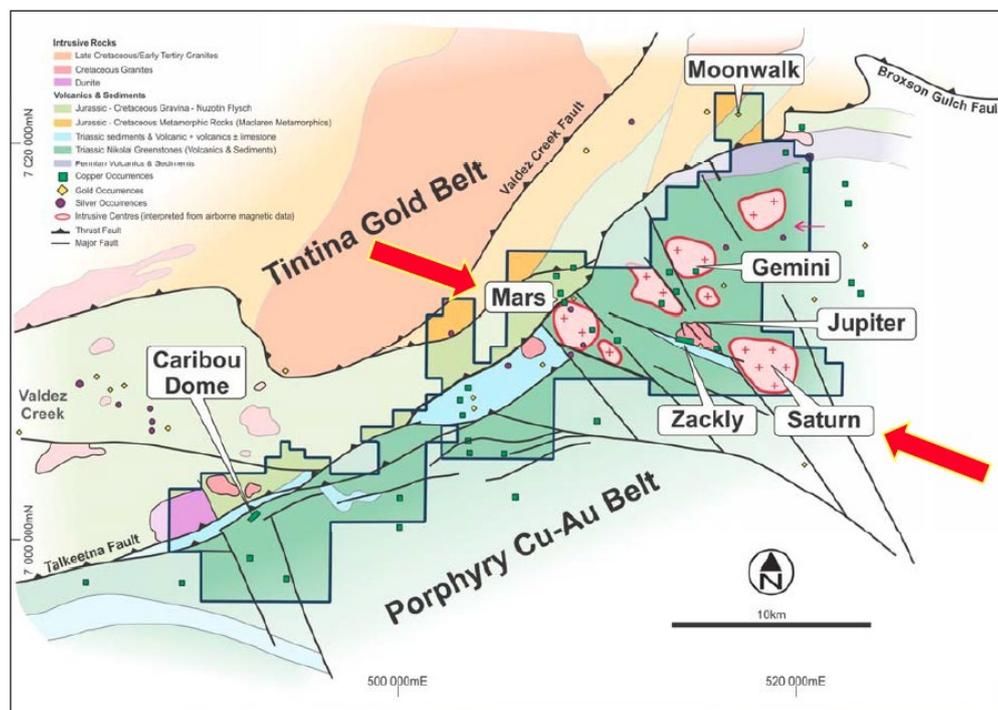


Source: PolarX

## MAGNETICS INTERPRETATION

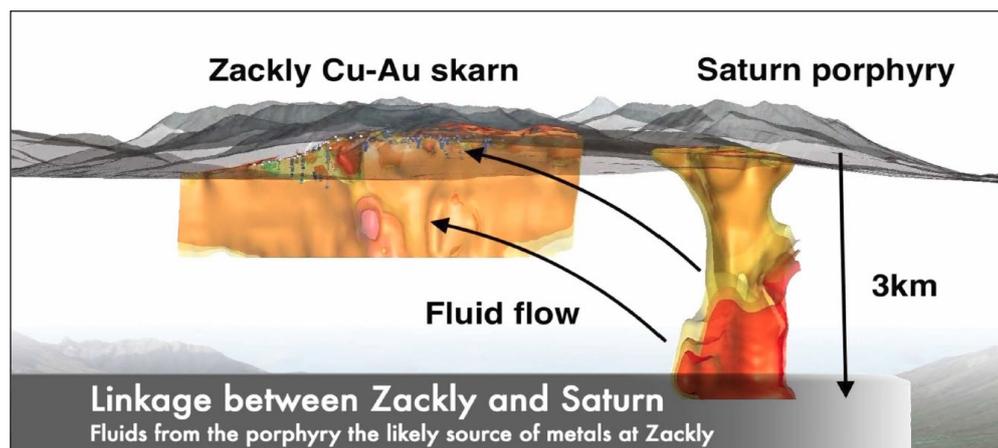
- ◆ Interpretation of the historic and recently flown detailed magnetics surveys has been ongoing, with this including 3D inversion modelling of the data - the geology as interpreted from this is shown in Figure 5.
- ◆ The interpretation has recognised a steeply plunging feature extending from the Saturn porphyry cluster at surface to a depth of at least three kilometres - this interpreted porphyry body is thought to be the likely fluid source for the Zackly Cu-Au skarn mineralisation (Figures 5 and 6); Saturn itself provides a prime target for porphyry-style mineralisation, and will be tested by drilling in 2019.

Figure 5: Geological interpretation from regional magnetics reprocessing and detailed magnetics survey area



Source: PolarX

Figure 6: Interpreted Saturn-Zackly relationship



Source: PolarX

## OTHER ACTIVITIES

### Mars Porphyry Cu-Au Target

- ◆ As discussed in our November note the Company carried out geological mapping, and detailed soil and rock-chip sampling on a 200m x 150m grid at Mars in August, with very positive results recently being released, with these to be used to prioritise possible 2019 drilling targets over this very promising prospect.

- ◆ This, and earlier work, defined coincident geochemical and geophysical signatures typical of porphyry systems - these include a Cu-Au-Mo-As geochemical anomaly, coincident with an IP chargeability anomaly (with a modelled depth of 100 m to 150 m below surface) and a cluster of magnetic highs.
- ◆ In addition to the soil anomalism, (which covers an area of 2 km by 1.5 km) rock chip sampling returned values of up to over 50% Cu and 6.93 g/t Au.

## PLANNED ACTIVITIES

- ◆ The May to October 2019 field season will have a strong focus on drilling (due to commence in late July), including:
  - 32 line-km of IP data to be collected over Saturn, with this commencing this week to help drill targeting,
  - 5,000 m of drilling to be undertaken at Saturn (and possibly Mars), the results of which will be used by Lundin Mining in the decision whether to exercise the option for the earn-in period of the agreement,
  - 2,000 m of drilling planned at Zackly for commencement later this northern summer, to expand the Zackly resource; and,
  - Metallurgical test-work at Zackly to commence in earnest later this quarter, however with some preliminary work already underway.
- ◆ Results of the Zackly drilling, expanded resource and metallurgical test work will be used in the Zackly PEA/PFS, which the Company plans to commence by the end of 2019.

## PEERS

- ◆ PolarX is one of a number of explorers and developers looking at poly-metallic resources, with these shown in Table 3, which also includes producers - this has been updated from the peer comparison table in our previous update report.

**Table 3: PolarX peers**

Table 4: PolarX peers							
Company	Project	EV Undiluted (A\$m)	Equity Resource (Kt)	CuEq Grade (%)	Deposit/Target Style	Project stage	Metals (all resources)
Auralia Metals	Hera, Nymagee	\$269.5	13,404	3.54%	Cobar	Hera, Peak - Production Nymagee - FS	Cu, Pb, Zn, Ag, Au
Heron Resources	Woodlawn	\$180.6	18,100	3.79%	VMS	Producing	Cu, Pb, Zn, Ag, Au
Terramin	Angas, Tala Hamza	\$161.2	54,158	2.39%	Various	FS - Hamza C & M - Angas	Zn, Pb
Nzuri Copper	Kalongwe	\$93.5	11,459	2.73%	Copperbelt	Feasibility, Takeover bid	Cu, Co
Orion Minerals	PCM	\$69.8	22,357	2.74%	VMS	Feasibility	Cu, Zn
Peel Mining	Mallee Bull	\$69.7	7,535	3.28%	Cobar	Drilling, Resource Expansion	Cu, Pb, Zn, Ag, Au
Red River Resources	Thalanga	\$69.4	7,075	5.22%	VMS	Production	Cu, Pb, Zn, Ag, Au
Venturex Resources	Sulphur Springs	\$47.9	25,707	3.00%	VMS	Looking to Development	Cu, Pb, Zn, Ag, Au
Hot Chili	Productora	\$34.5	363,600	0.33%	Porphyry	DFS	Cu, Au, Mo
PolarX	Alaska Range	\$30.5	5,640	2.80%	Sedex, Skarn, Porphyry	Exploration, Drilling	Cu, Au
PNX Metals	Hayes Creek	\$16.5	4,076	4.41%	VMS	Feasibility	Cu, Pb, Zn, Ag, Au
Rex Minerals	Hillside	\$14.0	337,800	0.60%	IOCG	Permitting	Cu, Au, Fe
Ironbark	Citronen	\$10.3	70,800	2.33%	Sedex	Feasibility	Zn, Cu, Pb
White Rock	Mt Carrington Red Mountain	\$9.6	16,700	3.67%	VMS	Exploration, SFR earning in	Cu, Pb, Zn, Ag, Au
Alta Zinc	Gorno	\$2.7	3,300	2.69%	MVT	Development Studies	Pb, Zn, Ag
Marindi Metals	Prairie	\$1.9	2,980	2.70%	Structurally-hosted	Exploration	Zn, Pb, Ag

Source: IRESS, Company Reports, IIR analysis

- ◆ This has been sorted on undiluted enterprise value, highlighting the upside potential of the Alaska Range Project and the Company.
- ◆ We have calculated the copper equivalent (“CuEq”) grade using current metal prices and exchange rates - this does not take into account expected or actual metallurgical recoveries.
- ◆ We would expect uplift in value with increasing resources and exploration/drilling success - the Company has an EV at the lower end of its peers.

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## RISKS

- ◆ **Exploration:** This is a key risk for any explorer, however the positive results of work to date, both historical and by PolarX outside of Zackly and Caribou Dome have partly mitigated this.
- ◆ **Resource:** This is a key risk at both Zackly and Caribou Dome, where the Company is looking at a potential operation - resources will need to be able to support, given the location, a relatively expensive operation.
- ◆ **Location and climate:** Any potential operation may be comparatively high cost, given the harsh winter climate and location.
- ◆ **Funding:** PolarX is now well funded for the 2019 field season; and, dependent upon Lundin Mining deciding to proceed with the earn-in agreement should be at least partially funded for activities outside of the earn-in area over the next few years.
- ◆ **Markets:** Although reasonable at the moment, markets can turn on a dime and funding for juniors can dry up very quickly. This is somewhat mitigated in PolarX’s case given the above.

## BACKGROUND - ALASKA

### General

- ◆ Alaska, which is the largest state in the US ranks 48th in terms of population (~750,000) and last in terms of population density.
- ◆ The capital city is Juneau, with the largest city being Anchorage, with a population of ~300,000; Fairbanks (with a population of ~100,000) is Alaska's second largest city and 190 km as the crow flies north of the Project.
- ◆ Alaska has a strong mining background and well-developed mining industry, and in 2018 was ranked 5th globally and 2nd in the US in the Fraser Institute survey - the state has steadily improved its ranking over recent years.
- ◆ This is supported by well-developed transport infrastructure including road and rail.
- ◆ Given the size of the state and population density there is no state wide power grid, however the populated areas from Fairbanks south to Anchorage are served by the interconnected "railbelt" grid, which services a large part of the Alaskan population.
- ◆ Natural gas supplies ~50% of Alaska's electricity generation, hydro ~25% and petroleum liquids and coal the majority of the rest - petroleum liquids generation is prevalent in regional communities which have no grid access.
- ◆ The nearest power station to the Alaska Range Project is a 30 MW coal fired facility at Healy, some 60 km north of Cantwell and located on the "railbelt" grid - this is also on the main George Parks highway and railroad, connecting Seward and Anchorage in the south to Fairbanks in the north.

### Mining

- ◆ Alaska has a long history of mining, with Russian explorers mining placer gold in the early 1800's, with both placer and hard rock mining continuing and growing after the US purchase of the territory in 1867.
- ◆ Large placer discoveries and operations included Nome (discovered in 1899, and with over 5 Moz produced) and Fairbanks (discovered in 1902, and with over 6 Moz produced).
- ◆ Closer to the Project is the Valdez Creek Mine, with alluvial gold first being discovered in 1903 - Valdez Creek was operated by Cambior from 1984 to 1995, producing some 459,162oz of gold at up to 75,000 oz annually, making it North America's largest placer operation in 1992.
- ◆ Modern hard rock gold operations include Fort Knox (7 Moz Au, operated by Kinross) and Pogo (4.15 Moz Au, operated by Northern Star Minerals) - these large mines are both within 200 km of Alaska Range.
- ◆ Pogo was acquired by Northern Star from Sumitomo in August 2018 for US\$260 million, with this soon followed by a 24% upgrade in JORC 2012-compliant Mineral Resources.
- ◆ Other major discoveries and operations include Teck's Red Dog zinc deposit, one of the largest and highest grade zinc mines in the world and located above the Arctic Circle in NW Alaska, and the Pebble Cu-Au-Mo porphyry deposit, located 320km SW of Anchorage, which is currently being permitted.
- ◆ Pebble, which is owned by Northern Dynasty Minerals, contains some 107 Moz Au, 81 Blbs Cu, 5.6 Blbs Mo and 514 Moz of Ag in a resource of 10 Bt at a 0.3% CuEq cut-off.
- ◆ Another significant project is the Donlin Gold Project, 50:50 owned by Novagold Resources and Barrick Gold Corporation - with resources of over 39 Moz and plans to produce over 1.1 Mozpa over a 27 year mine life, this is one of the largest advanced gold projects globally, and was recently fully permitted.
- ◆ Alaska has a well-developed coal industry, with coal first being mined in the state in 1855, and has a large oil producing industry, being one of the top crude producing states in the US.

### Mining Tenements

- ◆ Alaska's mining and exploration permitting regime is transparent, however rigorous - permitting and approval of work programmes can involve up to twelve federal and state agencies, depending upon the complexity of the activities, however in the case of PolarX requires approvals from one state agency only.
- ◆ Claims are based on 160 acre (and sometimes 40 acre) parcels for hard rock "lode" mineralisation, and 20 acre placer claims.

- ◆ Claims are unpatented, meaning that ownership still resides with the federal or state governments (all of the Project claims are with the state authorities, and not the federal Bureau of Land Management “BLM”, thus making permitting of any operation potentially simpler than otherwise).
- ◆ As long as the annual rental and expenditure requirements are kept up claims can be held in perpetuity - rentals range from US\$140 per 160 acre claim for years 1 to 5, US\$280 for years 6 to 10, and US\$680 thereafter.
- ◆ The minimum expenditure (referred to as “annual labour”) is US\$100/claim.
- ◆ As for most jurisdictions globally, approval of mining operations can include a number of federal and state agencies, an environmental impact assessment (“EIA”) and stakeholder engagement; in the case of PolarX, given that the Project is on state claims, only state approvals may be necessary - the only federal input would be from the Army Corps of Engineers should the Project impact wetlands.

## BACKGROUND - DEPOSIT STYLES - A BRIEF OVERVIEW

- ◆ The styles of mineralisation being explored for by PolarX are well understood, and are widespread globally, in addition they are major sources of the sought for metals.

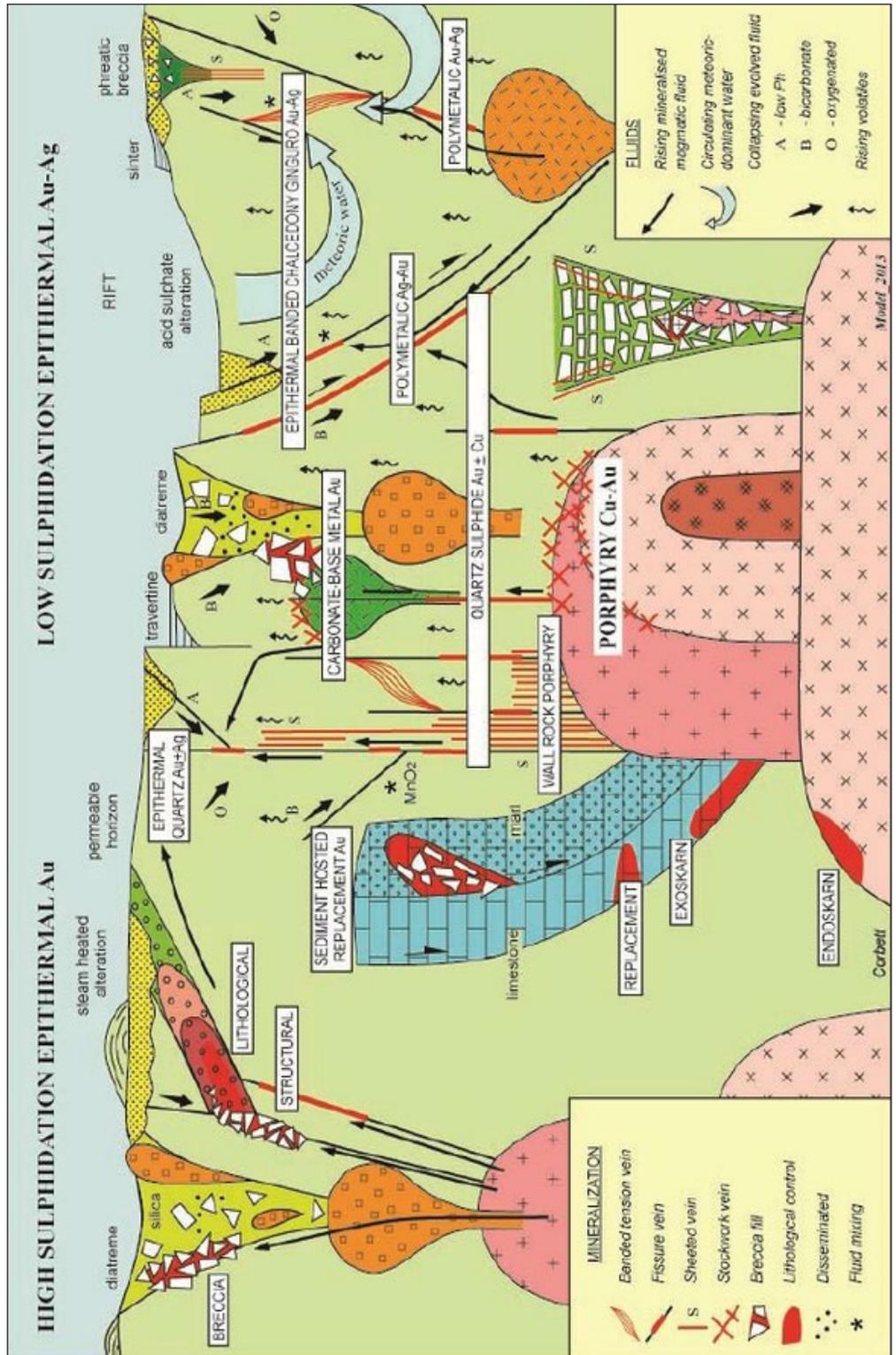
### Porphyry and Porphyry-Related Cu-Au-Mo

#### Geology

- ◆ Porphyry copper deposits are the main source of copper globally, and are found in numerous regions, including North, Central and South America, SE Asia and Oceania and Mongolia amongst others.
- ◆ They form at convergent plate margins - these include island arc settings (e.g. the Philippines, Indonesia) and continental margins (e.g. the current South American western continental margin and the historical North American plate margin in Alaska, Figure 4).
- ◆ Copper production from the world’s largest producer, Chile, is largely from porphyry copper deposits, as is that from Peru and the US, both major global copper producers.
- ◆ Molybdenum and gold are major by-products, again with Chile, the US and Peru being major producers.
- ◆ Although the primary ore is generally low grade, with a mean copper grade of ~0.5%, and gold grades ranging from 0.05 g/t to ~1 g/t, this is more than made up by size, with many containing 100’s of millions to billions of tonnes of mineralisation.
- ◆ The key copper minerals are chalcopyrite and bornite, with mineralisation generally being disseminated and in stockwork vein zones - in the continental margin porphyries (such as those in South America) mineralisation commonly forms a shell to a barren core or a cupola over the top of the high-level, sub-volcanic porphyry intrusions.
- ◆ Notable examples include Pebble (Alaska, 10Bt), Chuquibambilla (Chile) and Grasberg (Irian Jaya).
- ◆ Magmatic arc porphyry deposits are related to a number of other mineralisation styles, including gold-copper skarns, epithermal gold and mesothermal base metal carbonate vein gold - the relationship between these mineralisation styles is shown conceptually in Figure 7.
- ◆ Skarns, with an example being Zackly, are formed by the alteration of reactive rocks, such as limestone and marl with metal and volatile rich fluids emanating from an intrusive (Figure 7) - common metals include copper, gold, tungsten tin, lead, zinc and iron, with the metal types dependent on those enriched in the source intrusive.
- ◆ Skarns commonly exhibit metal zonation and numerous mineralising events - these include prograde and retrograde skarns, with the former due to alteration by the original hot fluids, and the latter due to alteration by cooling fluids during the waning of the hydrothermal system.
- ◆ As discussed earlier, the Zackly skarn is interpreted as being at least partly related to a buried porphyry intrusive, with the possibility that this is overprinting an earlier skarn related to the older, outcropping diorite.
- ◆ Major global skarn deposits include Ertsberg in Irian Jaya, paragenetically related to the nearby Grasberg porphyry copper deposit, and Ok Tedi, again with skarn mineralisation related to the adjacent porphyry mineralisation - skarn also forms within the porphyritic intrusives (endoskarn).

- ◆ These major deposits show a clear relationship between skarns and porphyries - another example includes the Cadia complex in New South Wales, Australia.

Figure 7: Conceptual model - magmatic arc related mineralisation styles



Source: Corbett and Leach, various publications

**Exploration**

- ◆ Porphyry copper deposits have distinctive geochemical and geophysical signatures, which are exhibited by the targets with the Alaska Range Project.
- ◆ Zoned geochemical signatures include a core of copper +/- gold +/- molybdenum, with this grading out to possibly lead or zinc on the peripheries.
- ◆ Other pathfinder elements commonly include tin, bismuth arsenic and antimony, with these also showing zonation.

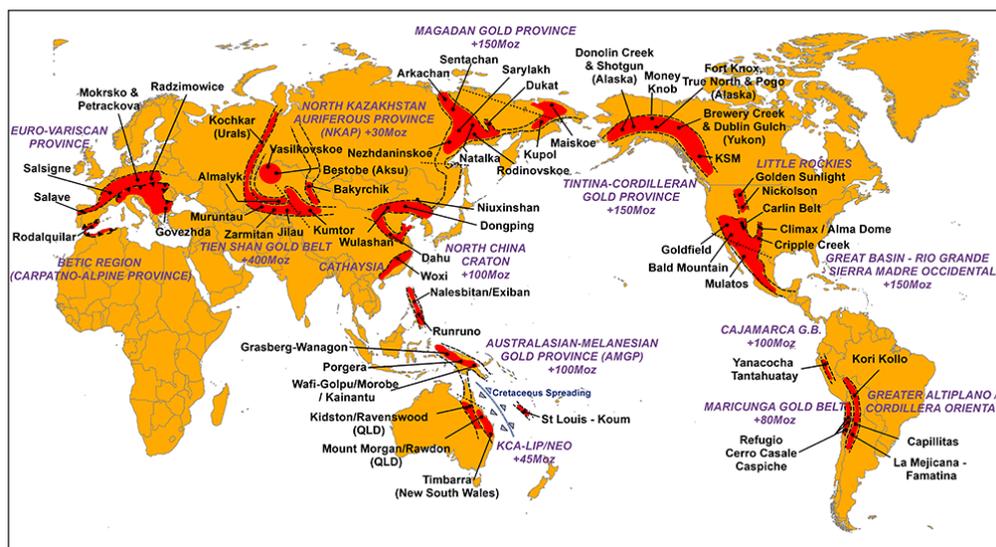
- ◆ The two major geophysical tools are magnetics and IP (chargeability) - they are often (but not always) characterized by a bulls eye magnetic anomaly, due to the presence of a core of magnetite-rich potassic alteration, surrounded by an annular low, due to the magnetite destructive propylitic and phyllic zones - this will particularly show up where the porphyry has intruded into magnetic rocks, such as basalts and andesites.
- ◆ One of the features of particularly the phyllic alteration zone is large quantities disseminated pyrite, which provides a perfect target for IP chargeability surveying.
- ◆ Geologically, porphyries are associated with distinctive alteration styles in the wallrocks, which can be recognised in outcrop.
- ◆ In skarns metal associations include proximal base metal, grading through precious metal to distal Pb-Zn-Ag veining - the metals present will depend upon the skarn style.
- ◆ Typical geophysical tools include magnetics (skarns, due to the presence of magnetite, can be highly magnetic) and EM, due to the common presence of massive sulphides.

## Intrusion Related Gold Systems

### Geology

- ◆ IRGS deposits span a gamut of mineralisation styles, however are all associated with post orogenic intrusives, largely situated along the continental side of a convergent plate margin, as is seen in the Tintina Belt in Alaska and British Columbia (Figures 8 and 9).
- ◆ The mineralisation style was first postulated in 1999, with steady advances in the understanding subsequent to this.

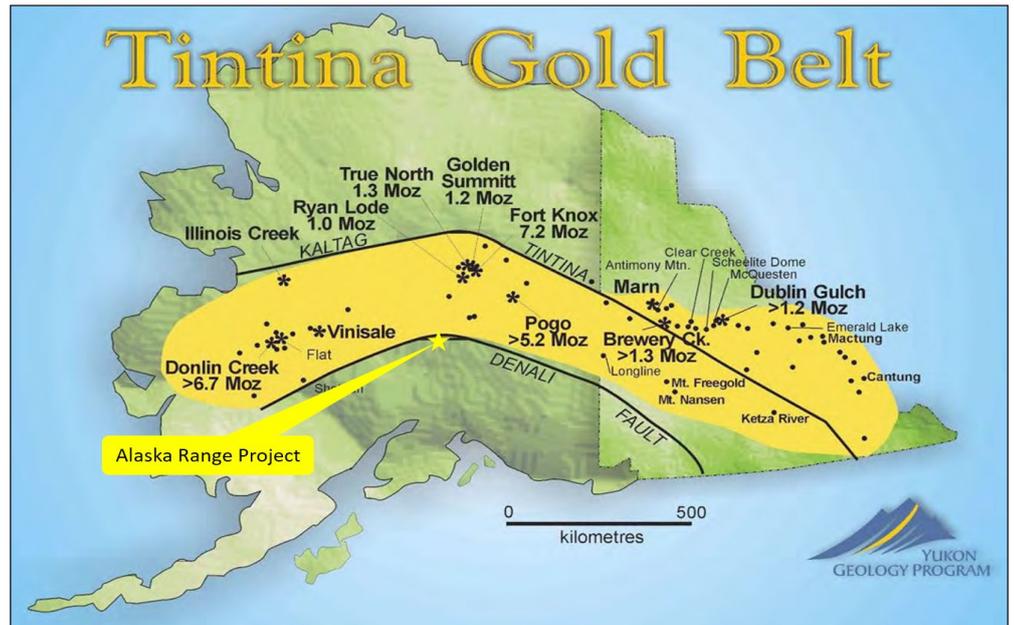
Figure 8: Global distribution of IRGS belts



Source: Adapted from Lang and Baker (2001)

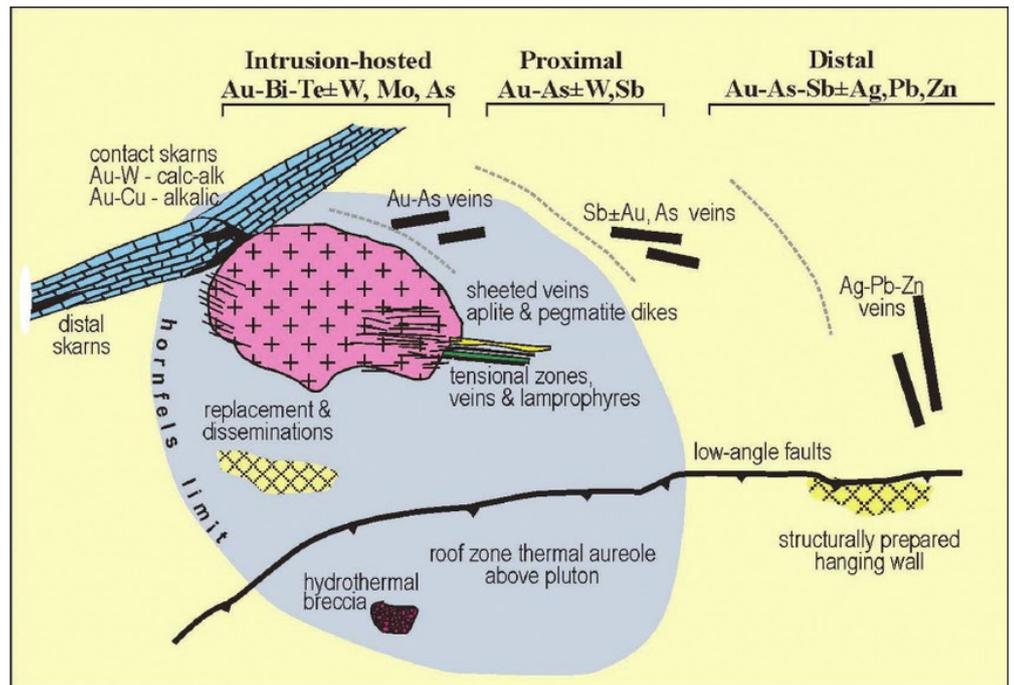
- ◆ Figure 10 shows the styles of mineralisation within the IGRS grouping - mineralisation forms over a wide depth range, from <1km to >8km, with one of the most common form of mineralisation being low sulphide sheeted veins within the host intrusion, with the intrusive event and mineralisation largely being contemporaneous.
- ◆ These styles are also associated with other broad mineralisation groupings, including orogenic gold, with which IRGS systems are often confused.
- ◆ Differentiating features are tectonic setting (post orogenic vs orogenic), location of mineralisation within and around the cupola of the host intrusions and geochemical signatures and zonation; in addition, IRGS mineralisation is generally related to smaller intrusive bodies including stocks - they are not related to batholiths as is commonly the case with orogenic gold deposits.
- ◆ Geochemically the deposits lack significant copper, and also there is concentric mineral zoning due to a sharp geothermal gradient around the causative intrusion.

Figure 9: Tintina Gold Belt and deposits



Source: Adapted from Anchor Resources presentation

Figure 10: IRGS deposit styles



Source: Adapted from Hart (2002)

**Exploration**

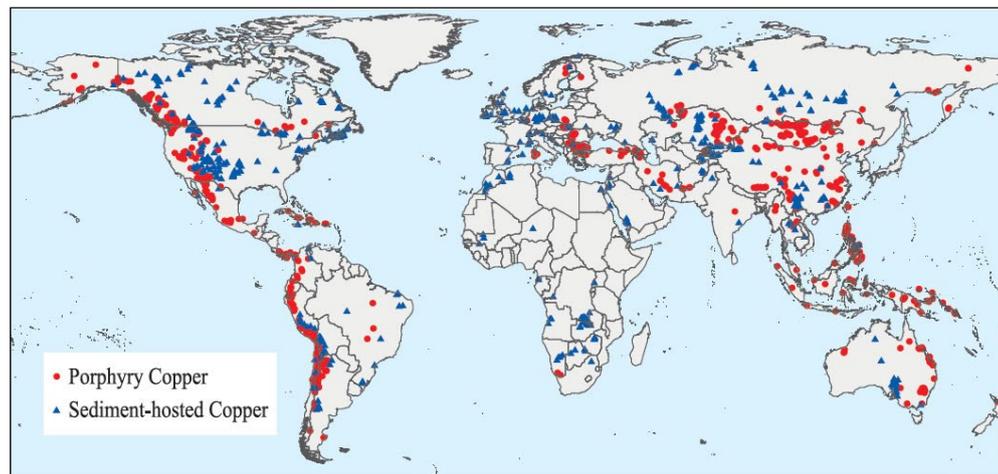
- ◆ Key exploration tools, in addition to geological mapping of the well developed alteration zones, include geochemistry and sometimes geophysics.
- ◆ Geochemical signatures are shown in Figure 10 with these similar to the Au-As-Bi-Sb-W-Zn anomalism seen at Moonwalk.
- ◆ The key geophysical tool, in areas of cover and buried intrusives, includes magnetics to recognise various intrusive phases - electrical methods are generally inconclusive given the lack of sulphides.

## Sediment Hosted Copper

### Geology

- ◆ Like IRGS systems, sediment hosted copper mineralisation includes a broad gamut of mineralisation styles.
- ◆ However key discriminants include the stratiform or stratabound nature of mineralisation, and as the name suggests, an association with sediments.
- ◆ Major examples include the Kupferschiefer in Western and Central Europe and the major deposits of the Central African Copperbelt, historically the world's largest producer of copper - Figure 11 shows the global distribution of both sediment hosted and porphyry copper deposits.

**Figure 11: Global copper deposits**



Source: Geology.com

- ◆ The majority of these formed during diagenesis, with oxidised copper bearing basal brines being reduced by the reaction with reduced (pyritic, carbonaceous or calcareous) sediments to form the copper minerals, including primary chalcocite, bornite and chalcopyrite.
- ◆ Alaskan examples, which are also termed "Kennecott style" or "basalt copper" deposits include Kennecott, which, as mentioned previously produced ~4 Mt of ore at 13% Cu.
- ◆ However, also as mentioned earlier, it has been suggested that mineralisation at Kennecott is reasonably late, with structurally controlled fluids reacting with the limestone to form the mineralisation, which includes structural and solution breccias.
- ◆ Other North American examples include the Keeneenaw and Porcupine districts of Michigan.
- ◆ One interpretation of the mineralisation at Caribou Dome, as discussed earlier, is that the mineralisation is syngenetic, being formed by the direct precipitation of copper sulphides in a euxinic environment, with the source of the copper being from the basalts of the Nikolai Greenstone.

### Exploration

- ◆ Given the stratabound nature of mineralisation one of the main exploration tools is geology, and mapping out the target stratigraphy.
- ◆ This has been demonstrated at Caribou Dome/Senator, as has geophysics (IP) and geochemistry.
- ◆ Secondary and trace element geochemistry depends on the deposit, source rocks and fluid chemistry, but can include cobalt (Central African Copperbelt amongst others), precious metals, vanadium and molybdenum.

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