

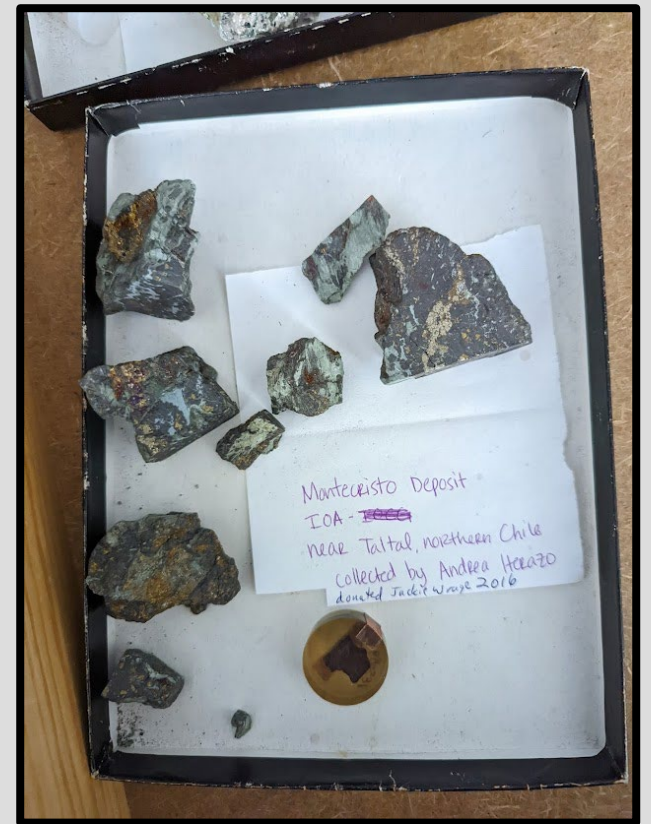
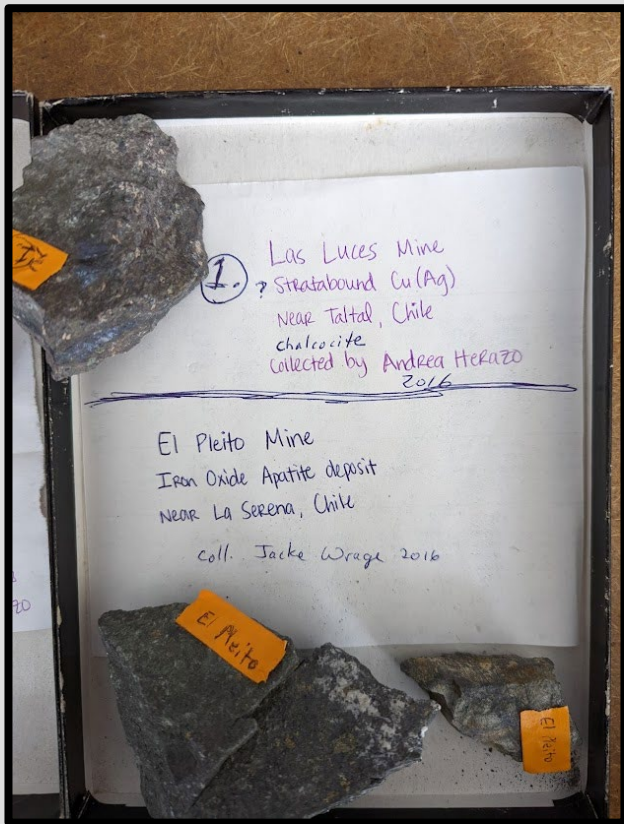
THE PANULCILLO SKARN DEPOSIT

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NDSU Geol 422 – Petrology

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MY MOTIVATIONS



SKARN

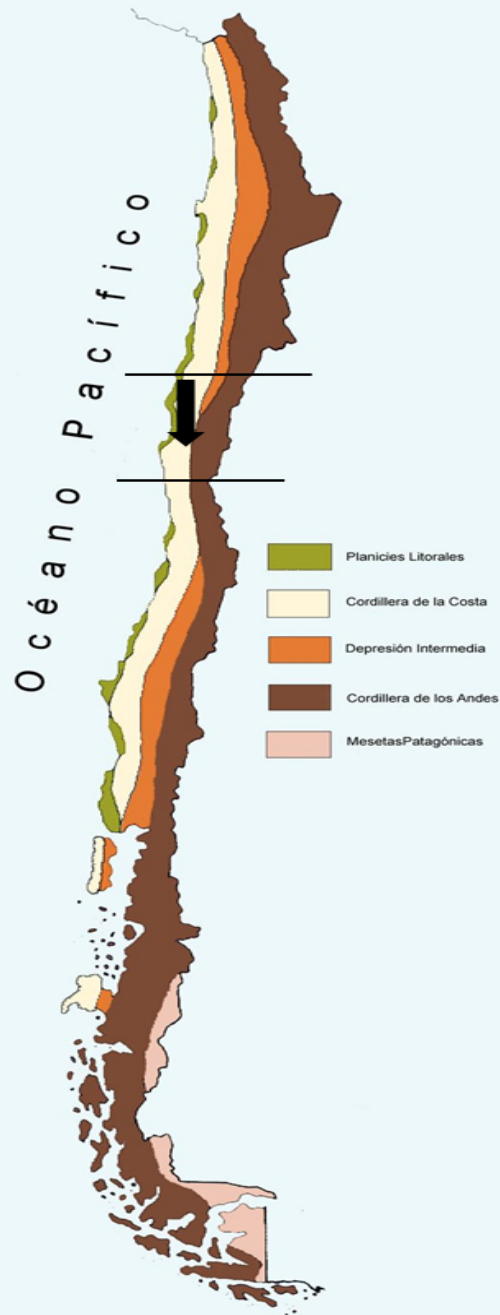
- Metamorphic rock formed by contact metamorphism.
- Skarns are formed when a magma intrudes a body of carbonate sedimentary rock such as limestone. (Gonzales)
- Exoskarn: Formed from sedimentary protolith.
- Endoskarn: Formed from igneous protolith.
- Mostly garnets and pyroxenes are formed together with ore minerals.



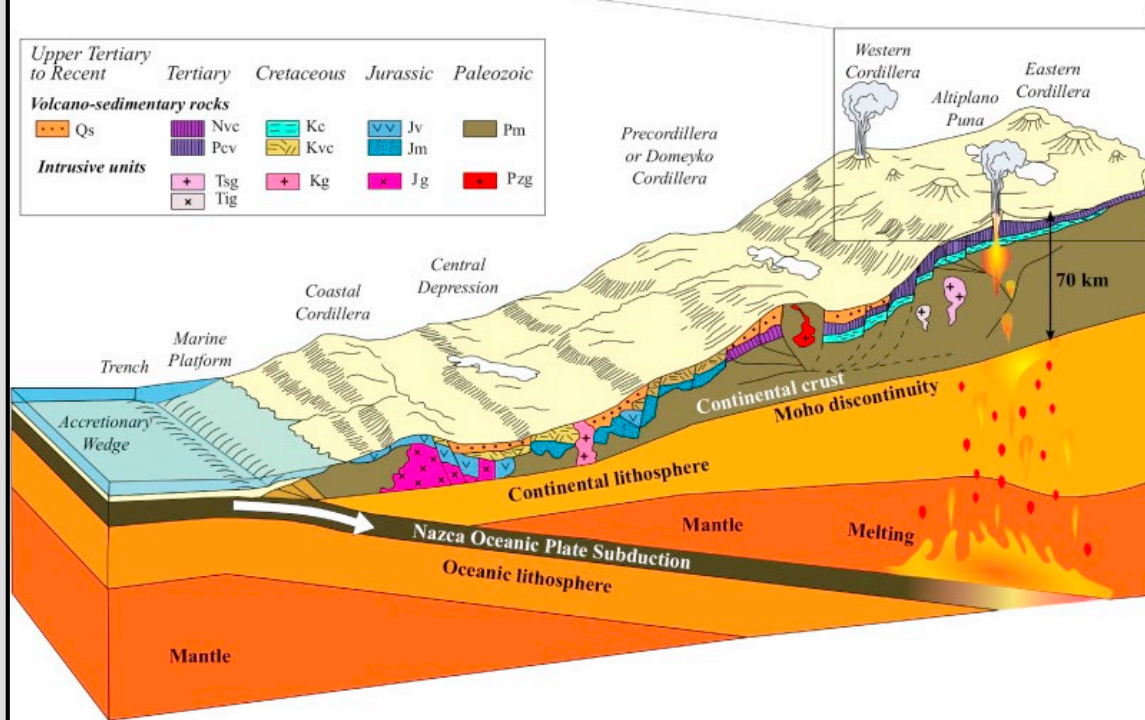
LOCATION

- South of the city La Serena, in the IV region of Chile

Mapa Geomorfológico de Chile

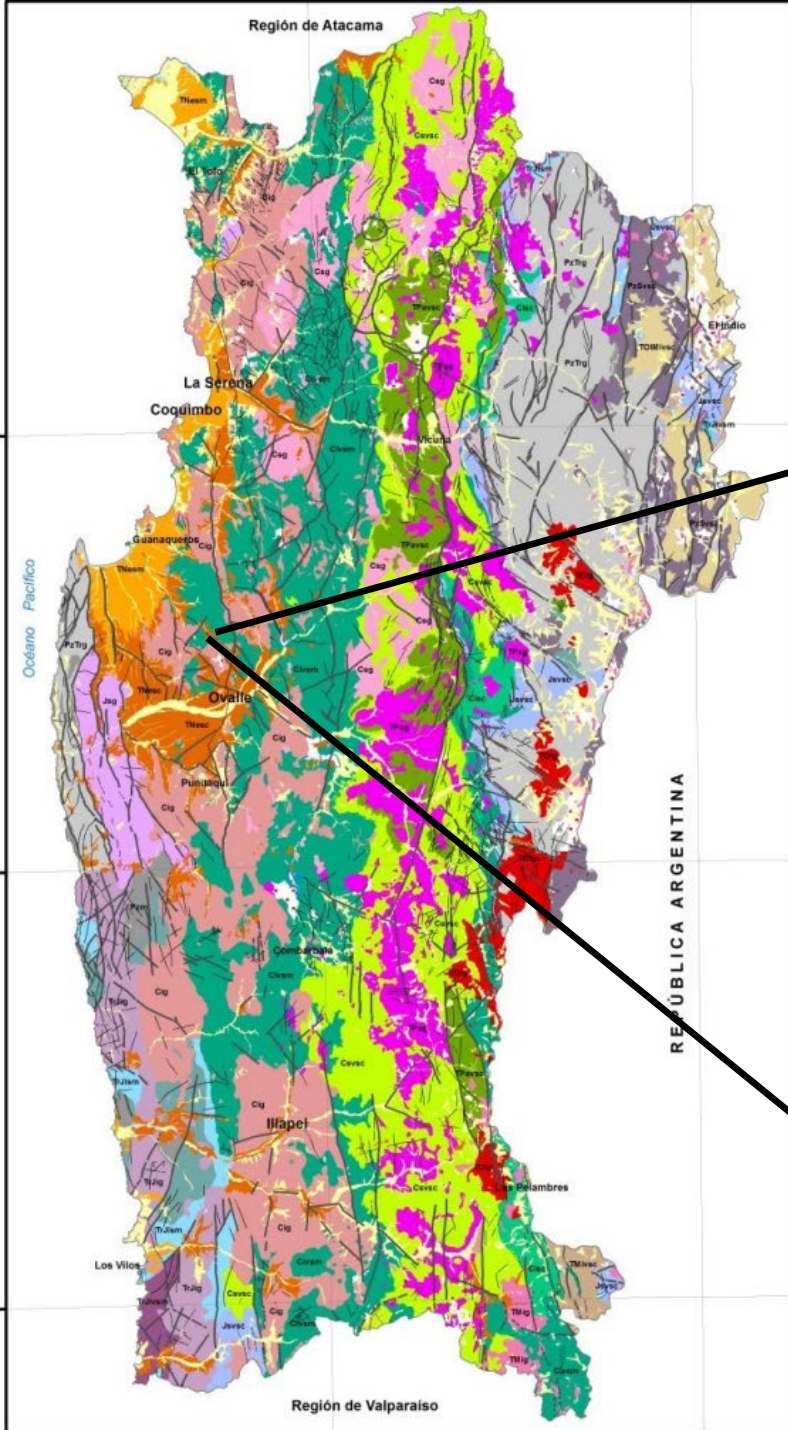


Geomorphology of Chile and Coquimbo Region



Modified from mediateca.cl

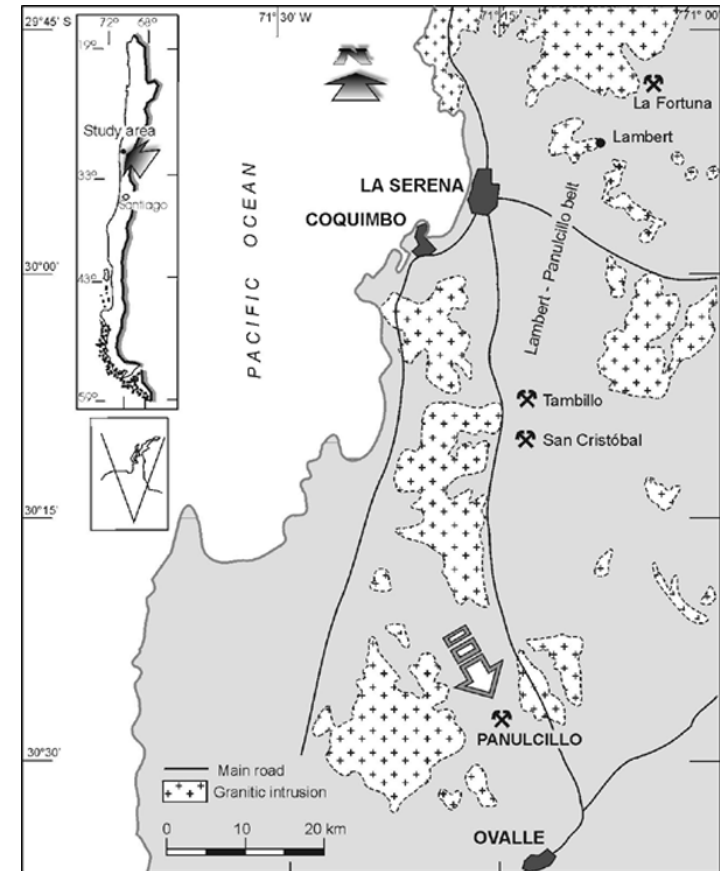
Elevation Profile Google Earth



Modified from Arredondo et al.

GEOLOGIC BACKGROUND

- Cretaceous granitic intrusions.
- Panulcillo deposits are found between two igneous intrusions.
 - Carbonate rock with silica rich magma
 - Results in contact metamorphism..
 - Forming skarn.



- Brown to green, medium grained garnet crystals in a light yellowish-brown, fine grained rock.
- Same yellowish to brown fine-grained matrix but with presence of Sulfur minerals.
 - Pyrite and chalcopyrite.

HAND SAMPLES

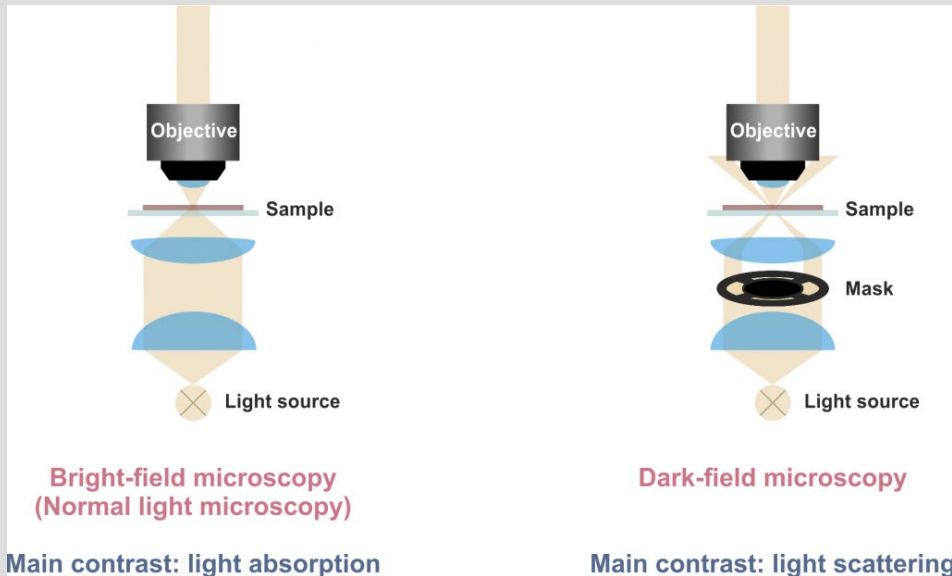


GUIDING QUESTIONS

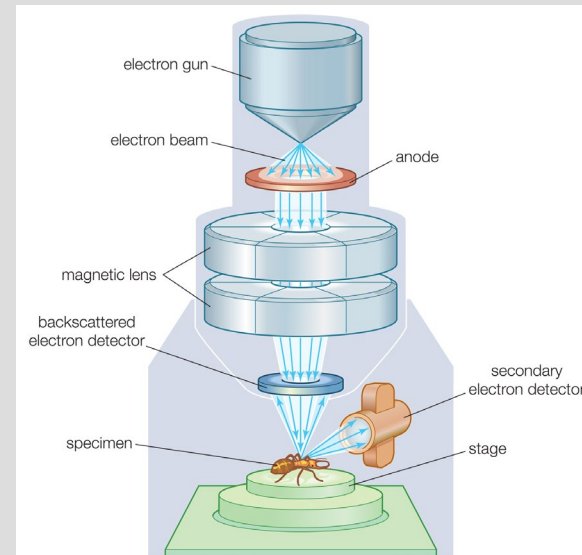
- What type of garnets are the ones found in my sample?
- What ore minerals are found in my sample?
- How does my sample composition compare to those in literature?

METHODS

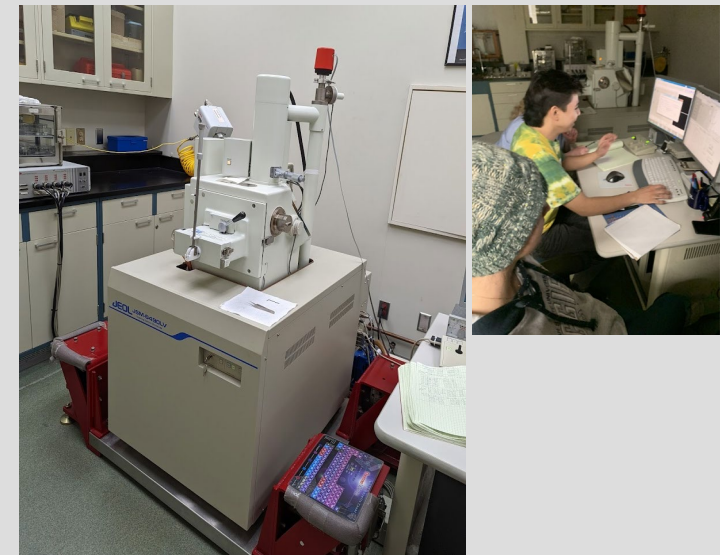
- Reflective and transmitted light microscopy
 - Allowed me to identify both anisotropic and isotropic minerals like chalcopyrite
 - Allowed me to find places of interest in my sample.



- Scanning Electron Microscope (SEM)
 - Allowed me to get data of the composition of my minerals.



Encyclopedia Britannica





STEPS BEFORE DOING LIGHT MICROSCOPY

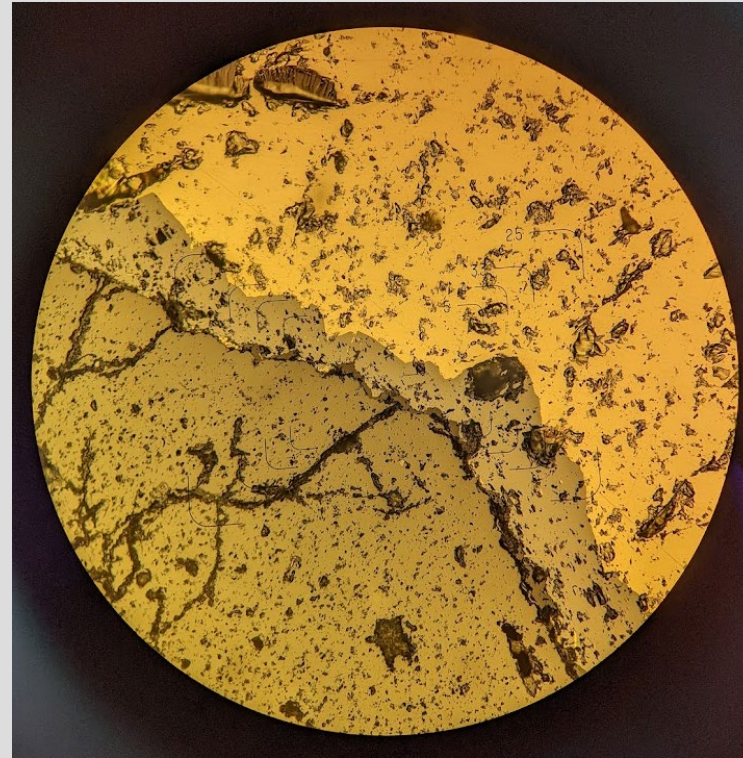
- Cut my rock
- Polish until 600 grid
- Stick it to a sample slide or put into cylinder mold using epoxy
- Let it dry for a whole night
- Cut it again until is thin enough
- Do more polishing
 - Until grid of 1 micron in order to take it to SEM



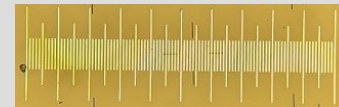
RESULTS: THIN SECTIONS



Mineral: Garnet
Possible zonation of garnets
What type of garnets are present?

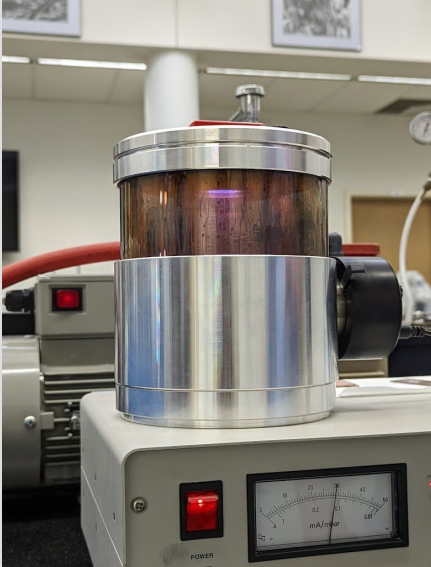


Minerals: chalcopyrite
What are the different shaded minerals?
Is there any star-like crystals of sphalerite as mentioned in literature? (Sugaki et al)

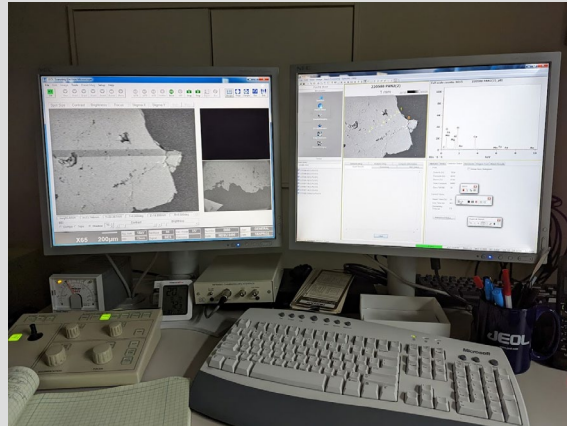
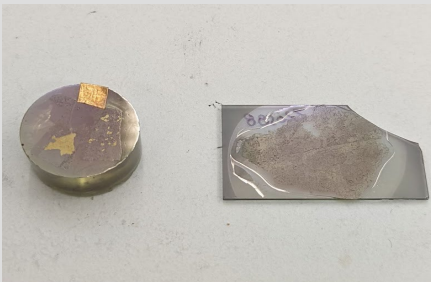


1mm

NEXT STEPS BEFORE THE SEM



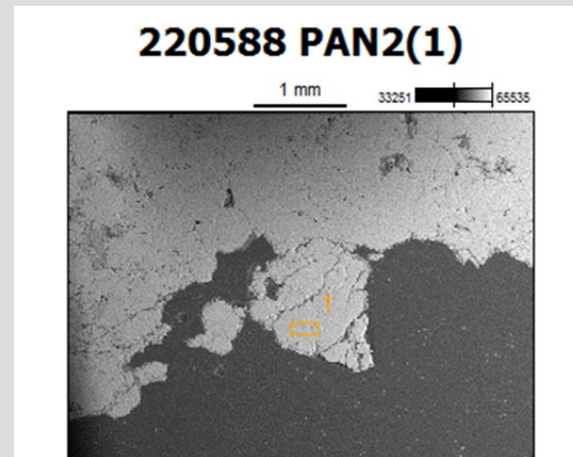
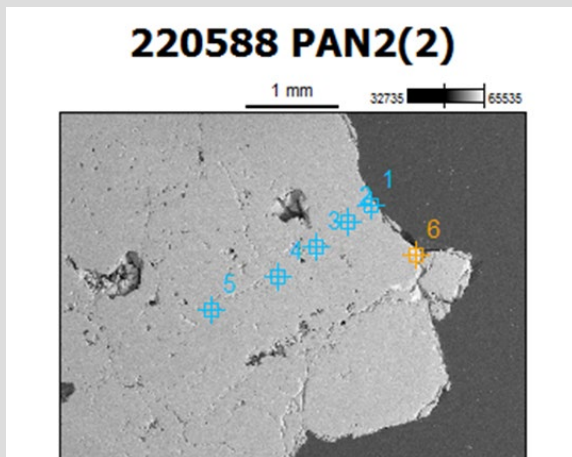
- Coating them
- Selecting points to analyze.
- Jayma put copper arrows to facilitate finding the minerals.



RESULTS: CHEMICAL COMPOSITION OF GARNET

My Data (Panulcillo)							
	PAN2-1	PAN2-2 Pt 1	PAN2-2 Pt 2	PAN2-2 Pt 3	PAN2-2 Pt 4	PAN2-2 Pt 5	PAN2-2 Pt 6
SiO ₂	37.46	38.06	38.69	38.41	38.80	37.11	36.61
TiO ₂	0.27	0.00	0.00	0.00	0.00	0.00	0.00
Al ₂ O ₃	14.97	14.67	13.91	10.06	12.35	13.86	14.20
FeO	9.98	10.22	10.81	15.45	12.50	11.21	10.83
MnO	2.14	1.92	1.62	1.47	1.92	2.22	2.36
MgO	0.52	0.51	0.79	0.00	0.00	0.00	0.00
CaO	34.65	34.62	34.18	34.62	34.43	35.60	36.00
Na ₂ O	0	0.00	0.00	0.00	0.00	0.00	0.00
K ₂ O	0	0.00	0.00	0.00	0.00	0.00	0.00
Total	99.99	100.00	100.00	100.00	100.00	100.00	100.00

- This indicates the presence of ugrandite garnets.
 - More specifically
Grossular or Andradite
- $Ca_3Al_2Si_3O_{12}$ Grossular
- $Ca_3Fe_2Si_3O_{12}$ Andradite



My Data (Panulcillo)							
	PAN2-1	PAN2-2 Pt 1	PAN2-2 Pt 2	PAN2-2 Pt 3	PAN2-2 Pt 4	PAN2-2 Pt 5	PAN2-2 Pt 6
SiO2	37.46	38.06	38.69	38.41	38.80	37.11	36.61
TiO2	0.27	0.00	0.00	0.00	0.00	0.00	0.00
Al2O3	14.97	14.67	13.91	10.06	12.35	13.86	14.20
FeO	9.98	10.22	10.81	15.45	12.50	11.21	10.83
MnO	2.14	1.92	1.62	1.47	1.92	2.22	2.36
MgO	0.52	0.51	0.79	0.00	0.00	0.00	0.00
CaO	34.65	34.62	34.18	34.62	34.43	35.60	36.00
Na2O	0	0.00	0.00	0.00	0.00	0.00	0.00
K2O	0	0.00	0.00	0.00	0.00	0.00	0.00
Total	99.99	100.00	100.00	100.00	100.00	100.00	100.00

LITERATURE DATA

Sugaki et al. Data (Panulcillo)							
	1	2	3	4	5	6	7
SiO2	38.8	38.2	38.1	39	37.7	35.5	37.8
TiO2	0	0	0	0.1	0.8	2.6	0.9
Al2O3	16.7	15.6	14.7	19.1	16.7	14.8	12.4
Fe2O3	8.4	8.7	11	5.2	8.1	11.3	13
MnO	2.6	2.6	2.4	4.6	4.1	2.5	2.1
MgO	0.2	0.2	0.3	0.2	0.1	0.1	0.1
CaO	34.1	35.6	33.5	31.8	32.1	33.7	33.5
Na2O	0	0	0	0	0	0	0
K2O	0	0	0	0	0	0	0
Total	100.8	100.9	100	100	99.6	100.5	99.8

Gonzales Data (Panulcillo)	
SiO2	38
TiO2	0
Al2O3	20.18
Fe2O3	5.32
MnO	1.02
MgO	0.75
CaO	34.7
Na2O	0
K2O	0
Total	99.97

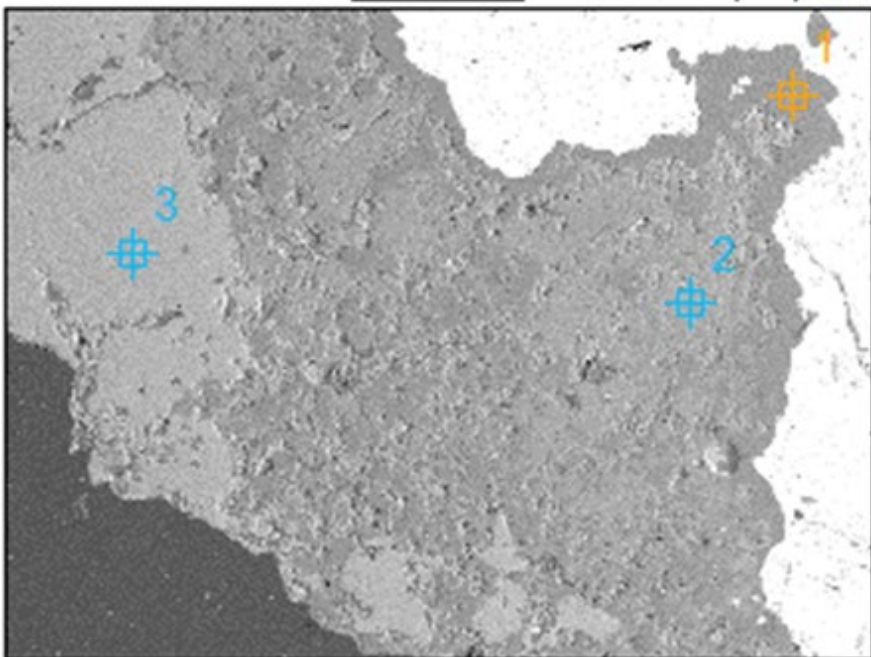
Changyun Data (South Korea)							
	1	2	3	4	5	6	7
SiO2	35.36	35.49	35.64	36.42	36.23	36.36	35.8
TiO2	0	0	0	0.27	0.01	0.01	0.05
Al2O3	0.45	1.46	1.98	6.13	5.47	5.94	5.23
Fe2O3	30.33	28.16	27.3	21.26	22.91	22.81	22.36
MnO	0.23	0.33	0.41	0.41	0.25	0.44	0.4
MgO	0.06	0.21	0.02	0.14	0.05	0.05	0.05
CaO	32.14	33.41	32.85	33.44	34.54	34.61	32.47
Na2O	0	0	0	0	0	0	0
K2O	0	0	0	0	0	0	0
Total	98.57	99.06	98.2	98.07	99.46	100.22	96.36

- Mainly andradite
 $Ca_3Fe_2Si_3O_{12}$

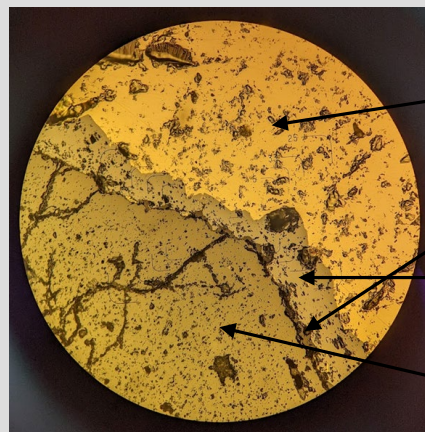
RESULTS FOR MINERALS IN ORE ZONE

220569 PAN3(2)

1 mm 39379 65535



Weight %	PAN3(2) pt1	PAN3(2) pt2	PAN3(2) pt3
O	53.21	28.32	40.39
Si	46.2	0	17.86
Al	0.36	0	6.61
Ca	0	68.92	23.19
Ti	0	0	0.25
Mn	0	2.76	2.08
Fe	0	0	9.62
Total	99.77	100	100



Chalcopyrite (CuFeS_2)

Calcite (CaCO_3)

Quartz

Wollastonite (CaSiO_3)

CONCLUSIONS

- This sample of skarn contains calcium rich garnets more specifically, grossular and andradite.
- It would be predictable to have calcium garnets when it comes to skarns due to its protolith being carbonate sedimentary rocks as we can compare our data to the one in a different location, it is still high in calcium.
- The main ore mineral is chalcopyrite and wollastonite with some quartz and calcite present as well.

REFERENCES

- Arredondo, C., Carrasco, R., Moscoso, R., Prieto, X., Uribe, F., & Pantoja, G. (2014). (rep.). Avance del Mapa de Yacimientos Metalíferos y de Rocas y Minerales Industriales de la región de Coquimbo. Santiago: Gobierno de Chile. Retrieved from <http://sitiohistorico.sernageomin.cl/pdf/presentaciones-geo/Mapa-yacimientos-metaliferos-region-Coquimbo.pdf>.
- Castellon, R. M. (2017). Geología del Yacimiento Punilcillo, Características Geoquímicas y Control Estructural de Cuerpos Mineralizados (thesis). <https://repositorio.uc.cl/handle/11534/22244>
- Changyun Park, Woohyun Choi, Ha Kim, Myong-Ho Park, Il-Mo Kang, Ho-Sun Lee, Yungoo Song, Oscillatory zoning in skarn garnet: Implications for tungsten ore exploration, Ore Geology Reviews, Volume 89, 2017, Pages 1006-1018, ISSN 0169-1368, <https://doi.org/10.1016/j.oregeorev.2017.08.003>.
- González Pacheco, E. (1954). Estudio geológico-económico del distrito minero de Panulcillo y regiones vecinas. Anales de la Facultad de Ciencias Físicas y Matemáticas, 11(11), Pág. 45-92. Consultado de <https://analesfcfm.uchile.cl/index.php/AFCFM/article/view/37050/38636>
- Sugaki, Asahiko & Campos, Eduardo & Kojima, Shoji. (2000). Mineralogy of the Panulcillo skarn copper deposit, Coquimbo Region, Chile. Revista Geologica De Chile - REV GEOL CHILE. 27. 10.4067/S0716-02082000000200001. <http://www.andeangeology.cl/index.php/revista1/article/view/498/html>