Guidebook

Society of Economic Geologists Foundation, Inc. Student-Dedicated Field Course – IOCG and Cu-Ag Andesite-hosted Deposits, Chile

March 6 - 12, 2008

Erich U. Petersen[1]

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[2]New Mexico School of Mines, Socorro, NM, 87801

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This is the fourth in the series of SEG Foundation-sponsored student field courses. The course will emphasize the geology and geochemistry of Cu-Fe-Au systems, considered to be related to "IOCG-type" ore deposits, and of volcanic-hosted Cu-Ag systems comprising "Chilean-type" manto ore deposits. Visits to Mina Carola and Las Pintadas in the Copiapó region will allow participants to observe district-scale and mine-scale exposures of ore deposits variably described as skarns, breccia bodies, veins, replacement bodies, and "other". Additional information can be found on the website: www.mines.utah.edu/pyrite/chile2008/index.html.

In the Chilean coastal cordillera, the Cu-Ag systems hosted by intermediate to felsic volcanic rocks, including the Mantos Blancos District, will be visited. The geochemistry of these systems and the exploration and genetic characteristics of this important class of ore deposits will be emphasized.

The course will begin in Copiapó on the evening of March 6th, and end in Antofagasta on the evening of March 12th. Participants should plan to depart Antofagasta on March 13th or later.

Participants

1.	Acosta, Pedro	Univ Costa Rica (NMT)	pacosta@nmt.edu
2.	Bernabe Evans, Pablo	Universite de Concepcion	pbernabe@udec.cl
3.	Freemantle, Guy	University of the Witwatersrand	redbaron84@gmail.com
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8.	McClenaghan, Lindsay	University of Western Ontario	lmcclena@uwo.ca
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13.	Terracciano, Rosario	University of Napoli	peppe.terracciano@tin.it
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22.	Chávez Jr., William X.	New Mexico Inst. Tech.	wxchavez@nmt.edu
23.	Petersen, Erich U.	University of Utah	erich.petersen@utah.edu

FINAL

Society of Economic Geologists Foundation, Inc.
"IOCG" and Copper – Silver Districts of Northern Chile
6 – 12 March, 2008

Leaders: Dr. William X. Chávez, Jr.
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Date	Itinerary	Overnight
6 March Thursday	**Students**: **10:00 AM** assemble at **Antofagasta airport** for bus ride to Copiapó, (**if starting in Antofagasta**); arrive Copiapó late afternoon. **All**: **7:00PM meeting at Hotel Duna lobby** for logistics, safety, and itinerary discussion. **Students**: **Residencial Plaza**: 56-52-212671 Calle O'Higgins No. 670 Contact: María Cortés Rojas **Professionals**: **Hotel Duna**: Calle O'Higgins Nº 460; telephone: (56)-(52)-240203 Recepción: Elvira <recepcion@dunapart.cl>	Hotel Duna Residencial Plaza Copiapó
7 March Friday	**7:30AM** – Visit **Mina Carola structurally-controlled Cu-Fe-Au** deposit Contact: Ing. Nicolae Pop, Gerente de Geología <nicupop1947@yahoo.ca> Soc. Contractual Minera Carola Teléfono: 56-52-320-001 Secretaria: Orieta Gálvez <orieta.galvez@scmcarola.cl> Contacto: Ing. Constantin Isache (56-52-320-001) Contacto: Stefan Gonzci, geólogo (56-52-320-025)	Hotel Duna Residencial Plaza Copiapó
8 March Saturday	**9:00AM**- Field Visit: **Dr. Mark Barton and graduate student Doug Kreiner** Review of IOCG systems, field characteristics, alteration-mineralization Doug's house is (52)-221-910 Barton in Copiapó: 56-52-224-007	Hotel Duna Residencial Plaza Copiapó
9 March Sunday	**6:00AM** –Visit **Altamira District with andesite-hosted Cu-Ag mantos** Contact: Román Flores (cell: 56-9-2270-243) <rfv@centenariocopper.cl> Contact: Richard Colterjohn (Toronto): (416) 360-0059 <rcolterjohn@glencoban.com> Mine Contact: Lincoyán Hernández: 56-2-207-5086 (Santiago) <lhr@centenariocopper.cl> Hostería Taltal: 56-55-611-625 Contacto: Nury Cortes San Martín Hostal del Mar: 56-55-613-593 Residencial Paranal: Sr. LLamil Jalil Nara Negrete (dueño): 56-55-613-604 Hotel Mi Tampi: 56-55-613-605 Petronila Bodanovich <hotelmitampi@hotmail.com> O'Higgins 138 Taltal	Hostería Taltal Taltal

10 March Monday	**7:00AM** – Visit **Las Luces District with andesite-hosted Cu-Ag mantos** Contact: Julio Kemm V. Gerente Operaciones 56-2-462-3602 (mina) Contact: Juan Carlos Reyes, Geólogo Jefe Exploraciones 56-55-612-558 (mina)	Hotel El Tatio Hotel Costa Marfíl Antofagasta
	Lodging: *Professionals at Hotel El Tatio (**confirmed** 22 January (Alejandro)) **students at Costa Márfil Contact: **hotelcostamarfil**@yahoo.es (Sra. Erika Corrales Poblete) – or Danitza Teléfono: 56-55-225569 (oficina) ó -283590 (oficina) ó 269-361 (público) **Hotel El Tatio**: 56-55-419-111 <consultastatio@123.cl> Contact: Luís Castillo or Alejandro	
11 March Tuesday	**7:00AM** – Depart for **Mina Iván Cu-(Ag) breccia systems** Contact: Jorge Vargas, Gerente General <jvargas@milpo.com> 56-55-415-742 Contact: Carlos Zumarán, Supte. Servicios Técnicos czumaran@milpo.com 56-55-415-717 Contact: Tamara Palma, Geóloga tpalma@milpo.com 56-55-415-714 Milpo in Lima: Lucy Chu Lao: <lchulao@milpo.com>	Antofagasta Hotel El Tatio* Hotel Costa Marfil**
12 March Wednesday	**7:00AM** – Visit **Mantos Blancos volcanic-hosted Cu-Ag system** Contact: Diego Sanhueza <dsanhueza@anglochile.cl> Teléfono: 56-55-693-078 (mina) Contact: César Ulloa (mina) Teléfono: AngloChile office in Santiago: 56-2-230-6000 **7:00 PM** Wally's Pub Farewell Dinner	Hotel El Tatio Hotel Costa Marfil Antofagasta
13 March Thursday	**End of Course – Participants Return on his/her own schedule**	

Logistics: **Safety**

1. All participants **must** have steel toe boots, REFLECTIVE red or orange vests or jackets, sun and clear safety glasses (for underground) and hardhats. Please bring a flashlight for underground mine visits to the smaller mines on our itinerary.

2. Appropriate clothing for mine visits are long-sleeve shirts and long pants.

3. The weather in Copiapó and Antofagasta this time of year is generally warm, with substantial insolation. As such, please drink plenty of water during the field course, and plan for sun protection: sunscreen, lip balm, sunglasses, and perhaps a bandana.

4. The SEGF provides ground transportation during the course, in the form of a full-size bus; please obey all rules as put forth by the bus driver and trip leaders, such as wearing seat belts and placing personal baggage items securely in the overhead racks or under your seats.

5. Participants are responsible for meals; however, some breakfasts are included. At hotels, participants are responsible for all expenses other than lodging – all telephone calls, meals other than included breakfasts, laundry, and the like.

6. Participants are expected to follow ALL safety regulations and rules required at mine sites. As a general rule, mine staff want us to stay together AT ALL TIMES during mine visits, and to be aware of safety issues associated with mines and the mining environment. The field trip leaders will ask about handouts, PowerPoint presentations, etc. Please do not ask our hosts for copies of materials presented before consulting with a field trip leader, as this can be a sensitive issue for the mines.
   Please note that **we carry a first-aid kit with us at all times**; **please report ANY injury or incident to field course leaders immediately**. **Please be very careful with rock hammers and be aware of people around you**.

Miscellaneous

- Money Exchange: Banks and money-changers will exchange currency; some hotels will do so also, although for poorer exchange rates and for limited amounts of money. ATM's are ubiquitous.

- Food: Remember to wash all fruits and vegetables prior to consumption. Water should be bottled or served by the hotel or restaurant, and is generally safe for brushing teeth, washing, showers. It is recommended that you NOT consume mayonnaise, and do not even think of eating a Completo, unless you wish to test the efficacy of your hepatitis vaccine.

- Cameras and computers: Please fill in the requested information for your cameras and computers – this is requested by the mines and their security teams in order to account for materials brought into the mine area.

Minerals Commonly Found in the Oxide Zone of Copper Deposits

Alunite	$KAl_3(SO_4)_2(OH)_6$
Antlerite	$Cu_3SO_4(OH)_4$
Atacamite (paraatacamite, botallackite)	$Cu_2Cl(OH)_3$
Bonattite	$CuSO_4.3H_2O$
Brochanite	$Cu_4SO_4(OH)_6$
Ceruleite	$Cu_2Al_7(AsO_4)_4(OH)_{13}.12H_2O$
Chalcanthite	$CuSO_4.5H_2O$
Chalcosiderite (compare to tourquoise)	$CuFe_6(PO_4)_4(OH)_8.4H_2O$
Chenevixite	$Cu_2Fe_2(AsO_4)_2(OH4.H_2O$
Chrysocolla (mineraloid)	$Cu(Fe,Mn)O_x$-SiO_2-H_2O, with copper content varying from ~20-40 wt % Cu
Copiapite	$Fe_5(SO_4)_6(OH)_2.20H_2O$
Coquimbite	$Fe_2(SO_4)_3.9H_2O$
Goethite	a-FeOOH
Jarosite	$(K,Na)Al_3(SO_4)_2(OH)_6$
Kröhnkite	$Na_2Cu(SO_4)_2.2H_2O$
Levandulite	$NaCaCu_5(AsO_4)_4Cl.5H_2O$
Libethinite	$Cu_2PO_4(OH)$
Paramelanconite	Cu_4O_3 (see tenorite (CuO) and cuprite (Cu_2O)
Poitevinite	$(Cu,Fe,Zn)SO_4.H_2O$
Posnjakite	$Cu_4SO_4(OH)_6.H_2O$
Pseudomalachite	$Cu_5(PO_4)_2(OH)_4$
Scorodite	$FeASO_4.2H_2O$
Turquoise	$CuAl_6(PO_4)_4(OH)_8.4H_2O$
Voltaite	$K_2Fe_8Al(SO_4)_{12}.18H_2O$
Wroewolfeite (Langite)	$Cu_4SO_4(OH)_6.2H_2O$

Some Common Mineral Formulas

Chlorite ..... $(Mg,Fe)_3(Al,Si)_4O_{10}(OH)_2.(Mg,Fe)_3(OH)_6$

Biotite..... $KFe_3AlSi_3O_{10}(OH)_2$

Muscovite..... KAl3Si3O10(OH)2

Kaolinite..... $Al_2Si_2O_5(OH)_4$

Alkali feldspar..... $(K,Na)AlSi_3O_8$

Plagioclase ..... $CaAl_2Si_2O_8$

Dumortierite..... $Al_7O_3(BO_3)(SiO_4)_3$

Tourmaline..... $(Na,Ca)(Li,Mg,Al)(Al,Fe,Mn)_6(BO_3)_3(Si_6O_{18})(OH)_4$

Bornite ..... Cu_5FeS_4

Chalcopyrite..... $CuFeS_2$

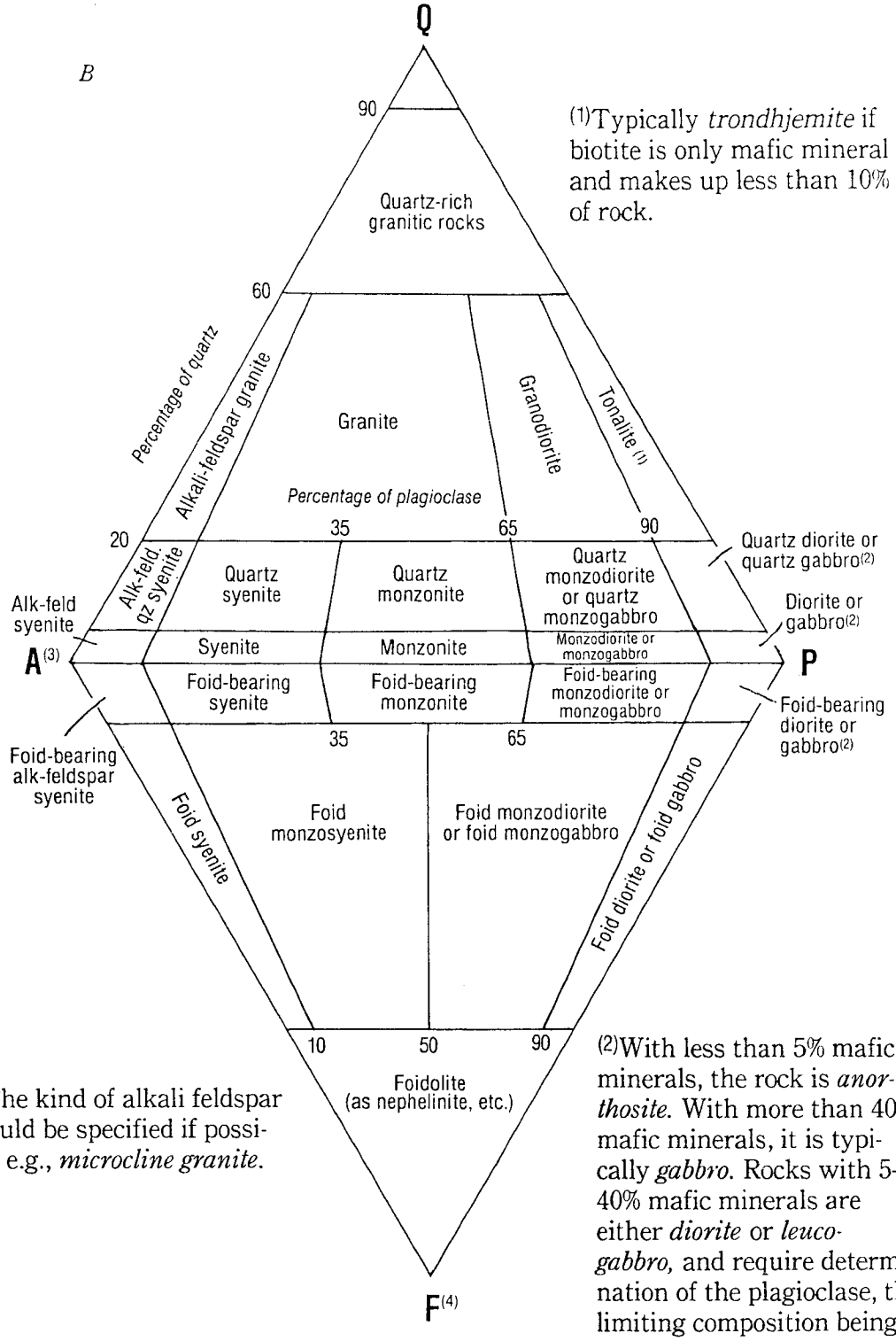
Chalcocite ..... Cu_2S

Covellite..... CuS

Cuprite ..... Cu_2O

Tenorite..... CuO

B

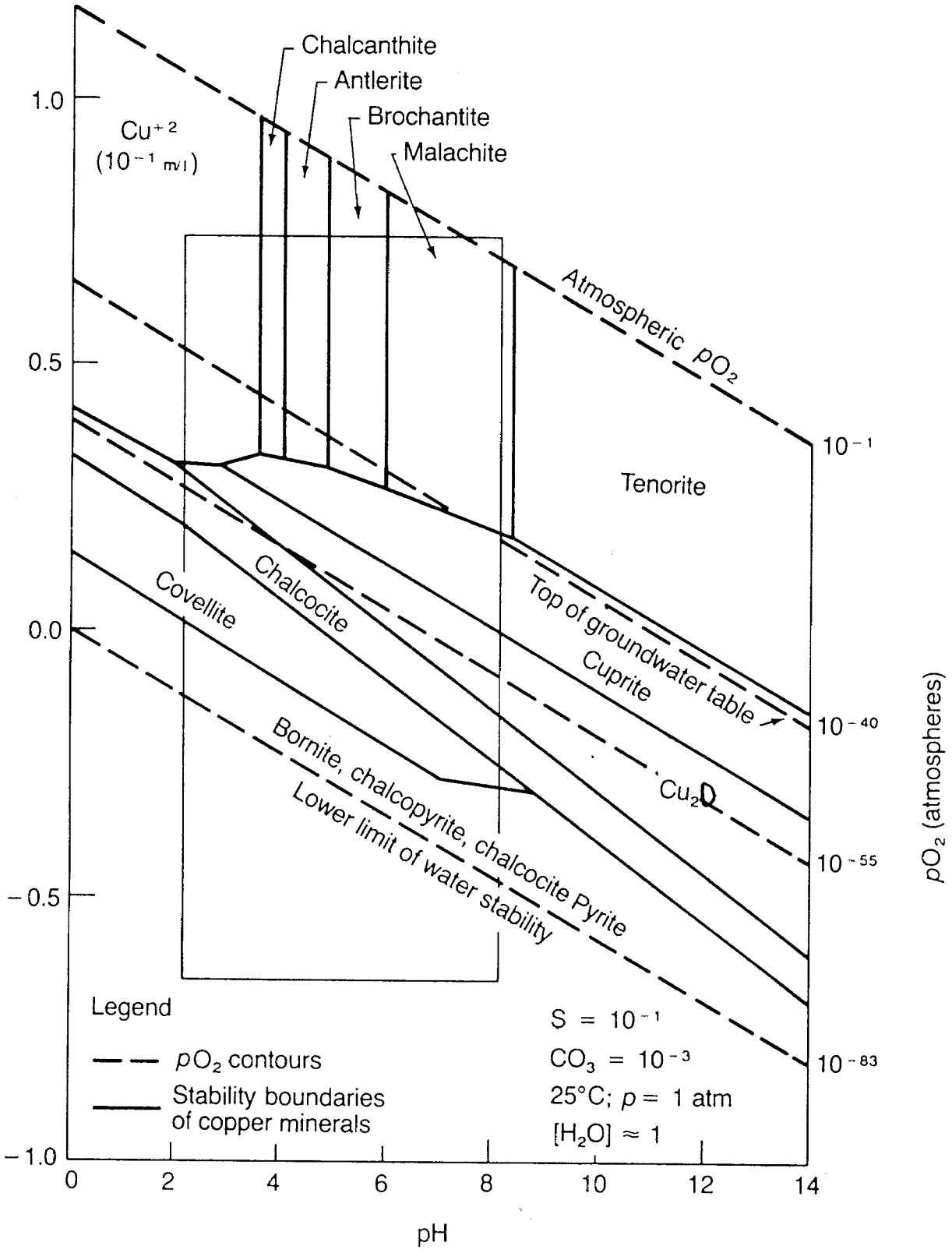


(1)Typically *trondhjemite* if biotite is only mafic mineral and makes up less than 10% of rock.

(2)With less than 5% mafic minerals, the rock is *anorthosite.* With more than 40% mafic minerals, it is typically *gabbro.* Rocks with 5-40% mafic minerals are either *diorite* or *leucogabbro,* and require determination of the plagioclase, the limiting composition being An_{50}.

(3)The kind of alkali feldspar should be specified if possible; e.g., *microcline granite.*

(4)The feldspathoid should be specified in each rock name; e.g., *nepheline syenite.*


Chalcanthite
Antlerite
Brochantite
Malachite
Cu+2
(10−1 m/l)
Atmospheric pO2
Tenorite
Top of groundwater table
Cuprite
Chalcocite
Covellite
Cu2O
Bornite, chalcopyrite, chalcocite Pyrite
Lower limit of water stability
10−1
10−40
10−55
10−83
1.0
0.5
0.0
−0.5
−1.0
0
2
4
6
8
10
12
14
pH
pO2 (atmospheres)
Legend
pO2 contours
Stability boundaries of copper minerals
S = 10−1
CO3 = 10−3
25°C; p = 1 atm
[H2O] ≈ 1

(*b*)

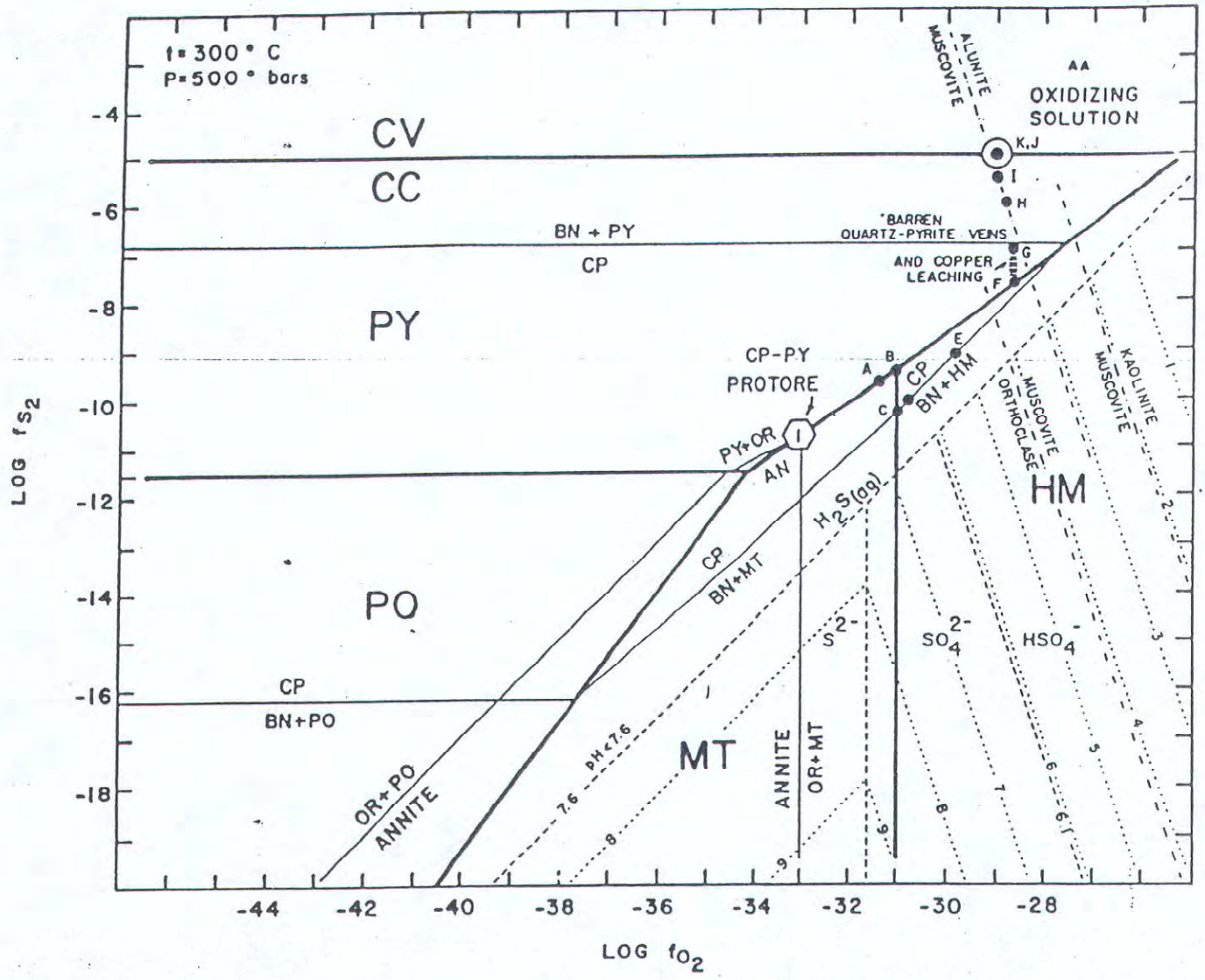


Figure 34. Isothermal isobaric fugacity diagram showing the stability fields of covellite (CV), chalcocite (CC), pyrite (PY), pyrrhotite (PO), magnetite (MT), and hematite (HM). Chalcopyrite field is surrounded by bornite plus an additional sulfide. Annite stability field is surrounded by orthoclase plus sulfides and oxides. Position of potassium-silicate protore at Butte, Montana is given at 1. Position of advanced argillic alteration assemblage and Main Stage oxidizing fluid is at the intersection of CV-CC phase boundary and that of alunite- muscovite. From Brimhall (1980) and Brimhall and Ghiorso (1983).

Acknowledgements

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Useful References

Williams, P.J., Barton, M.D., Johnson, D.A., Fontboté, L., de Haller, A., Mark, G., and Oliver, N.H.S., 2005, Iron Oxide Copper-Gold Deposits: Geology, Space-Time Distribution, and Possible Modes of Origin. Economic Geology 100th Anniversary Volume 371-405.