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TITLE OF THESIS FLUID INCLUSION AND STABLE ISOTOPE STUDIES OF THE GOLD DEPOSITS IN OKANAGAN VALLEY, BRITISH COLUMBIA

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Dusty Fairv

ABSTRACT

Two kinds of gold mineralization, epithermal and mesothermal, occur in the Okanagan Valley, southern British Columbia. Fluid inclusion and stable isotope studies indicate that two distinctive hydrothermal fluids were responsible for the mineralization events. At Dusty Mac, the epithermal fluid had a temperature of about 240°C, a low salinity of about 0.5 wt% NaCl equivalent and a low value for $\delta^{18}O(SMOW)$= -7--9 per mil. The mineralization process probably occurred at a depth of more than 380 meters. At Oro Fino and Fairview, the mesothermal fluids had a high CO_2 content, temperatures of 280°-330°C, salinities of 4-6 wt% NaCl equivalent and $\delta^{18}O(SMOW)$ of +4-+6 per mil. The mineralization occurred at a depth of 3-4 km. The data indicate that fluids involved in both mineralization processes originated from meteoric water, with the shallow circulation responsible for the epithermal deposit(Dusty Mac) and deep circulation for the mesothermal ones(Oro Fino and Fairview).

TABLE 1. MICROTHERMOMETRY DATA

Sample	Mineralogy	Inclusion type	Temperature (°C) $TmCO_2$ Range	Mean	Tmice Range	Mean	Tmclath Range	Mean	$ThCO_2$ Range	Mean	Th Range	Mean
					DUSTY	MAC						
D-14-V	Qtz	3			-0.3--2.6(11)	-1.5					236-303(13)	264
		4			-0.7(1)						131-209(5)	184
D-15	Qtz	3			-0.3--1.0(7)	-0.5					163-283(18)	219
		4			-0.2-0.0(2)	-0.1					116-146(6)	131
D-29-V	Qtz	3			-0.3--0.9(9)	-0.5					193-295(24)	242
		4									148-186(3)	163
D-13	Qtz	3			-0.3--1.0(6)	-0.5					168-284(11)	228
D-28	Qtz	3			-0.2--1.1(7)	-0.4					161-276(19)	215
D-29-B	Qtz	3			-0.6-0.0(5)	-0.3					204-276(10)	234
					ORO FINO							
O-1	Qtz	1									318-349(3)	333
		4									197-221(2)	212
O-8	Qtz	1	-56.9--57.3(4)	-57.1			7.7-8.1(4)	7.9	30.2-30.9(4)	30.5	289-323(4)	301
O-11	Qtz+py	1	-56.7--56.8(2)	-56.8			5.5-7.1(2)	6.3	28.6-29.4(2)	29.0	302-314(2)	308
		3			-0.4-0.0(9)	-0.2					246-351(12)	310
O-12	Qtz+Py	1	-56.6--57.5(8)	-57.0			5.6-7.3(9)	6.5	27.0-30.3(10)	29.1	277-343(10)	298
		3									251-318(3)	278
					TWIN	LAKE						
T-10	Qtz	1	-56.5--57.1(5)	-56.9			4.8-8.3(9)	6.3	21.7-31.0(15)	27.1	264-342(19)	306
T-11	Qtz	1	-56.9--57.2(2)	-57.1			7.0-7.7(2)	7.4	28.1-28.4	28.3	285-303(5)	294
		2	-57.0--57.3(2)	-57.2					27.0-29.9(2)	28.5		
		3			-1.3-0.0(4)	-0.7					250-302(7)	270
		4			-0.7--2.2(4)	-1.6					160-201(10)	177
T-12	Qtz	3			-5.1--5.7(3)	-5.5					220-328(9)	267
					STEMWINDER							
S-3	Qtz	1	-56.6--57.1(5)	-56.9			6.1-8.5(9)	7.5	8.9-27.6(13)	20.0	229-313(21)	263
		4									172-199(4)	186
S-8	Qtz	1	-56.8--58.3(7)	-57.6			8.1-9.6(12)	9.0	17.0-27.1(12)	21.1	245-320(21)	285
		2	-56.5						12.9			
S-12	Qtz+Py	1	-56.9--57.5(8)	-57.2			7.6-9.5(16)	8.7	16.2-27.5(19)	24.7	224-313(31)	258
		4			-0.3--0.7(2)	-0.5					168-238(7)	190

salinity of 0.5 wt% NaCl equivalent.

Only a few of the secondary inclusions were large enough for measurement. Their homogenization temperatures range from 116°C to 209°C.

5.3.2 Oro Fino

The samples of Oro Fino and Twin Lake deposits used for the study were collected from the veins near the main shafts and waste dumps.

Both CO_2-H_2O and aqueous inclusions were observed in the samples from Oro Fino, but the CO_2-H_2O type dominates. The inclusions are generally smaller than 10 μm. At room temperature, the CO_2-H_2O inclusions usually show three phases(liquid H_2O, liquid CO_2 and vapor CO_2). The CO_2 phase is about 10 to 30 volume percent of the inclusion. The vapor bubbles of aqueous inclusion occupy a similar percentage of the volume.

Homogenization temperatures of the CO_2 phase range from 27.0°C to 30.9°C, with the average of 29.4°C. This gives a CO_2 density of 0.62 g/cm^3. The range of melting temperatures of clathrate is from 5.5°C to 8.1°C and the corresponding salinity ranges from 3.8 to 8.3 wt% NaCl equivalent. Average melting temperature of clathrate of 6.4°C corresponds to a salinity of 6.8 wt% NaCl equivalent. Homogenization of H_2O-CO_2 varies from 277°C to 349°C, with an average of 305°C.

Determinations of the depression of the freezing point of aqueous inclusions range from 0.0°C to -0.4°C(sample

O-11), which is equivalent to 0.0 to 0.7 wt% NaCl. This is somewhat lower than that measured for CO_2-H_2O inclusions. Homogenization temperatures of aqueous inclusions range from 246°C to 351°C, with an average of 304°C.

Three secondary inclusions have the homogenization temperatures of 197°C to 227°C, with an average of 212°C.

5.3.3 Twin Lake

The characteristics of inclusions from the Twin Lake deposit are very similar to that of Oro Fino, but a few CO_2 inclusions were observed at Twin Lake.

For CO_2-H_2O inclusions, melting temperatures of clathrate are from 4.8°C to 8.3°C, which is equivalent to 3.4 to 9.4 wt% NaCl equivalent. The average melting temperature of clathrate of 6.5°C correponds to a salinity of 6.6 wt% NaCl equivalent. The average homogenization temperature of 27.4°C for the CO_2 phase gives a CO_2 density of 0.66 g/cm^3. The total homogenization temperatures range from 264°C to 342°C, with an average of 307°C.

Sample T-11 gives an average melting temperature of ice for aqueous inclusions of -0.7°C, but the sample T-12 gives an average of -5.5°C. Two temperatures indicate salinities of 1.2 and 8.6 wt% NaCl equivalent, respectively. Homogenization temperatures of aqueous inclusions range from 195°C to 301°C, with the average of 246°C.

Two CO_2 inclusions in sample T-11 have melting temperature of solid CO_2 at -57.2°C and homogenization

TABLE 4. OXYGEN ISOTOPIC COMPOSITIONS OF QUARTZ AND ROCKS FROM ORO FINO AND TWIN LAKE

Sample	Mineral/Rock	$\delta^{18}O$
O-1	Quartz	+11.8
O-8	Quartz	+12.3
O-11	Quartz	+12.5
O-6	Amphibolite	+5.2
O-7	Amphibolite	+6.7
O-18	Gneissic amphibolite	+4.4
T-1	Gneissic amphibolite	+3.4
T-4	Amphibolite	+1.9
T-10	Quartz	+11.8
T-11	Quartz	+10.8
T-12	Quartz	+12.7

TABLE 5. SUMMARY OF THE CHARACTERISTICS OF HYDROTHERMAL ORE-FORMING FLUIDS IN THE OKANAGAN VALLEY

	Dusty Mac	Oro Fino	Fairview
Temperature (°C)	≈240	≈330	≈280
Depth (meters)	≥380	≈3600	≈4000
Salinity (wt%NaCl)	≈0.5	≈6	≈4
CO_2 content	Very low	High	High
$\delta^{18}O_{H_2O}$SMOW(‰)	-7--9	+4-+6	+4-+6
$\delta^{13}C_{CO_2}$PDB(‰)			-8--9
W/R ratio	1-2		

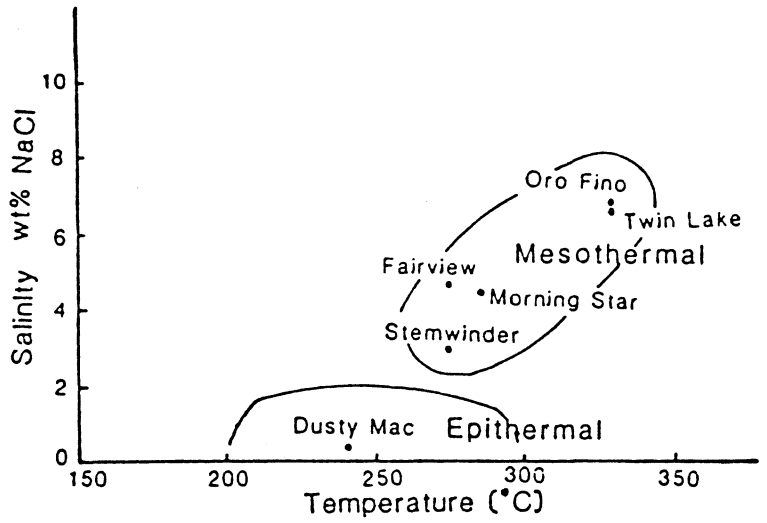

Fig. 23. Temperature-salinity relationship of the hydrothermal ore-forming fluids in the Okanagan Valley.

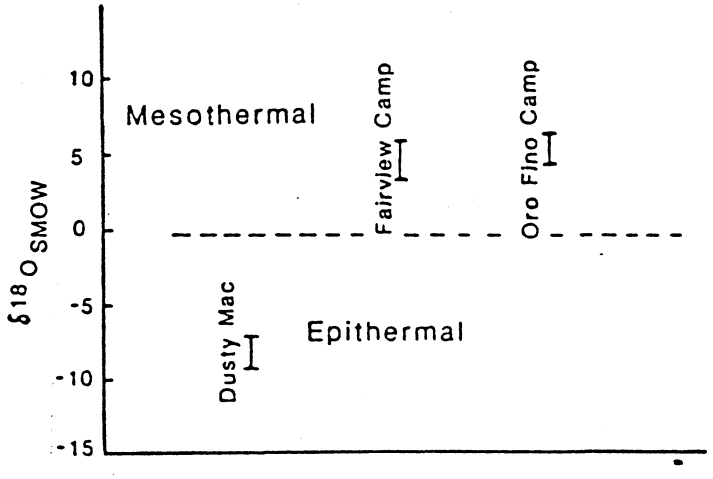

Fig. 24. Oxygen isotopic compositions of the hydrothermal ore-forming fluids in the Okanagan Valley.

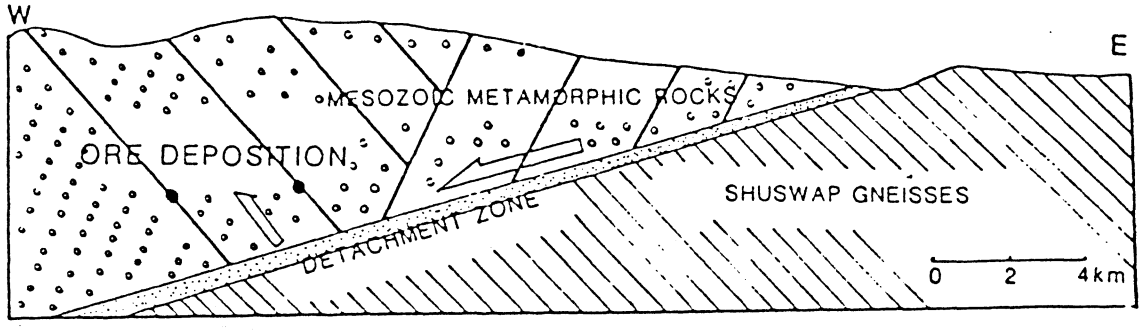

Fig. 26A. Idealized cross section showing the detachment zone and extensional fault system as channel for deep circulation of meteoric water. The ore deposited when the fluids ascend along the faults.

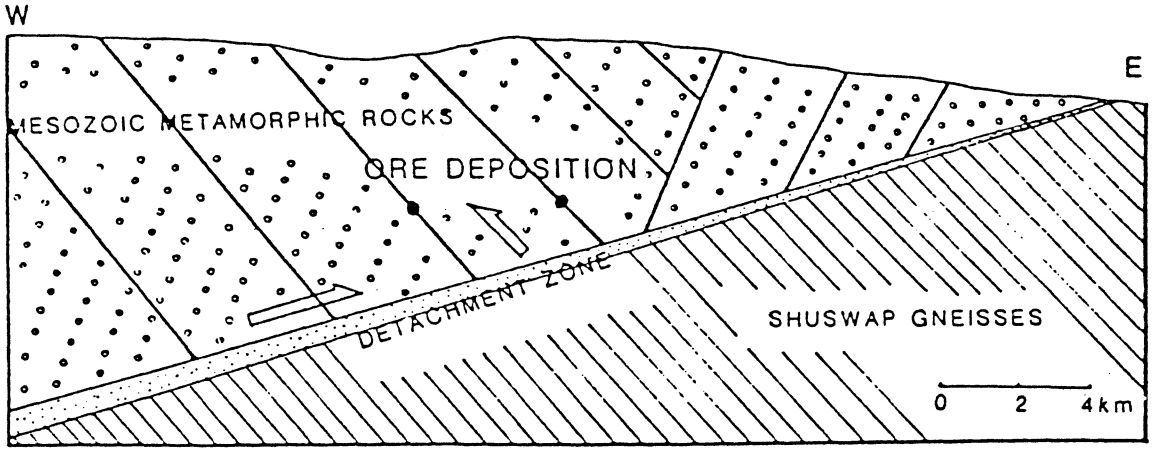

Fig. 26B. Cross section showing the fluids flowing along the detachment zone from west to east.

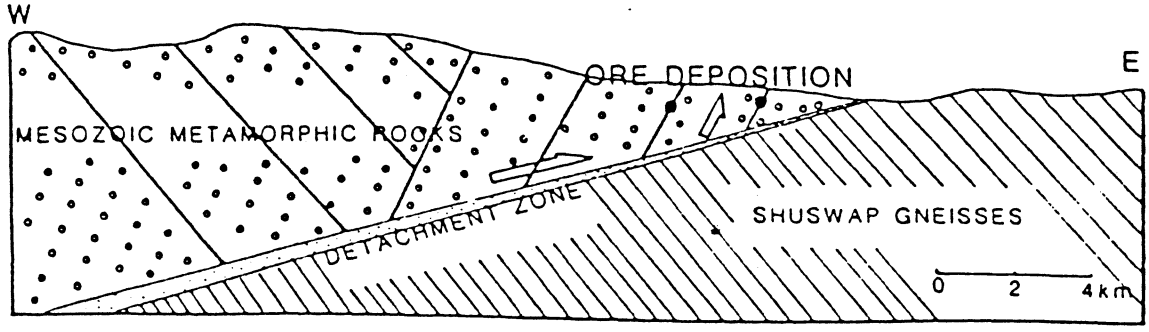

Fig. 26C. Tempelman-Kluit's(1984) mineralization model.