Developments in Mineral Deposit Modeling

JAMES D. BLISS, Editor

U.S. GEOLOGICAL SURVEY BULLETIN 2004

U.S. DEPARTMENT OF THE INTERIOR
MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY
Dallas L. Peck, Director

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1992

For sale by the
Books and Open-File Reports Section
U.S. Geological Survey
Federal Center, Box 25425
Denver, CO 80225

Library of Congress Cataloging-in-Publication Data

Developments in mineral deposits modeling / James D. Bliss, editor.
p. cm. — (U.S. Geological Survey bulletin ; 2004)
Includes bibliographical references.
Supt. of Docs. no. : I 19.3:2004
1. Ore deposits. 2. Mines and mineral resources. I. Bliss, James D. II. Series.

QE75.B9 no. 2004	557.3 S—dc20	91–40084
[TN263]	[622'1]	CIP

CONTENTS

Introduction and overview of mineral deposit modeling, by Dan L. Mosier and James D. Bliss 1

Numerical mineral deposit models, by Richard B. McCammon 6

DEPOSIT MODELS

11d Descriptive model of thorium-rare-earth veins, by Mortimer H. Staatz 13
Grade and tonnage model of thorium-rare-earth veins, by James D. Bliss 16
19c Descriptive model of distal disseminated Ag-Au, by Dennis P. Cox 19
Grade and tonnage model of distal disseminated Ag-Au, by Dennis P. Cox and Donald A. Singer 20
25a Grade and tonnage model of hot-spring Au-Ag, by Byron R. Berger and Donald A. Singer 23
26a Grade and tonnage model of sediment-hosted Au, by Dan L. Mosier, Donald A. Singer, William C. Bagby, and W. David Menzie 26
28a.1 Grade and tonnage model of Sierran kuroko deposits, by Donald A. Singer 29
32e Descriptive model of solution-collapse breccia pipe uranium deposits, by Warren I. Finch 33
Grade and tonnage model of solution-collapse breccia pipe uranium deposits, by Warren I. Finch, Charles T. Pierson, and Hoyt B. Sutphin 36
34f Descriptive model of oolitic ironstones, by J.B. Maynard and F.B. Van Houten 39
Grade and tonnage model of oolitic ironstones, by Greta J. Orris 41
36a.1 Grade and tonnage model of Chugach-type low-sulfide Au-quartz veins, by James D. Bliss 44
38g Descriptive model of laterite-saprolite Au, by Gregory E. McKelvey 47
Grade and tonnage model of laterite-saprolite Au, by James D. Bliss 50

Preliminary descriptive deposit model for detachment-fault-related mineralization, by Keith R. Long 52

40a Descriptive model of detachment-fault-related polymetalic deposits, by Keith R. Long 57

References cited 59

APPENDIXES

A. Classification of deposit models by lithologic-tectonic environment 63
B. Locality abbreviations 64
C. Taxonomy used to define the attributes of numerical mineral deposit models 64
D. Worksheets for numerical mineral deposit models 79
E. Minerals identified in solution-collapse breccia pipe uranium deposits 168

FIGURES

1. Sketch of idealized model showing relationship of thorium-rare-earth veins to alkalic rocks and carbonatites **15**

2–19. Graphs showing:

2. Tonnages of thorium-rare-earth veins **17**
3. Thorium-oxide grades of thorium-rare-earth veins **17**
4. Rare-earth-oxide grades of thorium-rare-earth veins **18**
5. Tonnages of distal disseminated Ag-Au deposits **21**
6. Gold grades of distal disseminated Ag-Au deposits **21**
7. Silver grades of distal disseminated Ag-Au deposits **22**
8. Tonnages of hot-spring Au-Ag deposits **24**
9. Gold grades of hot-spring Au-Ag deposits **24**
10. Silver grades of hot-spring Au-Ag deposits **25**
11. Tonnages of sediment-hosted Au deposits **27**
12. Gold grades of sediment-hosted Au deposits **28**
13. Silver grades of sediment-hosted Au deposits **28**
14. Tonnages of Sierran kuroko deposits **30**
15. Copper grades of Sierran kuroko deposits **30**
16. Zinc grades of Sierran kuroko deposits **31**
17. Lead grades of Sierran kuroko deposits **31**
18. Gold grades of Sierran kuroko deposits **32**
19. Silver grades of Sierran kuroko deposits **32**

20 Schematic cross section of a solution-collapse breccia pipe in the Grand Canyon region, showing the general distribution of uranium ore within the pipe **35**

21. Graph showing tonnages of solution-collapse breccia pipe uranium deposits **36**
22. Graph showing uranium-oxide grades of solution-collapse breccia pipe uranium deposits **37**
23. Scatter plot of logarithms of uranium-oxide grade vs. tonnage of uranium ore **38**
24. Diagram of generalized stratigraphic model for oolitic ironstones **40**

25–31. Graphs showing:

25. Tonnages of oolitic ironstone deposits **41**
26. Iron grades of oolitic ironstone deposits **42**
27. Silica grades of oolitic ironstone deposits **42**
28. Phosphate grades of oolitic ironstone deposits **43**
29. Tonnages of Chugach-type low-sulfide Au-quartz vein deposits **45**
30. Gold grades of Chugach-type low-sulfide Au-quartz vein deposits **45**
31. Silver grades of Chugach-type low-sulfide Au-quartz vein deposits **46**

32. Sketch of idealized cross section of laterite-saprolite Au deposit **47**
33. Graph showing tonnages of laterite-saprolite Au deposits **50**
34. Graph showing gold grades of laterite-saprolite Au deposits **51**
35. Location map of major detachment faults and detachment-fault-related mineral deposits in Arizona, southeastern California, and southernmost Nevada **53**
36. Schematic diagram showing structural position of detachment-fault-related polymetallic mineralization, Ba-F-Mn veins, and lacustrine manganese mineralization in detachment-faulted terranes **54**

TABLES

1. Quantization levels for presence/absence of particular mineral deposit 7
2. Quantization levels and associated scores for mineral deposit models 8
3. Worksheet for numerical model of Sn greisen deposits 10
4. Comparison of classification between Prospector II and panel of geologists using the Cox-Singer deposit classification for 124 metalliferous lode deposits in Alaska (Nokleberg and others, 1987) 11
5. Grades and tonnages of distal disseminated Ag-Au deposits 20
6. Grades and tonnages of hot-spring Au-Ag deposits 23
7. Grades and tonnages of sediment-hosted Au deposits 27
8. Grades and tonnages of Sierran kuroko deposits 29
9. Summary statistics of chemical analyses of one selected sample from each of the five solution-collapse breccia pipe uranium deposits 38
10. Grades and tonnages for detachment-fault-related polymetallic deposits 56

GRADE AND TONNAGE MODEL OF CHUGACH-TYPE LOW-SULFIDE Au-QUARTZ VEINS

By James D. Bliss

COMMENTS Vein deposits in the Chugach National Forest, Alaska, have gross deposit characteristics that are consistent with the descriptive model for low-sulfide Au-quartz veins (Berger, 1986c). However, grade and tonnage data collected from these deposits during the preparation of the quantitative mineral resource assessment of undiscovered mineral deposits in the Chugach National Forest showed that the typical deposit has about half the tonnages and half the Au grades as those for low-sulfide Au-quartz veins elsewhere (Bliss, 1986). An important regional aspect of these deposits appears be the absence of association with batholithic-scale intrusive bodies, as is commonly found with low-sulfide Au-quartz vein deposits elsewhere. These low-sulfide Au-quartz veins are a subtype, here referred to as "Chugach-type low-sulfide Au-quartz veins." They are located along faults and joints without a "consistent association with igneous activity" (Goldfarb and others, 1986). Major regional faults with mineralization are absent in the Chugach National Forest; such faults are important sites of mineralization for these low-sulfide Au-quartz vein deposits elsewhere. Fluid inclusion data for this area suggest that these deposits were deposited by low-salinity fluids generated by low-grade metamorphism (Goldfarb and others, 1986). The host rocks in the Chugach National Forest are metamorphosed to medium greenschist facies. A distinctive local characteristic of these deposits is that they exhibit much less wall-rock alteration (Goldfarb and others, 1986) than low-sulfide Au-quartz veins elsewhere (Berger, 1986c).

Data for Chugach-type low-sulfide Au-quartz veins are from deposits in or adjacent to the Chugach National Forest and may bias the grade and tonnage model in ways not identified. Deposit definition was made using the same spatial rules concerning proximity of workings as in the model for low-sulfide Au-quartz veins (that is, properties within one mi of each other are aggregated) (Bliss, 1986). Data sources are from Jansons and others (1984) and the U.S. Geological Survey computerized data base on mineralized occurrences, prospects, and mines (the Minerals Resources Data System (MRDS)). In some cases, an estimate of tonnage was made using the technique developed by Bliss (1988). Significant correlation is present between Ag and Au grades (n=21, r=0.77); this is also the case for low-sulfide Au-quartz vein deposits (Bliss, 1986). More Ag grades were found in Chugach-type low sulfide Au-quartz vein deposits (70 percent) than in low sulfide Au-quartz vein deposits (10 percent) (Bliss, 1986). When Ag grades are reported for Chugach-type low-sulfide Au-quartz vein deposits, it is typically from 6 to 40 percent of Au grade compared with 11 to 89 percent for low-sulfide Au-quartz vein deposits. The data giving the ratio of Ag to Au grades between the main deposit type and the subtype are not significantly different at the 5 percent level (Mann-Whitney U Test). See appendix B for locality abbreviations. See introduction for explanation of the grade and tonnage model as shown in figures 29–31.

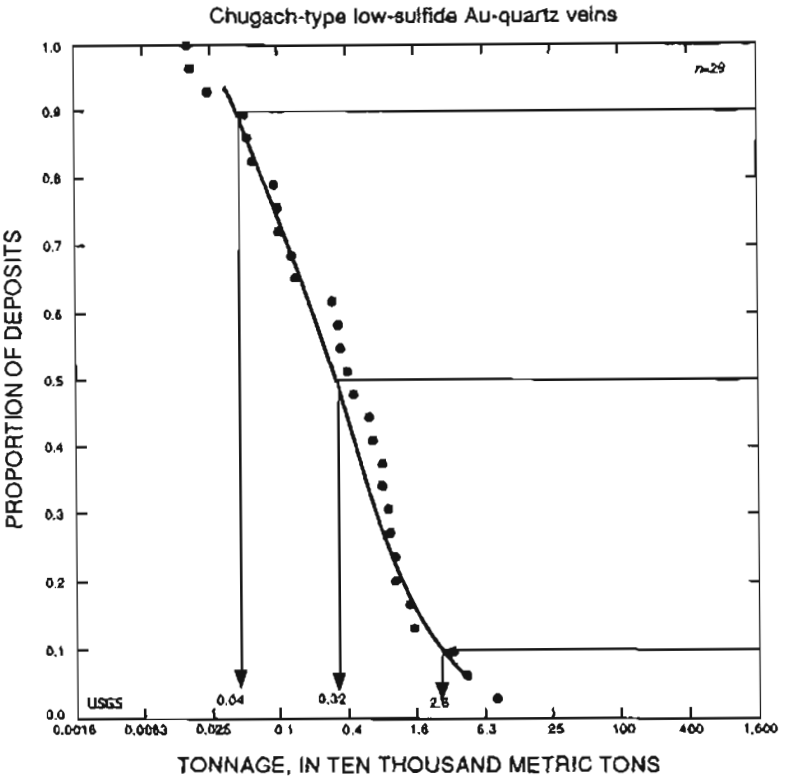

Figure 29. Tonnages of Chugach-type low-sulfide Au-quartz vein deposits.

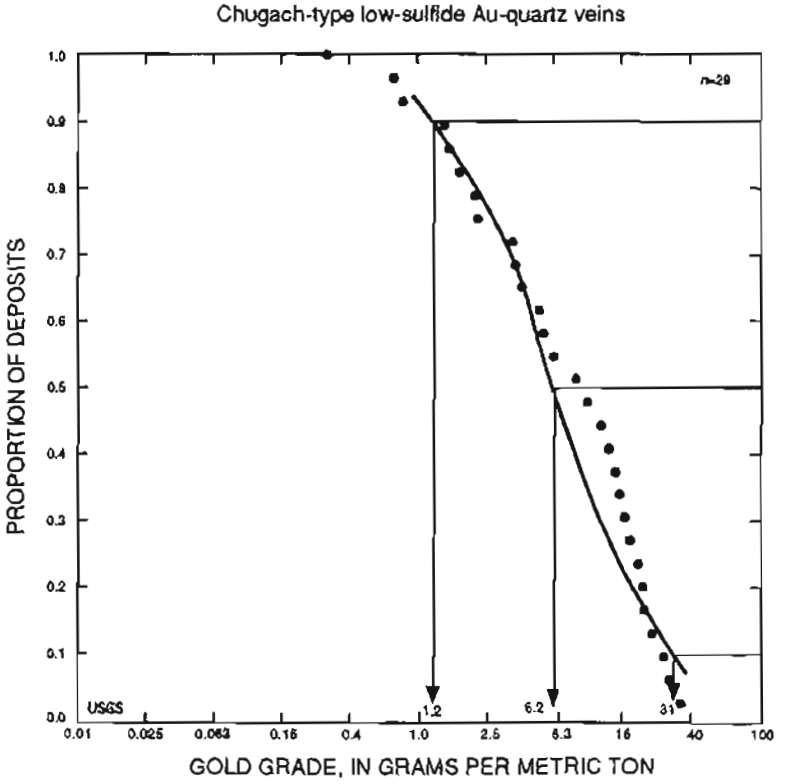

Figure 30. Gold grades of Chugach-type low-sulfide Au-quartz vein deposits.

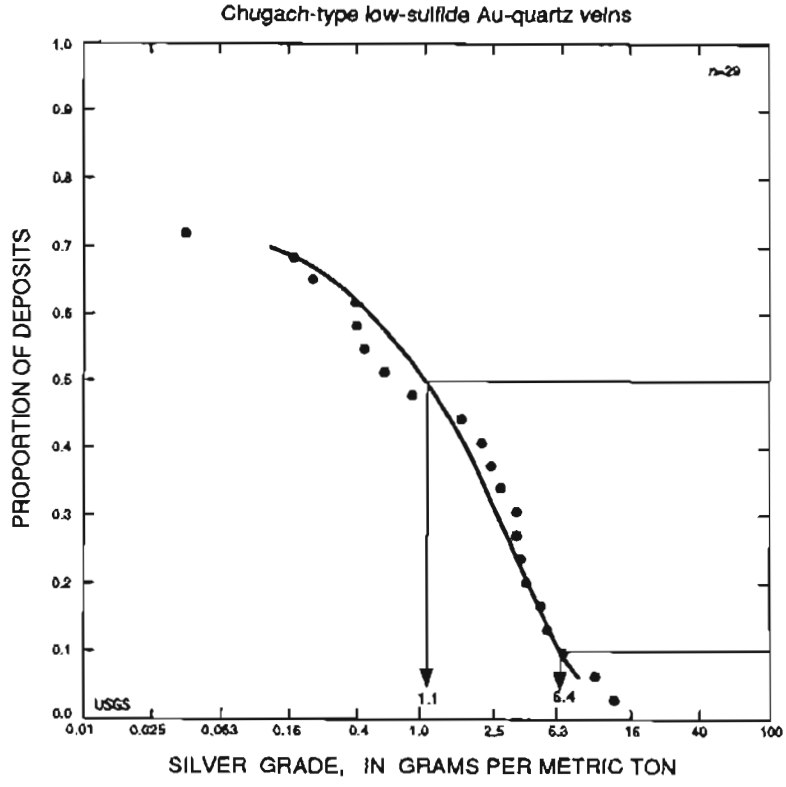

Figure 31. Silver grades of Chugach-type low-sulfide Au-quartz vein deposits.

DEPOSITS		DEPOSITS	
Name	Country	Name	Country
Alaska Homestake	USAK	Imperial	USAK
Cameron-Johnson	USAK	Kana	USAK
Cliff-Sealy	USAK	Kenai Lu	USAK
Crown Point–Fall Creek	USAK	Little Giant	USAK
Cube	USAK	Mayfield	USAK
Donohue	USAK	McMillan	USAK
Downing	USAK	Mineral King	USAK
Gold King	USAK	Monarch-Bahrenburg	USAK
Granite Lake (1)	USAK	Nearhouse	USAK
Granite Lake (2)	USAK	Primrose	USAK
Granite-Snowball	USAK	Ramsay-Rutherford	USAK
Heaston-James	USAK	Rough & Tough	USAK
Hercules-Big Four	USAK	Seward Bonanza	USAK
Hirshey-Carlson	USAK	Tomboy-Lansing	USAK
Hirshey-Lucky	USAK		

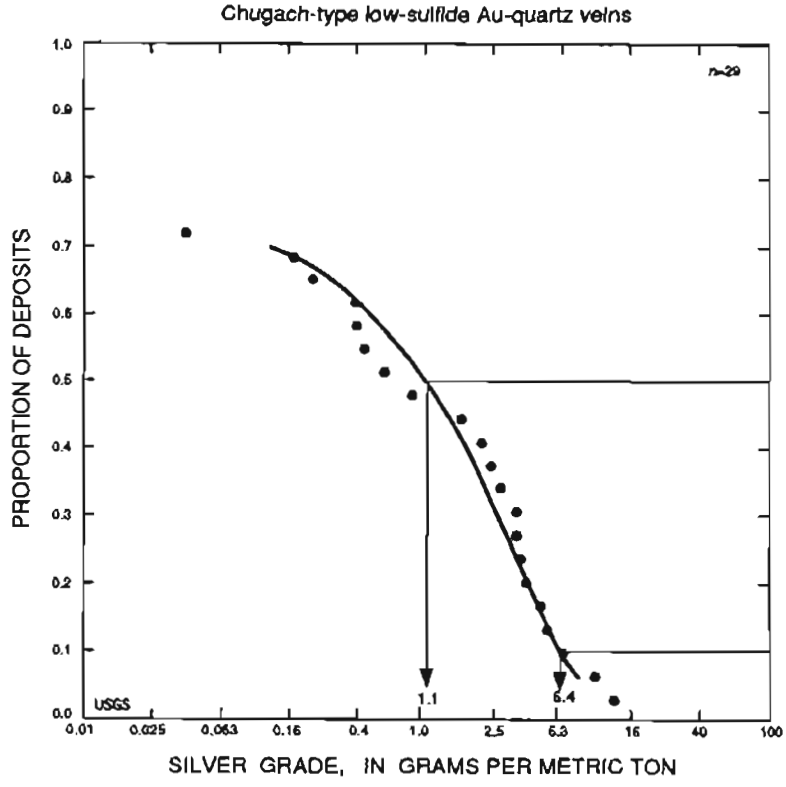

Figure 31. Silver grades of Chugach-type low-sulfide Au-quartz vein deposits.

DEPOSITS		DEPOSITS	
Name	Country	Name	Country
Alaska Homestake	USAK	Imperial	USAK
Cameron-Johnson	USAK	Kana	USAK
Cliff-Sealy	USAK	Kenai Lu	USAK
Crown Point–Fall Creek	USAK	Little Giant	USAK
Cube	USAK	Mayfield	USAK
Donohue	USAK	McMillan	USAK
Downing	USAK	Mineral King	USAK
Gold King	USAK	Monarch-Bahrenburg	USAK
Granite Lake (1)	USAK	Nearhouse	USAK
Granite Lake (2)	USAK	Primrose	USAK
Granite-Snowball	USAK	Ramsay-Rutherford	USAK
Heaston-James	USAK	Rough & Tough	USAK
Hercules-Big Four	USAK	Seward Bonanza	USAK
Hirshey-Carlson	USAK	Tomboy-Lansing	USAK
Hirshey-Lucky	USAK		