UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Mineral Deposit Grade-Tonnage Models II

By D. A. Singer[1] and D. L. Mosier[1], Editors

Open-File Report

83-902

[1]Menlo Park, California

1983

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INTRODUCTION

This compendium of 20 grade-tonnage models is presented as an aid in mineral resource assessments. These models supplement those assembled by Singer and Mosier (1983) and should be used in conjunction with the descriptive ore deposit models assembled by D. P. Cox (1983a and 1983b). Both the descriptive and the grade-tonnage models were prepared for an assessment of the country of Colombia, but the models are generalized and applicable elsewhere.

The nickel laterite model replaces the nickel laterite-oxide model given in Singer and Mosier (1983) because most lateritic nickel deposits are mixtures of the oxides and silicates. A new podiform chromite model based primarily on Turkish deposits is provided as an alternative model for regions where larger podiform deposits occur. The grade-tonnage model of Superior-Algoma iron does not have an associated descriptive model in Cox (1983a, 1983b).

Estimated premining tonnages and average grades of well-explored prototype deposits of each type were used to construct the grade-tonnage models. Where several different estimates were available for a deposit, the estimated tonnage and average grades associated with the lowest cutoff grade were used. Stratiform deposits such as sedimentary manganese and marine phosphate could have substantially larger tonnages and corresponding lower grades if consistent information on thickness and cutoff grades were available. Grades not available were treated as zero. Because over 1100 deposits were employed constructing these models, references are provided to data sources only in cases where one or two sources were used.

The grade-tonnage models are presented in graphical form in order to make it easy to compare deposit types and to display the data. All plots of the same commodity or tonnage are presented on the same scale on the x-axis, while the y-axis is always the cumulative proportion of deposits. Deposits, plotted as dots, are cumulated from the highest tonnage or grade to the lowest. Missing values for deposits are not shown on the figures. All original tonnage and grade units were transformed, if necessary, so that they would plot on a single page; a logarithmic transformation was used for tonnages, and nickel, platinum group elements, and copper grades, whereas a square root transformation was used for other grades. Values on the x-axis were transformed back to the original units and rounded to two significant places. The curve through the plotted deposits was hand drawn to provide a general guideline. Connected to this curve are lines representing the 90th, 50th, and 10th percentiles and their associated tonnage or grade. The number of deposits employed for each model is given at the upper right of each plot. Correlations among grades and tonnages are reported in the text when significant.

DEPOSIT TYPE Podiform chromite MODEL NUMBER 1.1

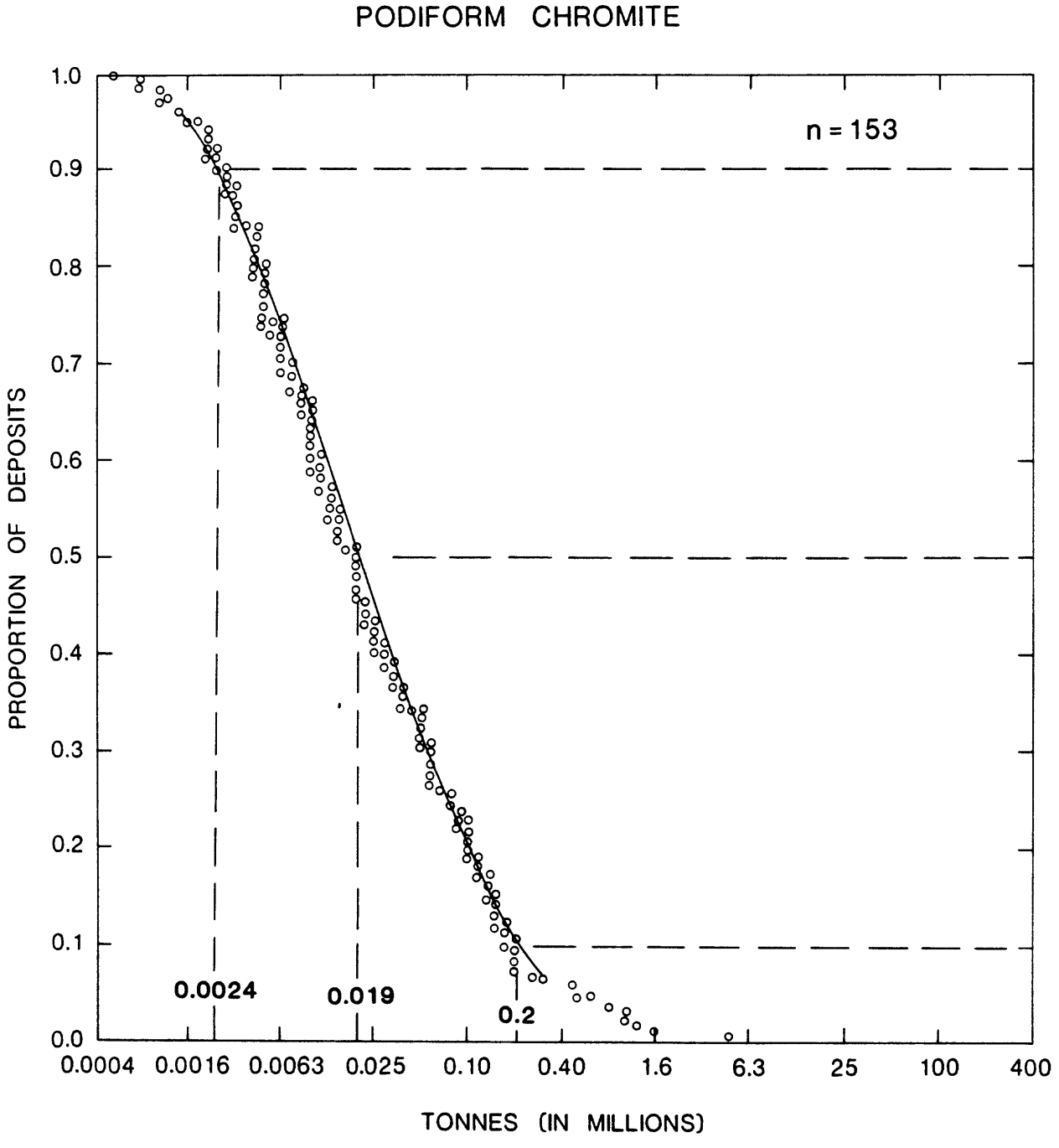
AUTHOR D. A. Singer, N. J Page, and B. R. Lipin

COMMENTS This model is provided as an alternative to the podiform chromite model based on California and Oregon deposits.

DEPOSITS

Name	Country	Name	Country
Abdasht	IRAN	Cezni	TRKY
Akarca	TRKY	Chagrin	NCAL
Akcabuk	TRKY	Child Harold	NCAL
Akkoya	TRKY	Consolation	NCAL
Alice Louise	NCAL	Cosan	TRKY
Alpha	NCAL	Coto	PLPN
Altindag	TRKY	Cromita	CUBA
Amores	CUBA	Dagardi	TRKY
Andizlik	TRKY	Dagkuplu	TRKY
Anna Madeleine	NCAL	Danacik	TRKY
Asagi Zorkum	TRKY	Dcev 7	NCAL
Aventura	CUBA	Delta	CUBA
Avsar	TRKY	Demirli	TRKY
Bagin	TRKY	Dinagat	PLPN
Bagirsakdire	TRKY	Dogu Ezan	TRKY
Balcicakiri	TRKY	Dogu Kef	TRKY
Batikef	TRKY	Domuzburnu II	TRKY
Bati-N. Yarma	TRKY	Dovis	IRAN
Bati-Taban	TRKY	East Ore Body	PLPN
Bati- W. Yarma	TRKY	El Cid	CUBA
Bellacoscia	NCAL	Eldirek	TRKY
Bellevue	NCAL	Ermenis	TRKY
Bereket	TRKY	Fanroche	NCAL
Bezkere-Bulurlii	TRKY	Findikli	TRKY
Bicir-Cakir	TRKY	Findikli #301	TRKY
Bicir-Gul	TRKY	Findikli #306-307	TRKY
Bonsecours	NCAL	Findikli #326	TRKY
Bozkonus	TRKY	General Gallieni	NCAL
Bozotluk-No. 551	TRKY	Gerdag	TRKY
Bugugan	TRKY	Golalan	TRKY
Buyiik Gurleyen	TRKY	Gorunur	TRKY
Buyiik Karamanli	TRKY	Govniikbelen	TRKY
Caledonia	CUBA	Gr2h	NCAL
Camaguey	CUBA	Guillermina	CUBA
Catak	TRKY	Gunliik Basi	TRKY
Catak-Koraalan	TRKY	Herpit Yayla	TRKY
Catolsinir I	TRKY	Igdeli Payas	TRKY
Catolsinir II	TRKY	Ikisulu-Gercek	TRKY
Cenger	TRKY	Jose	CUBA
Cenger-Adatepe	TRKY	Kagit Octu	TRKY
Cenger-Demirk	TRKY	Kandira	TRKY
Cenger-Domuza	TRKY	Kapin	TRKY

Name	Country
Karaculha	TRKY
Karageban	TRKY
Karakcali	TRKY
Karani	TRKY
Karaninar	TRKY
Karasivri	TRKY
Karatas-Kumocak	TRKY
Kartalkoyu	TRKY
Kauakdere	TRKY
Kazadere-Kandil	TRKY
Kefdag-East	TRKY
Kemikli Inbasi	TRKY
Kilic-Kafasi 1	TRKY
Kilic-Kafasi 2	TRKY
Kiranocak	TRKY
Koca	TRKY
Komek	TRKY
Koycegiz-Curukcu	TRKY
Koycegiz-Kurardi	TRKY
Koycegiz-Orta	TRKY
Kuldoden	TRKY
Kundikan-Keluskdere	TRKY
Kundikan-Kelusktepe	TRKY
Kurudere	TRKY
Kuyuluk Isletmesi	TRKY
Kuzkavak	TRKY
La Caridid	CUBA
Lagonoy	PLPN
La Victoria	CUBA
Lolita	CUBA
Marais Kiki	NCAL
Meululter	TRKY
Middle Ore Body	PLPN
Mirandag Koru	TRKY
Mirandag Mevki	TRKY
Morrachini	NCAL
Musa Danisman	TRKY
Narciso	CUBA
Ni Te Ocutes	CUBA
Ochanocagi	TRKY
Ofelia	CUBA
Orta Ezan	TRKY
Otmanlar-Harpuzlu	TRKY
Otmanlar-Mesebuku	TRKY
Panamana-An	PLPN
P. B.	NCAL
Pergini	TRKY
Potosi	CUBA
Ruff Claim No. 32	PLPN
Saka	TRKY
Salur	TRKY
Sarialan	TRKY
Sarikaya	TRKY
Saysin	TRKY
Sekioren	TRKY
Shahin	IRAN
Sicankale	TRKY
Sirac	TRKY
Sofulu	TRKY
Sogham	IRAN
Sta. Cruz	PLPN
Stephane	NCAL
Suluiyeh	IRAN
Sulu	TRKY
Suluk	TRKY
Sutpinar	TRKY
Suzanne	NCAL
Tekneli	TRKY
Tepebasi	TRKY
Terlik	TRKY
Tiebaghi	NCAL
Tilkim-Karanlik	TRKY
Togobomar	PLPN
Tosin	TRKY
Toparlar-Alacik	TRKY
Tuzlakaya	TRKY
Uckopru	TRKY
Vieille Montagne 1	NCAL
Vieille Montagne 2	NCAL
West Ore Body	PLPN
Yanikara	TRKY
Yaprakli	TRKY
Yayca Boyna	TRKY
Yilmaz Ocagi	TRKY
Yukari Zorkum	TRKY
Yunus Yayla	TRKY
Yurtlak	TRKY
Zambales Ch	PLPN
Zimparalik	TRKY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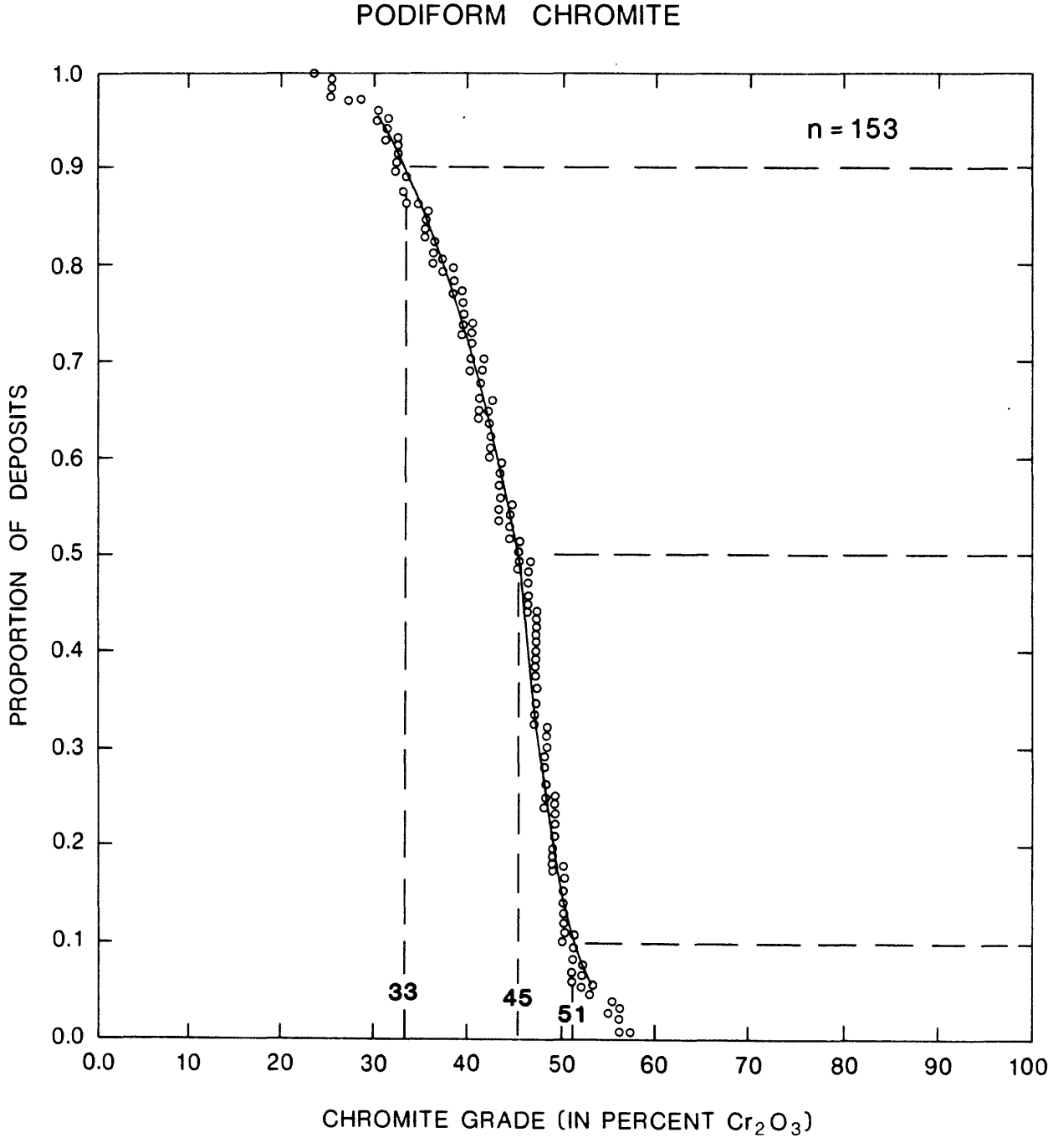
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0024
0.019
0.2
0.0004
0.0016
0.0063
0.025
0.10
0.40
1.6
6.3
25
100
400
TONNES (IN MILLIONS)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PROPORTION OF DEPOSITS
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0.8
0.7
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0.5
0.4
0.3
0.2
0.1
0.0
33
45
51
0.0
10
20
30
40
50
60
70
80
90
100
CHROMITE GRADE (IN PERCENT Cr_2O_3)

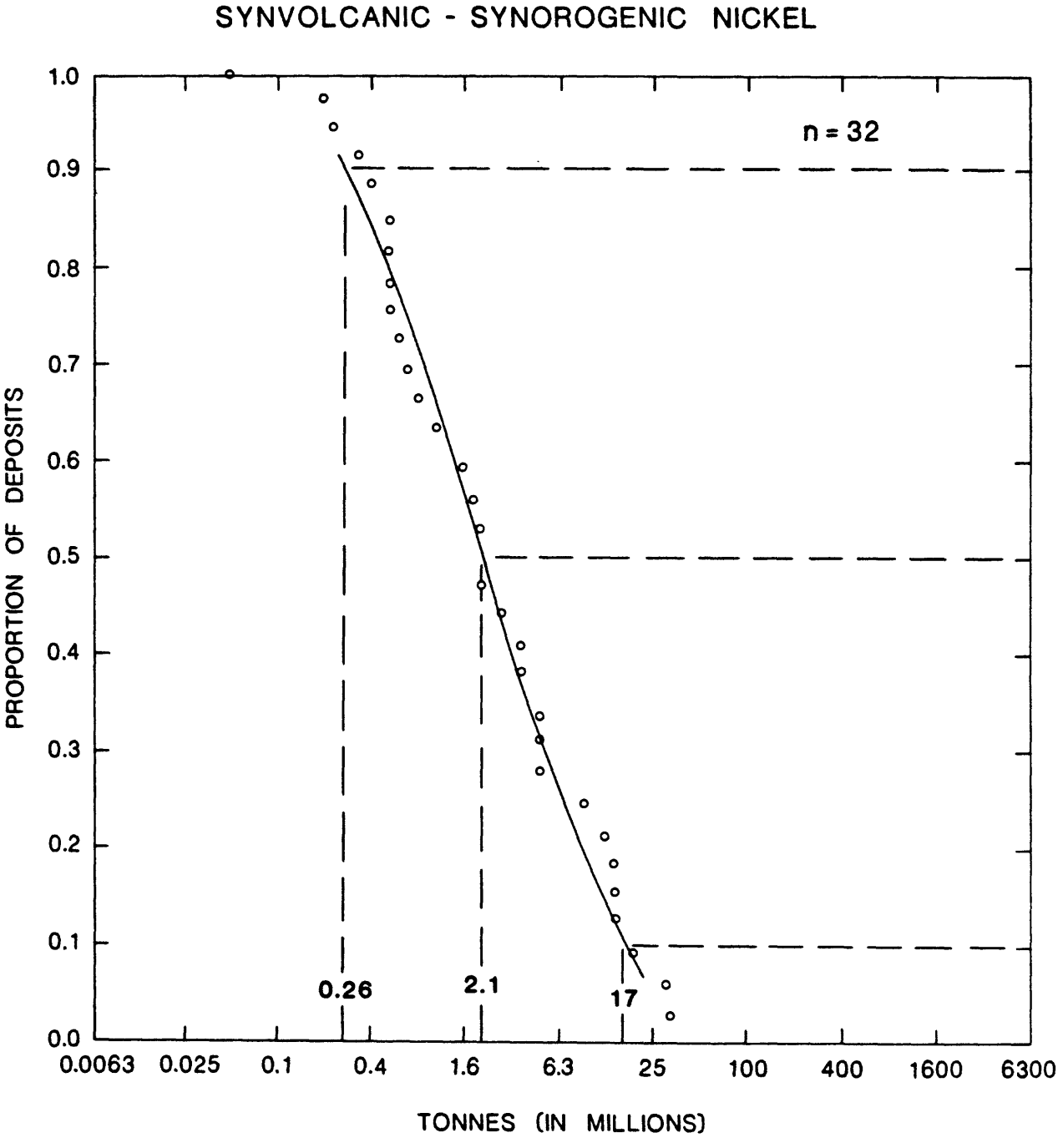
DEPOSIT TYPE Synvolcanic - synorogenic nickel MODEL NUMBER 1.7

AUTHOR D. A. Singer, N. J Page, and W. D. Menzie

COMMENTS

DEPOSITS

Name	Country	Name	Country
Bamble	NRWY	Makola	FNLD
Carr Boyd	AUWA	Mjodvattnet	SWDN
Empress	ZIMB	Montcalm	CNON
Flaat	NRWY	Mt. Sholl	AUWA
Funter Bay	USAK	Phoenix	BOTS
Gap	USPA	Pikwe	BOTS
Giant Mascot	CNBC	Renzy	CNQU
Hosanger	NRWY	Risliden	SWDN
Kenbridge	CNON	Selebi	BOTS
Kylmakoski	FNLD	Selebi N.	BOTS
Lainijaur	SWDN	Selkirk	BOTS
Lappuattnet	SWDN	Tekwane	BOTS
Laukunkawges	FNLD	Thierry	CNON
Lorraine	CNQU	Vakkerlien	NRWY
Lynn Lake	CNMN	Vammala	FNLD
Madziwa	ZIMB	Yakobi Island	USAK


SYNVOLCANIC - SYNOROGENIC NICKEL
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PROPORTION OF DEPOSITS
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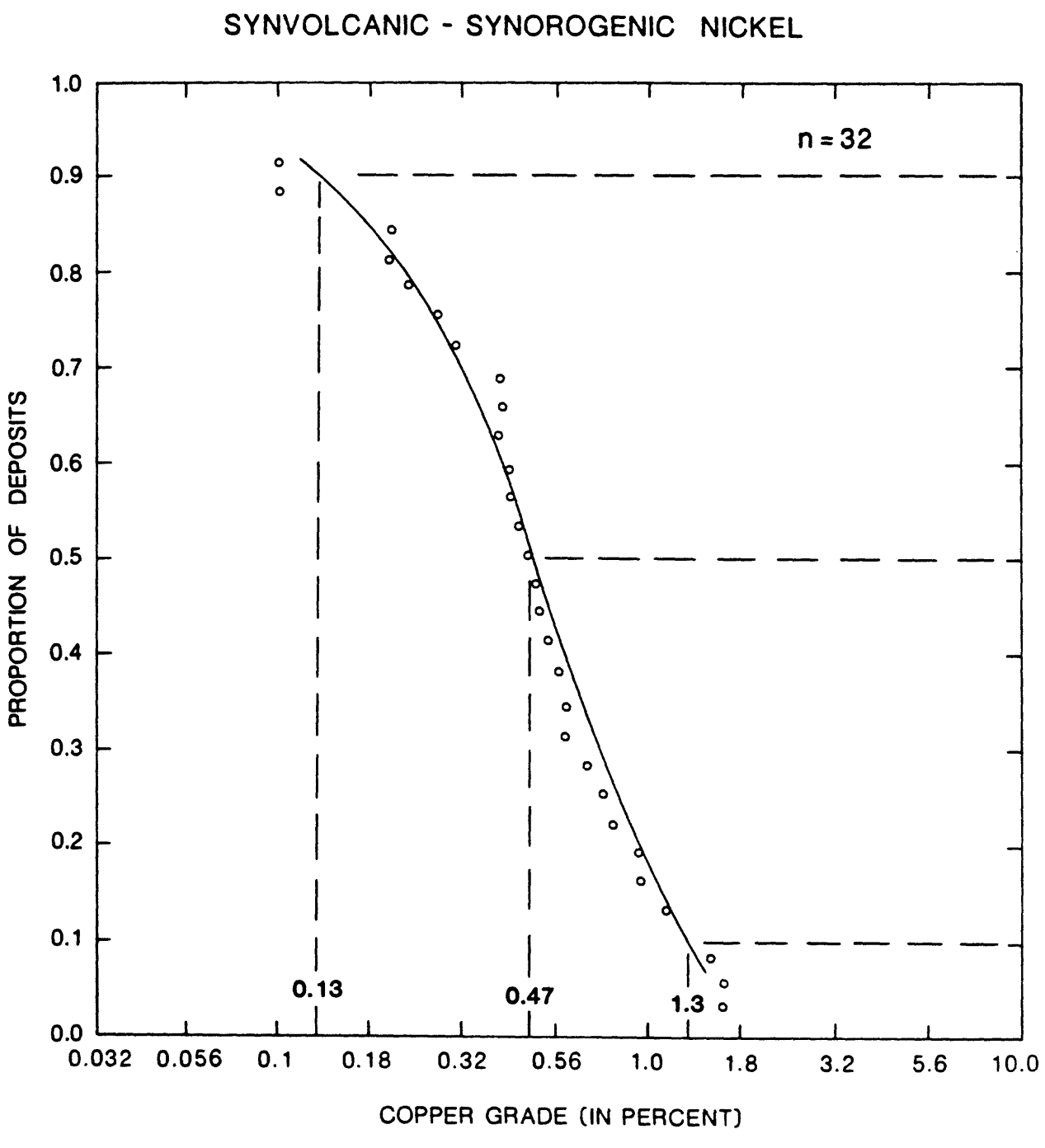
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.26
2.1
17
0.0063
0.025
0.1
0.4
1.6
6.3
25
100
400
1600
6300
TONNES (IN MILLIONS)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PROPORTION OF DEPOSITS
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0.7
0.6
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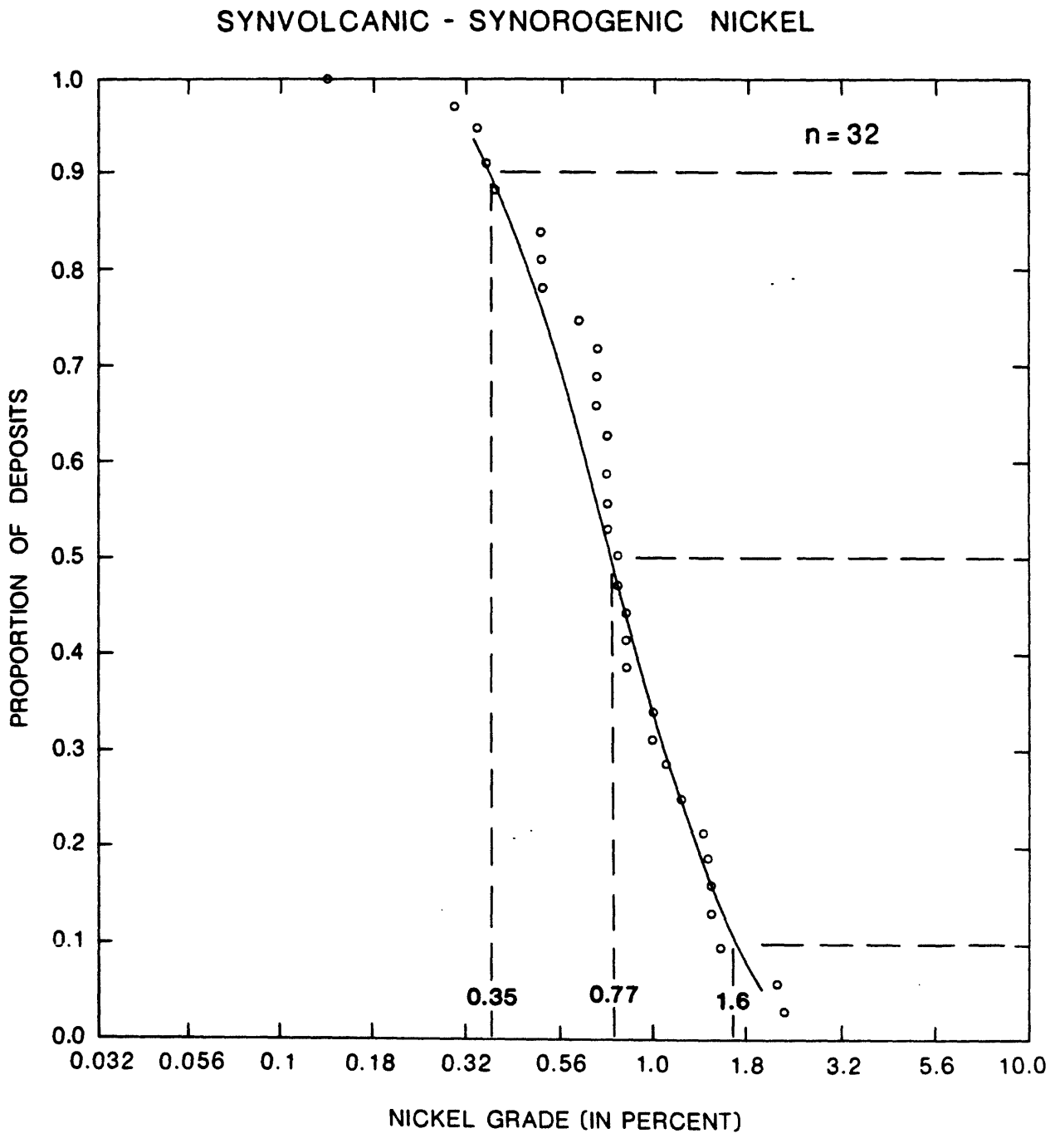
0.4
0.3
0.2
0.1
0.0
0.13
0.47
1.3
0.032
0.056
0.1
0.18
0.32
0.56
1.0
1.8
3.2
5.6
10.0
COPPER GRADE (IN PERCENT)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n = 32
PROPORTION OF DEPOSITS
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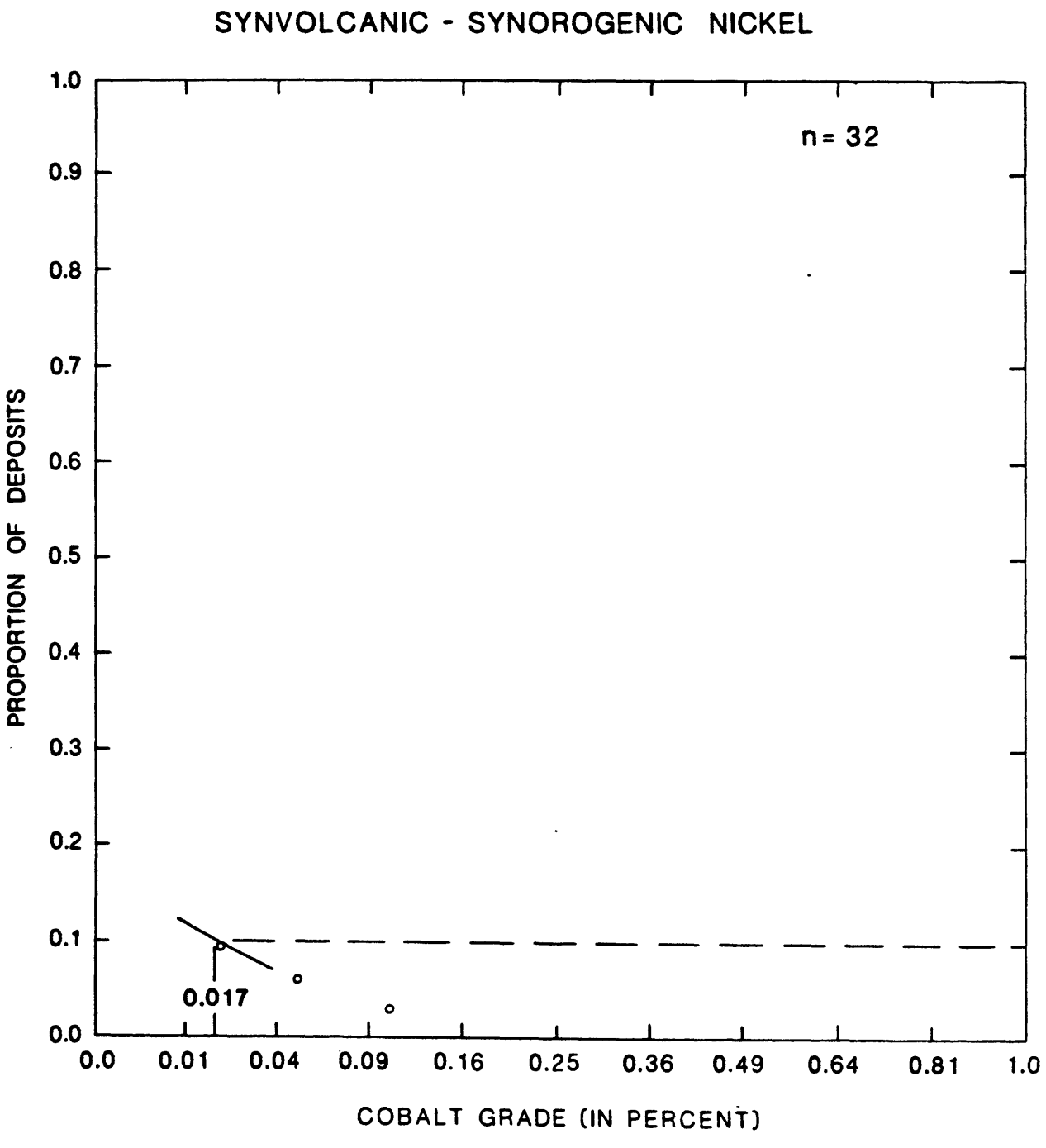
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.35
0.77
1.6
0.032
0.056
0.1
0.18
0.32
0.56
1.0
1.8
3.2
5.6
10.0
NICKEL GRADE (IN PERCENT)


SYNVOLCANIC - SYNOROGENIC NICKEL
n= 32
PROPORTION OF DEPOSITS
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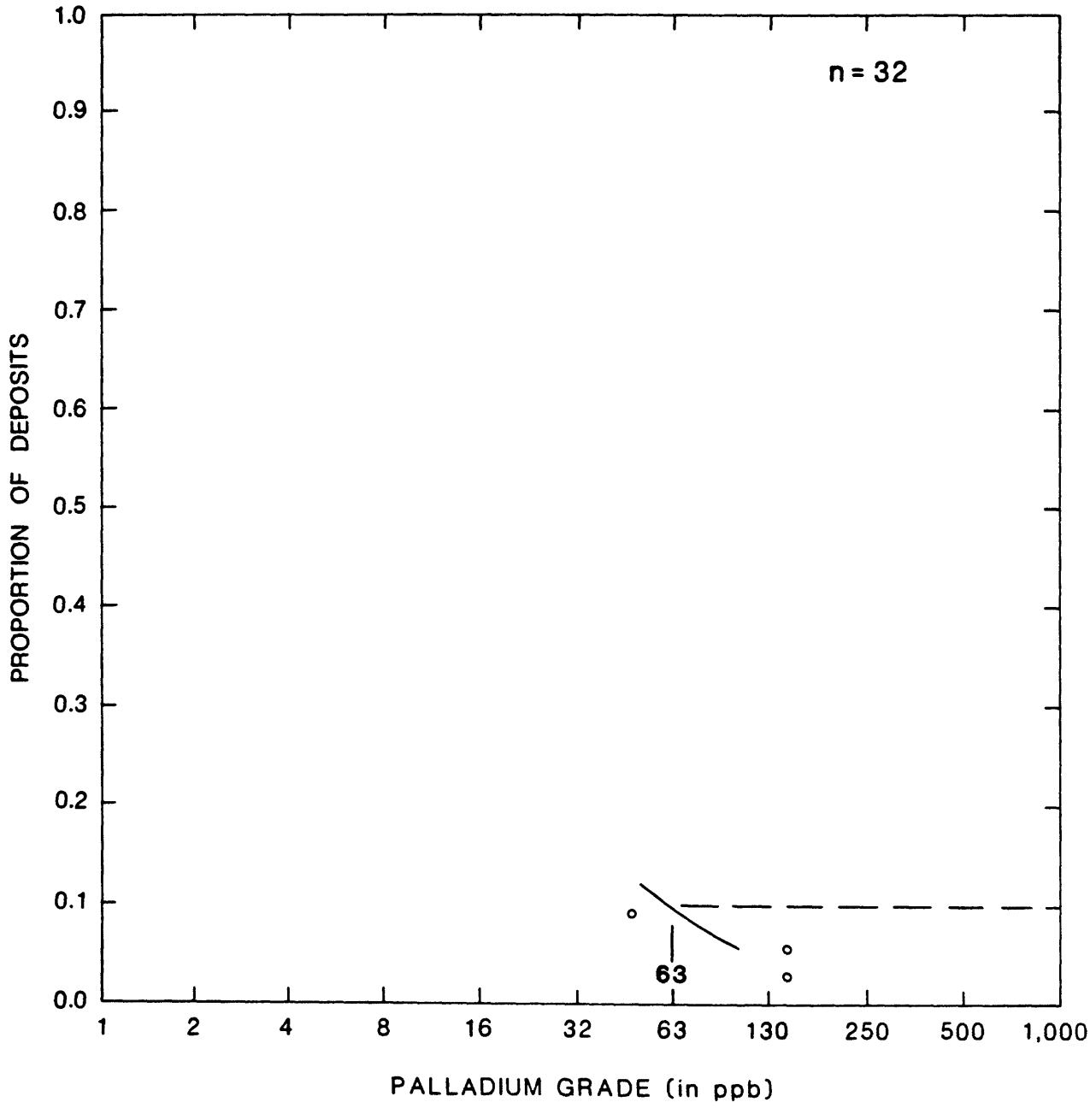
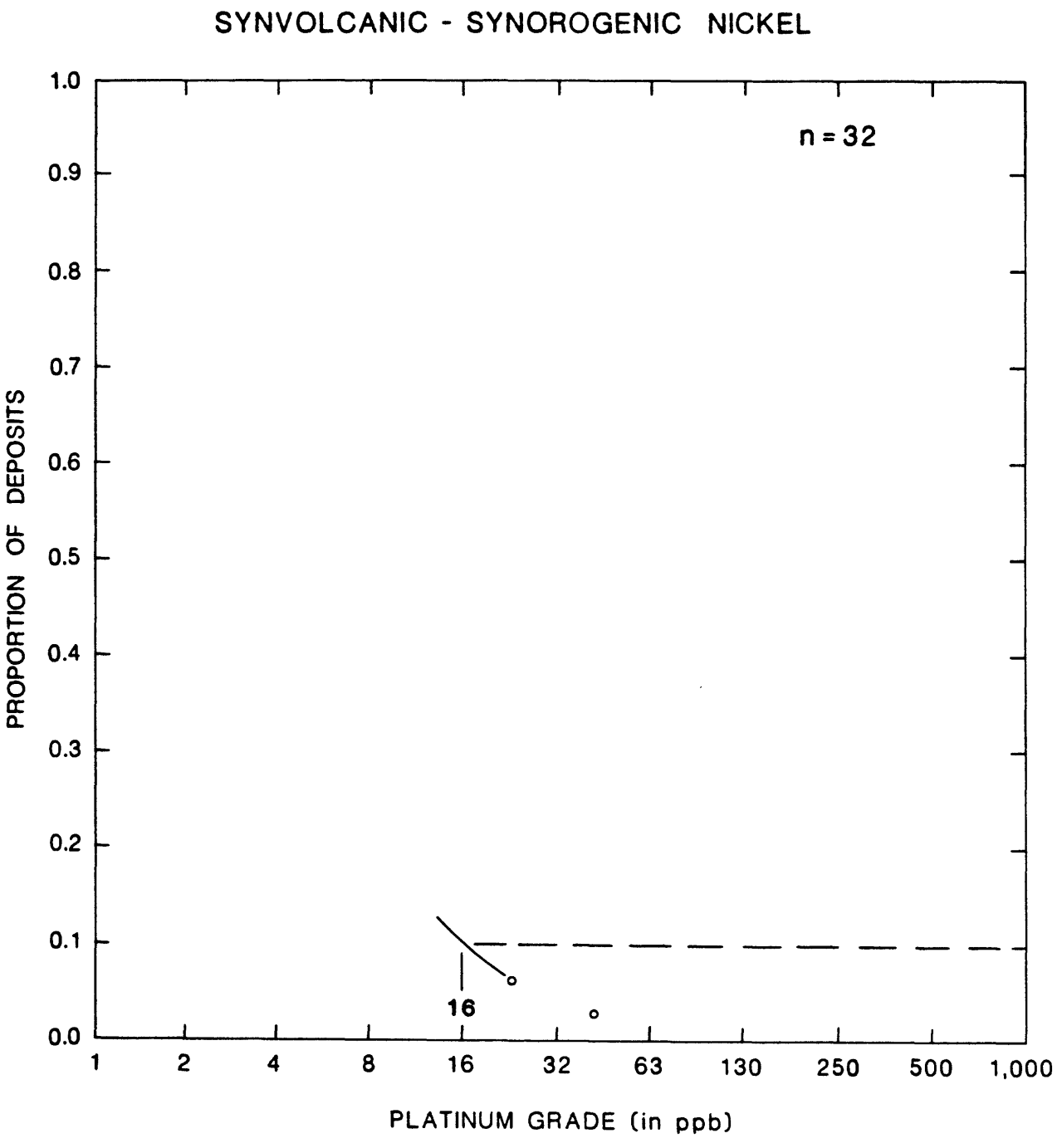
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.017
0.0
0.01
0.04
0.09
0.16
0.25
0.36
0.49
0.64
0.81
1.0
COBALT GRADE (IN PERCENT)


SYNVOLCANIC - SYNOROGENIC NICKEL
n = 32
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
63
1
2
4
8
16
32
63
130
250
500
1,000
PALLADIUM GRADE (in ppb)


SYNVOLCANIC - SYNOROGENIC NICKEL
n = 32
PROPORTION OF DEPOSITS
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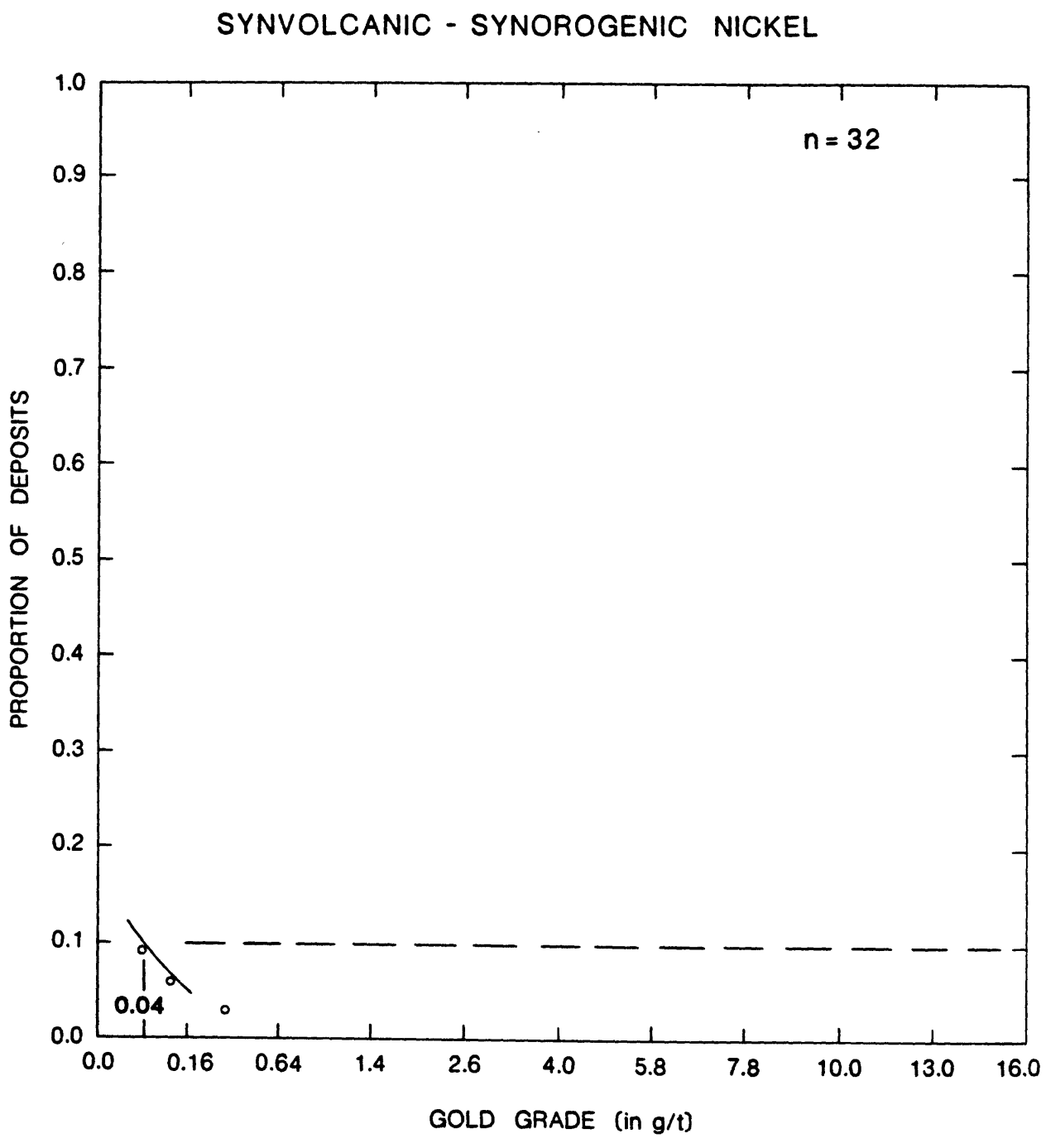
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
16
1
2
4
8
16
32
63
130
250
500
1,000
PLATINUM GRADE (in ppb)


SYNVOLCANIC - SYNOROGENIC NICKEL
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PROPORTION OF DEPOSITS
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0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.04
0.0
0.16
0.64
1.4
2.6
4.0
5.8
7.8
10.0
13.0
16.0
GOLD GRADE (in g/t)

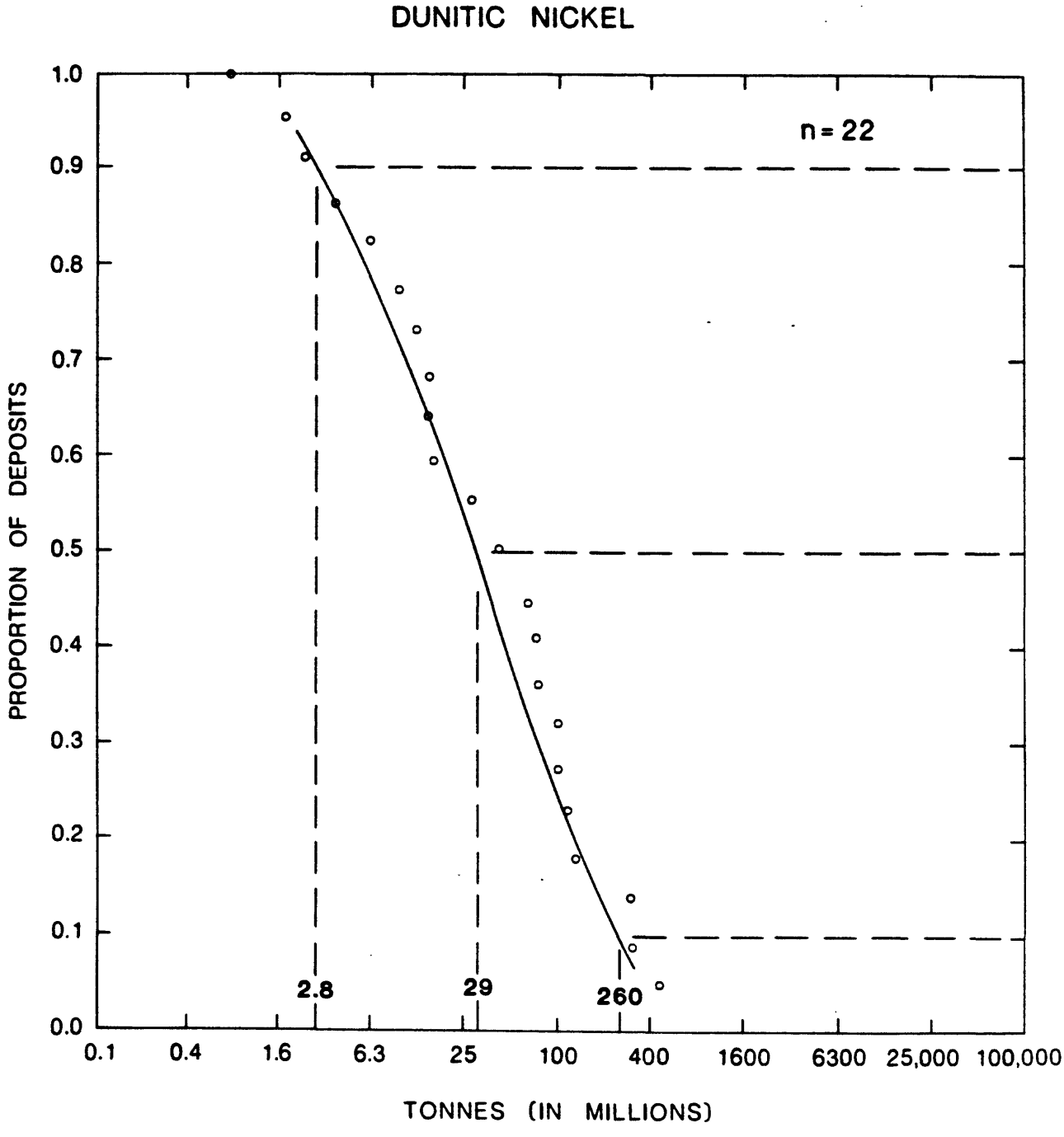
DEPOSIT TYPE Dunitic nickel MODEL NUMBER 1.8

AUTHOR D. A. Singer and N. J Page

COMMENTS Tonnage is correlated with nickel grade (r=-0.54). Nickel grade is correlated with copper grade (r=0.84, n=12), with palladium grade (r=0.88, n=5), and with gold grade (r=0.94, n=5).

DEPOSITS

Name	Country
Agnew (Perseverance)	AUWA
Amax	CNMN
Birch Tree	CNMN
Black Swan	AUWA
Bowden Lake	CNMN
Bucko	CNMN
Discovery	CNMN
Dumont	CNQU
Forrestania Group	AUWA
Geol. Reser. No. 34	CNMN
Hambone	CNMN
Honeymoon Well	AUWA
Manibridge	CNMN
Moak	CNMN
Mt. Keith	AUWA
Mystery Lake	CNMN
Pipe	CNMN
Six Mile	AUWA
Soab N.	CNMN
Soab S.	CNMN
Thompson	CNMN
Weebo Bore	AUWA


DUNITIC NICKEL
n = 22
PROPORTION OF DEPOSITS
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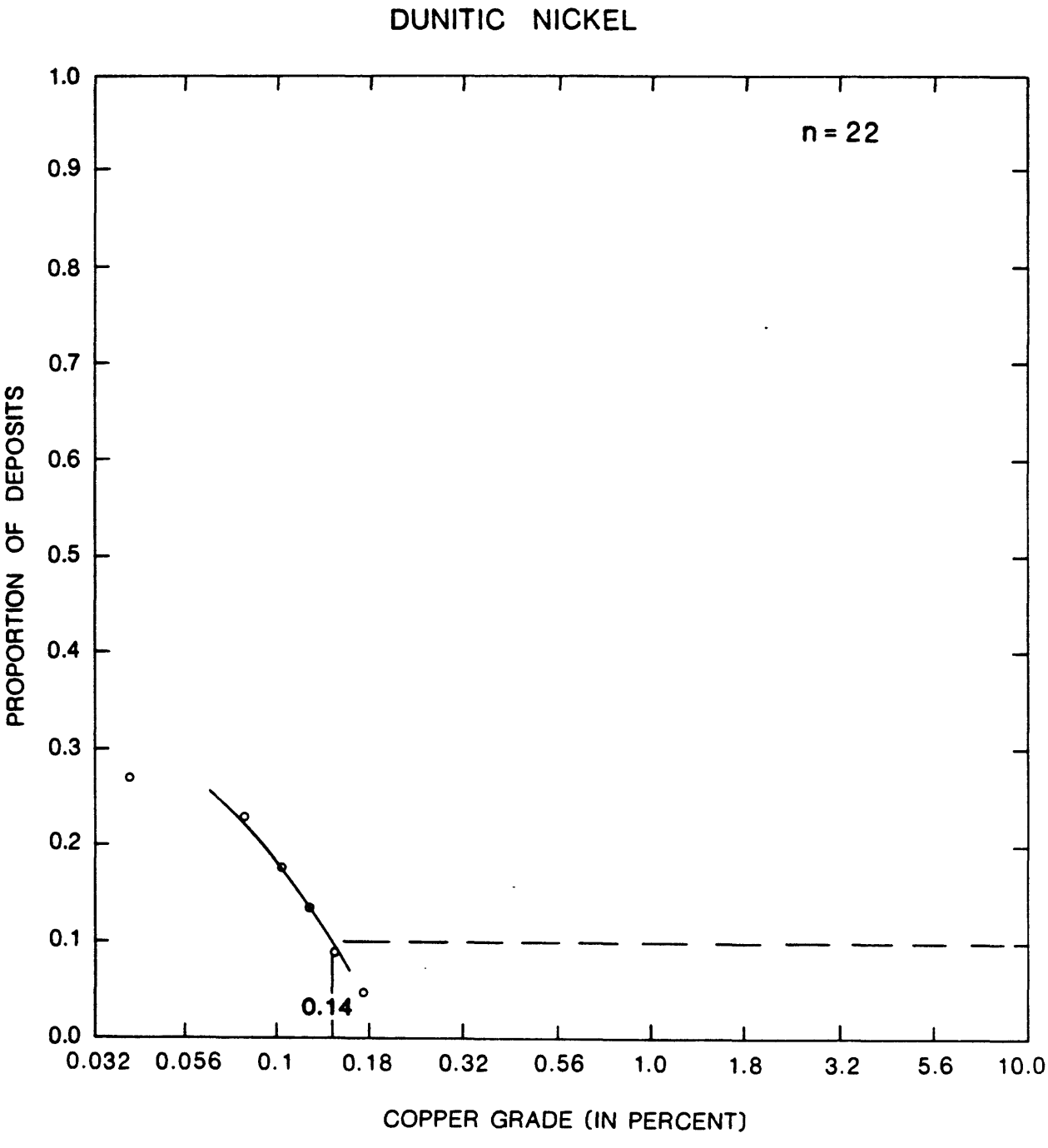
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2.8
29
260
0.1
0.4
1.6
6.3
25
100
400
1600
6300
25,000
100,000
TONNES (IN MILLIONS)


DUNITIC NICKEL
n = 22
PROPORTION OF DEPOSITS
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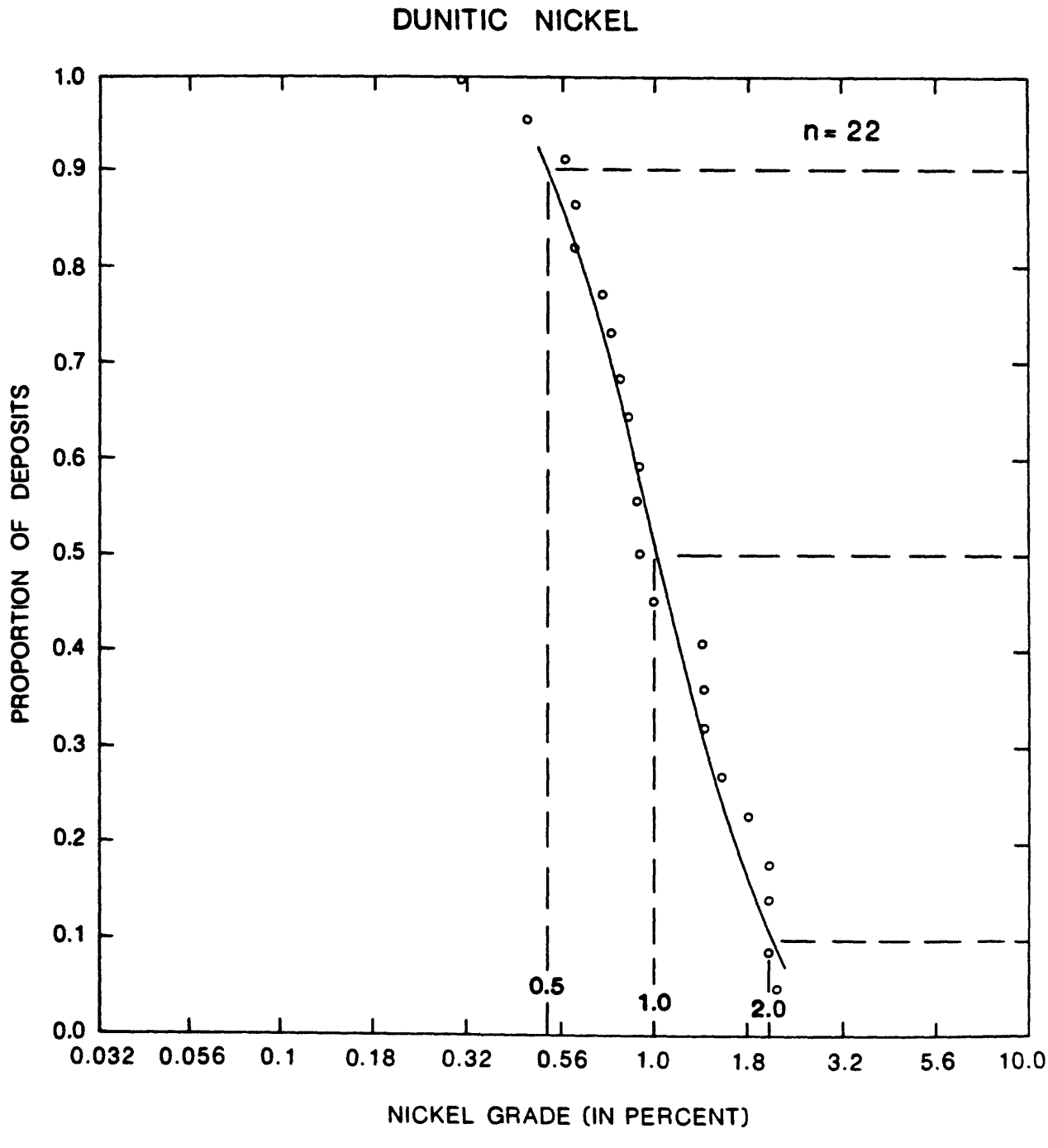
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.14
0.032
0.056
0.1
0.18
0.32
0.56
1.0
1.8
3.2
5.6
10.0
COPPER GRADE (IN PERCENT)


DUNITIC NICKEL
n = 22
PROPORTION OF DEPOSITS
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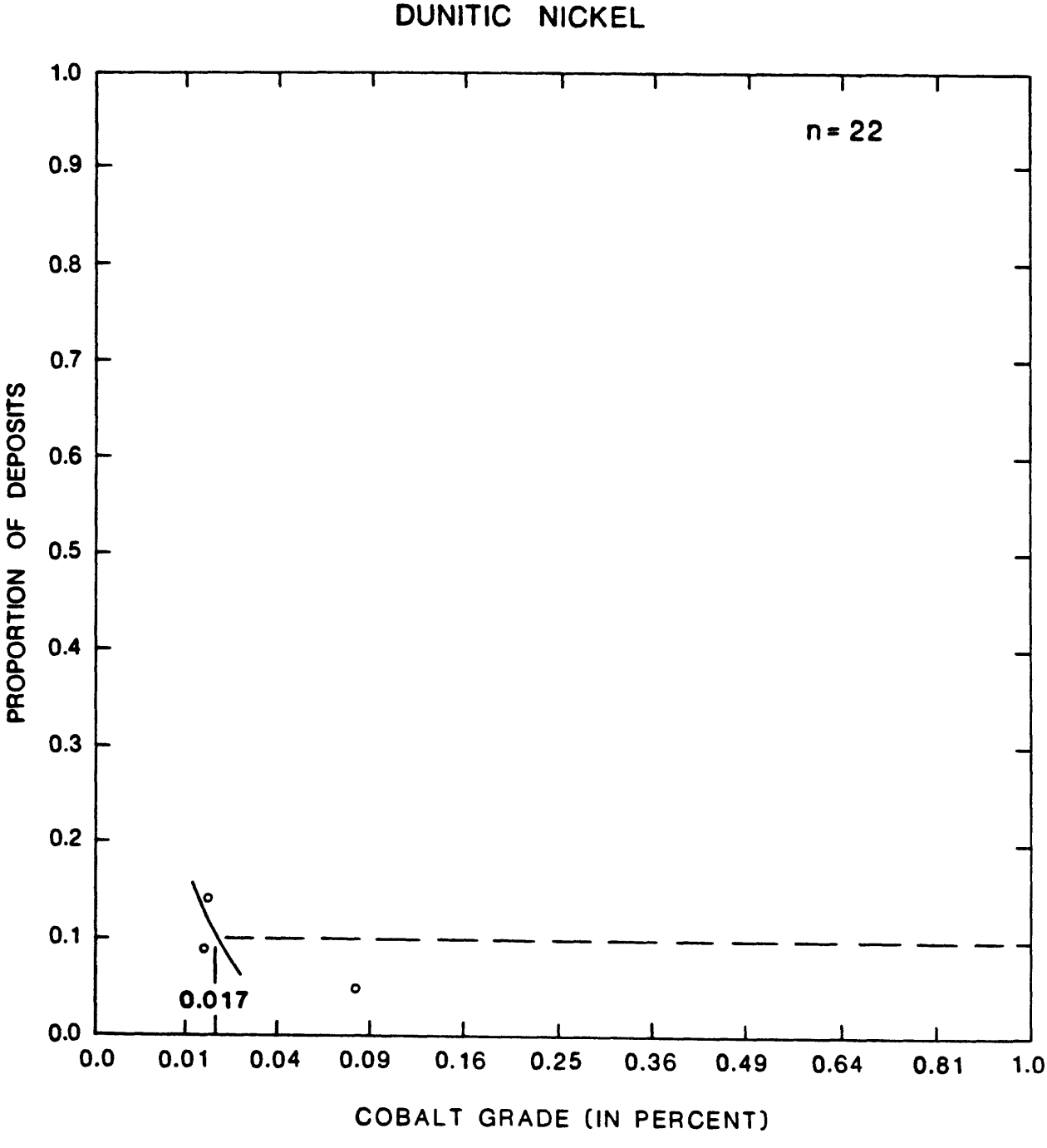
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.5
1.0
2.0
0.032
0.056
0.1
0.18
0.32
0.56
1.0
1.8
3.2
5.6
10.0
NICKEL GRADE (IN PERCENT)


DUNITIC NICKEL
n = 22
PROPORTION OF DEPOSITS
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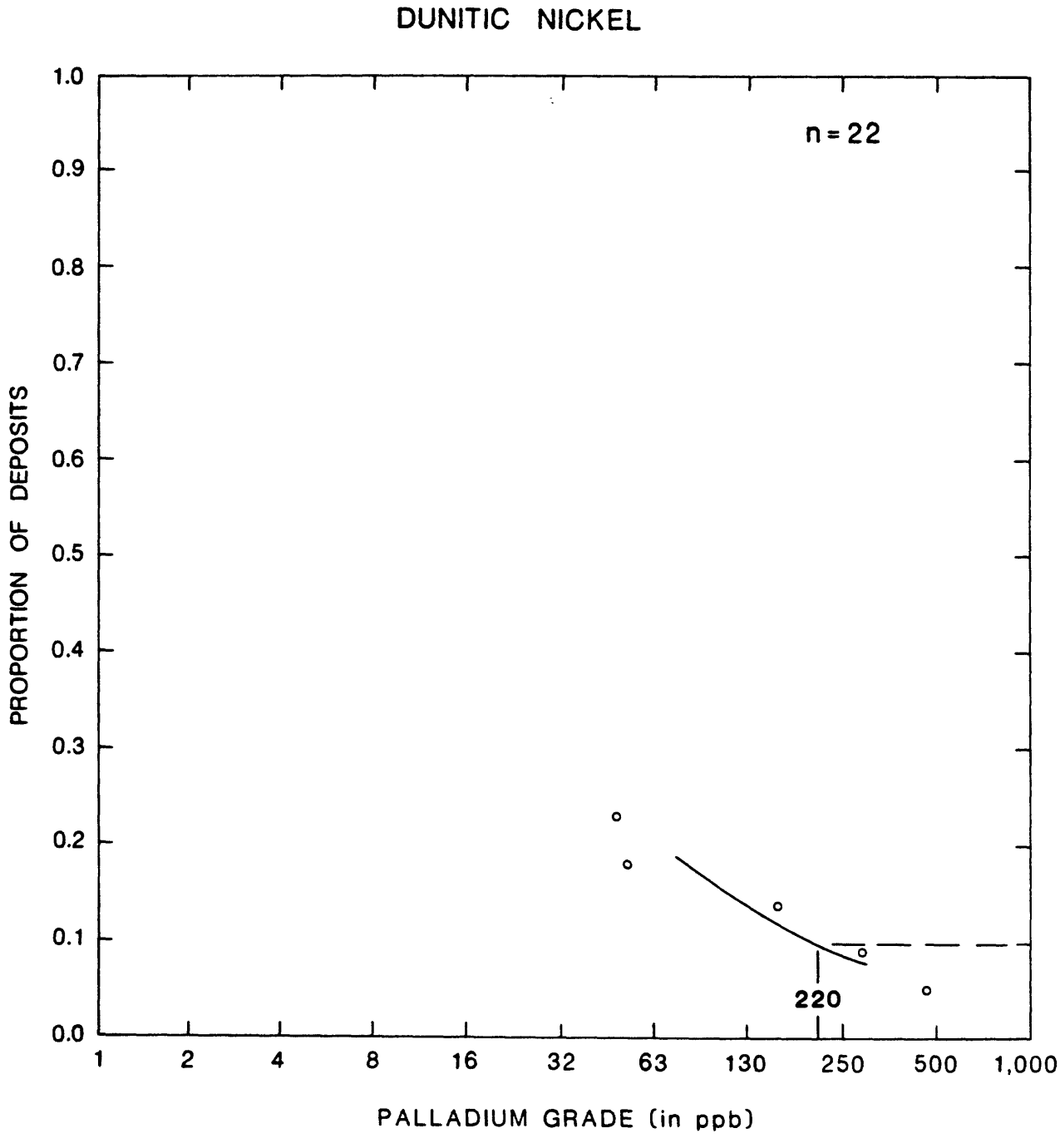
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.017
0.0
0.01
0.04
0.09
0.16
0.25
0.36
0.49
0.64
0.81
1.0
COBALT GRADE (IN PERCENT)


DUNITIC NICKEL
n = 22
PROPORTION OF DEPOSITS
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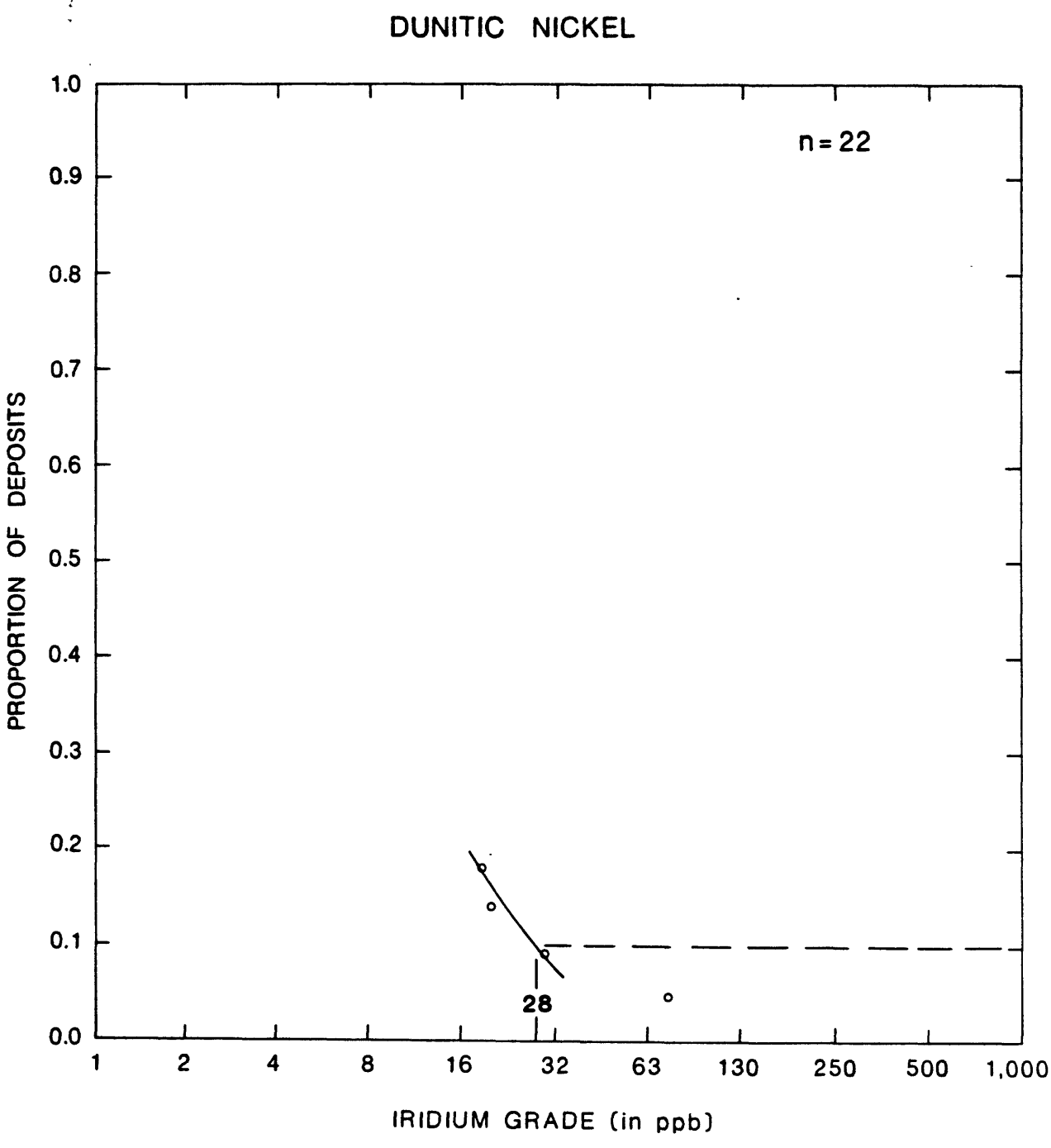
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
220
1
2
4
8
16
32
63
130
250
500
1,000
PALLADIUM GRADE (in ppb)


DUNITIC NICKEL
n = 22
PROPORTION OF DEPOSITS
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0.8
0.7
0.6
0.5
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0.2
0.1
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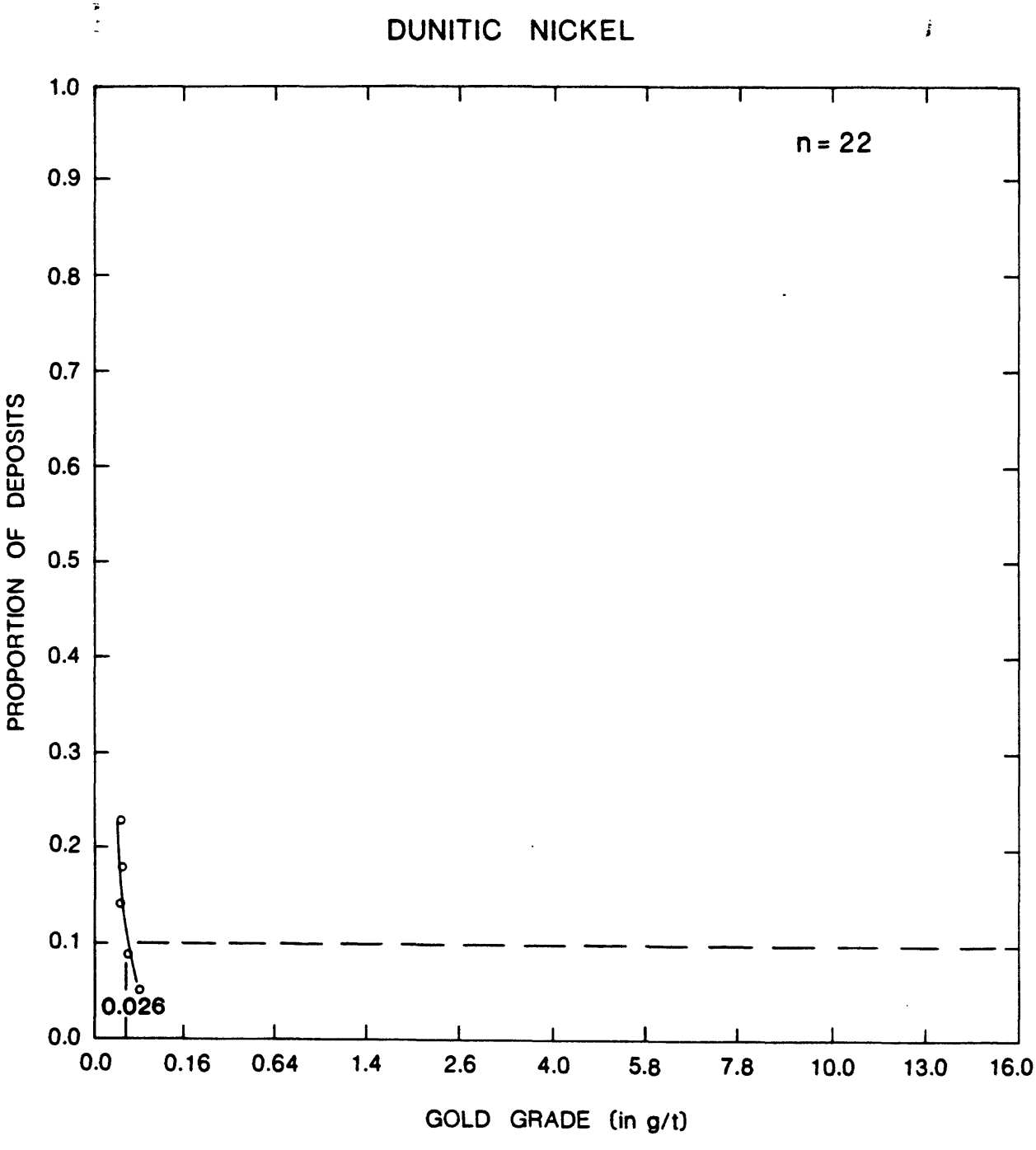
2
4
8
16
32
63
130
250
500
1,000
IRIDIUM GRADE (in ppb)


DUNITIC NICKEL
n = 22
PROPORTION OF DEPOSITS
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0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.026
0.0
0.16
0.64
1.4
2.6
4.0
5.8
7.8
10.0
13.0
16.0
GOLD GRADE (in g/t)

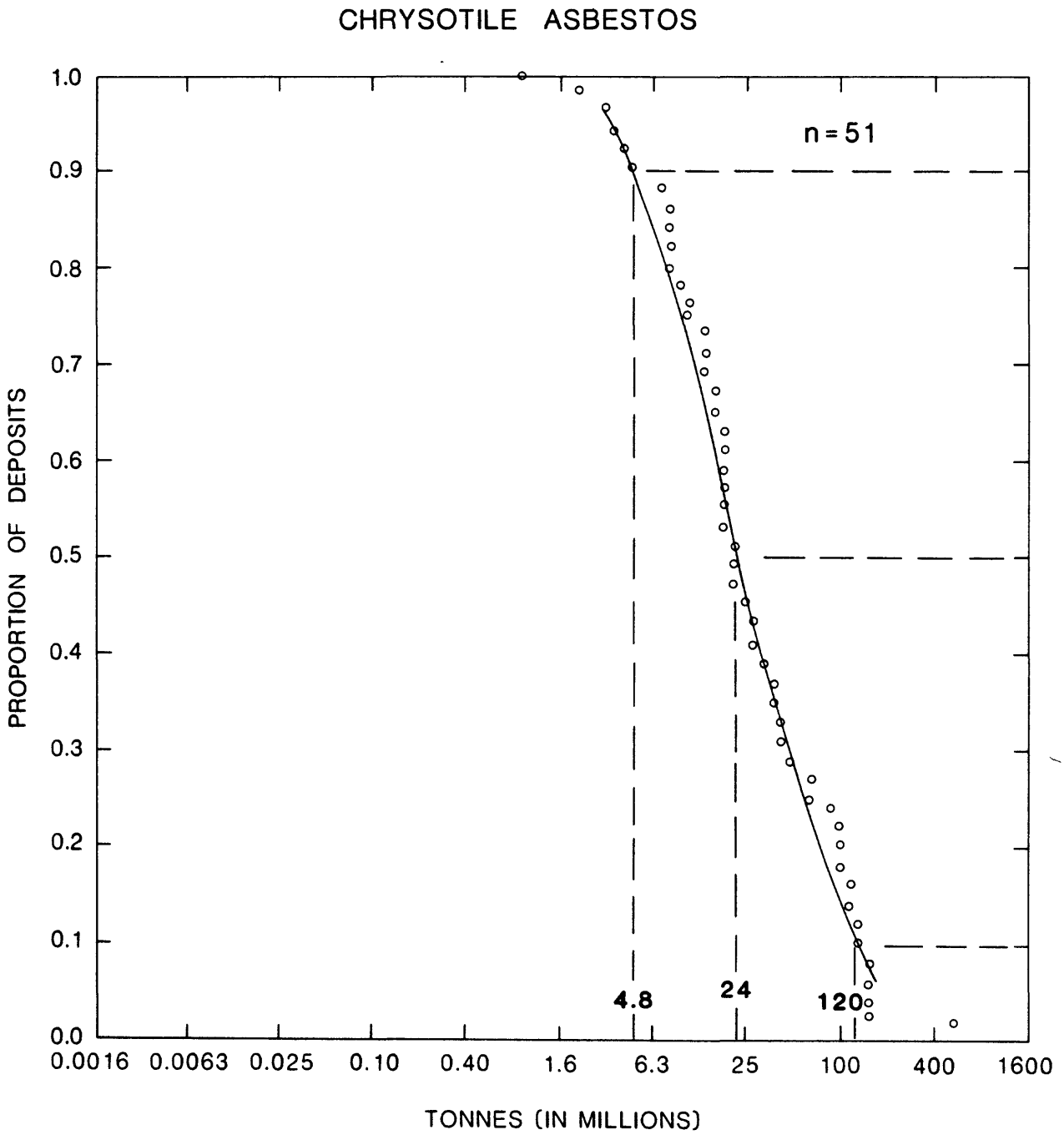
DEPOSIT TYPE Chrysotile asbestos MODEL NUMBER 1.9

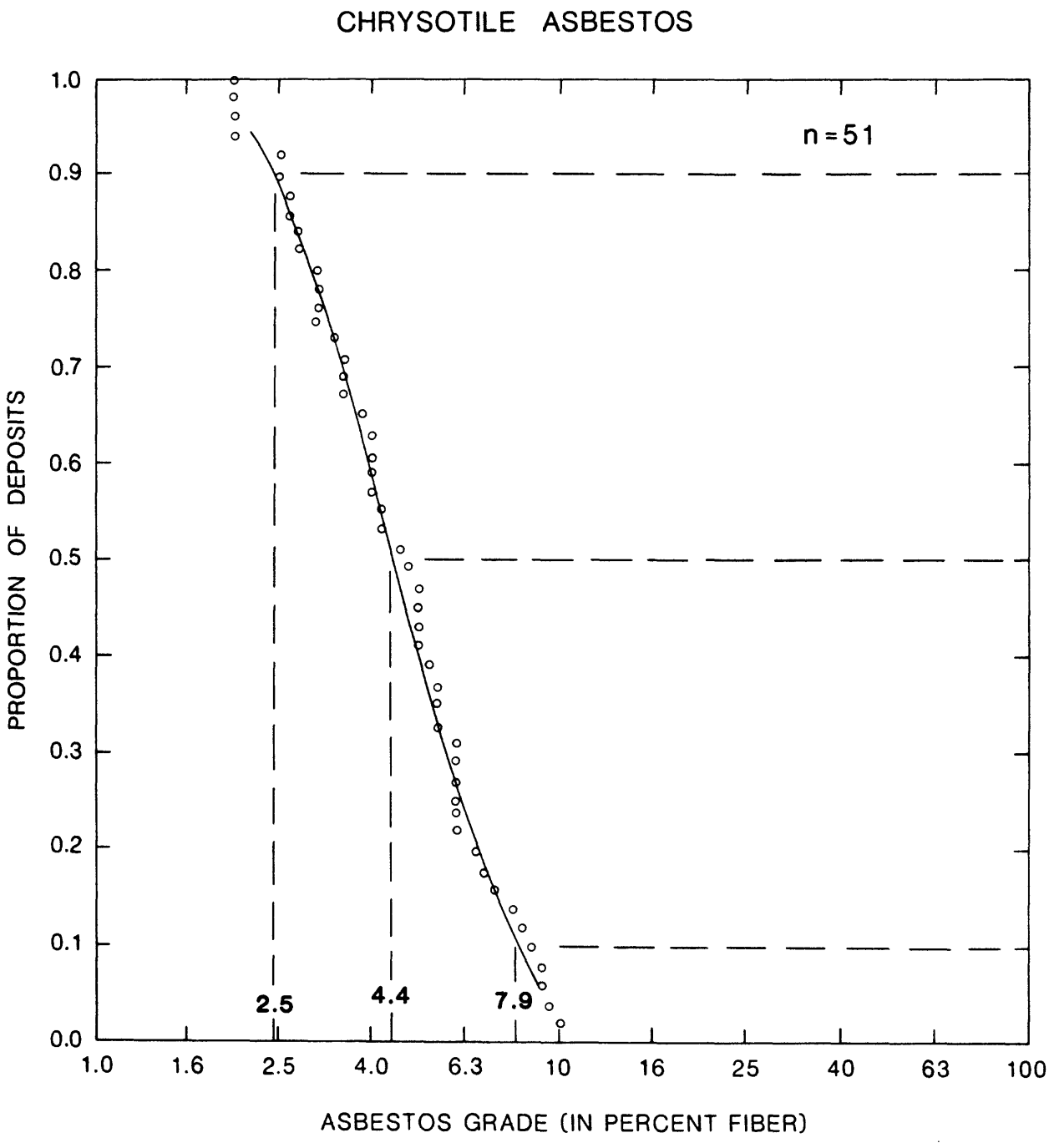
AUTHOR G. Orris

COMMENTS Long and short fibers are combined.

DEPOSITS

Name	Country	Name	Country
Abitibi	CNQU	McAdam	CNQU
Advocate	CNNF	McDame	CNBC
Asbestos Hill	CNQU	Midlothian	CNON
Asbestos Island	CNQU	Moladezhnoye	URRS
Bell Mine	CNQU	Msauli	SAFR
Belvidere	USVT	Munro	CNON
Black Lake	CNQU	National	CNQU
British Canadian	CNQU	Nicolet Asbestos	CNQU
Caley	CNYT	Normandie/Penhale	CNQU
Carey/East Broughton	CNQU	Pontbriand	CNQU
Cana Brava	BRZL	Qala-el-Nahl?	SUDN
Cassiar Mine	CNBC	Reeves	CNON
Clinton Creek	CNYT	Rex	CNYT
Continental	CNQU	Roberge Lake	CNQU
Copperopolis	USCA	St. Adrien Mtn.	CNQU
Courvan Mine	CNQU	St. Cyr	CNQU
Cranbourne	CNQU	Santiago Papalo	MXCO
Daffodil	CNON	Sayan	URRS
Eagle	USAK	Shihmien	CINA
Gilmont	CNQU	Steele Brook	CNQU
Golden Age	CNQU	Tuolumne	USCA
Jeffrey	CNQU	Windsor	CNQU
King-Beaver Mine	CNQU	Woodsreef Mine	AUNS
Kudu Asbestos Mine	ZIMB	Zindani	GREC
Lake Asbestos	CNQU		
Las Brisas	CLBA		
Lili	CNQU		


CHRYSOTILE ASBESTOS
n = 51
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
4.8
24
120
0.0016
0.0063
0.025
0.10
0.40
1.6
6.3
25
100
400
1600
TONNES (IN MILLIONS)


CHRYSOTILE ASBESTOS
n=51
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2.5
4.4
7.9
1.0
1.6
2.5
4.0
6.3
10
16
25
40
63
100
ASBESTOS GRADE (IN PERCENT FIBER)

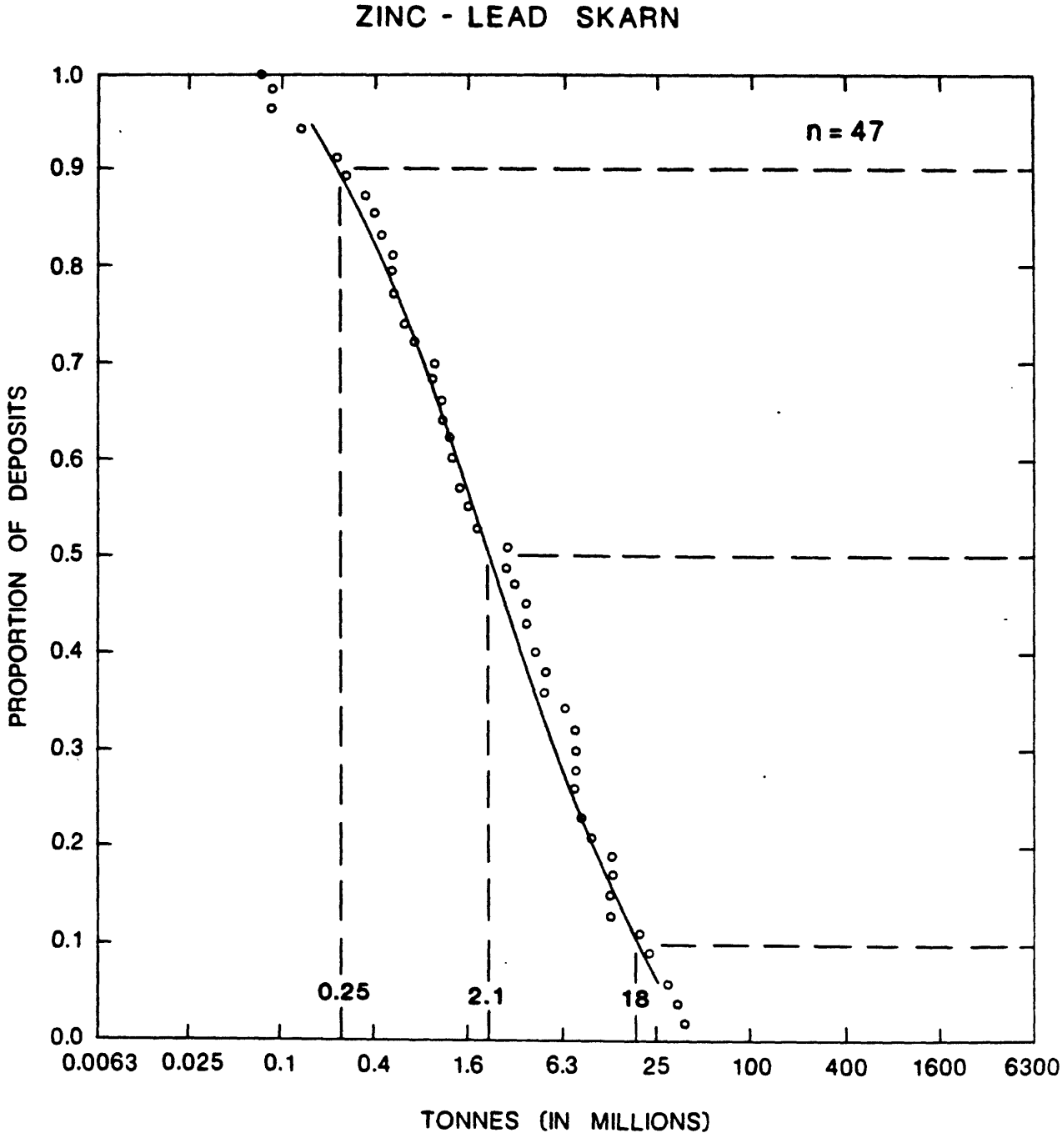
DEPOSIT TYPE Zinc-lead skarn MODEL NUMBER 2.7

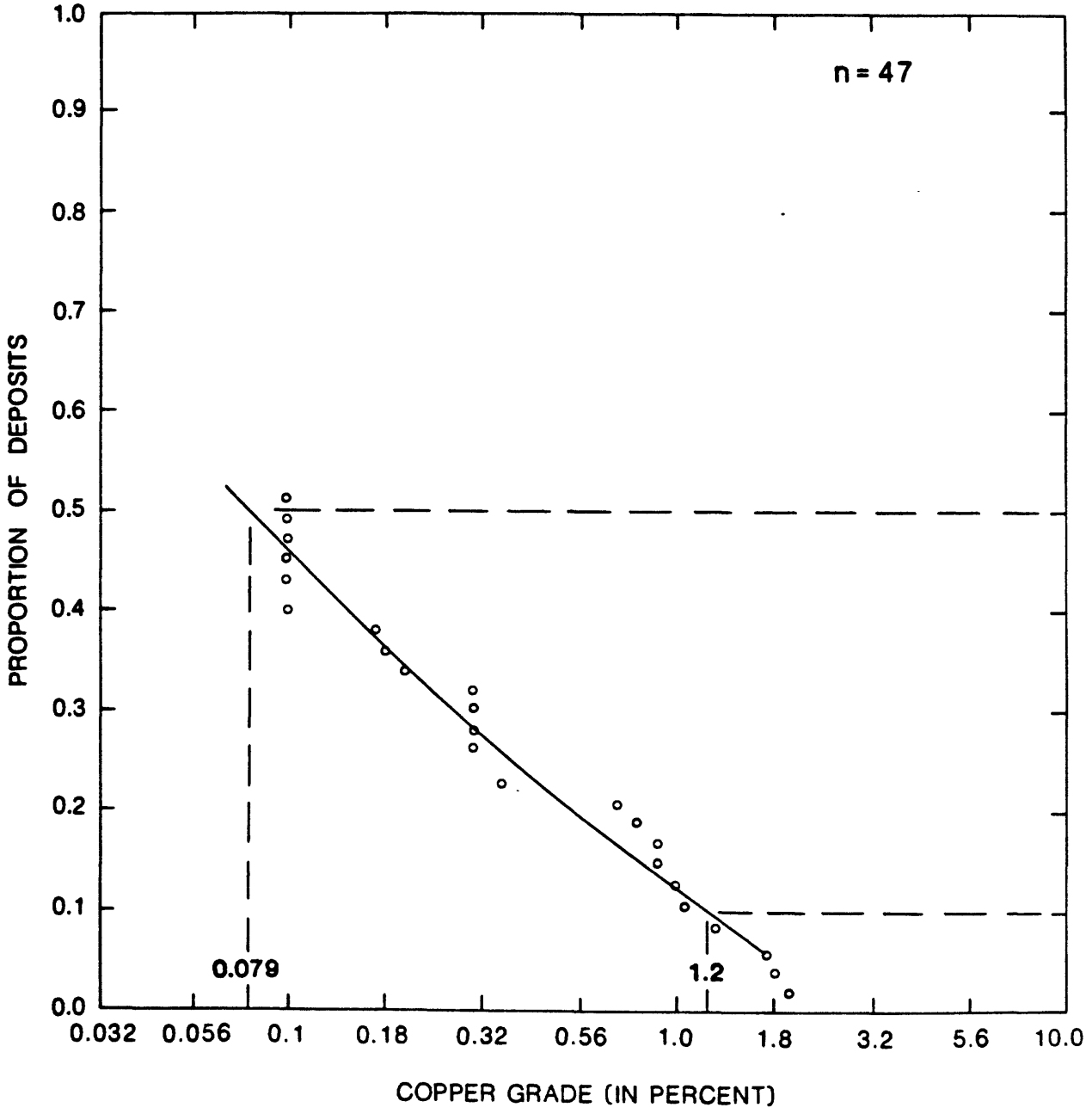
AUTHOR D. L. Mosier

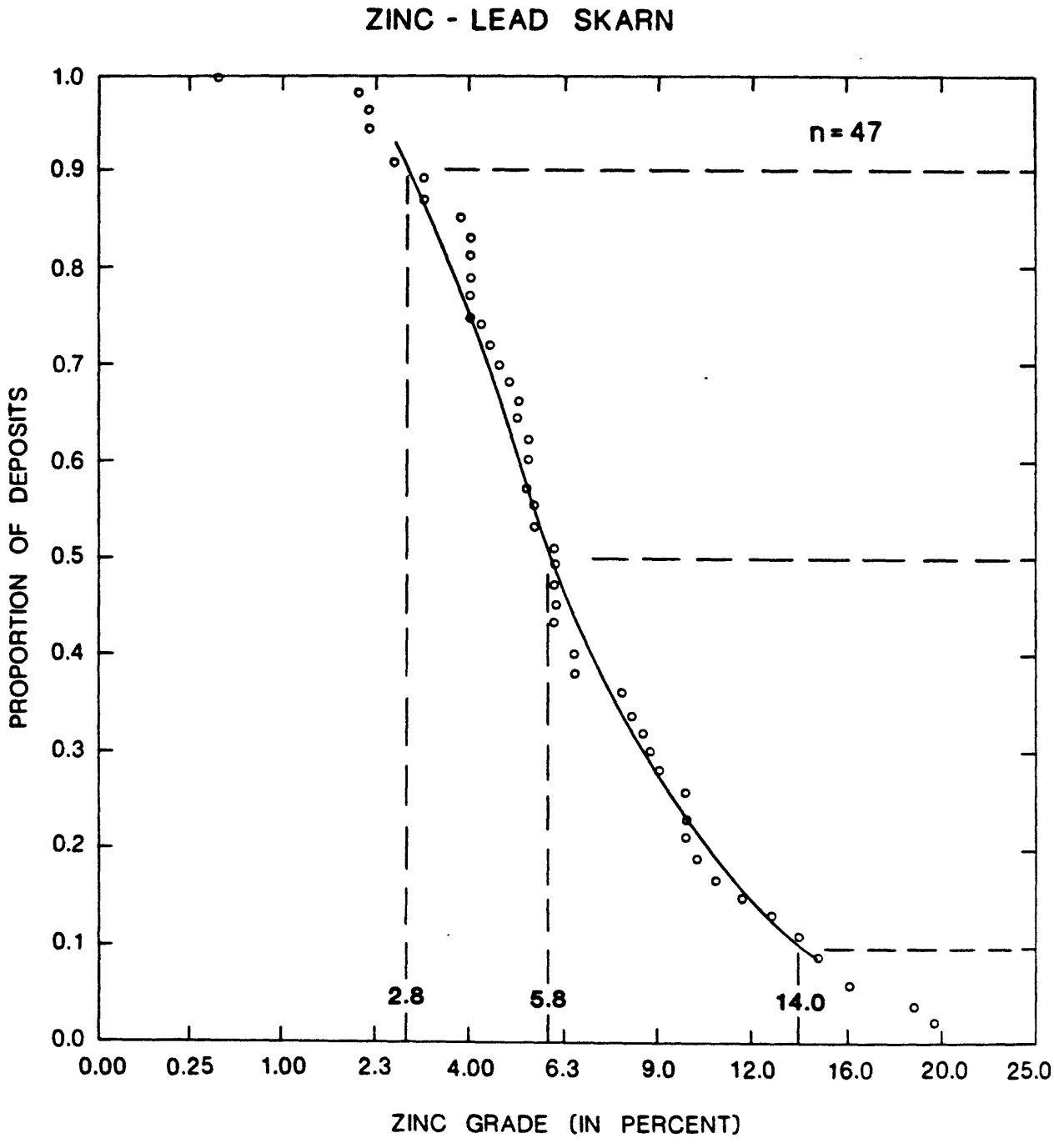
COMMENTS Lead grade is correlated with zinc grade (r=0.53, n=45).

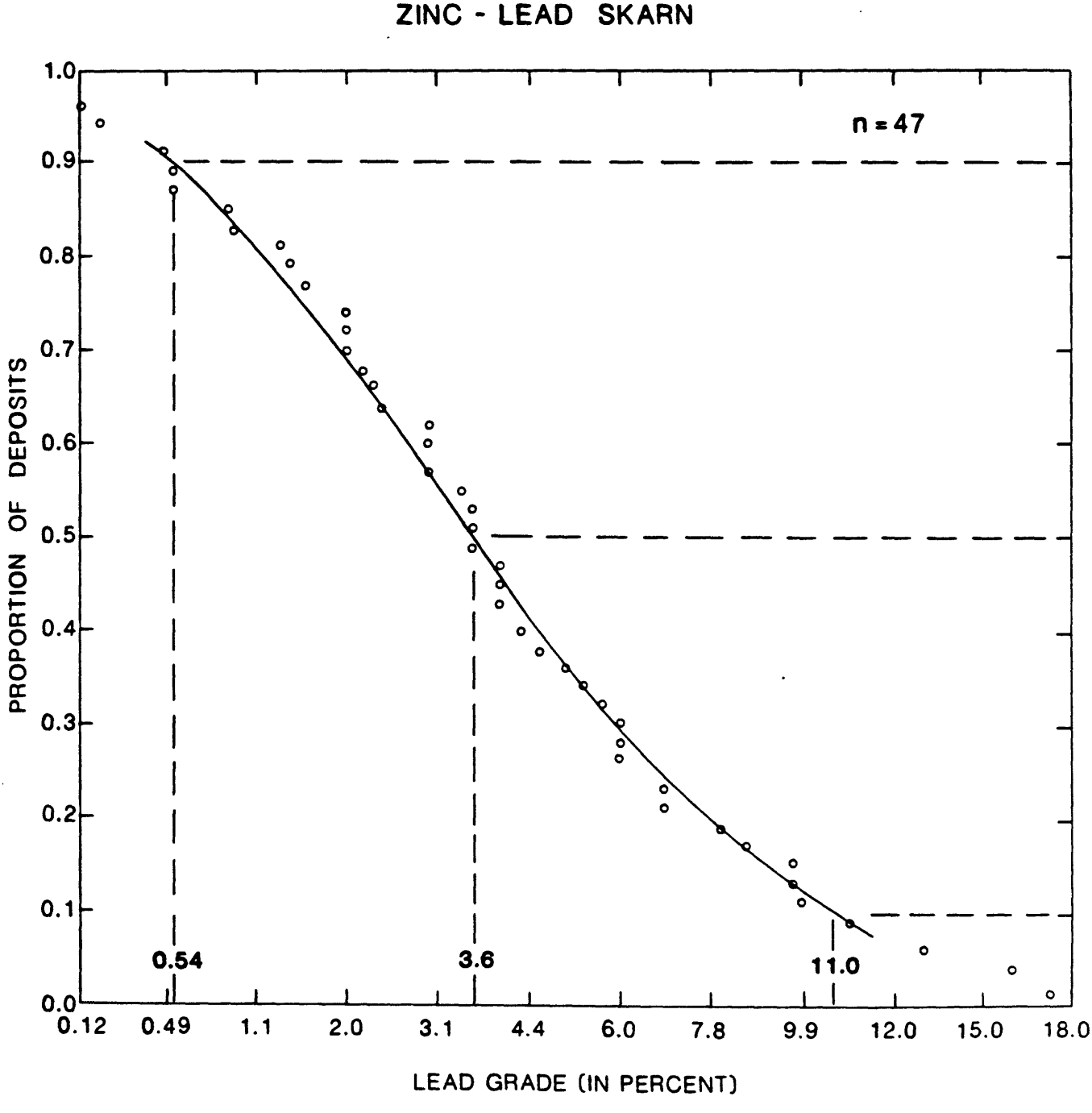
DEPOSITS

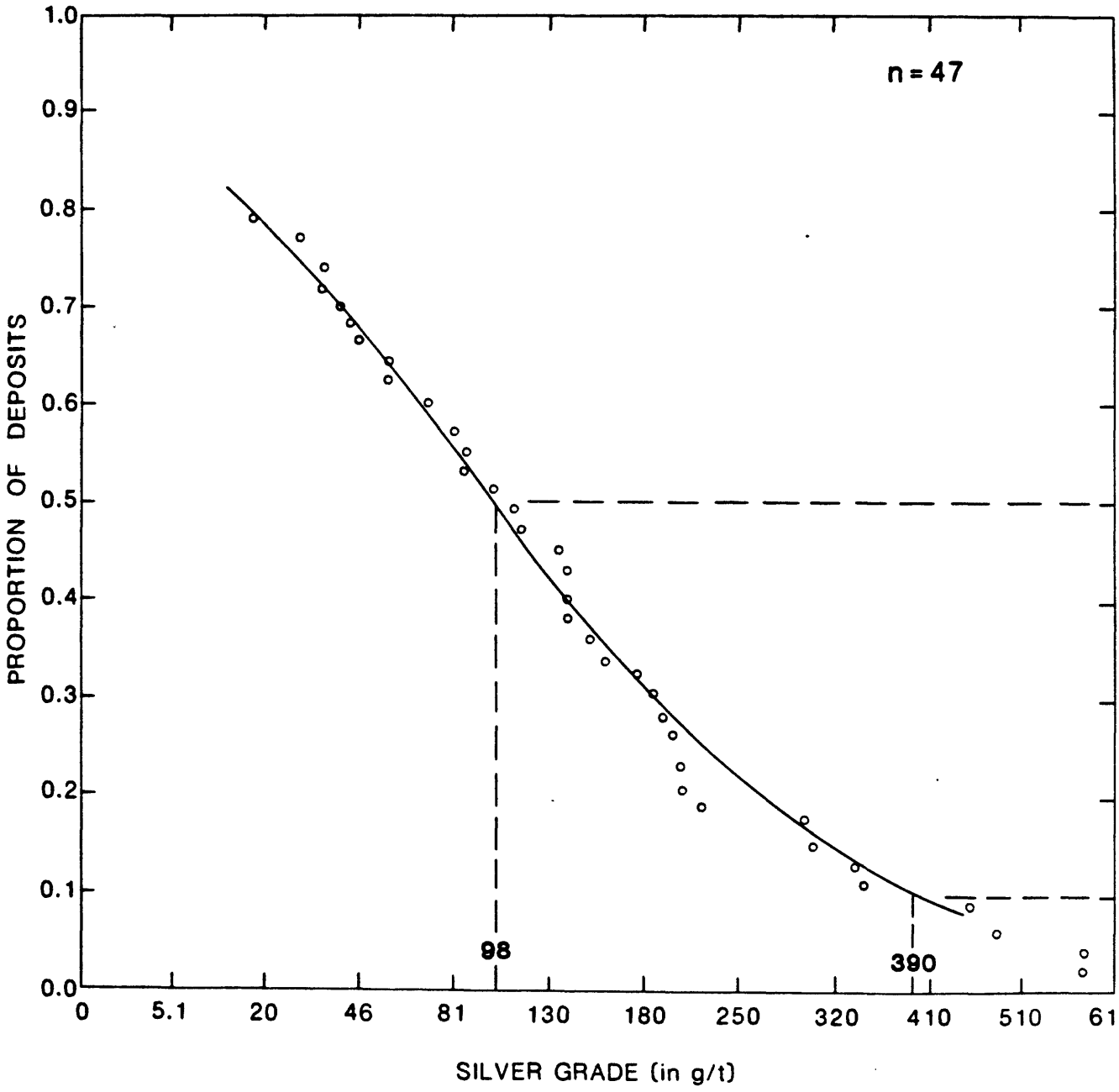
Name	Country	Name	Country
Aguilar	AGTN	Nyseter	NRWY
Ajvalija	YUGO	Parroquio-Magistral	MXCO
Ammeberg	SWDN	Ryllshyttan	SWDN
Aravaipa	USAZ	Sala	SWDN
Black Hawk	USNM	San Martin	MXCO
Bluebell	CNBC	Santa Eulalia	MXCO
Chalchihuites	MXCO	Saxberget	SWDN
Dolores	MXCO	Shuikoushan	CINA
El Mochito	HNDR	Staritrg	YUGO
Empire	USNM	Stollberg	SWDN
Falun	SWDN	Svardsio	SWDN
Garpenberg	SWDN	Tetyukhe	URRS
Garpenberg Odal	SWDN	Tienpaoshan	CINA
Groundhog	USNM	Trepca	YUGO
Kalvbacken	SWDN	Uchucchacua	PERU
Kamioka	JAPN	Ulchin	SKOR
Lampazos	MXCO	Velardena	MXCO
Magno	CNBC	Washington Camp	USAZ
Mazapil	MXCO	Yanchiachangtze	CINA
McDame Belle	CNBC	Yeonhwa I	SKOR
Meat Cove	CNNS	Yeonhwa II	SKOR
Mount Hundere	CNYT	Zimapan	MXCO
Naica	MXCO	Zip	CNBC
Nakatatsu	JAPN		


ZINC - LEAD SKARN
n = 47
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.25
2.1
18
0.0063
0.025
0.1
0.4
1.6
6.3
25
100
400
1600
6300
TONNES (IN MILLIONS)


ZINC - LEAD SKARN
n = 47
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.079
1.2
0.032
0.056
0.1
0.18
0.32
0.56
1.0
1.8
3.2
5.6
10.0
COPPER GRADE (IN PERCENT)


ZINC - LEAD SKARN
n = 47
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
2.8
5.8
14.0
0.00
0.25
1.00
2.3
4.00
6.3
9.0
12.0
16.0
20.0
25.0
ZINC GRADE (IN PERCENT)


ZINC - LEAD SKARN
n = 47
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.54
3.6
11.0
0.12
0.49
1.1
2.0
3.1
4.4
6.0
7.8
9.9
12.0
15.0
18.0
LEAD GRADE (IN PERCENT)


ZINC - LEAD SKARN
n = 47
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
98
390
0
5.1
20
46
81
130
180
250
320
410
510
61
SILVER GRADE (in g/t)

DEPOSIT TYPE Volcanogenic gold MODEL NUMBER 3.3

AUTHOR D. L. Mosier

COMMENTS Deposits were combined when they occur within one mile of each other.

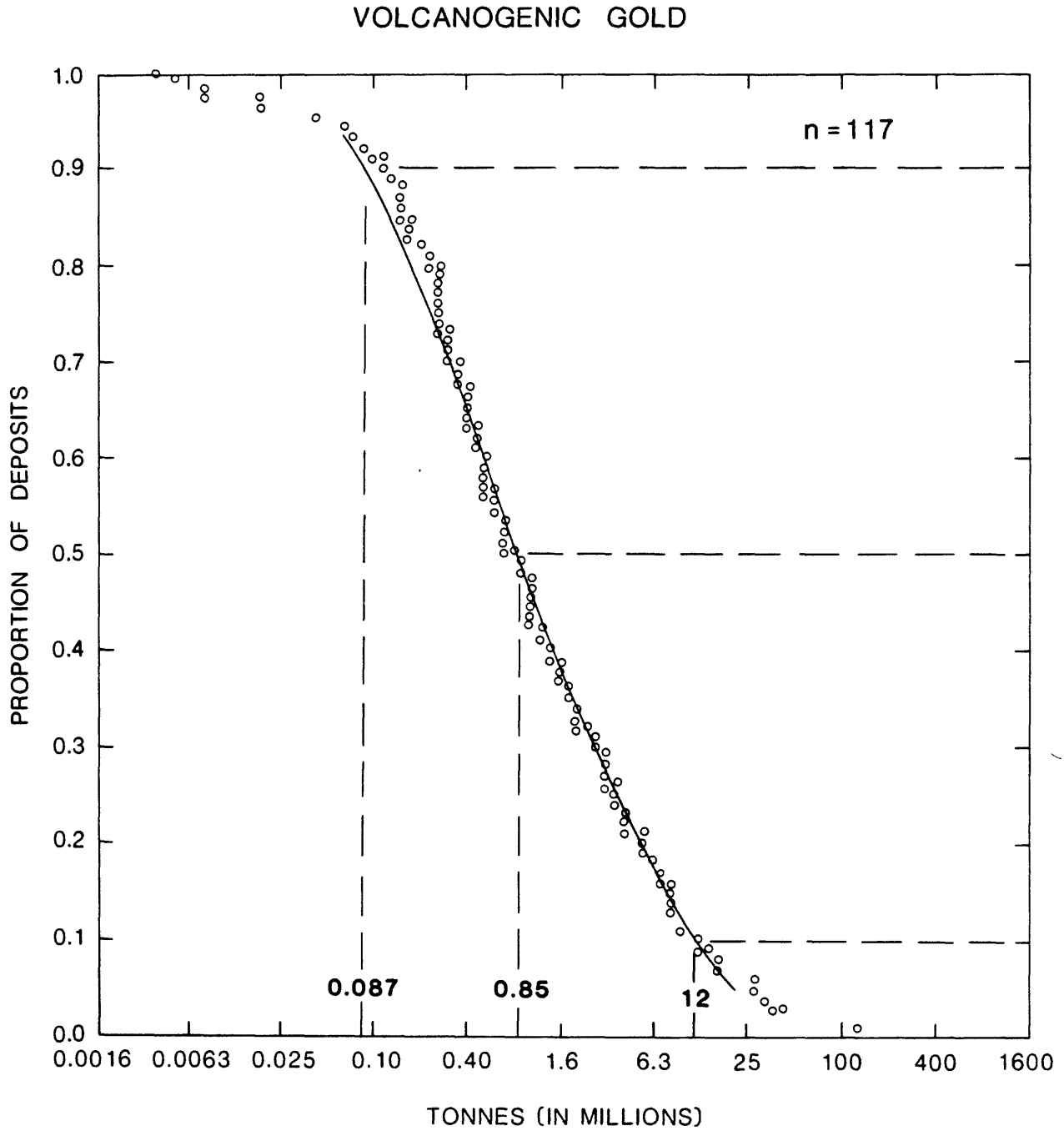
DEPOSITS

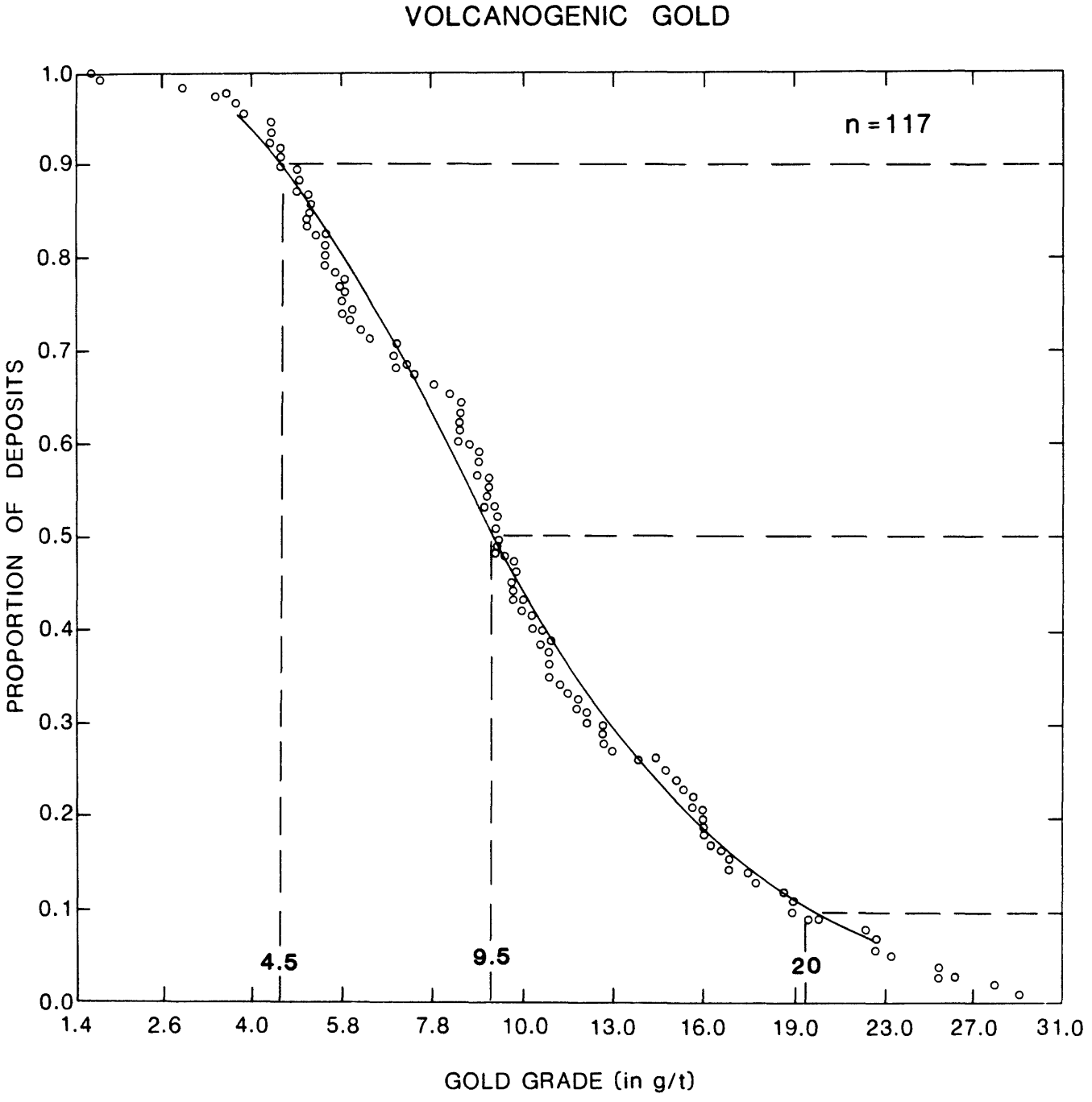
Name	Country	Name	Country
Agassiz	CNMN	Geita	TNZN
Albino	CNON	Gimlet-Slippery	AUWA
Ankerite-Aunor-Delnite	CNON	Gladstome-Sand Queen	AUWA
Arrowhead	CNQU	God's Lake	CNMN
Ashley	CNON	Gold Eagle-McKenzie	CNON
Bankfield-Tombill	CNON	Gold Hawk	CNON
Barbara-Surprise	AUWA	Gold Hill	CNON
Barber-Larder	CNON	Golden Ridge	AUWA
Barberton	SAFR	Gongo Socco	BRZL
Barry Hollinger	CNON	Gurney	CNMN
Bellevue	AUWA	Hard Rock-McLeod-Cockshutt	CNON
Bidgood-Moffatt-Hall	CNON	Hasaga-Howey	CNON
Big Bell	AUWA	Hollinger and others	CNON
Black Range-Oroya	AUWA	Homestake	USSD
Bob	ZIMB	Hutti	INDA
Bonnievale	AUWA	Ida H.	AUWA
Bouscadillac and others	CNON	Island Lake	CNMN
Broulan and others	CNON	Jason	CNON
Buffalo Red Lake	CNON	Jerome	CNON
Burbanks	AUWA	Kerr Addison	CNON
Calder-Bousquet	CNQU	Kiabakari	TNZN
Campbell Red Lake-Dickenson	CNON	Kilo-Moto	CNGO
Carshaw-Tommy Burns	CNON	Kolar	INDA
Cathroy Larder	CNON	Laguerre	CNON
Central Manitoba	CNMN	Lancefield	AUWA
Central Patricia	CNON	Lapa Cadillac	CNQU
Cheminis-Fernland-Omega	CNON	Leitch-Sand River	CNON
Chesterville	CNON	Lingman	CNON
Connemara	ZIMB	Little Long Lac	CNON
Coolgardie	AUWA	Madsen	CNON
Copperhead	AUWA	Magnet Cons.	CNON
Cosmopolitan	AUWA	Marble Bar	AUWA
Cullaton Lake	CNNT	Martin-Bird	CNON
Davidson	CNON	Matachewan Cons. & others	CNON
Day Dawn-Main Line	AUWA	Matona-Stairs	CNON
De Santis	CNON	McFinley	CNON
Dome-Paymaster-Preston	CNON	McMarmac	CNON
Edna May	AUWA	McWatters	CNQU
Emu-Great Eastern	AUWA	Menzies	AUWA
Fraser's	AUWA	Minto-Tyranite	CNON
Fuller-Tisdale	CNON	Morris-Kirkland	CNON

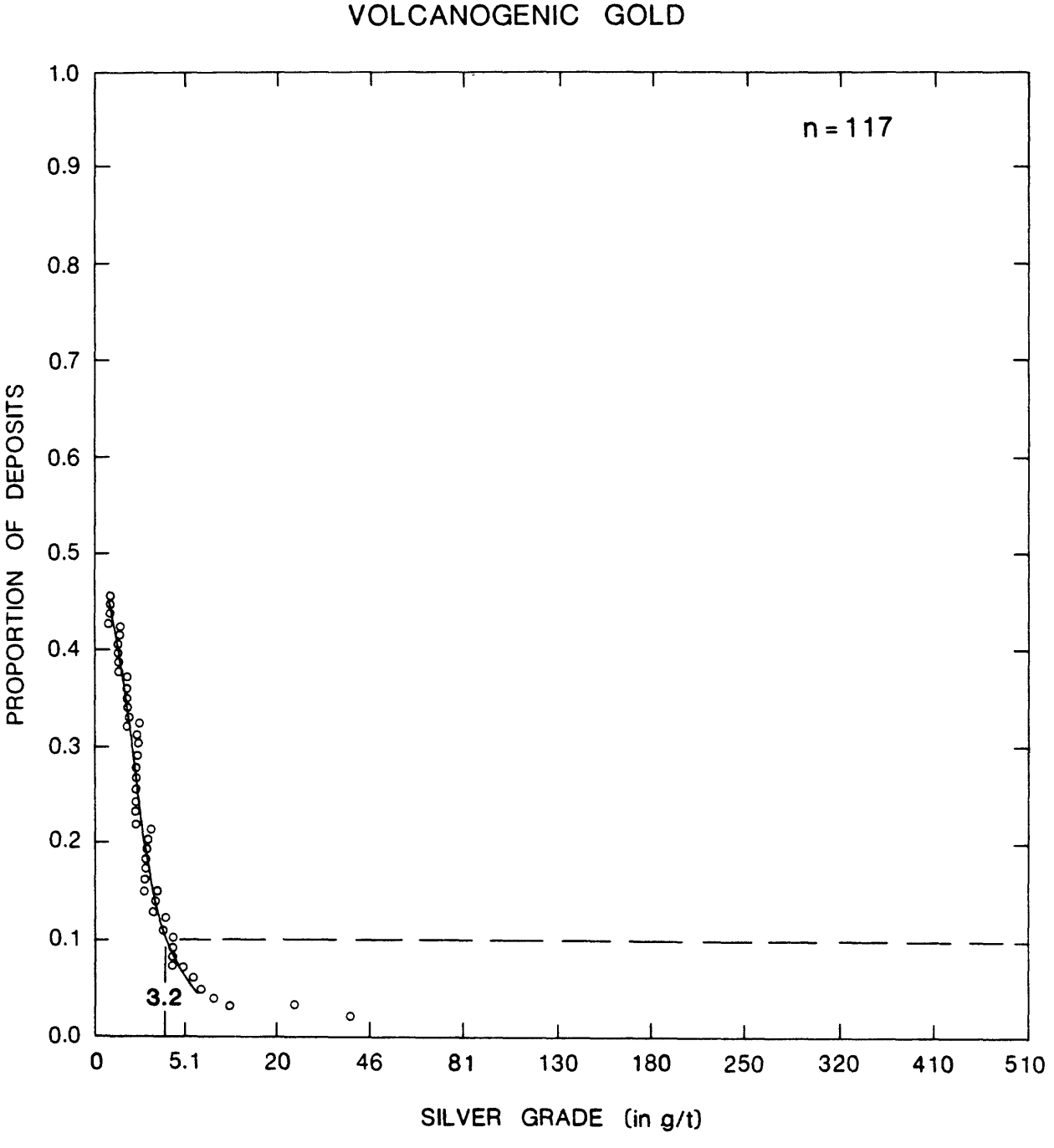
DEPOSIT TYPE Volcanogenic gold MODEL NUMBER 3.3

DEPOSITS (Continued)

Name	Country
Morro Velho	BRZL
Mt. Magnet	AUWA
Mt. Morgans	AUWA
Naybob	CNON
Nobles Nob	AUWA
Norseman-Dundas	AUWA
Orpit	CNON
Paddy's Flat	AUWA
Palmer's Find	AUWA
Passagem	BRZL
Pickle Crow	CNON
Queenston	CNON
Raposos	BRZL
Red Crest	CNON
Red Lake Gold Shore	CNON
Ross	CNON
Rouyn Merger	CNQU
Sanshaw	CNON
Shamva-Cymric Gp.	ZIMB
Son of Gwalia	AUWA
Stadacona	CNQU
Starratt-Olsen	CNON
Talmora Longlac	CNON
Thompson Bousquet	CNQU
Timoni	AUWA
Triton	AUWA
Uchi	CNON
Upper Beaver	CNON
Upper Canada	CNON
Wasa Lake	CNQU
White Feather	AUWA
Wilmar and others	CNON
Wiluna-Moonlight	AUWA
Youanmi	AUWA


VOLCANOGENIC GOLD
n = 117
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.087
0.85
12
0.0016
0.0063
0.025
0.10
0.40
1.6
6.3
25
100
400
1600
TONNES (IN MILLIONS)


VOLCANOGENIC GOLD
n = 117
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
4.5
9.5
20
1.4
2.6
4.0
5.8
7.8
10.0
13.0
16.0
19.0
23.0
27.0
31.0
GOLD GRADE (in g/t)


VOLCANOGENIC GOLD
n = 117
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3.2
0
5.1
20
46
81
130
180
250
320
410
510
SILVER GRADE (in g/t)

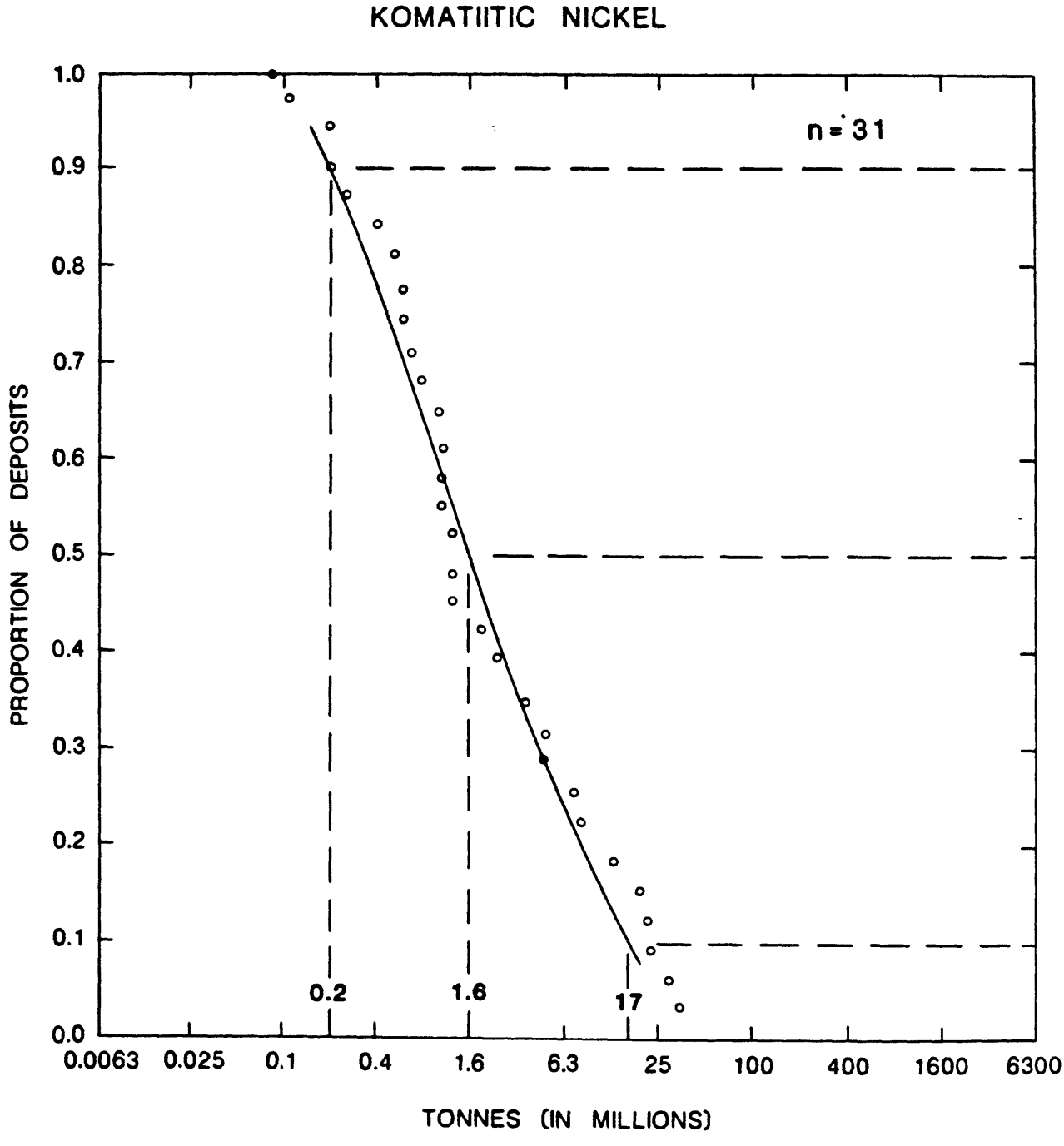
DEPOSIT TYPE Komatiitic nickel MODEL NUMBER 3.4

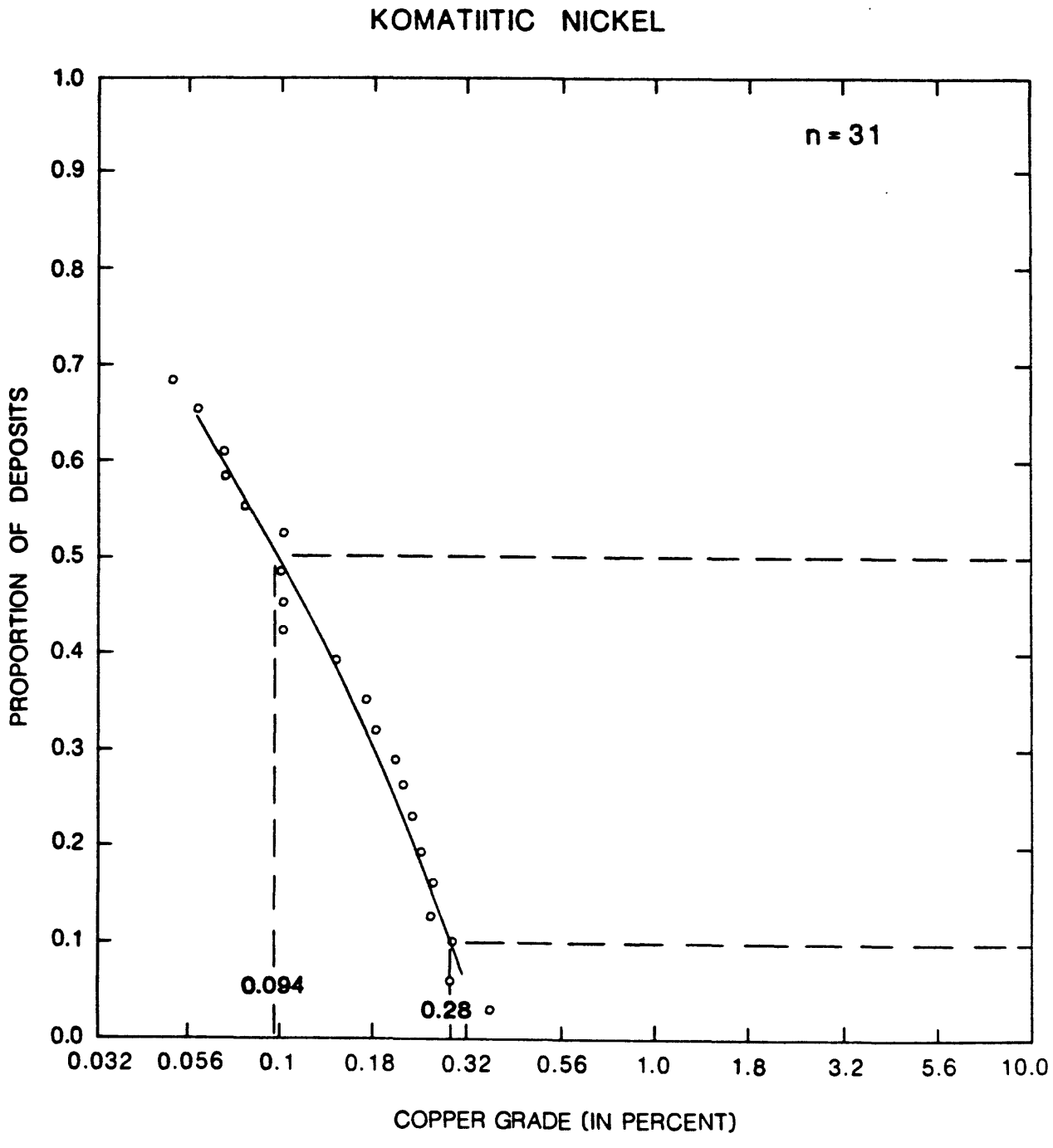
AUTHOR D. A. Singer, N. J Page, and W. D. Menzie

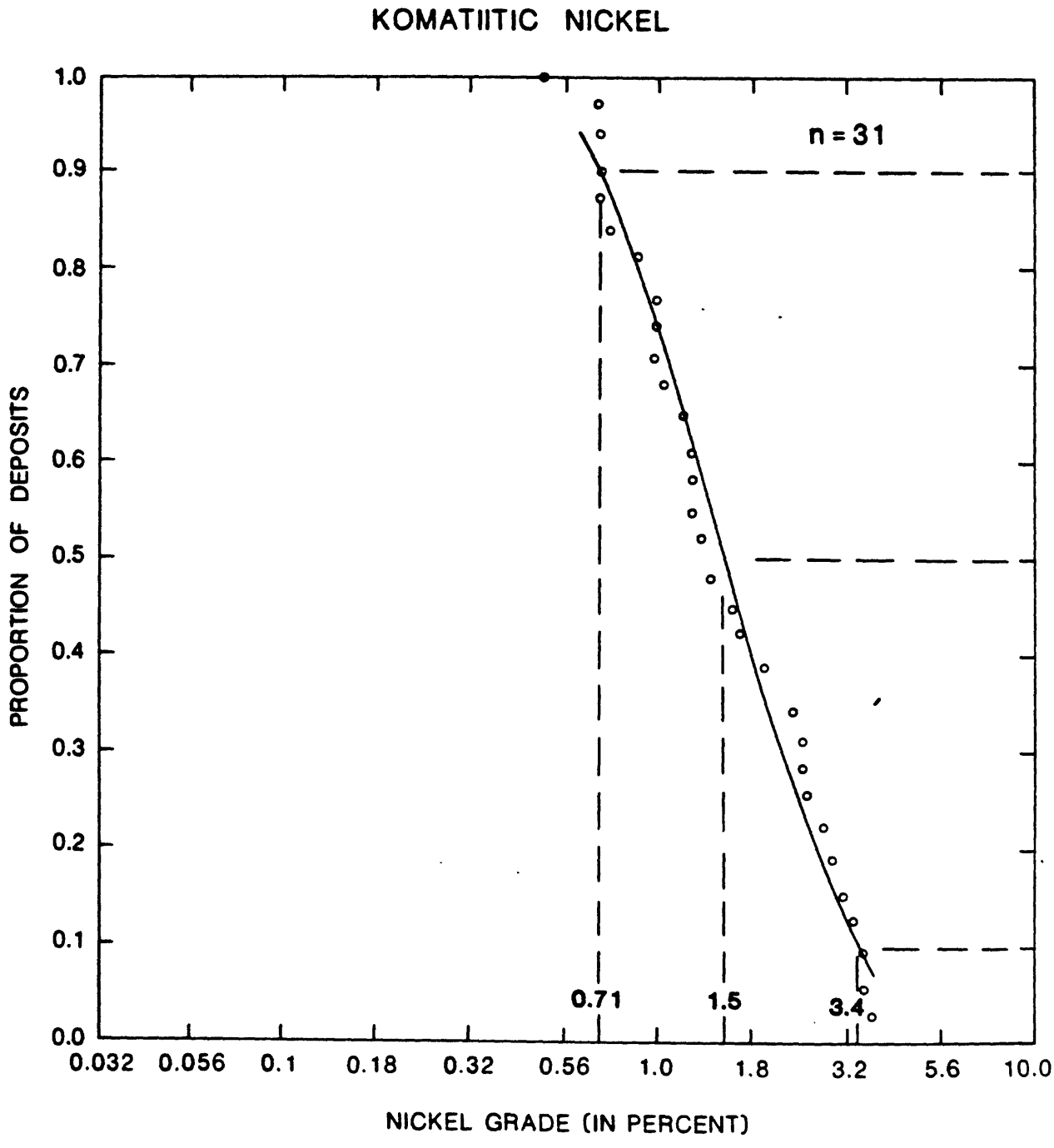
COMMENTS Nickel grade is correlated with tonnage (r=-0.47) and with copper grade (r=0.59).

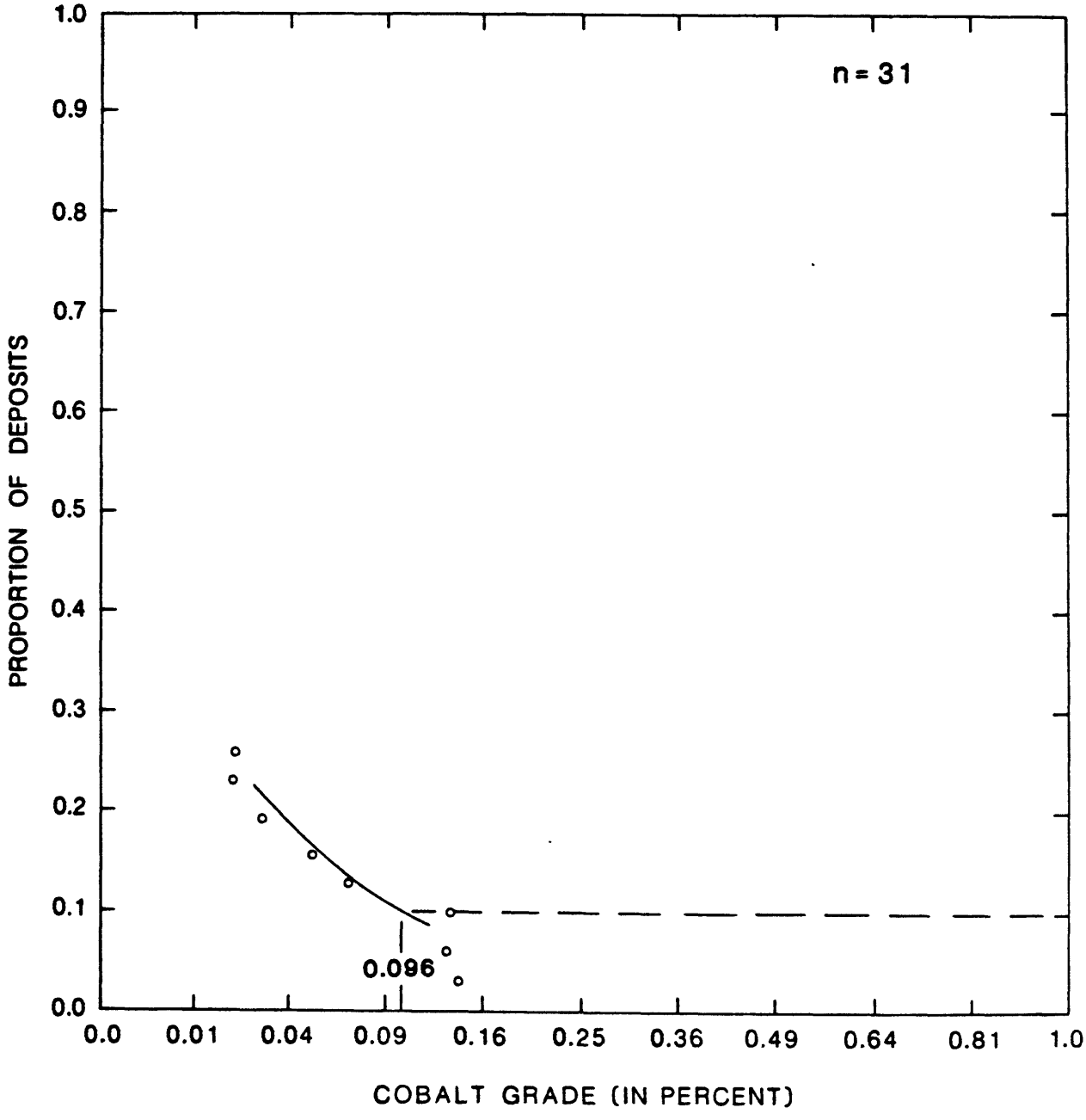
DEPOSITS

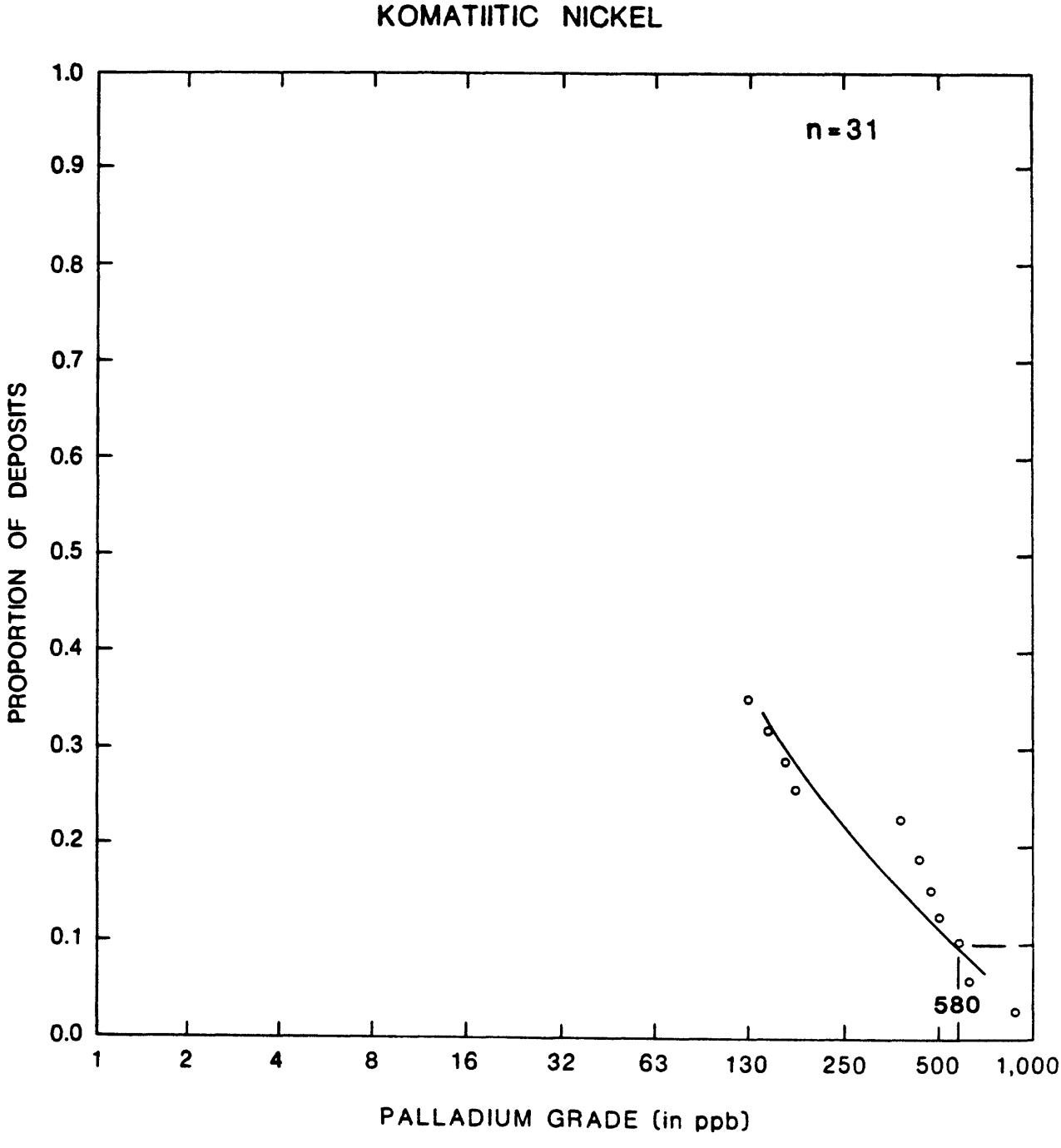
Name	Country
Carnilya E.	AUWA
Carnilya Hill	AUWA
Damba	ZIMB
Epoch	ZIMB
E. Scotia	AUWA
Hitura	FNLD
Huntersroad	ZIMB
Kambalda	AUWA
Kotalahti	FNLD
Langmuir 1	CNON
Langmuir 2	CNON
Marbridge	CNQU
McWatters	CNON
Miriam	AUWA
Mt. Edwards	AUWA
Mt. Windarra	AUWA
Munda	AUWA
Nepean	AUWA
Perserverance	ZIMB
Rankin Inlet	CNNT
Redross	AUWA
Scotia	AUWA
Selukwe	ZIMB
Shangani	ZIMB
Sothman Twp.	CNON
Spargonville	AUWA
S. Windarra	AUWA
Textmont	CNON
Trojan	ZIMB
Wannaway	AUWA
Wigie 3	AUWA

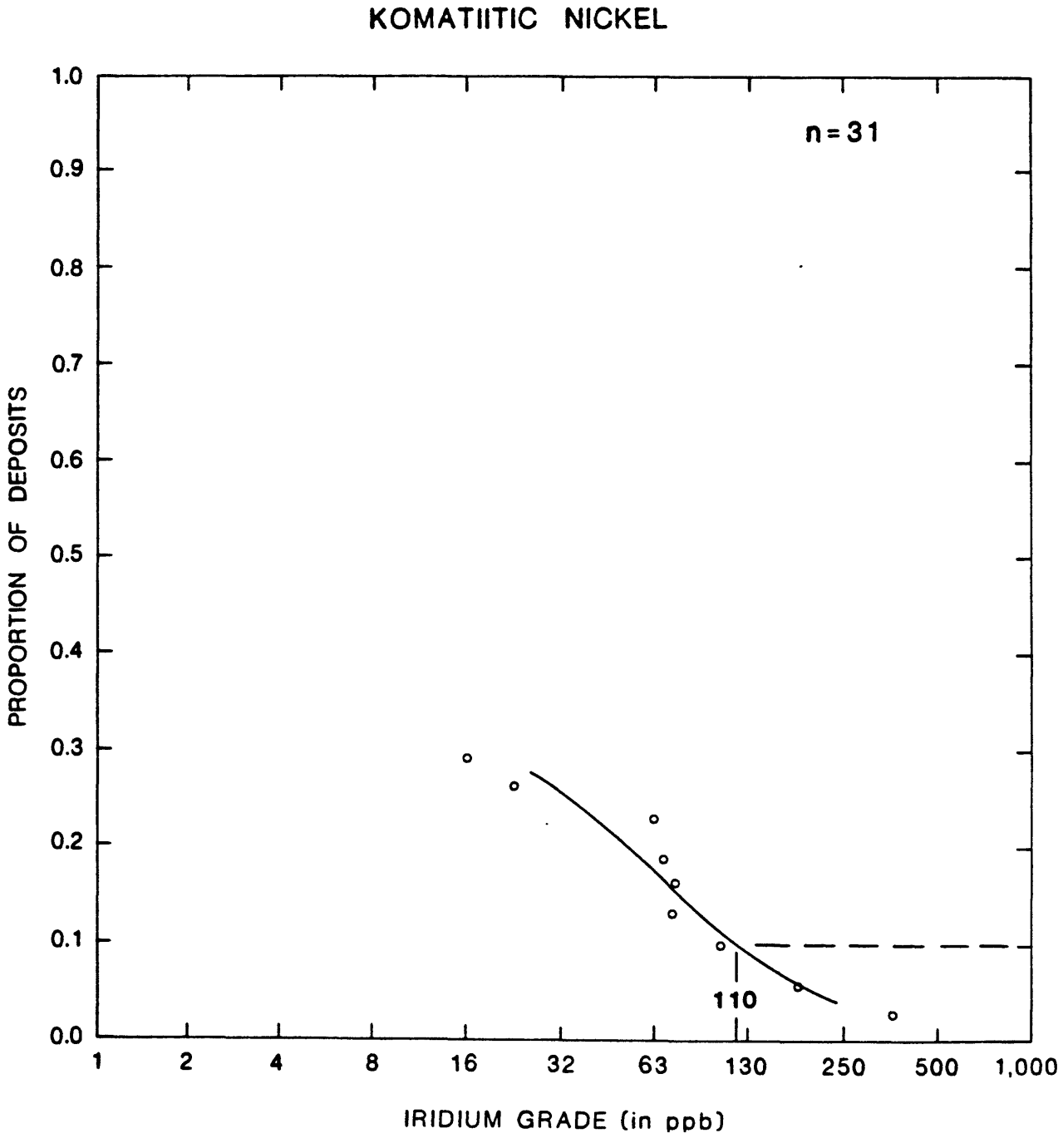

KOMATIITIC NICKEL
n = 31
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.2
1.6
17
0.0063
0.025
0.1
0.4
1.6
6.3
25
100
400
1600
6300
TONNES (IN MILLIONS)

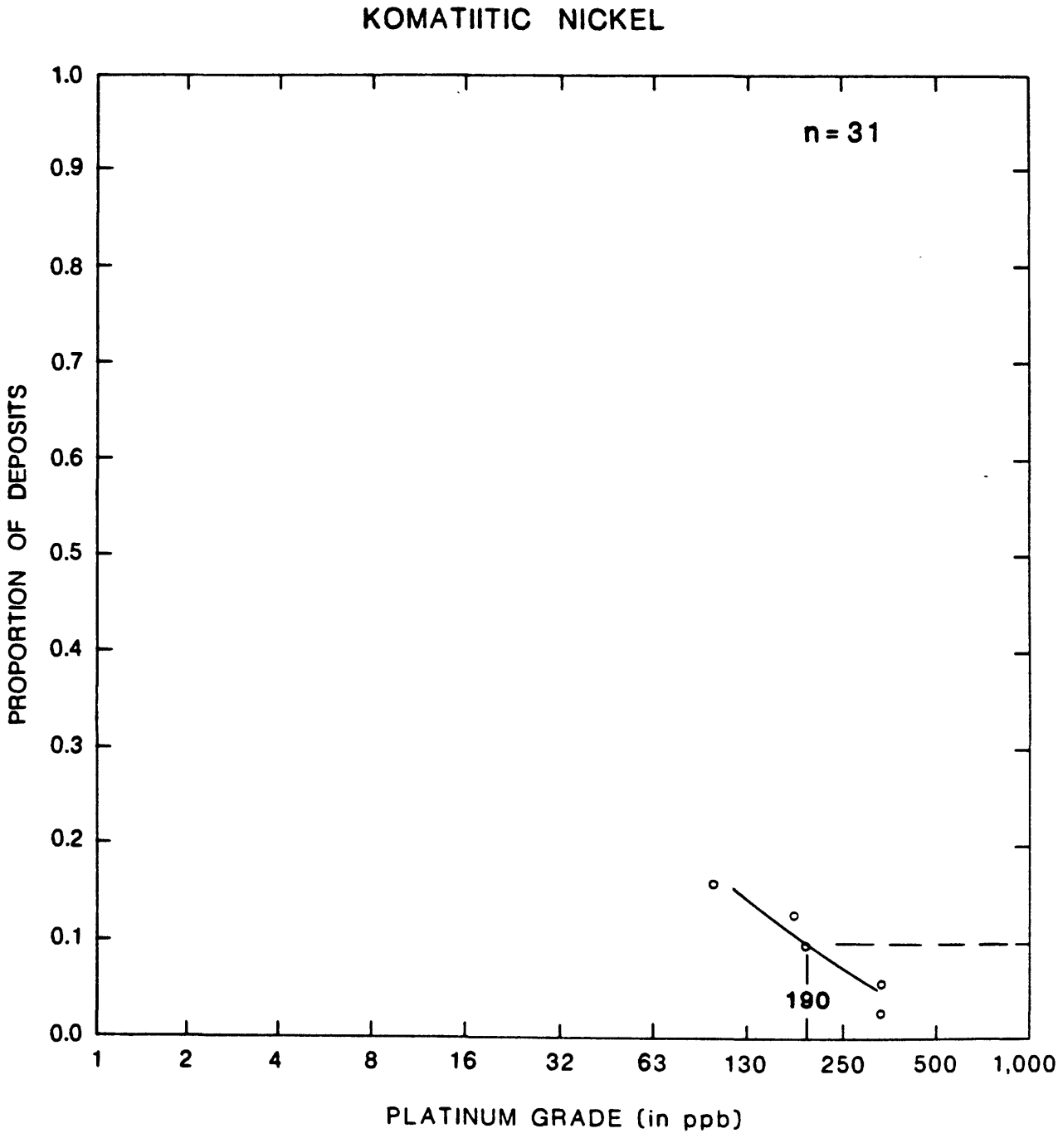

KOMATIITIC NICKEL
n = 31
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.094
0.28
0.032
0.056
0.1
0.18
0.32
0.56
1.0
1.8
3.2
5.6
10.0
COPPER GRADE (IN PERCENT)

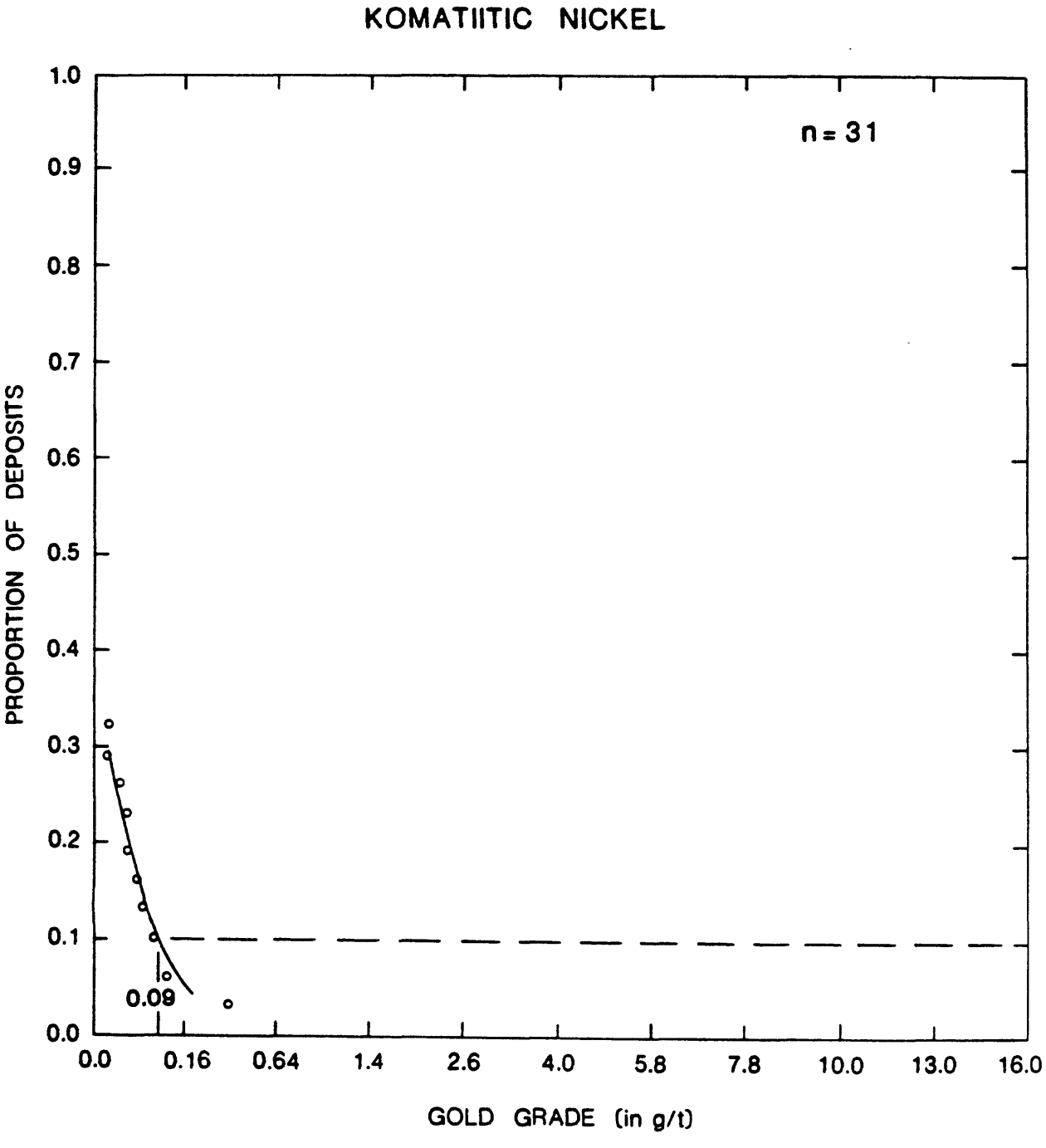

KOMATIITIC NICKEL
n = 31
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.71
1.5
3.4
0.032
0.056
0.1
0.18
0.32
0.56
1.0
1.8
3.2
5.6
10.0
NICKEL GRADE (IN PERCENT)


KOMATIITIC NICKEL
n = 31
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.096
0.0
0.01
0.04
0.09
0.16
0.25
0.36
0.49
0.64
0.81
1.0
COBALT GRADE (IN PERCENT)


KOMATIITIC NICKEL
n=31
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
580
1
2
4
8
16
32
63
130
250
500
1,000
PALLADIUM GRADE (in ppb)


KOMATIITIC NICKEL
n=31
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
110
1
2
4
8
16
32
63
130
250
500
1,000
IRIDIUM GRADE (in ppb)


KOMATIITIC NICKEL
n = 31
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
190
1
2
4
8
16
32
63
130
250
500
1,000
PLATINUM GRADE (in ppb)


KOMATIITIC NICKEL
n = 31
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.09
0.0
0.16
0.64
1.4
2.6
4.0
5.8
7.8
10.0
13.0
16.0
GOLD GRADE (in g/t)

DEPOSIT TYPE Volcanogenic manganese MODEL NUMBER 3.5

AUTHOR D. L. Mosier

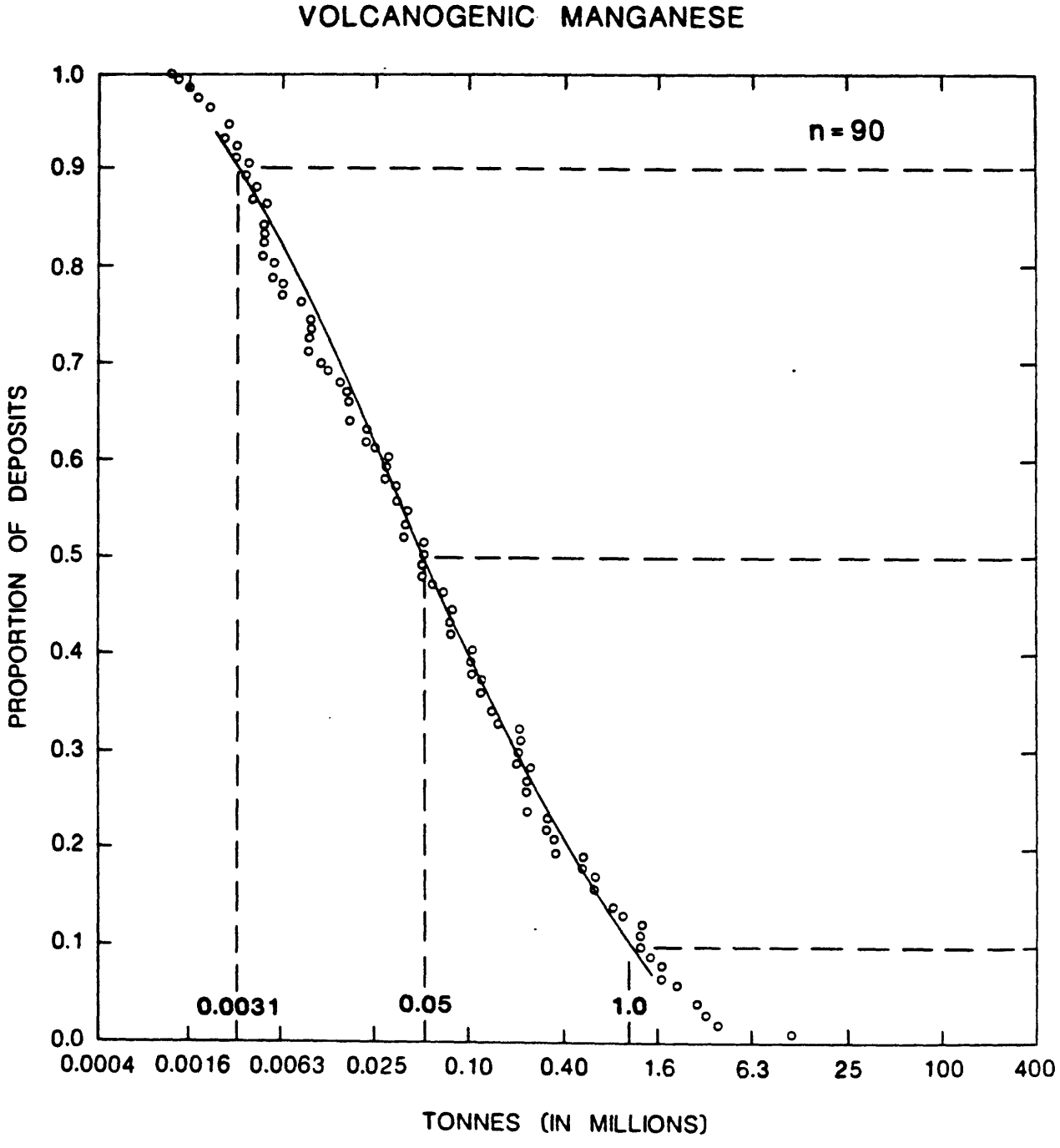
COMMENTS Manganese grade is correlated with tonnage at the 1% level of significance (r=-0.33).

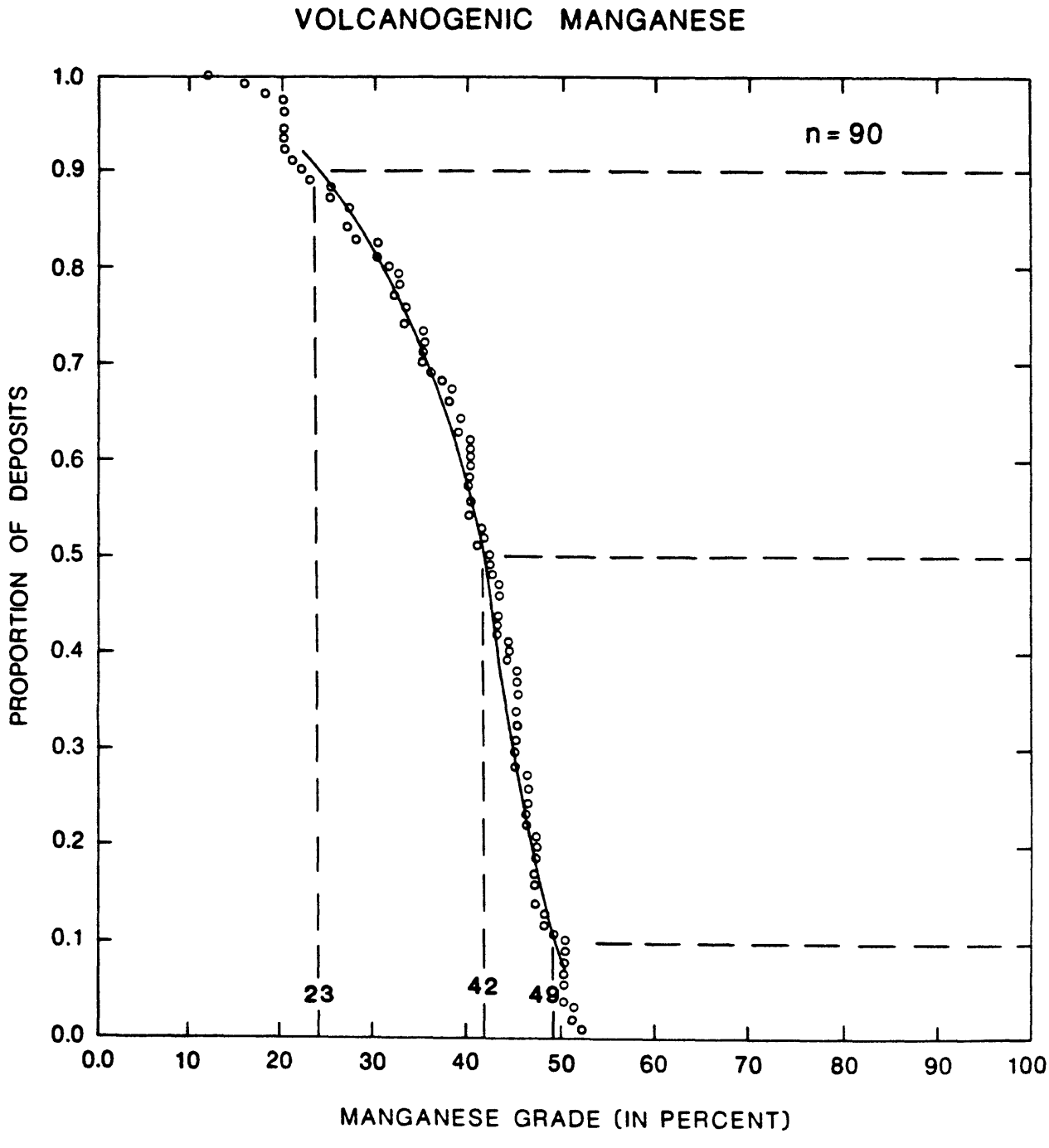
DEPOSITS

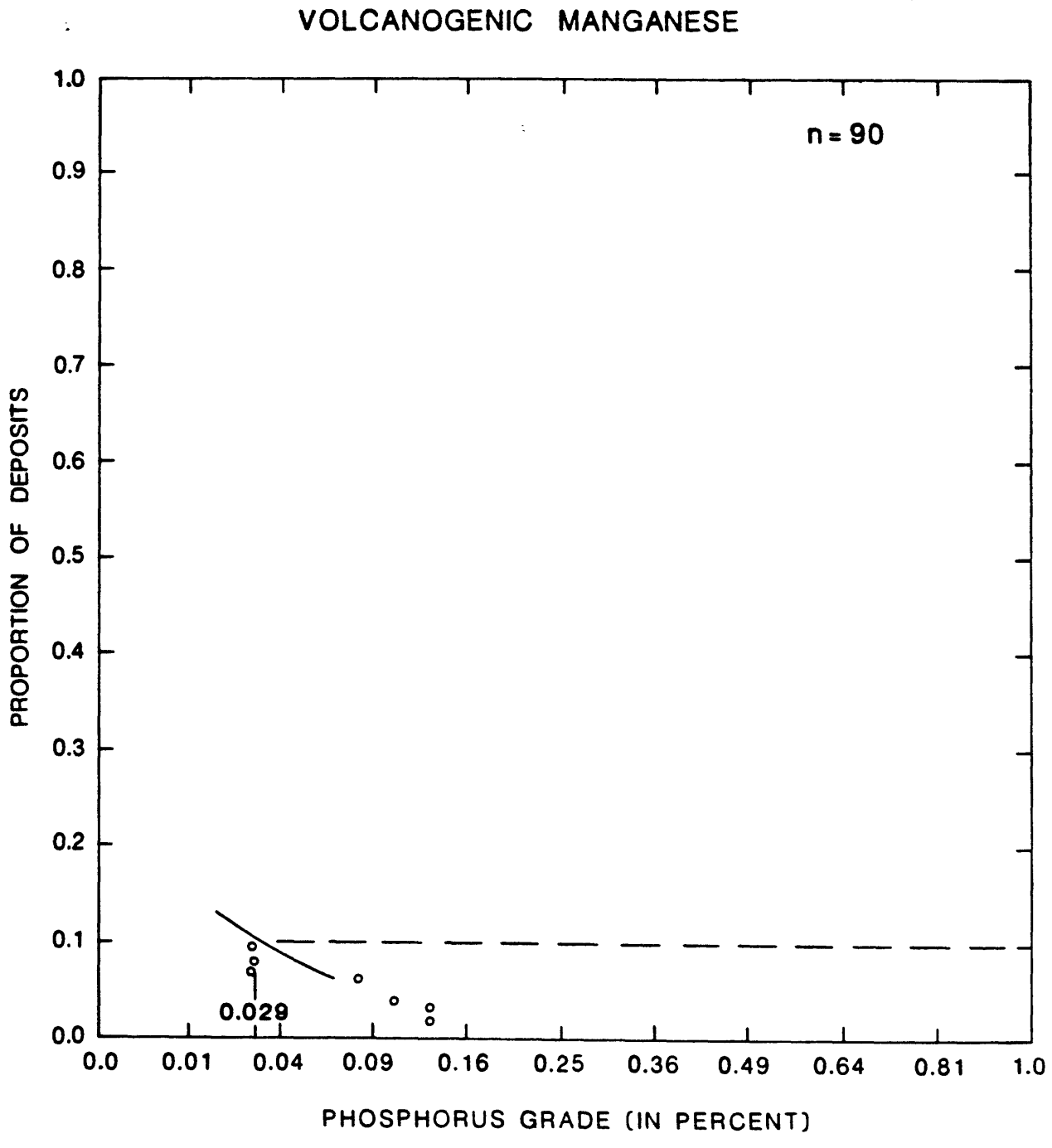
Name	Country	Name	Country
Abuhemsin (Abiulya)	TRKY	Gloria-Elvira-Polaris	CUBA
Abundancia	TRKY	Gocek Koyu	TRKY
Akcakilise Topkirazlar	TRKY	Guanaba Group	CUBA
Akoluuk	TRKY	Gunbasi (Akcakese)	TRKY
Akseki Gokceovacik	TRKY	Hyatt No. 1	PANA
Antonio	CUBA	Idikel	MRCO
Augusto Luis & others	CUBA	Ilave	CUBA
Avispa	CUBA	Jo7	NCAL
Black Diablo	USNV	Jutinicu	CUBA
Blue Jay	USCA	Komurluk Koyunun	TRKY
Boston Group	CUBA	Korucular	TRKY
Briseida Group & others	CUBA	La Calanesa	SPAN
Buckeye	USCA	Ladd	USCA
Bueycito	CUBA	Lagnokaha	UVOL
Buritirama	BRZL	Lasbela	PKTN
Cadiz	CUBA	La Unica	CUBA
Castillode Palanco	SPAN	Laverton-Mt. Lucky	AUWA
Cavdarli-Komurluk	TRKY	Liberty	USCA
Cayirli Koy	TRKY	Lucia (Generosa)	CUBA
Charco Redondo-Casualidad	CUBA	Lucifer	MXCO
Crescent	USWA	Magadalena	CUBA
Cubenas	CUBA	Manacas Group	CUBA
Cubuklu Koyu	TRKY	Manuel	CUBA
Cummings	USCA	Montenegro-Adriana	CUBA
Curiol-Playa Real-Pavones	CORI	Mrima	KNYA
Dassoumble	IVCO	Pirki	TRKY
Djebel Guettara	ALGR	Piskala	TRKY
Durnovskoe	URRS	Ponupo	CUBA
El Cuervo	SPAN	Ponupo de Manacal	CUBA
Esperancita	CUBA	Pozo Prieto	CUBA
Estrella-Sopresa	CUBA	Progreso	CUBA
Fabian	USCA	Quarzazate	MRCO
Faucogney	FRNC	Quinto	CUBA
Foster Mountain	USCA	Raymond	NCAL
Glib en Nam	MRCO	Rhiw	GRBR

DEPOSITS

Name	Country	Name	Country
Sabanilla	CUBA	Tiere	UVOL
Sapalskoe	URRS	Tiouine	MRCO
Sereno	BRZL	Tokoro	JAPN
Sigua	CUBA	Topkirozlar	TRKY
Soloviejo	SPAN	Toscana (Cerchiara)	ITLY
South Thomas	USCA	Tutunculer	TRKY
Taratana	CUBA	Valle de Manganeso	CUBA
Taritipan	INDS	Welch	USCA
Thatcher Creek	USCA	Woody Woody	AUWA
Thomas	USCA	Yeya	CUBA


VOLCANOGENIC MANGANESE
n = 90
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0031
0.05
1.0
0.0004 0.0016 0.0063 0.025 0.10 0.40 1.6 6.3 25 100 400
TONNES (IN MILLIONS)


VOLCANOGENIC MANGANESE
n = 90
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
23
42
49
0.0
10
20
30
40
50
60
70
80
90
100
MANGANESE GRADE (IN PERCENT)


VOLCANOGENIC MANGANESE
n = 90
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.029
0.0
0.01
0.04
0.09
0.16
0.25
0.36
0.49
0.64
0.81
1.0
PHOSPHORUS GRADE (IN PERCENT)

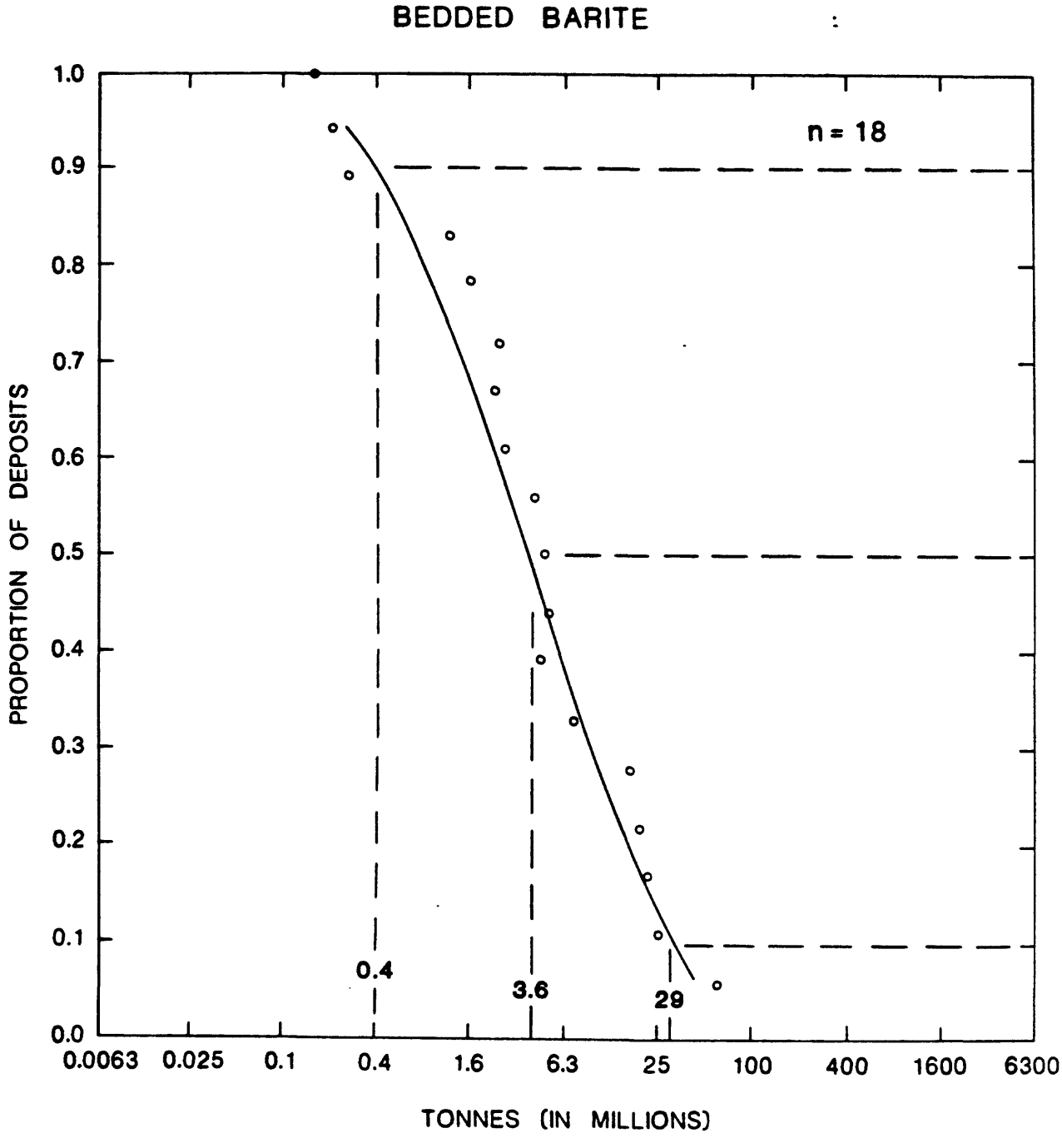
DEPOSIT TYPE Bedded barite MODEL NUMBER 4.9

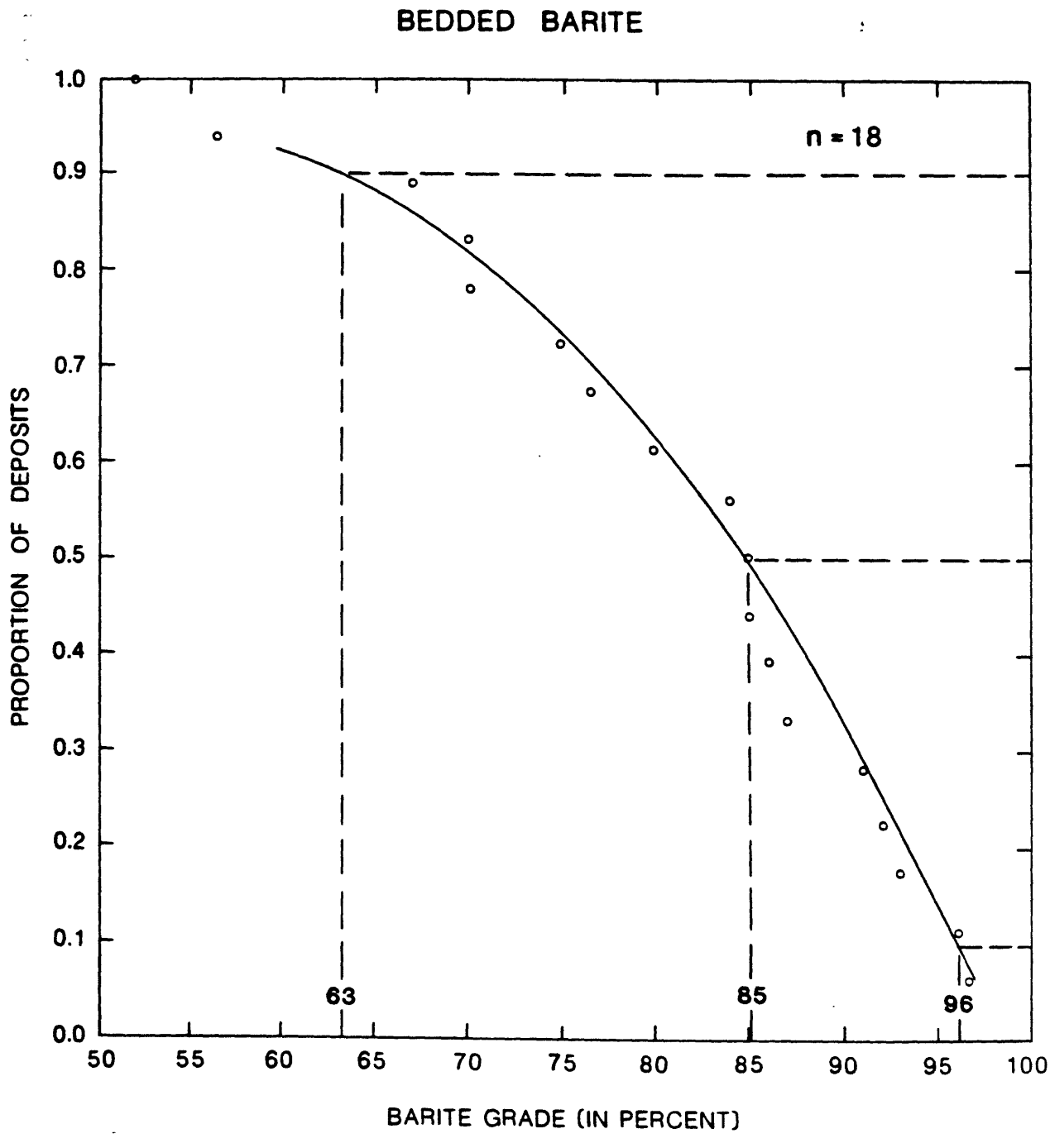
AUTHOR G. Orris

COMMENTS

DEPOSITS

Name	Country
Balleynoe	IRLD
Barite (Mouse)	CNYT
Barite Valley	SWAZ
Baw Hin Khao	THLD
Brookfield	CNNS
Cirque	CNBC
Khuzdar	PKTN
Magcobar	IRLD
Magnet Cove	USAR
Mangampetta N.	INDA
Mangampetta S.	INDA
Meggen	GRMY
Mel	CNYT
Nimiuktuk	USAK
Rammelsberg	GRMY
Snake Mountain	USNV
Tea	CNYT
Uribe	USWA


BEDDED BARITE
n = 18
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.4
3.6
29
0.0063
0.025
0.1
0.4
1.6
6.3
25
100
400
1600
6300
TONNES (IN MILLIONS)


BEDDED BARITE
n = 18
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
63
85
96
50
55
60
65
70
75
80
85
90
95
100
BARITE GRADE (IN PERCENT)

DEPOSIT TYPE Low-sulfide quartz gold Model Number 5.3

AUTHOR J. Bliss

COMMENTS All deposits in the model are from the Mother Lode of California. All mines within one mile were combined and only deposits containing more than 100 tonnes are included. Gold grade is significantly correlated with tonnage (r = -0.40)

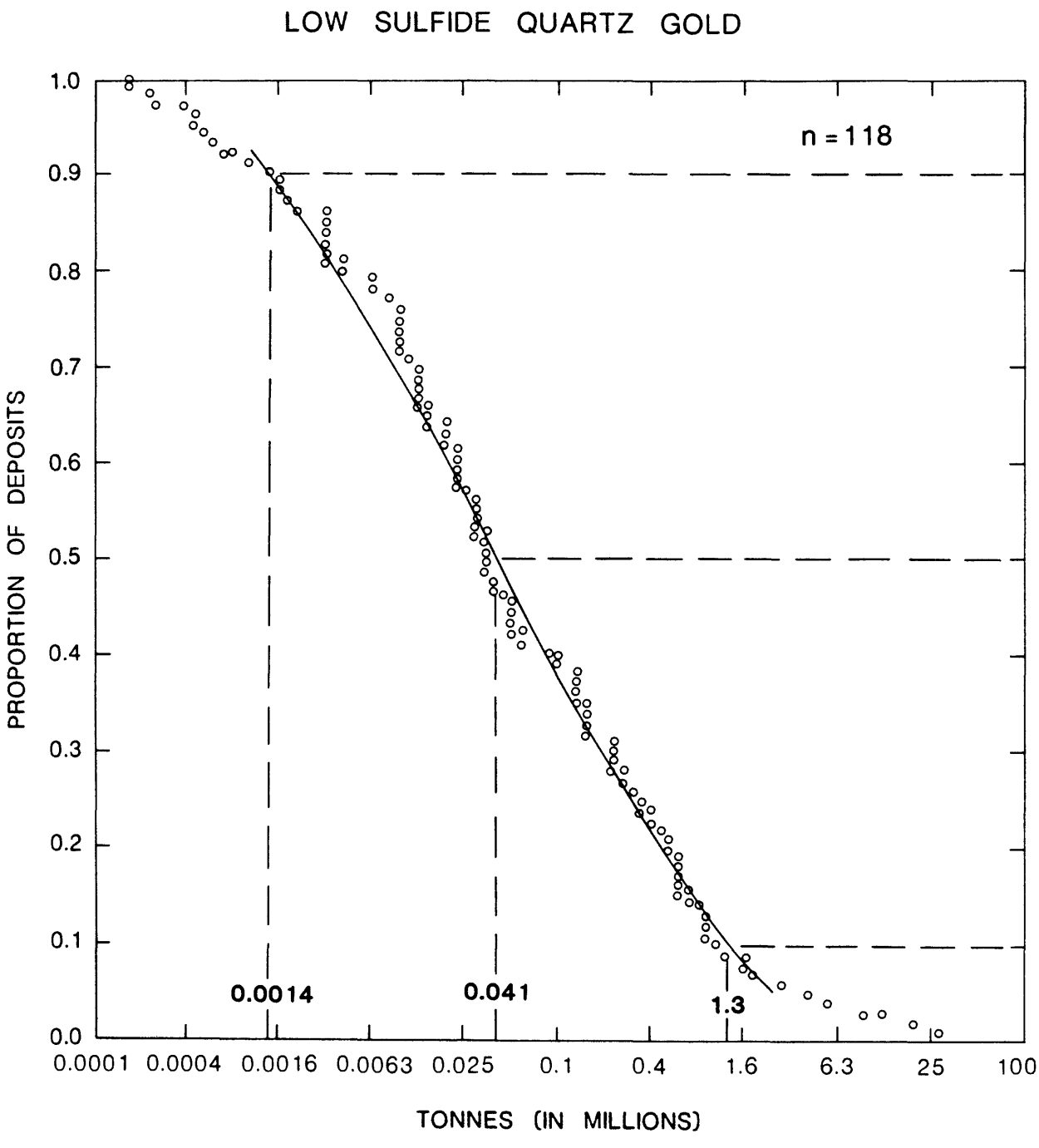
DEPOSITS

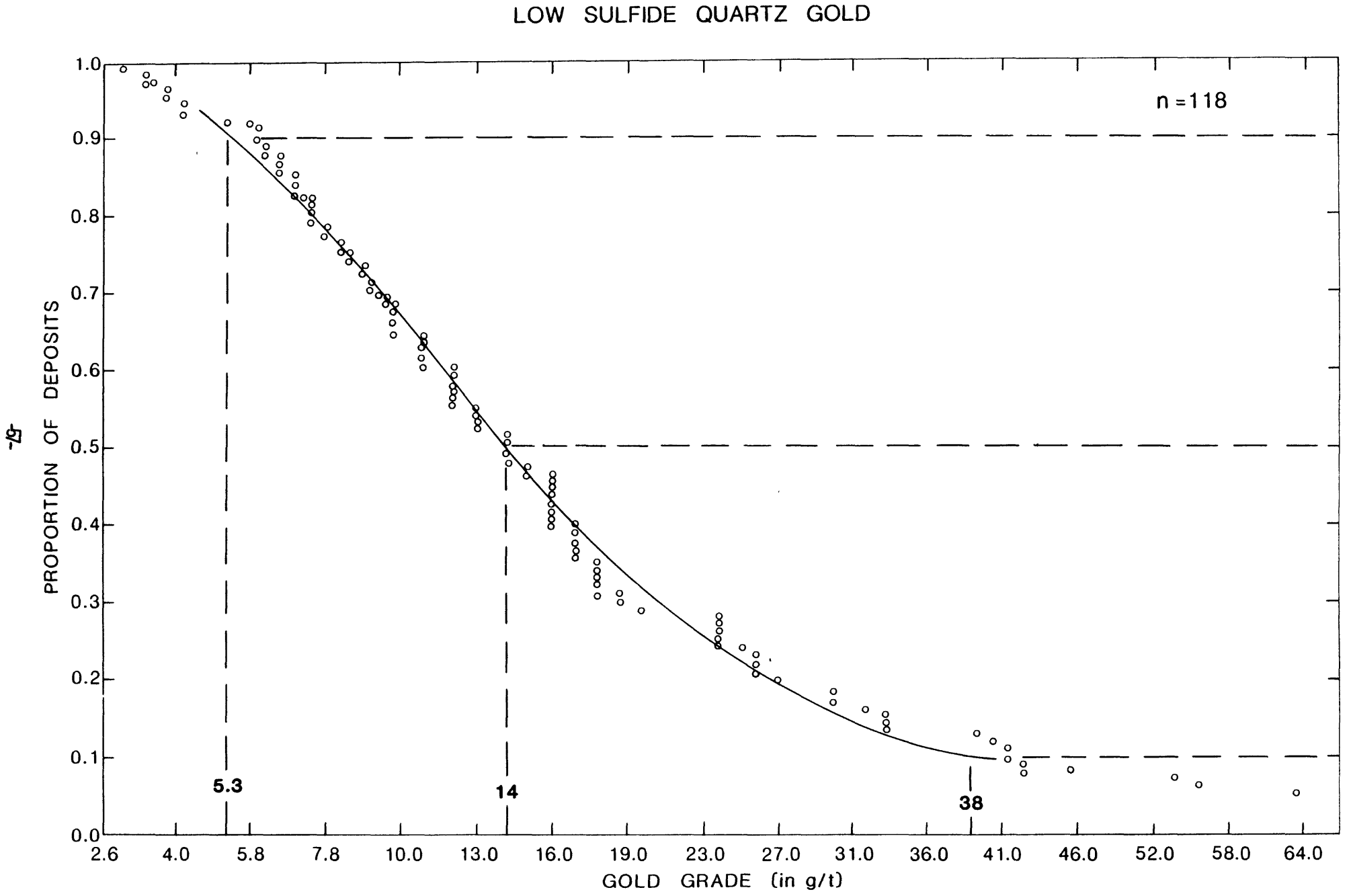
Name	Country	Name	Country
Alice	USCA	Finney	USCA
Alleghany East	USCA	Forbestown	USCA
Alleghany West	USCA	Ford	USCA
Alto	USCA	Fourth Cross	USCA
Amador City	USCA	French	USCA
American Bar	USCA	Gambetta	USCA
Angels-Carson	USCA	Gem	USCA
Argo	USCA	Gem Olive	USCA
Atlas	USCA	German Bar	USCA
Bagby	USCA	Giant Grass V.	USCA
Bagby North	USCA	Glencoe-Woudhouse	USCA
Bear Valley	USCA	Gold Bug	USCA
Bear Valley South	USCA	Golden Chariot	USCA
Belden	USCA	Gold Point	USCA
Berry Creek	USCA	Golden-Eldorado	USCA
Big Oak Flat	USCA	Grand Victory	USCA
Blackstone	USCA	Granite King	USCA
Blue Mountain	USCA	Greater Grass V.	USCA
Bondurant	USCA	Green-Excelsior	USCA
Coarsegold	USCA	Gwynne	USCA
Colfax	USCA	Ham-Birney	USCA
Colombo	USCA	Herman	USCA
Confidence	USCA	Hornitos	USCA
Coulterville	USCA	Horseshoe I	USCA
Coulterville South	USCA	Hunter Valley	USCA
Cove	USCA	Iconoclast	USCA
Damascus	USCA	Jacksonville W.	USCA
Defender	USCA	Jamestown	USCA
Demarest	USCA	Joe Walker	USCA
Dinero	USCA	Julian-Banner	USCA
Eagle Shawmut	USCA	Kelsey	USCA
Early-Sweetwater	USCA	Kelsey N.	USCA
Eclipse No. 1	USCA	Kinsley	USCA
El Dorado	USCA	Kinsley N.	USCA
El Portal	USCA	Lamphear	USCA
Enterprise	USCA	Locarno	USCA
Esmeralda	USCA	Lone Mary	USCA
Experimental	USCA	Mammoth	USCA
Felicianna	USCA	Mariposa	USCA
Fifty-Fifty	USCA	Mokelumne	USCA
Fine Gold	USCA	Moore's Flat	USCA

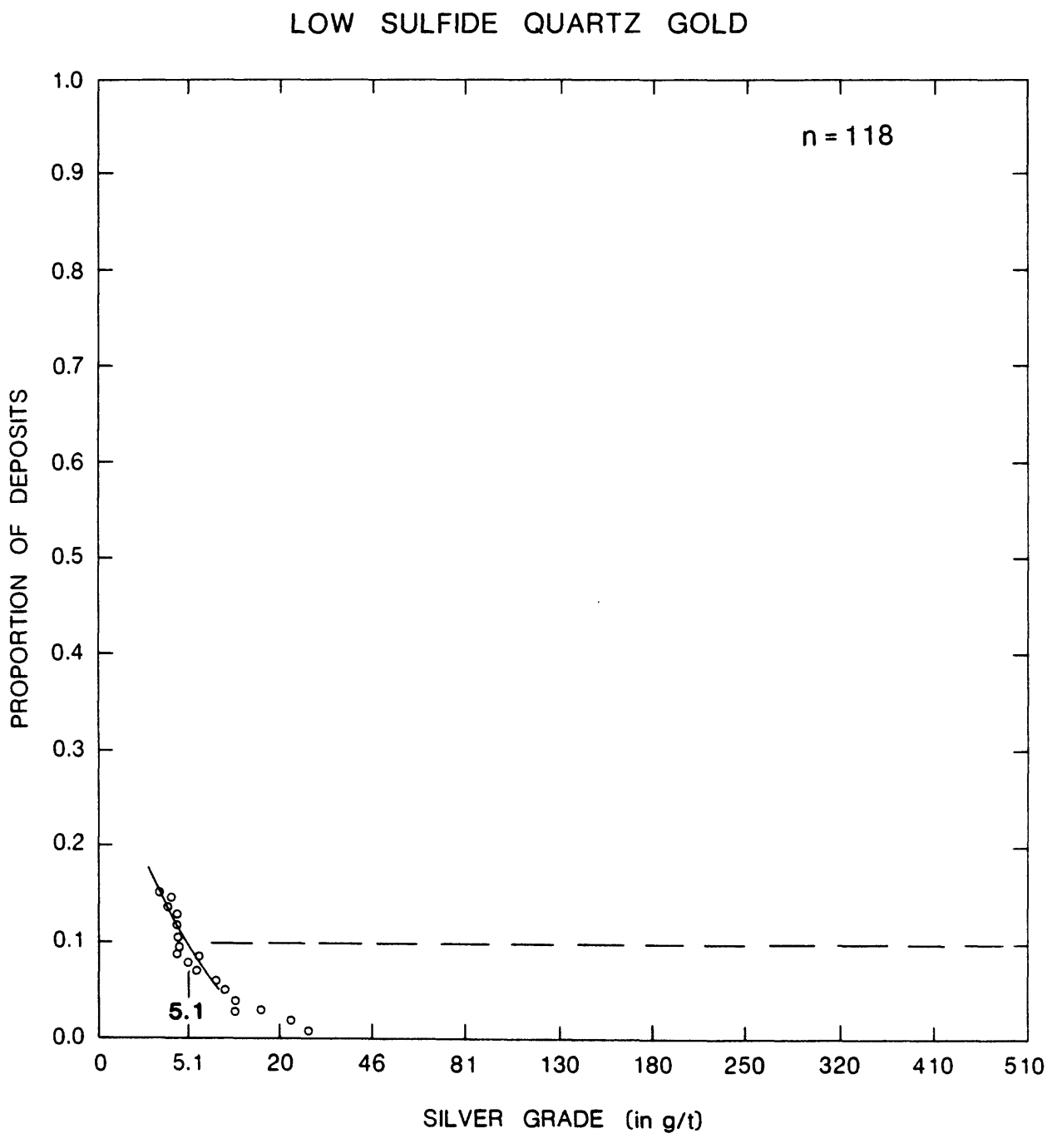
DEPOSIT TYPE Low sulfide quartz gold MODEL NUMBER 5.3

DEPOSITS (Continued)

Name	Country
Mormon Bar	USCA
Morris Ravine	USCA
Mount Bullion	USCA
Mount Gaines	USCA
Mountain King	USCA
Mt. Pleasant	USCA
Murphy N.	USCA
Nashville S.	USCA
Ophir	USCA
Paloma Gwin	USCA
Patrick	USCA
Penryn	USCA
Phoenix	USCA
Placerville	USCA
Pyramid	USCA
Rainbow	USCA
Ranch	USCA
Rich	USCA
Rich Gulch	USCA
Rindge No. 1	USCA
Royal Mt. King	USCA
R.R. Flat S.	USCA
Ryan	USCA
Sheep Ranch	USCA
Sliger	USCA
Soulsbyville	USCA
Sutter Creek	USCA
Taylor	USCA
Valley View	USCA
Washington	USCA
Whitlock E.	USCA
Whitlock W.	USCA
Wilshire-Bishop	USCA
Yankee Hill	USCA
Zeila	USCA


LOW SULFIDE QUARTZ GOLD
n = 118
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0014
0.041
1.3
0.0001 0.0004 0.0016 0.0063 0.025 0.1 0.4 1.6 6.3 25 100
TONNES (IN MILLIONS)


LOW SULFIDE QUARTZ GOLD
n = 118
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
5.3
14
38
2.6
4.0
5.8
7.8
10.0
13.0
16.0
19.0
23.0
27.0
31.0
36.0
41.0
46.0
52.0
58.0
64.0
GOLD GRADE (in g/t)


LOW SULFIDE QUARTZ GOLD
n = 118
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
5.1
0
5.1
20
46
81
130
180
250
320
410
510
SILVER GRADE (in g/t)

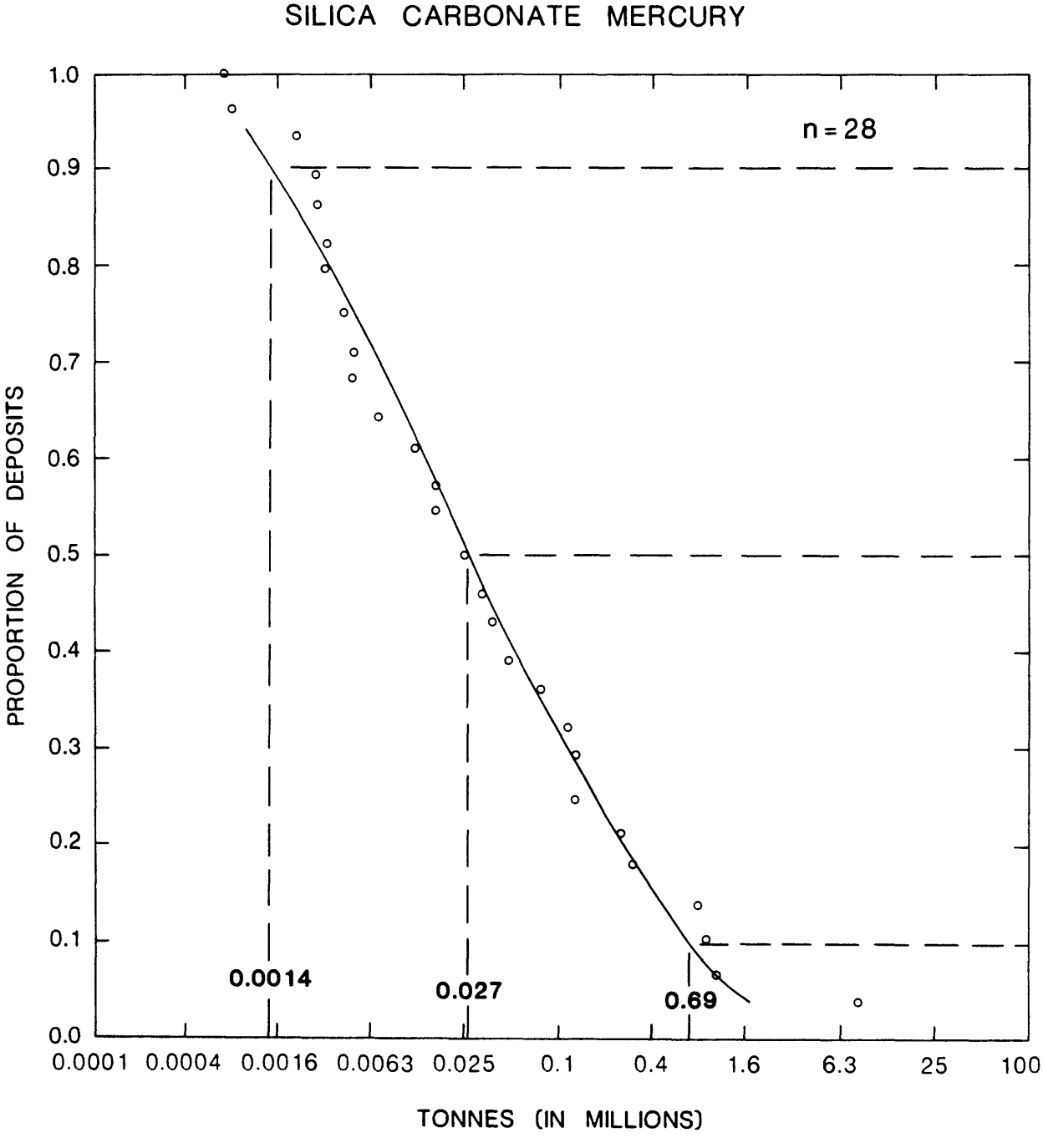
DEPOSIT TYPE Silica-carbonate mercury MODEL NUMBER 5.8

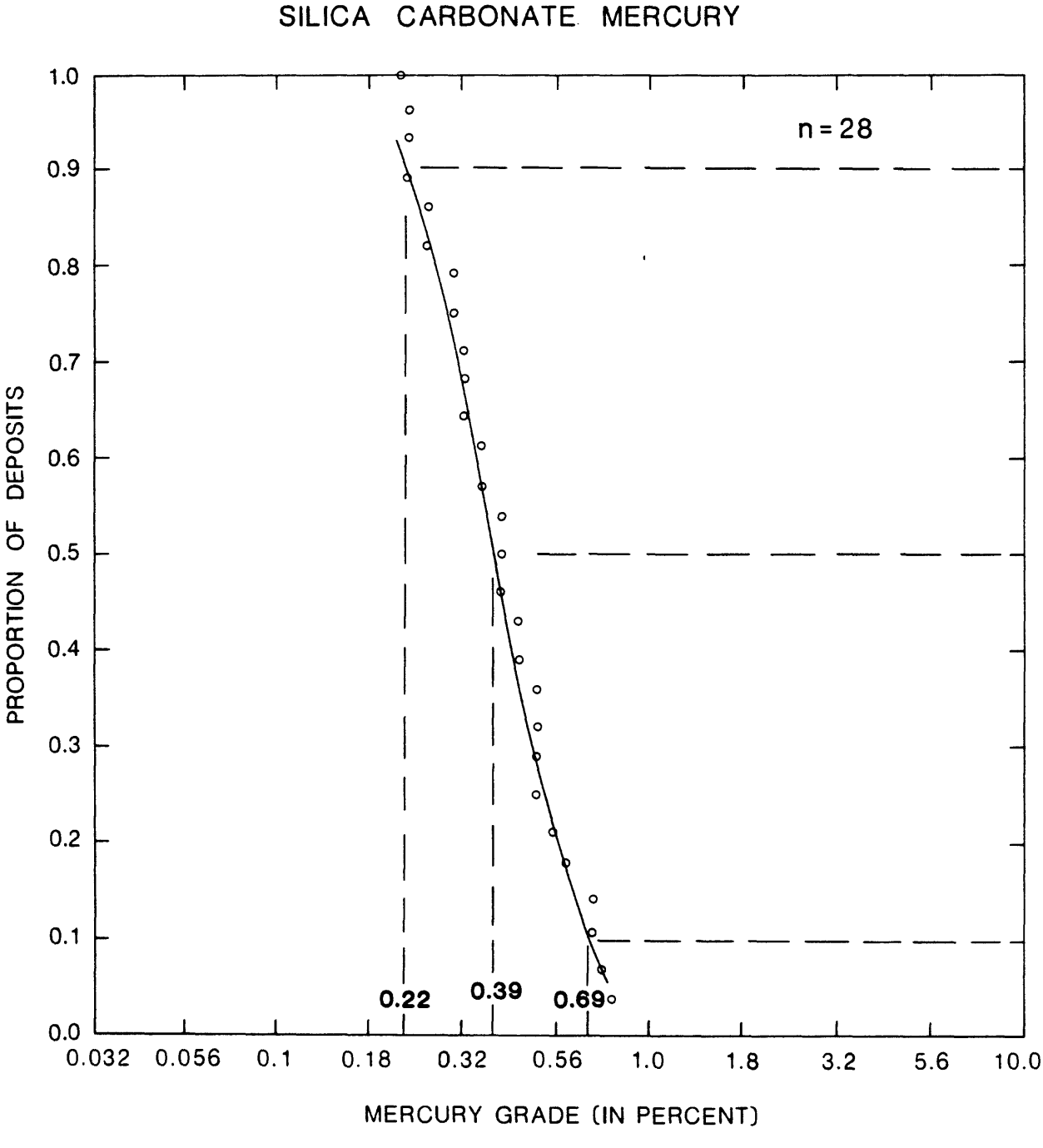
AUTHOR J.J. Rytuba and S. Cargill

COMMENTS

DEPOSITS

Name	Country
Abbott	USCA
Aetna	USCA
Bella Oak	USCA
Chicago	USCA
Contact	USCA
Corona	USCA
Culver Bear	USCA
Dewey's	USCA
Esperanza	USCA
Great Eastern-Mt. Jackson	USCA
Harrison	USCA
Helen	USCA
Keystone	USCA
Knoxville	USCA
La Joya	USCA
La Libertad	USCA
Lion Den	USCA
Mirabel	USCA
Mt. Diablo	USCA
New Almaden	USCA
Patriquin	USCA
Polar Star	USCA
Red Elephant	USCA
Red Rick	USCA
Reed	USCA
Socrates	USCA
Twin Peaks	USCA
Wall Street	USCA


SILICA CARBONATE MERCURY
n = 28
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0014
0.027
0.69
0.0001 0.0004 0.0016 0.0063 0.025 0.1 0.4 1.6 6.3 25 100
TONNES (IN MILLIONS)


SILICA CARBONATE MERCURY
n = 28
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.22
0.39
0.69
0.032
0.056
0.1
0.18
0.32
0.56
1.0
1.8
3.2
5.6
10.0
MERCURY GRADE (IN PERCENT)

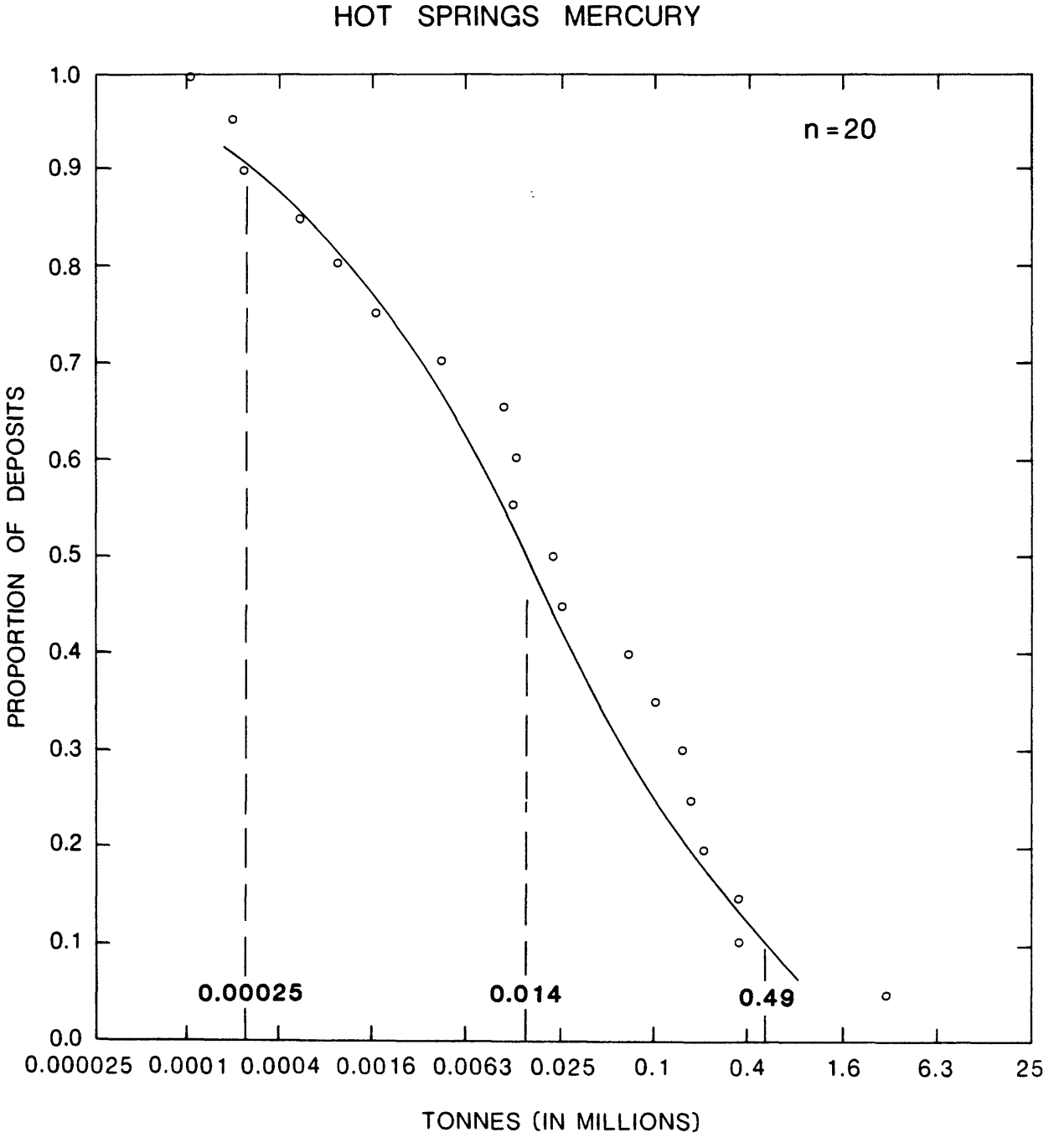
DEPOSIT TYPE Hot springs mercury MODEL NUMBER 5.9

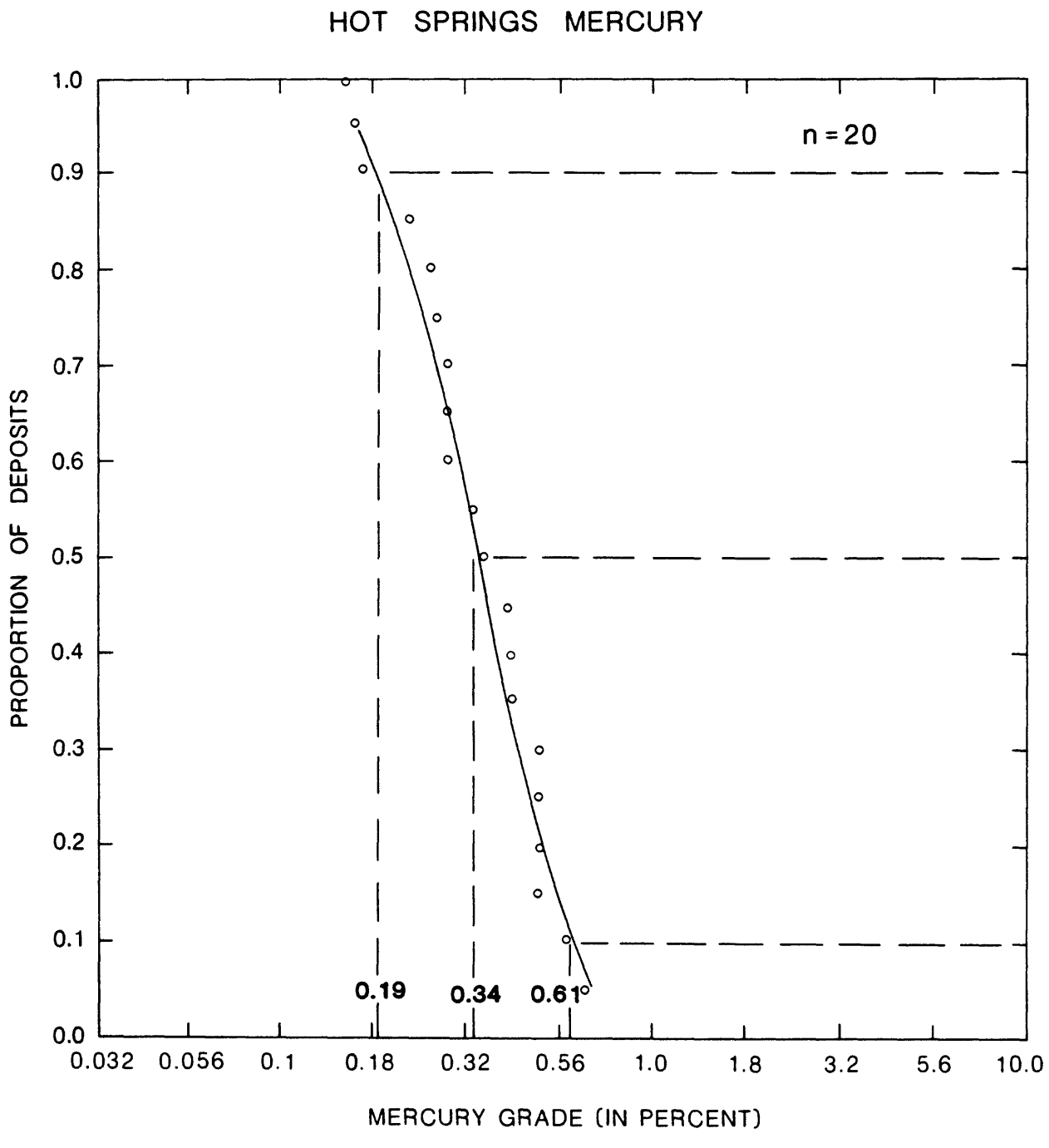
AUTHOR J. J. Rytuba

COMMENTS

DEPOSITS

Name	Country
Baldwin	USNV
B and B	USNV
Bretz	USOR
Butte	USNV
Coleman	USNV
Cordero	USNV
F and L Mine	USNV
Glass Butte	USOR
Goldbanks	USNV
Governor	USNV
Idaho Almaden	USID
Mahattan	USCA
McDermitt	USNV
Nevada Sulphur co.	USNV
Opalite	USOR
Rim Rock and Homestake	USNV
Silver Cloud	USNV
Steamboat Springs	USNV
Sulphur Bank	USCA
Walibu	USCA


HOT SPRINGS MERCURY
n = 20
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.00025
0.014
0.49
0.000025 0.0001 0.0004 0.0016 0.0063 0.025 0.1 0.4 1.6 6.3 25
TONNES (IN MILLIONS)


HOT SPRINGS MERCURY
n = 20
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.19
0.34
0.61
0.032
0.056
0.1
0.18
0.32
0.56
1.0
1.8
3.2
5.6
10.0
MERCURY GRADE (IN PERCENT)

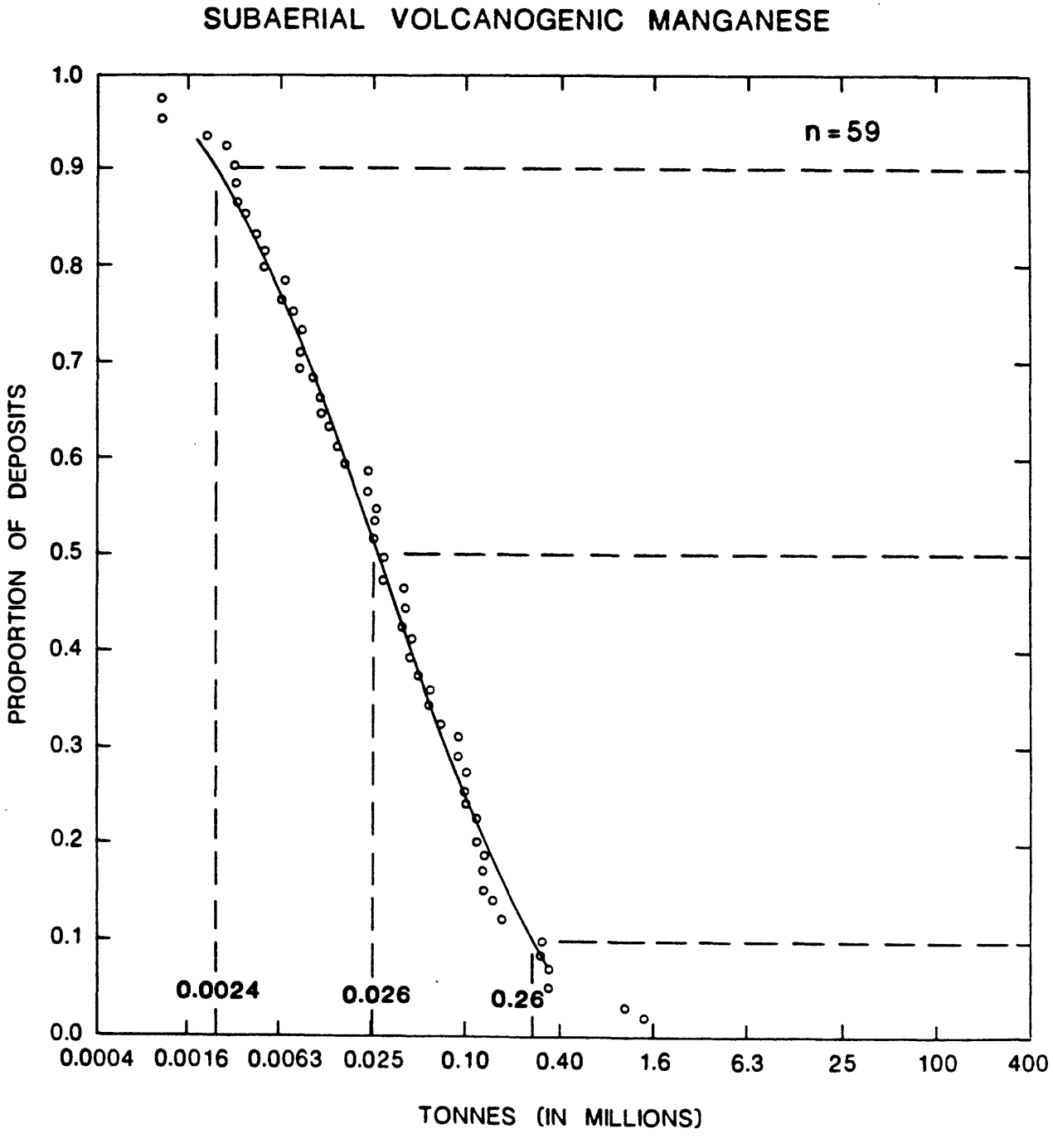
DEPOSIT TYPE Subaerial volcanogenic manganese MODEL NUMBER 5.13

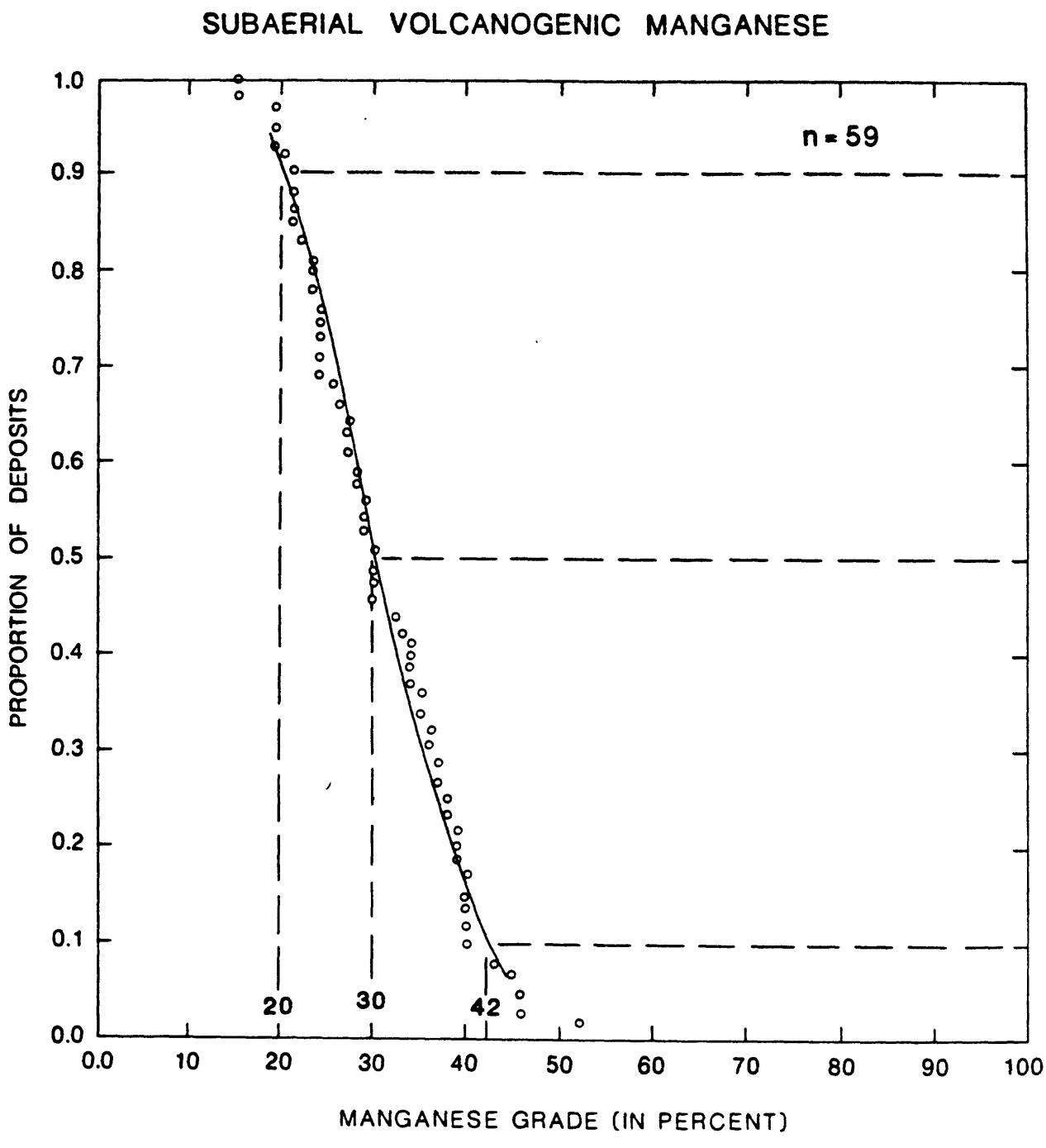
AUTHOR D. L. Mosier

COMMENTS Manganese grade is correlated with tonnage at the 5% level (r=-0.28).

DEPOSITS

Name	Country	Name	Country
Abra Negra	MXCO	Murguia	MXCO
Armour Group	USAZ	Nacozari	MXCO
Atenguillo	MXCO	Niggerhead	USNM
Black Crow-San Juan	USNM	Oviachic 1&2	MXCO
California Group	USAZ	Phillips Lease	USNM
Casa de Janos	MXCO	Pito Real	MXCO
Casas Grandes	MXCO	Red Hill-Red Hill Ext.	USNM
Ciudad Obregon	MXCO	St. Pietro	ITLY
Cliff Roy	USNM	San Bernardo	MXCO
Estacion Llanos	MXCO	San Miguel El Alto	MXCO
Gloryana	USNM	Santa Ana	MXCO
Griffith	USNM	Sardegna	ITLY
Hatton	USAZ	Satevo	MXCO
J.M. Meadows Group	USAZ	Selimiye	TRKY
JVB Claim	USNM	Shag Rock	CNBC
Karangnunggal	INDS	Sierra de El Alto	MXCO
Karatas	TRKY	Sierra de Enmedio	MXCO
Kliripan	INDS	Sierra Los Organos	MXCO
Lajas	MXCO	Soto	MXCO
La Leona	MXCO	Talamantes	MXCO
La Noria	MXCO	Terrenates	MXCO
Las Varas-La Vaca	MXCO	Thurston & Hardy	USAZ
Los Borregos	MXCO	Topock	USAZ
Los Volcanes	MXCO	Turfullar	TRKY
M and M Group	USNM	U.S. Group	USAZ
Manganese Chief	USNM	Viterbo-Roma	ITLY
Manganese Development	USAZ	West Niggerhead	USNM
Matamoros	MXCO	Yahualica	MXCO
Mezcala	MXCO	Zacate-Cerro Chino	MXCO
Montosa	MXCO		


SUBAERIAL VOLCANOGENIC MANGANESE
n = 59
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0024
0.026
0.26
0.0004
0.0016
0.0063
0.025
0.10
0.40
1.6
6.3
25
100
400
TONNES (IN MILLIONS)


SUBAERIAL VOLCANOGENIC MANGANESE
n = 59
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
20
30
42
0.0
10
20
30
40
50
60
70
80
90
100
MANGANESE GRADE (IN PERCENT)

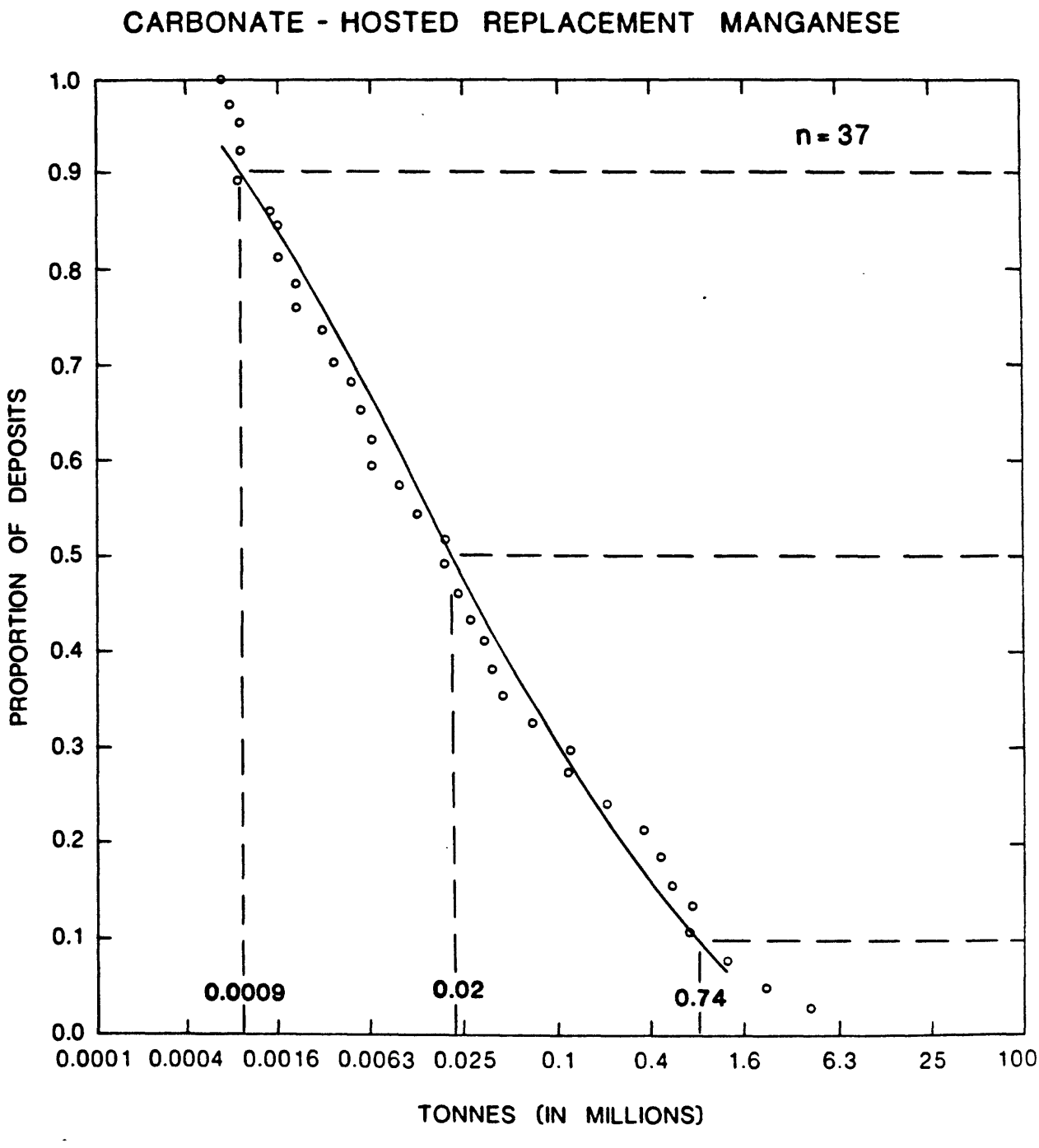
DEPOSIT TYPE Carbonate-hosted replacement manganese MODEL NUMBER 5.14

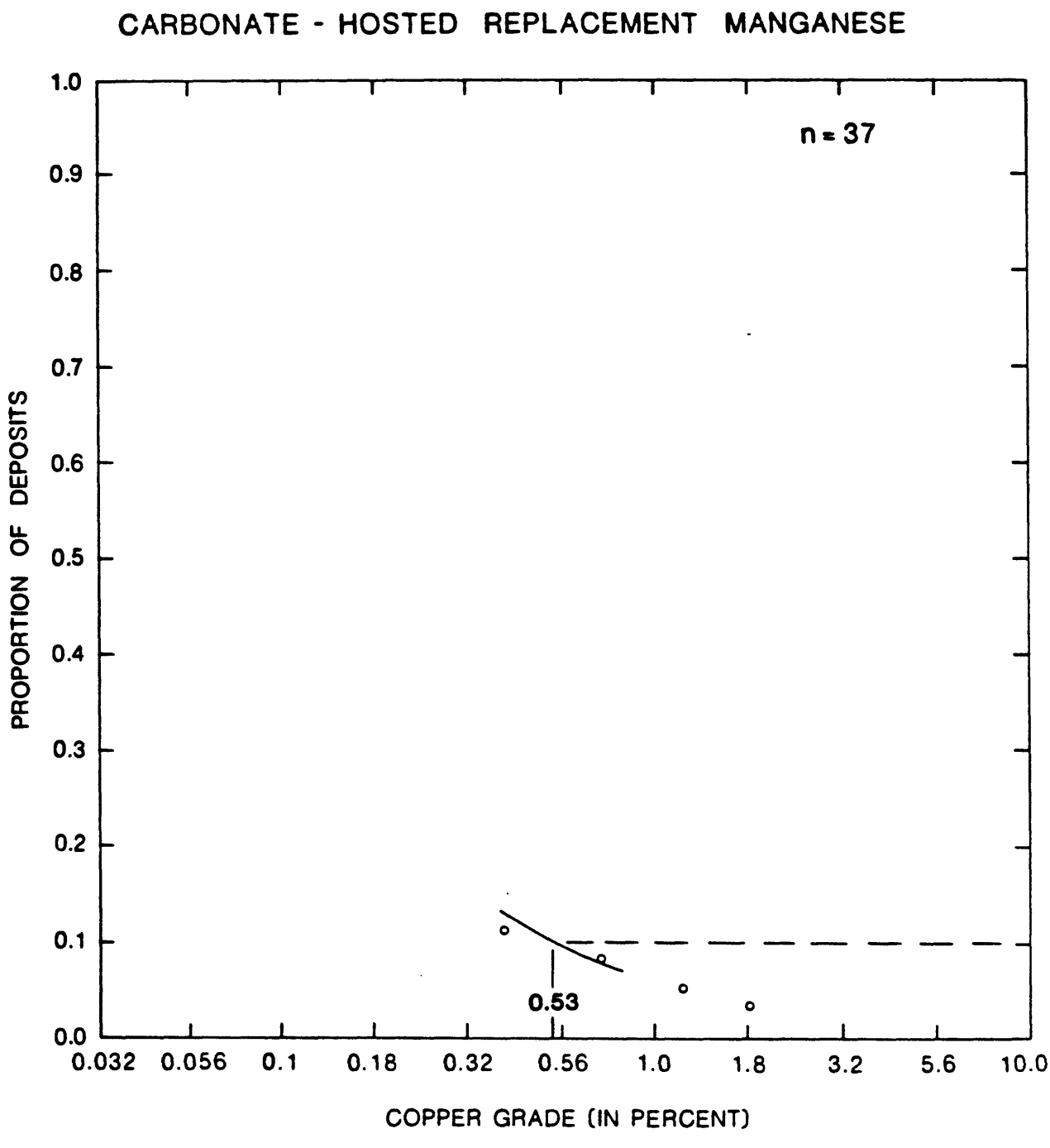
AUTHOR D. L. Mosier

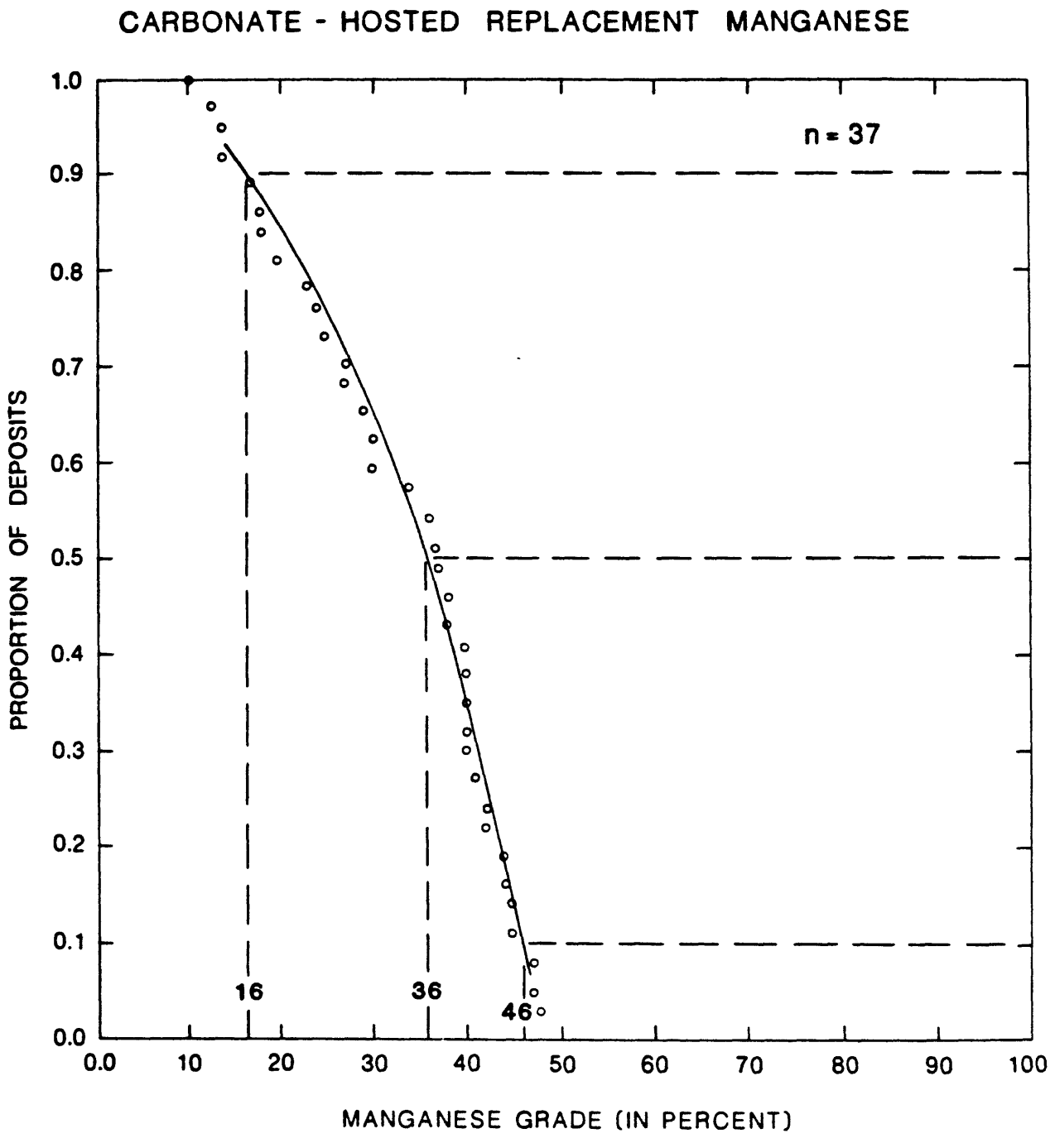
COMMENTS Copper grades are only available for some of the low tonnage deposits.

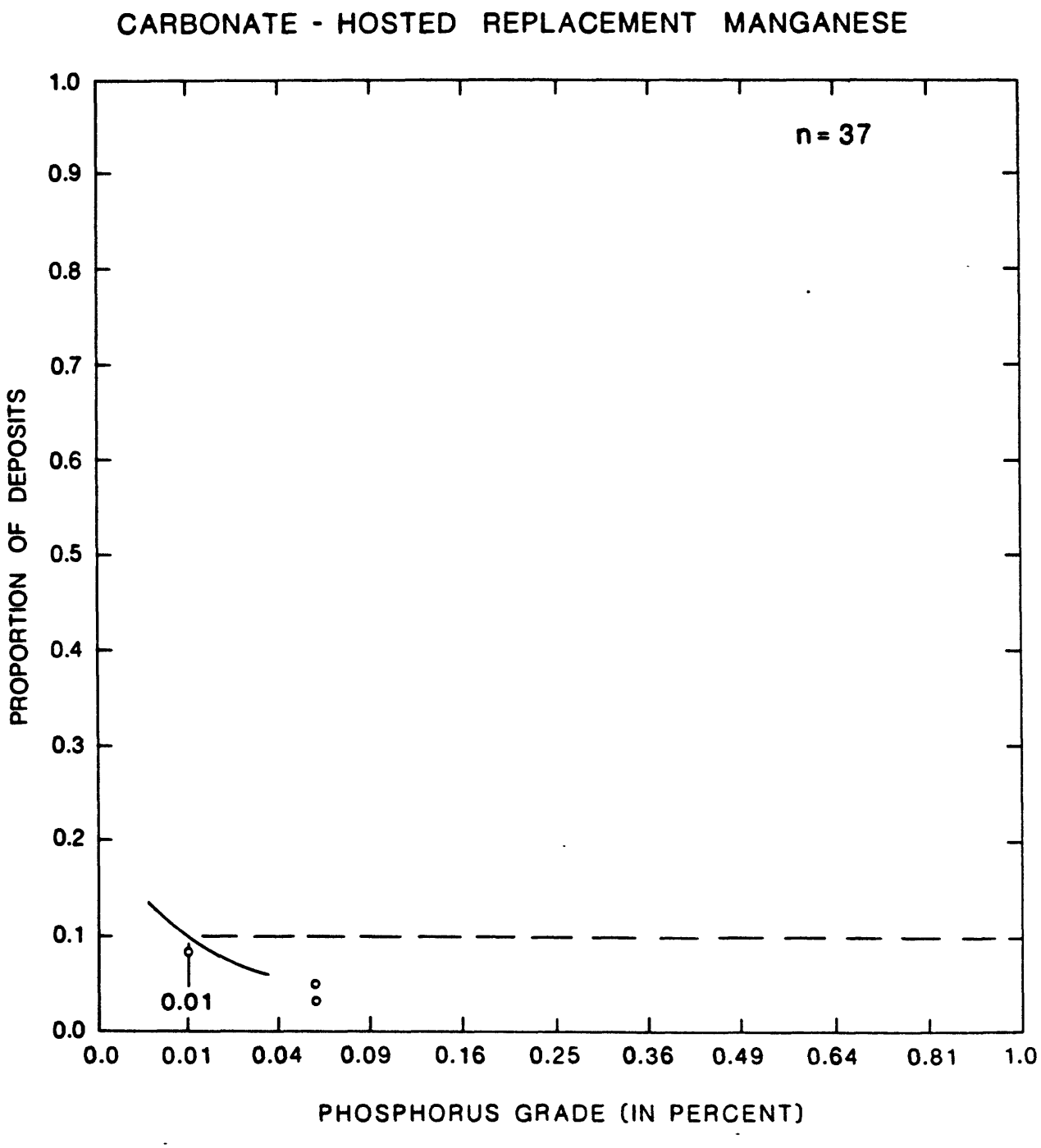
DEPOSITS

Name	Country
Atlas	USAZ
Bear Mountain	USNM
Birchfield	USNM
Blinman	AUSA
Brachy	FRNC
Chloride Flat	USNM
Crown King	USAZ
Cynthia	GREC
Danville-Hanchette	USAZ
Detroit	USUT
Dinamita	MXCO
Djebel El Aziza	TUNS
Essex and Steptoe	USNV
Golden Gate	USAZ
Hendricks-Twilight	USAZ
Kahal de Brezina	ALGR
Kingston	USNM
Lake Valley	USNM
Lammereck	ASTR
Las Ambollas	FRNC
Las Cabesses	FRNC
Lone Mountain	USNM
Los Volcanes	MXCO
Mammoth	USAZ
Mercedes	CUBA
No. 4-Summit	USAZ
Philipsburg	USMT
Poludnig-Hermagor	ASTR
Oregon	USAZ
Saligny	FRNC
San Carlos	MXCO
Sattelberges	ASTR
Thuburnic	TUNS
Ulukoy	TRKY
Veitsch	ASTR
Vorderen Strubberges	ASTR
Waterloo	USAZ


CARBONATE - HOSTED REPLACEMENT MANGANESE
n = 37
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0009
0.02
0.74
0.0001 0.0004 0.0016 0.0063 0.025 0.1 0.4 1.6 6.3 25 100
TONNES (IN MILLIONS)


CARBONATE - HOSTED REPLACEMENT MANGANESE
n = 37
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.53
0.032
0.056
0.1
0.18
0.32
0.56
1.0
1.8
3.2
5.6
10.0
COPPER GRADE (IN PERCENT)


CARBONATE - HOSTED REPLACEMENT MANGANESE
n = 37
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
16
36
46
0.0
10
20
30
40
50
60
70
80
90
100
MANGANESE GRADE (IN PERCENT)


CARBONATE - HOSTED REPLACEMENT MANGANESE
n = 37
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.01
0.0
0.01
0.04
0.09
0.16
0.25
0.36
0.49
0.64
0.81
1.0
PHOSPHORUS GRADE (IN PERCENT)

DEPOSIT TYPE Platinum--gold placers MODEL NUMBER 6.3

AUTHOR D. A. Singer and N. J Page

DATA REFERENCES Calkins and others, 1978.

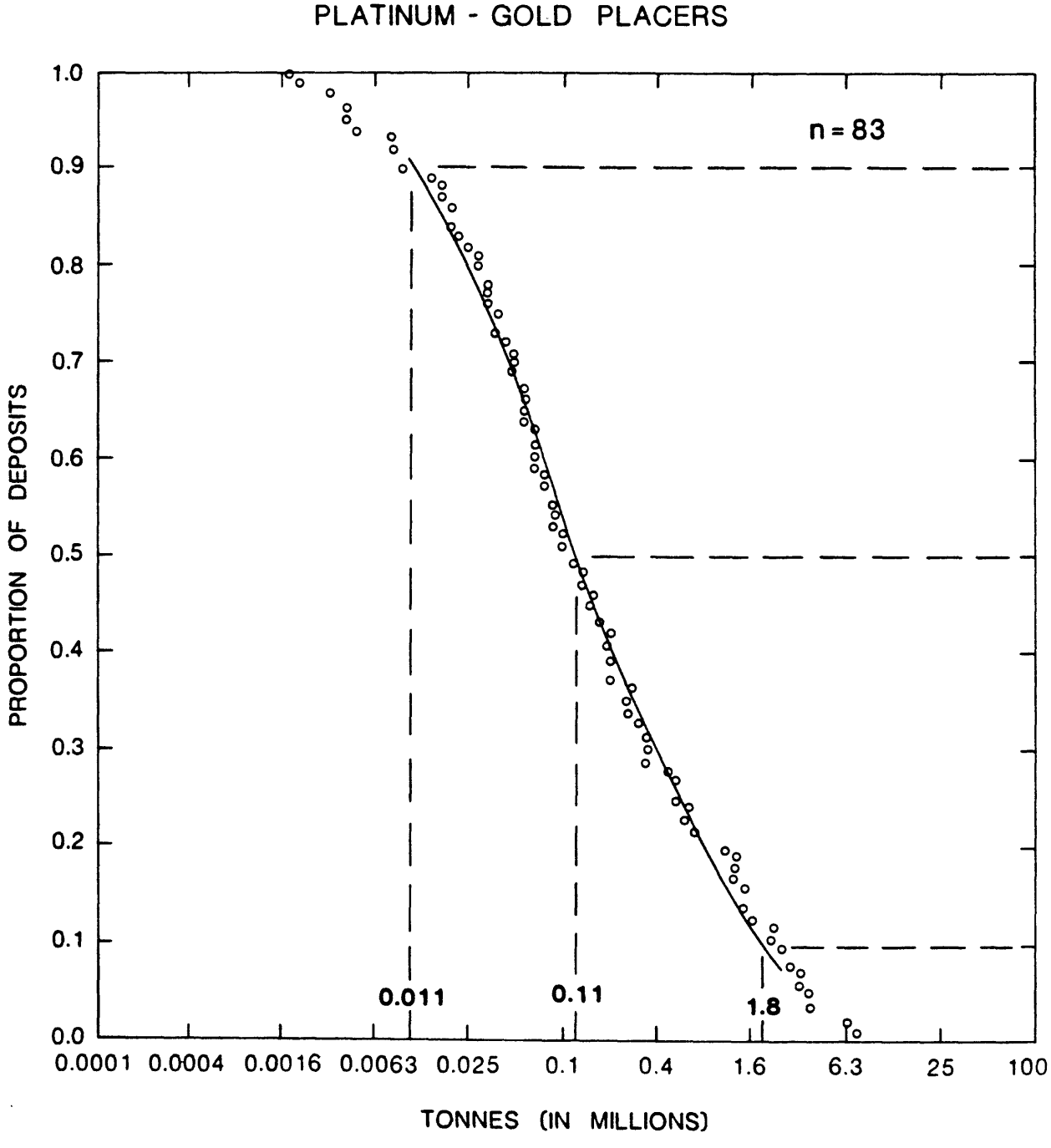
COMMENTS All deposits used for the model are from the Urals of USSR. The platinum grade plot suggests these populations. Many of the deposits with grades less then 1,000 ppb Pt were probably mined by dredges, whereas the majority of deposits were mined by conventional placering methods. Some of the very high grades may represent reporting errors such as grades for a high grade portion of a deposit being reported as representative of the total deposit. Probably because of the effects of combining deposits mined by two technologies, tonnage is correlated with platinum grade (r=0.42) and with gold grade (r=-0.52, n=22). Platinum grade is correlated with gold grade (r=0.56, n=22), with osmium grade (r=0.89, n=21), with isidium grade (r=0.98, n=10), and with palladium grade (r=0.99, n=13). Gold grade is correlated with palladium grade (r=0.97, n=6). Osmium grade is correlated with iridium grade (r=0.97, n=9) and with palladium grade (r=0.89, n=12). Iridium grade is correlated with palladium grade (r=0.97, n=9). Other correlations were not significant with the available number of samples. All correlations were calculated with logarithmically transformed data.

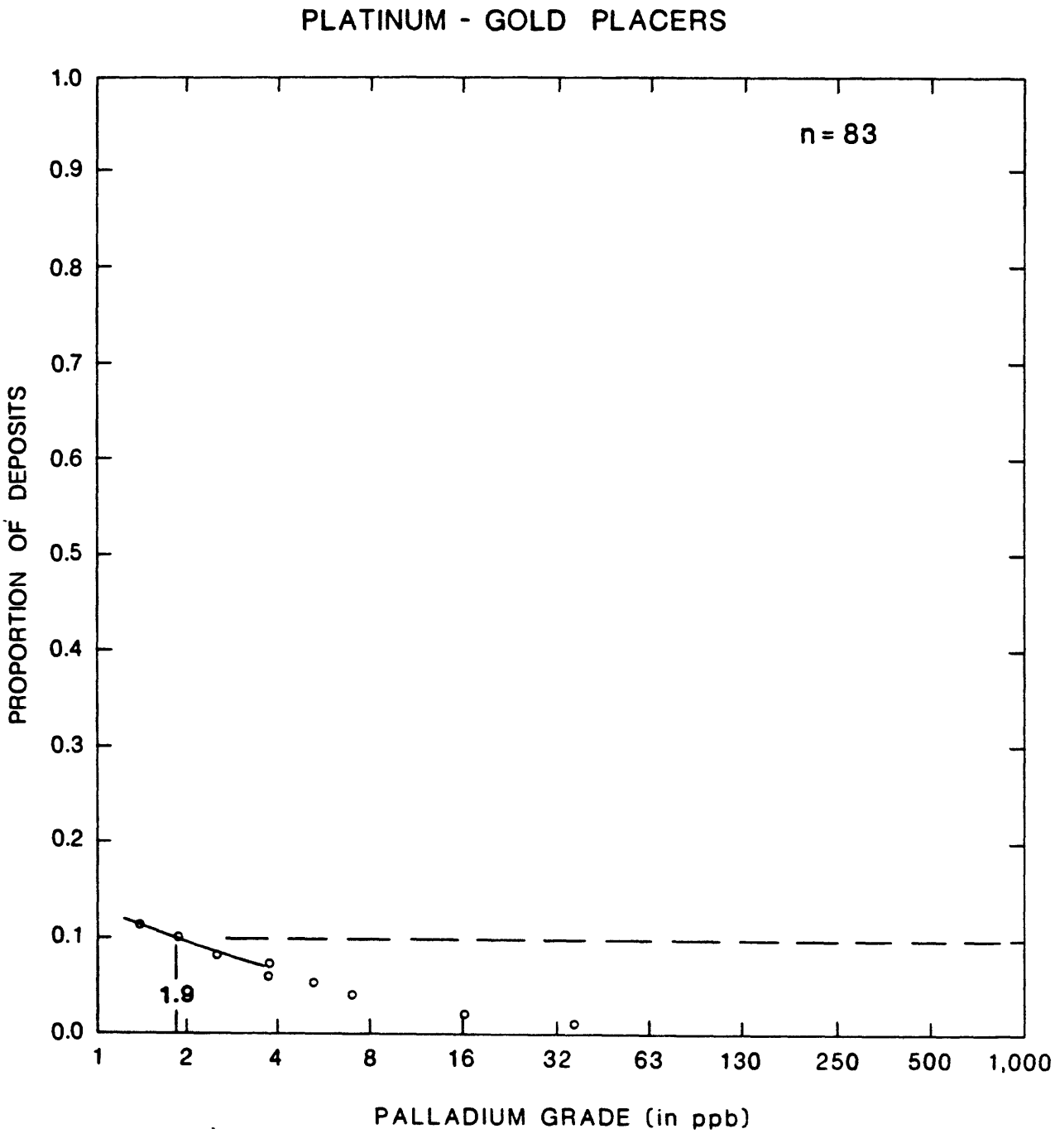
DEPOSITS

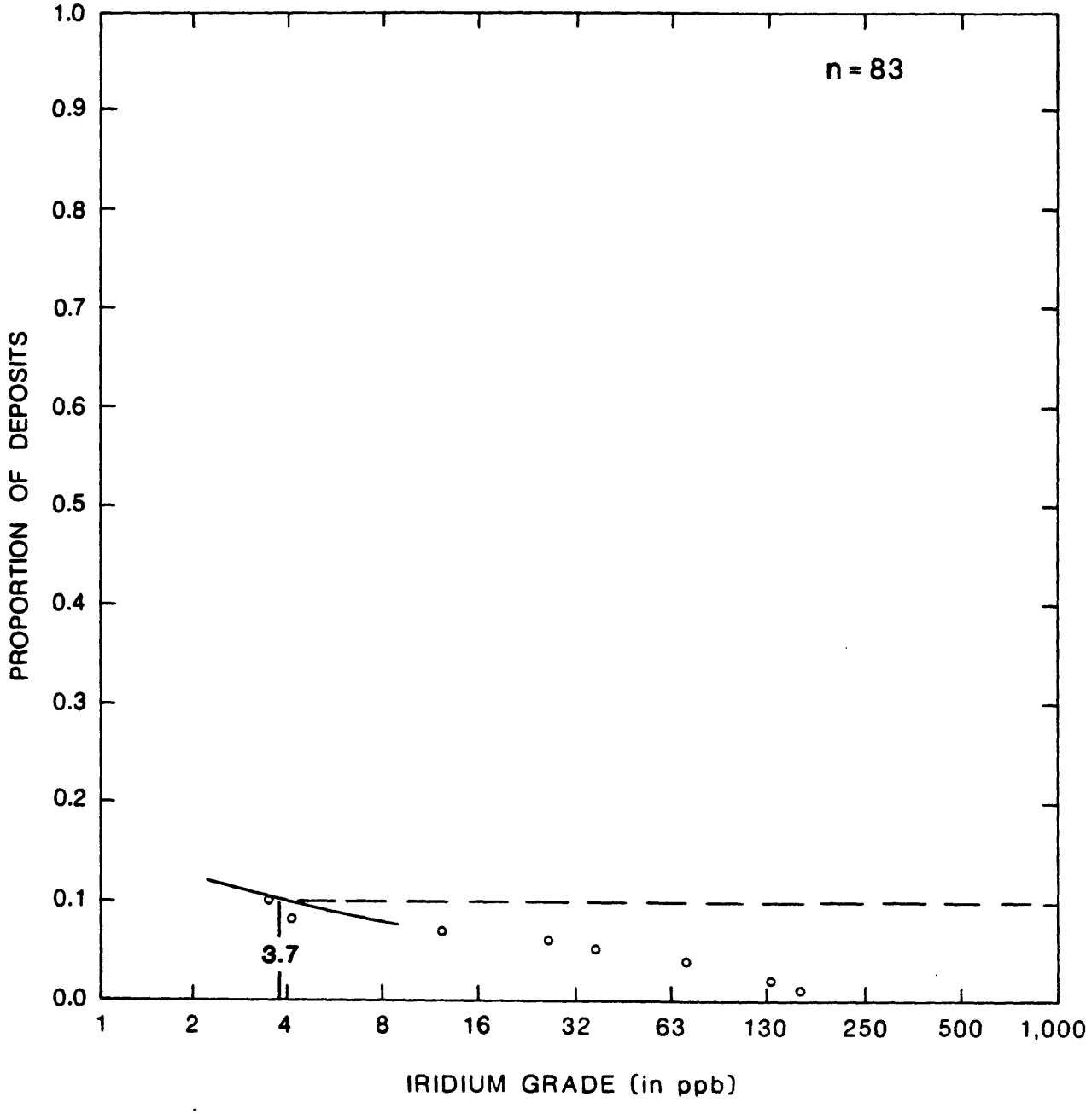
Name	Country	Name	Country
Aleksandrovskii Log	URRS	Kamenka	URRS
Alexii-Olginsky Log	URRS	Kamenka R.	URRS
Anianowsky Lojok	URRS	Kisslaia-Peruonatchainik	URRS
Arkhangelskii Log	URRS	Kitlim, Severniy R.	URRS
Besimianni Log	URRS	Korobowsky Lojok	URRS
Bielgorsky Log	URRS	Kossia R.	URRS
Bobrowka River	URRS	Kossoi-Log	URRS
Bolshaya Choumika R.	URRS	Kossorgskii Log	URRS
Bolshaya Kamenouchka	URRS	Krutoi Log	URRS
Bolshaya Ossokina R.	URRS	Lobwa R.	URRS
Bolshaya Prostokischenka	URRS	Log No. 1-Propretschnoi	URRS
Bolshaya Sosnovka	URRS	Log No. 2-Suftlii Bor	URRS
Bolshoi Pokap R.	URRS	Log No. 3-Suftlii Bor	URRS
Bolshoi Sakciam	URRS	Log No. 6-Suftlii Bor	URRS
Boyandinskaia	URRS	Log No. 7-Suftlii Bor	URRS
Ejowka	URRS	Logwinska	URRS
Gloubokia 1	URRS	Lojok at Bisserskaya	URRS
Gloubokia 2	URRS	Lojok No. 1&2 Omoutnaia	URRS
Illinsky Log	URRS	Main Valley of Kisslaia	URRS
Ivov R.	URRS	Malaia Koswa R.	URRS
Jerusalimsky-Priisk	URRS	Malaia Prostokischenka	URRS
Jourawlik R.	URRS	Malaia Sosnowka	URRS
Judinsky-Lojok	URRS	Malomalsky-Priisk	URRS
		Malot Pokap	URRS

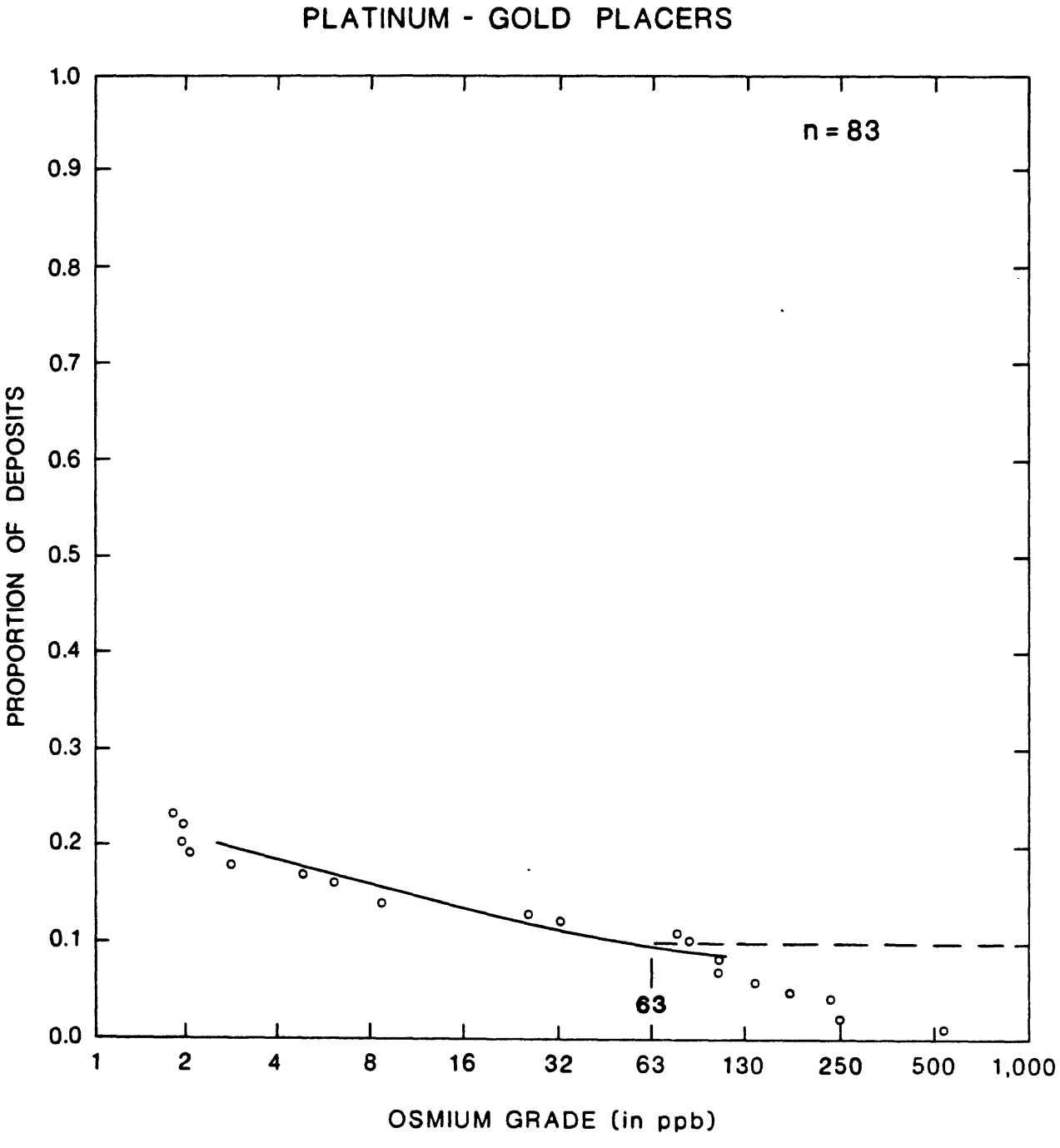
DEPOSITS

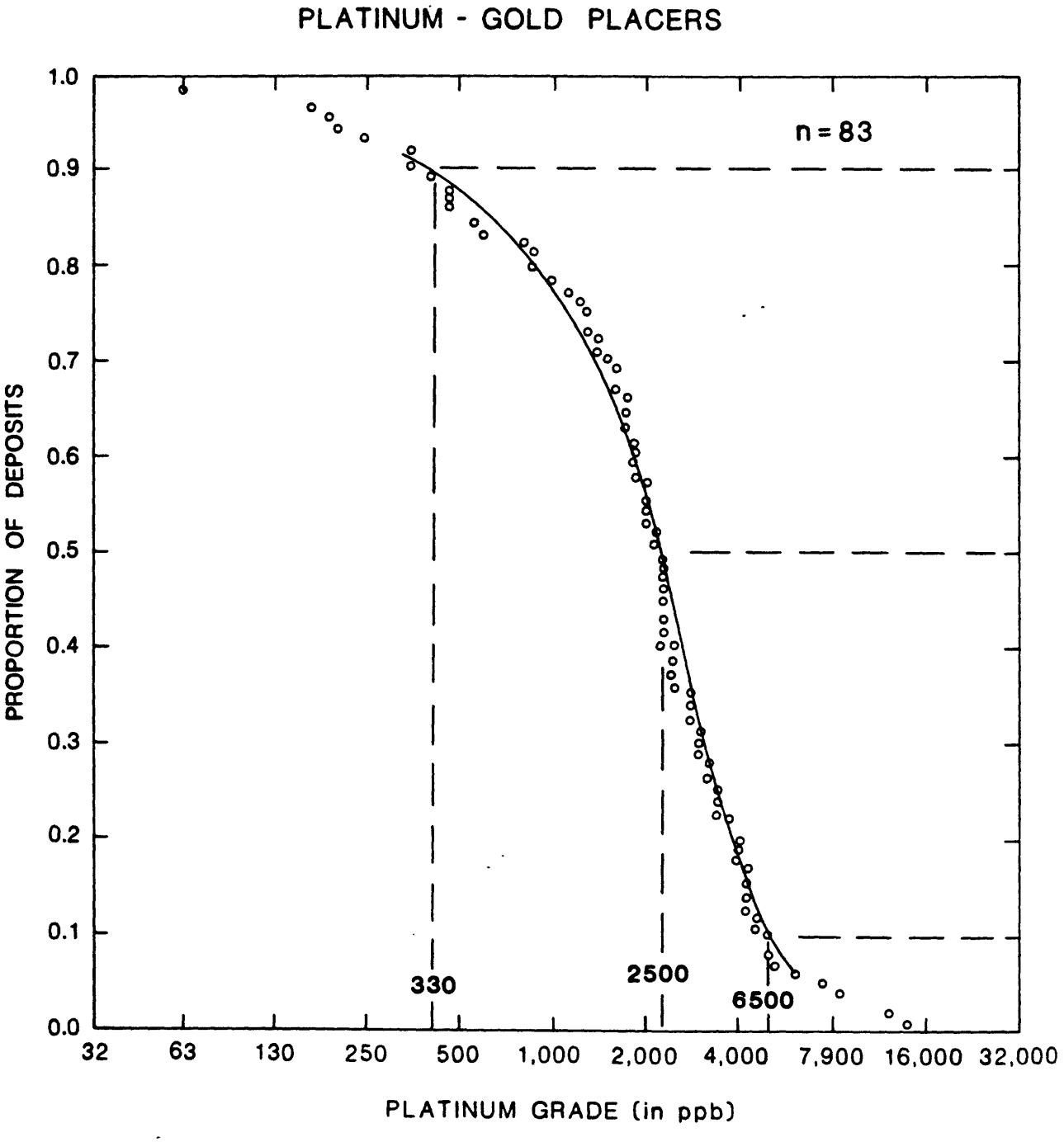
Name	Country	Name	Country
Martian R.	URRS	Small unnamed-Weressowy	URRS
Melnitschnaia	URRS	Solovyevskii Log	URRS
Molitchowka	URRS	Soukhoi Log	URRS
Morphine-Log	URRS	Srednia-Prostokischenka	URRS
Niasman R.	URRS	Stepanoff-Log	URRS
Nikolai-Tschoudotworsky	URRS	Syssim R.	URRS
Novoi-Log	URRS	Tilai R.	URRS
Obodranny-Lojok	URRS	Toura R.	URRS
Panowka	URRS	Trudny-Log	URRS
Patchek	URRS	Tsauch R.	URRS
Pestchanka R.	URRS	Tschachewitaia	URRS
Phedinan R.-Triok	URRS	Tschch R.	URRS
Podbornaia	URRS	Unnamed creek-B. Sosnowka	URRS
Podmoskowoi-Log	URRS	Verkho-Tourie	URRS
Popowsky-Lojok	URRS	Wyssim R.	URRS
Popretschne-Log	URRS	Yermakof-Log	URRS
Roublewik R.	URRS	Zaetzeff, R.	URRS
Sirkov Log	URRS	Zemlianoi-Mostik Log	URRS

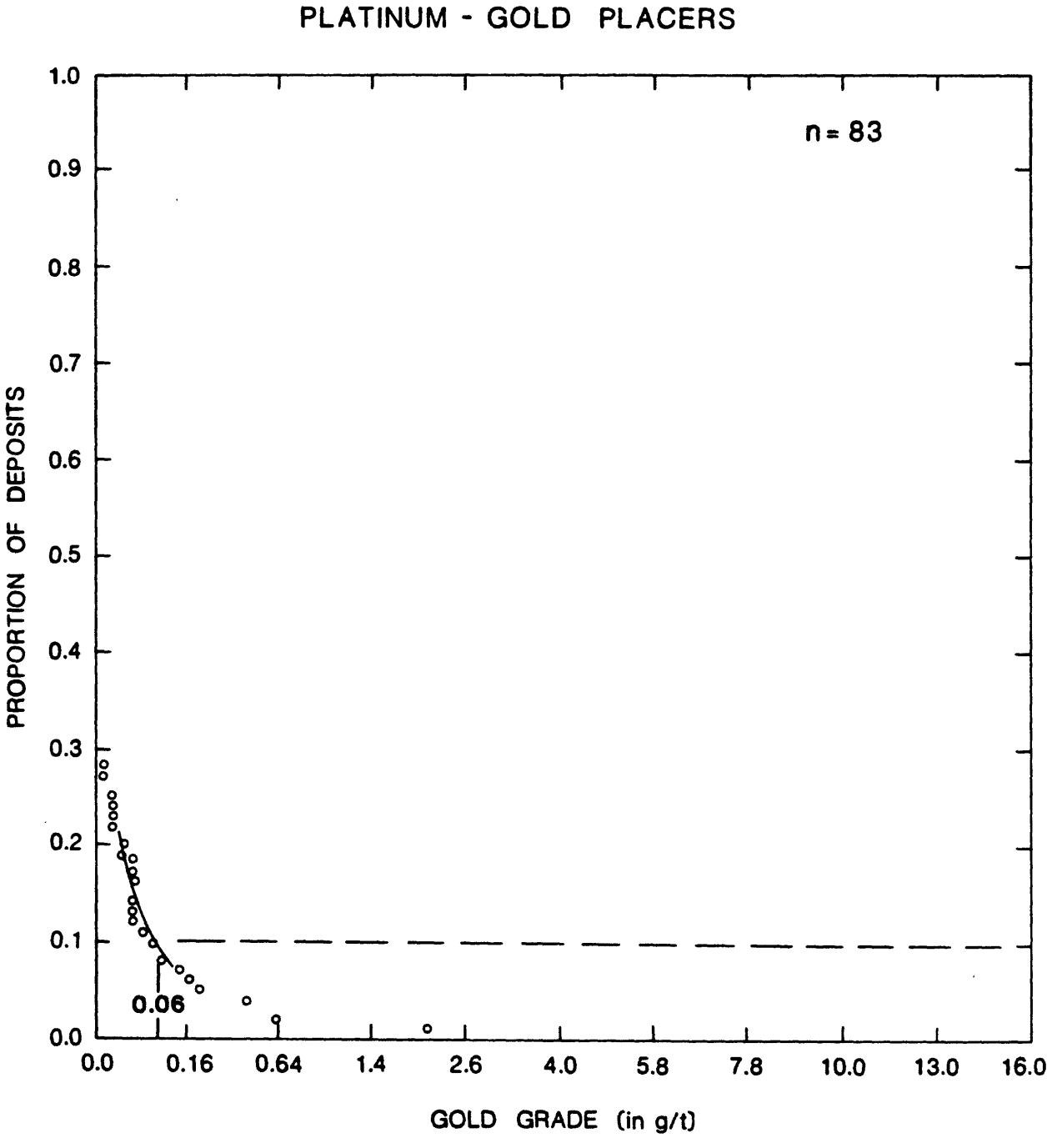

PLATINUM - GOLD PLACERS
n = 83
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.011
0.11
1.8
0.0001 0.0004 0.0016 0.0063 0.025 0.1 0.4 1.6 6.3 25 100
TONNES (IN MILLIONS)


PLATINUM - GOLD PLACERS
n = 83
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1.9
1
2
4
8
16
32
63
130
250
500
1,000
PALLADIUM GRADE (in ppb)


PLATINUM - GOLD PLACERS
n = 83
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
3.7
1
2
4
8
16
32
63
130
250
500
1,000
IRIDIUM GRADE (in ppb)


PLATINUM - GOLD PLACERS
n = 83
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
63
1
2
4
8
16
32
63
130
250
500
1,000
OSMIUM GRADE (in ppb)


PLATINUM - GOLD PLACERS
n = 83
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
330
2500
6500
32
63
130
250
500
1,000
2,000
4,000
7,900
16,000
32,000
PLATINUM GRADE (in ppb)


PLATINUM - GOLD PLACERS
n = 83
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.06
0.0
0.16
0.64
1.4
2.6
4.0
5.8
7.8
10.0
13.0
16.0
GOLD GRADE (in g/t)

DEPOSIT TYPE Sedimentary manganese MODEL NUMBER 6.5

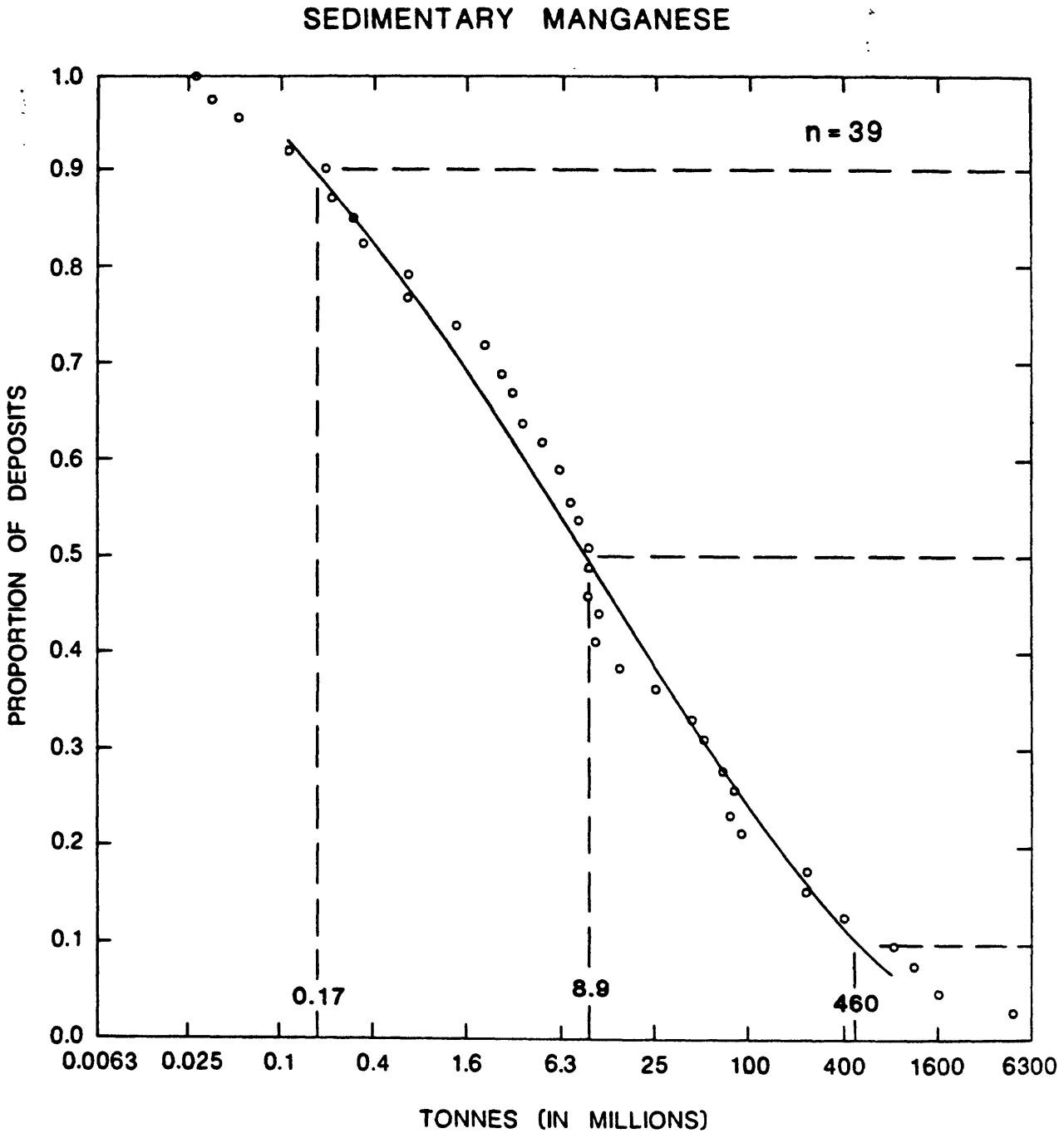
AUTHOR D. L. Mosier

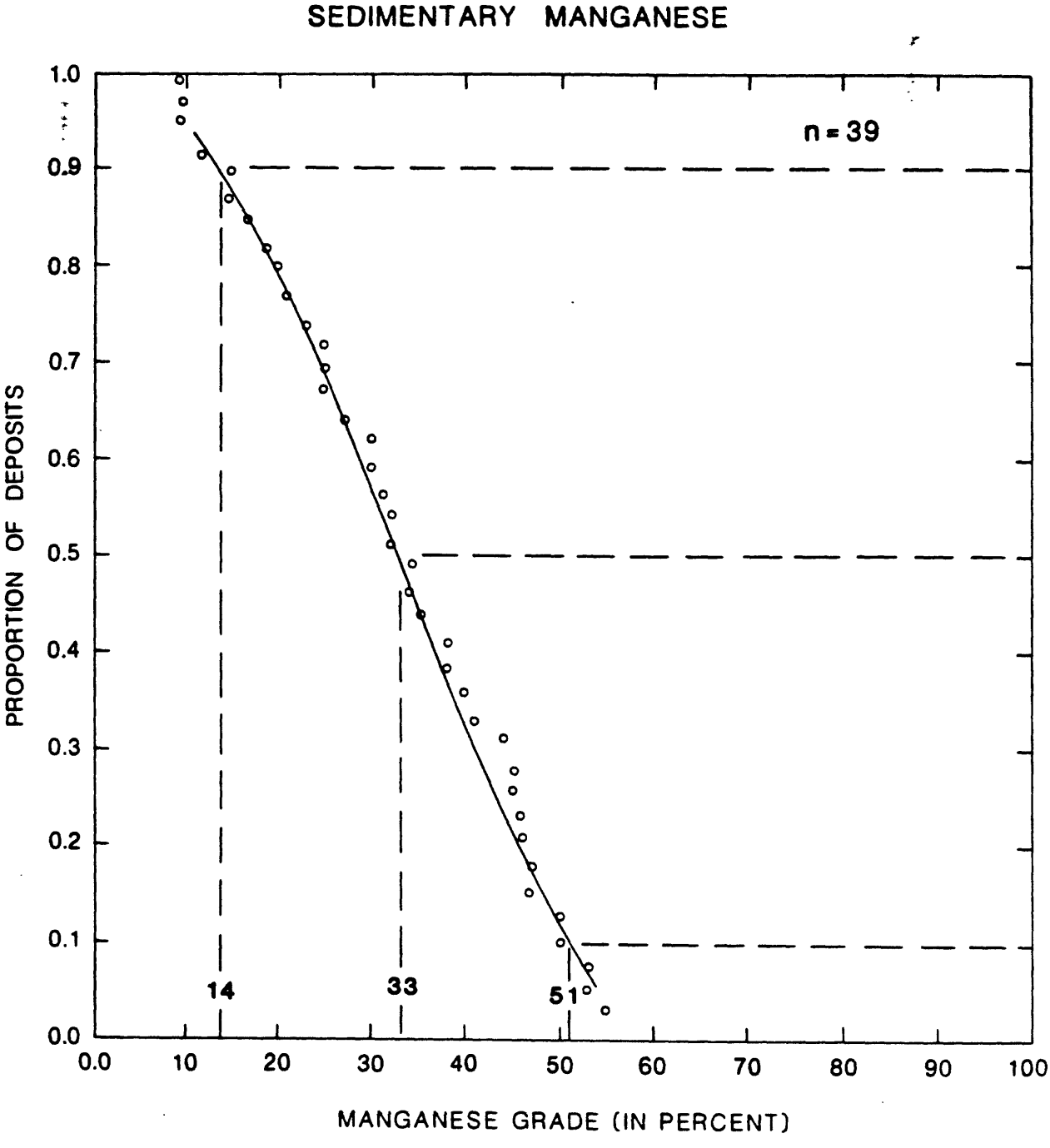
DATA REFERENCES Most data from Anon., 1983.

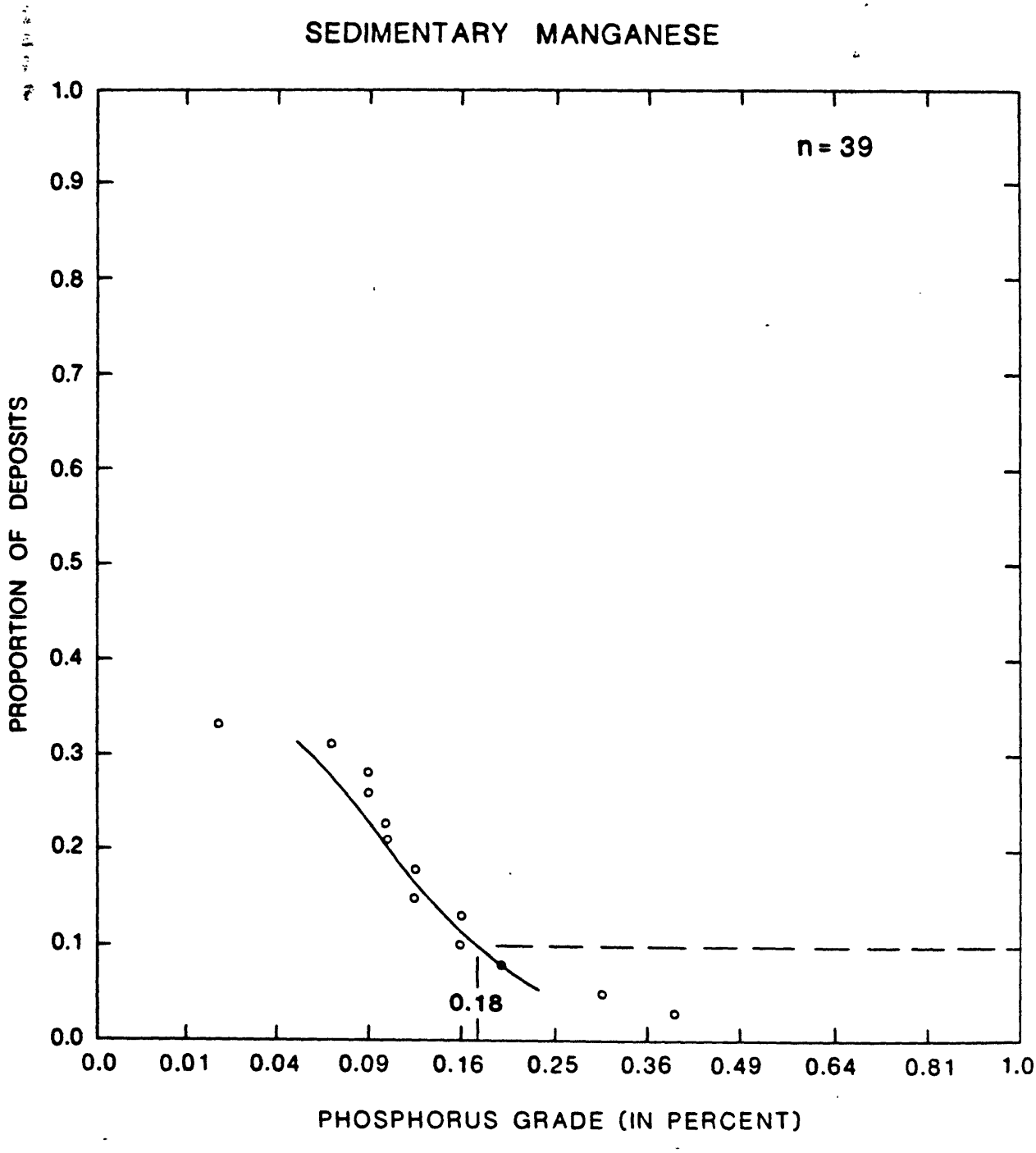
COMMENTS Because available grade and tonnage estimates represent mines from, in some cases, very extensive deposits and because the numbers are calculated at differing cutoff grades, the endowment of these deposits is undoubtedly much larger than indicated in these figures.

DEPOSITS

Name	Country	Name	
Akviran	TRKY	Manuel Killigrews	CNNF
Andhra Pradesh	INDA	Matese-Ciociaria	ITLY
Ansongo	MALI	Molango	MXCO
Azul-Carajas	BRZL	Morro da Mina	BRZL
Bolske-Tokmak	URRS	Naniango	UVOL
Chiatura	URRS	Nikolaevskoe	URRS
Chiwefwe	ZIMB	Nikopol	URRS
Groote Eylandt	AUNT	Nizne-Udinskaja	URRS
Gujarat	INDA	Otjosondu	SAFR
Horseshoe	AUWA	Ravensthorpe	AUWA
Hsiangtan	CINA	Seiba	URRS
Imini	MRCO	Shimoga (Karnatoka)	INDA
Istranca	TRKY	Timna	ISRL
Kalahari	SAFR	Uracum	BRZL
Kamenskoe	URRS	Urkut	HUNG
Kaochiao	CINA	Usinsk	URRS
Madhya Pradesh	INDA	Varna	BULG
		Wafangtzu	CINA


SEDIMENTARY MANGANESE
n = 39
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.17
8.9
460
0.0063
0.025
0.1
0.4
1.6
6.3
25
100
400
1600
6300
TONNES (IN MILLIONS)


SEDIMENTARY MANGANESE
n = 39
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
14
33
51
0.0
10
20
30
40
50
60
70
80
90
100
MANGANESE GRADE (IN PERCENT)


SEDIMENTARY MANGANESE
n = 39
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.18
0.0
0.01
0.04
0.09
0.16
0.25
0.36
0.49
0.64
0.81
1.0
PHOSPHORUS GRADE (IN PERCENT)

DEPOSIT TYPE Marine phosphate-upwelling type MODEL NUMBER None

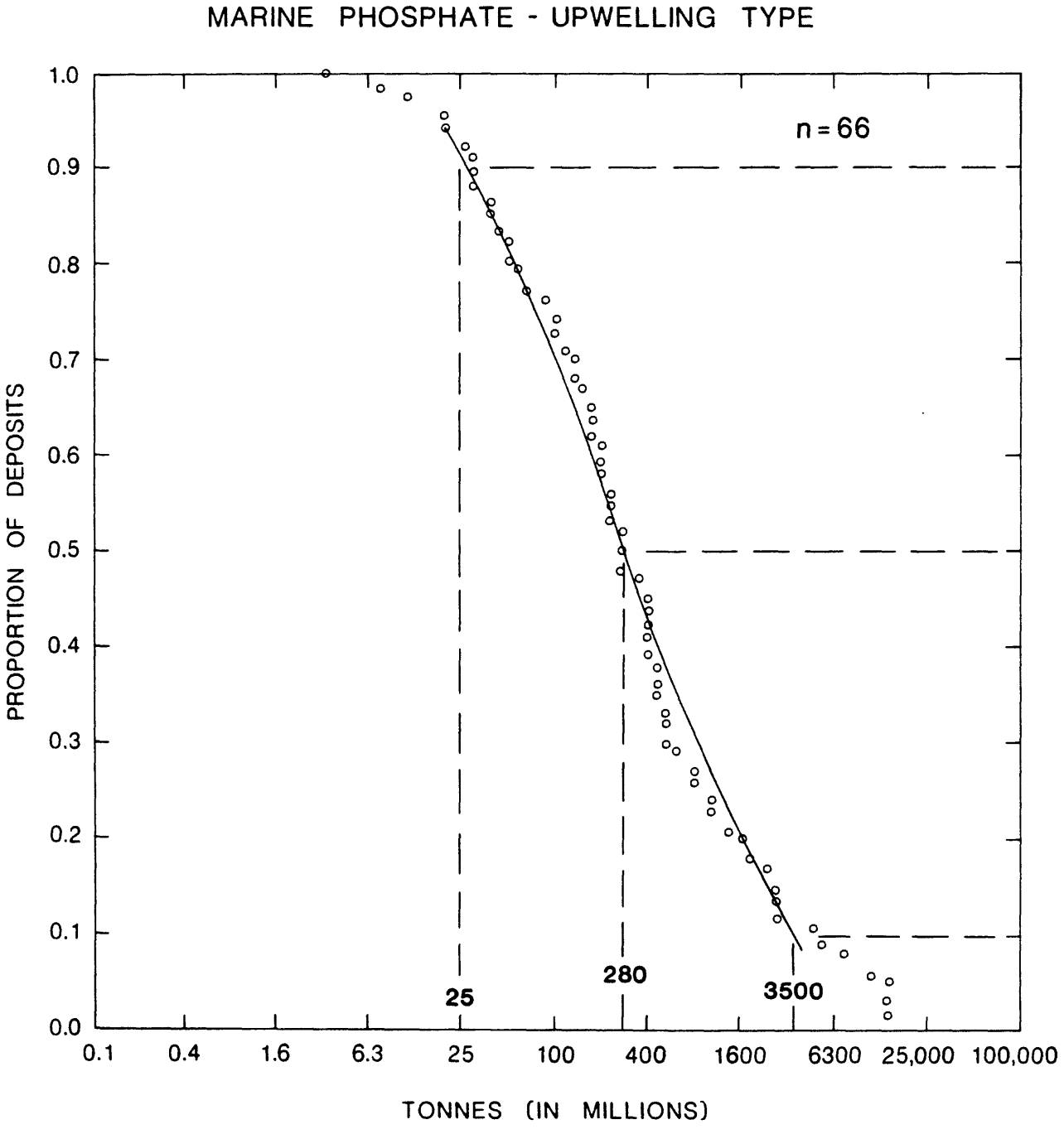
AUTHOR D. L. Mosier

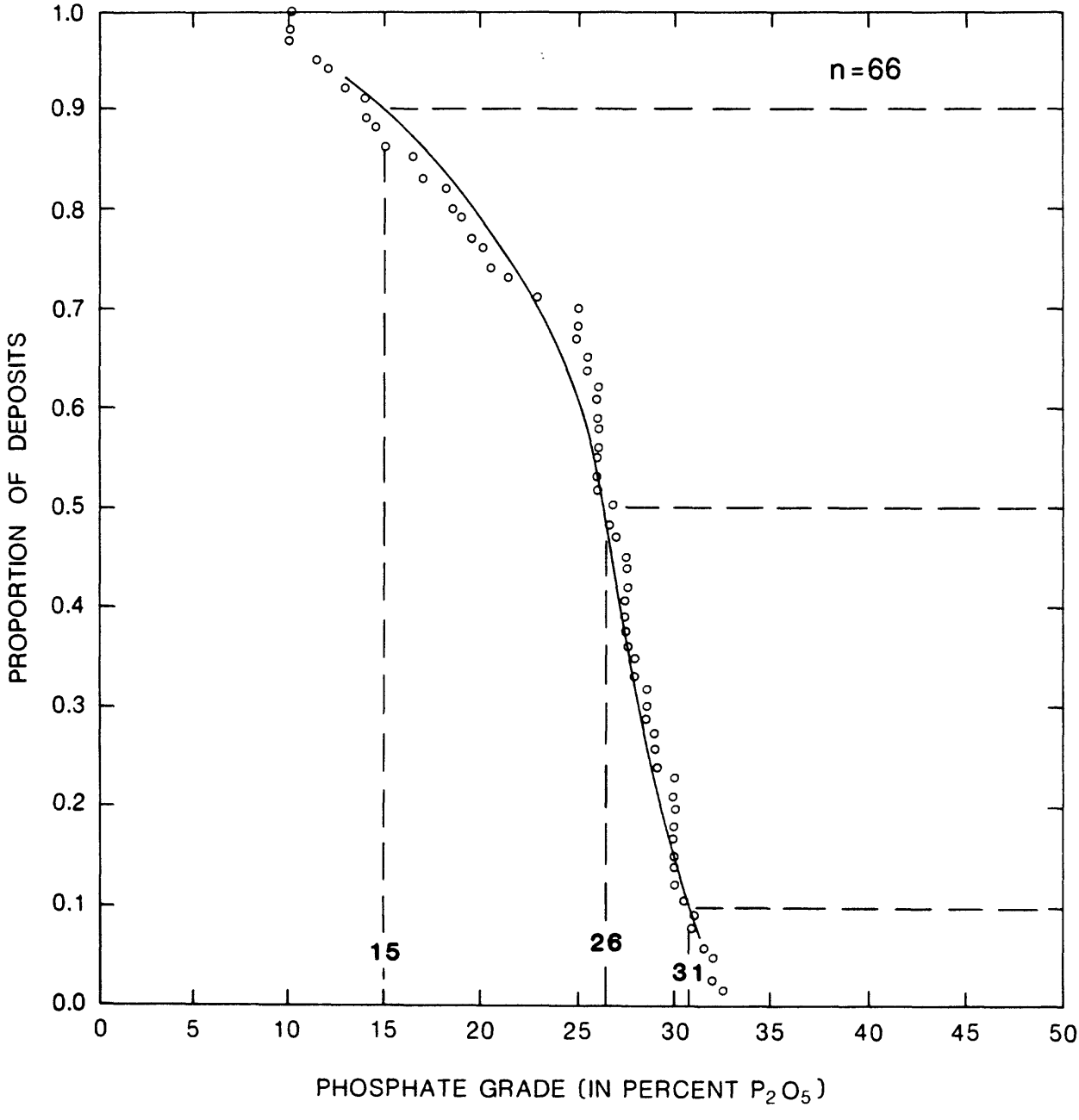
DATA REFERENCES Anon., 1983

COMMENTS

DEPOSITS

Name	Country	Name	Country
Abu Tartur	EGPT	Mazidagi	TRKY
Akashat	IRAQ	Mdilla	TUNS
Aktyubinsk	URRS	Meskala	MRCO
Al-Hasa/Oatrana	JRDN	Metlaoui	TUNS
Arad	ISRL	Montana	USMT
Beersheva	ISRL	Moulares	TUNS
Ben-Guerir	MRCO	Mrata	TUNS
Bou Craa	SPAN	Mzaita	ALGR
Brooks Range	USAK	Nahal-Zin	ISRL
Chilisai	URRS	New Cuyama	USCA
Conda	USID	Oron	ISRL
Dimitrovsk	URRS	Oulad-Abdoun	MRCO
Djebel Onk	ALGR	Patos de Minas	BRZL
D-Tree	AUQL	Qusseir	EGPT
Duchess	AUQL	Redeyef	TUNS
Eastern A&B	SYRA	Ruseifa	JRDN
El Hamrawein	EGPT	Safaga	EGPT
Ganntour	MRCO	San Juan de la Costa	MXCO
Hahotoe	TOGO	Sechura	PERU
Haikou	CINA	Sehib	TUNS
Henry	USID	S.E. Idaho	USID
Hubsugul	MNGL	Shediyah	JRDN
Idfu-Qena	EGPT	Sherrin Creek	AUQL
Kalaa Khasba	TUNS	Sidi Daoui	MRCO
Kara Tau	URRS	Stra Quertane	TUNS
Khneifiss	SYRA	Taiba	SNGL
Kondonakasi	ANGL	Thamar-Kotra	INDA
Kun Ming	CINA	Thies	SNGL
Lady Annie	AUQL	Uinta Mtns.	USUT
Lee Creek	USNC	Vernal	USUT
Le Kouif	ALGR	Warm Springs	USMT
Lily Creek	AUQL	Wooley Valley	USID
Makhtesh	ISRL	Wyoming	USWY
Maybe Canyon	USID	Youssoufra	MRCO


MARINE PHOSPHATE - UPWELLING TYPE
n = 66
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
25
280
3500
0.1
0.4
1.6
6.3
25
100
400
1600
6300
25,000
100,000
TONNES (IN MILLIONS)


MARINE PHOSPHATE - UPWELLING TYPE
n=66
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
5
10
15
20
25
30
35
40
45
50
15
26
31
PHOSPHATE GRADE (IN PERCENT P_2O_5)

DEPOSIT TYPE Marine phosphate-warm current type MODEL NUMBER None

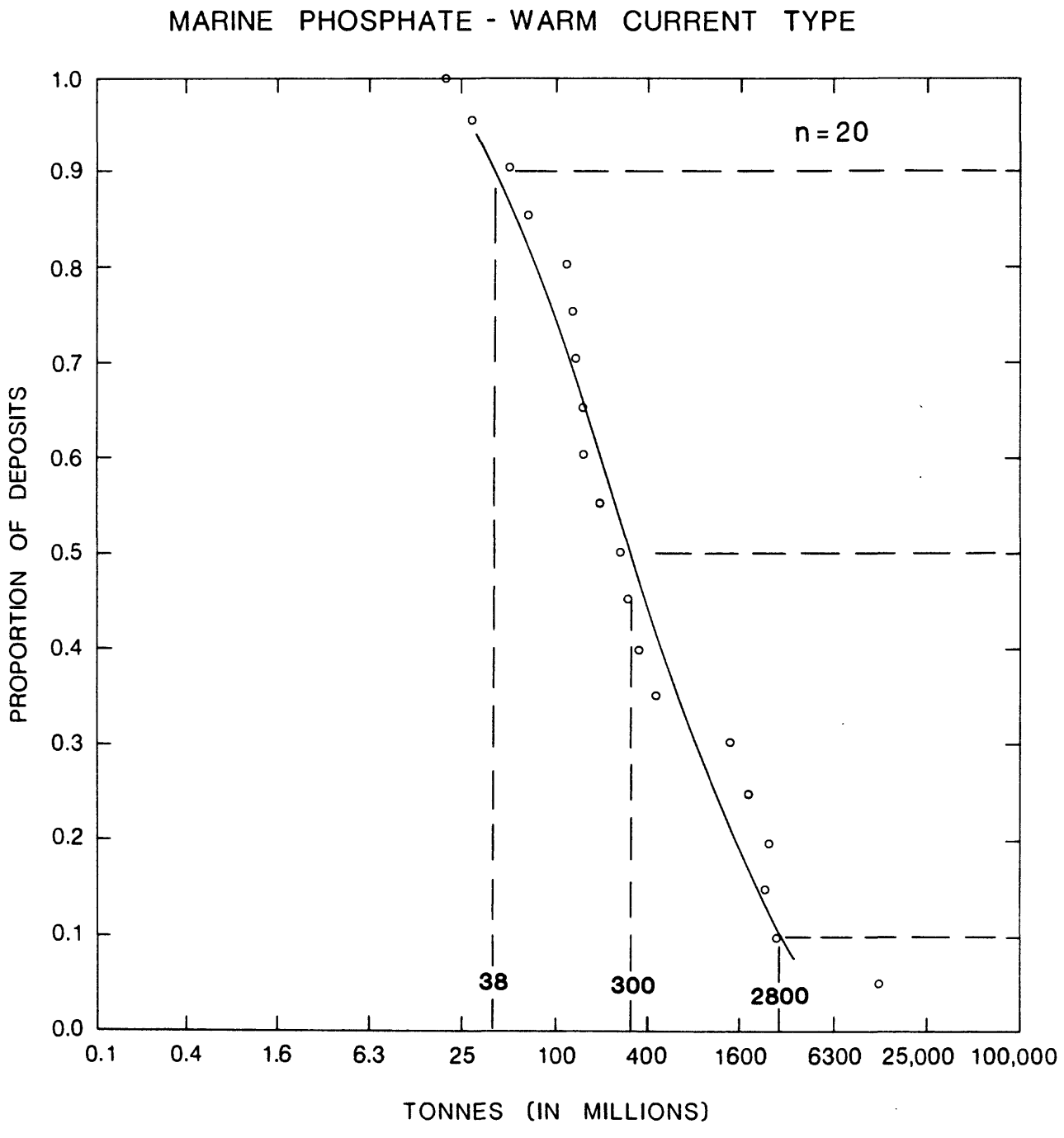
AUTHOR D. L. Mosier

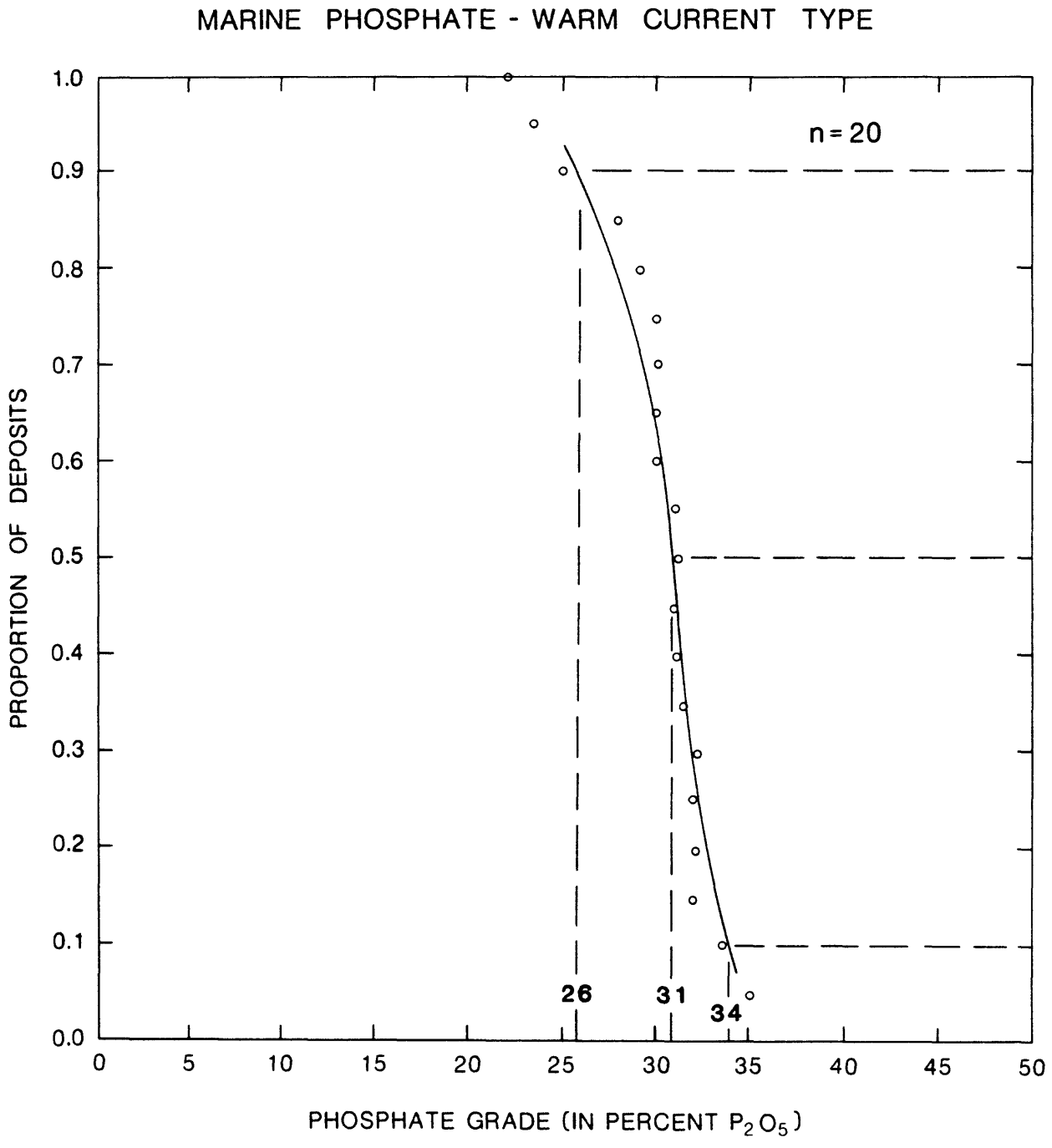
DATA REFERENCES Anon., 1983

COMMENTS Sometimes called the East Coast type.

DEPOSITS

Name	Country
Big Four	USFL
Bonny Lake	USFL
Clear Springs	USFL
East Florida	USFL
Fort Green	USFL
Hard Rock	USFL
Haynsworth	USFL
Kingsford	USFL
Land Pebble	USFL
Lonesome	USFL
Noralyn-Phosphoria	USFL
North Florida	USFL
North Carolina	USNC
Northeast Florida	USFL
Offshore Savannah	USGA
Paulista	BRZL
Payne Creek	USFL
Rockland	USFL
Saddle Creek	USFL
South Florida	USFL


MARINE PHOSPHATE - WARM CURRENT TYPE
n = 20
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
38
300
2800
0.1
0.4
1.6
6.3
25
100
400
1600
6300
25,000
100,000
TONNES (IN MILLIONS)


MARINE PHOSPHATE - WARM CURRENT TYPE
n = 20
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
5
10
15
20
25
30
35
40
45
50
26
31
34
PHOSPHATE GRADE (IN PERCENT P_2O_5)

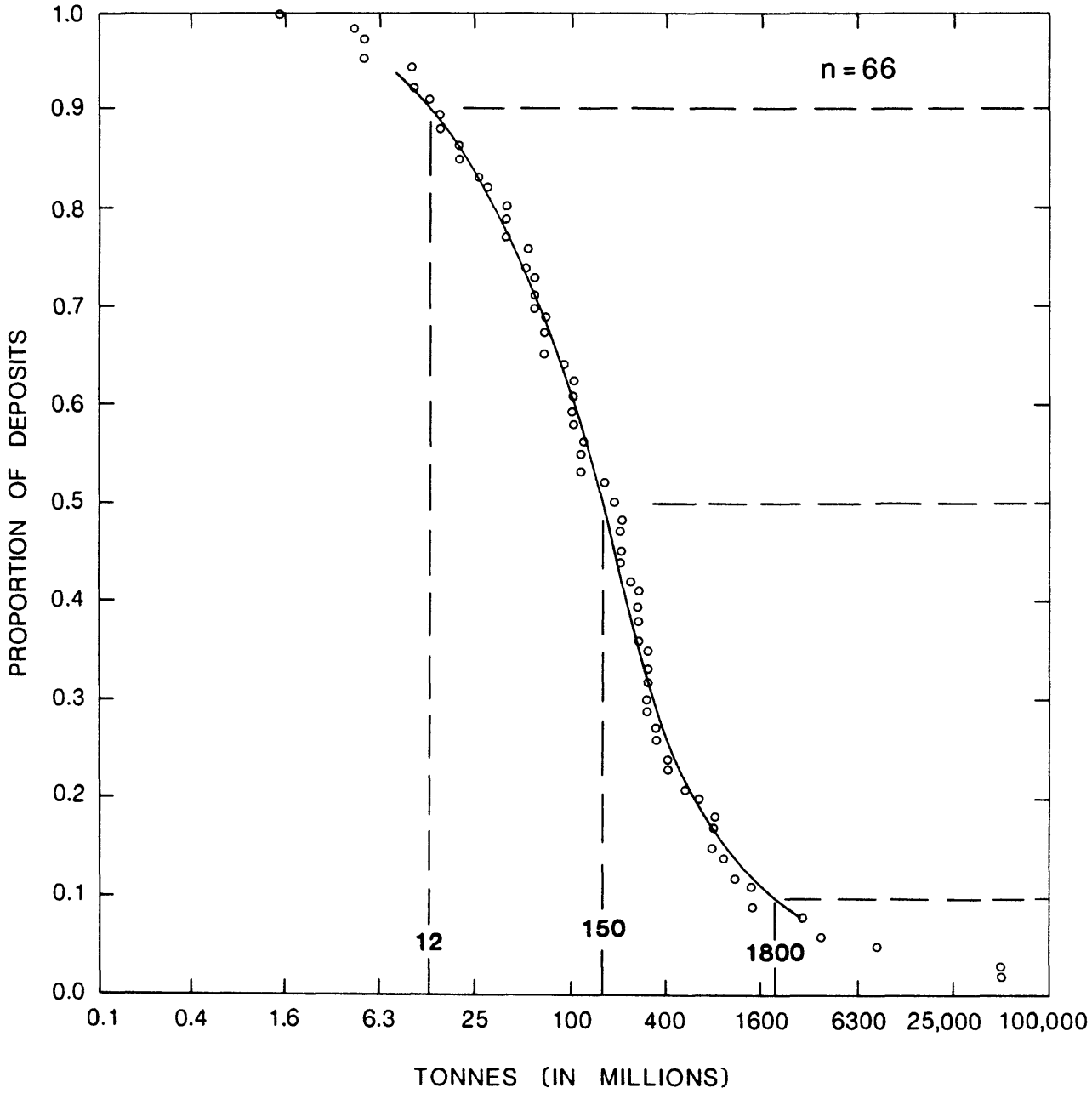
DEPOSIT TYPE Superior-Algoma iron MODEL NUMBER none

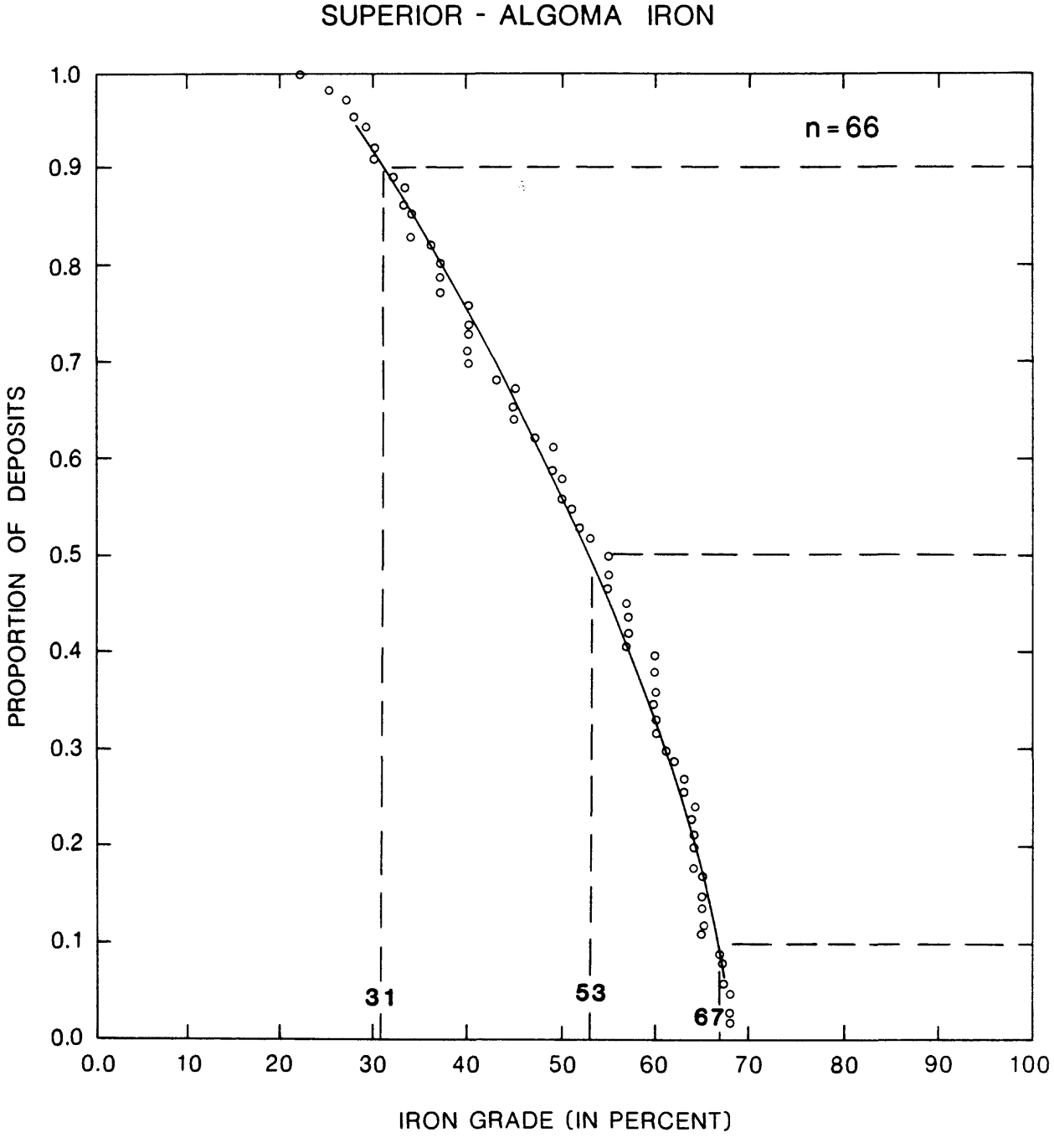
AUTHOR D. L. Mosier

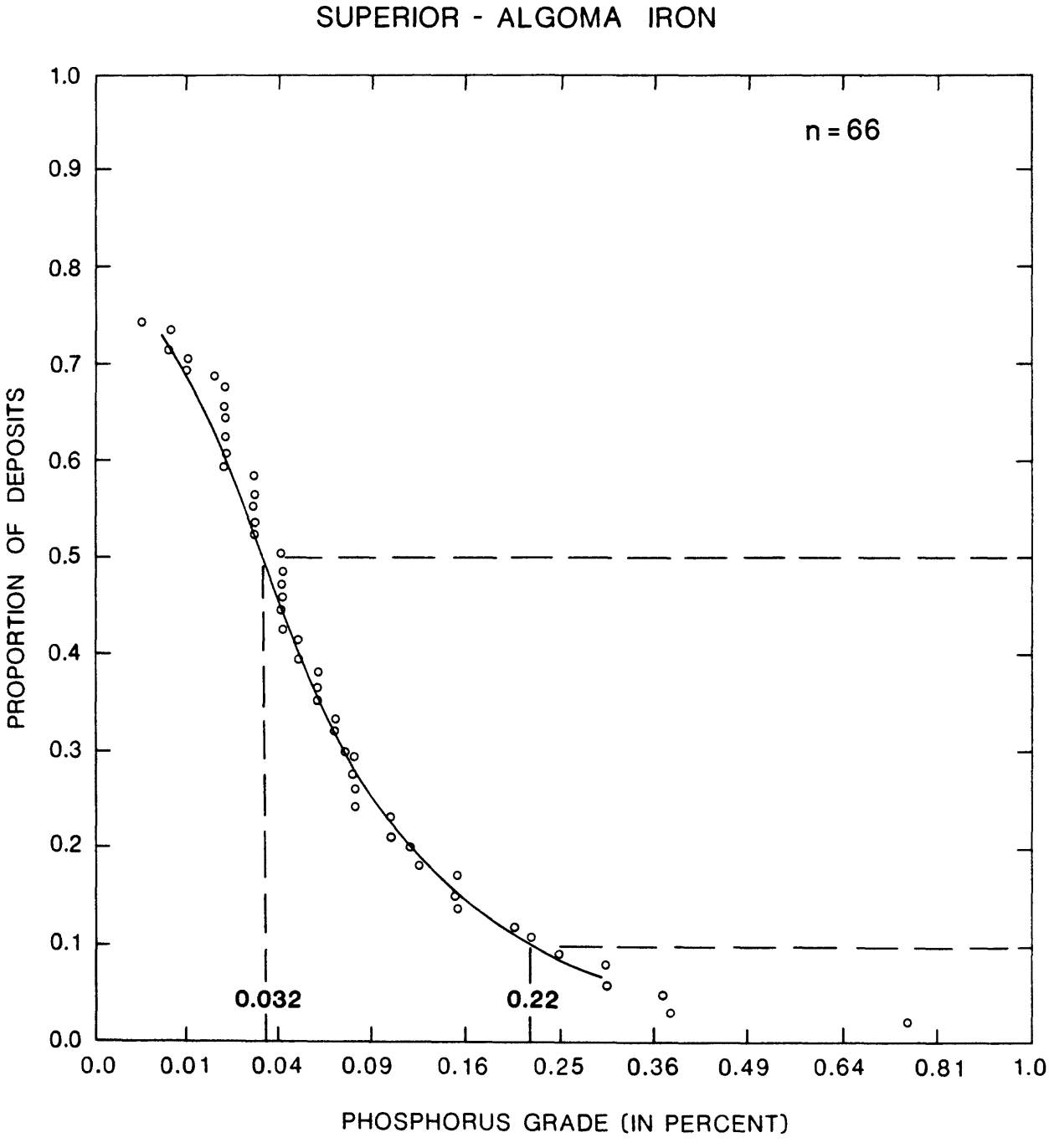
COMMENTS Archean and Proterozoic banded iron formations are combined.

DEPOSITS

Name	Country	Name	Country
Altamira-Frontera	VNZL	Noamundi-Joda-Gua etc.	INDA
Amapa	BRZL	Norberg	SWDN
An-shan	CINA	Pa-pan-ling	CINA
Bahia	BRZL	Pen-chi-hu	CINA
Bailadila	INDA	Piacoa	VNZL
Bellary	INDA	Porkonen	FNLD
Bicholim	INDA	Relun	CILE
Burnt Hill-Knob Lake	CNQU	Rowghat	INDA
Cerro Bolivar	VNZL	Sangalwara	INDA
Chityal and others	INDA	Santa Barbaara	VNZL
Cuyuna	USMN	Sirigao	INDA
Dhalli-Rajhara	INDA	Ssu-chia-ying	CINA
El Pao	VNZL	Stripa-Striberg	SWDN
Fiskefjord	NRWY	Sydvananger	NRWY
Fort Apache	USAZ	Tallering Peak	AUWA
Fort Gourand	MAUR	Thabazimbi	SAFR
Gogebic	USMN	Tonkolili	SRLN
Gorumahisani and others	INDA	Vermilion	USMN
Goulais	CNON	Vestpolltind	NRWY
Guntur	INDA	Weld Range-Wilgie Mia	AUWA
Iron Monarch-Iron Knob	AUSA	Zalpa	AGTN
Jussaari	FNLD		
Kanjamalai and others	INDA		
Kemmangundi and others	INDA		
Koolyanobbing	AUWA		
Krivoi-Rog	URRS		
Kudremukh and others	INDA		
Kung-changling	CINA		
Kusalpur	INDA		
Labrador Quebec	CNQU		
Lohara and others	INDA		
Los Castillos	VNZL		
Maria Luisa	VNZL		
Marquette	USMN		
Mato Grosso	BRZL		
Menominee	USMN		
Mesabi	USMN		
Minas Gerais	BRZL		
Moose Mountain	CNON		
Mount Gibson	AUWA		
Mount Gould	AUWA		
Mount Hale	AUWA		
Mount Philp	AUQL		
Musan	NKOR		
Mutum	BLVA		


SUPERIOR - ALGOMA IRON
n = 66
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
12
150
1800
0.1
0.4
1.6
6.3
25
100
400
1600
6300
25,000
100,000
TONNES (IN MILLIONS)


SUPERIOR - ALGOMA IRON
n = 66
PROPORTION OF DEPOSITS
IRON GRADE (IN PERCENT)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.0
10
20
30
40
50
60
70
80
90
100
31
53
67


SUPERIOR - ALGOMA IRON
n = 66
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.032
0.22
0.0
0.01
0.04
0.09
0.16
0.25
0.36
0.49
0.64
0.81
1.0
PHOSPHORUS GRADE (IN PERCENT)

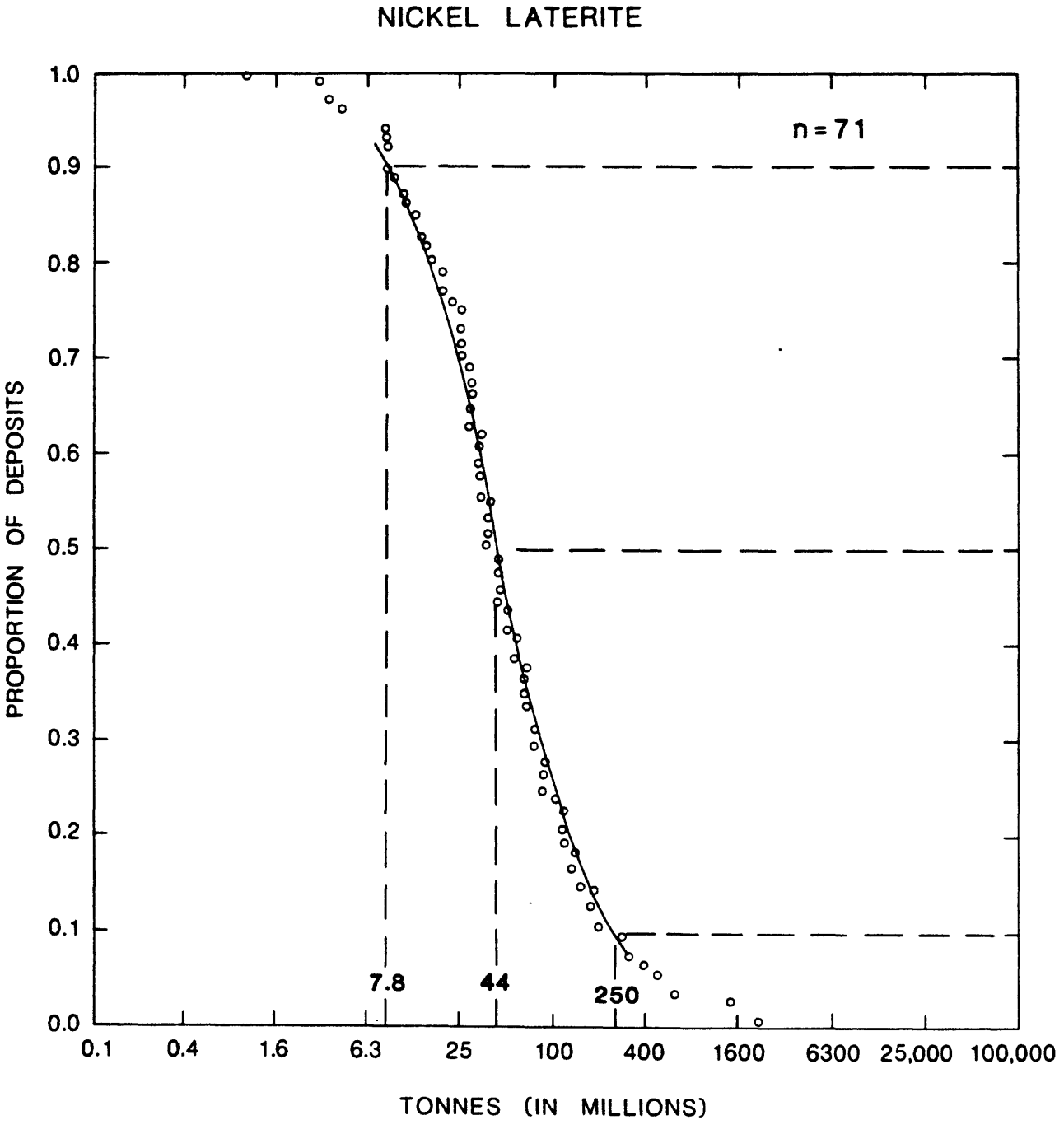
DEPOSIT TYPE Nickel laterite MODEL NUMBER 7.2

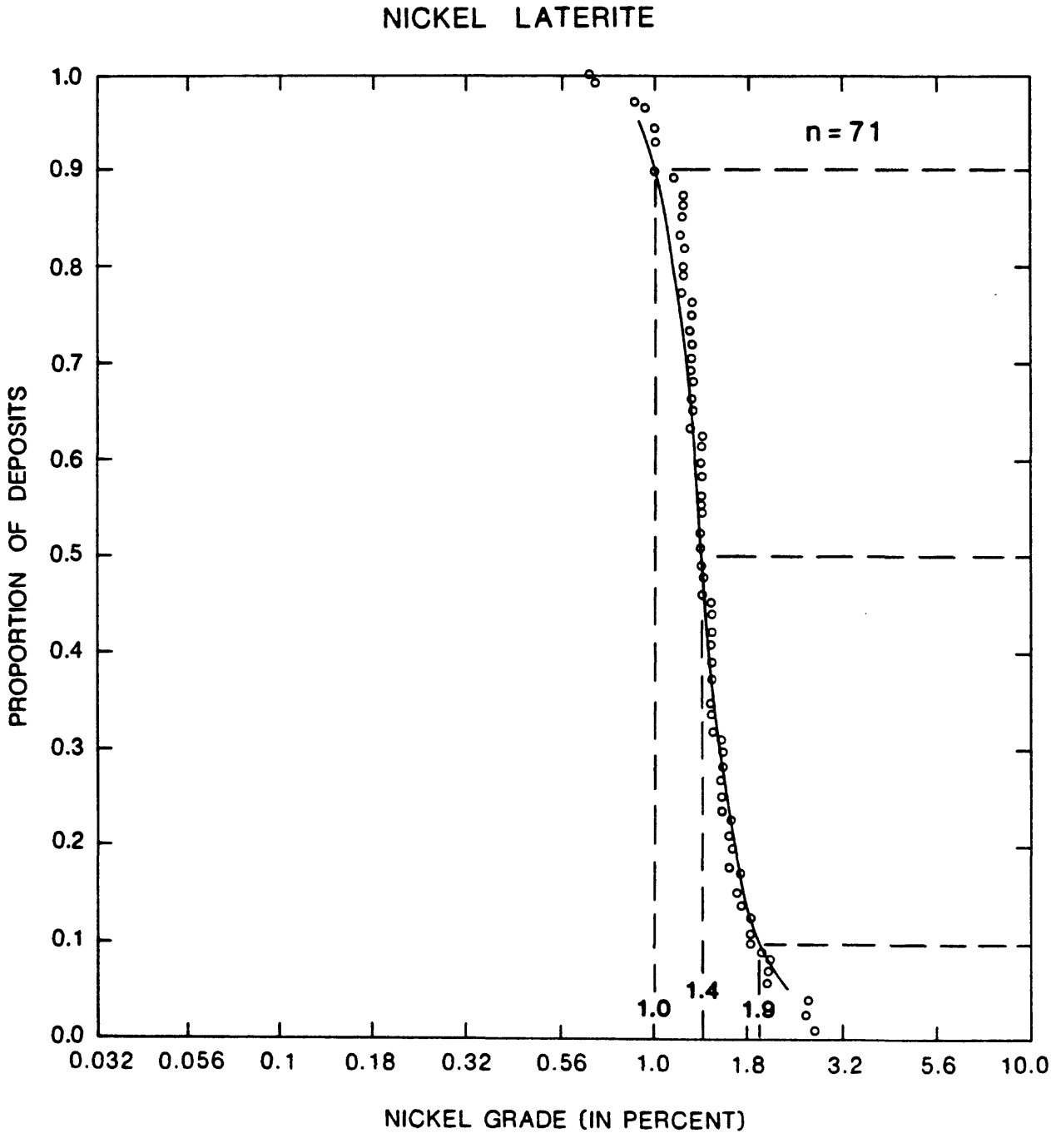
AUTHOR D. A. Singer

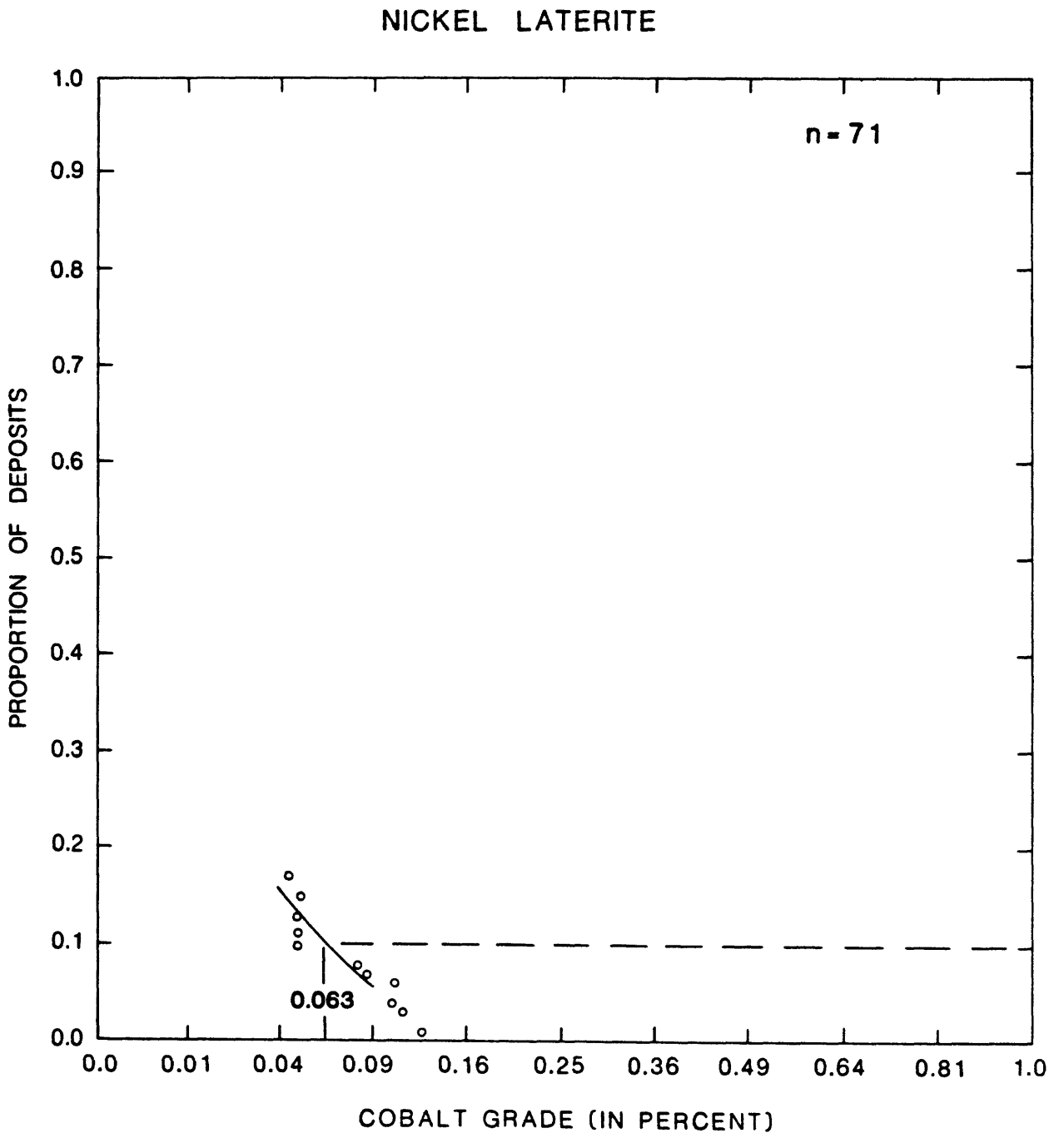
COMMENTS Higher grades are typically associated with the silicate type. Numerous low grade (less than 1 % Ni) and low tonnage deposits were not included in the data. Nickel grade is correlated with tonnage at the 1% level (r=-0.31).

DEPOSITS

Name	Country	Name	Country
Ambatory	MDGS	Mon Bay	CUBA
Analumay	MDGS	Moorsom	PLPN
Barro Alto	BRZL	Moramanya	MDGS
Berong	PLPN	Morro de Engenho	BRZL
Bhimatangar	INDA	Mwaytung	BRMA
Br. Solomon Is.	SLMN	Nepoui	NCAL
Cabo Rojo	PTRC	New Frontier	PLPN
Cerro Matoso	CLBA	Niquelandia	BRZL
Claude Hills	AUSA	Nonoc	PLPN
Cyclops	INDS	Obi	INDS
Dinaget Is.	PLPN	Ora Banda	AUWA
Eubocu	GREC	Orsk	URRS
Eximbal	GUAT	Pojada Pen.	PLPN
Falconbridge	DMRP	Pomaloa	INDS
Gag Is.	INDS	Poro	NCAL
Golesh Mt.	YUGO	Poum	NCAL
Golos	YUGO	Pratapolis	BRZL
Goro	NCAL	Prony	NCAL
Greenvale	AUQL	Ramona-Loma	CUBA
Halmahera	INDS	Riddle	USOR
Ipaneme	BRZL	Rio Tuba	PLPN
Jacupuenga	BRZL	Sablayon	PLPN
Kaliapani	INDA	Sao Joando Piaui	BRZL
Kansa	INDA	Saruabi	INDA
Kauadarci	YUGO	S.E. Kalimantan	INDS
Laguney	PLPN	Sidamo	ETHP
Lake Joanina	GREC	Simlipal	INDA
Leviso R.	CUBA	Soroaka	INDS
Loma de Hierro	VNZL	Sukinda	INDA
Long Point	PLPN	Surigao	PLPN
Magios Ioannis	GREC	Taco Bay	CUBA
Marlborough	AUQL	Thio	NCAL
Masinloc	PLPN	Tiebaghi	NCAL
Mayari	CUBA	Wingelinna-Daisy	AUWA


NICKEL LATERITE
n = 71
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
7.8
44
250
0.1
0.4
1.6
6.3
25
100
400
1600
6300
25,000
100,000
TONNES (IN MILLIONS)


NICKEL LATERITE
n = 71
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1.0
1.4
1.9
0.032
0.056
0.1
0.18
0.32
0.56
1.0
1.8
3.2
5.6
10.0
NICKEL GRADE (IN PERCENT)


NICKEL LATERITE
n = 71
PROPORTION OF DEPOSITS
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.063
0.0
0.01
0.04
0.09
0.16
0.25
0.36
0.49
0.64
0.81
1.0
COBALT GRADE (IN PERCENT)

COUNTRY NAMES

AGTN	Argentina
ALGR	Algeria
ANGL	Angola
AUNS	Australia, New South Wales
AUNT	Australia, N. Territory
AUQL	Australia, Queensland
AUSA	Australia, South Australia
AUTS	Australia, Tasmania
AUVT	Australia, Victoria
AUWA	Australia, Western Australia
ASTR	Austria
BULG	Bulgaria
BLVA	Bolivia
BRMA	Burma
BOTS	Botswana
BRZL	Brazil
CILE	Chile
CINA	China
CLBA	Colombia
CNBC	Canada, British Columbia
CNGO	Congo
CNMN	Canada, Manitoba
CNNB	Canada, New Brunswick
CNNF	Canada, Newfoundland
CNNS	Canada, Nova Scotia
CNNT	Canada, Northwest Territory
CNON	Canada, Ontario
CNQU	Canada, Quebec
CNSK	Canada, Saskatchewan
CNYT	Canada, Yukon Territory
CORI	Costa Rica
CUBA	Cuba
CYPS	Cyprus
CZCL	Czechoslovakia
DMRP	Dominican Republic
ECDR	Ecuador
EGPT	Egypt
ELSA	El Salvador
ETHP	Ethiopia
FIJI	Fiji
FNLD	Finland
FRNC	France
GHNA	Ghana
GRBR	Great Britain
GREC	Greece
GRLD	Greenland
GRMY	Germany
GUAT	Guatemala
HATI	Haiti
HONG	Hong Kong
HNDR	Honduras
HUNG	Hungary
INDA	India
INDS	Indonesia
IRAN	Iran
IRAQ	Iraq
IRLD	Ireland
ISRL	Israel
ITLY	Italy
IVCO	Ivory Coast
JAPN	Japan
JRDN	Jordan
KNYA	Kenya
MALI	Mali
MAUR	Mauritania
MDGS	Madagascar (Malgasy Rep.)
MLYS	Malaysia
MNGL	Mongolia
MRCO	Morocco
MXCO	Mexico
NCAL	New Caledonia
NCRG	Nicaragua
NKOR	North Korea
NRWY	Norway
NZLD	New Zealand
OMAN	Oman
PANA	Panama
PERU	Peru
PKTN	Pakistan
PLPN	Philippines
PORT	Portugal
PPNG	Papua New Guinea
PTRC	Puerto Rico
RMNA	Romania
SAAR	Saudi Arabia
SAFR	South Africa
SKOR	South Korea
SNGL	Senegal
SPAN	Spain
SRLN	Sierra Leon
SUDN	Sudan
SWDN	Sweden
SYRA	Syria
THLD	Thailand
TIWN	Taiwan
TNZN	Tanzania
TOGO	Togo
TRKY	Turkey
TUNS	Tunisia
UVOL	Upper Volta
URAM	USSR, Armenia
URKZ	USSR, Kazakhstan
URRS	USSR, Russia undiff.
URTD	USSR, Tadzhilistan
URUZ	USSR, Uzbekistan
USAK	US, Alaska

USAR	US, Arkansas
USAZ	US, Arizona
USCA	US, California
USCO	US, Colorado
USFL	US, Florida
USGA	US, Georgia
USID	US, Idaho
USME	US, Maine
USMN	US, Minnesota
USMS	US, Massechusetts
USMT	US, Montana
USNC	US, North Carolina
USNM	US, New Mexico
USNV	US, Nevada
USOR	US, Oregon
USPA	US, Pennsylvania
USUT	US, Utah
USVT	US, Vermont
USWA	US, Washington
USWI	US, Wisconsin
USWY	US, Wyoming
VNZL	Venezuela
VTNM	Vietnam
YUGO	Yugoslavia
ZIMB	Zimbabwe

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