U. S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Industrial Minerals Deposit Models:
Grade and tonnage models

edited by

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Open-File Report

92-437

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INTRODUCTION

This report consists of a series of grade, tonnage, and other deposit-specific models for industrial minerals similar to those found in U.S. Geological Survey (USGS) Bulletin 1693 (Cox and Singer, 1986). Most of these models are new, others are updates of models originally published in Cox and Singer (1986), and three of the models have been previously published in non-USGS publications and are included here for the convenience of model users. Correlations between grades and tonnages are reported only when they are significant at the 5 percent level. Country codes for the deposits listed in this report may be found in Appendix A. Model numbers refer to the classification system used by Cox and Singer (1986) and modified by Orris and Bliss (1991). Descriptive models for most of the quantitative models in this report can be found in Orris and Bliss (1991) or in Cox and Singer (1986).

The user should be also be aware of the following items:

-- Deposits, except for diamond placers, were not grouped by the authors using distance rules such as those used to model polymetallic veins (Bliss and Cox, 1986) or low-sulfide Au-quartz veins (Bliss, 1986). However, some deposits as reported are probably composed of multiple bodies of mineralization.

-- The grade distributions for barite veins, sandstone-quartzite silica, bedded barite, silica sand, marine bedded gypsum, and bedded celestite exhibit extreme economic bias towards high grades.

-- The grade distributions of wollastonite, potash in bedded salt, lacustrine gypsum, and lacustrine borates are normal.

-- For several deposit types, grades and ore tonnages were not available, but contained material figures were used to construct models.

-- In all cases, all known production and reserves were used to estimate deposit size, but the user should be aware that many industrial mineral deposits are never formally evaluated for reserves (reserve figures are geologic estimates and not drilled ore bodies) and production figures may be incomplete.

-- For some deposits, the exact physical nature of a deposit is not known. Some deposits may be single lenses or veins; others could be groups of lenses or veins within a single stratigraphic horizon or host rock.

-- Some deposit types such as different types of pegmatites, skarns, and brines may be as reflective of economic divisions as geologic differences.

GRADE AND TONNAGE MODEL OF SERPENTINE-HOSTED ASBESTOS

By G.J. Orris

An earlier version of this model was published by Orris (1986a). Deposits in this model are single deposits composed of stockworks of chrysotile asbestos. Grade is reported as percent of asbestos fibers with no distinction made between cross and slip fibers. There is no significant correlation between grade and tonnage in this model. See figs. 1, 2.

DEPOSITS

Name	Country	Name	Country
Abitibi	CNQU	Kwangchon	SKOR
Advocate	CNNF	Lake Asbestos	CNQU
Asbestos Hill	CNQU	Las Brisas	CLBA
Asbestos Island	CNQU	Lili	CNQU
Baryulgil	AUNS	Lewis Brook	CNNF
Bell Mine	CNQU	Loghar	AFGH
Belvidere	USVT	Maizerets	CNQU
Bird-Ginn (Matheson)	CNON	McAdam	CNQU
Black Lake	CNQU	McDame	CNBC
British Canadian	CNQU	Midlothian	CNON
Caley	CNYT	Moladezhnoye	USSR
Carey/East Broughton	CNQU	Morro Dois Irmãos	BRZL
Cana Brava	BRZL	Msauli	SAFR
Cassiar Mine	CNBC	Munro	CNON
Clinton Creek	CNYT	National	CNQU
Coalinga	USCA	Nicolet Asbestos	CNQU
Continental	CNQU	Normandie/Penhale	CNQU
Copperopolis	USCA	Pontbriand	CNQU
Courvan	CNQU	Qala-el-Nahl	SUDN
Cranbourne	CNQU	Reeves	CNON
Daffodil	CNON	Rex	CNYT
Eagle	USAK	Roberge Lake	CNQU
Gilmont	CMQU	St. Adrien Mtn.	CNQU
Golden Age	CMQU	St. Cyr	CNQU
Havelock Mine	SWAZ	Santiago Papalo	MXCO
Hedman	CNON	Sayan	USSR
Ingessana Hills	SUDN	Shihmien	CINA
Jeffrey	CNQU	Steele Brook	CNQU
King-Beaver Mine	CNQU	Tuolumne	USCA
Kinlock	SAFR	Windsor	CNQU
Kolubara-Azbet	YUGO	Woodsreef Mine	AUNS
Kudu Asbestos Mine	ZIMB	Zidani	GREC

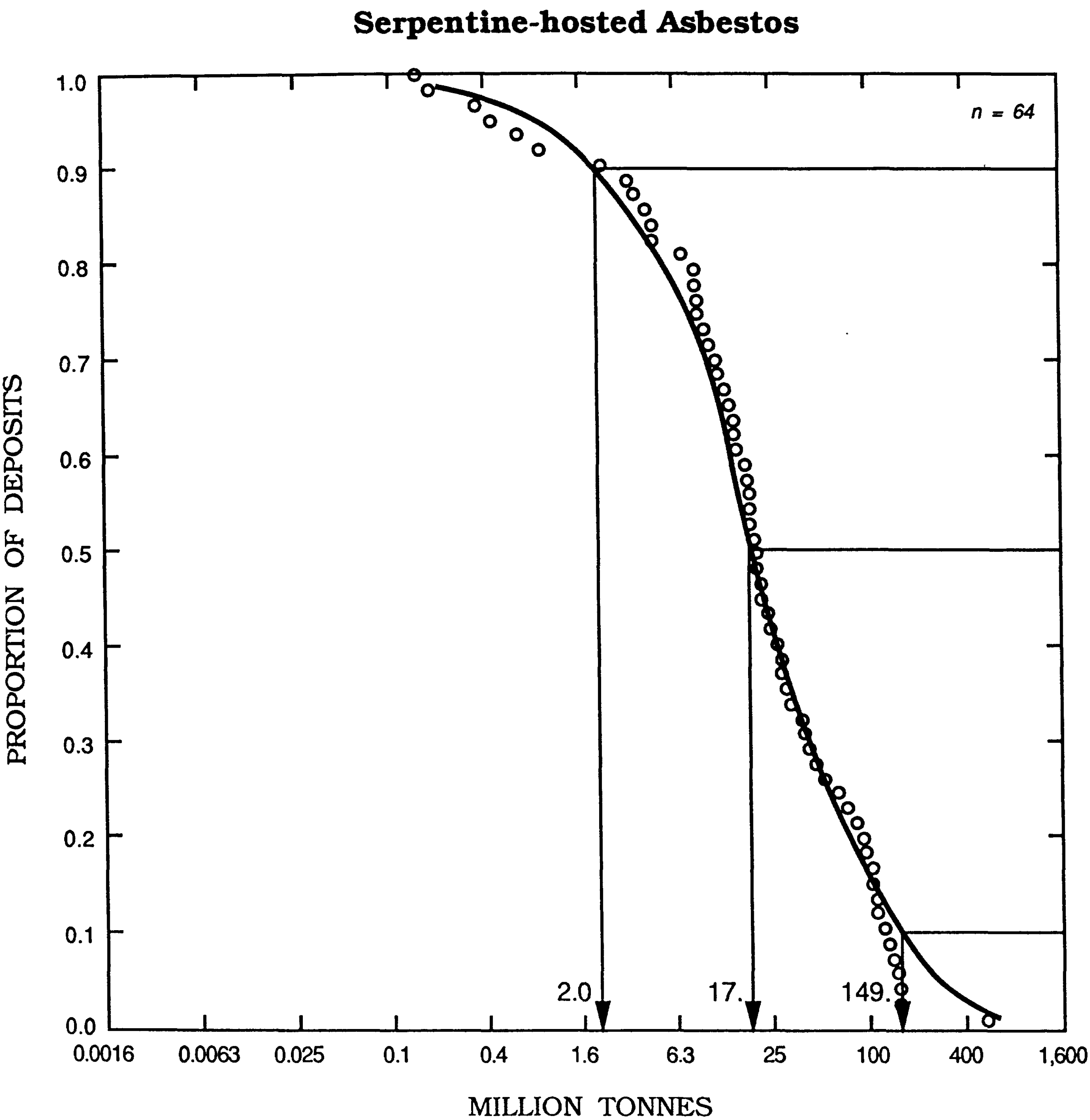

Figure 1. Tonnage model for serpentine-hosted asbestos.

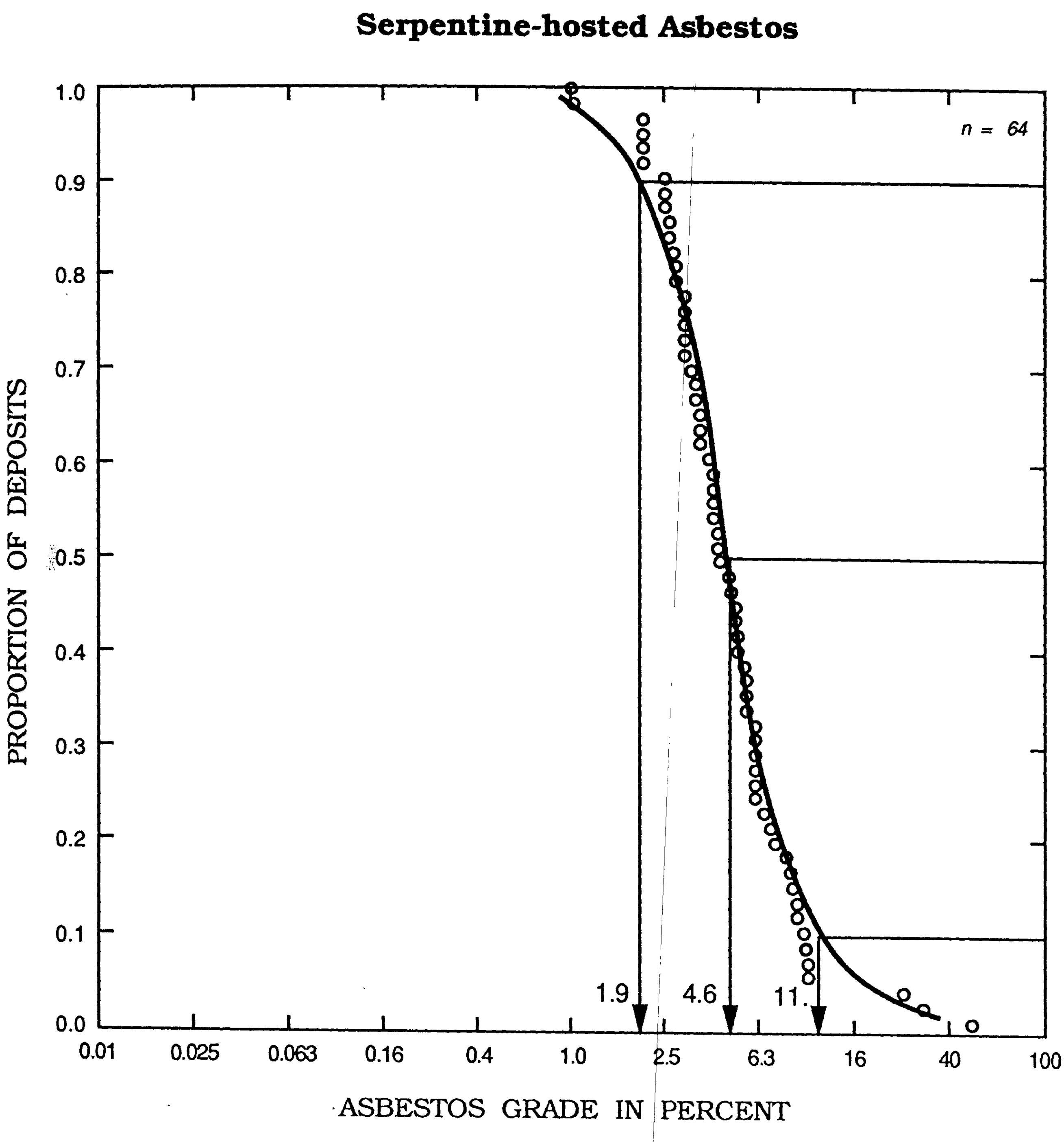

Figure 2. Grade model for serpentine-hosted asbestos.

GRADE, TONNAGE, AND DEPOSIT-SPECIFIC MODELS OF DIAMOND KIMBERLITE PIPES

By James D. Bliss

COMMENT: In addition to size and grade, average carat size and percentage of diamonds of industrial grade are needed to characterized diamond kimberlite pipes. Also included is a target-area model of outcrop areas. Classification of kimberlite pipes and kimberlite dikes is not always clear and one or more diamond kimberlite dikes may have been included. Data sets are rarely complete and resulted in various number of deposits used in each model. Percentage of industrial diamonds was not used from the Letlhankane and Jwaneng pipes. Both are outliers on a scatter plot of diamond grade and percentage of industrial diamonds. There is no significant correlation between grade and tonnage. There is significant correlation between largest diamond size and tonnage (r=0.82, n=10), and between outcrop area and tonnage (r=0.74, n=18). See figs.3-7.

DEPOSITS

Name	Country	Name	Country
Bultfontein	SAFR	Letseng-La-Terai	LSTO
De Beers	SAFR	Majhgawan	INDA
Dokolwayo	SWAZ	Mir	USSR
Dutoitspan	SAFR	Monastery	SAFR
Finsch	SAFR	Mwadwi (Williamson)	TNZN
Frank Smith	SAFR	Orapa	BOTS
Jagersfontein	SAFR	Premier	SAFR
Jwaneng	BOTS	Sloan 1 & 2	USCO
Kamfersdam	SAFR	Udatchnaya	USSR
Kimberley	SAFR	Venetia	SAFR
Koffiefontein	SAFR	Victory No. 1	CINA
Letlhankane (DK1)	BOTS	Wesselton	SAFR
Letlhankane (DK2)	BOTS	Zarnitsa	USSR

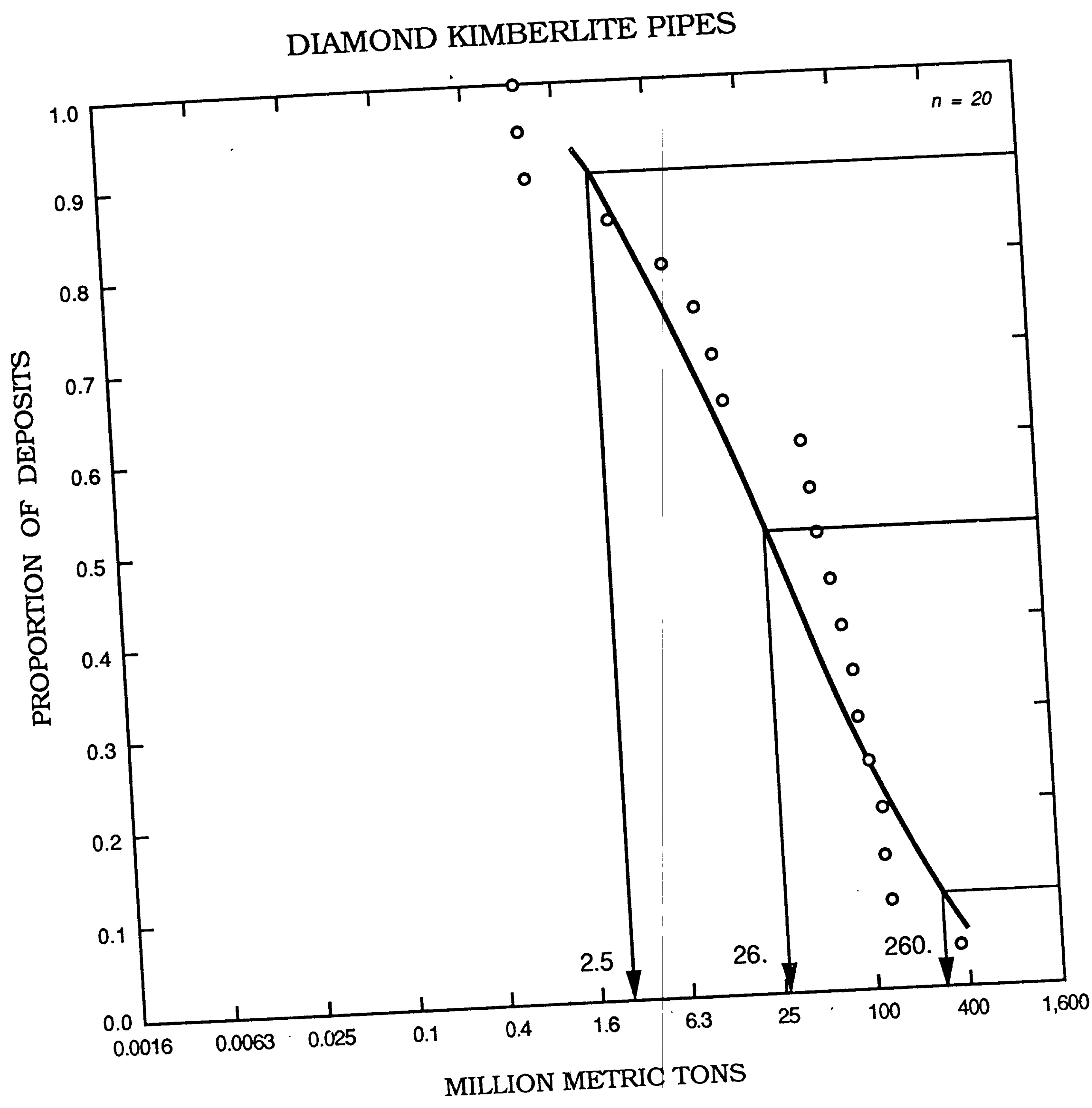

Figure 3. Tonnage model of diamond kimberlite pipes.

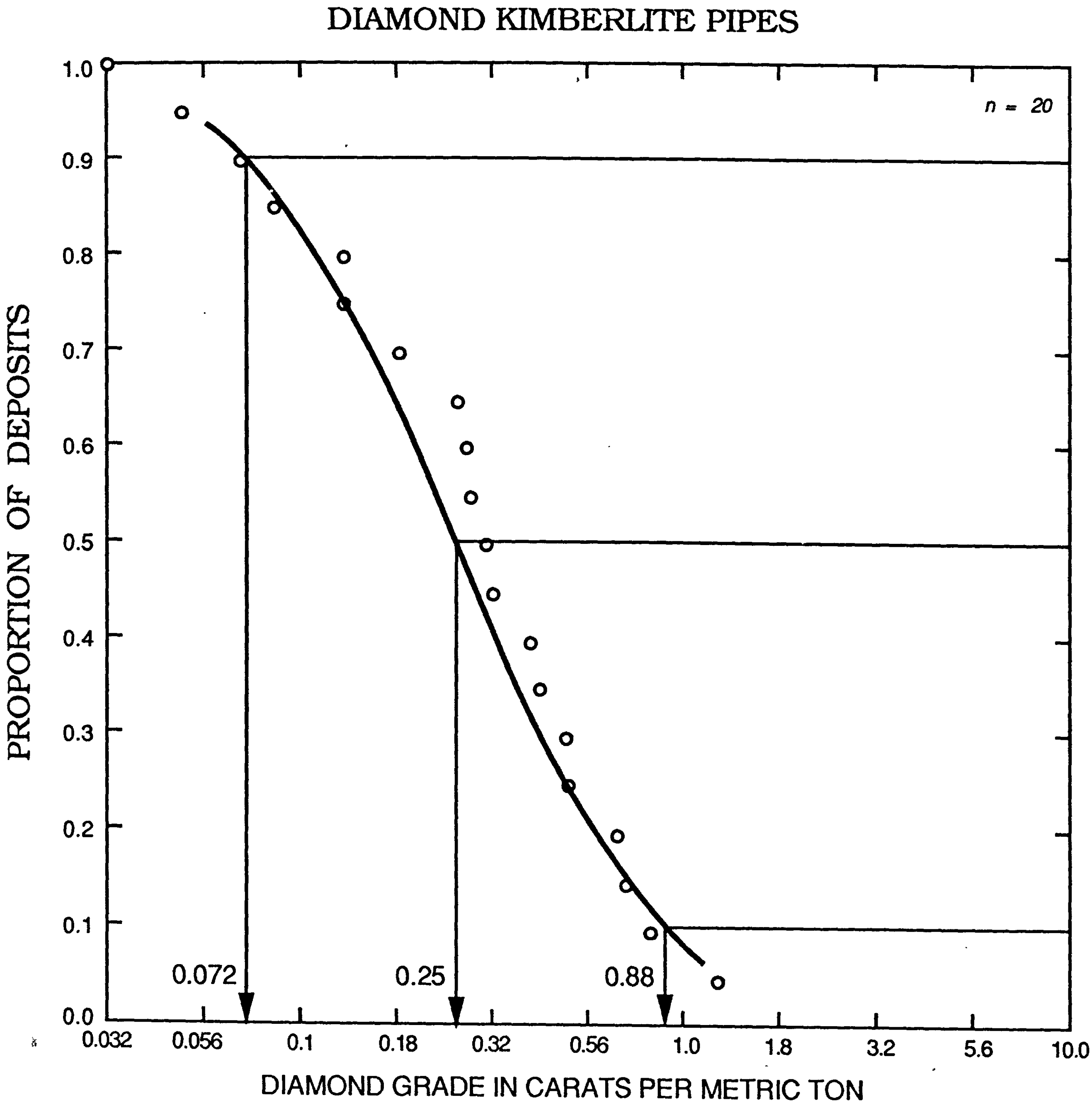

Figure 4. Model of diamond grade distribution in diamond kimberlite pipes.

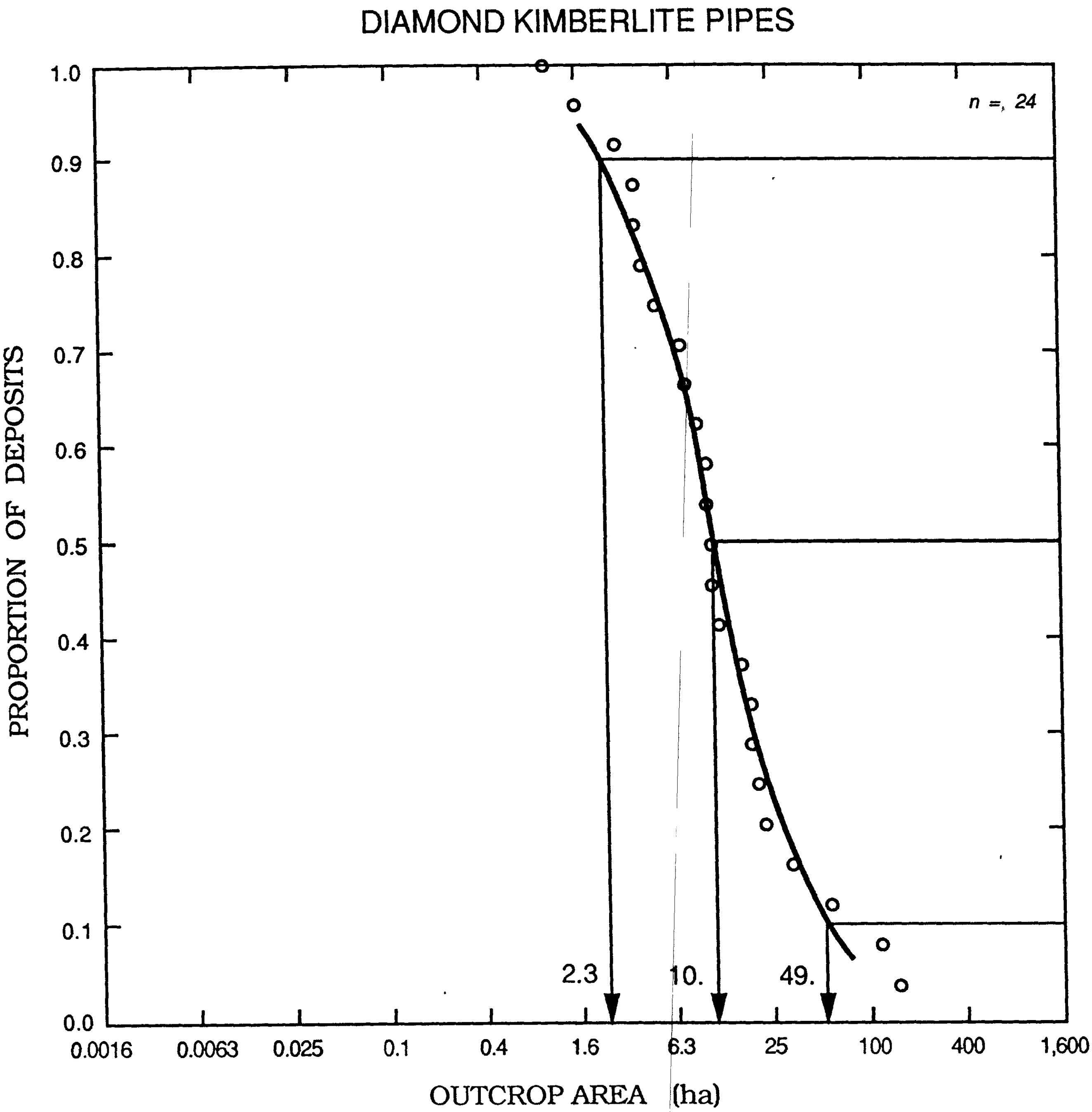

Figure 5. Model of outcrop areas of diamond kimberlite pipes.

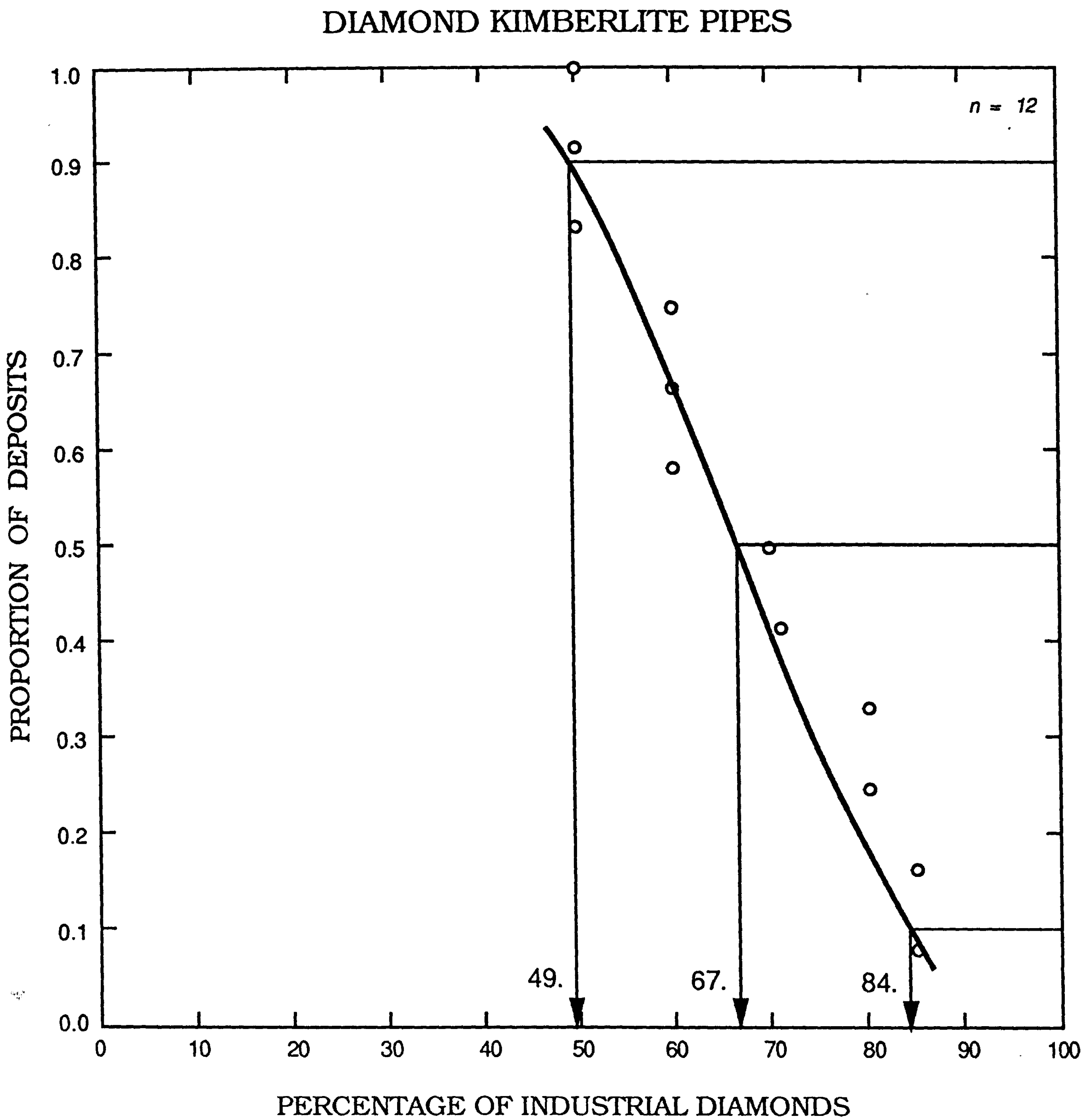

Figure 6. Model of the percentage of industrial diamonds in diamond kimberlite pipes.

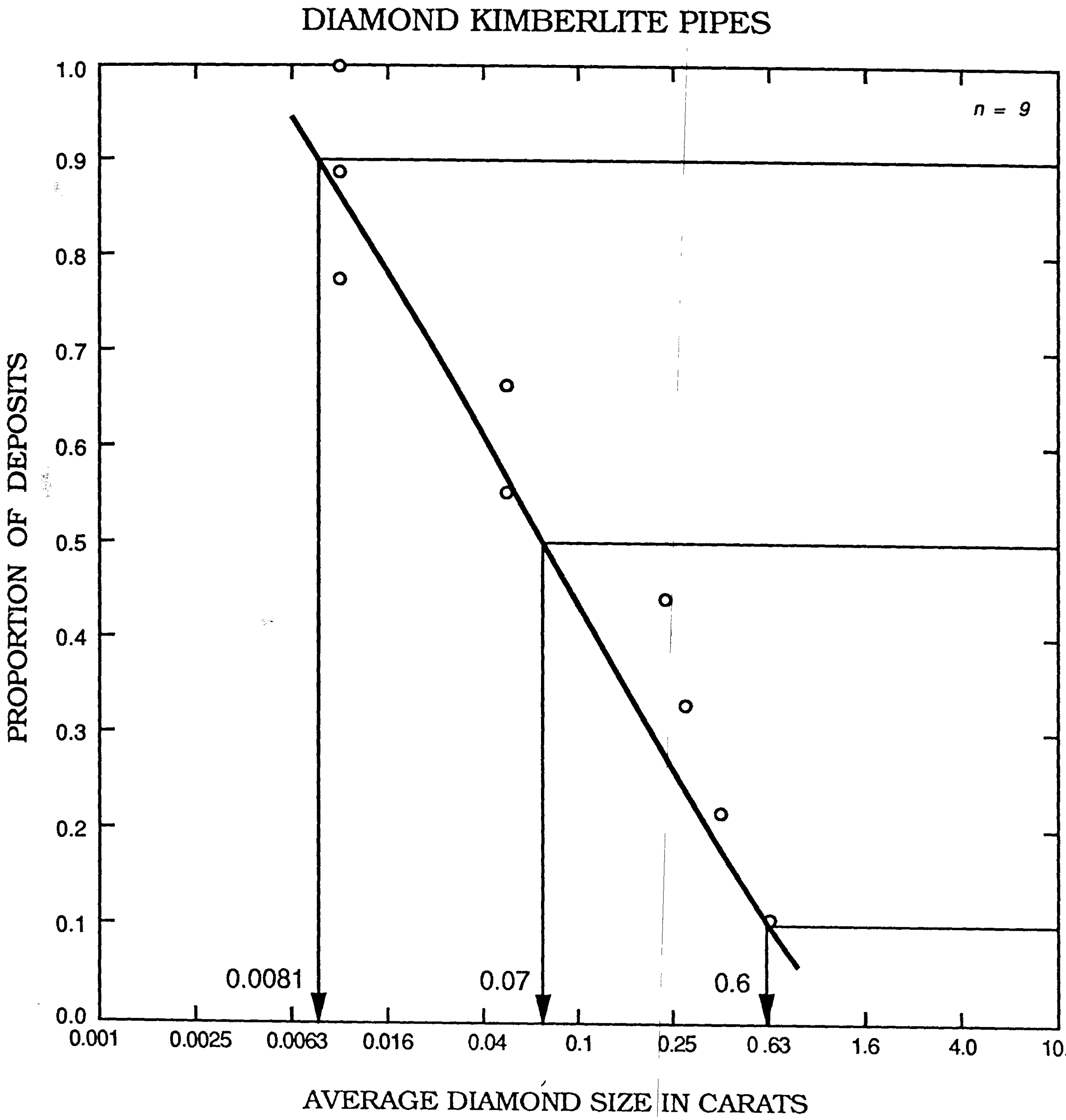

Figure 7. Model of average diamond size.

GRADE AND TONNAGE MODEL OF LITHIUM PEGMATITES

By J.D. Bliss and G.J. Orris

The grades and tonnages in this model are for the distribution of lithium minerals, especially spodumene, in pegmatites. Other commodities, commonly from other zones of the pegmatite may also be of economic interest. The deposits are composed of single pegmatites or groups of closely spaced pegmatites. There is no significant correlation between grade and tonnage in this model. See figs. 8, 9.

DEPOSITS

Name	Country	Name	Country
Ann (Ann Dyke)	CNNT	Lower Pasghushta	AFGH
Assinica Lake	CNQU	Lucy (Lucy No. 1)	CNMN
Aumacho	CNON	Lun-Echo (Mavis Lake)	CNON
Authier	CNQU	MAC (McDonald)	CNNT
Bernic Lake	CNMN	Manono	ZIRE
Bet (Best Bet)	CNNT	McVittie	CNON
Big (Murphy, UM)	CNNT	Mount Marion	AUWA
BIN (LI)	CNNT	MUT (J.S.J.-2)	CNNT
Bouvier	CNQU	Nama	CNON
Buck/Coe	CNMN	Nite (LI)	CNNT
Buckham Lake	CNNT	Obok-tong	SKOR
Conway	CNON	Ontario Lithium	CNON
Duval	CNQU	Paint	CNNT
Eagle	CNMN	Pasghushta	AFGH
Elk	CNNT	Paskhi	AFGH
FI (J.M., Lit)	CNNT	Pidlite Dike	USNM
Georgia Lake	CNON	Quebec Lithium	CNQU
Goldreef	CNMN	Root Lake (McCombe)	CNON
HID (lita)	CNNT	São José da Safira	BRZL
International Lithium	CNQU	Shamakit	AFGH
Irgon	CNMN	Spot	CNMN
Jake	CNNT	Taghawlor	AFGH
Jamanak	AFGH	Tanyang	SKOR
Jean Lake	CNON	Thor (Echo, Tanco)	CNNT
Jim (Greg, Ben)	CNNT	Tsangal	AFGH
KI (Hidden Lake)	CNNT	Vegan	CNON
Kings Mountain	USNC	Violet	CNMN
Lac La Croix	CNON	VO (Cota)	CNNT
Lens	CNNT	Wisa Lake	CNON
Lit (Green Bay)	CNMN	Yaryhgul	AFGH

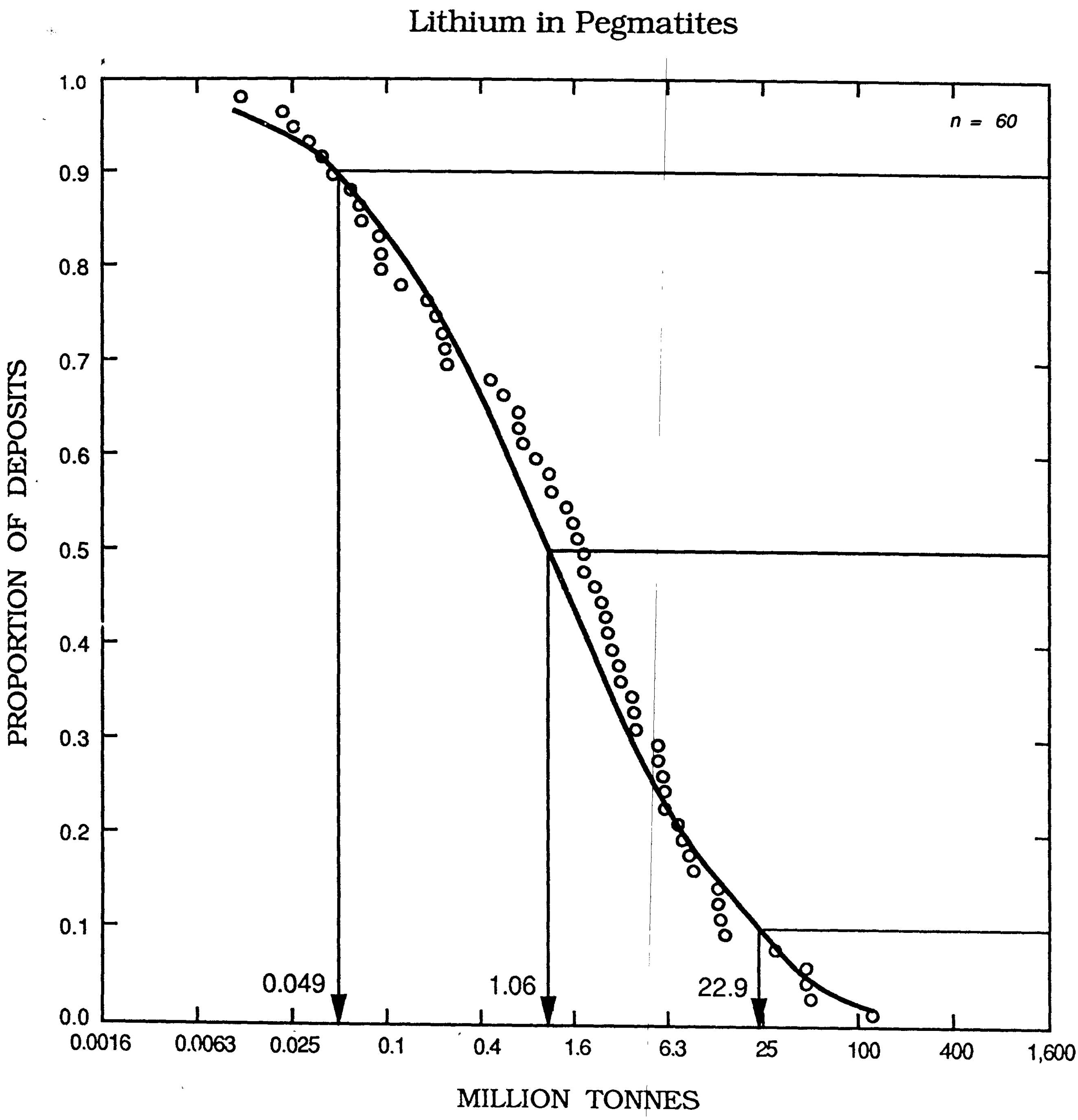

Figure 8. Tonnage model for lithium pegmatites.

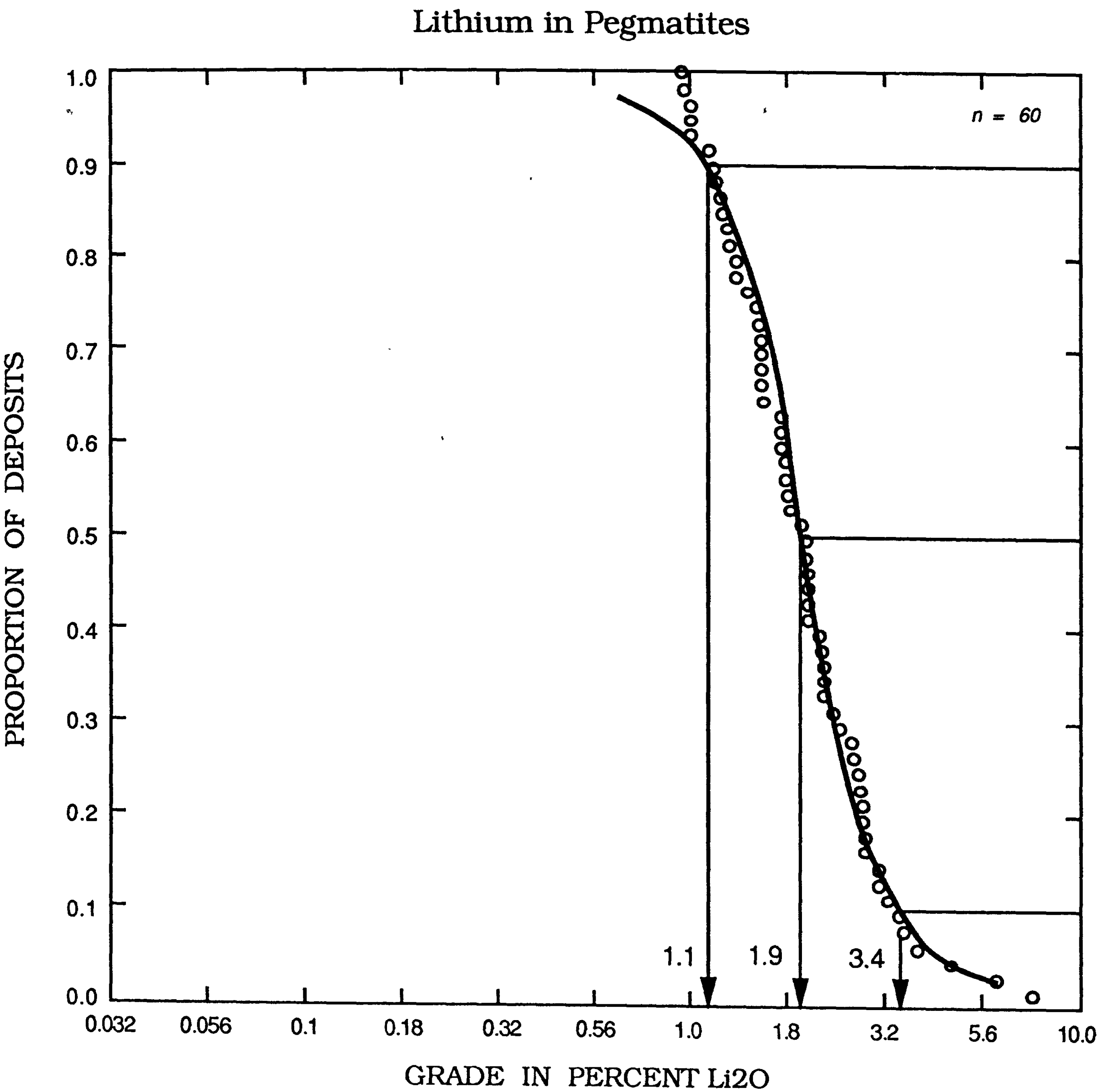

Figure 9. Grade model for lithium pegmatites.

GRADE AND TONNAGE MODEL OF FELDSPAR IN PEGMATITES

By J.D. Bliss and G.J. Orris

This model shows the contained feldspar within pegmatites. This distribution represents those pegmatites that have been worked by hand or could be worked by hand. Other commodities, commonly from other zones of the pegmatite, may also be of economic interest. See fig. 10.

DEPOSITS

Name	Country	Name	Country
Ambeau	CNOT	Foxton	CNOT
Besner	CNOT	Friction	USAZ
Big Boulder	USCO	Furlong	CNOT
Bobs Lake	CNOT	Gardner	CNOT
Botelhos	BRZL	Genesee No. 2	CNOT
Brignall	CNOT	Gleason-Campbell	CNOT
Burnham	CNOT	Gole	CNOT
C.F. McQuire	CNOT	Gunter	CNOT
Cameron	CNOT	Hickey	CNOT
Cameron & Aleck	CNOT	Holmes	CNOT
Canadian	CNOT	Hoppins	CNOT
Canadian Beryllium	CNOT	Imperial	CNOT
Card	CNOT	Jenkins	CNOT
Carey	CNOT	Keays	CNOT
Caruaru	BRZL	Keyfortmore	CNOT
Causeway	CNOT	Kirkham	CNOT
Charles	CNOT	Loughrin Township	CNOT
Christie Township	CNOT	MacDonald	CNOT
Clora May	USCO	Magnetawan	CNOT
Conger	CNOT	Mahoney & Morin	CNOT
Consolidated Feldspar	CNOT	Martin	CNOT
Craig	CNOT	Mattawa	CNOT
Crystal No. 8	USCO	McQuire & Robinson	CNOT
Cubar	CNOT	Mendels	CNOT
Devil's Hole	USCO	Mink Lake	CNOT
Dryden Township	CNOT	Morin & Neault	CNOT
Elizabeth	CNOT	Mt Pleasant	CNOT
Equador	BRZL	Muqui	BRZL
Eureka	CNOT	Nepawassi Lake	CNOT
F. Raymond	CNOT	Norrero	CNOT
Federal	CNOT	O'Brien & Fowler (Calvin Township)	CNOT
Feldspar Quarries	CNOT		
Five Mile	CNOT		

Name	Country
O'Brien & Fowler (March Township)	CNOT
O'Brien & Fowler (Mattawan Township)	CNOT
Ojaipee	CNOT
Orser	CNOT
Orser-Kraft	CNOT
Outpost	USAZ
Patterson	CNOT
Perth	CNOT
Prince & Prince	CNOT
Purdy	CNOT
Purdy Mica	CNOT
Reeves	CNOT
Reynolds	CNOT
Rock Lake	CNOT
Rosemont	USCO

Name	Country
Rowe's North Mine	USCO
Silver Queen	CNOT
T.H. Craig	CNOT
Thompson	CNOT
Tough	CNOT
Truelove	CNOT
W.B. Cameron	CNOT
W.J. Barr	CNOT
Wanup (Davis Township)	CNOT
Wanup (Dill Township)	CNOT
Watson No. 2 & 3	CNOT
Wheeling	CNOT
Wilson	CNOT
Winnipeg	CNOT
Woodcox	CNOT
Woods	CNOT

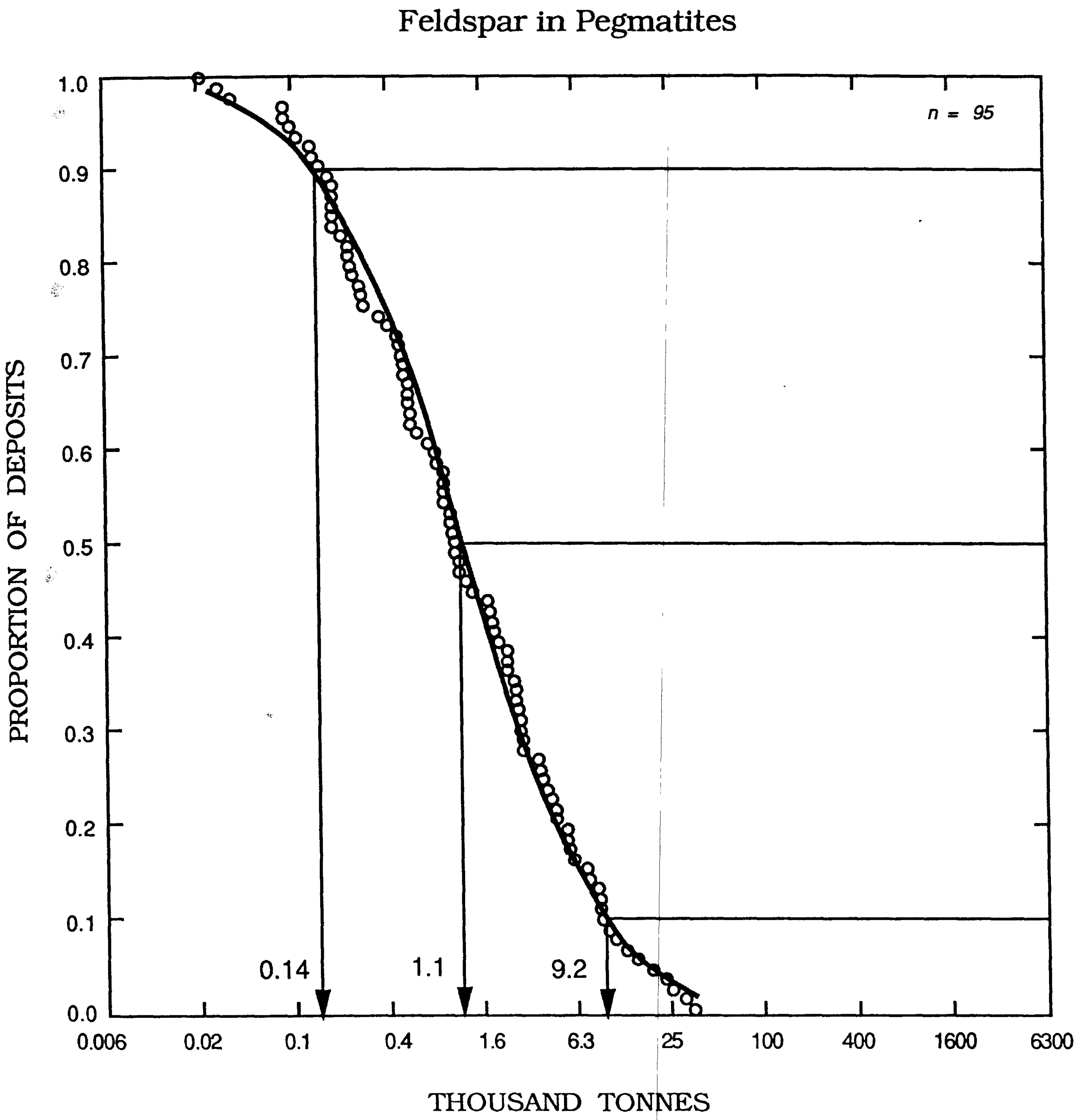

Figure 10. Contained tonnage model of feldspar in pegmatites.

GRADE AND TONNAGE MODELS OF QUARTZ VEINS

By G.J. Orris

The quartz in this model is of interest for its silica content and not for quartz crystals. The deposits consist of single veins or pegmatites or closely clustered groups of veins. There is no significant correlation between grade and tonnage in quartz veins and pegmatites. See figs. 11, 12.

DEPOSITS

Name	Country	Name	Country
Bahia Kino	MXCO	Lahey	USMT
Brown	USMT	Langsjokullen	SWDN
Corral Gulch	USMT	Leu	USMT
Diamond Cove	CNNF	Mejdasen	SWDN
El Novillo	USMX	Palmyra	USVA
Freeman Lake	USID	Petty Creek	USMT
Getberget	SWDN	Quartz Creek	USMT
Haines Point	USMT	Ranaka	BOTS
La Scie	CNNF	Veta Grande	USNV
Lac Bouchette	CNQU	West Beach	CNNB

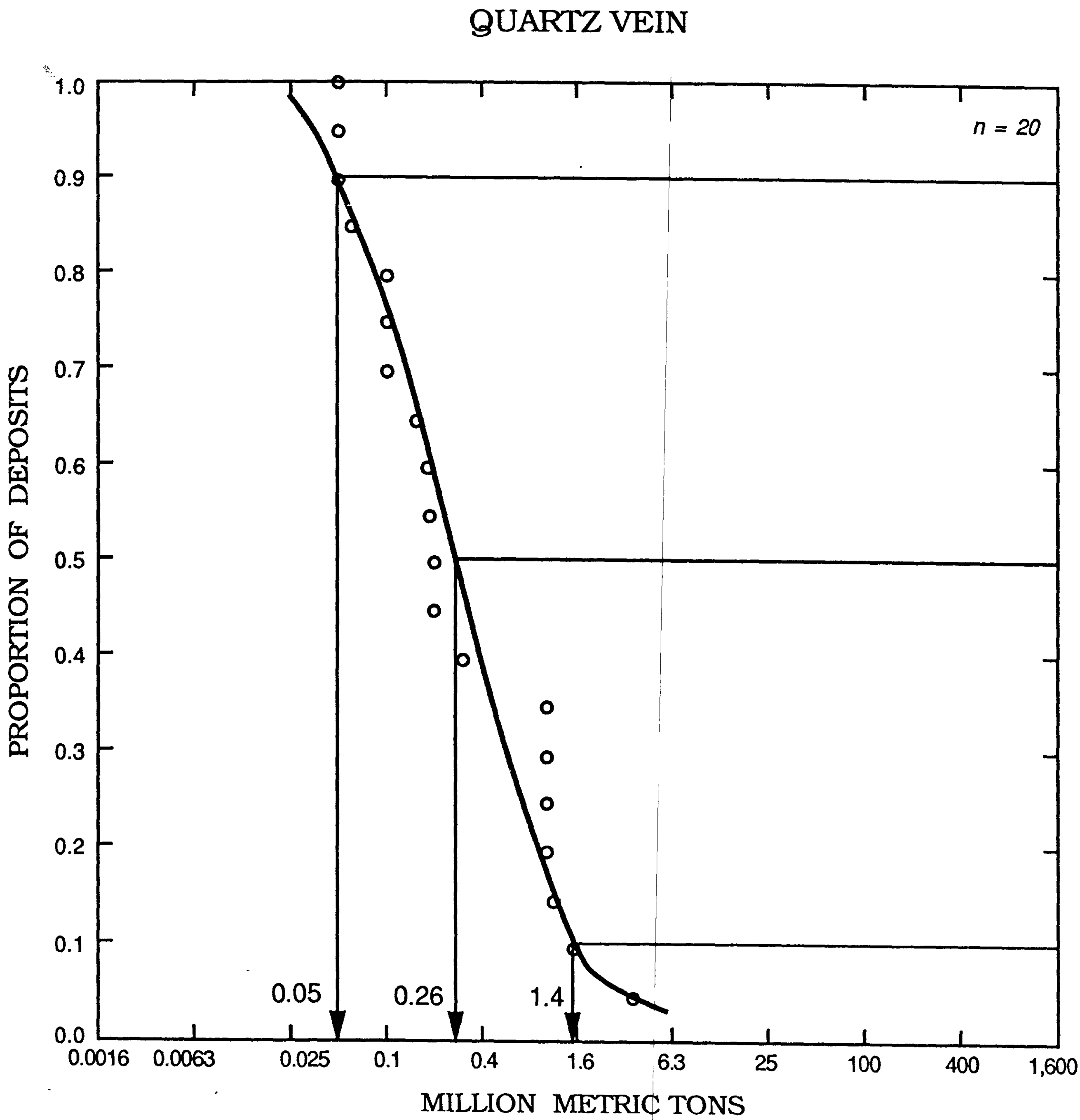

Figure 11. Tonnage model for quartz in veins and pegmatites.

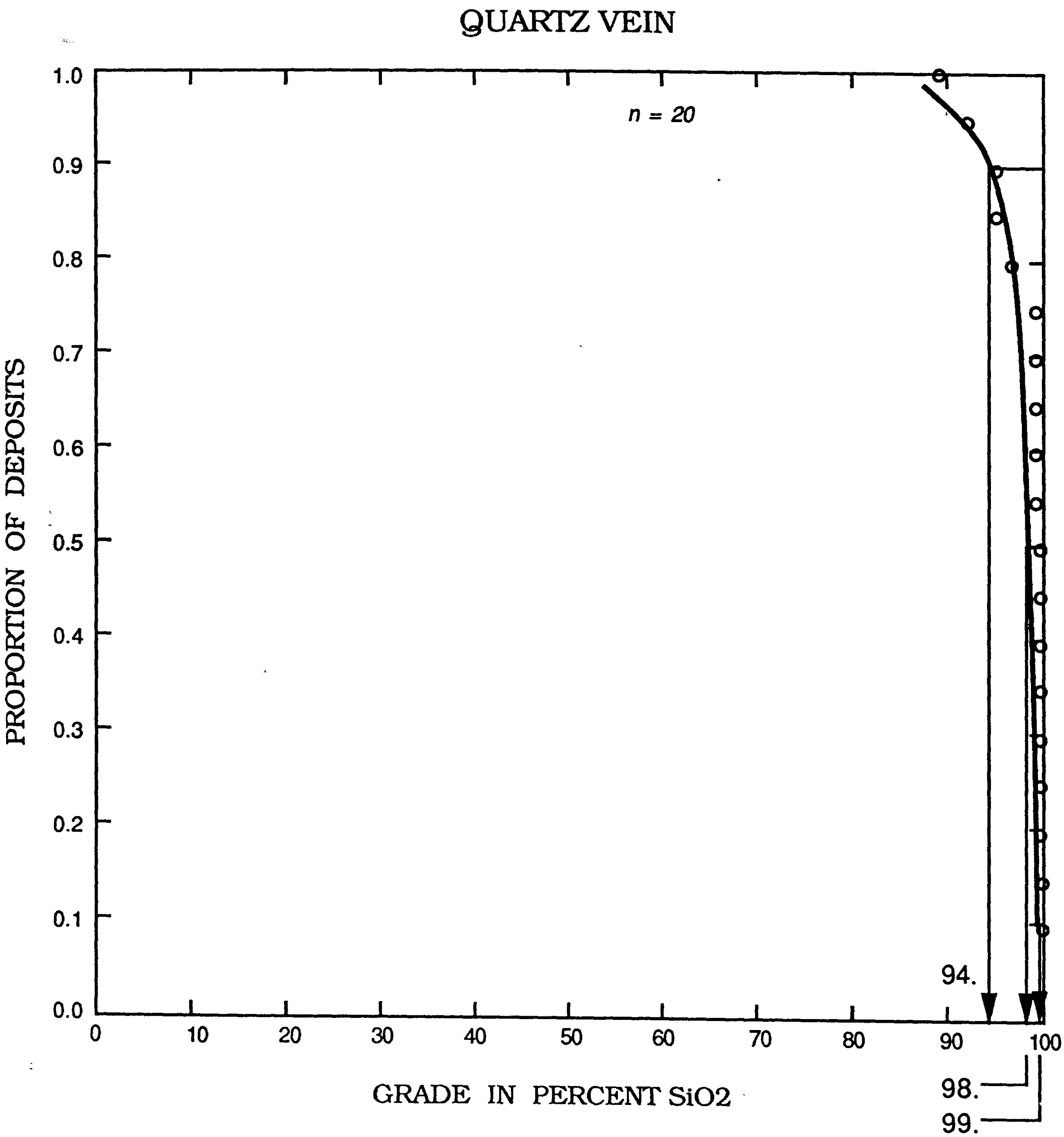

Figure 12. Grade model for quartz in veins and pegmatites.

GRADE AND TONNAGE MODEL OF WOLLASTONITE SKARNS

By G.J. Orris

There is significant correlation between grade and tonnage in this model (r = - 0.581). The grade distribution for this model is normal, not lognormal. See figs. 13, 14.

DEPOSITS

Name	Country	Name	Country
Deershead	USNY	Mineral Hill	CNBC
Deloro	CNON	Motueka	NZLD
Ethiudna	AUSA	Mouth Kopaonik	YUGO
Fox Knoll	USNY	Mt. Grove	CNON
Garies	SAFR	Nakpai	USSR
Kimmerica	GREC	Oak Hill	USNY
Lapeenranta	FNLD	Puumala	FNLD
Lewis	USNY	Sandy Bay	NZLD
Limestone Creek	AUTS	San Martin- South Body	MXCO
Lolkidongai	KNYA	Sechelt	CNBC
Marmora	CNON		

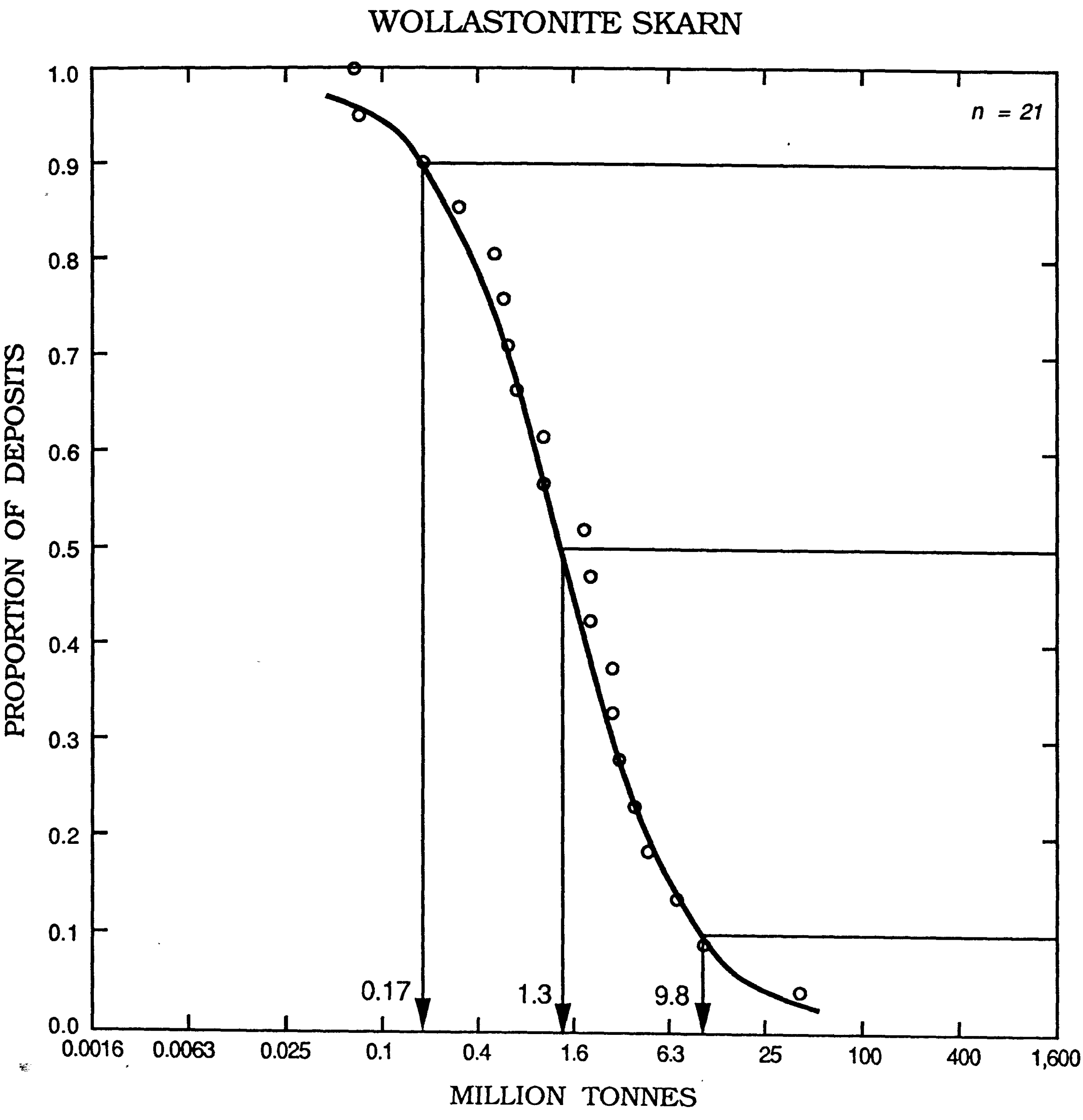

Figure 13. Tonnage model for wollastonite skarns.

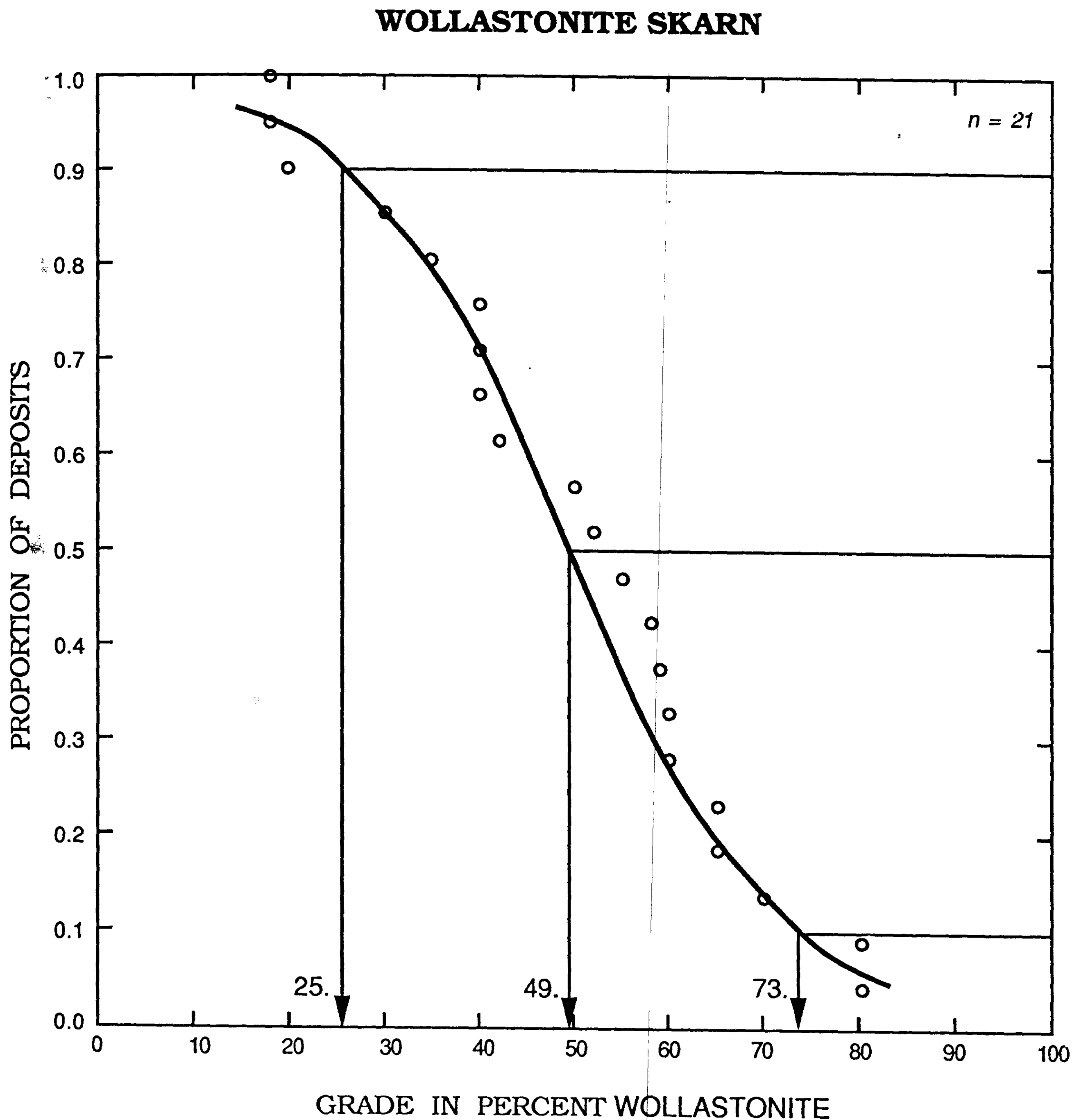

Figure 14. Grade model for wollastonite skarns.

GRADE AND TONNAGE MODEL OF AMORPHOUS GRAPHITE

By James D. Bliss and David M. Sutphin

COMMENT: Classification of deposits into amorphous and disseminated flake is not always clear and this may lead to some deposits being misclassified (also see disseminated flake graphite). Amorphous-graphite deposits have been mined using mechanized and hand methods. In the latter case, the grade and tonnage reported may be for the hand-sorted ore. This can result in higher grades and lower tonnages then if the mines were worked mechanically. The mix of mining methods probably accounts for some of the irregularities see in the distribution of data points in the model. See Sutphin and Bliss (1990) for a comparison between amorphous and disseminated flake graphite deposit types. See figs. 15, 16.

DEPOSITS

Name	Country	Name	Country
Amakaze	JAPN	Mutale	SAFR
Asahina	JAPN	Nippon	JAPN
Bukovik Mt.	YUGO	Noginskoje	USSR
Chinoya	JAPN	Ohara	JAPN
Chubang	SKOR	Paileng	TIWN
Collinsville	AUQL	Sanya-Wolmyong	SKOR
East Heilongjiang	CINA	Shirogahara	JAPN
Hanaki	JAPN	Sogung	SKOR
Hatakedani	JAPN	Takase	JAPN
Kaerim	SKOR	Takimoto	JAPN
Kanekawa	JAPN	Tonichi	MXCO
Kureyka	USSR	Trabajo y Fe	MXCO
Kurosawa	JAPN	Tsutsu	JAPN
Lourdes	MXCO	Tung Shan	CINA
Mount Bauple	AUQL	Undercliffe Mountain	AUNS
Mtubatuba	SAFR		

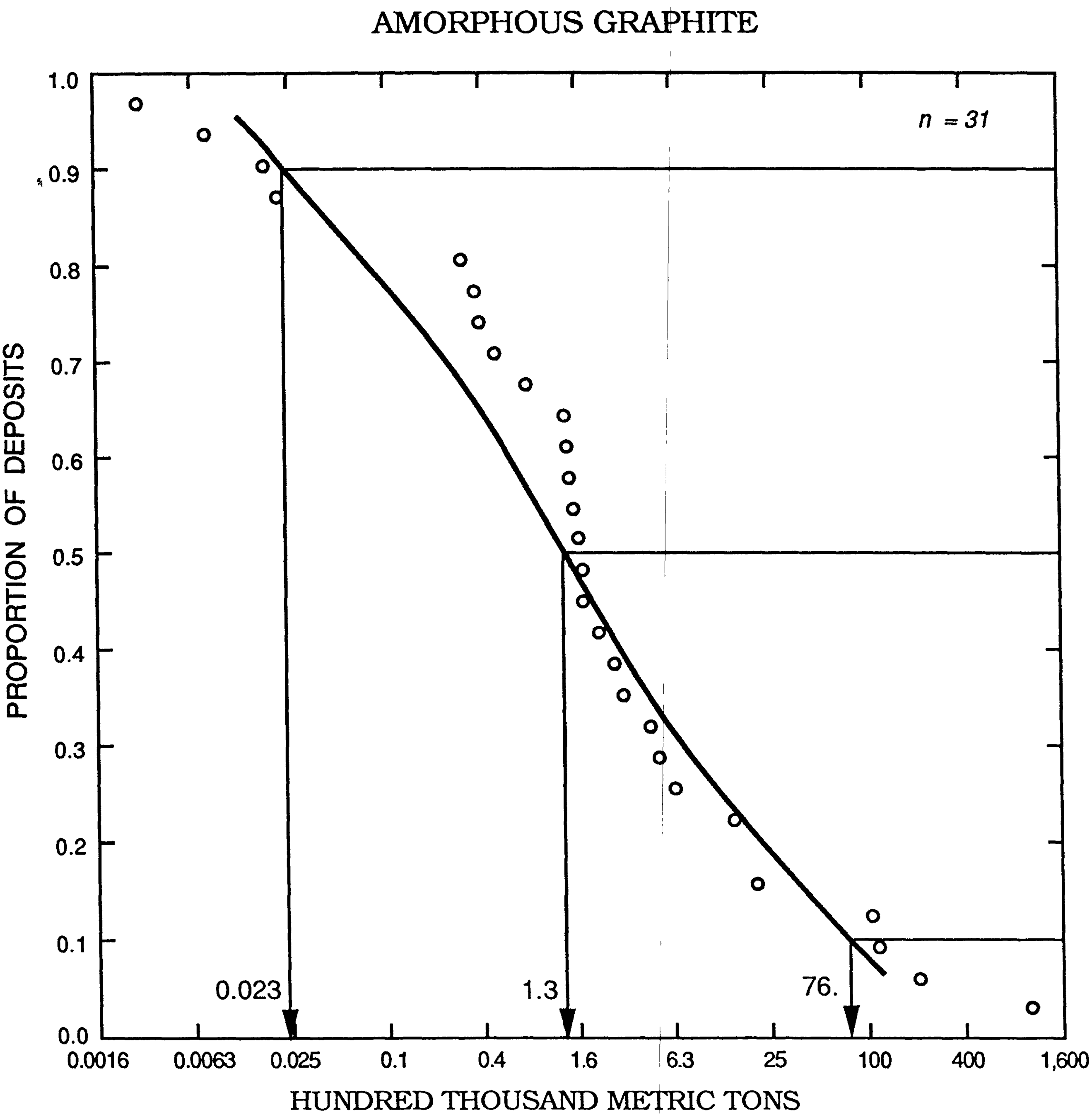

Figure 15. Tonnage model for amorphous graphite (modified from Sutphin and Bliss, 1990).

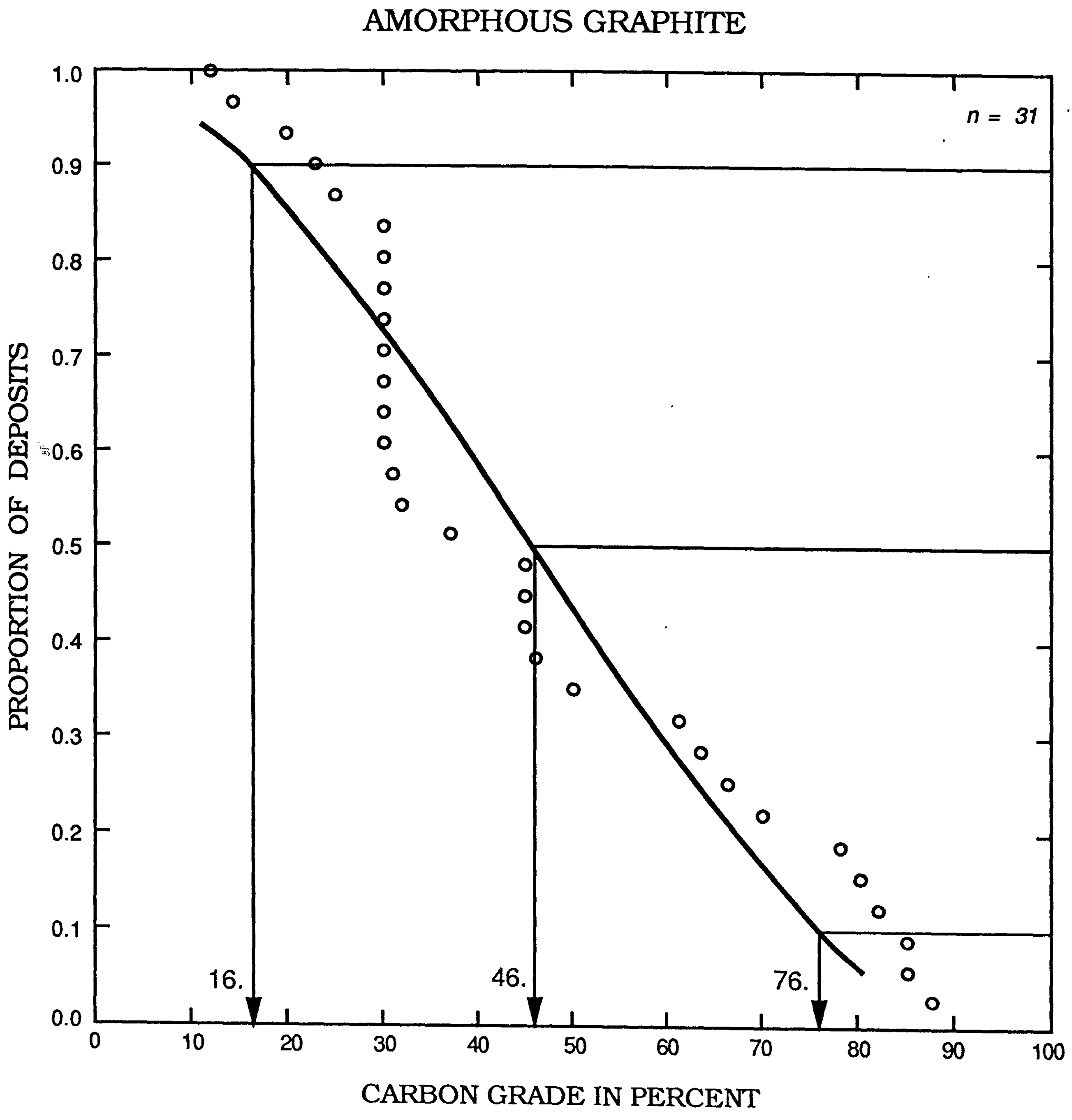

Figure 16. Grade model for amorphous graphite (modified from Sutphin and Bliss, 1990).

GRADE AND TONNAGE MODEL OF FUMAROLIC SULFUR

By Keith Long

There is no significant correlation between grade and tonnage in this model. See figs. 17, 18.

DEPOSITS

Name	Country	Name	Country
Abra de Chutinza	CILE	Leviathan	USNV
Aucanquilcha	CILE	Luz Marina	BLVA
Cerro Bayo	AGTN	Ocana	BLVA
Cerro Orero	AGTN	Ocana	CILE
Chocosuela I	CORI	Ollague - Santa Rosa	CILE
Chocosuela II	CORI	Piedra Parada	CILE
Coquimbo	CILE	Polan	CILE
Crater Group	USCA	Purace	CLBA
Dos Conos	AGTN	Rio Grande	AGTN
El Desierto	BLVA	Rosario	CILE
El Portal - Cabana	BLVA	Rosario del Rey	BLVA
El Tatio Este	CILE	Saciel	CILE
Golovnin	USSR	Salar de Azufrera	CILE
Gongora	CORI	San Pablo de Napa	BLVA
Hilda Mary	AGTN	Sillayhuay	BLVA
Huallatire	CILE	Sillillica	CILE
Irruputuncu	CILE	Tacora	CILE
Ishizu	JAPN	Tahapaca	CILE
Juan de la Vega	CILE	Takinosawa	JAPN
Julia	AGTN	Tocarauri	CILE
Kengtzeping	TIWN	Volcan Overo	AGTN
La Fortuna	CORI	Volcan Viejo	CORI

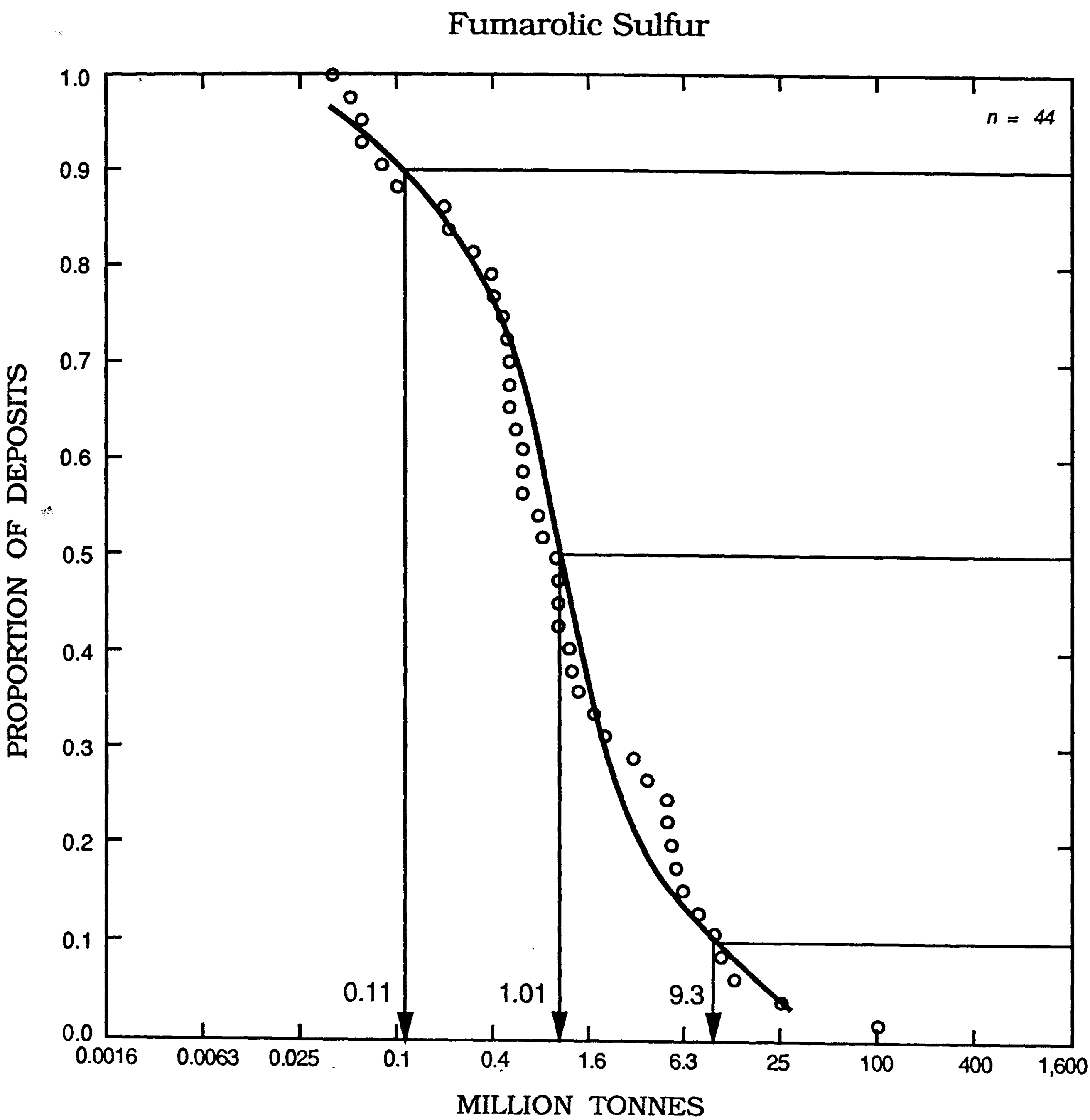

Figure 17. Tonnage model for fumarolic sulfur.

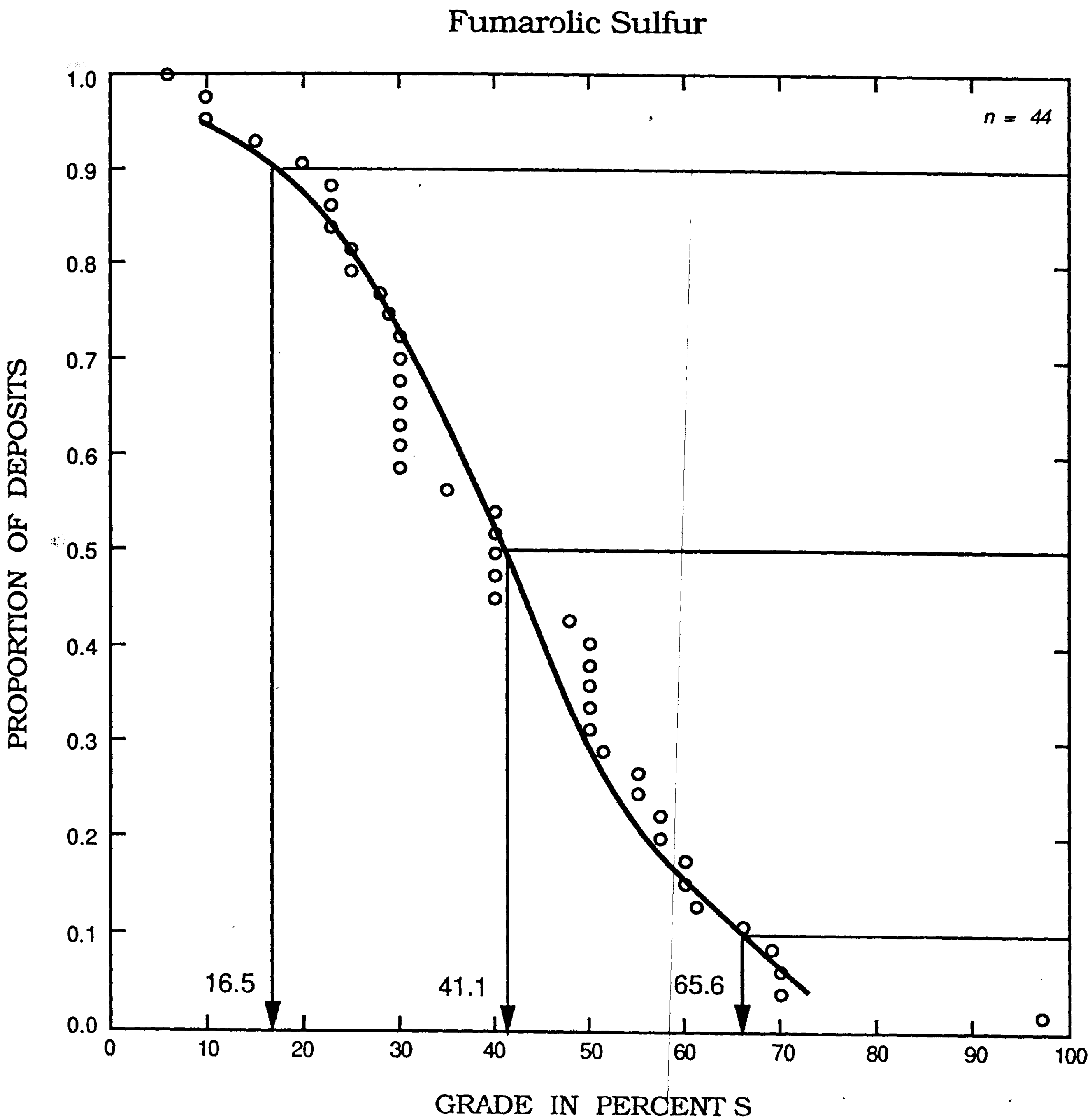

Figure 18. Grade model for fumarolic sulfur.

GRADE AND TONNAGE MODEL OF FLUORITE VEINS

By G.J. Orris

This model does not include deposits with a significant barite component. There is no significant correlation between grade and tonnage in this model. See figs. 19, 20.

DEPOSITS

Name	Country	Name	Country
Achèmeche	MRCO	Jebel Tirremi	MRCO
Argentelle	FRNC	Le Barlet	FRNC
Baton-Whangapeka	NZLD	Longstone Edge-Sallet Hole	UKEN
Buffalo	SAFR	Macossa	MZMB
Canxixe	MZMB	Muscadroxiu-Genna Tres Montis	ITLY
Chioco-Djanguire	MZMB	Okorusu-Marburg	NAMB
Director Mine	CNNF	Osor	SPAN
El Hamman	MRCO	Pakozd	HUNG
Escarro	FRNC	Sierra du Lújar	SPAN
Fission (Richardson)	CNON	White Eagle	USNM
Great Eagle	USNM	Zwartkloof	SAFR
Hlabisa	SAFR		
Huckleberry Mine	USNM		
Jebel Semeih	SUDN		

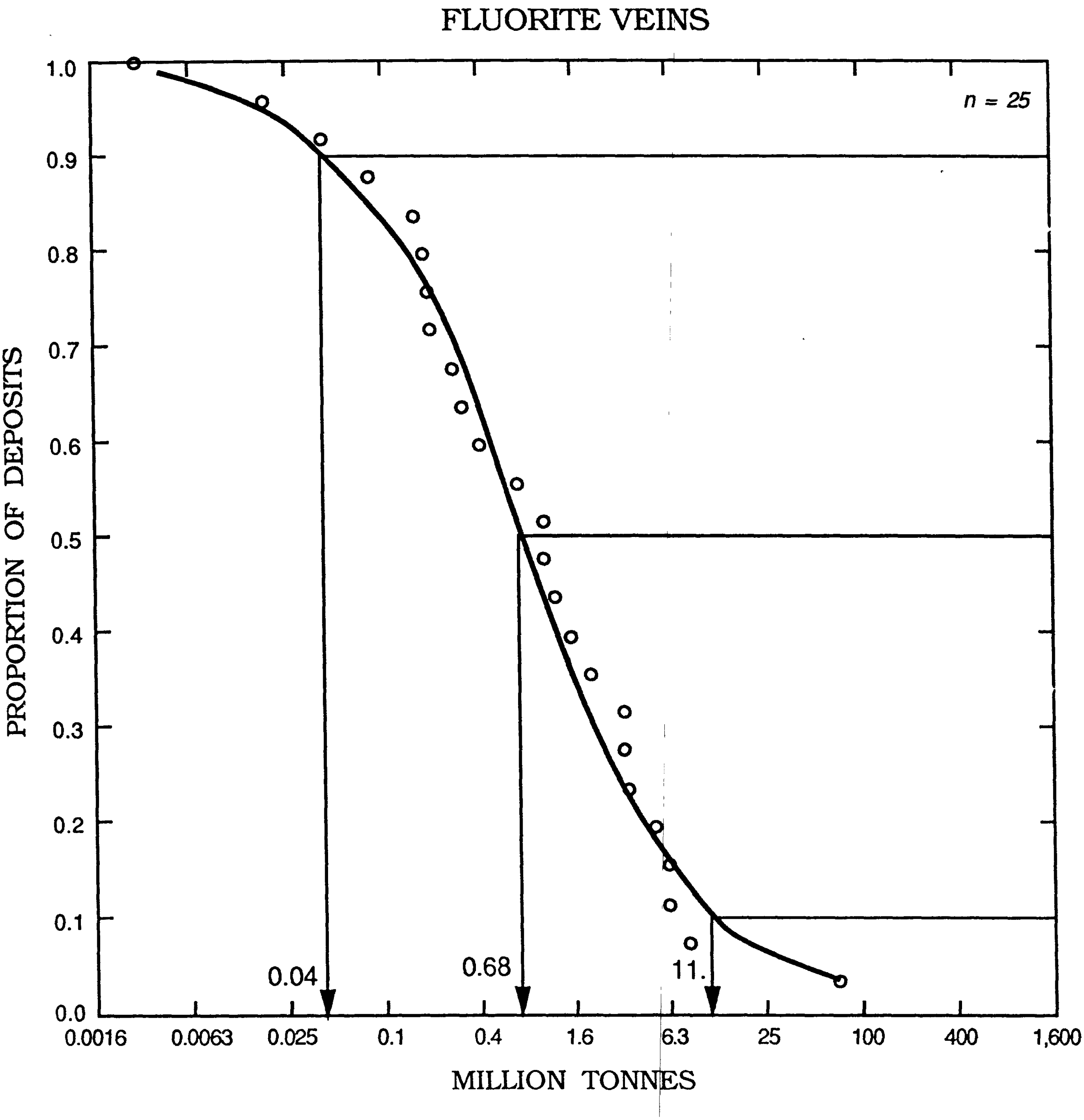

Figure 19. Tonnage model for fluorite veins.

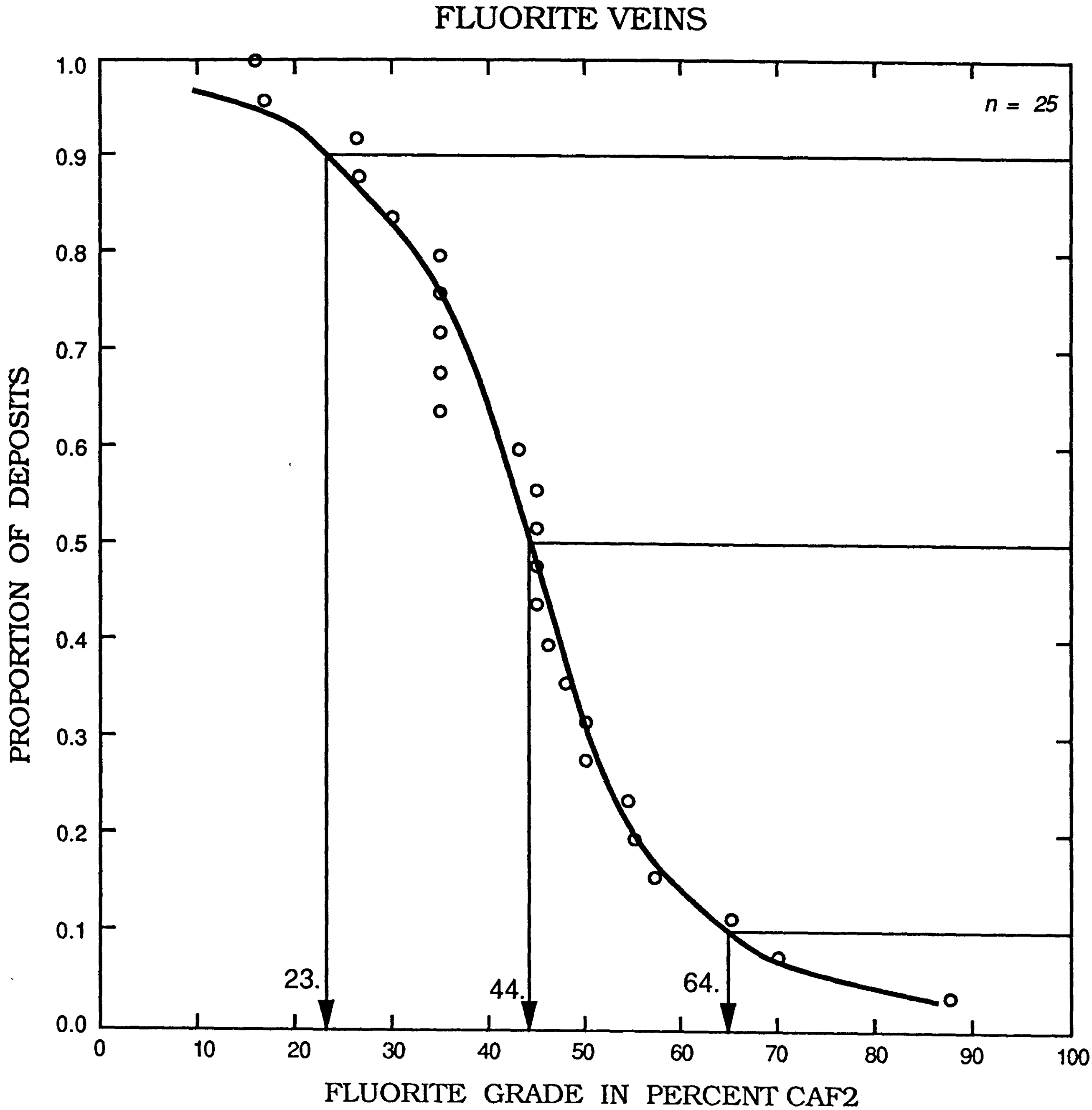

Figure 20. Grade model for fluorite veins.

GRADE AND TONNAGE MODEL OF BARITE VEINS

By G.J. Orris

There is no significant correlation between grade and tonnage in this model. The grade distribution for this model reflects extreme economic bias towards high grade deposits. See figs. 21, 22.

DEPOSITS

Name	Country	Name	Country
Asht Mostec	MXCO	Madam Howard Plain	AUTS
Affensou	ALGR	Madsen Mine	USWA
Barite Mountain	CNYT	Mata	MRCO
Bear Mine	USNV	McKeller	CNON
Beulah	AUTS	Montega (Mont 'Ega)	ITLY
Boguszow	PLND	Mouzai les Minesa	ALGR
Cliefden Springs	AUNS	Noarlunga	AUSA
Cobargo	AUNS	Oraparinna	AUSA
Collier Cove	CNNF	Palestro Narrows	ALGR
Cranbrook	AUWA	Pernathy Lagoon	AUSA
Darreh	IRAN	Porres	FRNC
Dorchester	CNNB	Premier Langmuir	CNON
Gouraya	ALGR	Sangilyn	AFGH
Hamiz Dam	ALGR	St. Fabien (Roy-Ross)	CNQU
Ibitiara	BRZL	Tarhwacht Mine	MRCO
Inverway	AUNT	Taza (Tarza)	MRCO
Jebel Ighoud	MRCO	Wildcat	USNV
Keddara/Palestro	ALGR	Zelmou	MRCO
Lacan	FRNC	Zouggara	ALGR
Les Porres	FRNC		

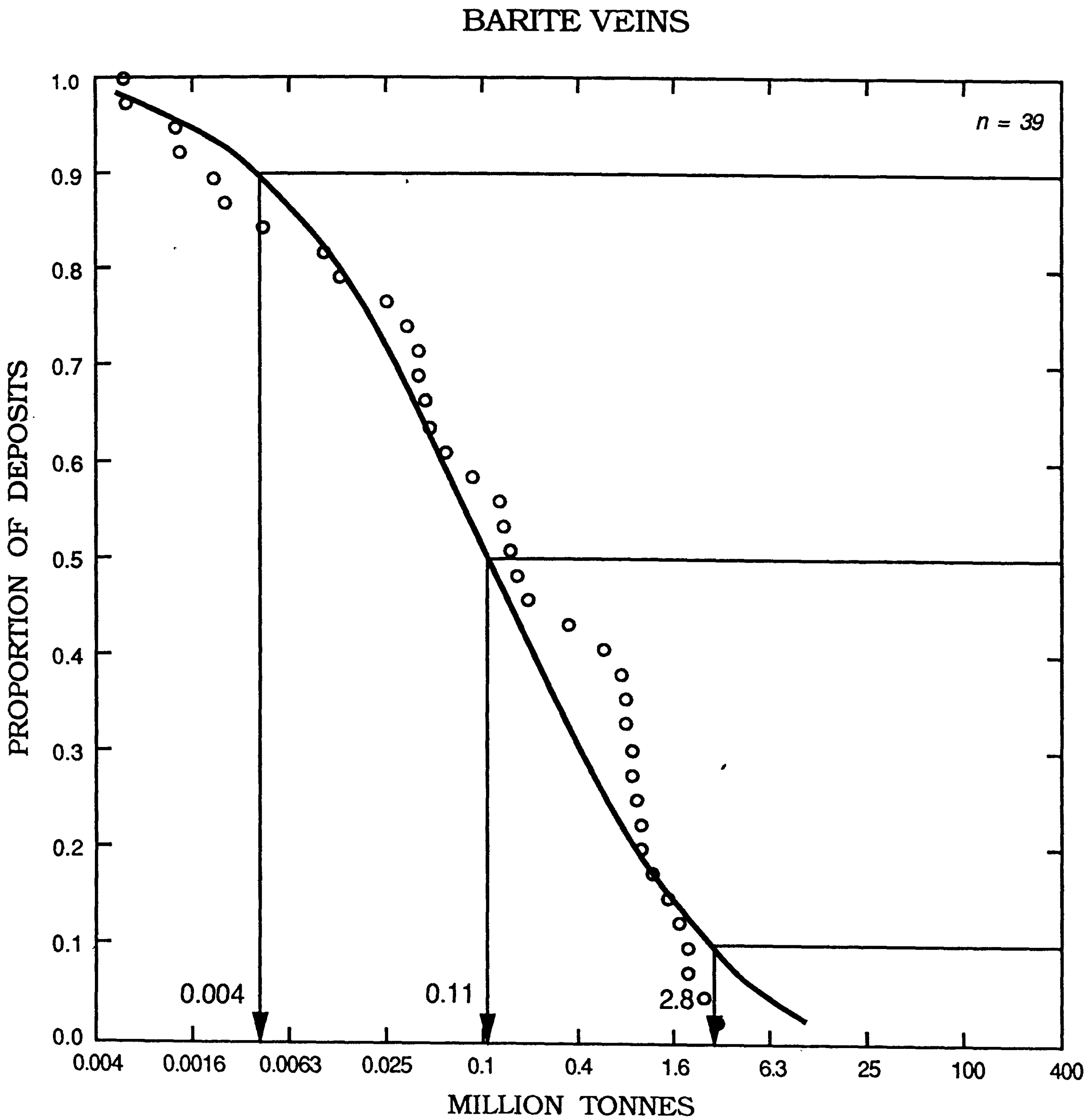

Figure 21. Tonnage model for barite veins.

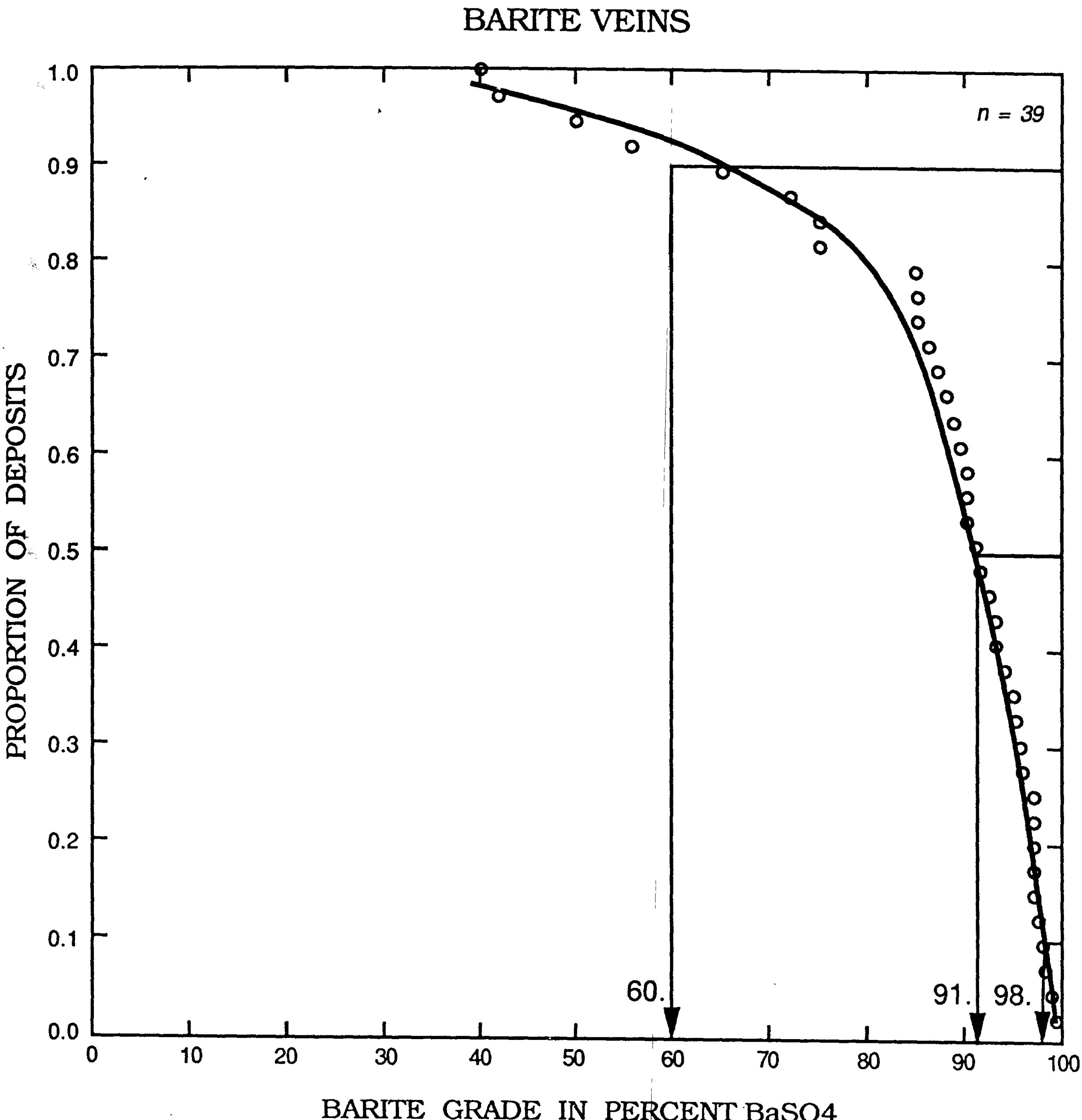

Figure 22. Grade model for barite veins.

GRADE AND TONNAGE MODEL OF SANDSTONE/QUARTZITE SILICA

By G.J. Orris

There is no significant correlation between grade and tonnage in this model. Iron oxide and alumina contents may restrict the usage of the silica derived from these deposits. See figs. 23, 24, 25, 26.

DEPOSITS

Name	Country
Aorere	NZLD
Burchill Road	CNNB
Chashma-i-Shafa	AFGH
Chegoggin Quartzite	CNNS
Chesnaye Lake	CNQU
Delmas	SAFR
Dicks Point	CNNF
Ditsotswane Hill	BOTS
Dunville	CNNF
Fortune	CNNF
Grey River - Gulch Cove	CNNF
Hajigak	AFGH
Hastings	AFGH
Jabal Burmah	SAAR
Joyceville	CNON
Kati-Takalyar	AFGH
Landslip Hill	NZLD
Leeds Metals	CNQU
Leven	AUTS
Lobatse	BOTS
Nantucket Island	CNNB
Paddle	CNON
Petit Lac Malbaie	CNQU
Plumbago Creek	USWY
Reefton	NZLD
St. Vianney	CNQU
Unidentified Quartzite Deposit	CNLA
White Head Island	CNNB

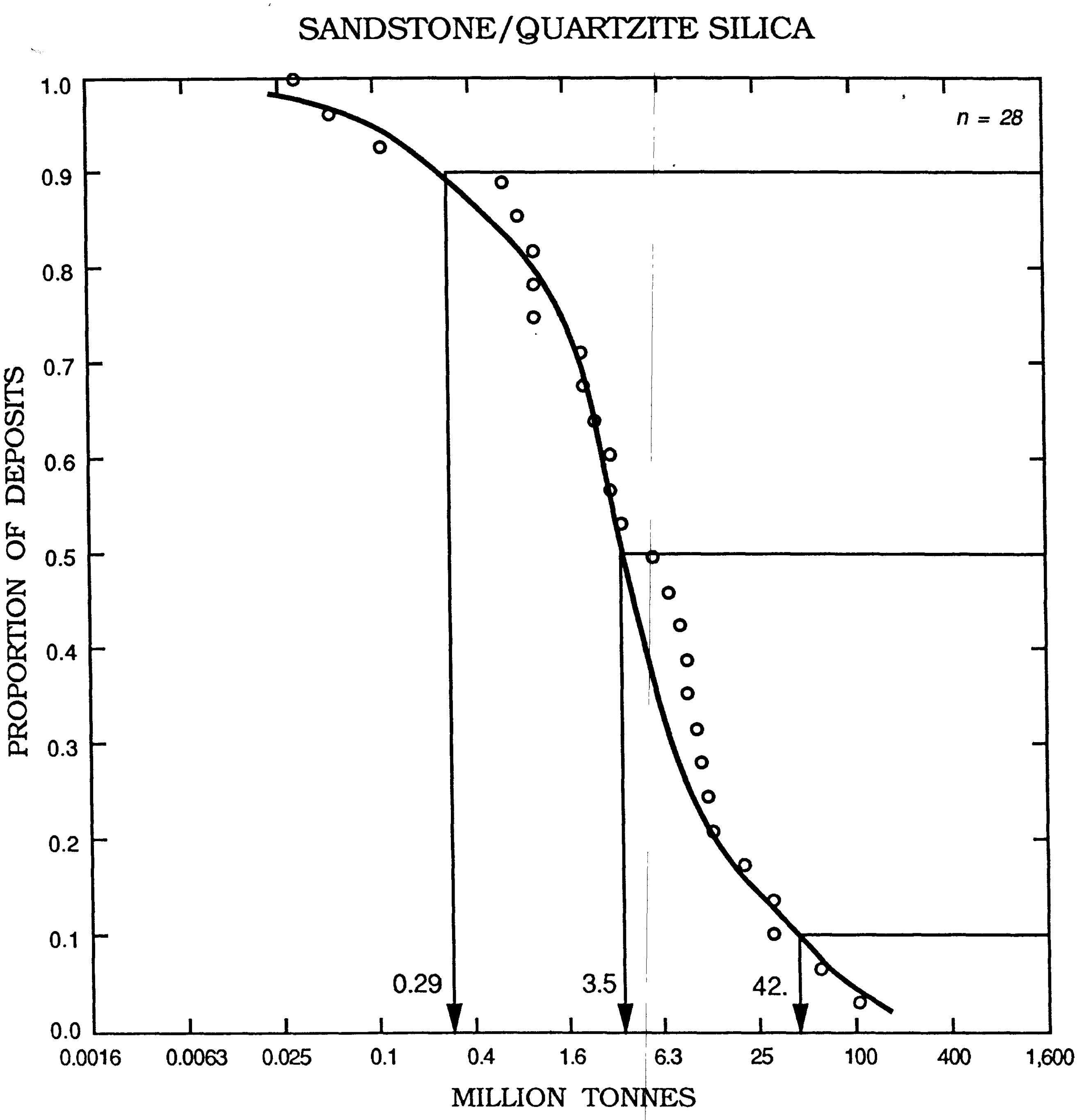

Figure 23. Tonnage model for sandstone/quartzite silica.

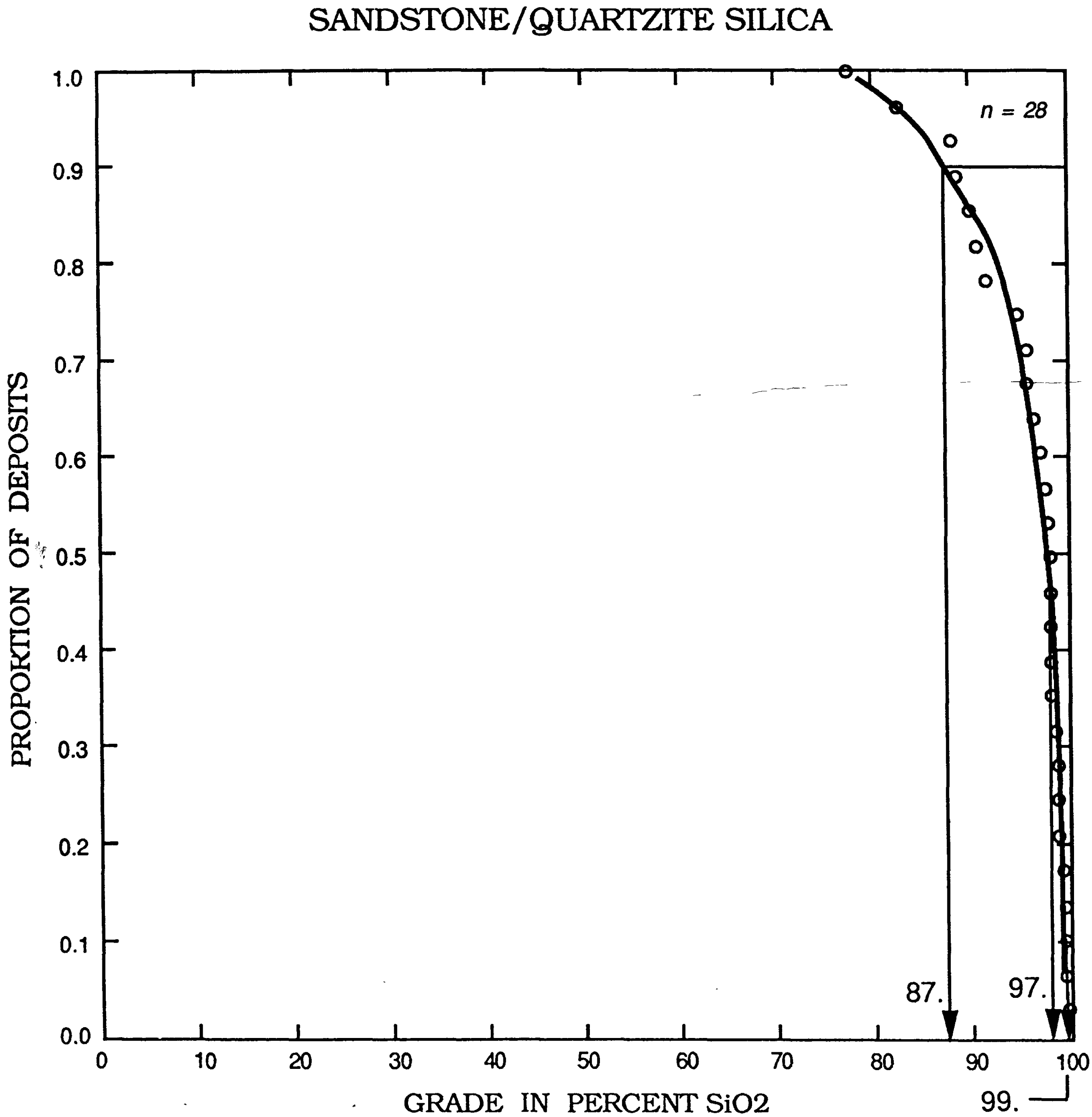

Figure 24. Grade model for sandstone/quartzite silica.

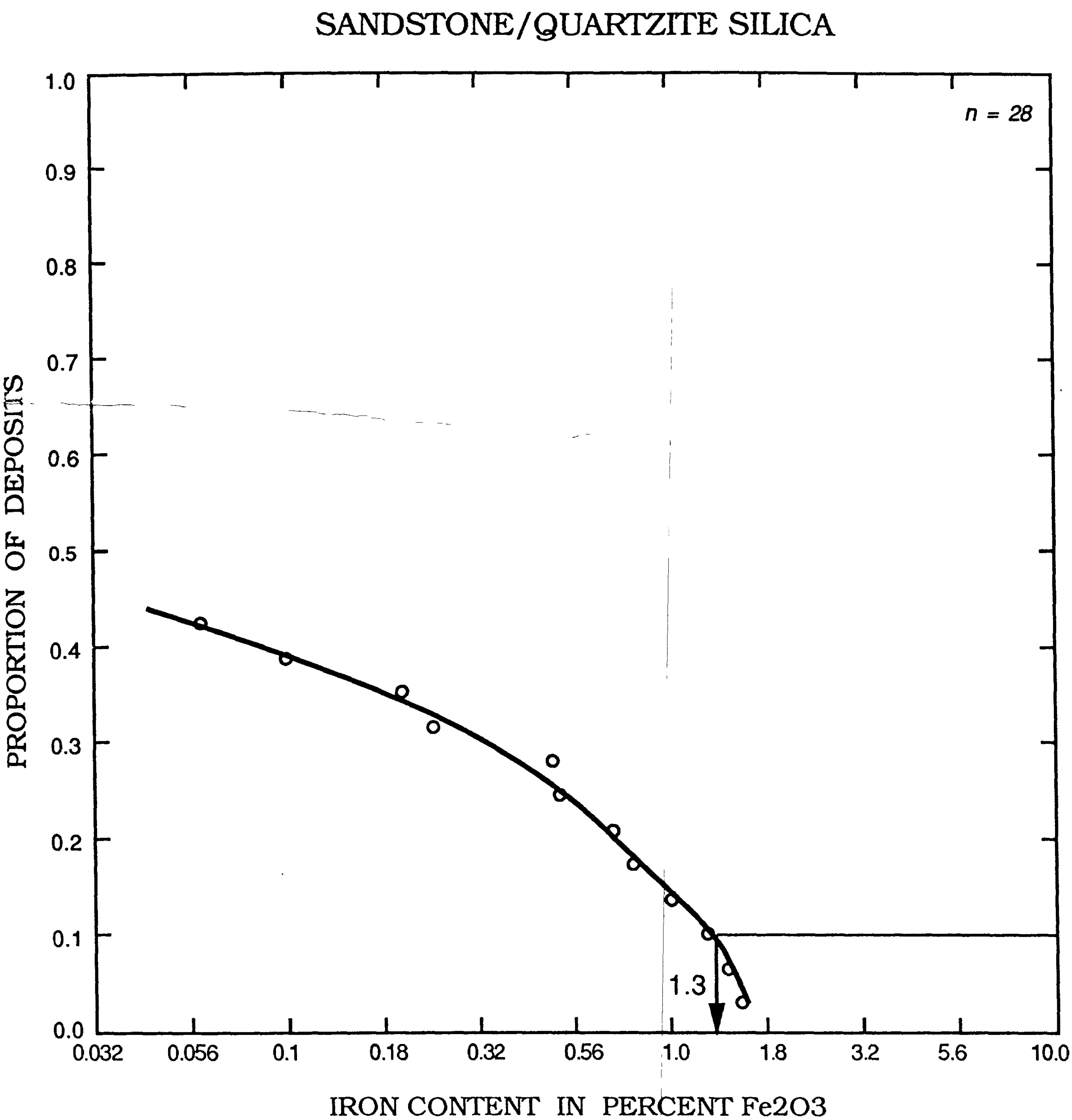

Figure 25. Iron model for sandstone/quartzite silica.

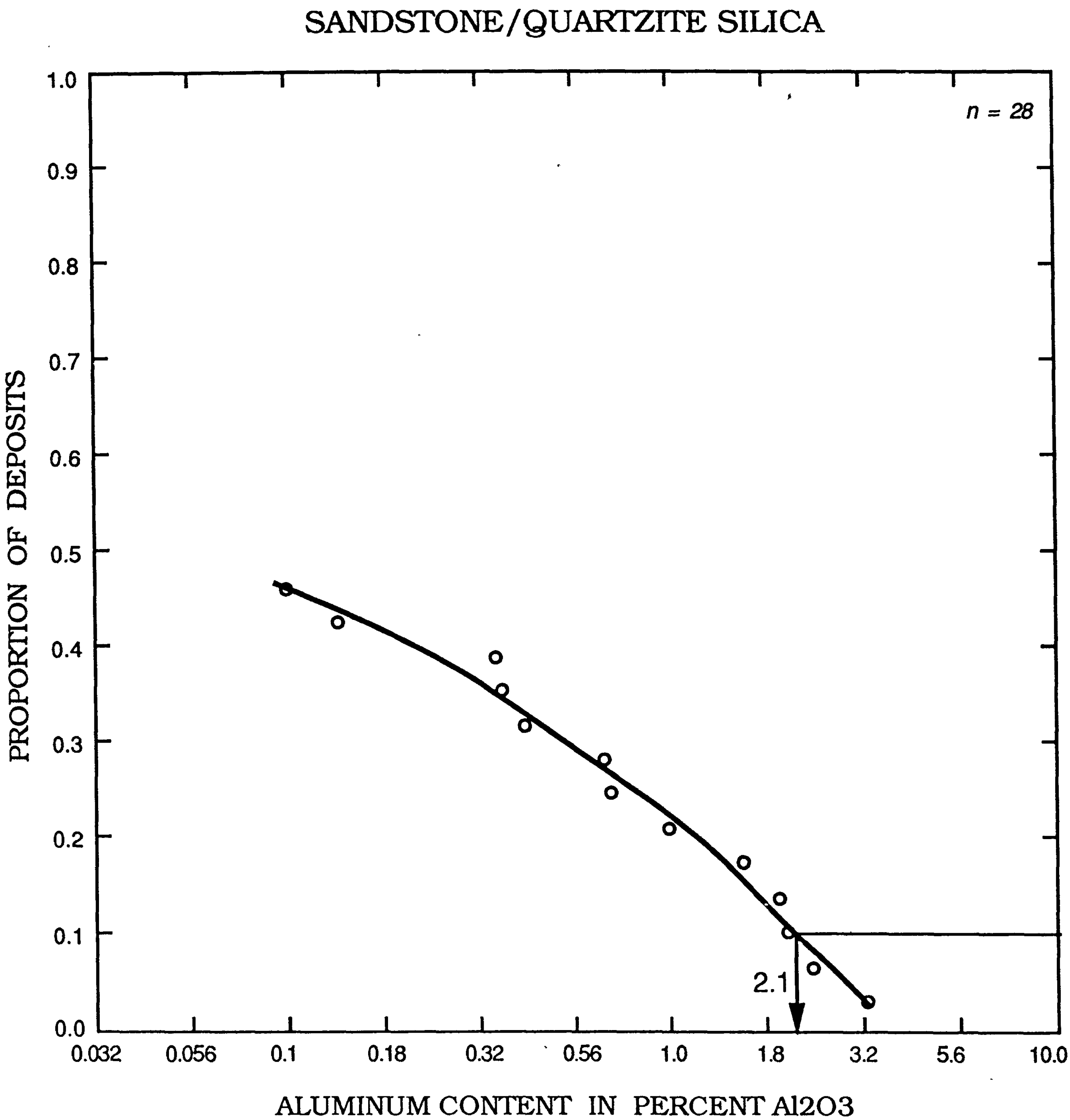

Figure 26. Alumina model for sandstone/quartzite silica.

GRADE AND TONNAGE MODEL OF BEDDED BARITE

By G.J. Orris

There is no significant correlation between grade and tonnage in this model. This model is an updated version of a previously published model (Orris, 1986b). See figs. 27, 28.

DEPOSITS

Name	Country	Name	Country
Balleynoe (Silvermines)	IRLD	Homestake	CNBC
Ban Thimontha	THLD	Kempfield	AUNS
Barite (Moose)	CNYT	Khuzdar	PKTN
Barite Mountain	CNYT	La Minita	MXCO
Barite Valley	SWAZ	Magnet Cove	USAR
Baw Hin Khao	THLD	Mangampeta North	INDA
Big Stubby	AUWA	Mangampeta South	INDA
Brookfield	CNNS	Mazatan	MXCO
Camamu Bay	BRZL	Meggen	GRMY
Castle Island	USAK	Mel	CNYT
Cathy (Walt)	CNYT	Mountain Springs	USNV
Changdo	NKOR	Nimiuktuk	USAK
Cirque	CNBC	Phu Mai Tong	THLD
Cobachi	MXCO	Rammelsberg	GRMY
Democrat	USCA	Rein	CNYT
Dodge	ZIMB	Savercool	USCA
El Portal	USCA	Schoonaard	SAFR
Farenjal	AFGH	Snake Mountain	USNV
Foss-Ben Eagach	UKSL	Tea	CNYT
Greystone	USNV	Uribe	USWA
Gurrunda	AUNS	Walton	CNNS
		Weekaroo	AUSA

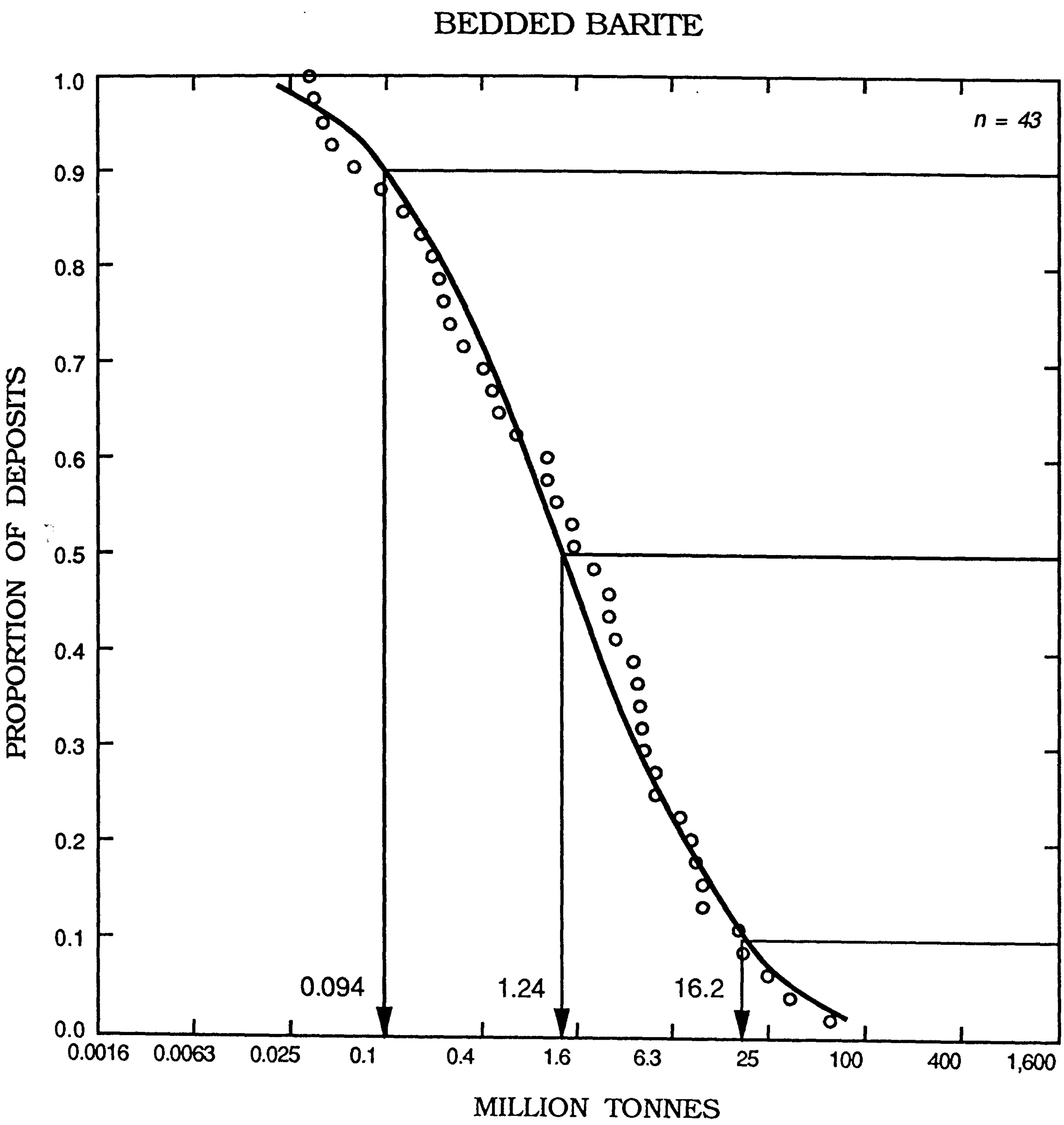

Figure 27. Tonnage model for bedded barite.

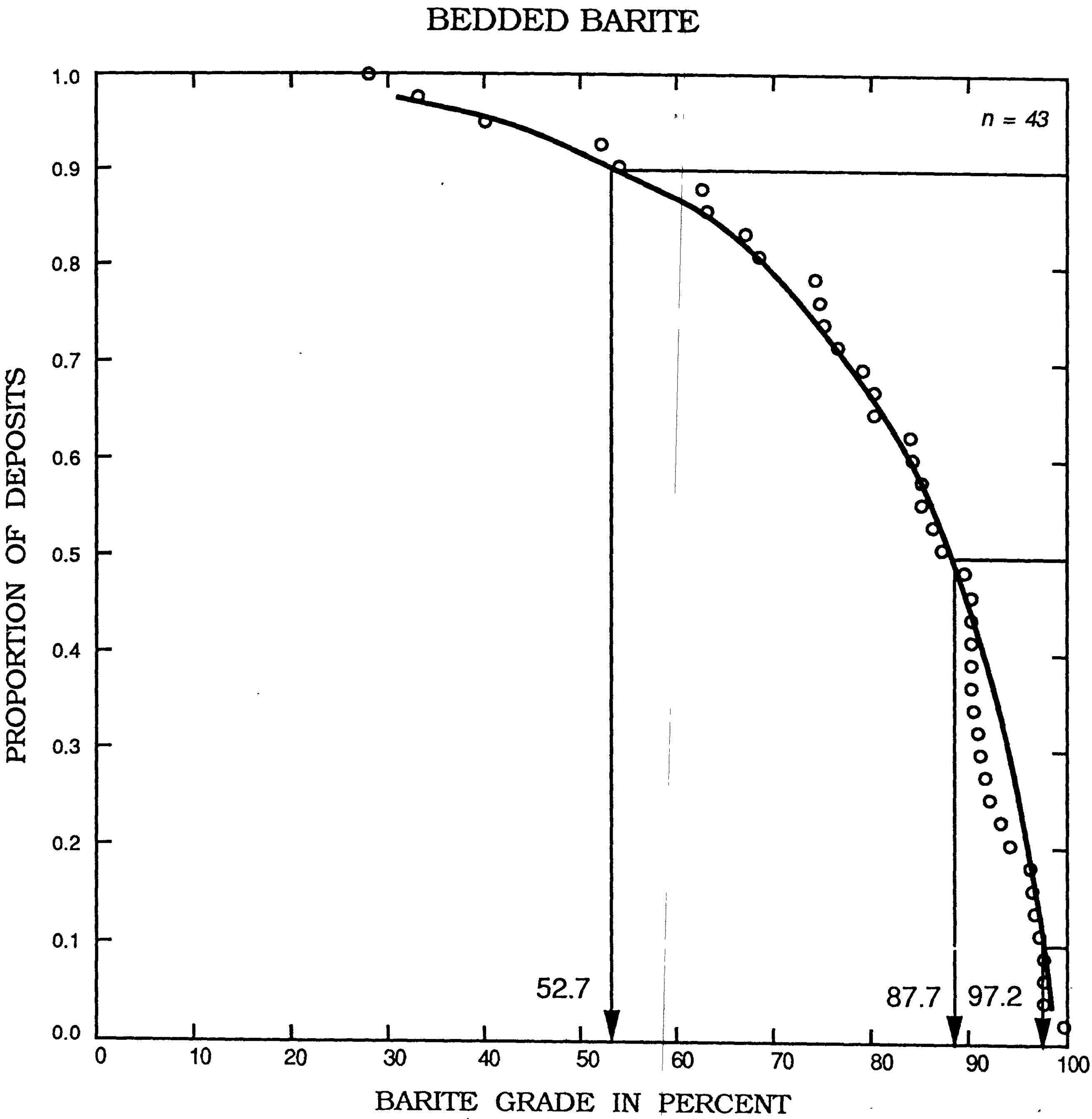

Figure 28. Grade model for bedded barite.

PRELIMINARY CONTAINED MATERIAL MODEL OF SEDIMENTARY KAOLIN

By G.J. Orris

Grade information was insufficient for a grade model. This model is for contained kaolin. See fig. 29.

DEPOSITS

Name	Country	Name	Country
Bovill	USID	Onakawana Lignite Area	CNON
Boralesgamuwa	SRIL	Ploemeur-D'Arvor	FRNC
Bratunac	YUGO	Ploemeur-Morbihan	FRNC
Escalera	VENE	Pugu Hills	TNZN
Etsubora	JAPN	Rio Capim	BRZL
Iwate HIne	JAPN	Stanford Clay Deposit	USID
Jari	BRZL	Wadi Sallah	SAAR
Kalabsha	EGPT	Wankie	ZIMB
Khushaym Radi	SAAR	Wilkinson Kaolin	USGA
Maoming	CINA	Xuzhou	CINA
Meudon	FRNC		

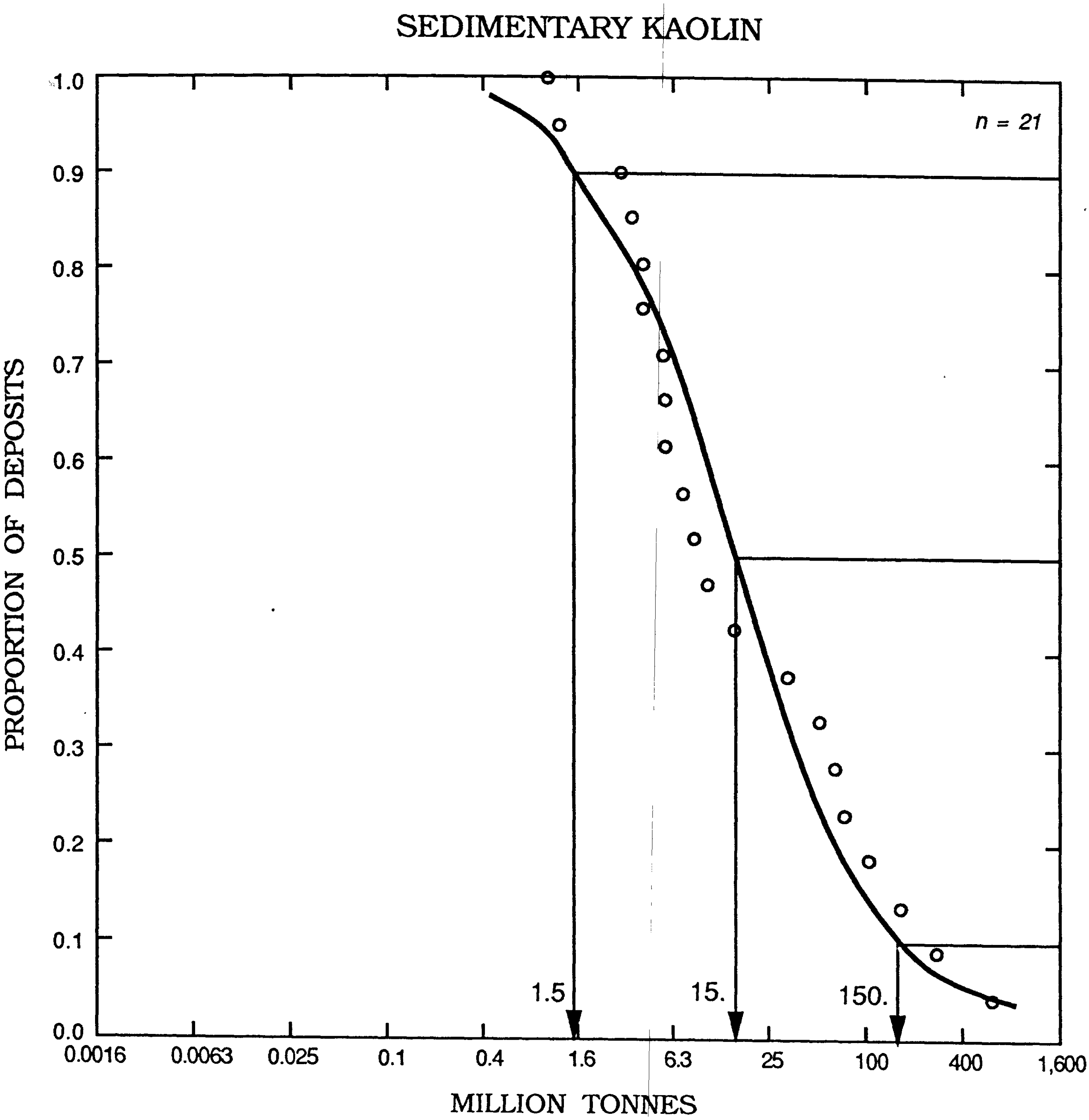

Figure 29. Contained kaolin model for sedimentary kaolin deposits.

PRELIMINARY CONTAINED MATERIAL MODEL OF LIMESTONE

By G.J. Orris

This is a contained material model and no distinction is made as to the type of end usage. Insufficient grade and chemical data were available for further modeling. See fig. 30.

DEPOSITS

Name	Country	Name	Country
Amador Camacho	MXCO	Nkalagu	NIGR
Bamyon-I	AFGH	Onigbolo	BENN
Blue Rocks	AUNS	Pilkington	AUQU
Borenore	AUNS	Rosebrook	AUNS
Cabano	CNQU	San Pedro	MXCO
Cal-White	USCA	Santa Ana	MXCO
Ewekoro	NIGR	Sormony	CNNB
Glencoe	CNNS	Tin Hrassan	UVOL
Kingsdale	AUNS	Umm al Ghirban	SAAR
Lower Cove Bay	CNNF	Wazo Hill	TNZN
Mount Frome	AUNS	White Hope	USCA
Mountain Springs	USCA	Yacuses	BLVA

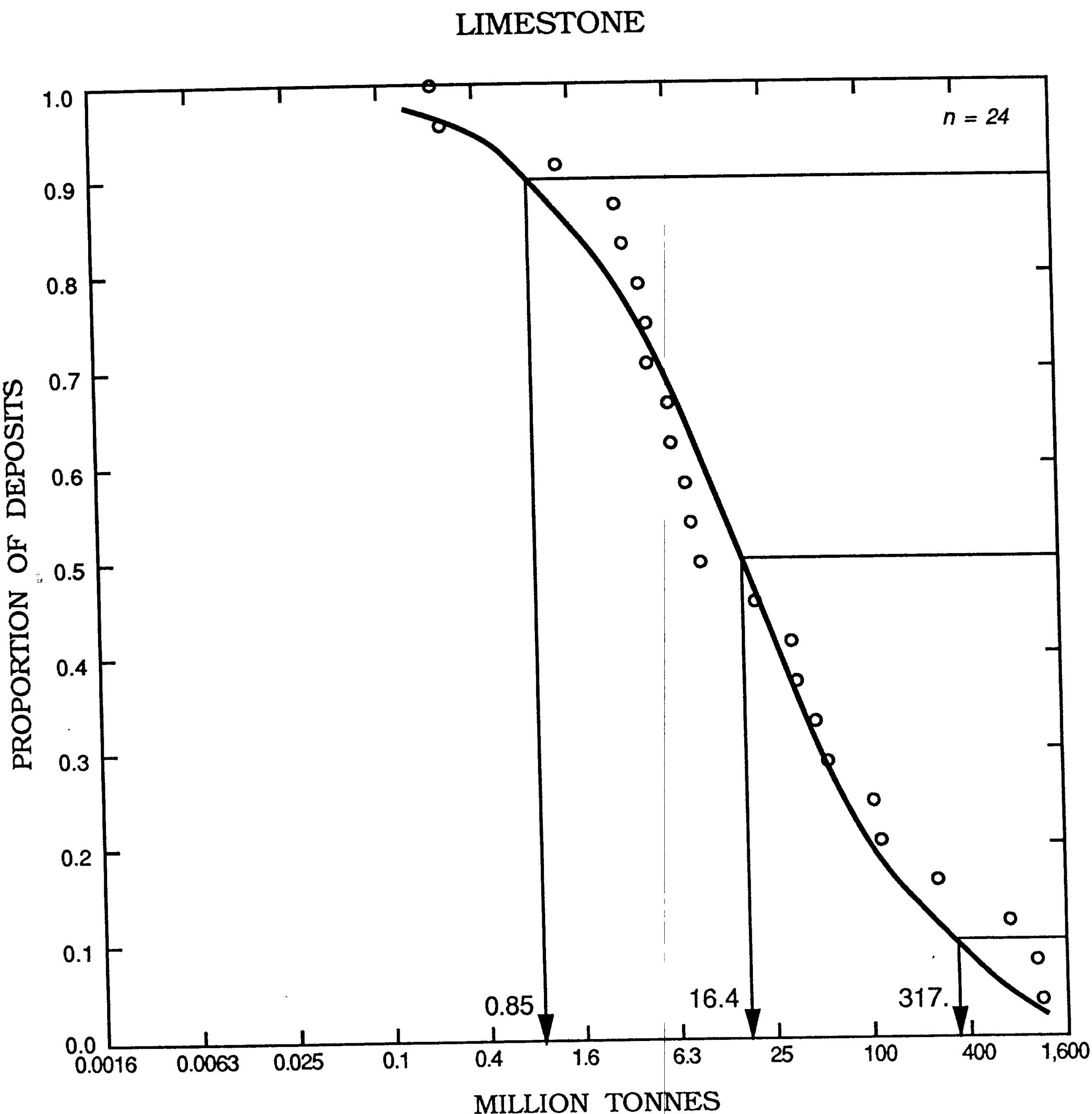

Figure 30. Contained material model for limestone.

PRELIMINARY GRADE AND TONNAGE MODEL OF BEDDED CELESTITE

By G.J. Orris

There is no significant correlation between grade and tonnage in this model. See figs. 31, 32.

DEPOSITS

Name	Country	Name	Country
Black Butte	USAZ	Nuevo Leon	MXCO
Kaiser (Loch Lomond, Enon)	CNNS	Quesseir	EGPT
Kunduz (Qonduz)	AFGH	San Agustin	MXCO
Montevive	SPAN	Tangi-Murch	AFGH
Montezuma Claims	USAZ	Unnamed	QATR
Nakhjir-Dashte Kavir (Molkabad)	IRAN		

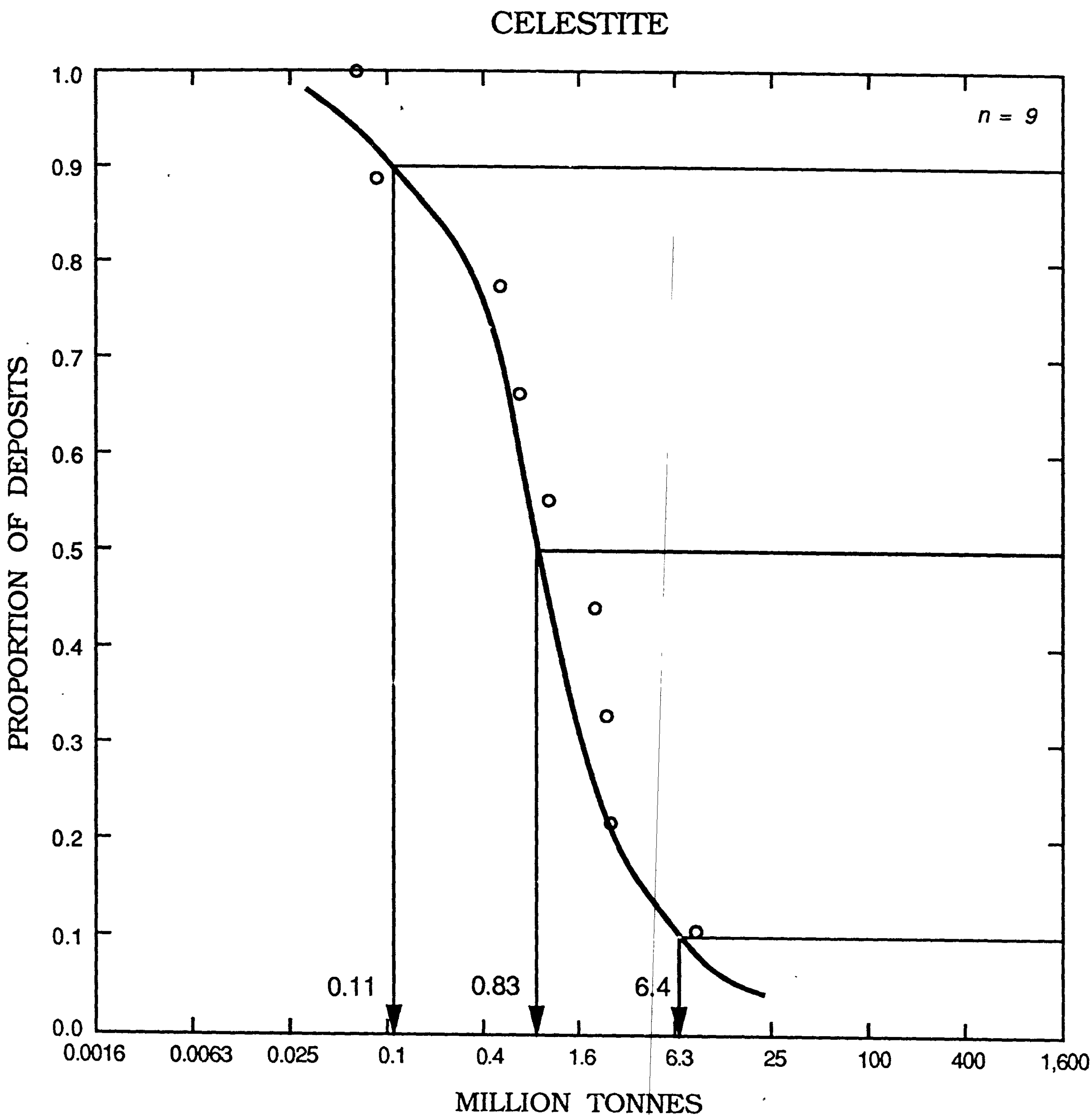

Figure 31. Tonnage model for marine bedded celestite.

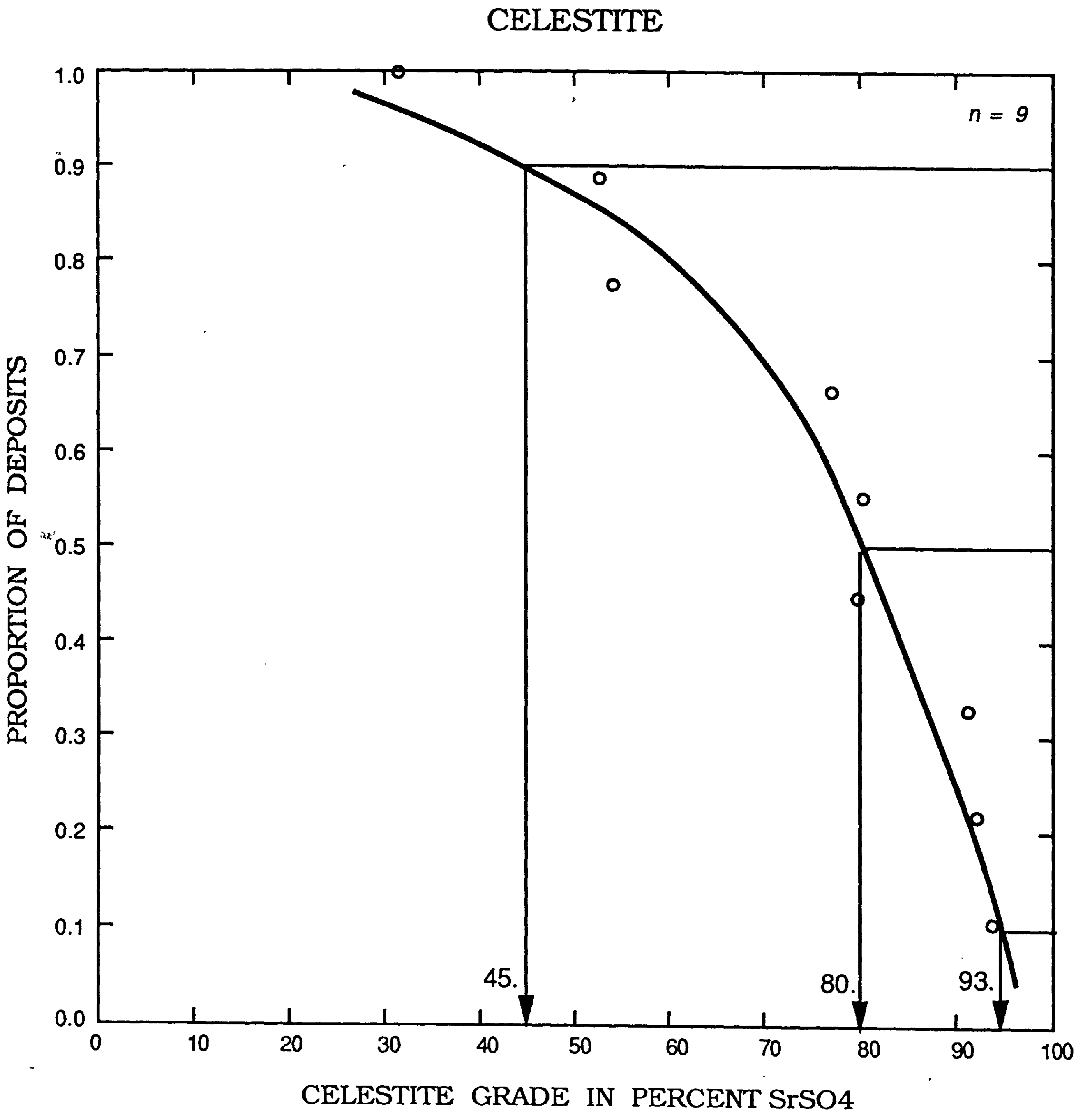

Figure 32. Grade model for marine bedded celestite.

GRADE AND TONNAGE MODEL OF POTASH-BEARING BEDDED SALT

By G.J. Orris

Some of the deposits in this model consist of multiple mineralized horizons which may be hundreds of meters apart stratigraphically. There is no significant correlation between grade and tonnage in this model. See figs. 33, 34.

DEPOSITS

Name	Country	Name	Country
Alsace	FRNC	Llobregat	SPAN
Canamex	CNMN	Malargue	AGTN
Cardona	SPAN	McAuley - St. Lazare	CNMN
Carlsbad	USNM	Plumweseep	CNNB
Colonsay (Central Canada)	CNSK	Rocanville	CNSK
Denison-Potacan	CNNB	Rosario do Catete	BRZL
Esterhazy	CNSK	Russell	CNMN
Holle	CNGO	Salt Springs	CNNB
		Zielitz	EGER

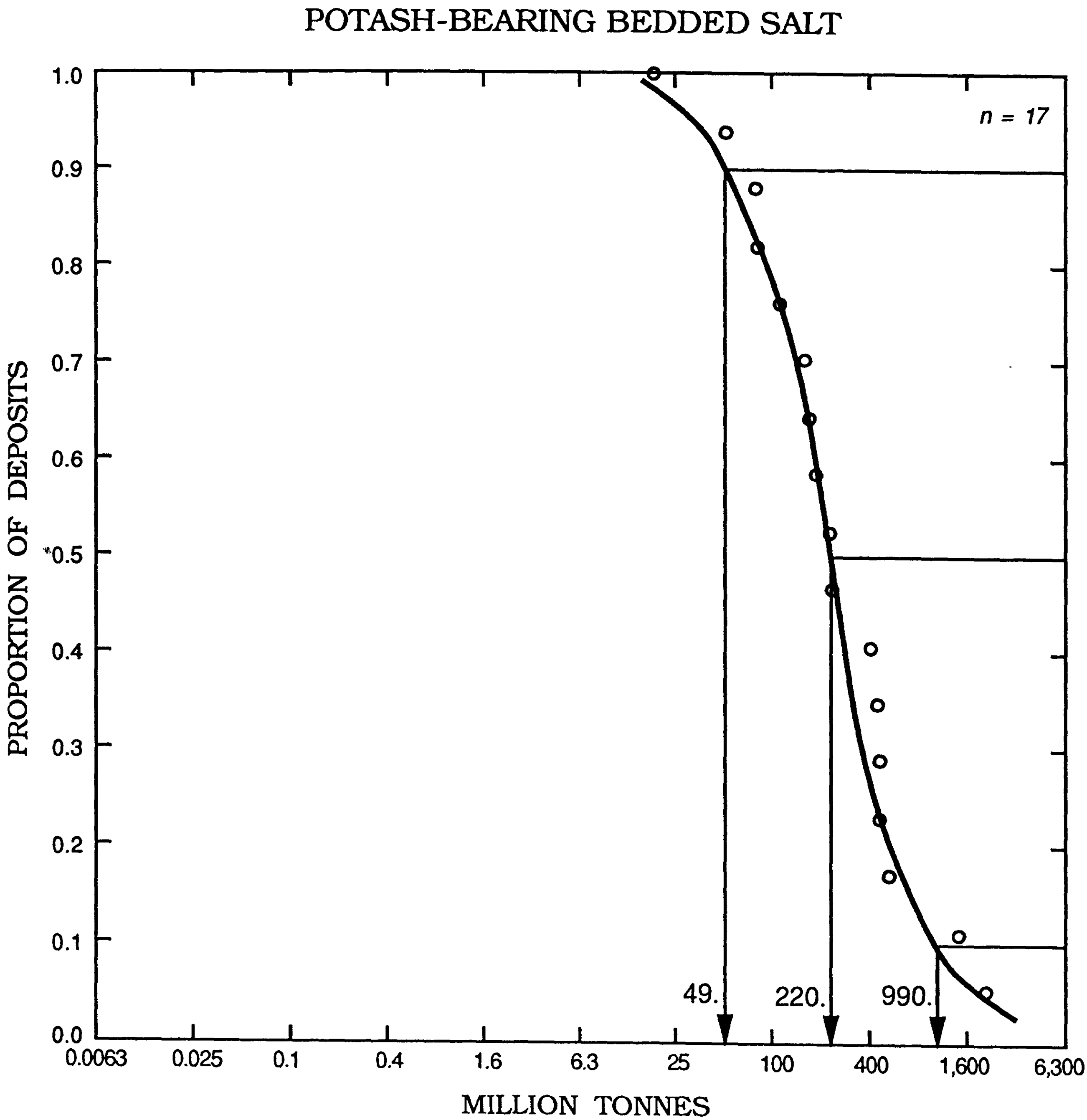

Figure 33. Tonnage model for potash-bearing bedded salt.

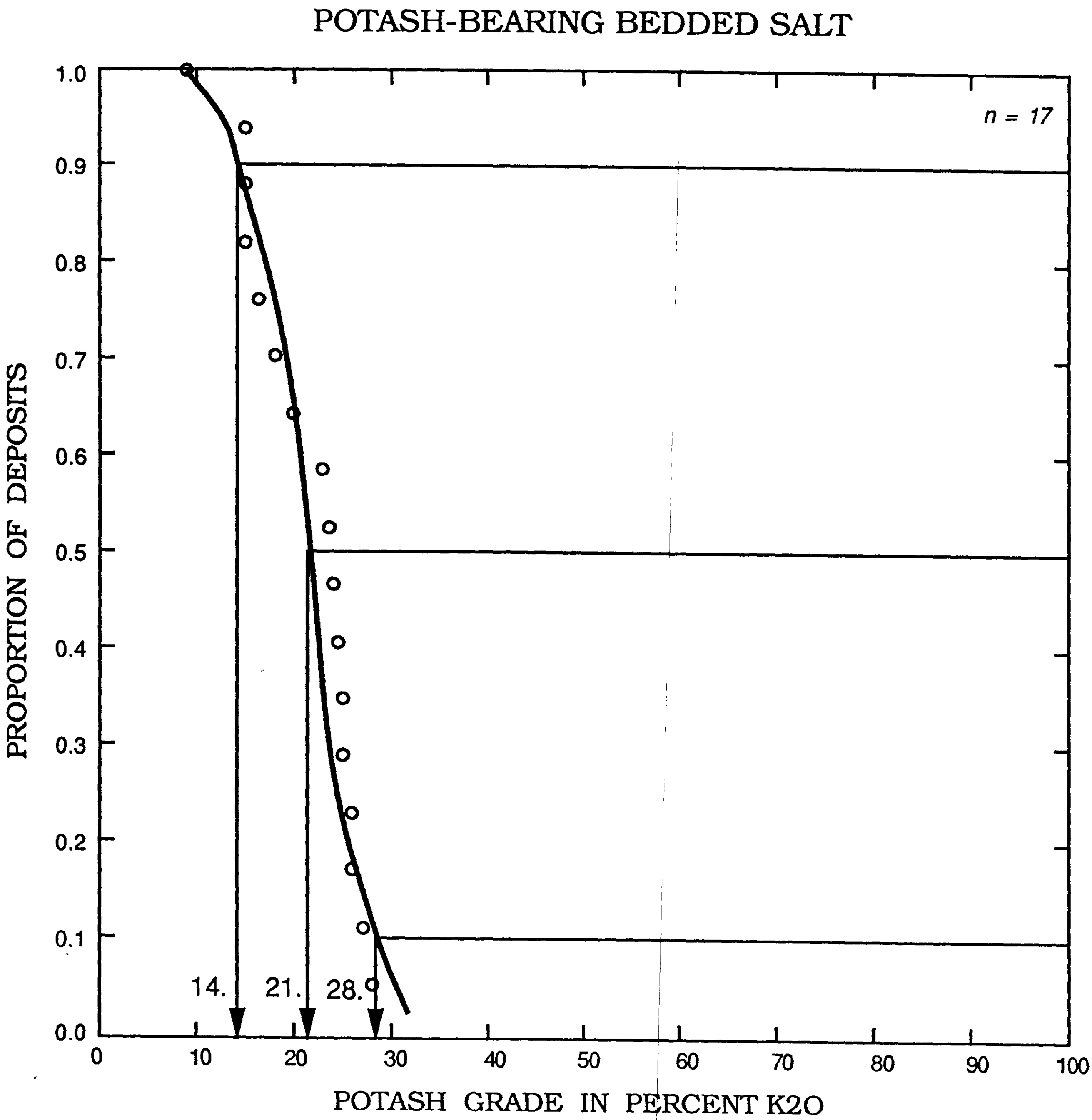

Figure 34. Grade model for potash-bearing bedded salt.

PRELIMINARY GRADE AND TONNAGE MODELS OF MARINE BEDDED GYPSUM

By G.J. Orris

There is no significant correlation between grade and tonnage in this model. This model is a mix of districts/areas and single deposits. The districts/areas may contain more than one deposit. See figs. 35, 36.

DEPOSITS

Name	Country	Name	Country
Blaine Fm - Southwest Oklahoma	USOK	Pouillon	FRNC
Cloud Chief	USOK	Suria Malableh	SOML
Flat Bay	CNNF	Tabernas	SPAN
Fort McMurray (Athabasca)	CNAL	Taverny	FRNC
Glangevin	EIRE	Weatherford-Clinton District	USOK
Peace Point	CNAL	White Mesa	USMX
Penchard	FRNC	Windermere	CNBC

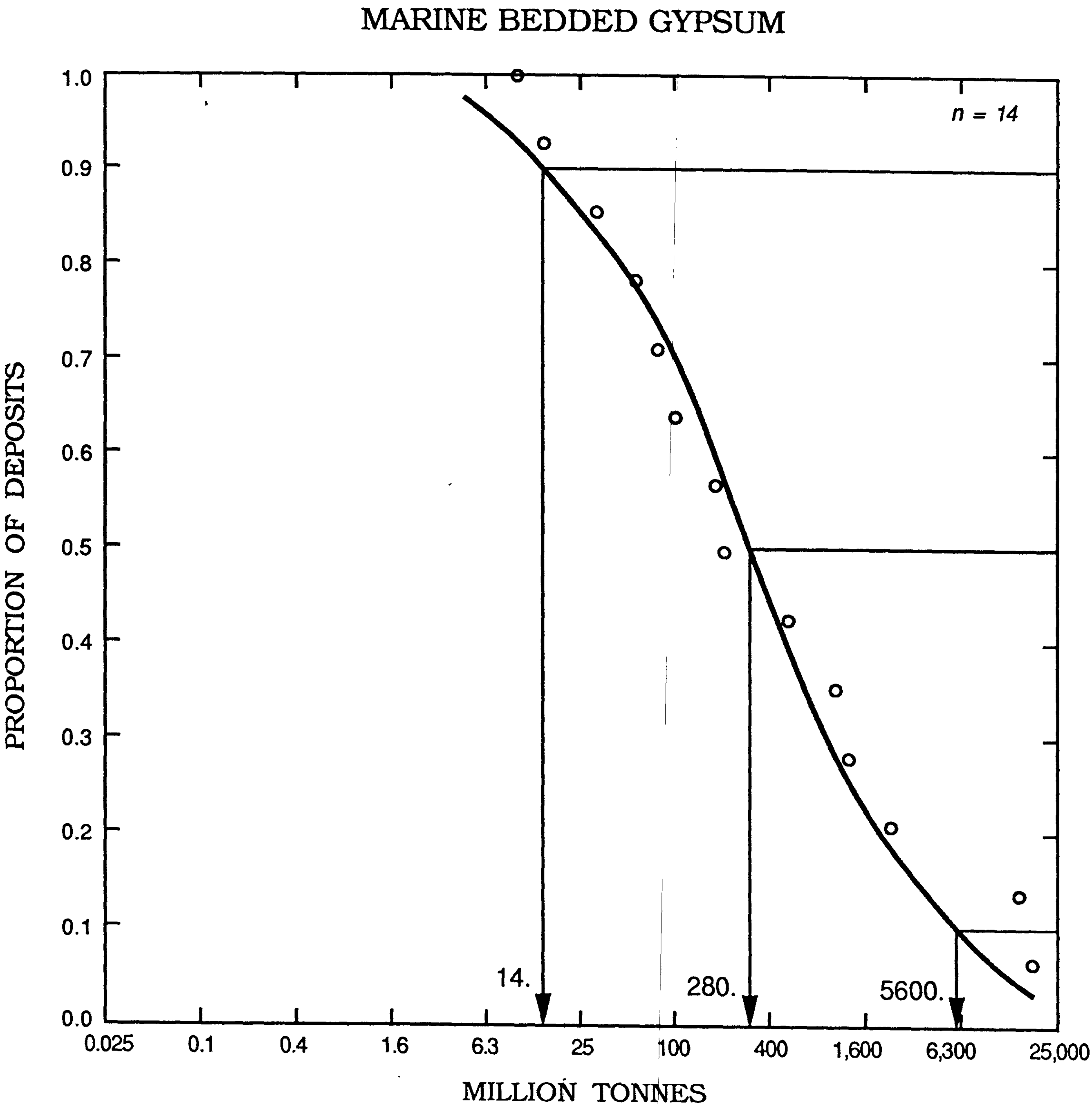

Figure 35. Tonnage model for marine gypsum.

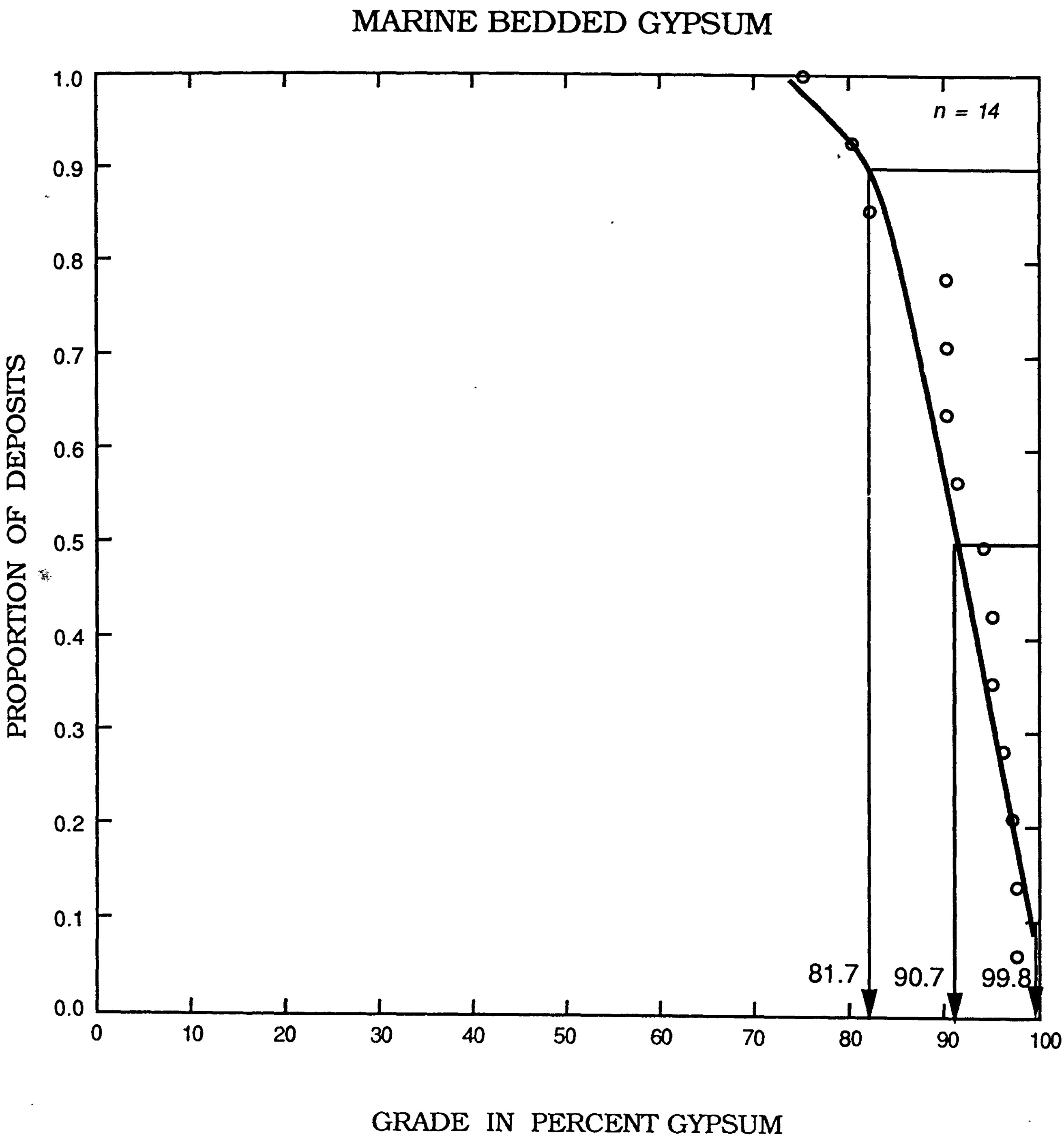

Figure 36. Grade model for marine gypsum.

PRELIMINARY GRADE AND TONNAGE MODEL OF LACUSTRINE BORATES

By G.J. Orris

In addition to grade and tonnage models (figs. 37, 38), the distribution of the colemanite content of the borate mineralization is shown in figure 39. There is no significant correlation between borate grade and tonnage in this model, nor is there a significant correlation between percent borate and percent colemanite. However, there is a strong negative correlation (r = -0.654) between tonnage and percent of borate mineralization composed of colemanite.

DEPOSITS

Name	Country	Name	Country
Bigadic	TRKY	Maria*	USCA
Billie	USCA	Monte Blanco	USCA
Boraxo	USCA	Played Out	USCA
Callville Wash (Anniversary Mine)	USNV	Rho (Kramer Junction)	USCA
Corkscrew	USCA	Sigma	USCA
DeBely	USCA	Terry	USCA
Emet	TRKY	Upper Biddy McCarthy	USCA
Gerstley I	USCA	Widow No. 3 (New Widow)*	USCA
Gerstley II	USCA	Widow No. 7 (Old Widow)*	USCA
Grand View	USCA		
Inyo	USCA		
Lizzy V. Oakley	USCA		
Lower Biddy McCarthy	USCA		

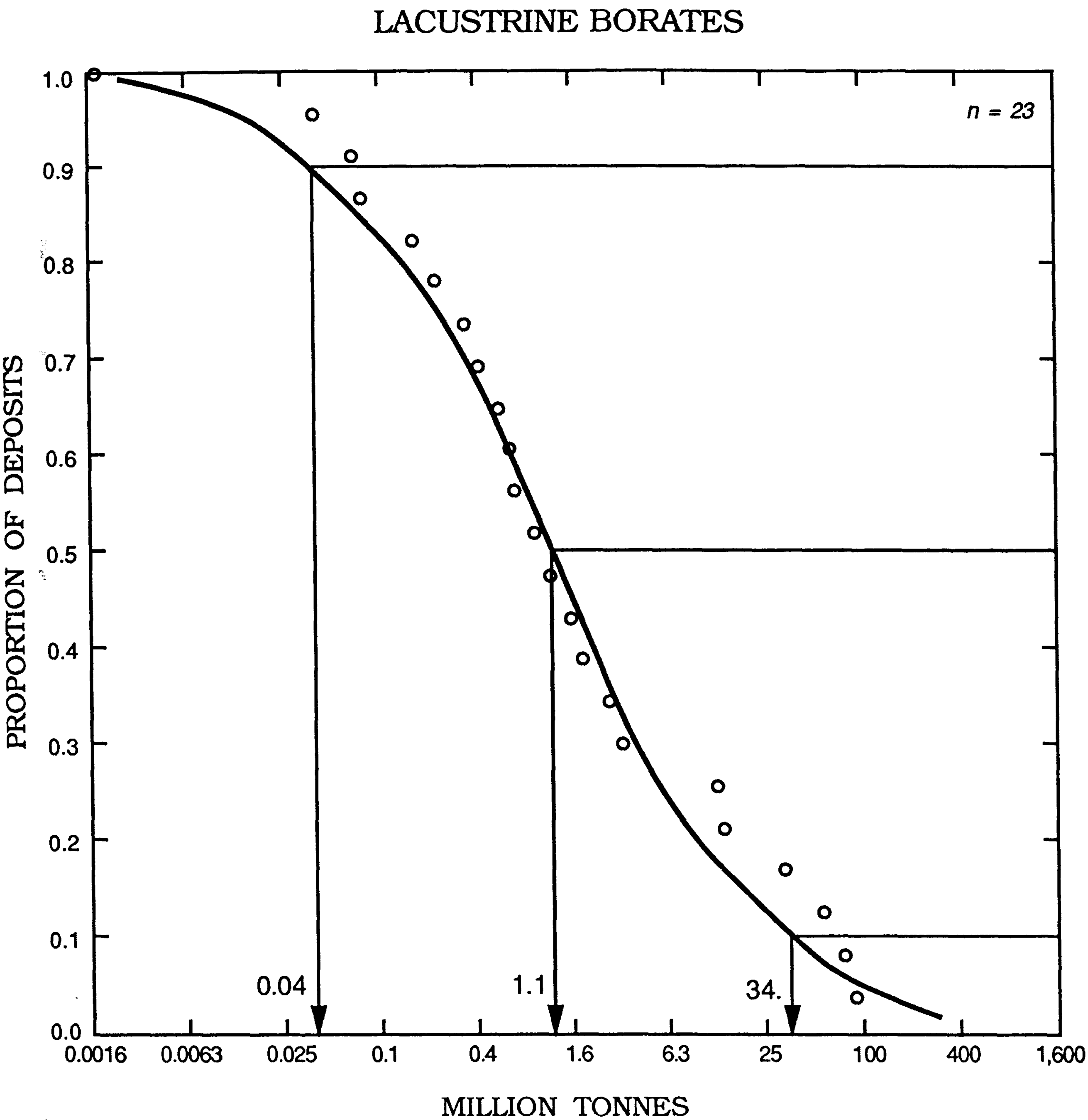

Figure 37. Tonnage model for lacustrine borates.

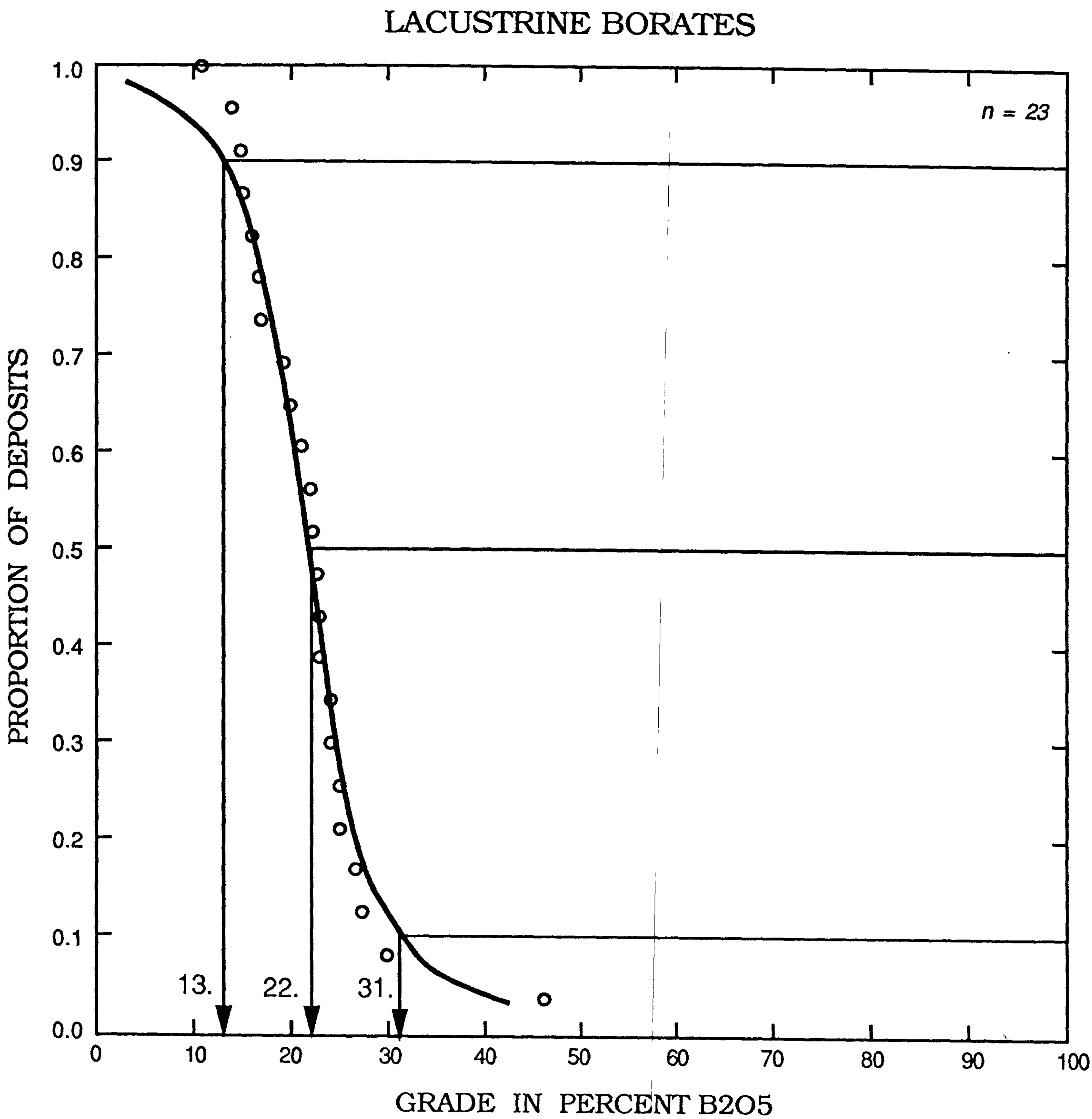

Figure 38. Tonnage model for lacustrine borates.

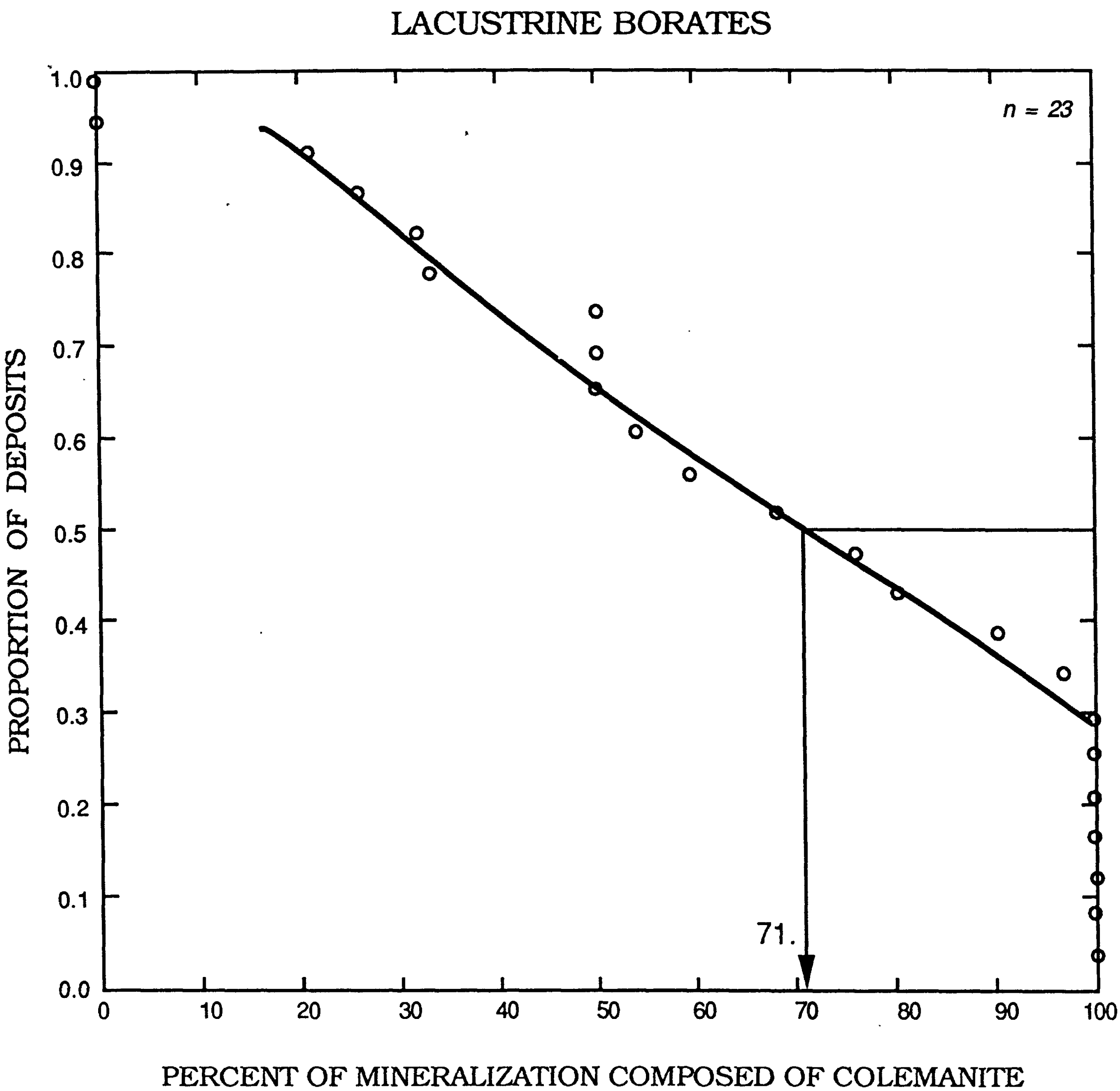

Figure 39. Percent of borate mineralization as colemanite.

PRELIMINARY GRADE AND TONNAGE MODELS OF LACUSTRINE GYPSUM

By G.J. Orris

There is no significant correlation between grade and tonnage in this model. See figs. 40, 41.

DEPOSITS

Name	Country	Name	Country
Apex	USNV	Spider Lake	AUSA
Boologooro Station	AUWA	Streaky Bay	AUSA
Central Wash	USAZ	Tromen-Auguilcó	AGTN
Gemshok Hollow	SAFR	Vaca Muerta	AGTN
Lake MacDonnell	AUSA	Yarra Yarra Lakes	AUWA
Marion Lake	AUSA	Yzerfontein	SAFR
Parcoola	AUSA		
Snow Lake	AUSA		

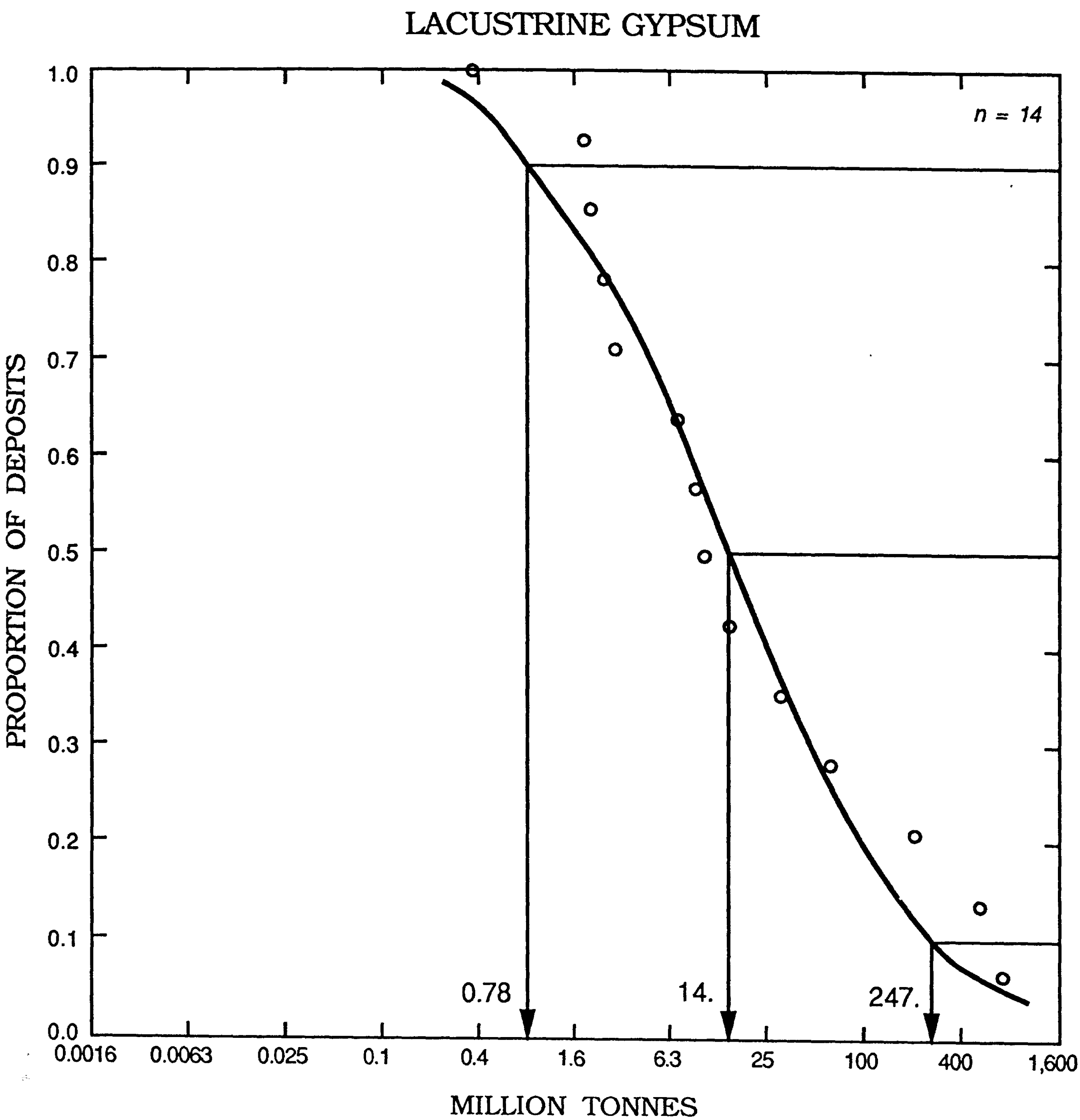

Figure 40. Tonnage model for lacustrine gypsum.

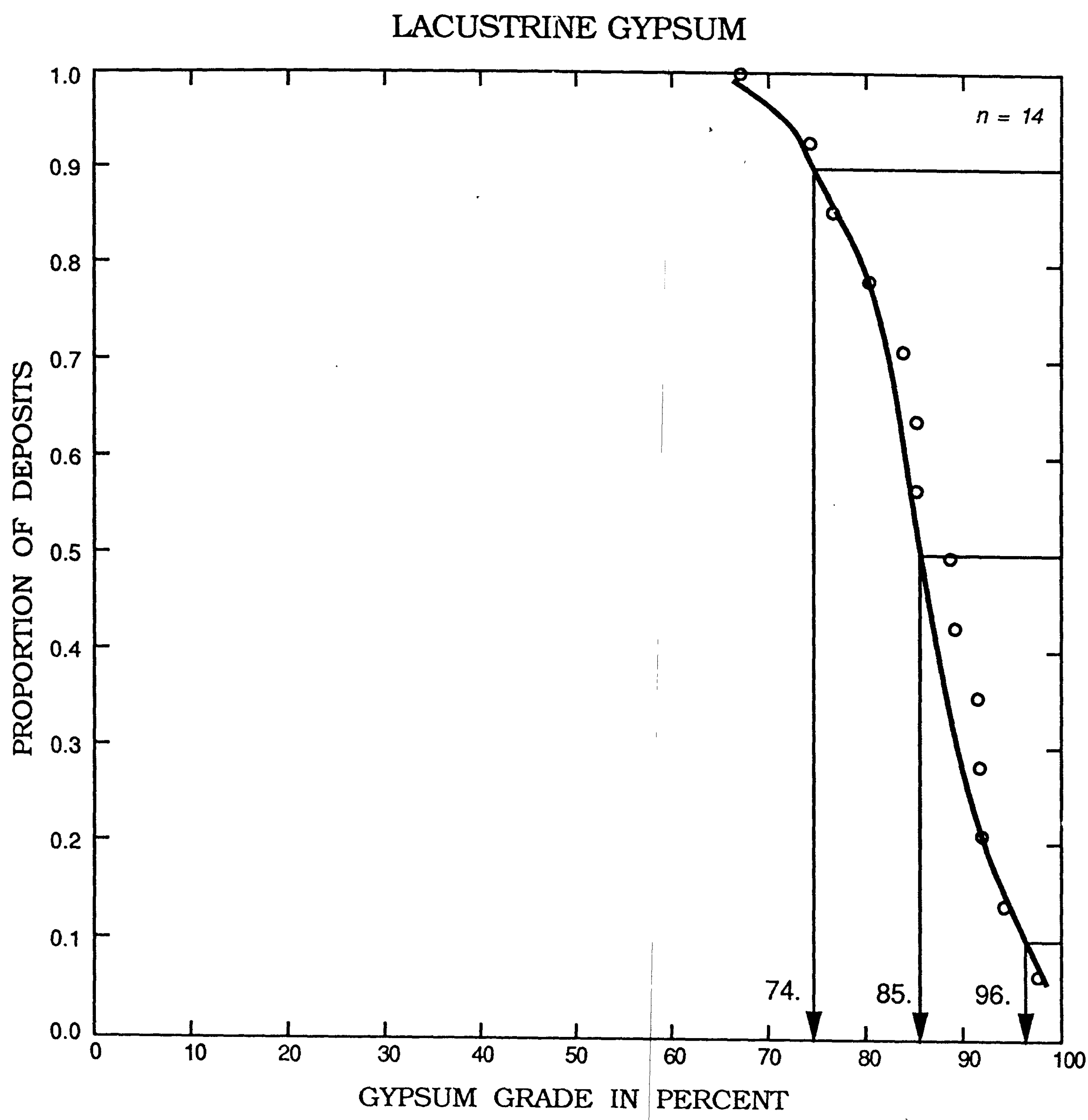

Figure 41. Grade model for lacustrine gypsum.

CONSTITUENT MODELS OF SODIUM CARBONATE (SULFATE, CHLORIDE) BRINES

By G.J. Orris

There is significant correlation between the solutes in this model. Sodium carbonate is correlated with sodium sulfate (r = 0.683), sodium carbonate with sodium chloride (r = 0.704), and sodium sulfate with sodium chloride (r = 0.863). See figs. 42-44.

DEPOSITS

Name	Country	Name	Country
Black Lake	USCA	Lake Van	TRKY
Borax Lake	USCA	Lonar Lake	ETHP
Hailar (Hailaeh)	CINA	Mono Lake	USCA
Harney Lake	USOR	Omak Lake	USOR
Jess Lake	USNB	Pretoria Salt Pan	SAFR
Lago Texcoco	MXCO	Soap Lake	USOR
Lake Abert	USOR	Sua Pan	BOTS
Lake Magadi	KNYA	Summer Lake	USOR

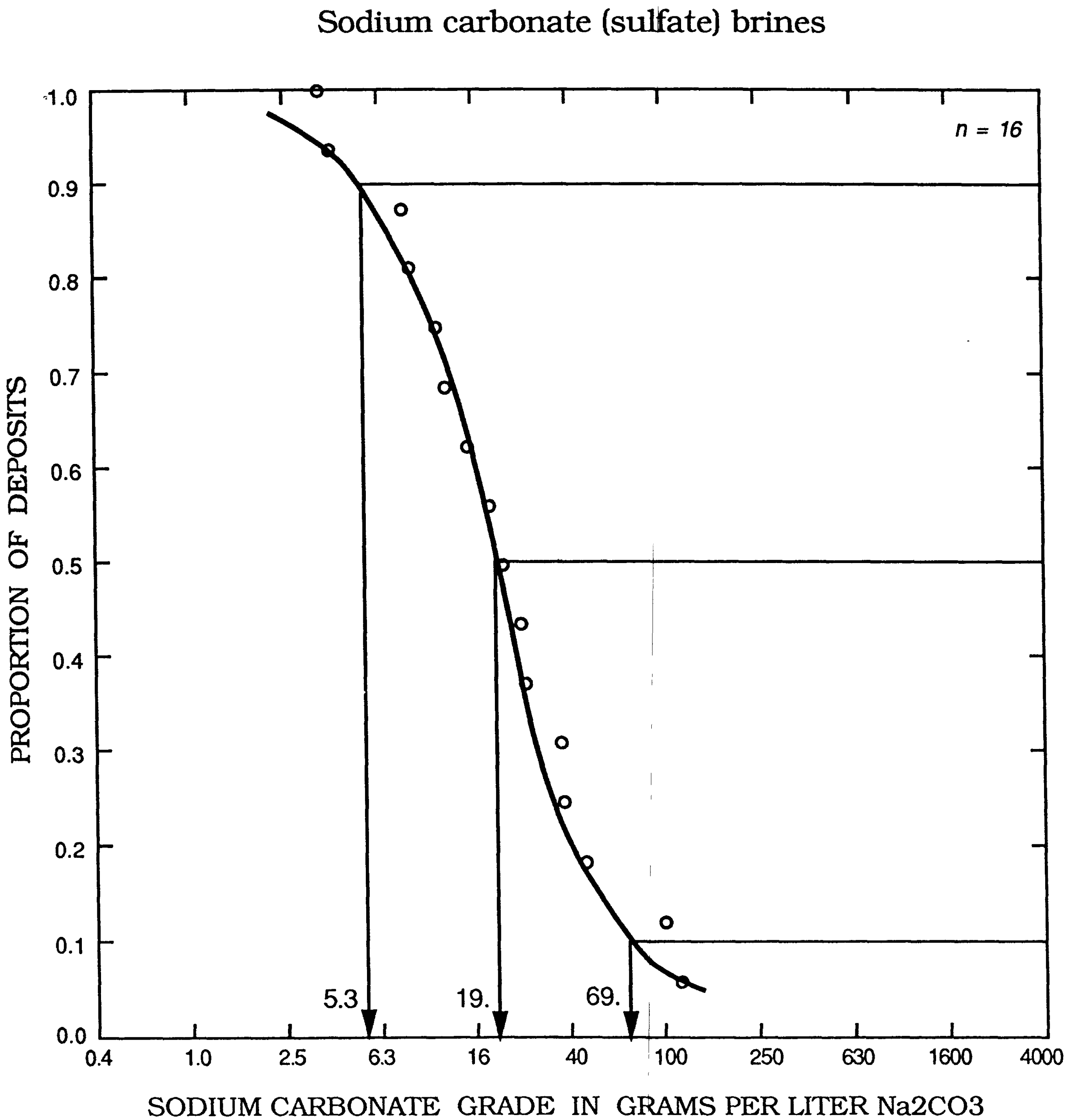

Figure 42. Solute model for sodium carbonate brines.

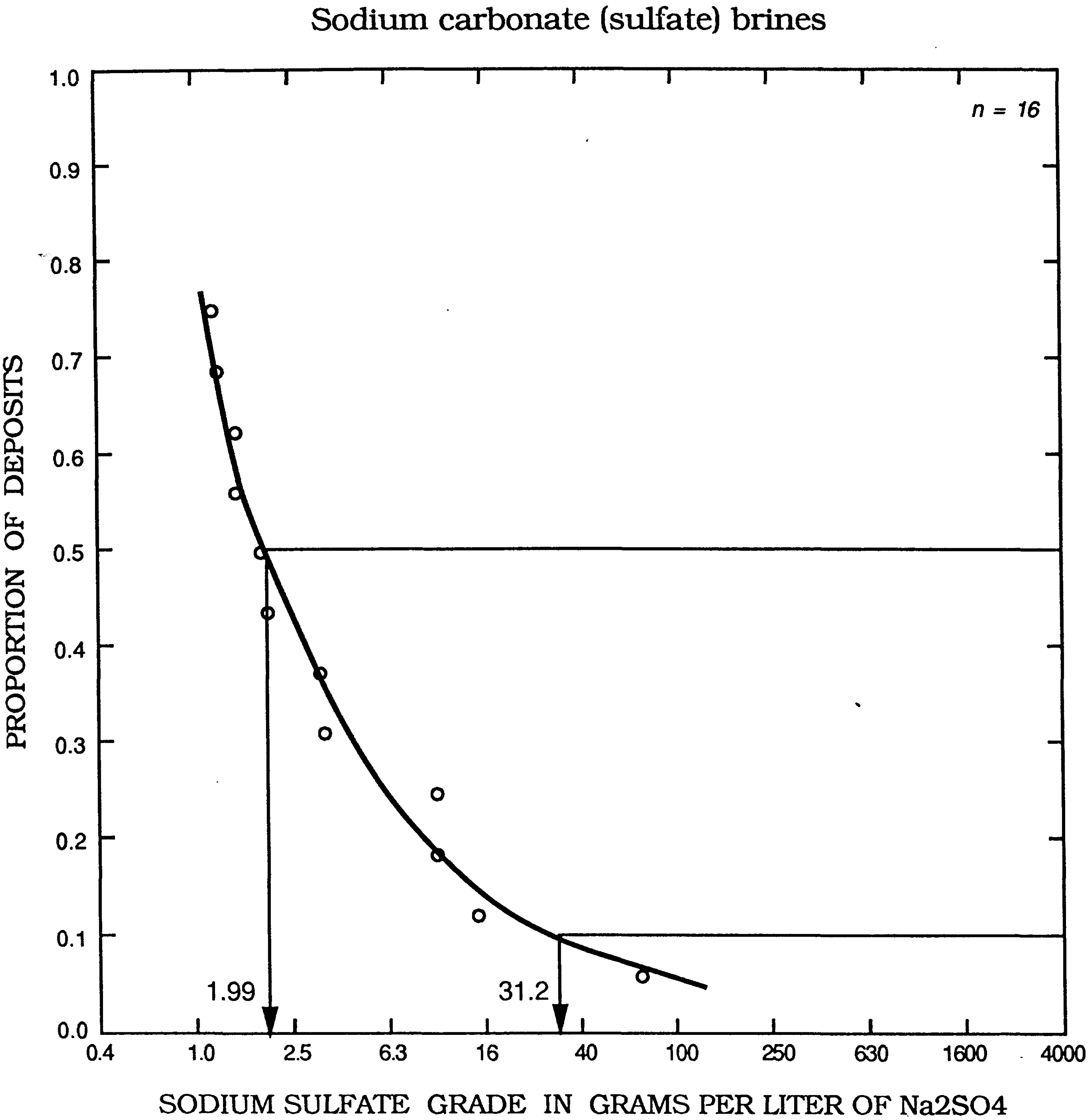

Figure 43. Solute model for sodium carbonate brines.

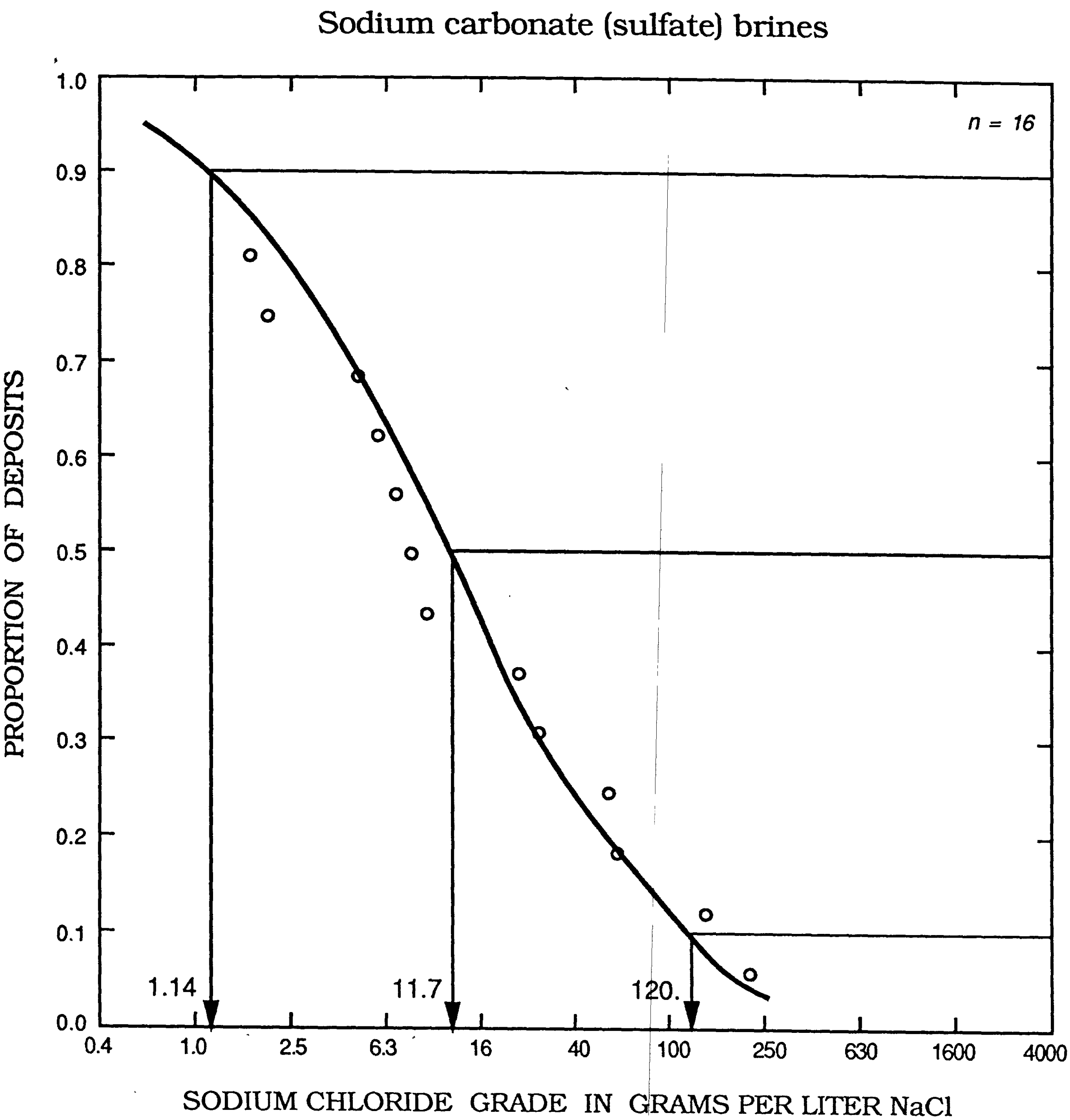

Figure 44. Solute model for sodium carbonate brines.

GRADE AND TONNAGE MODEL OF DISSEMINATED FLAKE GRAPHITE

By James D. Bliss and David M. Sutphin

Disseminated flake graphite deposits have been mineduusing predominantly mechanized methods. Classification of deposits into amorphous and disseminated is not always clear and this may lead to some deposits being misclassified (also see amorphous graphite). There is no significant correlation between grade and tonnage in this model. This model has been prebiously published in a non-USGS publication (Sutphin and Bliss, 1990). See Sutphin and Bliss (1990) for a comparison between amorphous and disseminated flake graphite deposit types. See figs. 45, 46.

DEPOSITS

Name	Country	Name	Country
Ambatomitamba	MDGS	Girard	USPA
Amo	JAPN	Globe	USCA
Andasifahatelo	MDGS	Graphex	CNQU
Ashidani	JAPN	Gumbu	SAFR
Azad Kashmir	PKTN	Hainan Island	CINA
Bell Graphite	CNQU	Harcourt	CNON
Black Donald	CNON	Itotone	MZMB
Bosiljgrad	YUGO	Kanziku	KNYA
Buryat	USSR	Kashmiri	PKTN
Cal Graphite	CNON	Katsuno	JAPN
Canadian Graphite	CNQU	Kingston	CNON
Carter Lake	USCA	Kirkham	CNON
Ceylon	USAL	Kongodo	JAPN
Cheong-pyong (#104)	SKOR	Konstantin	CZCL
Cheong-pyong (#33.43)	SKOR	Koppio	AUSA
Chung Nam	SKOR	Kropfmühl	GRMY
Chung Puk	SKOR	Kyeryong	SKOR
Cornell	USCA	Liu-Mao	CINA
Cup Lake	CNON	Lynx	ZIMB
Dawn 71	SAFR	Madurai	INDA
Dun Raven	CNQU	Marovintsky	MDGS
Faliarano	MDGS	Mestry-vrch	CZCL
Federal Carbon	USPA	Mont Laurier	CNQU
Fermont	CNQU	Monte Nipacue	MZMB
Genda	JAPN	Munglinup River	AUWA

Name	Country	Name	Country
Naoi	JAPN	Samgong	SKOR
National Graphite	CNON	Satemua	MZMB
Nhanhar	MZMB	Shihung	SKOR
Njoka	ZMBA	Skaland Grafitrerk	NRWY
Notre-Dame-du-Laus	CNQU	Southwestern	USTX
Oaxaca	MXCO	Soyusnoye	USSR
Orrwell	CNQU	Taskazgan	USSR
Oryu	SKOR	Tayginsk	USSR
Pasumpon-Muthuramalingam	INDA	Telixtlahuaca	MXCO
Pedra Azul	BRZL	Timmins	CNON
Pennsylvania Graphite	USPA	Todd	CNON
Pickering Valley	USPA	Tonkin-Dupont	CNON
Pollon Lake-(Reindeer Lake)	CNSK	Tsavo	KNYA
Port Clarence	USAK	Uley	AUSA
Princeton	CNON	Virginia Graphite	CNON
Pyontack	SKOR	Yongwon	SKOR
		Zaval'yevsky	USSR

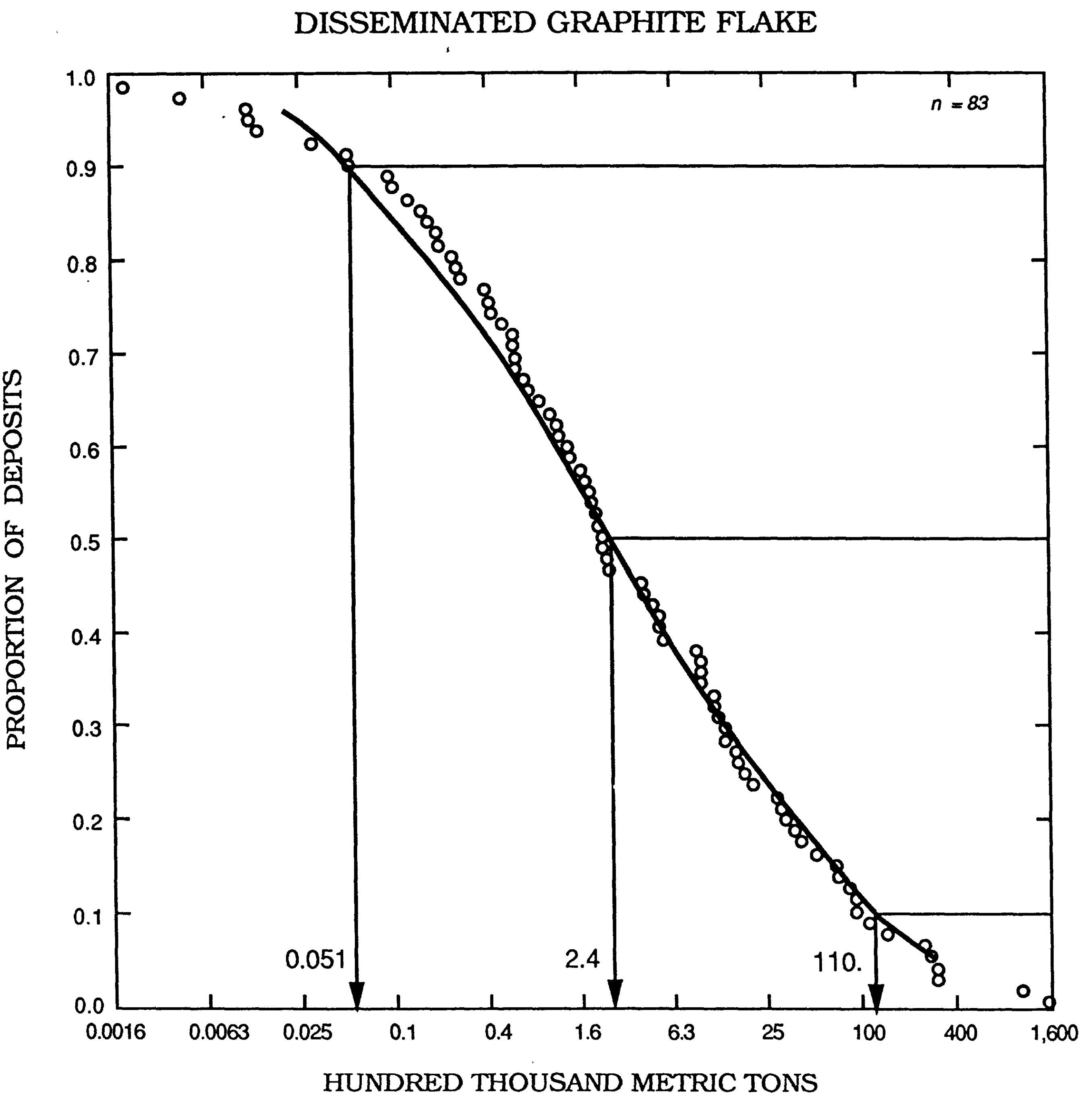

Figure 45. Tonnage model for disseminated graphite (modified from Sutphin and Bliss, 1990).

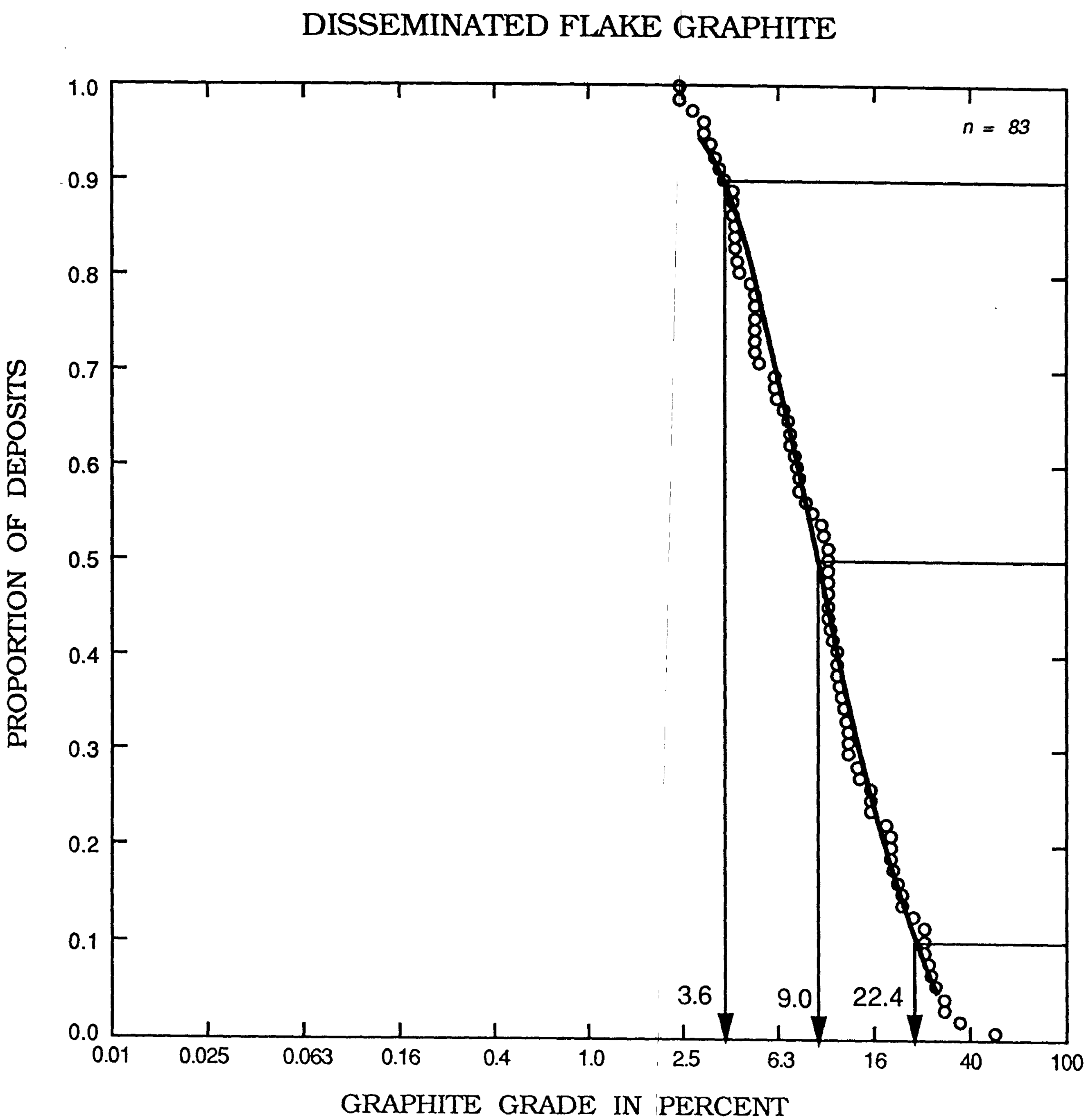

Figure 46. Grade model for disseminate graphite (modified from Sutphin and Bliss, 1990).

PRELIMINARY CONTAINED MATERIAL MODEL FOR RESIDUAL KAOLIN

By G.J. Orris

There was insufficient information to construct a grade model for this deposit type. See figure 47.

DEPOSITS

Name	Country	Name	Country
Cerro Copeyal	VENE	Nagar Parker	PKTN
Escalera	VENE	Palmira	BLVA
Eureka	AGTN	Sanchong	SKOR
Hagstad	SWDN	Tala-Barfek	AFGH
Karacevo	YUGO	Topira	GUYN
Km 88	VENE	Weipa	AUQL
Linden	GUYN		

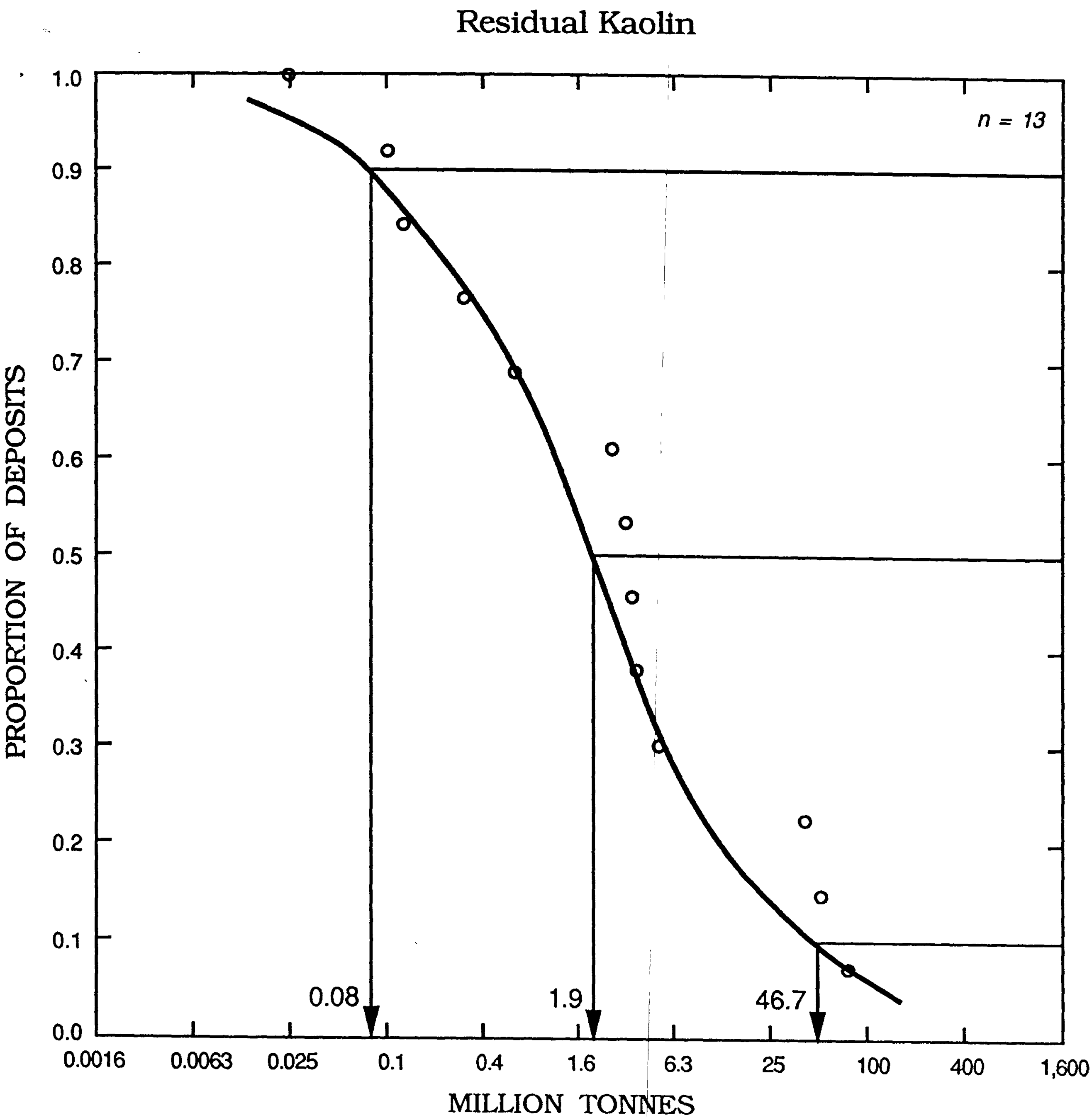

Figure 47. Contained material model for residual kaolin.

GRADE, VOLUME, AND DEPOSIT-SPECIFIC MODELS OF DIAMOND PLACERS

By James D. Bliss

COMMENT: In addition to size and grade, average carat size and percentage of diamonds of industrial grade are needed to characterize diamond placers. Most deposits are alluvial but several are residual placers over kimberlite pipes. Beach placers are excluded. Given the type of data available, data on workings within 1.5 km were considered to be a single deposit. Several deposits are large in area with workings of unknown spacing. Deposits must have diamond grade and volume to be included in those models. However, reporting on average carat size and percentage of diamonds of industrial quality was less frequently available and all reported values for these characteristics were used in the models whether or not associated grade and volume data were available. The percent of diamonds of industrial quality is correlated with deposit size ($r = 0.93$, $n = 7$) if the Prairie Creek residual placer is excluded from the analysis. Other commodities known to have been produced from diamond placers, but not modeled, include Au, PGE, Ta_2O_5, and other types of gemstones. See figs. 48-51.

DEPOSITS

Name	Country	Name	Country
Acorn Security	INDO	Limestone Creek	AUWA
Aredor	GNEA	Lower Smoke Creek	AUWA
Baule Basin	GNEA	Lucapa-Andrada-Cuango River	ANGL
Bingara Field	AUNS	Mabuki	TNZN
Birim River	GHNA	Mwamanga	TNZN
Boabab	TNZN	Namaqualand	SAFR
Boshoff	TNZN	Potaro Field	GUYA
Copeton	AUNS	Prairie Creek	USAR
Campo Sampaio	BRZL	Raw Bean	BRZL
Feijao Cru	BRZL	Rio Caroní	VNZL
Hlane	SWAZ	Tejucana	BRZL
Koidu Field	SRLN	Upper Smoke Creek	AUWA
Kolmanskop	SAFR	Vila Santa Maria	BRZL
Kurupung Field	GUYA		

Diamond Placers

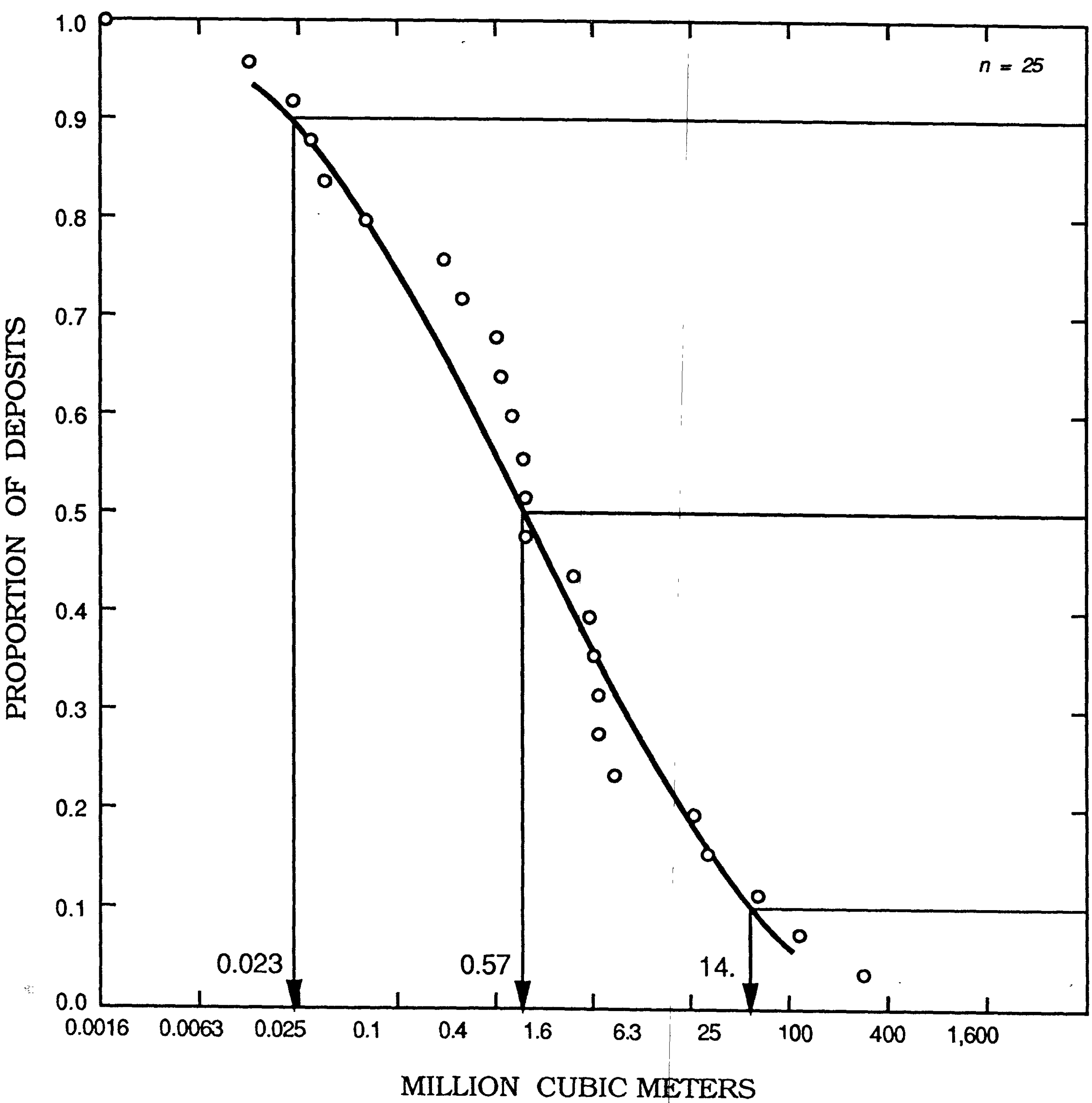

Figure 48. Size model for diamond placers.

Diamond Placers

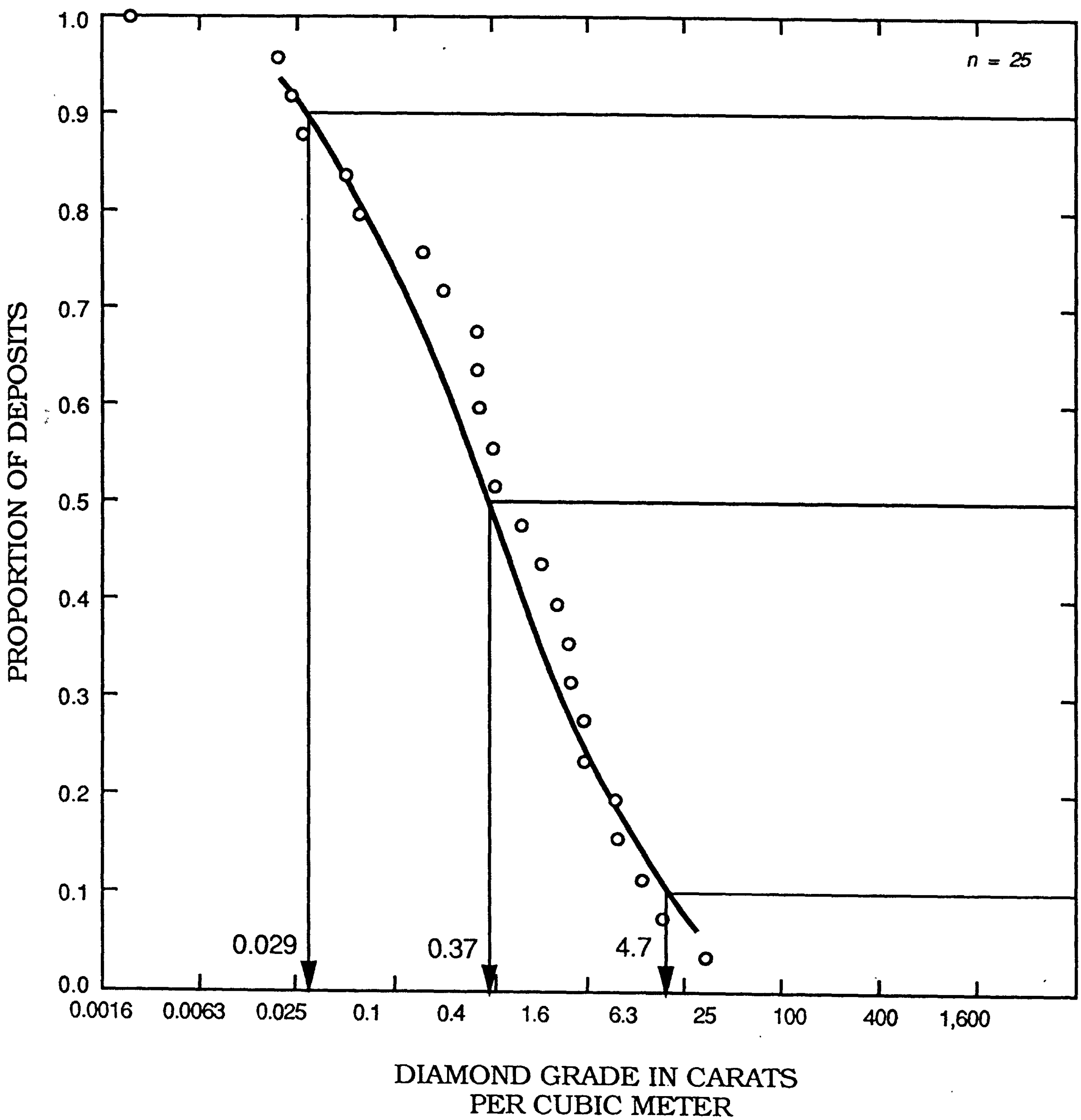

Figure 49. Diamond grade model for placer diamonds.

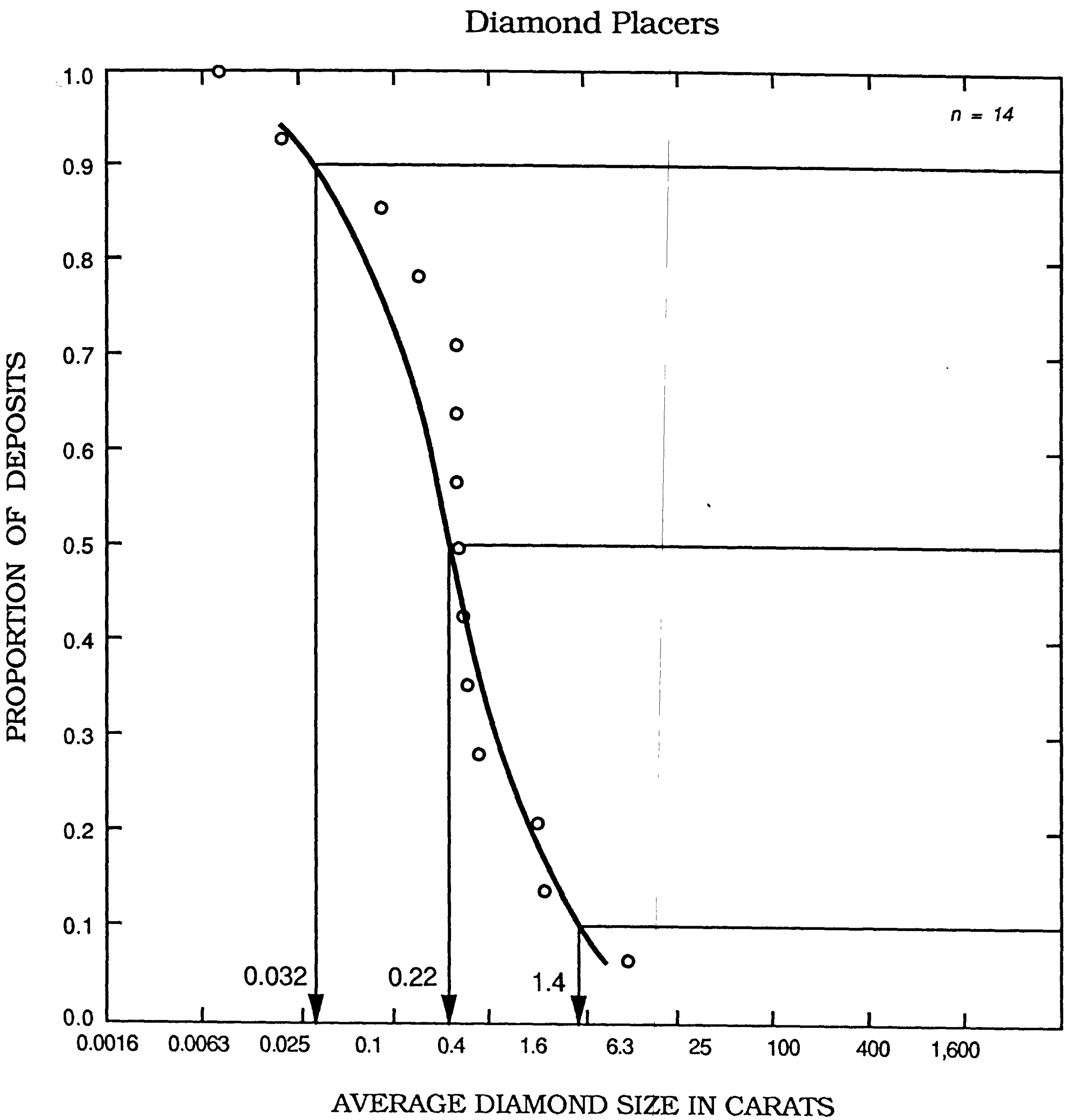

Figure 50. Diamond size model for placer diamonds.

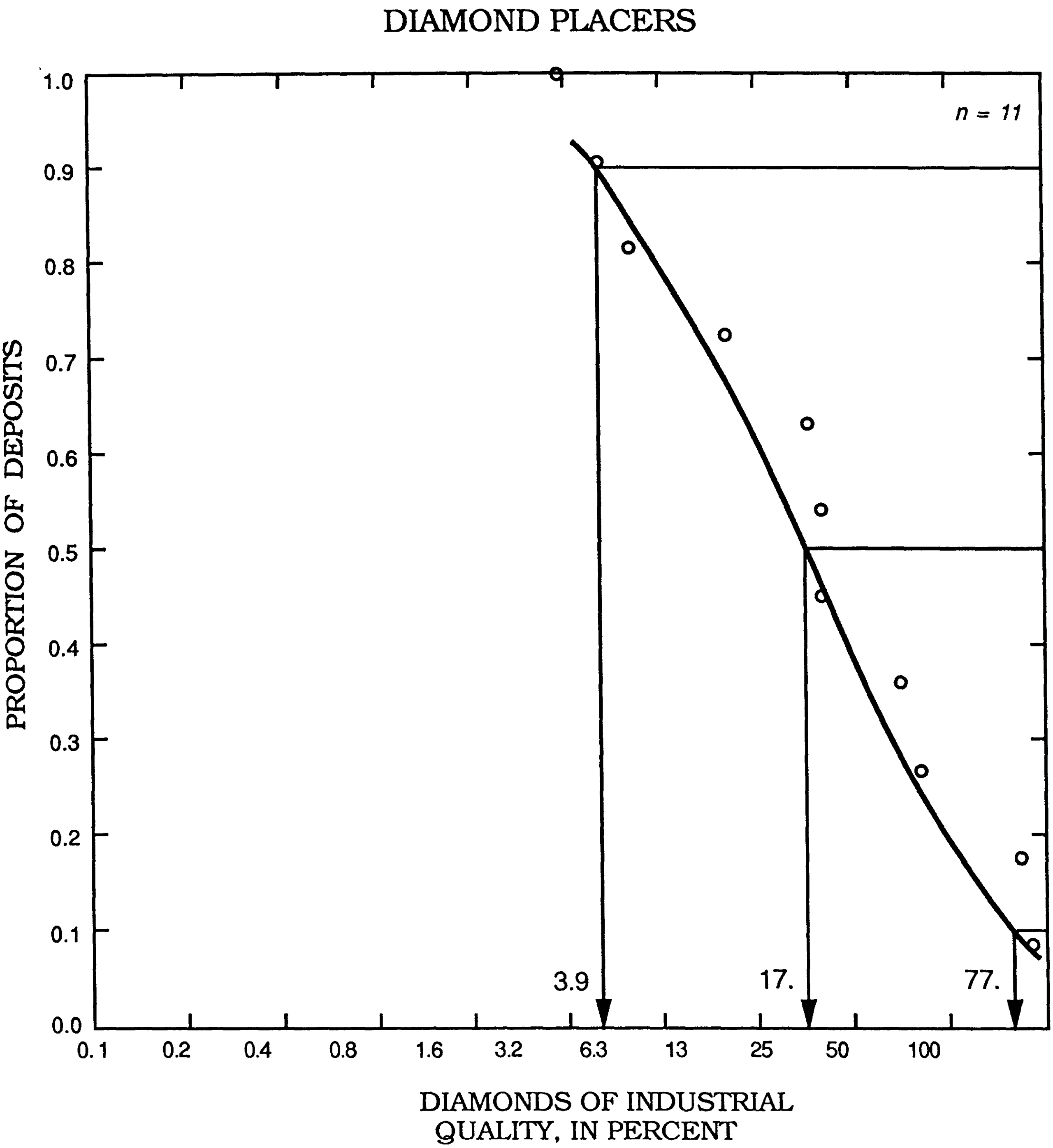

Figure 51. Diamond quality model for placer diamond deposits.

PRELIMINARY GRADE AND TONNAGE MODELS OF SILICA SAND

By G.J. Orris

There is no significant correlation between grade and tonnage in this model. See figs. 52, 53.

DEPOSITS

Name	Country	Name	Country
Abu Darag - upper horizon	EGPT	Madeleine Islands (South)	CNQU
Abu Darag - lower horizon	EGPT	Nylstroom	SAFR
Black River	JMCA	Parengarenga	NZLD
Cape Flats	SAFR	Planknek 43 KS Farm	SAFR
Demerara River	GYNA	Plumbago Creek	USWY
Diogenes	CNNS	Red Deer River	CNSK
Madeleine Islands (North)	CNQU	Sandy Ground	JMCA
		Weferlingen	GRMY

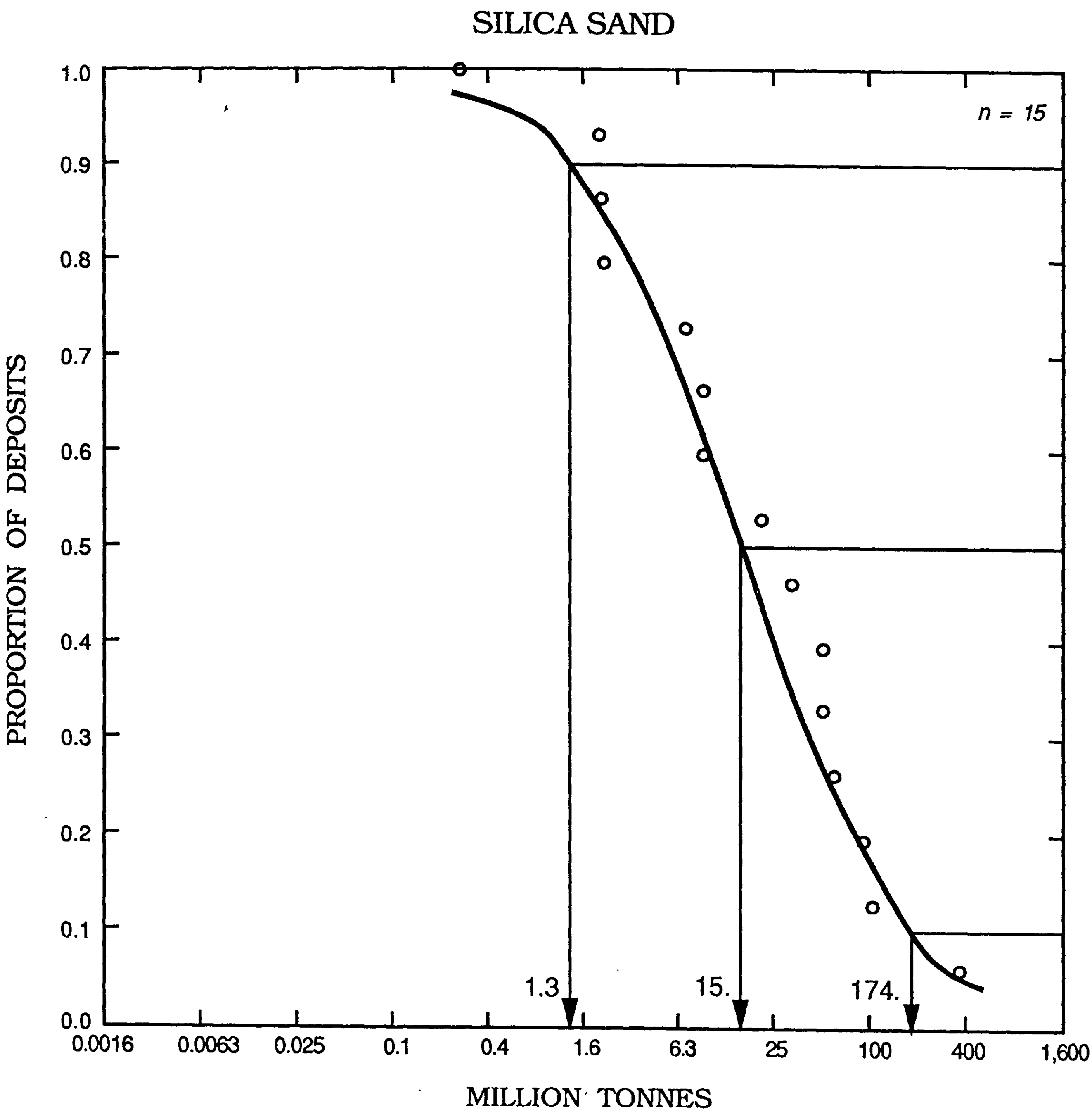

Figure 52. Tonnage model for silica sand.

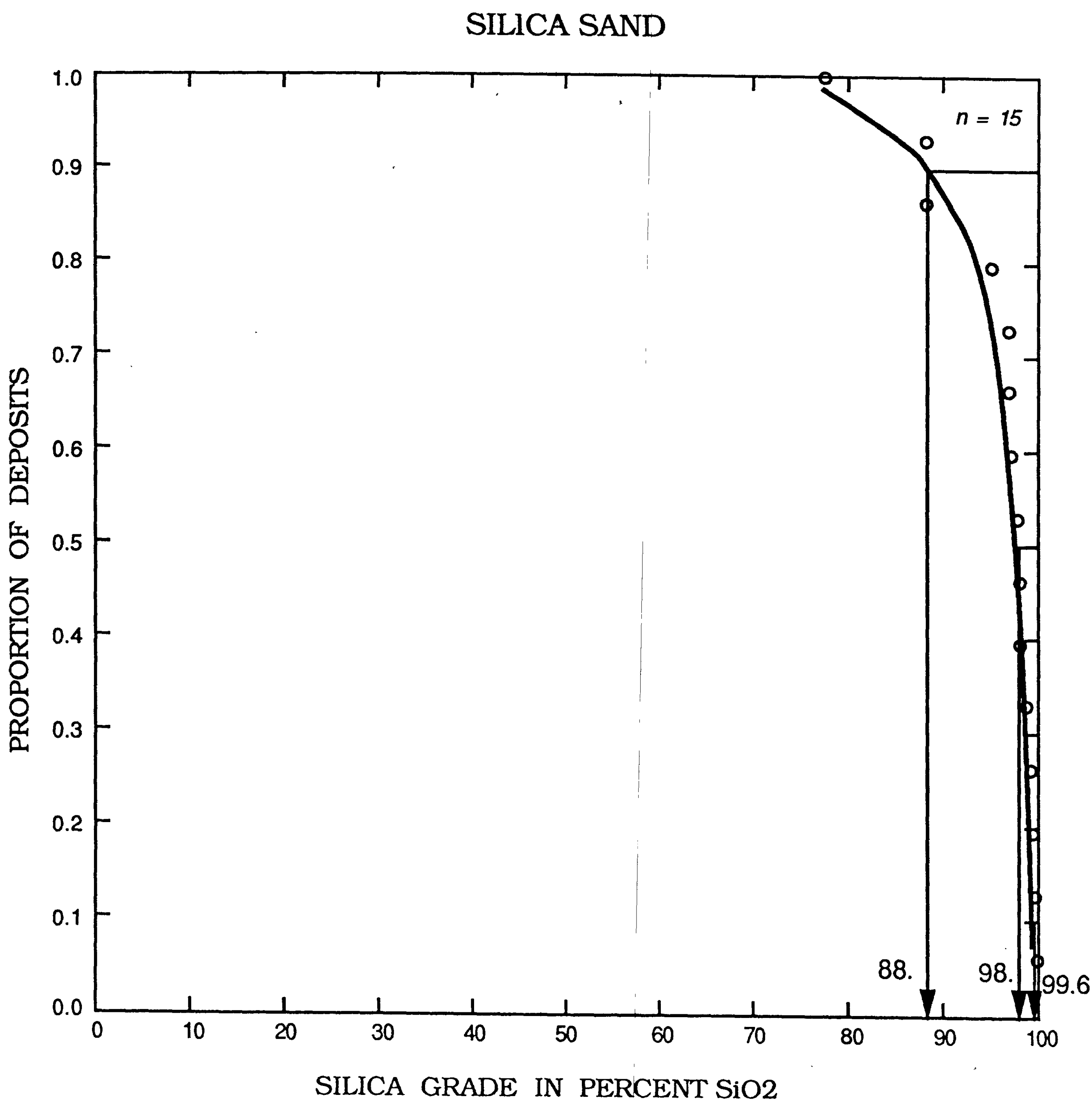

Figure 53. Grade model for silica sand.

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APPENDIX A:

COUNTRY CODES

Code	Name
AFGH	Afghanistan
AGTN	Argentina
ALGR	Algeria
ANGL	Angola
AUNS	Australia, New South Wales
AUNT	Australia, Northern Territory
AUQL	Australia, Queensland
AUSA	Australia, South Australia
AUTS	Australia, Tasmania
AUWA	Australia, Western Australia
ASTR	Austria
BENN	Benin
BLVA	Bolivia
BOTS	Botswana
BRZL	Brazil
CILE	Chile
CINA	China
CLBA	Colombia
CNAL	Canada, Alberta
CNBC	Canada, British Columbia
CNGO	Congo
CNMN	Canada, Manitoba
CNNB	Canada, New Brunswick
CNNF	Canada, Newfoundland
CNNS	Canada, Nova Scotia
CNNT	Canada, Northwest Territories
CNON	Canada, Ontario
CNQU	Canada, Quebec
CNSK	Canada, Saskatchewan
CNYT	Canada, Yukon Territory
CORI	Costa Rica
CZCL	Czechoslovakia
EGPT	Egypt
ETHP	Ethiopia
FNLD	Finland
FRNC	France
GHNA	Ghana
GNEA	Guinea
GREC	Greece
GRMY	Germany
GUYN	Guyana

Code	Name
HUNG	Hungary
ICLD	Iceland
INDA	India
IRAN	Iran
IRLD	Ireland
ITLY	Italy
JAPN	Japan
JMCA	Jamaica
KNYA	Kenya
LSTO	Lesotho
MDGS	Madagascar
MRCO	Morocco
MXCO	Mexico
MZMB	Mozambique
NIGR	Nigeria
NKOR	North Korea
NRWY	Norway
NZLD	New Zealand
PKTN	Pakistan
PLND	Poland
QATR	Qatar
SAAR	Saudi Arabia
SAFR	South Africa
SKOR	South Korea
SOML	Somalia
SPAN	Spain
SRIL	Sri Lanka
SRLN	Sierra Leon
SUDN	Sudan
SWAZ	Swaziland
SWDN	Sweden
THLD	Thailand
TIWN	Taiwan
TNZN	Tanzania
TRKY	Turkey
UKSL	United Kingdom, Scotland
USAL	United States, Alabama
USAK	United States, Alaska
USAZ	United States, Arizona
USAR	United States, Arkansas
USCA	United States, California
USCO	United States, Colorado
USGA	United States, Georgia
USID	United States, Idaho
USLA	United States, Louisiana
USMT	United States, Montana
USNB	United States, Nebraska

Code	Name
USNC	United States, North Carolina
USNM	United States, New Mexico
USNV	United States, Nevada
USNY	United States, New York
USOK	United States, Oklahoma
USOR	United States, Oregon
USPA	United States, Pennsylvania
USSR	formerly of the United Soviet Socialist Republics
USTN	United States, Tennessee
USTX	United States, Texas
USVA	United States, Virginia
USVT	United States, Vermont
USWA	United States, Washington
USWY	United States, Wyoming
UVOL	Upper Volta (Burkina Fasso)
VENE	Venezuela
YUGO	formerly of Yugoslavia
ZIMB	Zimbabwe
ZIRE	Zaire
ZMBA	Zambia