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Macintosh decoder and retrieval program for the international igneous rock data base IGBA

The international igneous rock data base, which currently contains petrographical and geochemical data on about 15,000 igneous rocks, has been available to users to manage and query through specialized sets of FORTRAN subroutines. Now it is possible to use the data base through a user-friendly, stand-alone (run-time) program that decodes and retrieves from the data base and that can be used almost immediately by anyone who has a Macintosh. (Ed.)

Introduction

The international igneous rock data base (IGBA) has been developed under the aegis of two successive IGCP projects (169 and 239) and under the IUGS Subcommission on Data Bases for Petrology. A working data base was designed and then developed that currently contains petrographical and geochemical data on about 15,000 igneous rocks, worldwide. At present, magnetic tapes of the IGBA are available at nominal cost to anyone who applies to World Data Center-A (Colorado), or free of charge to all who contribute analyses directly to the data base. The history of the IGBA (and of petrological data bases in general) and details of its practice and implementation have been amply described by Chayes (1983, 1987, and 1990), by Le Maître (1982), and – in a broader review of computing developments in petrology and mineralogy – by Rock (1991).

The IGBA was a pioneer in its class, and it indeed still carries some marks of its conception in the early 1970s and gestation in the decade that followed – a time when computing was regularly practiced on mainframes by relatively few geologists because of the inaccessibility, cost, and inapproachability of these machines and their software. For example, the data-base management systems (DBMS) available at the time were few, very costly, and prohibitively difficult to use, which led to the development of specialized sets of FORTRAN subroutines (together with BASIC versions

thereof) for the managing and querying of the IGBA (Chayes, 1983). These subroutines still represent the only software currently released with the data base on tape, and they present some difficulties to users without FORTRAN expertise. Again, storage costs at the time meant that compactness was a major aim, and considerable effort was therefore put into the development of an elaborately coded, ultra-condensed data-format (see fig. 8). Although it was never intended that ultimate users would have to master this, it does nowadays appear somewhat impenetrable and may unfortunately discourage some of today's potential users, who may perhaps be more used to natural (English-like) computer interfaces; in any case, it requires complete decoding for practical use.

Data bases developed in the microcomputer era have faced different, but on the whole, lesser problems: developers have had available a wealth of versatile DBMSs that can be bought off the shelf at relatively little cost, compared to their mainframe forebears (for example, dBase, FoxBase, Oracle, and Paradox¹). The prodigious decrease in computing costs has also made compactness less of an issue, so that the storage of full original data in natural language form nowadays presents fewer technical difficulties, even though it inevitably leads to bigger files (though it can still cause major retrieval problems discussed, among others, by Rock and others, 1990). We therefore concentrate on the following ways to decode and retrieve from the IGBA's established format, by the use of today's software.

Some options for implementing a data base

One of the major aims of IGCP Project 239, in coordination with the IUGS Subcommission on Data Bases for Petrology, has been to develop ways of making the IGBA more accessible and user-friendly, so as to encourage greater familiarity with and use of the immense range of valuable information in the data base. From the

¹ Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the IUGS.

Table 1. – Comparison of four different approaches to implementing a data base

	Commercial DBMS	Public-domain DBMS	Source code DBMS	Run-time version
Commercial cost	High	Low or nil	Nil	Low or moderate
User community	Those with the full DBMS only	Those with the full DBMS only	Anyone with a language compiler	Those with run-time DBMS
Data base portability	Low without major translation effort	Low without major translation effort	High, though may depend on computer	Not portable
Expertise required to set up a data base	Expertise with DBMS and its language	Expertise with DBMS and its language	Programming ability in high-level language	Not adaptable
Learning difficulty	High	Intermediate	Low	High

programming point of view, there are several, often equally viable, ways of going about this, and it is appropriate to summarize their relative advantages and disadvantages (table 1 and below), in order to establish why the particular course adopted here was followed. Alternatives are being actively investigated by other participants in the IGBA project, as also described briefly below:

1. Implement IGBA in a commercial DBMS.—A number of participants in IGCP 239 have been developing working versions of the IGBA in dBase, probably the most widely used DBMS on IBM-PC and compatible microcomputers. A major advantage of this approach is that users experienced with dBase can make immediate use of a full working version of the IGBA. The corollary of course is that those without access to dBase or who are unable to use the program efficiently are not so well served. Even the relatively modest cost of dBase might restrict its promulgation in many of the Eastern Bloc and Third World countries who participated in IGCP 239. Even dBase devotees will also probably admit that this particular DBMS has a steep learning curve, requiring an 'assistant' program for the inexperienced. Another disadvantage, not restricted to dBase, is that any commercial DBMS is itself changed outside the control of the user, requiring the development, coordination, and distribution of constant updates to maintain complete compatibility across users and to make use of significant new features. Furthermore, dBase is by no means the only major DBMS on the PC market; the equivalent project to IGBA in the sedimentary area (IGCP 296—SEDBA) has already decided to use a quite different DBMS, Paradox. Meanwhile, other major national and international geological data bases are being made available in different packages again, such as Oracle (for example, the Australian Bureau of Mineral Resources' interlinked data bases on igneous rock analyses (PETCHEM), mineral deposits (MINDEP), and others). Although Oracle has the advantages of being an international de facto DBMS standard, and providing power support for distributed data bases, structured queries (via SQL), and so forth, it is even more complex and expensive than dBase. In short, the use of a full-featured commercial DBMS tends to restrict the applicability of any working data base to those relatively few experts who have the particular software, and it may promote a proliferation of mutually incompatible and unintelligible versions of the same or of related data bases. Although, in theory, any data base can be translated between different DBMS via ASCII, this is still a complex task that requires the rebuilding of all the more sophisticated features of the data base other than the raw data themselves (including all input-output procedures, preset queries, validation routines, and so forth). The inevitable conclusion is that this approach is limited in IGBA terms to platforms where a single DBMS has not only achieved the status of a standard, but is also widely available at reasonable cost. These conditions are probably met for PC-users, who have as a result achieved considerable success in implementing IGBA via dBase; for the reasons elaborated below, we believe neither is met with the Macintosh.

2. Use public domain DBMS or DBMS-like programs.—A number of such programs are now available free, either with hardware or via networks and bulletin boards. One of the most exciting examples is Apple's Hypercard, an information managing program currently available free with Macintosh microcomputers. Hypercard allows the creation of 'stacks' of interlinked 'cards' (or screens) of information, in an approach that mimics some features of a DBMS. It has its own full-featured Pascal-like programming language (Hypertalk), which can itself be compiled. There has been quite an explosion in the development of geological 'stackware' using Hypercard, which now extends to numerous stacks on paleontology, mineralogy, and petrology in particular (Rock, 1991). The advantages of this over approach (1) are twofold: such

programs (notably Hypercard) tend to be far simpler and easier to use than a full-featured DBMS, and they are free. For example, Chayes (1991) has already described a simple Hypercard IGBA decoder, IgbaHyp, that takes the raw IGBA format of small subsets from the data base and writes them in a more intelligible tabulated form; the reverse direction is also possible.

3. Develop DBMS source code.—Developing a new DBMS effectively from scratch was the only practicable approach with all the early petrological data bases (for example RKNFSYS from Chayes 1982; CLAIR, PETROS from Le Maitre, 1982; and with IGBA itself, until recently). The FORTRAN source code still made available with the IGBA base is also free, and it can be implemented by anyone with a modicum of programming knowledge (and the relevant FORTRAN compiler) on any computer. It can also, of course, be adapted and recompiled to individual user's requirements, with commensurate forfeit of interchangeability. For the many geologists lacking programming expertise, compiled versions can easily be made available, in theory, for particular machines. The disadvantage of this approach is that the full sophistication of a commercial DBMS is simply not available without Herculean programming effort—and the experiences of geological organizations have been that such an effort is rarely, if ever, cost-effective when commercial microcomputer DBMS are now available off-the-shelf for the cost equivalent of a few days' programming.

4. Run-time version.—An approach that to some extent combines some of the above is available with some (but not all) DBMS, in which a data base is made available in compiled (executable) form. With some commercial DBMS (for example, 4th Dimension for the Macintosh), the interested user is only required to possess a run-time version of the DBMS itself, which is far less expensive than the full version; with some others (for example, Clipper for PCs), even this is not required, for the run-time data base is a self-contained, compiled program. The downside of this approach is that the run-time program cannot be adapted, modified, or improved in any way by its recipient.

Towards a Macintosh version of the IGBA

The Apple® Macintosh® series of microcomputers has spread rapidly in the world of geoscience—particularly in academia—primarily because of their exceptional ease of use. Matters have now reached the point where any self-respecting, internationally oriented product such as the IGBA needs to be available for the Macintosh, as a matter of course, as well as for PC and mainframe platforms. In working towards such an implementation of the IGBA, all four above approaches were first considered in detail. On the basis of substantial previous experience in erecting other geological data bases via commercial Macintosh software (for example, Rock and others, 1990), it was decided that approaches (1) and (2) were not the best for a full retrieval program for the IGBA, on the following grounds.

- Among the various DBMS available for the Macintosh (reviewed in depth by Wheatley and Rock, 1989), none has achieved the wide dissemination of dBase or even Oracle or other platforms; the choosing of one particular Macintosh DBMS would therefore inevitably restrict a Macintosh IGBA to an unacceptably small audience.
- These programs, though sophisticated and powerful, tend to be rather slow in operation and have a steep learning curve (at least in relation to other Macintosh software).

- Completed self-contained run-time versions are not possible; a package must always be bought.

As indicated above, approach (2) of the previous section has already been tested using Hypercard (Chayes, 1991), which has proved to be a remarkably effective medium for a base-building (editing) program. However, we believe, along with Chayes himself, that it is likely to suffer from certain drawbacks if used for a base-exploiting (retrieval) program, on the following grounds:

- The very substantial programming overheads associated with the user-friendly Hypercard interface mean that the program operates even more slowly than the Macintosh DBMS; in practice, Chayes (1991) estimates that it would require 7–8 hours just to load the current about 15,000 samples (records, rocks) in the IGBA into IgbHyp, and retrievals cannot be performed until this has been done.
- The same overheads make the storage space of even relatively simple Hypercard stacks substantially (about 50 percent) larger than their precursor ASCII files. Although, as already indicated, storage is not the problem it once was, it does mean that the size of a stack containing the full IGBA base would be over 8 Mb, whereas a specially written program could work on the original ASCII files (5.5 Mb).
- Hypercard's programming language is not intrinsically designed to handle numerical queries of the type likely to be required routinely by IGBA users (for example, locate all analyses with $\text{SiO}_2 < 50$ percent), primarily because it handles numbers as character strings and not as real numbers or integers; although Chayes (1991) has found that retrievals are still far more effective than might in principle be expected, there is still little doubt that Hypercard will be more cumbersome for many types of retrievals than a program written in any general purpose language.

For the above reasons, approaches (3) and (4) of the previous section have been adopted. In fact, these two approaches merge here, because the Macintosh is such a special case. Source code written for this machine is both extremely difficult to write (which reduces the number of experienced geologist practitioners to a very select fraternity!) and cannot be ported readily to other machines (or vice versa), because much of the code is taken up in implementing the many features of the WIMP (Windows, Icons, Menus, Pointers) interface.

Introduction to the MacIGBA program

The main aim of the present work has been to make available a user-friendly, stand-alone (run-time) program that decodes and interrogates the IGBA and that can be used almost immediately by anyone having a Macintosh. The source code was written in Think's Light-speed Pascal™ version 2. We freely admit that in providing a free Macintosh program we have not overcome the problem of promulgating the IGBA among those lacking the necessary Macintosh hardware. However, we believe this is a step in the right direction.

The MacIGBA is not a complete DBMS, because it deliberately does not deal with one of the most demanding parts of a data-base job—the building, correcting, extending, and updating of the base itself. The reasons for this are discussed below. The MacIGBA is instead restricted to three important functions that allow anyone to use the base but not to change it: (1) to decode and display IGBA data in natural (geological) language; (2) to search for samples that match specified criteria such as rock-type, chemistry, mineralogy, and geographical or geopolitical location; (3) to extract (export) subsets of the base, either in the standard IGBA format or in a format more suited to processing in other Macintosh applications such as statistics or spreadsheet programs. The next section explains how to perform these three functions in turn. The Appendix performs the

function of a reference manual, briefly explaining each of the menus and menu items in the MacIGBA program in sequence.

Four, and in some cases five, files are required for the MacIGBA to operate [items (1) to (4) should be together in the same folder, whereas item (5) can be anywhere]:

1. The MacIGBA (the main application).
2. Refs.text (a file containing bibliographic source material, which corresponds to file IGBAREF4 in the current tape version of IGBA).
3. IGBA Codes (a folder containing six separate index files that are used to translate between IGBA codes and their decoded full-text equivalents). Programs have been written for building these index files from simple ASCII input files.
4. An optional index file for the data-file being searched. This has the syntax "filename.index," and its use is explained below.
5. An ASCII data-file in IGBA format, which may be the complete base or a subset, as required. This must have only carriage-return-terminating lines, as is standard in the Macintosh world, and not carriage-return/line-feed pairs, as is normal in the PC world. (Many public domain conversion programs are available to interconvert these alternative formats, such as File Filter).

Although many operations in MacIGBA work on a sequential-file basis, three specific operations require prior creation of the filename.index file (4) above, namely: returning to the previous record; going to a particular (numbered) record; and saving a file of trace element data in Macintosh format. This index is specific to each IGBA file (complete base or extract) but does not have to be created each time a given IGBA file is interrogated. Once created, it can be moved between machines in the normal Macintosh way, provided it resides in the same folder as its parent file. If such a file does not exist at the time a given data-file is opened, MacIGBA will ask (see fig. 4) whether it should be created straight away (indexing the complete IGBADAT41 on a MacIIx takes under 3 minutes). If one of the three specific operations is requested, when an index file has still not been created (or cannot be found in the correct folder), the same dialog box will appear. If "cancel" is selected, the specific operation will be aborted.

The reason MacIGBA does not include a data-base building or editing facility is that the IGBA was designed to be centrally handled via the IGBA office and distributed via World Data Center-A; it is therefore essential to retain only one "clean" master copy, at all times, that incorporates all corrections and additions to the date of general issue. To build an editing facility in MacIGBA would tempt users into creating innumerable variants of this master copy, which would then be impossible to coordinate.

Throughout the remainder of this text, menus within MacIGBA are identified by <angle brackets>, individual menu items by {curly brackets}, buttons and icons by [square brackets], and keyboard keys by |vertical brackets|.

Browsing through decoded IGBA data

Launching MacIGBA results in the presentation first of a startup screen (fig. 1) and then of a standard Macintosh dialog box requesting the user to choose the input IGBA-format data-file, which may be a subset or the complete base (fig. 2). This dialog can be returned to at any time to choose a new IGBA data-file. If the data-file is not in the correct IGBA format, a warning message is presented (fig. 3) and the process aborts. The user is also asked whether an index should be created at this stage, if one does not already exist (fig. 4). After this, the first record in the chosen data-file is decoded and the data for that sample displayed (fig. 5).

Figure 1.—Start-up screen for MacIGBA.

Figure 2.—Standard Macintosh dialog initiated on startup, for choosing the name of the input IGBA-format ASCII file.

The top of figure 5 displays general information. If an index file already exists, the sequential number of the sample in the data-file will be displayed at the top-center (as in fig. 5). Other information includes both the rock-type as specified in the original reference, and the IGBA number and corresponding rock-name. Remaining information is displayed in lists, most of which are scrollable. The left-hand list contains the major oxide analyses, the author's total, and a calculated total as a check (the sum of the major oxides—note that discrepancies as in figure 5 are horrendously common!). The upper central list contains any decoded trace element data. Analyses shown as "element>?" signify that only a trace of the element was detected. A figure in brackets to the right of an analysis identifies the bibliographic reference from which the analysis is derived. The same convention is used in other lists. The right-hand list decodes the minerals identified in the specimen. Any mineral information flags are expanded into descriptions appended to the mineral name. All remaining information is displayed in the bottom-right list. This includes status, age, petrographic descriptors, and additional information. Wherever possible, codes used in the IGBA are expanded into normal geological English. However, text in any of the lists may be truncated if there is insufficient space for it to be displayed;

Figure 3.—Warning message indicating that the chosen data-file is not in the appropriate IGBA format.

Figure 4.—Dialog box asking whether to generate an index file.

clicking on any line of information in a list will then display the unabbreviated text at the bottom of the window.

Three icons are displayed on the right of figure 5. The [book-icon] accesses source reference data (fig. 6), which are presented in the IGBA as two record preface cards preceding each block from the same source reference(s). Each reference is numbered and provides a cross-reference to the displays in figure 5. The [next record] icon (arrow) displays the next record in the active data-file that matches any search criteria that have already been set (see next section), or the next sample sequentially if none have been set. The [globe] icon displays a small world map with crosshairs revealing the sample location (fig. 7). The original IGBA ASCII format from which figure 5 is decoded can also be viewed (fig. 8). This can be useful to check whether a possible error in interpretation is in fact an error in the IGBA data-file.

Searching the IGBA

Eight retrieval mechanisms are provided in MacIGBA, described below. Any number of these can be active at once, in which case they are chained (that is, separate criteria are Boolean ANDed together). The one conceivable type of IGBA searching currently awaiting implementation is searching based on sample age; this reflects the complexity of the required parsing in IGBA and the need to devise an "intelligent" module to handle it. We hope to implement age searching in later versions.

- **Searching by rock-type (fig. 9).**—The window displays two scrolling lists of names. The left-hand alphabetical scrolling list contains all the names used in IGBA, while the right-hand is initially empty. Copying one or more of these names into the right-hand list specifies the rock-type(s) to be located. Clicking on

IGBADAT41			
Specimen: AA A		Sequence no: 1	
Location: 38.500N 15.000E			
Rock type: OBSIDIAN			
Unit: ROCHE ROSSE, LIPARI			
Rock name: 2500: Obsidian			
SiO2	74.22	Zr=350ppm [1]	Orthoclase (microclitic)
TiO2	0.11	Cl=300ppm [1]	Quartz (microclitic)
Al2O3	12.98	Ba>0 [1]	Glass
Fe2O3	0.40		
FeO	1.60		
MnO	0.01		
MgO	0.04		
CaO	0.67		
Na2O	4.13		
K2O	4.97		
P2O5	0.14		
CO2	•		
H2O+	0.27		
H2O-	0.04		
Total	99.74		
Calc. T	99.58		
		Location to nearest tenth of degree only	
		Some essential oxide(s) not determined	
		flow, glassy, microclitic, fresh	
		Nuisance component(s): SO3=BP4,1	
		specific gravity info: 2.370	
		Refractive index info: RF=1.488-9	
		Contributor's comment: TRACES IN AUTH-TOT

Figure 5.—The main display window for the first sample (record, rock) in the complete IGBA base (file IGBADAT41). See text for explanation of lists and icons on right. Note that missing data (in this case for CO₂) are automatically decoded to the standard Macintosh "bullet" character (ASCII code 165, keyboard option-8), so that MacIGBA preserves the distinction between "not analyzed" (missing data) and "not detected" (analyzed but below detection limit).

Record Identifier: AA	
LAVAS OF LIPARI, ITALY	
Latitude: 39N	Contributor: BARKER, D.S.
Longitude: 15E	
References:	
<div style="border: 1px solid black; padding: 5px;"> [1] Washington, H.S., 1920 The Rhyolites of Lipari American Journal of Science, v. 200, p. 446-462 </div>	
<div style="border: 1px solid black; border-radius: 10px; padding: 5px 20px; display: inline-block;">OK</div>	

Figure 6.—Window displaying bibliographic data for the sample displayed in figure 5.

[OK], followed by the [next sample] right-arrow icon in figure 5, which then reappears, will then begin the search for the next record that actually matches these rock-type(s). Note that the active file is searched sequentially from the current position; an option is included to return to the top of the file as required. If several rock-types are chosen, as in figure 9, the search is a Boolean .OR. (that is, samples matching any of the chosen rock-types are selected), because of course a given sample cannot correspond to more than one rock-type.

- **Searching by location (fig. 10).**—The window displays the same map as in figure 7, but rectangle(s) can here be drawn to select search region(s). This method works well for continents and large or isolated countries (for example, Antarctica, Australia, New Zealand, North America), and for some oceanic islands, but it is not really effective for small, densely packed, or irregularly spaced countries (for example, Belgium, Liechtenstein), which are better located using the place-name method described below and in figure 13.
- **Searching by major element composition (fig. 11).**—Minimum and maximum values can here be entered for one or more oxides (fig. 11). Only samples whose chemistries lie within the specific-

drange(s) will then be located. When more than one oxide has been specified, the search is a Boolean .AND.—that is, all of the oxides must be in the specified range. A Boolean .OR. (that is, at least one of the oxides in the range) is easily done via separate searches, one oxide at a time. Combinations of .AND. and .OR. have not been implemented in this or other MacIGBA search mechanisms, because of ambiguities that would unavoidably arise in any menu selection format.

- **Searching by mineral assemblage (fig. 12).**—Selecting by mineral is slightly more complicated than selecting by rock-type, because of the fact that the IGBA codes minerals hierarchically (for example, N=feldspar, NF=microcline). The windows in figure 12 display three lists: one each for mineral groups (top left) and species (bottom left), and one for items selected (right). Initially, only mineral groups will appear in the top-left list, with the other two lists empty. If any mineral group (one-letter code) is then selected in the top-left list, its constituent mineral species (two-letter codes) will appear in the bottom-left list (fig. 12A). Names can then be copied across from the left to the right lists in a similar manner to the rock search procedures, described above. If mineral group codes are copied across, records with either the mineral groups or any of their constituent mineral species will be retrieved; if mineral species codes are copied across, only records with those species will be retrieved (as in fig. 12A). A pair of radio buttons (bottom of fig. 12) allows specification of whether the located rocks should contain all of the nominated mineral groups/species (.AND.), or at least one of them (.OR.). Finally, [Lookup] enables direct searching of the IGBA mineral code index itself (fig. 12B).
- **Searching by place name (fig. 13).**—Searching by place name is similar to selecting by mineral assemblage. Most of the records in the IGBA data base have their location coded using another hierarchical scheme called FIPS (NBS, 1990), which encodes all the world's geopolitical regions and subregions (countries, states, island groups, and so forth) by the use of four letters (the first two for major regions like countries (for example, US for USA), the other two for subdivisions like states (for example, US06 is California). The window (figure 13) initially displays two-letter codes and country names in the top-left list, selecting on any of which will bring up that country's constituent states, provinces, and so forth, in the bottom-left list, as in fig. 13A. As with mineral searches, [Lookup] enables direct interrogation of the complete FIPS code index (fig. 13B). Unlike mineral searches, however,

Figure 7.—Window showing the location of the sample displayed in figure 5.

'A' card:	
RZYVHA 37750N 14990E	PHONOLITIC TEPHRITE ETNA-HISTORIC LAUAS AFTER 1971
'B' card:	
RZYVHB 1 4820 1271790 659 366 016 604 883 456 194 055	072 00410046 3515
Data from other cards:	
1D,20,4A,4B::1974AD,1:AV,FP,1B:N4,R64,SC74,US74A,UAA,UB4:(XPT03):	
OK	

Figure 8.—Window showing the original IGBA-format ASCII record for the sample displayed in figure 5.

Figure 9.—Window for defining target rock-types. Three alternative rock-types have been selected here (Kimberlite or Lamproite or Lamprophyre). Rock-types are selected from the left-hand scrolling list by clicking on the name, by using the $\uparrow$ or $\downarrow$ keys on the keyboard, or by typing the first few characters of the rock-type on the keyboard. The name is then copied across by clicking the [= >] button or by hitting return. Rock-types can be removed from the right-hand list by selecting them, then clicking in the [Remove] button. When the appropriate rocks have been selected, clicking the [OK] button (or [enter] key) will confirm the selection and return to the main sample window (fig. 5). Hitting the Enter key is equivalent to clicking [OK].

Figure 10.—Window for defining target areas. Two alternative areas have been defined here: Australia or New Zealand. One rectangle is drawn by clicking and dragging with the Macintosh mouse in the usual way. The shift key is held down to drag out more than one rectangle, as here.

Figure 11.—Window for defining target major oxide chemistry. This example locates rocks with both SiO_2 , in the range 10–20 percent, and MgO , in the range 20–50 percent. The $\uparrow$ or $\downarrow$ keys can be used to move up and down the list of oxides, and the [return] or [tab] keys to move between the minimum and maximum values. Hitting Enter is equivalent to clicking [OK].

A

N : FELDSPAR
 O : FELDSPATHOID
 P : PHYLLOSILICATE
 Q : AMPHIBOLE/AMPHIBOLOID
 R : PYROXENE/PYROXENOIDS
 S : OLIVINE
 T : OTHER SILICATE
 U : OXIDE

N1: Albite
 N9: Other Feldspar
 NA: No mineral info.
 NB: Feldspar
 NC: Alkali feldspar
 ND: Anorthoclase
 NE: K-Feldspar
NF: Microcline

ND: Anorthoclase
 NF: Microcline

☐ Find rocks containing all of the selected minerals
☒ Find rocks containing at least one of the selected minerals

OK Cancel

B

N : FELDSPAR
 O : FELDSPATHOID
 P : PHYLLOSILICATE
 Q : AMPHIBOLE/AMPHIBOLOID
 R : PYROXENE/PYROXENOIDS
 S : OLIVINE
 T : OTHER SILICATE
 U : OXIDE

NB: Feldspar
 O : FELDSPATHOID
 OA: Feldspathoid

☐ Find rocks containing all of the selected minerals
☒ Find rocks containing at least one of the selected minerals

OK Cancel

Feld

Figure 12.—Window for defining target mineralogy. A, Use of the hierarchical IGBA codes to specify rock containing either anorthoclase or microcline. B, Use of the [Lookup] button to locate all minerals in the IGBA system with the four-letter character string "Feld." Clicking on any mineral group in the top-left list will reveal corresponding mineral species in the bottom-left list. Similarly, clicking on any entry in the right-hand list will generate corresponding entries in the other two lists. Items can be added to the right-hand list by selecting in the left-hand lists and clicking the upper or lower [=>], and removed by selecting in the right-hand list and clicking [Remove]; standard shift-click Macintosh operations will select a range of items. Typing Return is equivalent to clicking on [Lookup] and typing [Enter] to clicking on [OK].

Figure 13.—Windows for locating target source localities from the FIPS code. A, This example will locate rocks from Western Australia. Australia has been chosen in the top-left window, which automatically brings up all constituent States and Territories of Australia in the bottom-left window for selecting into the right-hand window. B, Here, [Lookup] has been initiated for the word “West,” which has located all FIPS items with this character string.

Figure 14.—Window for defining target trace element data. This example locates rocks with data for Au or Ag or Pt.

Figure 15.—Window for targeting specific IGBA status codes. As in previous windows of this type (figs. 9, 12, and 13), selecting an item in the left-hand scrolling list and clicking [Remove] will move it to the right-hand list. Clicking [OK] (or typing [Enter]) will then confirm the selection and return to the main window (fig. 5).

copying several entities to the right-hand list will always result in a Boolean .OR. search, with rocks from any one of the nominated regions/subregions being selected; an .AND. search is clearly absurd here, as a sample cannot be from several places at once.

- **Searching by trace element analyses (fig. 14).**—This option displays a periodic table, from which any element(s) can be selected. Rocks that include analyses of the selected trace elements will then be located. As with searches by oxide and mineral assemblage, retrievals can be on all of the selected trace elements (Boolean .AND.), or on at least one of them (.OR.). Note, however, that this search method simply determines the existence of data for a particular trace element(s); it does not allow searching by range of value (see fig. 11).
- **Searching by status codes (fig. 15).**—The IGBA specifically flags certain types of information (or, more commonly, missing information) about a sample record using a two-character status code: for example, imprecise locations (1A, 1B, 1C), major element data normalized to 100 percent (2B), H_2O^- = loss on ignition (2G), or as in figure 15, rocks with no petrographic information given (4J). This option allows all records with a particular status code to be located.

Figure 16.—Window for targeting additional information tags. This example selects rocks with either specific gravity or refractive index information. The corresponding tags XD, XX have been inserted automatically by MacIGBA.

- **Searching by additional information (fig. 16).**—The final section of an IGBA data record contains an additional information list. Each item is categorized by a two-character tag (for example, XD—specific gravity data or XI— isotope data), and MacIGBA can locate records with any specified tag. The tags for four common items in the additional information list can be selected easily by clicking in the four check boxes labeled isotope, specific gravity, modal analysis, and refractive index (fig. 16). This will then automatically insert the appropriate tag codes into the edit box. Other codes can be typed in, as required, by reference to the full code list enumerated in IGBA Circulars. Each tag should be separated with a comma. For example, Deep Sea Drilling Project-samples can be located by searching for additional information tags "XS" and "S* ". The search here is Boolean .OR.—at least one of the specified types of information must be present.

Extracting an IGBA subset

The third of the MacIGBA functions, saving a subset of IGBA, will write data for all samples from the current file that match the current

Figure 17.—Dialog box for exporting a subset of the active data to a new output file. The output file format is here set to IGBA, to create an IGBA-format ASCII data-file.

Figure 18.—Dialog box for selecting what information is output to a new Macintosh-format export file.

search criteria (preset via figs. 9–15) to a new file. A standard Macintosh file selection dialog box is first displayed to set the name of the export file (fig. 17). The new file format can also be specified here. Two formats are provided:

- IGBA format—An ASCII file in the standard IGBA coded format (see fig. 8). This is the only file format that can be read back into MacIGBA for subsequent processing.
- Macintosh format—A tab-delimited Macintosh file containing names of the variables (SiO_2 , Ba, and so forth) in a first label line, followed by data in subsequent lines, one line per sample. This same format is also used by most recent Macintosh software, geological or otherwise, including that developed by the present authors (for example, Wheatley and Rock, 1988). Major elements are listed first, then trace elements (if selected) are listed alphabet-

Figure 19.—Dialog box for setting creator signature for Macintosh output files; default (shown) is EDIT (that is, ASCII "TEXT" file). Other useful types are STAT (Statview), CRGF (Cricket Graph), XCEL (Excel), and MSWD (Microsoft Word).

ically. Samples with no data are omitted. Values of "<X" are coded as 0 ppm. Missing data for a particular element are coded as "•" [ASCII 165, the standard Macintosh code for missing data].

If Macintosh format is selected, a further dialog box (fig. 18) allows the user to determine which of the many IGBA information fields is exported. The creation of a new file containing trace element data is a two-pass process through the data file: on the first pass, the number of different trace elements analyzed in the matching samples is determined; and on the second pass, the data are actually written to the export file. The export can be interrupted at any time by use of the standard Macintosh [control-full stop] sequence. Whether an export is allowed to proceed to completion or not, the user is automatically informed how many records have been written to the new file.

Exported Macintosh files are written by default with creator signature "EDIT" (that is, Macintosh ASCII "TEXT" format) and can be opened directly and used immediately by Edit, itself, by any text-editor like QUES/M, or they can be imported into any Macintosh data-processing application with a reasonably intelligent text-file import procedure (for example, Data Desk, Excel, or Statview II). In the latter case, the file must be opened from within the application rather than by double-clicking on the file itself. Other creator signatures can be selected using a {Preferences} option (fig. 19), provided the user knows the defined Macintosh code for that particular program. For example, typing STAT in the box on figure 19 will create an output file that Statview will recognize and be able to open directly upon double-clicking the file itself, rather than having to import the file from within Statview. Figure 20 shows a file resulting from the dialogs in figures 16 and 17, after importation into Statview via either method.

Exactly what will result from double-clicking directly or importing indirectly does depend to some extent on the application being used. For example, Statview is sophisticated enough to recognize the initial label line in the MacIGBA export file as containing the names of the variables (columns) that will then become headers to the file (fig. 20), whereas Cricket Graph and Excel cannot distinguish labels from data and will place the labels as data in row 1 of their spreadsheets. Some other applications cannot deal with initial label lines at all and throw up errors on import; in such cases, creator signature "EDIT" should be used and the initial label line edited out first (for example, in Edit).

IGBA Australia																	
	Seqe...	Location	Rock Type	SiO2	TiO2	Al2O3	Fe2O3	FeO	MnO	MgO	CaO	Na2O	K2O	P2O5	CO2	N2O+	Total
1	301	NSW	Teschenite	44.78	2.49	14.03	4.15	9.15	.14	9.57	8.12	3.30	1.77	.62	*	2.05	100.31
2	302	NSW	Teschenite	44.73	2.58	14.42	2.93	9.51	.15	8.08	8.31	3.60	1.96	.64	*	2.89	100.03
3	320	NSW	Basalt	45.63	2.04	14.54	1.98	10.21	.19	9.18	9.83	3.46	1.04	.50	*	1.09	100.25
4	321	NSW	Basalt	42.07	2.57	11.24	5.08	7.92	.18	8.81	8.53	3.66	.32	.57	.21	5.12	100.05
5	322	NSW	Basalt	46.80	2.61	16.93	1.76	7.99	.12	5.32	10.88	3.95	1.00	.54	.07	1.40	100.67
6	323	NSW	Dolerite	46.97	3.49	15.04	2.59	9.12	.16	2.56	6.82	6.54	2.12	1.26	.10	2.86	100.17
7	324	NSW	Dolerite	48.50	3.04	15.53	2.90	8.28	.15	4.45	10.14	3.90	1.05	.66	*	.98	100.03
8	841	Tasmania	Granophyre	57.70	1.43	15.16	3.76	7.54	.20	1.20	6.56	2.65	1.82	.21	*	1.87	100.42

Figure 20.—Extract of a Macintosh file exported from MacIGBA using the dialog in figure 18 and then imported into Statview II. Samples are those from Australia. Each column (field, variable) is separated by a tab character (ASCII 13), each sample (row, record, rock) by a carriage-return (ASCII 9). The initial label line in the MacIGBA export file is automatically recognized by Statview

as containing the names of the variables and is therefore read as column headings rather than as part of the data. Double-clicking on the exported file is sufficient for Statview to recognize and launch it. Note that missing CO₂ data are distinguished by bullets, as in figure 5.

Speed and storage requirements

In order to estimate its general usefulness to the global community, MacIGBA has been briefly tested for speed. To optimize speed, two versions have been written for Macintoshes with and without coprocessors. To search through the entire current data base (IGBADAT41) of 14,722 records currently takes a little under 3 minutes on an 8 Mb Macintosh IIfx (using 881 version of MacIGBA), running the base from an external hard disk, and just over 7 minutes on a standard 1 Mb Macintosh SE (using normal version), running the base from a PL/I removable hard disk. Searching for a place name similarly takes about 6 minutes on the IIfx and 26 minutes on the SE. These times are considered acceptable for meaningful interaction and extraction from IGBA and will of course be substantially shortened on faster machines or on subsets of the base. Because the files have to be searched sequentially, matters are obviously speeded up if the samples required happen to be nearer the top of the active data-file.

As the complete IGBADAT41 ASCII base itself occupies about 5.5 Mb of disk space, MacIGBA can clearly only interrogate it on a Macintosh equipped with a hard disk, although subsets of 1.4 Mb or less (800 k or less for older machines) will of course be usable from floppy disks. The MacIGBA software itself only requires 68 k of disk space and a recommended 500 k of RAM, but the Codes folder and Refs.list files require an addition 324 k, so running on a standard dual-floppy 1 Mb Macintosh is clearly asking a good deal of the machine!

Availability

Disk copies of a B-release of executable MacIGBA, sample IGBA data files, and this paper are available free of charge to any interested user, on receipt by the authors of at least one Macintosh 3.5-in. diskette, plus an addressed envelope, and US\$10 (to cover costs of reproduction and postage only) in an international postal coupon or nominal funds in exchangeable currency (for example, US\$10 note, no personal checks please). Users in the USA can obtain copies, under the same preconditions, from Professor F. Chayes (Chairman, IUGS Subcommittee on Data Bases for Petrology, Smithsonian Institution, Dept. Mineral Sciences MS119, Washington, D.C.

20560, USA, e-mail: chayes@simsc.bitnet) or Dr. J. Frizado (Chairman IGBA project, Dept. Geology, Bowling Green University, Ohio 43403, USA; e-mail: frizado@andy.bgsu.edu). When the program has been adequately B-tested, it is hoped that MacIGBA will be distributed along with the IGBA itself, which is already available from World Data Center-A, NOAA/NGDC, Building E/GC3, 325 Broadway, Boulder, Colorado 80303-3328, USA. Macintosh-readable copies of the complete IGBA base are unfortunately too large to be sent even on 1.4 Mb diskettes (even in compressed format), but they can easily be extracted from the magnetic tape available from World Data Center-A. The possibility of eventual distribution on CD-ROM is being looked into.

Explanation of individual menus and menu items in MacIGBA (in order of appearance)

The complete menus and their contents are displayed in figure 21. Some items are permanently disabled (greyed out), such as all except <Copy> in the <Edit> menu, but depending on the precise situation, others may be enabled (black) or disabled (grey), as explained below.

<File> menu

{Open data file}—Displays a standard Macintosh file selection dialog box for selecting an input file (fig. 2). The file must be an IGBA-format ASCII file with carriage-returns only at the end of each line; if this is not the case, a warning message is presented (fig. 3). This item will be disabled (greyed out), as in figure 21, once a file has been successfully opened. At present, only one IGBA ASCII-format data-file can be opened at once, so this menu will be dimmed, once such a file has been opened.

{Close data file}—Closes the active IGBA file (the one whose window is frontmost). The standard Macintosh close box in the top-left of the active file's window will perform the same function.

{Index data file}—If an index file already exists for the active data-file, this menu item will be disabled, as in figure 21. If not, this item initiates a dialog (fig. 4) to generate such an index, as is required by some of the retrieval operations (previous sample, go to sample, and saving trace element data in Macintosh format).

Figure 21.—The main menu bar and contents of the four MacIGBA menus.

The same dialog will also be automatically initiated the first time one of these operations is selected and an index file for the selected data-file (filename.index) cannot be found.

{First sample}, {Previous sample}, {Next sample}—These perform exactly the same functions as the equivalent menu items in Hypercard: namely {first sample} reads the very first (top) sample (record) in the active file, {next sample} reads the next sample record sequentially, and so forth. Note the difference from the {Next sample} here, which goes to the next sample *irrespective of any selection criteria*, and the {next sample} right-arrow icon in figure 5 or its equivalent {next matching sample} item in the <Display> menu (fig. 21), which select only the next sample that fulfills the current selection criteria, skipping those that do not. The {next sample} and {next matching sample} items are equivalent only if no search criteria have been specified. {First sample} can be used to return to the top of the active data-file when making a new search, or when completing a search that began in the middle of the active data-file. {Go to sample} will achieve the same result (see next entry). There is currently no direct option for selecting “last sample,” as in Hypercard, since this would not seem to be a particularly useful operation in MacIGBA. However, it can be simulated by selecting {Go to sample} (next entry) and choosing a large number (that is, larger than the number of indexed samples in the file).

{Go to sample, ...}—Initiates the dialog in figure 22, allowing direct access to a particular sample in the file. This can also be used to locate the last sample or the total number of indexed samples in the file, simply by responding with a large number.

{Save as, ...}—Initiates the dialog in figure 17, for saving samples from the active IGBA file as a separate file, in IGBA or Macintosh (tab-delimited) format (use the pop-up menu at bottom of figure 17 to determine format). If no selection criteria have been specified, the entire active file will be saved. If selection criteria have been specified, the menu item changes to

{Save matching samples as}, and only samples matching the criteria will be saved. If Macintosh format is chosen, the dialog in figure 18 will also then appear, to determine what extract of information will be exported to the new file (see text for further details).

{Preferences, ...}—Initiates the dialog in figure 19 for choosing the filetype for a Macintosh output data-file. The default (as in fig. 19) is EDIT, a simple ASCII “TEXT” file, readable by Edit and many

Figure 22.—Dialog box for going to a particular indexed sample number.

other Macintosh programs, but any other defined Macintosh four-letter signature can be inserted here (for example, XCEL for Excel, STAT for Statview, CRGF for Cricket Graph, MSWD for Microsoft Word), whereupon any output files will be readable by the chosen program. The set preferences are not saved when the user quits the program.

{Quit}—Quits to the Macintosh Finder in the usual way.

<Edit> menu

Only the {Copy} menu is enabled. This will copy any selectable highlighted item to the clipboard in the usual Macintosh way. For example, in figure 13A, selecting this item would copy AS: AUSTRALIA to the clipboard.

<Find> menu

Items actively selected from this menu will have a ✓ next to them.

{Rock type}—Initiates the dialog in figure 9, for selecting specified rock-types from the active IGBA file.

{Location}—Displays the world map in figure 10, for selecting samples from specified regions from the active IGBA file. Use the Macintosh mouse (click-and-drag) to specify rectangular areas.

{Majors}—Initiates the dialog in figure 11, for selecting samples with a specified range of chemistry from the active IGBA file.

{Minerals}—Initiates the dialog in figure 12, for selecting samples containing a specified mineral or suite of minerals from the active IGBA file.

{Place name (FIPS code)}—Initiates the dialog in figure 13, for selecting samples from specified geographic regions or subregions from the active IGBA file (based on their hierarchical FIPS codes as described in the text).

{Trace elements}—Initiates the dialog in figure 14, for selecting samples containing data for specified trace element(s) from the active IGBA file.

{Status codes}—Initiates the dialog in figure 15, for selecting samples containing specific status codes.

{Additional information}—Initiates the dialog in figure 16 for selecting samples with specified information tags from the active IGBA file.

{Clear finds}—Clears the current selection criteria (and removes the ✓ from beside the corresponding items above). Any subsequent operations (for example, exporting data) will be executed on the whole active IGBA file.

<Display> menu

- [Bibliographic data]—Reproduces the function of the [book] icon on the right of figure 5, namely brings up the bibliographic data for the current sample record (as in fig. 6).
- [Next matching sample]—Reproduces the function of the [right arrow] icon on the right of figure 5, namely searches for the next sample record sequentially in the active IGBA file that matches the current selection criteria (that is, those with against them in <Find> menu).
- [Sample location]—Reproduces the function of the [globe] icon on the right of figure 5, namely brings up a world map showing the location of the currently selected sample with a crosshair (as in fig. 7).
- [IGBA ASCII data]—Shows the original IGBA coded data-format for the currently displayed record, as in figure 8.

Acknowledgments

We thank Felix Chayes and Joe Frizado for comments on earlier drafts of this report.

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