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生物地层学图形对比软件包SinoCor 1.0*

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提要　用于生物地层学定量分析对比的软件包SinoCor 1.0采用Visual Basic 3.0程序设计语言编写，由三个主要功能模块组成：(1)数据输入、修改模块，(2)数据分析、处理模块，(3)数据输出模块。操作采用人机交互方式，运行于Windows 3.x图形环境下，功能完全菜单化。一次可分析、处理20个生物地层剖面、60个分类单元。

关键词　SinoCor 1.0　图形对比　Visual Basic语言　程序设计

1　前言

随着计算机技术的飞速发展，生物地层学在定量划分对比等方面产生了许多新的技术和方法，其中图形对比(Graphic Correlation)方法是当今国际上使用较多、效果较好的一种。该方法的原理和分析过程并不复杂，但由于涉及到大量的数据处理，手工操作不仅费时，而且容易出错，在处理过程中只要有个别数据运算出错，就会影响到整个最终结果，往往要从头运算。解决这一问题的最佳途径就是编制出计算机处理软件。

目前国外使用的现成软件主要有GraphCor(Hood，1986)和StratCor(Gradstein，1990)等，多数由工业机构开发，主要用于石油勘探中的井下生物地层对比。我国科技工作者除了需花费较昂贵的代价并通过特定途径购买外，在有些方面由于软件开发目的不同而无法取得理想效果。为此，笔者结合中国科学院95重点课题“奥陶系‘统’、‘阶’级全球界线层型剖面在中国的确立”的研究需要，从1997年下半年开始着手编制自己的图形对比软件SinoCor，主要目的是借助这一计算机软件，使研究中涉及复合对比的大量数据运算简单和精确，并使数据结果直观和图形化。由于很多生物地层工作者对计算机的原理和操作还不很熟悉，软件的操作必须简便、直观、易学。为此，在软件设计中采取了以下措施：(1)软件操作采用人机交互式，以便于使用者在操作过程中能了解工作流程，而且万一操作失误也容易纠正。(2)把软件做在Windows界面上，Windows在国内使用较为普遍，许多生物地层工作者也比较熟悉，同时，为了使SinoCor能在尽可能多的微机上运行，特别将它设计为适用于Windows 3.x版本(Windows 3.1和Windows 3.2)，而不是Windows 95或97。然而，由于Windows的向下兼容性，SinoCor 1.0理论上亦适用于Windows 95或97。(3)在编写语言上采用了图形功能较好、当前较为流行的Visual Basic语言，以便于以后把SinoCor 1.0扩充、完善为2.0版时，能较好地兼容1.0版的优良功能。(4)附有使用说明和操作手册。

SinoCor 1.0于1998年初已基本成形，随后进入调试和检验阶段，并对一些功能做了修改、补充和完善，全部工作于三月下旬结束。整个软件共包括三个主要功能模块：(1)数据输入、修改模块，(2)数据分析、处理模块，(3)数据结果的输出模块，实行流水操作。一次可分析、处理20个生物地层剖面、60个分类单元的数据量，可以满足目前大多数生物地层工作者的需要。

图形对比方法作为定量生物地层学研究的一种方法，除在中、新生代的井下地层分析对比中可以发挥重要作用外，在古生代地表露头剖面的分析和对比中同样达到令人满意的效果。SinoCor 1.0严格根据图形对比方法的原理和目标而设计，虽然设计

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的原始目的是针对奥陶纪生物地层,但作为一种地层分析方法的具体化和软件化,在各个时代含有化石的地层剖面的研究分析中都可以适用,并且行之有效。

笔者在研究过程中得到陈旭研究员的不懈支持,论文完成后又蒙詹仁斌博士审阅并提出了许多宝贵意见。本文初成后,曾在IGCP410项目1998年南京国际讨论会上报告,蒙项目负责人B. D. Webby教授和国际奥陶系分会主席S. C. Finney教授支持,均此致谢。

2 复合对比的原理和过程

单个剖面之间的生物地层对比存在许多误差。导致这些误差的因素至少有:(1)化石在地层中的不均匀分布,由于埋藏原因,某种化石的首次出现层位(FAD)或末次出现层位(LAD)在不同的剖面上可能存在差异。(2)剖面发育和出露程度的差异。(3)标本采集不全。(4)标本鉴定误差和同物异名、异物同名现象。(5)标本的异地埋藏。消除这些误差的方法有多种,复合对比是其中之一。

复合对比方法最早由Shaw(1964)提出,主要是通过对一个沉积盆地(或地区)内的多个生物地层剖面进行复合,建立综合整个盆地生物地层资料的复合标准序列。根据这一序列可以精确对比盆地内各个剖面,也可以与其他沉积盆地的复合标准序列进行精确对比。Miller(1977)对该方法进行了改进,使整个过程完全图解化。Edwards(1984)对该方法的可靠性进行了检验,证明是可行的,多个地层剖面中生物的复合序列比任何单个剖面的序列都更趋于真实。此后,该方法在生物地层学研究中得到了广泛应用(Sweet, 1984; Sweet and Tolbert, 1997; Kleffner, 1989, 1995; Cooper and Lindholm, 1990; Cooper, 1992; 张元动、陈旭, 1994; Zhang Yuandong, 1995; Carter *et al*., 1995; Grubb and Finney, 1995; Klapper *et al*., 1995; Macleod, 1995; Mann and Lane, 1995; Melnyk, 1995; Finney *et al*., 1996)。

复合对比的原理和过程简述如下。

1). 剖面原始资料整理。以地层的厚度为标度建立坐标轴,每一物种在地层中的产出主要由两个特征构成:Base——FAD的层位,Top——LAD的层位。据此统计、计算出每一剖面上所有物种的产出层位(Base和Top)、各剖面上的种数、每一物种在各剖面上的采集层数等,整理成二维图表的形式,以利于下面的分析。

2). 选择一个最佳剖面作为参照剖面。参照剖面的确立标准是:(1) 剖面代表的时间跨度最长;(2) 剖面出露最完整,构造简单,断层、褶皱少或无;(3) 化石最丰富,物种的分异度和丰度均较大,这可以通过比较每个剖面上每个种出现的层数之和——种层数来衡量,数值越大表明化石越丰富;(4) 采集最详细,这可以通过采集层数衡量;(5) 化石保存最好,鉴定最可靠。参照剖面的发育程度、研究状况、采集程度越好,在理论上造成复合分析误差的可能性就越小。

3). 根据相似的标准确定其余剖面的优劣顺序。

4). 投点、复合。以参照剖面为横轴,第二剖面为纵轴,将两剖面共有的种投入平面直角坐标系中,每一个种对应于两个坐标点,一个点以该种在两剖面上的Base为坐标值,一个点以该种在两剖面上的Top为坐标值。然后根据其中一些可靠的点计算剖面对比方程(correlation equation),求出对比线(LOC, line of correlation),再通过对比方程和对比线将第二剖面的数据投到参照剖面上,从而获得这两个剖面的复合标准序列CSS[1-2]。投影的具体步骤是,如果第二剖面上的某一个种的Base使参照剖面上该种的Base下移,或第二剖面上的某一种的

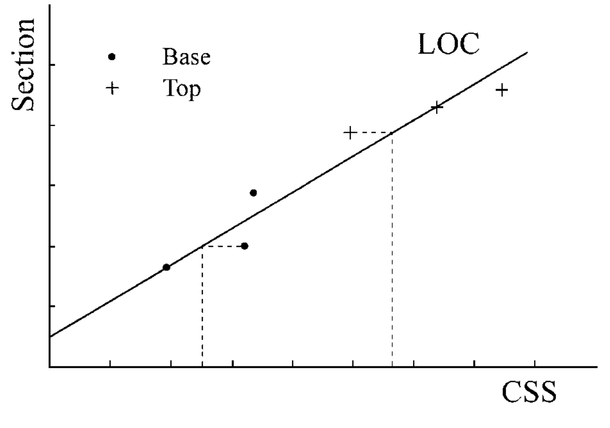


插图1 复合对比的原理示意图

Diagram illustrating the principle of graphic correlation

横坐标(CSS)代表复合标准序列,纵坐标代表参加该次复合的某一剖面,"•"和"+"分别代表某一分类单元的首次出现(Base)和末次出现(Top)

Abscissa represents composite standard sequence (CSS); Ordinate represents section that is compounding with CSS; Dot represents FAD of species and crosshair represents LAD of species; LOC represents line of correlation

Top 使参照剖面上该种的 Top 上延，则将第二剖面上的该数据值转换后(代入对比方程，求解)替换参照剖面中的相应值(插图 1)。

需要强调的是，计算对比方程时，应剔除那些有疑问的点，如明显偏离主体分布趋势的点，这些点代表的数据很可能来自一些采集不全或鉴定有误的标本。对比方程可通过下列公式求出：

$$y=\bar{y}+\frac{\sum[(y-\bar{y})(x-\bar{x})]}{\sum(x-\bar{x})^2}(x-\bar{x}) \text{ 或}$$

$$y=\frac{n\sum(x_iy_1)-(\sum x_i)(\sum y_i)}{n\sum(x_i^2)-(\sum x_i)^2}x+\frac{(\sum x_i^2)(\sum y_i)-(\sum x_i)(\sum x_iy_i)}{n\sum(x_i^2)-(\sum x_i)^2}$$

其中 x 代表参照剖面的坐标变量，y 代表第二剖面的坐标变量，$\bar{x}$、$\bar{y}$ 代表 x 或 y 的平均值，$\sum x$、$\sum y$、$\sum xy$ 等代表对相应值的求和。

在对比的过程中，假设两个剖面的沉积速率呈简单的线性相关，但事实上两个剖面的沉积速率很少表现为标准的线性关系，更多的情况下呈折线或对数曲线关系，因此需要通过线性相关系数来检验直线拟合的合理性。相关系数可以通过下列公式求得：

$$r=\frac{\sum[(x-\bar{x})(y-\bar{y})]}{\sqrt{\sum(x-\bar{x})^2}\sqrt{\sum(y-\bar{y})^2}} \text{ 或}$$

$$r=\frac{n\sum(x_iy_i)-\sum x_i\sum y_i}{\sqrt{n\sum x_i^2-(\sum x_i)^2}\sqrt{n\sum y_i^2-(\sum y_i)^2}}$$

然后查表确定线性拟合的可行性。

5) 以 CSS1-2 为横轴，第三个剖面为纵轴，重复步骤 4，可以得到 CSS1-3；依次类推，直到获得第一轮的复合标准序列 CSS1-n。

6) 对复合标准序列 CSS1-n 进行调整。以 CSS1-n 为参照剖面，把第二剖面至第 n 剖面逐次复合到其上。但在复合过程中应避免自身复合对比现象，也就是说，如果 CSS1-n 中的某个值来源于参加该次复合对比的剖面，即该剖面中的数据使得 CSS1-n 中相应种的延限变长，则必须从其它剖面中选择一个最接近的值代替。调整过程往往需要反复多次，直至复合标准序列趋于稳定。

需注意的是，在复合多个盆地内的大量剖面时，由于不同盆地间的沉积速率可能差别很大，同一物种在不同盆地内的首次出现时间和末次出现时间也会有所差别，因此应首先对各个盆地内部的剖面进行复合，获得各个盆地的复合标准序列，然后再进行各盆地间的复合。

3　SinoCor 1.0 的设计、结构功能和使用要求

为了使 SinoCor 1.0 达到实用、易学、直观，在编制过程中遵循以下原则：

1)．采用 Windows 下的程序设计语言。考虑到 Windows 的普及和它的一些特点(如友好的图形界面、良好的兼容性和设备无关性、使用的简便等)，为使大多数研究人员可以使用该软件，选择了微软公司(Microsoft)的 Visual Basic 3.0 for Windows 3.x (PC 版，本软件目前仅在 PC 型计算机上进行了测试，限于条件，未能对 Machintosh 型计算机即苹果电脑进行测试)进行程序设计。成型后的 SinoCor 1.0 直接运行于 Windows 图形界面下，采用人机交互的操作方式，完全达到了最初的设计要求。

2)．关于 SinoCor 1.0 界面中语言的问题。迄今为至，微软公司的 Windows 3.x 在华语地区使用较广的至少有以下几个版本：英文版 Windows 3.1，简体中文版 Windows 3.1，繁体中文版 Windows 3.1，英文版 Windows 3.11 for workstation，简体中文版 Windows 3.2。在许多国外生产的个人电脑、工作站上只安装了英文版的 Windows 3.1 或 Windows 3.11 for workstation，只有采用英文界面才能获得最大的兼容性。在 SinoCor 1.0 升级时，我们将会考虑分别制作英文和简体中文两个版本的 SinoCor。

3)．在设计的过程中，我们有一个贯穿始终的原则，即友好的界面、强大的功能和具备一定的智能。为此不惜增加了数倍的工作量，在软件包中增加了数个虽非必需但却极为有效的功能。对这些功能的说明和使用，将在下面的第 4 点中详细介绍。

4)．根据实践，我们认为该软件至少应包括以下几方面的功能模块(插图 2)：

(1) 数据的输入和修改模块。该模块具备三方面的功能：数据的即时输入、数据的修改和数据的文件调入。SinoCor 1.0 的输入界面如插图 3 所示，插图 4 为数据的文件调入界面，插图 5 为数据的文件保存界面。目前，SinoCor 1.0 一次可分析、处理 20 个生物地层剖面、60 个分类单元的数据量。

(2) 数据的分析和处理模块。该模块主要分为

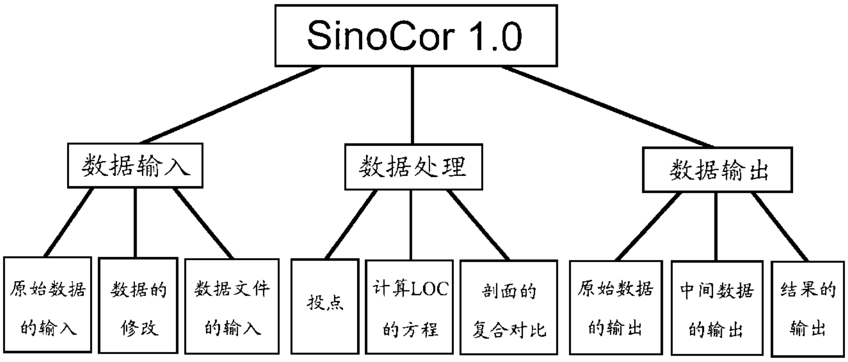
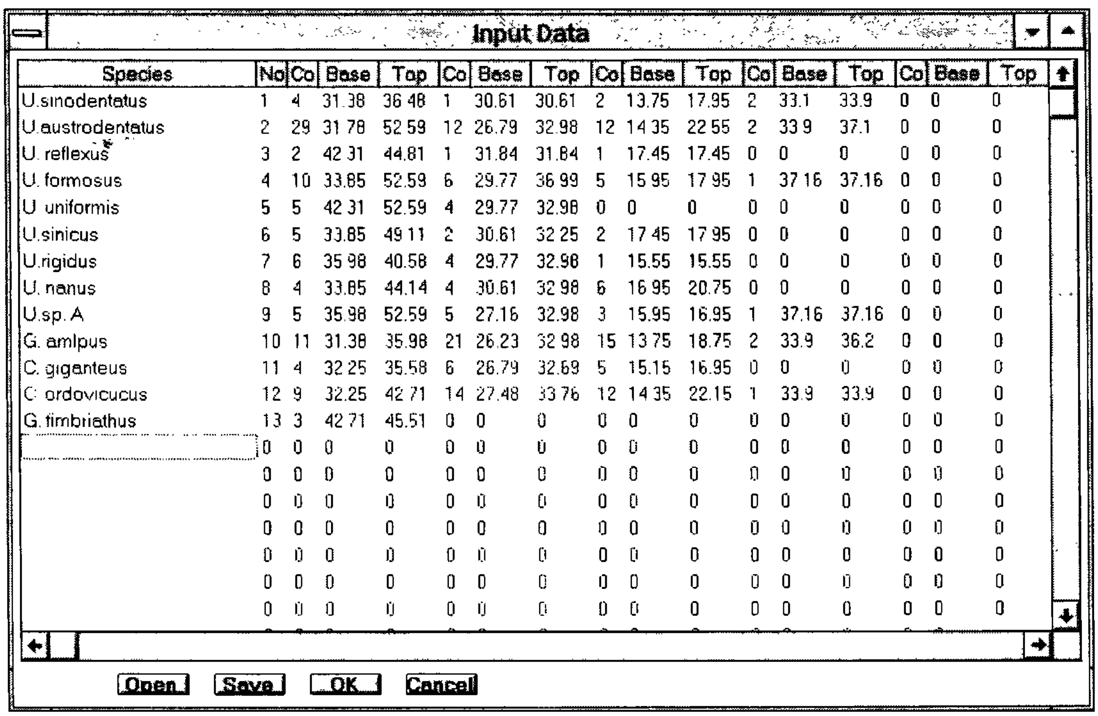


插图2 SinoCor 1.0的结构模块图

The diagram showing module construction of SinoCor 1.0



Input Data

Species	No	Co	Base	Top	Co	Base	Top	Co	Base	Top	Co	Base	Top	Co	Base	Top
U.sinodentatus	1	4	31.38	36 48	1	30.61	30.61	2	13.75	17.95	2	33.1	33.9	0	0	0
U.austrodentatus	2	29	31 78	52 59	12	26.79	32.98	12	14 35	22 55	2	33 9	37.1	0	0	0
U. reflexus	3	2	42 31	44.81	1	31.84	31.84	1	17.45	17.45	0	0	0	0	0	0
U. formosus	4	10	33.85	52.59	6	29.77	36 99	5	15 95	17 95	1	37 16	37.16	0	0	0
U uniformis	5	5	42 31	52.59	4	29.77	32.98	0	0	0	0	0	0	0	0	0
U.sinicus	6	5	33.85	49 11	2	30.61	32 25	2	17 45	17 95	0	0	0	0	0	0
U.rigidus	7	6	35 98	40.58	4	29.77	32.98	1	15.55	15.55	0	0	0	0	0	0
U. nanus	8	4	33.85	44.14	4	30.61	32 98	6	16 95	20.75	0	0	0	0	0	0
U.sp. A	9	5	35.98	52.59	5	27.16	32.98	3	15.95	16.95	1	37.16	37.16	0	0	0
G. amlpus	10	11	31.38	35.98	21	26.23	32 98	15	13 75	18.75	2	33.9	36.2	0	0	0
C. giganteus	11	4	32 25	35.58	6	26.79	32.69	5	15.15	16.95	0	0	0	0	0	0
C ordovicucus	12	9	32.25	42 71	14	27.48	33 76	12	14 35	22.15	1	33.9	33.9	0	0	0
G. timbriathus	13	3	42 71	45.51	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Open Save OK Cancel

插图3 SinoCor 1.0的数据输入界面

The interface of data input in SinoCor 1.0

表中有3个剖面的资料，所有数据引自张元动、陈旭(1994)。Species——种名；No——分类单元的序列号，在分析用以标识不同的分类单元；Co——采集的标本数；Base、Top——分类单元的首次出现和末次出现。Open——调入初始数据文件，Save——保存当前数据至文件

In the table there have already been three sections' data which are quoted from Zhang Yuan-dong and Chen Xu (1994). Species: name of species; No: ordinal number of species, it is employed to sign different species; Co: collection of samples; Base or Top: FAD or LAD of species; The four buttons on the lower part of the interface, Open, Save, OK and Cancel, will provide open and save functions

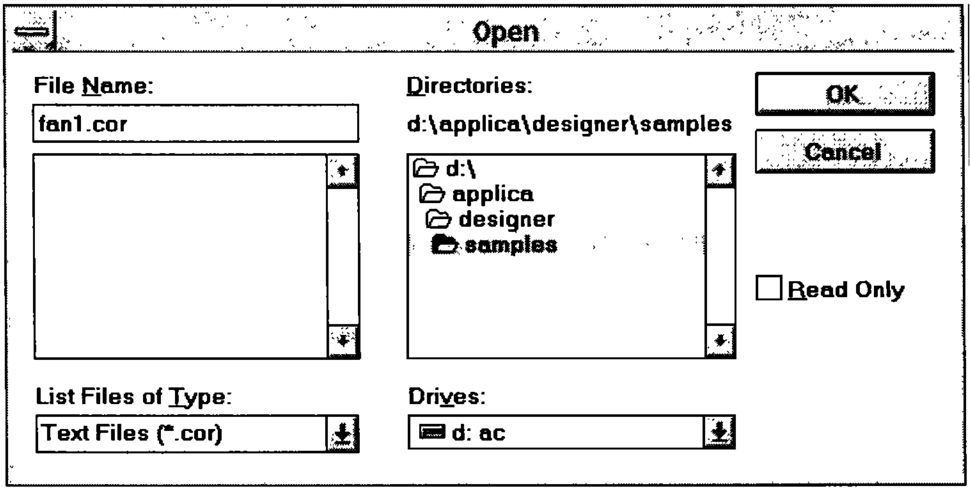


插图 4　SinoCor 1.0 的数据输入功能中的 Open 窗口

The Open window of the data input function in SinoCor 1.0

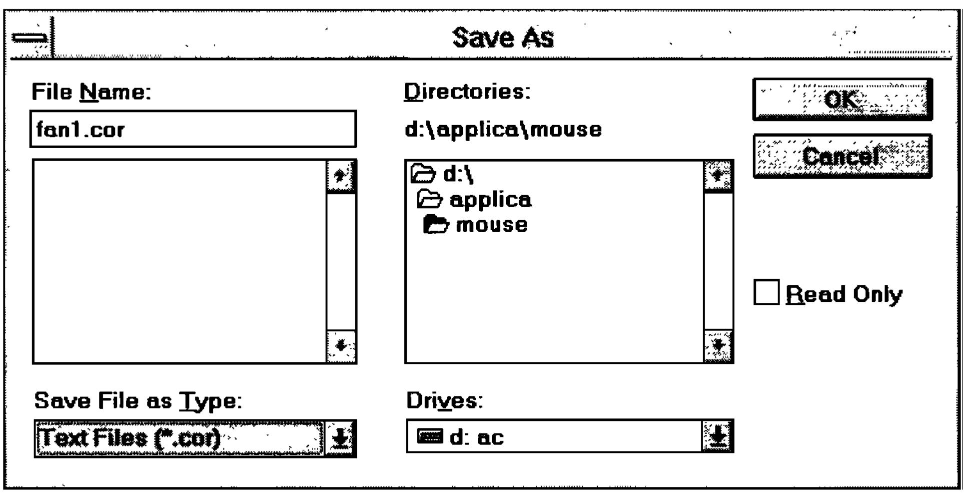


插图 5　SinoCor 1.0 的数据输入功能中的 Save 窗口

The Save window of the data input function in SinoCor 1.0

六个步骤：

a. 在参加对比的两个剖面中选择 Base 或 Top 都不为零的点投入平面直角坐标系中。这一功能由计算机自动完成。

b. 选择可靠的、可以作线性拟合的点。选点由用户根据投入坐标系中点的位置来确定。选点通过鼠标操作完成。同键盘操作相比，这种方法更为简洁、方便和直观。

为使用户选点时心中有数，我们在设计时设想在屏幕上应显示坐标点代表的古生物和地层含义，如种名、代表首次出现还是末次出现等。这一思路最终实现在插图 6 所示的数据分析和处理界面的右上角。再者，这些内容的显示是动态的，也就是说，当鼠标移动到某一点上时，界面中即会自动显示这些内容，而不需按下鼠标的左键或右键。此外，已选中的点被加圈表示，以区别于尚未被选中的点。

c. 求出对比方程，画出对比线。在坐标系的下方同时会显示对比方程和相似系数。

d. 将第二个剖面上的数据复合到参照剖面上。这一步由计算机自动完成。

e. 重复上述操作，即进行下一轮的复合对比。其中还设计了显示当前分析结果和储存中间数据两个功能。

f. 调整。

(3) 数据的输出模块。包括两方面的子模块：

a. 部分重要的中间数据和结果数据的文件输出，这一部分的功能事实上已做在上述的“数据的分析和处理”模块中。

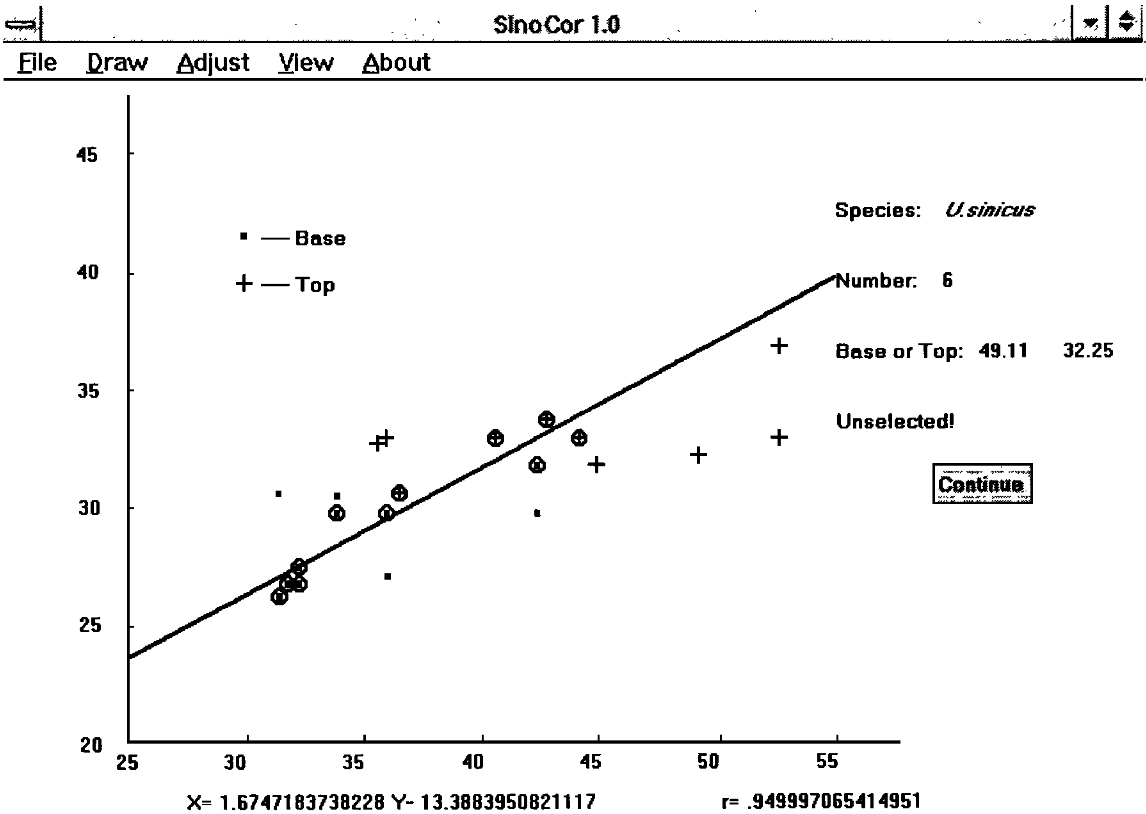


插图6 SinoCor 1.0 的数据处理和分析界面

The interface of data process in SinoCor 1.0

横坐标代表复合标准序列CSS，纵坐标代表参加该次复合的剖面。坐标系的右上方显示当前鼠标所指的点代表的种名、序号、在复合标准序列和当前剖面上的层位、是否已被选中。坐标系下方分别显示对比线(LOC)的方程和复合的相似系数

The horizontal axis represents CSS and the vertical axis represents section that is compounding with CSS. Crosshair or dot marked with circle means it has been selected. Some useful information is shown on the upper part to the right: Species, No, Base or Top values that current dot or crosshair represents, whether the current dot or crosshair has been selected. Under the coodinate, there is the equation of LOC and similar coefficient

表I 分析结果的打印输出

The output of results

No	Base	Top	Base	Top	Base	Top
1	31.38	38.002	30.097	38.263	28.425	38.263
2	30.913	52.59	30.913	52.59	30.913	52.59
3	40.284	44.81	37.291	44.81	37.291	44.81
4	33.85	52.59	33.85	52.59	33.85	52.59
5	36.443	52.59	36.443	52.59	36.443	52.59
6	33.85	49.11	33.85	49.11	33.85	49.11
7	35.98	42.399	33.597	42.399	33.597	42.399
8	33.85	44.14	33.85	44.14	33.85	44.14
9	31.6	52.59	31.6	52.59	31.6	52.59
10	29.874	42.399	29.874	42.399	29.874	42.399
11	30.913	41.861	30.913	41.861	30.913	41.861
12	32.193	43.847	31.264	46.429	31.264	46.429
13	42.71	45.51	42.71	45.51	42.71	45.51

b. 复合对比图件的打印机输出。由于SinoCor 1.0 直接依附于Windows环境，因此可以支持所有Windows 3.x 支持的打印机类型，如 Epson LQ1600K、Cannon 210sp、HP DJ200、HP 4L 等。插图7是利用 SinoCor 1.0 的打印功能输出到 HP LaserJet 6L 激光打印机的一份表。

5). SinoCor 1.0 适用于PC系列的兼容机，建议使用486以上的机型，4M以上内存，SinoCor 1.0 的安装盘为两张3.25'、1.44M的软盘，其安装需3M的硬盘空间，必须装有Windows 3.x。

6. SinoCor 1.0 的运行。执行SinoCor 1.0 的基本流程参见插图7。

7). SinoCor 1.0 的版权。SinoCor 1.0 的开发受中国科学院"九五"重点课题"奥陶系'统'、'阶'级全球界线层型剖面在中国的确立"的资助，开发人员为本文作者，其著作权和开发者为中国科学院南京地质古生物研究所。插图8所示为SinoCor 1.0

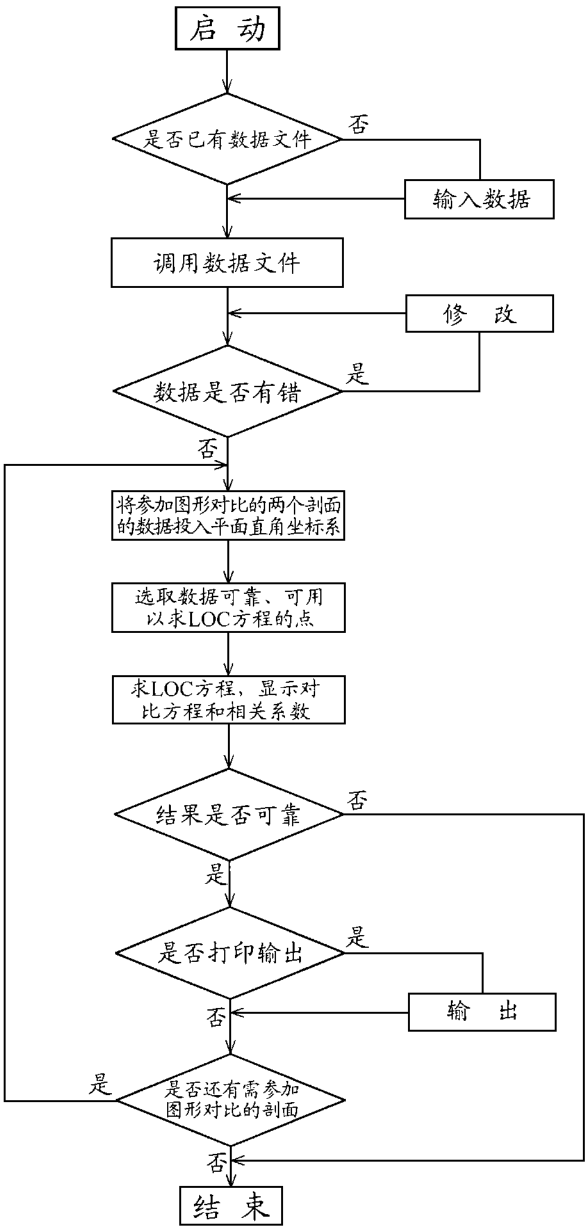


插图 7　SinoCor 1.0 的基本流程图

The basic flowchart of SinoCor 1.0

的启动界面。

8). SinoCor 1.0 的获取。需要使用 SinoCor 1.0 的同行们可与中国科学院南京地质古生物研究所科技处或著者本人联系。在使用中如遇到本文或软件的使用手册中未涉及的问题(仅针对 SinoCor 软件而言)，可与笔者联系，通信地址为中国科学院南京地质古生物研究所(210008)，E-mail 地址为 jxfan@jlonline.com 和 ydzhang@jlonline.com。

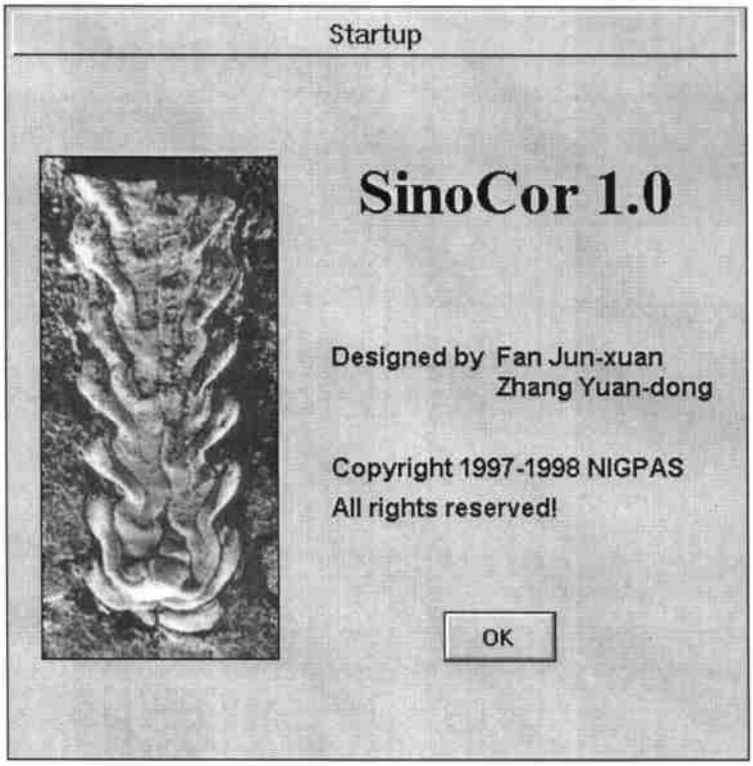


插图8 SinoCor 1.0的启动界面
The start interface of SinoCor 1.0

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SINOCOR 1.0, A BIOSTRATIGRAPHIC PROGRAM FOR GRAPHIC CORRELATION

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Key words　SinoCor 1.0, Graphic Correlation, Visual Basic, Programming

1　Introduction

As a method for quantitative biostratigraphic analysis, graphic correlation has been widely applied not only in drillhole biostratigraphic analysis in the Mesozoic and Cenozoic, but also in stratigraphic correlation of Paleozoic outcrops. SinoCor 1.0 is strictly designed in accordance with the principles of graphic correlation and therefore can be effectively used in stratigraphic analysis of fossiliferous sections of any age.

Several microcomputer programs for graphic correlation in biostratigraphy, such as GraphCor (Hood, 1986) and StratCor (Gradstein, 1990) etc., have been published and adopted widely. Most of them were designed by oil companies and used in drillhole biostratigraphic correlations in oil exploration. The present authors have applied these graphic correlation programs to Ordovician research in South China and found problems. First, users often have to do a large amount of calculation, and once the users make errors, they will have to repeat the process from the very beginning. Second, these are difficulties in operation, such as no use of a mouse, no graphic interface, and so on. Third, they don't support some common printers and also cannot output delicate diagrams for publication. Therefore we have programmed SinoCor 1.0 with the following advantages: (1) SinoCor 1.0 possesses interactive graphic interface. It supports both keyboard and mouse. (2) SinoCor 1.0 supports more types of printers, and it can output raw data, intermediate results and final results in tables or figures. (3) SinoCor 1.0 has a simple and clear interface and is very easy to use. Users need only to input data in tables and give a few instructions. For example, compounding of 30 sections and 60 taxa can be completed in one workday. Most of the time is spent in inputing data.

2　Principles of graphic correlation

Traditional biostratigraphic correlation methods may introduce some deviations. These deviations could be caused at least by the following factors. (1) Horizontally inhomogeneous distribution of the fossils. Due to different preservations, the FAD (first appearance datum) or LAD (last appearance datum) of a species may be different from one section to another. (2) Difference in exposure of different sections. (3) Inadequate collecting. (4) Misidentification and synonym and homonym problems. (5) Reworking of fossils. In order to eliminate such deviations, several methods had been used before. Shaw (1964) first proposed the graphic correlation method while establishing a composite standard sequence (CSS) by means of compounding many sections within one sedimentary basin. It was simplified to graphics by Miller (1977) and its reliability was verified by Edwards (1984). After that, the graphic correlation method has been widely used in biostratigraphic research (Sweet, 1984; Sweet and Tolbert, 1997; Kleffner, 1989, 1995;

Cooper and Lindholm, 1990; Cooper, 1992; Zhang Yuan-dong and Chen Xu, 1994; Zhang Yuan-dong, 1995; Carter *et al*., 1995; Grubb and Finney, 1995; Klapper and Kirchgasser; Macleod, 1995; Mann and Lane, 1995; Melnyk, 1995; Finney *et al*., 1996).

The principles and procedure of graphic correlation are briefly narrated as follows.

1). Data should be reduced to tabular form. The range of each species consists of two data points: Base FAD and Top LAD. These data will be used to calculate the number of species in each section, the number of species' levels and so on. All the data must be arranged in a 2-dimensional table so that they can be transferred easily to the succeeding analysis.

2). Select the best section as reference section. The criteria for best reference section are listed here. a. The thickest section and the longest time interval represented; b. the best exposed section with simplest structure; c. most abundant faunas with high diversity; d. fossils have been collected in most detail; e. fossils are well preserved and well studied. The more the reference section fits these criteria, the less the deviation of graphic correlation will be.

3). Use the same criteria for other sections.

4). Plot and compound. Establishing a 2-dimentional coordinate system in which the horizontal axis represents the reference section and the vertical axis represents the second best section. Plot the species that both of the two sections share into the coordinate system. The Base values and the Top values of each species compose two different points. The correlation equation of the two sections and the LOC (line of correlation) can be acquired according to some reliable points. Then the values of the second section should be plotted into the reference section through the correlation equation so as to obtain the composite standard sequence of the first two sections (CSS1-2). The detailed procedure of plotting is: if the Base value of some species in the second section extends downwards of that in the reference section or the Top value in the second section extends upwards of that in the reference section, it should be used to replace the corresponding value in the reference section after translation through the correlation equation (Text-fig. 1).

What should be paid special attention to is: while calculating the correlation equation, the questionable points, such as points obviously deviating from the array, often come from some misidentified or incompletely-collected specimens and should be excluded.

The correlation equation can be calculated by

$$y = \bar{y} + \frac{\sum[(y-\bar{y})(x-\bar{x})]}{\sum(x-\bar{x})^2}(x-\bar{x}) \text{ or}$$

$$y = \frac{n\sum(x_iy_i) - (\sum x_i)(\sum y_i)}{n\sum(x_i^2) - (\sum x_i)^2}x + \frac{(\sum x_i^2)(\sum y_i) - (\sum y_i)\sum(x_iy_i)}{n\sum(x_i^2) - (\sum x_i)^2}$$

where x represents the coordinate varition of the reference section, y represents the coordinate varition of the second section, $\bar{x}$ and $\bar{y}$ represent the mean values of x or y.

During the correlation, it is assumed that the accumulation rates of the two sections are simply linear correlation, but in some cases they are not typically linear and insteadly are broken-line or even curvilinear. So we should verify the rationality of linear simulation by way of a linear correlation coefficient. The coefficient can be calculated by

$$r = \frac{\sum[(x-\bar{x})(y-\bar{y})]}{\sqrt{\sum(x-\bar{x})^2}\sqrt{\sum(y-\bar{y})^2}} \text{ or}$$

$$r = \frac{n\sum(x_iy_i) - \sum x_i \sum y_i}{\sqrt{n\sum x_i^2 - (\sum x_i)^2}\sqrt{n\sum y_i^2 - (\sum y_i)^2}}$$

5). Take CSS1-2 as the horizontal axis and the third best section as the vertical axis, repeat step 4 to obtain CSS1-3.

Repeat above mentioned operations and the CSS1-n, the composite standard sequence of the first turn, will be established.

6). Adjust the CSS1-n. The CSS1-n should be taken as reference section and sections 2 to n should be compounded on it one by one. The adjustment should be repeated until the composite standard sequence remains stable.

While compounding many sections in several basins, the users should compound the sections in the same basin first to establish the composite standard sequence (CSS) of each basin and then compound the CSSes because the sedimentary rates may be greatly different and FAD and LAD of some species may deviate between different basins.

3 Modules and Structures of SinoCor 1.0

The design of SinoCor 1.0 was begun in 1997 and finished in early 1998. During the designing of it, four principles were involved.

1). Programming language

SinoCor 1.0 is written in Visual Basic programming language and designed for Windows.

Windows 3.X is the most popular operation system. It has convenient graphic interface, much better downward compatibility and is easy to operate. It is obvious that programming languages under windows 3.X such as Visual Basic 3.0 for Windows 3.X will be better for SinoCor 1.0. The present SinoCor directly runs under Windows' graphic circumstances and adopts interactive graphic interface and fits our initial design requirements. We only tested SinoCor 1.0 on PC computers so far.

2). Microsoft Windows 3.X has at least two English versions, three Chinese versions and some other language versions as well. Designing in English will obtain the most compatibility and is easy to apply internationally.

3). The module construction of SinoCor 1.0 is shown in Text-fig. 2. The program includes three basic modules:

a. Input module, including input and revision of raw data and input of data file. It is shown in Text-fig. 3. The Open window and Save window are shown in Text-fig. 4 and Text-fig. 5. So far as it is designed, the program can deal with 30 sections and 60 taxa at one time, and the capacity can be easily expanded.

b. Process module, dealing with plot of data, drawing LOC and compounding of sections. The interface of data process is shown in Text-fig. 6. The process can be divided into six steps.

i). The computer automatically selects species of which neither of the Base and Top values is equal to zero and plots them to coordinate.

ii). Users use mouse (instead of keyboard) to select reliable points which can be used for linear simulation directly.

For the users to select points conveniently, some important information is shown dynamically on the upper part to the right, such as species name, Base or Top values that current crossline or dot represents, whether the current crossline or dot has been selected. While mouse moves to some point, so-called information will be automatically shown on screen. Furthermore, the selected points will be marked with circles.

iii). Calculate correlation equation and draw the LOC in the coordinate. Under the coordinate, there will show the equation of LOC and the similarity coefficient.

iv). Computer automatically compounds the data of the second section to reference section to acquire primary CSS.

v). Repeat above-mentioned operations to other sections according to priority until acquiring CSS 1-n of the first turn.

vi). Adjustment.

c. Output module, including output of raw data, intermediate data and final results (see Text-fig. 7). SinoCor supports all the printers that can be used in Windows, such as HP LaserJet 6L, Cannon 210sp, Epson LQ1600K etc.

4) The basic flow chart of SinoCor 1.0 is shown in Text-fig. 8.

4 System requirements

SinoCor 1.0 is packed as two 3.5 inch setup disks and it is suggested that users install and run the program in the following circumstances:

1). PC, 486 or higher;

2). 4M RAM, 8M or higher will be better;

3). 1.44M, 3.5 inch floppy disk drive;

4). Windows 3.1 or higher version, the programme is initially designed for Windows 3.1, but also fits Windows 95 and 97 due to the downward compatibility of Windows.

5). At least 3M hard disk space.

5 Acquisition

SinoCor 1.0 was designed and programmed for scientific purpose, anyone who wants to have a copy please contacts the Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, P.R. China or the present authors. When problems not mentioned here and in the handbook of SinoCor 1.0 are met in running, consulting the authors is suggested. Our e-mail addresses are <jxfan@jlonline.com> and <ydzhang@jlonline.com>.

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