油田地下地质与沉积微相研究软件系统

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本软件系统是 1993 年 6 月为中国吉林油田研究开发完成的研究项目。本系统可在油田开发区充分研究若干勘探钻孔的岩心、测井资料和地震剖面资料等基础上,建立互相关的地区性岩性和沉积微相模式,通过试验,选择最佳判别模式,再用数字化的测井资料判别每一口井的地下地质情况,建成各类数据库,用以绘成任何钻孔和任何层段的岩性柱状图和微相演化图。再用地震资料补白没有钻孔地区的地下地质情况,生成各砂组的岩性、微相和优势微相数据库。能绘制出任何砂组或层段的各种岩性厚度或各种比值等值线图、优势微相分布图、岩性的或微相的栅状对比图等,还有对应的油层物性柱状图和平面图。除二维图形外,亦可制作三维图形和各种叠加图形。

本系统主要由以下几部份组成:

1 实时应用软件部份

1.1 基础沉积学研究软件包括以下几个程序

(1)粒度分析程序;(2)相相关分析程序;(3)古流向分析程序;(4)古构造背景分析程序。

1.2 测井资料数据处理软件包括以下几个程序

(1)模拟曲线数字化程序;(2)曲线回放检查程序;(3)自动分层与连续取样程序;(4)建立判别式模型程序;(5)绘制岩性柱状图与微相柱状图程序;(6)建立砂组岩性和微相厚度数据库程序;(7)建立砂组优势微相数据库程序;(8)建立砂组栅状图数据库程序;(9)绘制栅状图程序。

1.3 地震资料数据处理软件包括以下几个程序

(1)求层速度程序;(2)求孔隙度、渗透率程序;(3)求砂泥岩比值程序;(4)求层厚和砂岩厚度程序;(5)初次组合程序;(6)建立最终组合数据库程序。

1.4 油层物性研究软件

2 专用数据库部分

3 辅助制图软件部份

4 系统工具软件部份

上列基础沉积学研究软件,可以利用油田制作的粒度统计资料和钻孔柱状图资料,分析判别地区性的沉积环境类型,建立地区性相模式。利用砾石或斜层理的统计资料直接恢复其原始产状,计算统计出古流向,再用砂质岩类薄片成份统计资料研究物源区的构造背景,分析沉积环境的演化规律。这些内容对研究油田构造和生储盖层及物性特征等方面都有重要作用。

测井资料的数据处理步骤是:将模拟曲线数字化;回放检查;分层取样;数据归类;建立

若干种判别模型，用各种判别模型判别岩性和微相，绘制柱状图，对照取样钻孔研究实判效果，筛选和修定判别模型。在此基础上，建立以砂组为单位的所有钻孔的岩性和微相厚度数据库；建立砂组优势微相数据库；砂组栅状图数据库等利用这些数据库资料绘制各种岩比等值线图、沉积微相分布图、栅状图等。

地震资料数据处理：主要根据地震剖面的精度重新划分砂组或层段，利用测井资料的声波时差数据作为建模根据，在地震剖面图上选择适当位置截取补白孔。选取某个砂组或层段按一定深度读取波速值建成数据库，然后按层段计算层速度。根据判别模型计算层厚度和砂岩厚度，求砂泥岩比，求孔隙度和渗透率等。一般来说，地震补白孔主要是判别一个层段的岩相比例，对于沉积环境尚不能与测井相相比美。

油层物性研究：重点是研究各层岩石的孔隙度、渗透率和饱和度等数据，建成数据库。可以制作柱状图和平面等值线图。

本系统有一套规范化的数据文件，为了便于地区性对比研究，把所有钻孔数字化资料建成均一化的数据库和井位座标，砂组顶底深等基础数据库。在按砂组判别岩性和微相之后，生成每个钻孔的岩性、微相厚度数据库等，为随时制作各种图件时采用。

为了便于本系统开发的各种图形及其生成的数据库能适应更多外设绘制图形设备，特将本系统的图文件均与 Auto－CAD 软件接口或生成 SURF 软件能直接使用的数据文件，便于绘制常规等值线图。因此把 Auto－CAD 和 SURF 软件选为本系统的工具软件。

INDUSTRIAL MAPPING SOFTWARE OF SEDIMENTARY MICROFACIES AND PETROLEUM GEOLOGY

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ABSTRACT

This software is composed of a series of discriminant models based on the detailed comparison studies between the sedimentological features of cores and the geophysical characteristics of well loggings and seismic sections. Containing 3 parts i. e. basic sedimetological program, well log processing program and seismic processing program, the software has been successfully used to predict the oil/gas traps in Yingtai oil field of the Songliao Basin (NE China, Cretaceous) by the systermatic mapping of sedimentary microfacies and the detailed lateral correlation of thin bedded reservoir sand bodies.

Our study area of Yingtai oil field is in the Songliao Basin (42°—49°N, 120°—128°E) which is the largest oil generation basin of China contributing nearly half of the nation's oil production: more than 60 million tons per year. The whole studied area is about $500km^2$, contains 55 exploration wells and 172 production wells with 1 : 500/1 : 200 well-loggings, and is covered by 1×2km, 1×1km and 0.5×0.5km seismic profiles.

Heterogeneous reservoirs of Yingtai oil field often result in dry holes near a very high productive well, which is the main limitation for oil production. The project described here was supported by the Jilin State Oil Company in order to improve the prediction level for the heterogeneous reservoirs.

Three steps were taken for us to finish the project: ①sedimentological study on the cores from the well drillings to establish the standard models of lithologies and sedimentary microfacies; ②comparison study between cores and well-loggings to establish the discriminant models of microfacies and reservoir sandbody distributions; ③comparison study between cores/well-loggings and seismic sections to establish the seismic discriminant models mainly used for the areas without core/well-logging information.

The functions of the software are mainly as follows: ①to simulate sedimentological history (palaeocurrent, provinance, palaeotectonic and sedimentary facies); ②to calculate the thickness and distribution of reservoir sandbodies; ③to simulate the porosity and permeability of reservoir sandbodies; ④to simulate the primary oil migration process; ⑤to create all the database needed above.

The software of this paper is linked with TOPO and Auto-CAD software for drawing functions.

FOUNDATIONAL SOFTWARE FOR SEDIMENTOLOGICAL STUDY

This part of the software is for the study of core taking section about which a lot of previous thin-section and lithologic composition work have been done. Based on these available data the software can execute "grain size analysis", "correlation analysis" and finally get the "local sedimentary microfacies association models".

The statistics procedure of grain size analysis is according to the methods of Friedman's and Landim's (Liu, 1980, pp. 314—319). Palaeotectonic analysis is according to the Dickinson's principle (Zeng and Xia, 1986, pp. 256—258). Palaeocurrent reconstructions have been made mainly on the adjacent outcrops. And the final discrimination of sedimentary microfacies is again based on the formula of Friedman's and Landim's.

WELL LOG DATA PROCESSING SOFTWARE

Well-log sedimentary microfacies models were established by the correlation study between the sedimentological features of the core sections and well-log characteristics. The first step of the software was A/D transfer and caliberation to get the foundational database from the original log curves. Then classification indexes for stratigraphy and microfacies wer sorted by the correlation of core sections to the corresponding well-loggings. Finally the discriminant models for stratigraphy, lithology and microfacies were established on the basis of core taking section and were in turn used for all the well-loggings of the study area.

Several types of discriminant methods including grey cluster analysis, step-lineation method, logic discriminant method and illustration-empirical model were tested (Yong and Chen, 1990; Wang, 1990). The best of them proved to be the illustration-empirical model which mainly depend on the differences among different kinds of lithology-facies associations on spontaneous potential log and Gamma-ray log (Fig. 1.). Illustration here means that the discriminant indexes were sorted according to the cluster distribution of log curve eigenvalues in the right angle coordinate. And the empirical means that the discriminat formula were established according to the core taking section.

Sedimentary microfacies can be defined as origination-texture facies in the cases of well-log dependence facies classification, based on which the stratigraphic boundaries are generally those of sedimentary facies (Fig. 1). The spontaneous potential log has been given the highest priority in this study because of their very well correspondence of the log amplitude to the grains of the sedimentary sequence. The "hlaf amplitude point" of well log usually is at the same point of stratigraphic boundary. If an amplitude is greater than certain value called "threshold", we take the "half amplitude point" as classification boundary. And the "threshold" was chosen by repeated test in the core taking section.

After auto-stratigraphic classification several types of databases can be established which include the databases of lithology, microfacies and predominant microacies, strata thickness, reservoir sandbody thickness, porosity and permeability. Kriging method has been used in the lateral correlation among wells. Then we can get variours kinds of maps on sedimentology and petrloeum geology as detailed as we want (Figs. 2 and 3).

SEISMIC DATA PROCESSING SOFTWARE

Seismic sections are mainly used in the area called "blank dots" where there are neither core section nor well-log information. The discriminant models of seismicdata are established with the sections passing through several wells where the models of core sections and wellloggings have been well studied. The working procedure of this part of the software is as followings. Firstly the standard models of stratigraphic classification, reservoir sandbodies, microfacies and so on should be chosen from the results of core-section and well-logging studies. Secondly the seismic discriminant models can be constructed and the extrapolations can be made. At last several known sections have to be tested for self-checking and calibration. Then we can use the seismic discriminant models to all the blank area (Fig. 4). But one thing should be remembered here that the resolutions/sensitivities among core section, well-log and seismic are quite different. So that the "microfacies" of seismic are generally equivalent to the "predominant microfacies" of well-log. For example 19 sandbody layers are classified by well-log, but only 6 associations of them have be recognized by seismicdata. So seismic discriminant models are only used in inter-well area for extrapolation.

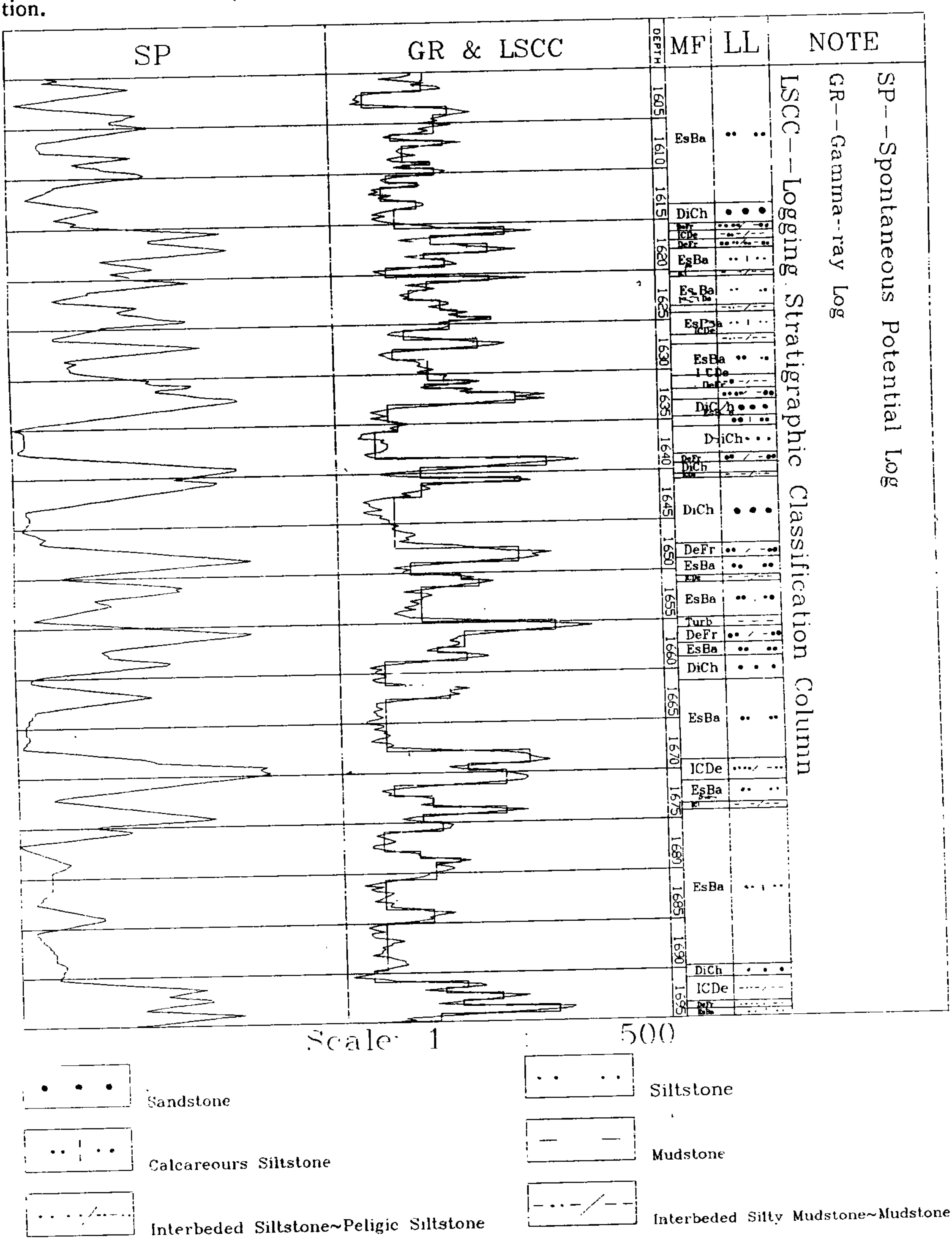

Fig. 1　Column diagram of microfacies and lithology

DiCh=distributary channel; EsBa=estuary bar; ICDe=interchannel deposits; DeFr=delta front; Turb=turbidites; MF=microfacies column; LL=lithological column

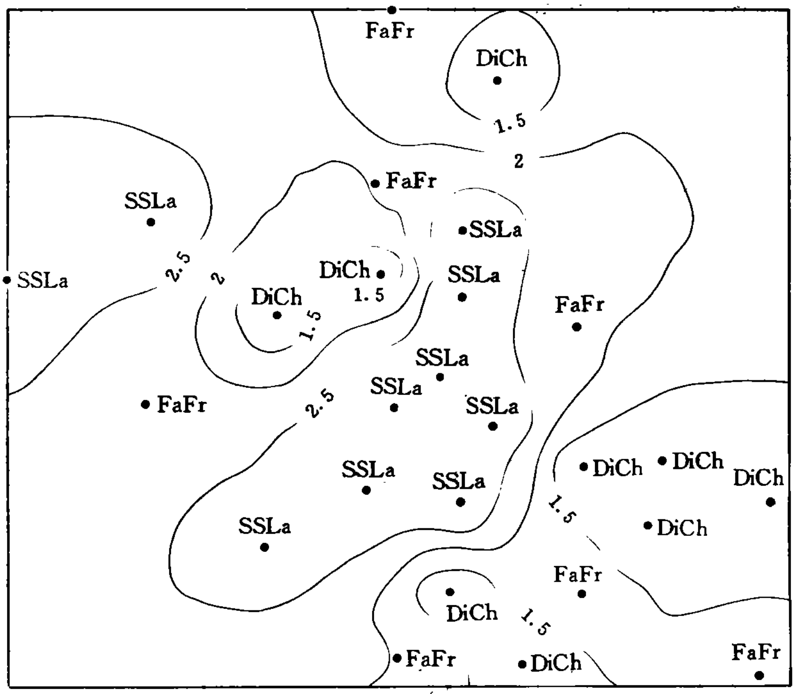

Fig. 2 Distribution map of sedimentary microfacies
(represented by the contour of predominant microfacies)
DiCh=distributary channel; FaFr=fan front; SSLa=shore-shallow lacustrine

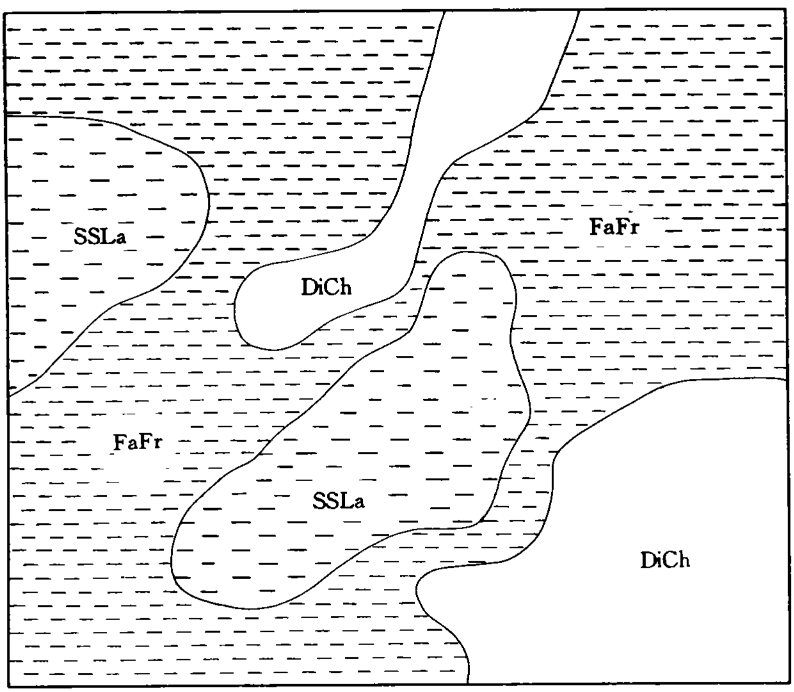

Fig. 3 Distribution map of sedimentary microfacies (represented by different symbols)
DiCh=distributary channel; FaFr=fan front; SSLa=shore-shallow lacustrine

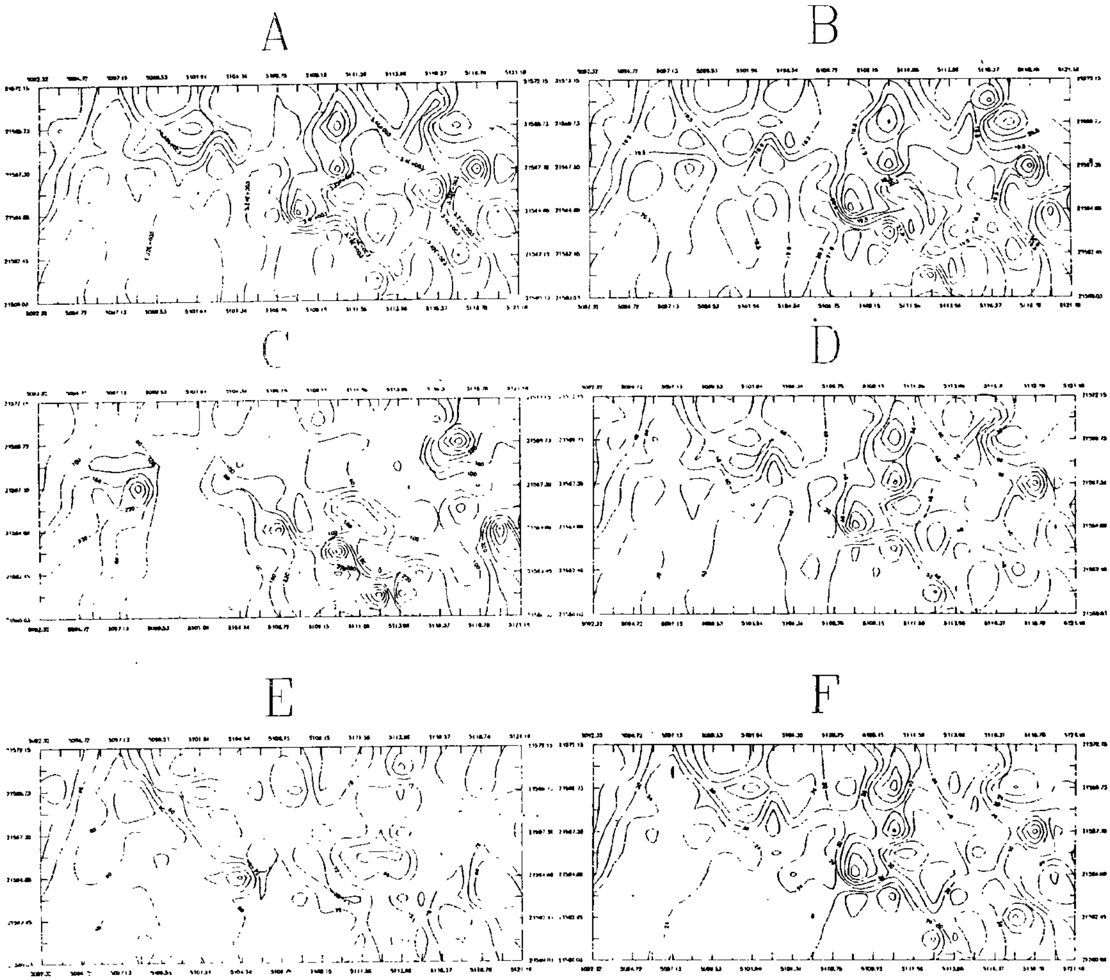

Fig. 4 Six types of contour maps computerised with seismic data

A=interval velocity; B=porosity; C=permeability; D=sand/mud ratio; E=strata thickness; F=sandstone thickness

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