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鄂尔多斯盆地地下水无机指标数据集（2014—2015 年度）

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摘要：本数据集包含了 2014 年、2015 年两年内在鄂尔多斯盆地采集的 742 个地下水样品的位置信息、取样层位信息及 35 项无机地球化学成分测试结果信息。采样过程规范，结果均由合格实验室测试完成，数据质量可靠。可以真实反映该时段鄂尔多斯盆地地下水质量状况，为研究鄂尔多斯盆地地下水循环演化提供地球化学指标参考。

关键词：鄂尔多斯盆地；地下水；地球化学；无机指标；数据集

数据服务系统网址：http://dcc.cgs.gov.cn

1　引言

水文地球化学是研究地质生态的重要技术方法 (陈宗宇 , 1995)，通过分析地下水的水化学特征 , 可揭示地下水的组成及来源，也是研究地下水循环和演化的重要手段 (叶思源等 , 2002 ；杨陨城等 , 2012)，该法在国内外已有较广泛的应用 (滕彦国等 , 2010 ；侯建军等 , 2017)。地下水的水文地球化学特征是受地下水循环演化过程控制的，它是地下水循环演化过程的信息库。由无机指标数据集绘制的地下水化学场可以与地下水流场、地下水温度场、地下水年龄等相互印证，共同用于研究地下水流系统的补给来源、径流途径、排泄方式等循环过程。另外，多期的无机指标数据集可以指示地下水化学演化方向，确定地下水环境演化过程中的环境变化特征和规律，是水循环演化研究的重要工具。

此外地下水的化学组成也是地下水质量评价的重要内容，地下水无机指标是评价地下水质量的直接参数，尤其是氟离子、三氮、重金属等无机毒理指标更是在饮用水评价标准中有着严格的要求。

本次采样由国家公益项目“ 鄂尔多斯盆地地下水污染调查评价 ”支持，该项目旨在确定鄂尔多斯盆地地下水质量现状，研究水环境污染程度。项目对采样过程、送样过程、

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测试环节进行严格质量把关。测试项包括了地下水和部分地表水无机指标和微量有机指标。本文针对其中可公开发布的无机测试结果进行整理，把数据较齐全的地下水样品的测试数据集进行发布。为研究鄂尔多斯盆地地下水循环演化提供数据支撑。

2 数据采集和处理方法

本次共采集测试地下水无机项样品 742 个。采样点基本覆盖了鄂尔多斯盆地全域不同类型的地下水，包括第四纪松散层孔隙水、白垩系碎屑岩裂隙孔隙水、石炭侏罗系碎屑岩裂隙水、奥陶系岩溶裂隙水和基岩裂隙水。其中第四纪松散层孔隙水 421 件，白垩系碎屑岩裂隙孔隙水 187 件，石炭—侏罗系碎屑岩裂隙水 58 件，奥陶系岩溶裂隙水 64 件，基岩裂隙水 12 件。采样水体为当地常用水井的主要开采层位。本次测试数据集元数据简表见表 1，采样点分布图见图 1。

表 1　数据库（集）元数据简表

条目	描述
数据库（集）名称	鄂尔多斯盆地地下水无机指标数据集
数据库（集）作者	马洪云，李成柱，张俊
数据时间范围	2014—2015
地理区域	鄂尔多斯盆地
数据格式	*.xls
数据量	220 KB（样品 742 个）
数据服务系统网址	http://dcc.cgs.gov.cn
基金项目	国家公益性项目：鄂尔多斯盆地地下水污染调查评价（12120114056201）
语种	中文
数据库（集）组成	采样日期、地理位置、采样层位、电导率、pH 及其他无机指标 33 项

采样点位置信息采用手持 GPS 进行定位，地图参数是以 1980 年西安坐标系为参照系，记录经纬度坐标及地名等地理位置信息。本次取样调查范围共跨越 5 个省及自治区，取样数量共 742 件，其中甘肃 76 件（平凉 24 件、庆阳 52 件），内蒙 224 件（鄂尔多斯 224 件），陕西 306 件（榆林 105 件、延安 122 件、咸阳 26 件、宝鸡 16 件、铜川 7 件、渭南 25 件、韩城 5 件），宁夏 50 件（吴忠 33 件、银川 7 件、固原 9 件、石嘴山 1 件），山西 86 件（吕梁 33 件，忻州 16 件，运城 11 件，临汾 26）。

样品测试采用现场测试和室内测试相结合，野外现场测试采用 LOVIBOND 多参数测定仪（SD150D）对 pH 值、电导率等进行现场测试，测试结果显示地下水样品中淡水水样 619 件，半咸水水样 110 件，咸水水样 13 件。同时，采集两瓶 500 mL 水样，采样瓶选用聚乙烯塑料瓶，密封送实验室用于室内分析无机 33 项。所有采集地下水样品均送往具资质实验室进行测试分析，并出具测试分析报告。鄂尔多斯盆地水样测试地下水类型和水质类型统计表见表 2。

数据未经处理，皆为实验室测试结果统计。

表 2　鄂尔多斯盆地地下水类型和水质类型统计表

地下水类型	测试样品数（件）	水质类型	测试样品数（件）
第四纪松散层孔隙水	421	淡水	619
白垩系碎屑岩裂隙孔隙水	187	半咸水	110
石炭—侏罗系碎屑岩裂隙水	58	咸水	13
奥陶系岩溶裂隙水	64		
基岩裂隙水	12		

3　数据样本描述

地下水无机数据按照统一格式汇总于 EXCEL 表格中，每行为一个样品，每个样品均包括：样品编号、取样日期、经纬度、地理位置（详细到村）、采样层位、电导率、pH 值、总矿化度、总硬度、永久硬度、暂时硬度、总碱度、溶解性总固体、Ca^{2+}、Mg^{2+}、K^{+}、Na^{+}、Cl^{-}、SO_4^{2-}、HCO_3^{-}、CO_3^{2-}、NO_3^{-}、NO_2^{-}、NH_4^{+}、F^{-}、H_2SiO_3、Mn、Zn、Fe、Hg、Cr^{6+}、As、Pb、Cd、Se、Al、I^{-}。

鄂尔多斯盆地地下水均来源于大气降水补给，以东西向的白于山为界，北部多为风积沙覆盖，降水入渗条件较好，地下水以淡水为主，局部受蒸发浓缩作用影响水质较差；南部多为黄土覆盖，降水入渗条件较差，沟壑较发育，沟谷中赋存第四纪松散孔隙水，水质相对较好，然而中、深层水受水动力条件较差，水循环缓慢，水质较差，多为咸水及半咸水。

4　数据质量控制和评估

（1）样品采集

样品采集和送检工作严格按照《地下水污染调查规范》要求执行，样品采集点主要布置在水文地质调查点（机井、民井、集中供水水源地水源井）。采样前作好采样计划，并与承担检测任务的实验室及时做好沟通；在样品采集现场及时填写了记录表和采样标签；现场测试指标均在现场测试，样品按规范要求加相应的保护剂。

地下水水化学成分的无机项比较稳定，光、热、震动等的变化对其影响甚微，因此，对取样过程、运输过程等环节没有特别的要求，主要是做到密闭，避免污染和泄露。采样作业中重点确保每个样品的代表性和真实性，使得每个样品尽可能准确的反映一个地区地下水环境质量。

（2）数据质量

所采水样均由西安地质矿产研究所实验测试中心承担。根据项目的要求，所有分析方法均采用了 DZ/T 0130.6-2006 地质矿产实验室测试质量管理规范和其他相关的国家和行业的标准，方法的技术参数均达到或优于相应标准以及本项目的要求。测试选择的分析方法的检出限也均达到或优于规范的要求。

每一批次试样随机抽取 20% 的重份分析，编成密码，重复分析相对偏差允许限为 $Y=11.0\,C\,X^{-0.28}$，其中，Y 为允许限，X 为各组分析结果的浓度度，mg/L，C 为不同分析项目的系数，测试结果的偏差允许限均小于 3%。

测试中心对所采集的全部地下水样品进行了阴阳离子总量平衡与可溶性固体总量平衡的检验，结果合格率达到规范的要求。

（3）质量总体评估

所有水质分析样品的采集均严格按照有关要求执行。样品的测试均由具有国家计量认证资质的实验中心完成，所测定的无机项目包括电导率、总硬度、永久硬度、暂时硬度、总碱度、溶解性总固体、pH 值、Ca^{2+}、Mg^{2+}、K^{+}、Na^{+}、Cl^{-}、SO_4^{2-}、HCO_3^{-}、CO_3^{2-}、NO_3^{-}、NO_2^{-}、NH_4^{+}、F^{-}、PO_4^{-}、H_2SiO_3、Cu、Mn、Zn、Hg、Cr^{6+}、As、Pb、Cd、Al、I^{-}、总矿化度、Fe、阴离子总计和阳离子总计共 35 种元素（或项目）的分析测试工作，分析测试结果真实可靠，符合质量要求。

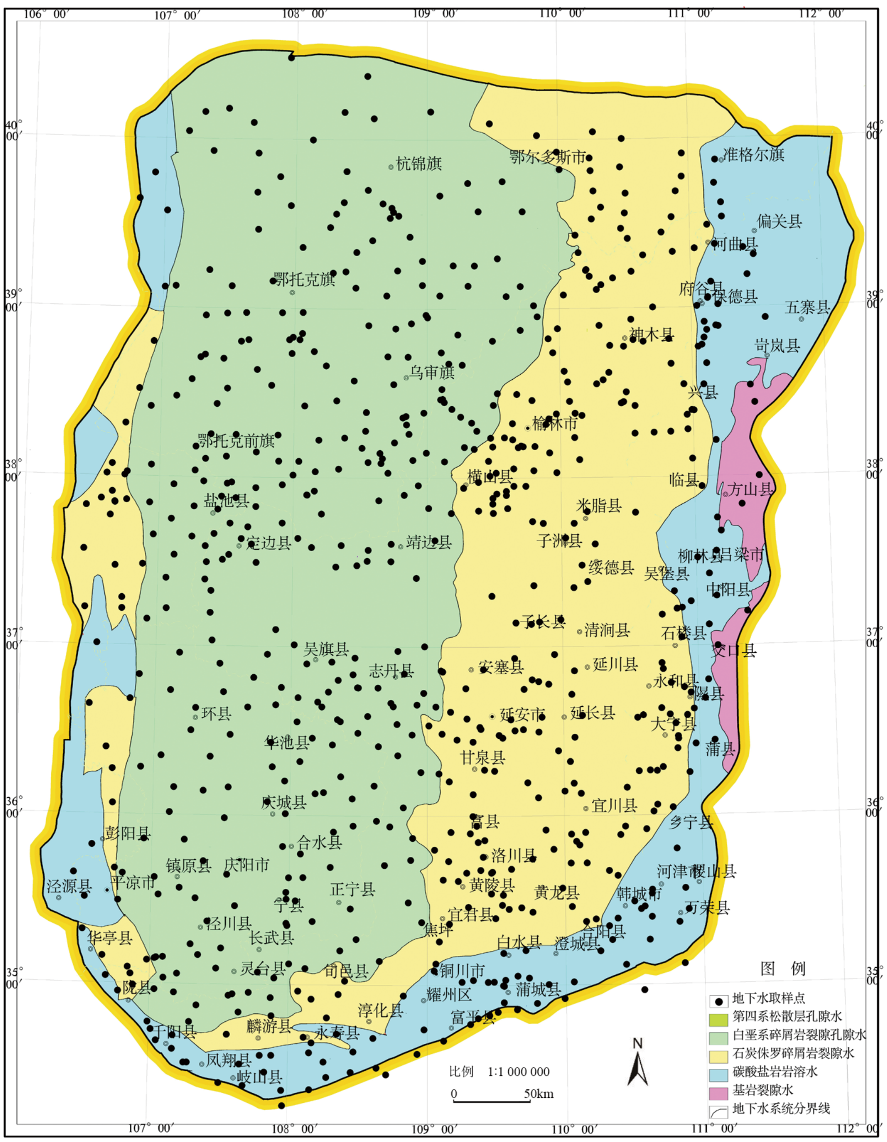

图 1 鄂尔多斯盆地地下水采样点分布图

5 结论

本数据集包含了 2014 年、2015 年两年内在鄂尔多斯盆地采集的 742 个地下水样品的位置信息、取样层位信息及 35 项无机地球化学成分测试结果信息。样品点分布覆盖了鄂尔多斯盆地 28 万 km^2，取样密度为每 300 km^2 一个样品。地下水采样过程规范，测试结果均由合格实验室测试完成，数据质量可靠，可以真实反映该时段鄂尔多斯盆地地下水质量状况，为研究鄂尔多斯盆地地下水循环演化提供地球化学指标参考。

致谢：感谢中国地质调查局西安地质调查中心实验测试中心在规范化采样方面给出的宝贵建议及对样品密闭措施的精心核查。

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Inorganic Indicator Dataset for Groundwater in Ordos Basin (2014—2015)

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Abstract: This dataset contains information about location, sampling horizon and 35-inorganic-geochemical-component testing results for 742 groundwater samples collected in Ordos Basin during 2014 and 2015. The sampling process for this dataset has been normalized while testing results have been obtained through a qualified laboratory. The data presented herein is reliable and truly reflects the quality of groundwater in Ordos Basin during the aforementioned period. All in all, this dataset provides geochemical indicator reference for studying circulation and evolution of groundwater in Ordos Basin.

Key words: Ordos Basin; groundwater; geochemistry; inorganic indicator; dataset

Data service system URL: http://dcc.cgs.gov.cn

1 Introduction

Hydrogeochemistry is an important technical method for researching on geological ecology (Chen Zhongyu, 1995), as the composition and source of groundwater can be revealed through analyzing hydrochemical characteristics of groundwater. In addition, it is an important approach for researching on circulation and evolution of groundwater (Ye Shiyuan et al., 2002; Yang Yuncheng et al., 2012). This method has been widely applied at home and abroad (Teng Yanguo et al., 2010; Hou Jianjun et al., 2017). The hydrogeochemical characteristics of groundwater are controlled by circulation and evolution processes of groundwater. They are also the information bank for the said processes. The chemical field drawn on the basis of inorganic indicator dataset can prove and be proven by the flow field, temperature field and age of groundwater. They are jointly used for researching on circulation process of groundwater flow system, such as supply source, runoff route and excretion mode. Moreover, the multi-phase inorganic indicator dataset can indicate the chemical evolution direction of groundwater and determine the features and laws of change in environmental characteristics in the course of evolution of groundwater environment. At the same time, it is an important tool for carrying out research on circulation and evolution of water.

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Furthermore, the chemical composition of groundwater is also an important content of evaluation of groundwater quality. The inorganic indicators of groundwater are direct parameters that are used to evaluate the quality of groundwater, while the inorganic toxicological indicators, such as fluorine ion, 3-nitrogen and heavy metal, are strictly required in determining the evaluation standard of drinking water.

For the purpose of this dataset, sampling process was supported by the national public welfare project "Investigation and Evaluation of Groundwater Pollution in Ordos Basin". The project aimed to determine the quality of groundwater and research on the degree of pollution in water environment in Ordos Basin. Moreover, the project strictly controlled the quality of sampling process, sample-transporting process, and testing process. Herein, the testing items cover inorganic indicators and trace organic indicators of groundwater and some surface water. This paper sorts out inorganic testing results that may be published, and features the testing dataset of groundwater samples that have relatively complete data. In this way, this paper provides data support for carrying out research on circulation and evolution of groundwater in Ordos Basin.

2 Data Collection and Processing Methods

As many as 742 samples were collected for testing on inorganic indicators of groundwater. The sampling points cover different types of groundwater throughout Ordos Basin, including Quaternary loose layer pore water, Cretaceous clastic rock fissure & pore water, Carboniferous Jurassic detrital rock fissure water, Ordovician karst fissure water, and bedrock fissure water, for which 421, 187, 58, 64 and 12 samples were collected, respectively. The water body sampled is the main recovery horizon for local common water wells. The metadata table of dataset is shown in Table 1. The distribution of sampling points is indicated in Fig.1.

Table 1 Metadata table of Database (Dataset)

Items	Description
Database (dataset) name	Ordos Basin Groundwater Inorganic Indicator Dataset
Database (dataset) authors	Ma Hongyun, Li Chengzhu and Zhang Jun
Data acquision time	2014—2015
Geographic area	Ordos Basin
Data format	*.xls
Data size	220KB (742 Samples)
Data service system URL	Http://dcc.cgs.gov.cn
Fund project	The State-run Non-profit Project: Groundwater Contamination Investigation & Assessment in Ordos Basin.（12120114056201）
Language	Chinese
Database (dataset) Composition	Sampling Date, Geographic Location, Sampling Horizon, Electrical Conductivity, pH and Other 33 Inorganic Indicators

The information about location of sampling points was obtained via hand-held GPS device. The map parameters were based on coordinate system of Xi'an in 1980. Meanwhile, information about geographic location, such as latitude and longitude coordinates and geographic name, were recorded. This sampling survey covered five provinces /autonomous regions and collected 76 samples from Ganshu (Pingliang 24, Qingyang 52), 224 from Inner Mongolia (Ordos 224), 306 from Shaanxi (Yulin 105, Yanan 122, Xianyang 26, Baoji 16, Tongchuan 7, Weinan 25, Hancheng 5), 50 from Ningxia (Wuzhong 33, Yinchuan 7, Guyuan 9, Shizuishan 1), 86 from Shanxi (Lyu Liang 33, Yizhou 16, Yuncheng 11 and Linfen 26), 742 in total.

At the same time, field testing and indoor testing were carried out. LOVIBOND multi-parameter measuring instrument (SD150D) was used to carry out field testing on pH value and electrical conductivity. The tests results indicate that 619 samples of the underground water samples are fresh water, 110 are brackish water and 13 are salt water. In addition, two polyethylene bottles of 500ml water sample were collected, sealed up and sent to the laboratory for indoor analysis of 33 inorganic indicators. All groundwater samples collected were transported to a qualified laboratory for analytical testing, and analytical testing report was issued. The groundwater type and water quality type of water samples used for testing in ordos basin is statistically shown in Table 2.

All data are not processed, and obtained on the basis of testing results of the laboratory.

Table 2 The statistical data of groundwater type and water quality type of the water sample test in the Ordos Basin

Groundwater type	Number of Sample	Water quality type	Number of Sample
Quaternary loose layer pore water	421	Fresh water	619
Creaceous clastic rock fissure & pore water	187	Brackish water	110
Carboniferous Jurassic detrital rock fissure water	58	Salt water	13
Ordovician karst fissure water	64		
Bedrock fissure water	12		

3 Descriptions of Data Samples

The inorganic data of groundwater has been summarized in EXCEL format in unified format. Therein, every line represents a sample, and every sample covers: sample number, sampling date, longitude and latitude, geographic location (detailed to village), sampling horizon, electrical conductivity, pH level, total mineralization, total hardness, permanent hardness, temporary hardness, total alkalinity, total dissolved solid, Ca^{2+}, Mg^{2+}, K^+, Na^+, Cl^-, SO_4^{2-}, HCO_3^-, CO_3^{2-}, NO_3^-, NO_2^-, NH_4^+, F^-, H_2SiO_3, Mn, Zn, Fe, Hg, Cr^{6+}, As, Pb, Cd, Se, Al, and I^-.

The source of underground water in Ordos Basin is precipitation recharge. Divided by the east-west Baiyu Mountain, in the northern area of Ordos Basin where is mostly covered with drift sand, the precipitation infiltration condition is favorable, underground water is mostly fresh water, but in some part of this area, the water quality is poor due to concentration caused by evaporation. The southern part of Ordos Basin is mostly covered with loess, so precipitation infiltration condition is relatively poor. In well developed valleys, there exists Quaternary loose layer pore water, so the quality of underground water there is relatively good. However, due to poor hydrodynamic conditions and slow water circulation in middle to deep layer, the water is poor in quality and mostly is salt water or brackish water.

4 Data Quality Control and Evaluation

(1) Sample Collection

The samples were collected and transported strictly in accordance with the requirements of the Specifications for Investigation on Groundwater Pollution. The sampling points are mainly distributed at hydrogeological survey points (driven wells, civil wells and water source wells in centralized water supply source location). Before the sampling, a sampling plan was duly prepared, and communication channels were established with the laboratory designated for carrying out sampling. Moreover, record forms and sampling labels were filled out at the sampling site. The indicators, which had to be tested on site, were tested on site, and the corresponding protective agent was added in samples, as required by specifications.

Furthermore, inorganic indicators of hydrochemical components of groundwater are relatively stable. They are mildly impacted by change in light, heat, and shock. Therefore, there is no special requirement on sampling process and transportation process, and the main requirement is to properly seal up the samples and avoid contamination and leakage. Meanwhile, during the sampling operation, focus was placed on ensuring the representativeness and authenticity of samples to ensure that each sample reflects the quality of groundwater environment in an area as accurately as possible.

(2) Data Quality

All water samples collected were tested by the Experimental Testing Center of Xi'an Institute of Geology and Mineral Resource. In accordance with the requirements of the Project, all analytical methods adopt the DZ/T 0130.6-2006 “Specification of Testing Quality Management for Geological Laboratories” and other relevant national/industrial standards. In addition, the technical parameters of such methods meet or exceed the corresponding standards and the requirements of the Project. At the same time, the detection limit of analysis method selected for the testing also meets or exceeds the requirements of such specifications.

As for every batch of samples, 20% were randomly selected for repeated analysis, and the results were encrypted. The allowable limit of relative deviation in repeated analysis is $Y=11.0\ C\ X^{-0.28}$, where “Y” is the allowable limit, “X” is the concentration as analysis result of every component (mg/L), and “C” is the coefficient of different analytical item. The allowable limit of deviation of testing results is less than 3%.

The testing center carried out inspection on balance of total cations/anions and balance of total dissolved solid for all groundwater samples collected. Therein, the qualified rate of results aptly meets specifications.

(3) Overall Quality Evaluation

All samples for water quality analysis were collected strictly in accordance with the relevant requirements. Sample testing was completed by the experimental center that has

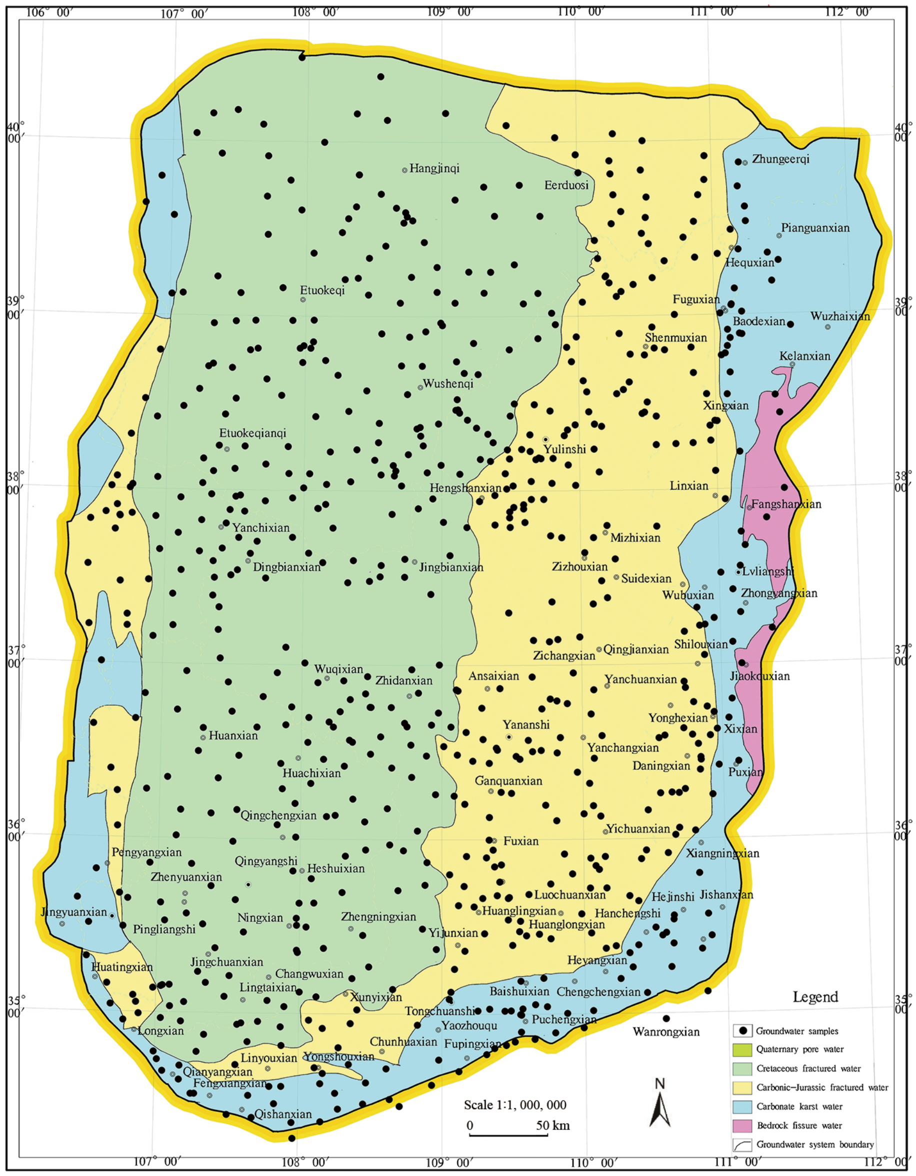

Fig. 1 Distribution of Sampling Points for Groundwater in Ordos Basin

the national metering authentication qualification. The inorganic indicators tested include 35 elements (or items), including electrical conductivity, total hardness, permanent hardness, temporary hardness, total alkalinity, total dissolved solids, pH, Ca^{2+}, Mg^{2+}, K^+, Na^+, Cl^-, SO_4^{2-}, HCO_3^-, CO_3^{2-}, NO_3^-, NO_2^-, NH_4^+, F^-, PO_4^-, H_2SiO_3, Cu, Mn, Zn, Hg, Cr^{6+}, As, Pb, Cd, Al, I^-, total mineralization, Fe, total anions, and total cations. The analytical testing results are true and reliable, and comply with the quality requirements.

5 Conclusion

This dataset contains information about location, sampling horizon and 35-inorganic-geochemical-component testing results for 742 groundwater samples collected in Ordos Basin during 2014 and 2015. The sampling points are distributed over an area of 280, 000 km^2 in Ordos Basin. The sampling density is one sample per 300 km^2. The sampling process for this dataset has been normalized while testing results have been obtained through a qualified laboratory. The data presented herein is reliable and truly reflects the quality of groundwater in Ordos Basin during the aforementioned period. All in all, this dataset provides geochemical indicator reference for studying circulation and evolution of groundwater in Ordos Basin.

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