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神东煤炭基地 1∶50 000 活鸡兔幅矿区水文地质图数据集

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摘要：本数据集在 1∶50 000 活鸡兔图幅内综合应用了遥感、地面调查、物探、钻探，以及水化学同位素等多种方法进行数据采集，共完成 2 期遥感数据解译 800 km^2，地面调查点 377 个，丰水期、枯水期地下水水位统测 240 点次，抽水试验 10 组，水体样品采集共计 127 组，水文地质钻探累计进尺 600 m。本数据集细化了工作区内第四系孔隙含水层、白垩系洛河组孔隙−裂隙含水层富水等级，填补了侏罗系安定组、直罗组水文地质信息的空白；同时，加入了与采煤相关的次生环境地质要素，并首次将浅层含水层疏干区较为准确地勾画出来，还建立了采煤影响下的地下水的循环模式，突出了矿区水文地质调查的特色。本数据集为矿区水文地质调查工作的规划、部署与总结提供常态化支持，对保障国家能源安全、生态安全具有重要的现实意义。

关键词：神东煤炭基地；活鸡兔幅；水文地质图；疏干区；1∶50 000

数据服务系统网址：http://dcc.cgs.gov.cn

1　引言

神东煤炭基地是国家规划建设的 14 个大型煤炭基地之一 (图 1)，是我国已探明储量最大的煤田。所属的神东矿区集中了我国目前生产能力超过千万 t 的大柳塔、哈拉沟、榆家梁、布尔台等数个大型矿井，原煤生产约占全国总产量的 6%、全国重点煤矿产量的 12%，为我国首个 2 亿 t 商品煤生产基地，对我国煤炭生产和保障国家能源安全都起着重要的支撑作用。然而，神东矿区却存在着突出的水文地质问题和环境地质问题，制约着矿区的可持续发展。主要表现在以下几个方面：

(1) 水资源严重缺乏

神东矿区位于干旱−半干旱地区，工作区多年平均降水量仅为 437.2 mm，水资源短缺。目前神东矿区供水量 22.3×10^4 m^3/d，缺水量：16.7×10^4 m^3/d，缺水比例为 42.8%。随着煤炭生产规模的不断扩大，未来矿区缺水量将会继续增加。

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图 1　全国煤炭基地分布图

(2) 含水层结构及地下水资源遭到严重破坏

神东矿区主要含水层直接覆盖在侏罗系含煤地层之上，煤层开采造成上覆含水层破坏，导致地下水位下降，泉水流量衰减，甚至含水层疏干，泉水断流，地下水资源遭到严重破坏 (段中会，2001；张茂省等，2010；曹志国等，2014；王振荣，2017)。

(3) 生态环境恶化

煤炭开采使矿区产生了地表塌陷、地裂缝、植被退化和土地沙化等生态环境问题 (徐友宁等，2008)。部分地区地裂缝最宽达 2 m，深 10 余 m，局部地面下降 2~3 m，最大塌陷深度达 6.5 m。地面塌陷、地裂缝以及地下水位下降造成植被破坏死亡，使土地沙漠化加剧。

(4) 老空区已成为煤矿开采的主要威胁

目前区内老空区工作欠账较多。国有大型煤炭企业集约化经营，其采空区已达空前规模。而煤炭企业内部老空区资料缺乏共享，各煤炭主体企业资料沟通非常态、不规范，从而造成矿界附近老空区资料成为盲区；同时，目前还存在采空区信息化程度不高，不利于动态安全监管。

正因如此，查明神东煤炭基地神东矿区含水层结构、地下水补给、径流和排泄，以及老空区分布特征，可以为矿区含水层保护、解决缺水问题和老空区水防治提供科学依据，从而保障能源基地的矿产开采安全、水资源安全、生态安全，具有重要的现实意义。

活鸡兔幅位于陕西省神木县和内蒙古自治区伊金霍洛旗交界处 (图 2)，属窟野河流域中游，是神东煤炭基地的中心地带，也是我国煤炭工业战略西移的首选生产基地 (党犇等，2007)。仅图幅内就分布有大柳塔矿、活鸡兔矿和上湾矿等数个千万 t 级的矿井。项目组充分结合当地政府和企业的实际需求开展工作，绘制了神东煤炭基地活鸡兔幅 1∶50 000 综合水文地质图。

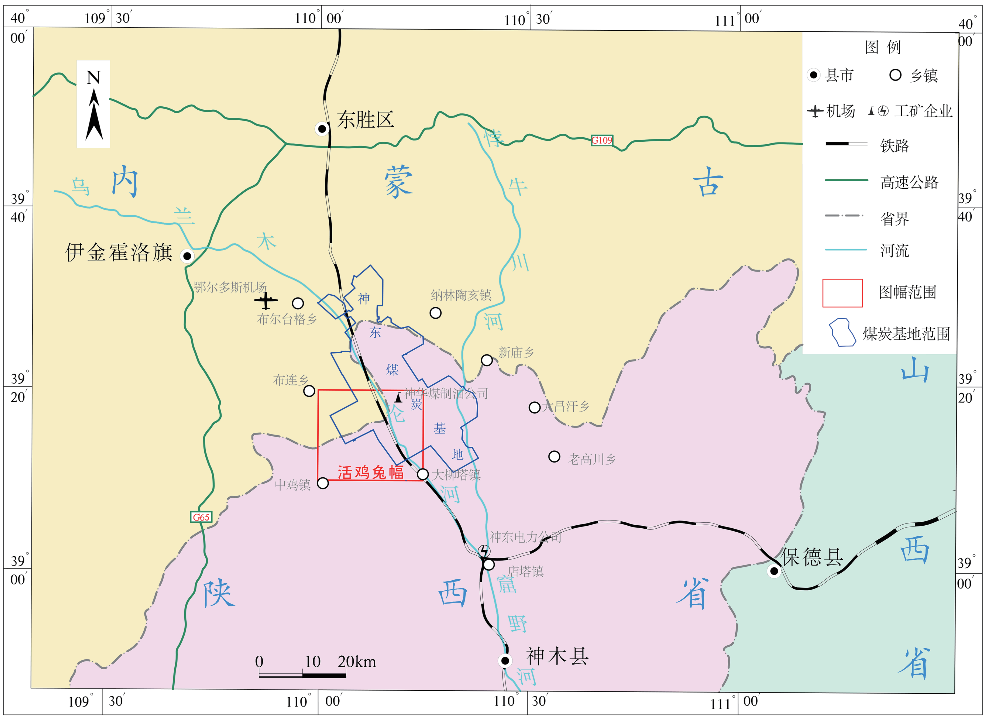

图 2 活鸡兔幅位置图

神东煤炭基地活鸡兔幅 1∶50 000 矿区水文地质数据集为 MapGIS 矢量图数据，元数据如表 1 所示。

表 1 数据库（集）元数据简表

条目	描述
数据库(集)名称	神东煤炭基地活鸡兔幅1∶50 000矿区水文地质数据集
数据库(集)作者	李向全，中国地质科学院水文地质环境地质研究所 马剑飞，中国地质科学院水文地质环境地质研究所 付昌昌，中国地质科学院水文地质环境地质研究所
数据时间范围	2014年1月—2016年12月
地理区域	陕西省神木县、内蒙古伊金霍洛旗
数据格式	MapGIS数据文件：*.wt，*.wl，*.wp
数据量	108 MB
数据服务系统网址	http://dcc.cgs.gov.cn
基金项目	中国地质调查局地质调查项目“神东煤炭基地水文地质调查与老空区普查”(DD20160296)
语种	中文
数据库（集）组成	该数据集主要由水文地质主图及剖面、水化学图(镶图)、采空区分布图(镶图)、径流模式图(镶图)组成。

2 数据采集方法

2.1 基础数据采集方法

本次工作综合应用遥感、地面调查、物探、钻探，以及水化学同位素等方法进行数据采集。在开展 1∶50 000 水文地质填图过程中，针对关键问题，开展综合专题研究。以 DZ/T0282–2015《水文地质调查规范（1∶50 000）》为基准，按照项目工作量设

计，在活鸡兔图幅内共完成遥感解译 800 km^2（2 期数据），调查点 377 个，水位统测点 60 个（按照丰水期、枯水期各统测两次，共计 240 点次），抽水试验 10 组，常规水质分析 45 组，同位素样品 82 组，水文地质钻探 600 m 等。

2.2 水质数据采集方法

常规水质分析样品及 δD、$\delta^{18}O$、^3H 同位素的委托测试单位为国土资源部地下水矿泉水及环境监测中心，采用常规测试方法。$\delta^{34}S\text{-}SO_4^{2-}$、$\delta^{18}O\text{-}SO_4^{2-}$同位素委托单位为核工业北京地质研究院分析测试研究中心。

2.3 地下水流场及疏干区数据采集方法

2.3.1 地下水流场

按照均匀布点，并兼顾各个含水层的原则，在图幅内选择 60 处机民井作为地下水位统测点，实测年内丰水期（10 月底）和枯水期（4 月底）的水位。本次图中显示的为枯水期地下水位等值线。

利用 Surfer 8.0 软件成图，网格化方法选择克里格，地下水位间距为 30 m，并依据水文地质条件进一步完善地下水等值线图。

2.3.2 地下水疏干区

主要根据采空区范围圈定地下水疏干区；同时，结合实地调查到的干涸的机民井和泉点，更进一步刻画地下水疏干区的边界。

2.4 采空区数据采集方法

本次采空区类型按照煤层的开采层位划分，包括：1−2、2−2 和 3−1 煤采空区。实地调查中，首先对整个矿的老空区（采空区、小煤窑）通过资料搜集、走访和现场调查，查明老空区总体分布特征；其次选择重点区段，主要采用浅层二维地震试验、瞬变电磁、高密度电阻率法、视电阻率对称四极剖面法 4 种物探方法，根据地质条件和物探区域存在的技术难点，选择有针对性的试验方案，组合使用上述方法，查清老空区和采空积水区的空间分布、岩性、构造、积水情况等；最后根据物探解译结果，进行老空区钻探施工验证。

2.5 地下水循环模式建立

通过对工作区地下水补给、径流和排泄条件进行分析，将工作区地下水循环分为三级系统，分别为：① 浅部地下水系统，与大气降水和地表水联系密切，径流距离较短；② 深部地下水系统，参与鄂尔多斯盆地区域地下水循环，径流距离长，径流缓慢；③ 局部地下水系统，受煤炭开采影响，径流方向较原生系统发生改变，在区域上形成多个降落漏斗，径流距离较短。

该循环模式作为矿区水文地质调查主要成果之一，以镶图的形式在水文地质图中进行展示。

3 数据处理方法

3.1 富水性等级划分方法

3.1.1 富水性等级

根据地下水系统的内涵，同一含水系统内的地下水往往具有相同的含水介质和共同

的补给来源，且具有同一时空演变过程。因此，将含水介质相同，具有固定边界所圈闭的统一含水岩系作为含水系统的划分依据。依据含水介质类型，区内地下水含水系统可划分为松散岩类孔隙水、碎屑岩类孔隙–裂隙水和烧变岩孔隙–裂隙水三类。其富水性划分标准为：

松散岩类孔隙水：

水量中等：单井涌水量 100~300 m^3/d

水量贫乏：单井涌水量 10~100 m^3/d；

水量极贫乏：单井涌水量<10 m^3/d；

碎屑岩类孔隙–裂隙水：

水量中等：单井涌水量 50~100 m^3/d

水量贫乏：单井涌水量 10~50 m^3/d

水量极贫乏：单井涌水量<10 m^3/d；

其中，单井涌水量为统一换算单井涌水量，即统一换算成 200 mm(约 8 吋) 口径、10 m 降深的涌水量。

烧变岩孔隙–裂隙水：

以烧变岩体作为储水空间，直接接受大气降水补给，在塌落形成的陡崖底部以下降泉的形式线状排泄或集中排泄。因此，烧变岩含水层富水性以泉水流量形式表示。

3.1.2 换算方法

换算公式为：

$$Q' = q \times s' \times \frac{\frac{r'}{r}+1}{2} \tag{1}$$

式中，Q'为统一口径统一降深的涌水量 (m^3/d)；q 为原钻孔抽水时的单位涌水量 [$m^3/(d \cdot m)$]；s'为换算降深 (统一为 10 m)；r'为换算的孔径 (200 mm)；r为原钻孔孔径 (mm)(袁建飞等，2016)。

3.1.3 主要参数确定方法

①单位涌水量计算

计算公式：$q=Q/S$

式中：q—单位涌水量 L/(s·m)；

Q—稳定段平均涌水量 L/s；

S—稳定段平均降深 m。

②单孔稳定流计算

本次参数计算采用单孔潜水稳定流裘布依公式进行计算。

$$K = \frac{0.732 Q \lg R/r}{H^2 - h^2} \tag{2}$$

$$R = 10S\sqrt{K} \tag{3}$$

式中：K—渗透系数 m/d；

Q—单井涌水量 m^3/h；

H—自然状态下含水层厚度 m；

h—稳定状态下含水层厚度 m；

S—抽水试验水位降深 m；

R—影响半径 m；

r—抽水段孔径 m。

3.2 地下水化学特征及水质评价方法

本次调查，共取 13 件第四系地层中的地下水样，11 件白垩系地层中的地下水样，15 件侏罗系安定组和直罗组地层中的地下水样，6 件延安组地层中的地下水样。测试指标包括 K^+、Na^+、Ca^{2+}、Mg^{2+}、Al^{3+}、NH_4^+、Cl^-、SO_4^{2-}、HCO_3^-、CO_3^{2-}、NO_3^-、F^-、Br^-、I^-、NO_2^-、总硬度 ($CaCO_3$)、总酸 ($CaCO_3$)、偏硅酸、游离 CO_2、铜、锌、铅、铁、锰、钴、镍、铬 (六价)、镉、锂、铬、锶、钡、汞、钼、硒、钒、银、砷、偏硼酸、耗氧量、pH 值。

3.2.1 地下水化学特征

选取地下水中主要离子组分 K^+、Na^+、Ca^{2+}、Mg^{2+}、Cl^-、SO_4^{2-}、HCO_3^-、CO_3^{2-}采用舒卡列夫分类法，将 8 种主要离子中含量大于 20%mg 当量的阴离子和阳离子进行组合。在实际应用中，首先将水化学类型按照阴离子划分为 HCO_3 型、SO_4 型和 Cl 型三大类 (表 2) 然后结合研究程度，在每项大类中按照阳离子组合进行细分。

表 2 神东煤炭基地地下水化学类型统计表

地下水类型	Piper水化学类型		个数
松散层及基岩风化带地下水	HCO_3型	HCO_3	8
		HCO_3-SO_4	3
	SO_4型	SO_4-HCO_3	1
		SO_4-Cl	1
	小计		13
中深层洛河组基岩裂隙水	HCO_3型	HCO_3	9
		HCO_3-SO_4	1
	Cl型	Cl-SO_4	1
	小计		11
中深层直罗组基岩裂隙水	HCO_3型	HCO_3	12
		HCO_3-SO_4	2
		HCO_3-Cl	1
	小计		15
中深层延安组基岩裂隙水	HCO_3型	HCO_3	1
		HCO_3-SO_4	2
	SO_4型	SO_4-HCO_3	2
		SO_4-Cl	1
	小计		6

本次工作利用软件 AquaChem 3.70 实现。

3.2.2 地下水质量评价

地下水水质特征见表 3。其中，松散层及基岩风化带地下水主要赋存于第四系萨拉乌苏组含水层和基岩风化带含水层，井深普遍介于 3~30 m。中深层基岩地下水主要赋存于白垩系洛河组含水层和侏罗系直罗组（包括安定组）含水层；此外，在乌兰木伦河两侧则主要赋存于延安组含水层，井深普遍介于 60~150 m

表 3 神东煤炭基地地下水水质统计表

	水质指标	单位	地下水Ⅲ类水质量标准	松散层及基岩风化带地下水(n=13)		中深层基岩裂隙水(n=32)	
				范围	超标个数	范围	超标个数
一般化学指标	pH值	–	6.5≤pH≤8.5	7.47~8.02	0	7.42~9.26	1
	总硬度	(以$CaCO_3$计)/(mg/L)	≤450	125.1~1551	2	9.01~681	2
	溶解性总固体	mg/L	≤1000	230.4~3205	2	193.6~3040	3
	硫酸盐	mg/L	≤250	10.5~1417	2	9.92~1026	4
	氯化物	mg/L	≤250	4.51~621.3	1	3.52~816.9	3
	铁	mg/L	≤0.3	<0.01~0.134	0	<0.01~0.485	1
	锰	mg/L	≤0.1	<0.001~0.12	1	< 0.001~0.279	2
	铜	mg/L	≤1	<0.01	0	<0.01	0
	锌	mg/L	≤1	<0.002~0.15	0	<0.002~0.116	0
	铝	mg/L	≤0.2	<0.02	0	<0.02	0
	耗氧量	(COD_{Mn}法，以O_2计)/(mg/L)	≤3	0.52~2.20	0	0.45~1.42	0
	氨氮	(以N计)/(mg/L)	≤0.5	<0.04~10.11	1	<0.04~0.51	1
	钠	mg/L	≤200	11.27~477.10	1	6.59~762.2	5
毒理学指标	亚硝酸盐	(以N计)/(mg/L)	≤1	<0.002~0.010	0	<0.002~0.002	0
	硝酸盐	(以N计)/(mg/L)	≤20	0.13~45.61	1	0.06~30.37	1
	氟化物	mg/L	≤1	0.05~0.82	0	0.05~3.6	3
	碘化物	mg/L	≤0.08	<0.02	0	<0.02~0.03	0
	汞	mg/L	≤0.001	<0.0001	0	<0.0001	0
	砷	mg/L	≤0.01	<0.001~0.002	0	<0.001~0.005	0
	硒	mg/L	≤0.01	<0.001	0	<0.001~0.006	0
	镉	mg/L	≤0.005	<0.002~0.002	0	<0.002~0.002	0
	铬(六价)	mg/L	≤0.05	<0.004	0	<0.004	0
	铅	mg/L	≤0.01	<0.001~0.009	0	<0.001~0.012	1

本次质量评价采用单因子评价法，选取 23 个指标，分为一般化学指标、无机毒理学指标和毒性重金属指标。其中，一般化学指标包括 pH、铁、锰、铜、锌、铝、氯化物、硫酸盐、总硬度、溶解性总固体、耗氧量、氨氮和钠；无机毒理指标包括碘化物、氟化物、硝酸盐和亚硝酸盐；毒性重金属指标包括砷、硒、镉、铬（六价）、铅、和汞。选评指标的限值以《地下水质量标准》（GB/T14848−2017）为依据。

4 数据样本描述

“神东煤炭基地活鸡兔幅地下水富水程度属性表”(表 4) 包含如下内容：图元编号、地下水类型、含水层富水性等级、单井涌水量 (m^3/d)、调查时间。地下水疏干区的单井涌水量为 0。

“神东煤炭基地活鸡兔幅地下水等水位线属性表”(表 5) 包含如下内容：等水位线值 (m)、地下水类型、水位统测日期。

表 4　神东煤炭基地活鸡兔幅地下水富水程度属性表

序号	字段名称	量纲	字段类型	实例
1	图元编号	–	字符串	10
2	地下水类型	–	字符串	松散岩类孔隙水
3	含水层富水性等级	–	字符串	水量贫乏
4	单井涌水量	m^3/d	字符串	10-50
5	调查时间	–	字符串	2015-6-30

表 5　神东煤炭基地活鸡兔幅地下水等水位线属性表

序号	字段名称	量纲	字段类型	实例
1	等水位线值	m	双精度型	1260.00
2	地下水类型	–	字符串	基岩裂隙水
3	水位统测日期	–	字符串	2015/4/20

“神东煤炭基地采空区属性表”(表 6) 包含“老空区”(区文件) 和“煤矿老窑调查点”(点文件)，其中“采空区”属性表包含如下内容：图元编号、采空区类型、采空区面积 (km^2)；“煤矿老窑调查点”属性表包含如下内容：编号、经度、纬度、硐口标高 (m)、矿坑名称、矿坑类型、地理位置、停采原因、停采时间、矿坑涌水量 (L/s)、取样情况、调查时间。

表 6　神东煤炭基地采空区属性表

类型	序号	字段名称	量纲	字段类型	实例
老空区	1	图元编号	–	字符串	10
	2	采空区类型	–	字符串	2-2煤采空区
	3	采空区面积	km^2	双精度型	6.25
煤矿老窑调查点	1	编号	–	字符串	C174
	2	经度	–	字符串	–
	3	纬度	–	字符串	–
	4	硐口标高	m	字符串	1084.65
	5	矿坑名称	–	字符串	炭窑峁矿
	6	矿坑类型	–	字符串	井采
	7	地理位置	–	字符串	陕西省神木县中鸡镇炭窑峁村
	8	停采原因	–	字符串	采完
	9	停采时间	–	字符串	2012/1/1
	10	矿坑涌水量	L/s	字符串	采完
	11	取样情况	–	字符串	C174(全分析+微量+DOT)
	12	调查时间	–	字符串	2014/8/10

“神东煤炭基地地下水化学特征属性表”(表 7) 包含“地下水化学类型分区”(区文件) 和“地下水化学采样点”(点文件)；其中“地下水化学类型分区”属性表包含如下内容：图元编号、地下水化学类型；“地下水化学采样点”属性表包含如下内容：野外编号、经度、纬度、取水层位、TDS(mg/L)、地下水化学类型、水质级别、超标组分及浓度 (mg/L)、取样日期。

表 7　神东煤炭基地地下水化学特征属性表

类型	序号	字段名称	量纲	字段类型	实例
地下水化学类型分区	1	图元编号	–	字符串	10
	2	地下水化学类型	–	字符串	Ca Mg-HCO_3
地下水化学采样点	1	野外编号	–	字符串	F4
	2	经度	–	字符串	
	3	纬度	–	字符串	
	4	取水层位	–	字符串	J2y
	5	TDS	mg/L	字符串	450
	6	地下水化学类型	–	字符串	Ca Mg-HCO_3
	7	水质级别	–	字符串	Ⅲ
	8	超标组分及浓度	mg/L	字符串	NO_3, F, TDS
	9	取样日期	–	字符串	2015/6/30

5　数据质量控制和评估

本次工作按照中国地质调查局统一安排开展工作方案设计、野外调查、样品采集、分析测试等工作。工作量达到或超过了《中华人民共和国水文地质调查规范（1∶50 000）》（DZ/T 0282−2015）的要求。保证了工作的精度满足实际解决问题的需要。

工作中严格执行国家和行业相关的标准、规范。其中含水层富水程度划分主要依据抽水试验，试验过程满足《煤矿床水文地质、工程地质及环境地质勘察评价标准MTT1091−2008》要求，其中抽水试验降程稳定段时间大于 8 h，水位变化幅度<1%，水量变化幅度<3%，单位涌水量 q<0.01L/(s·m)，达到合格标准。地下水水化学样品的采集、保存和运输均严格按照《水样的采取、保存与送检规程（地矿部 1982−12）》及《土工试验规程（SL237−1999）》的有关条款执行。

为保证数据采集质量，项目执行过程中严格按照中国地质调查局《地质调查项目管理办法》的要求，严格执行“三级质量检查制度”。做到数据自检、互检率 100%，项目负责人检查率大于 30%，质量检查组抽检率超过 10%。项目所有原始数据在抽检、质量检查和质量验收阶段的评级均为“优秀”。

以上措施和方法都保证了本次工作所有原始资料真实可靠，符合相关规范的要求，保证了成果的准确性。

6　数据实用价值

神东煤炭基地活鸡兔幅 1∶50 000 矿区水文地质数据集有以下实用价值：

(1) 建立了采煤影响下地下水的循环模式，用附图的方式反映了采煤活动影响下的孔隙水及裂隙水的水动力场空间演化特征和区域地下水补给、径流和排泄特征。从而让数据使用人员在第一时间可以对该图幅内水文地质结构特征有一个直观的认识，增强了数据的可读性。

(2) 本数据将作为煤矿主要充水水源的第四系含水层富水等级细化为三级，分别为：水量中等（单井涌水量 100~300 m^3/d）、水量贫乏（单井涌水量 10~100 m^3/d）、水量极贫乏（单井涌水量<10 m^3/d）。将白垩系洛河组富水等级划分为三级，分别为：水量中等（单井涌水量 50~100 m^3/d）、水量贫乏（单井涌水量 10~50 m^3/d）、水量极

贫乏（单井涌水量<10 m^3/d）。这样的划分方案将神东煤炭基地主要含水层富水规律更精确地表现出来，大幅提高了原有 1∶200 000 水文地质图的精度；同时填补了该地区侏罗系安定组、直罗组的水文地质条件、空间分布和水文地质参数的空白。可以为自然资源、城建、农田水利等部门的地下水资源合理开发、利用和保护提供更为详实的基础资料数据。同时可以为大型国有煤炭企业在生产规划、安全生产等方面提供更高精度的基础图件。

(3) 加入了与采煤相关的次生环境地质要素（如采空区、疏干区、矿坑水天然排水点、采空塌陷及地裂缝等），并标示出矿坑水天然排水点的排水量、出露地层及水化学指标，绘制了地下水化学图作为镶图。为自然资源、环保、灾害应急等相关部门相关政策的决策和部署提供基础数据。

(4) 集成遥感、物探及实地调查成果，查明了老空区的类型及分布范围，绘制了采空区分布图放置于镶图中。可为国有大型煤炭企业、安监部门的动态信息管理，安全生产，相关信息系统的建立等工作提供较为详实的基础调查数据。

7　结论

神东煤炭基地 1∶50 000 活鸡兔幅矿区水文地质数据集是在总结前人工作基础上开展相关实际工作，并创新性地进行矿区水文地质调查数据总结提升的基础上完成的。本次工作细化了第四系孔隙含水层、白垩系洛河组孔隙裂隙含水层富水等级，填补了侏罗系安定组、直罗组水文地质信息的空白。同时加入了与采煤相关的次生环境地质要素，突出了矿区水文地质调查的特色，具有一定的创新性和实用性。为矿区水文地质调查工作的规划、部署与总结提供常态化支持，对保障国家能源安全、生态安全以及生产安全具有重要的实用价值。

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Dataset of the 1∶50 000 Hydrogeological Map of the Huojitu Mine Area, Shendong Coal Base

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Abstract: For this dataset of the 1∶50 000 hydrogeological map of Huojitu, multiple methods such as remote sensing, surface survey, geophysical exploration, drilling exploration as well as hydrochemical isotope tests were applied for data acquisition. The remotely sensed data interpretation of 800 km^2 area was successfully achieved in two phases, together with 377 surface survey points, 240 points of simultaneous−measurement of groundwater level during rain and dry seasons, 10 sets of pumping tests, 127 sets of water samples and 600 m of cumulative hydrogeological drilling footage. The level of water yield property of the Quaternary porous aquifer and the Cretaceous Luohe Formation porous fissure aquifer within the working area was refined in this dataset, filling the gap in hydrogeological information about the Jurassic Anding Formation and Zhiluo Formation. Meanwhile, secondary environmental geologic elements related to coal mining were added, and the unwatering zone of the shallow aquifer was successfully delineated for the first time. Furthermore, a groundwater circulation mode under the impact of coal mining was established, highlighting characteristics of hydrogeological survey in mine areas. This dataset provides normal support to plan, deploy and summarize hydrogeological survey in the mine areas, which is really important to guarantee national security in both energy resources and ecology.

Key words: hydrogeological mapping; new dataset; 1∶50 000; unwatering zone; Shendong Coal Base; Huojitu; Shaanxi Province/Inner Mongolia

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

1 Introduction

The Shendong Coal Base is one of the 14 large coal bases nationally, under plan to be built (see Fig. 1). It is a coal field with the largest proven reserves in China. The Shendong

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Mine Area, to which it belongs, is home to several large mines in China, for instance, Daliuta, Halagou, Yujialiang and Buertai, with current production of over 10 000 000 tons. Its raw coal output accounts for 6% of national output and 12% of total output of key national coal mines. As the first 200 000 000–ton commercial coal base in China, Shendong plays an important supporting role in China's coal production and energy security. However, there are grave problems in hydrogeology and environmental geology over the Shendong Mine Area, restricting sustainable development. These problems are mainly as follows:

Fig. 1 Distribution map of coal bases in China

(1) Severe shortage of water resources

The Shendong mine area stands in an arid to semi–arid region where the mean rainfall is just 437.2 mm annually, showing a clear scarcity of water resources. At present, the Shendong mine area receives a water supply of 22.3×10^4 m^3/d with a shortage of 16.7×10^4 m^3/d, which is a 42.8% demand shortage. With expanding coal production, there will be a continuous increase in water shortage.

(2) Aquifer structure and groundwater resources are devastated

In the Shendong mine area, the main aquifer directly overlies Jurassic coal–bearing strata. Mining of the coal seams has resulted in damage to the overlying aquifer, leading to a decreased level of groundwater, declined spring flow, unwatered aquifers and spring cut off, thus resulting in devastated groundwater resources (Duan ZH, 2001; Zhang MS et al., 2010; Cao ZG et al., 2014; Wang ZR, 2017).

(3) Deteriorating eco–environment

Coal mining has resulted in eco–environmental problems over the mine area, such as subsided surfaces, ground fissuring, degraded vegetation and land desertification (Xu YN et al., 2008). In some regions, the ground fissures have grown up to 2 m wide and over 10 m deep, local surface have subsided to about 2–3 m, and the maximum subsided depth is 6.5 m. Subsidence, ground fissure and decreased groundwater levels have contributed to devastated or even dead vegetation, exacerbating land desertification.

(4) Goafs have become a main threat to coal mining

At present, few work is done on goafs. With the intensive operation of large coal State–owned Enterprises (SOEs), goafs have reached an unprecedented scale. Coal enterprises do not sufficiently share information on goafs internally. The occasional and irregular information dissemination among coal enterprises have caused goafs near the mine boundary to become dead zones. Meanwhile, the scarcity of existing information on goafs is unfavorable for dynamical safety regulation.

For this reason, identifying the aquifer structure, groundwater recharge, runoff, discharge and the distribution characteristics of goafs over the Shendong mine area in the Shendong Coal Base, will provide a scientific basis for protecting aquifers, solving water shortage problems, and preventing and controlling goafs over the mine area so as to ensure mining, water resources and the ecological security of the energy resource base.

Huojitu is situated at the intersection between Shenmu County, Shaanxi and Ejin Horo Banner, Inner Mongolia Autonomous Region (see Fig. 2), in the midstream of Kuye River Basin, which is a central zone of the Shendong Coal Base and also a preferred production base in the pushing westward for China’s coal industry strategy (Dang B et al., 2007). Within the map sheet, there are several 10 000 000–ton coal mines distributed over the area, such as Daliuta Mine, Huojitu Mine and Shangwan Mine. Taken into consideration the real needs of local government and enterprises, the project team prepared the 1∶50 000 comprehensive hydrogeological map of Huojitu, Shendong Coal Base.

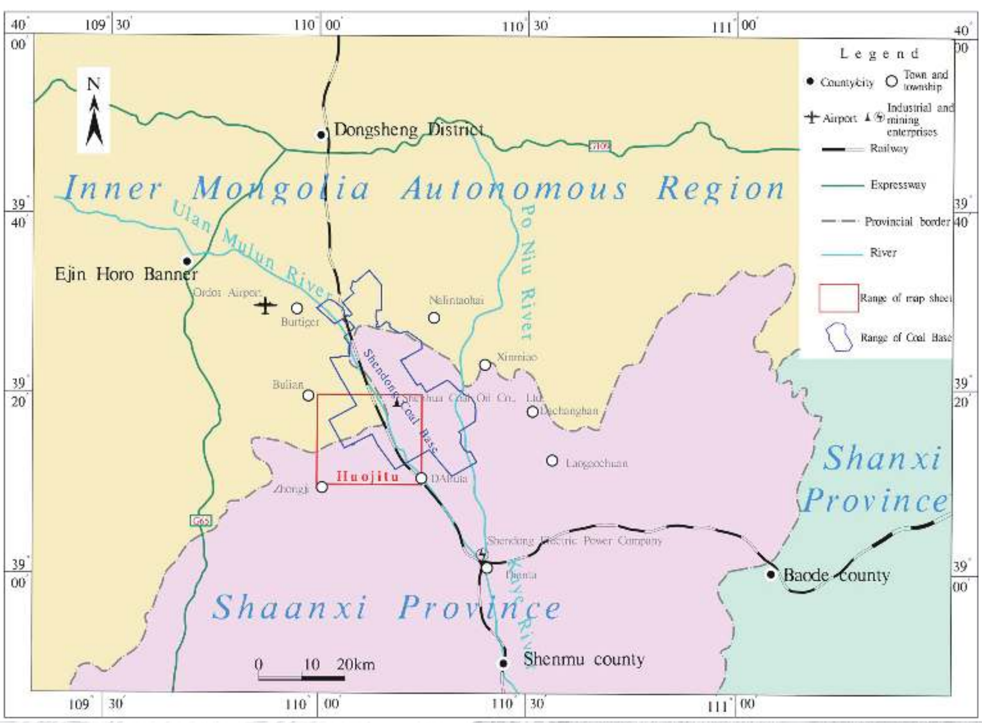

Fig. 2 Huojitu location map

The hydrogeological dataset of the mine area of the 1∶50 000 hydrogeological map of Huojitu within Shendong Coal Base applies MapGIS vector graph data, with metadata as shown in Table 1.

Table 1 Metadata Table of Database (Dataset)

Items	Description
Database (dataset) name	Dataset of the 1∶50 000 Hydrogeological Map of the Mine Area of Huojitu, Shendong Coal Base
Database (dataset) authors	Li Xiangquan, Institute of Hydrogeology and Environmental Geology, Chinese Academy of Geological Sciences Ma Jianfei, Institute of Hydrogeology and Environmental Geology, Chinese Academy of Geological Sciences Fu Changchang, Institute of Hydrogeology and Environmental Geology, Chinese Academy of Geological Sciences
Data acquisition time	Jan. 2014—Dec. 2016
Geographic area	Shenmu County, Shaanxi Province, and Ejin Horo Banner, Inner Mongolia
Data format	MapGIS data file: *.wt, *.wl, *.wp
Data size	108 MB
Data service system URL	http://dcc.cgs.gov.cn
Fund project	China Geological Survey project “Hydrogeological Survey and Goaf General Survey for Shendong Coal Base”(12120114086601)
Language	Chinese
Database (dataset) composition	The dataset mainly consists of the hydrogeological master map and profile, hydrochemical map (mosaic map), goaf distribution map (mosaic map) and runoff pattern map (mosaic map).

2 Data Acquisition

2.1 Basic Data Acquisition

For this project, data was acquired by using methods such as remote sensing, surface survey, physical exploration, drilling exploration as well as comprehensive hydrochemistry and isotope analysis. During preparation of the 1∶50 000 hydrogeological map, critical problems were highlighted as the key investigation points. The project workload was devised in accordance with DZ/T 0282−2015 *Specification for Hydrogeological Survey (1∶50 000)*. The project completed 800 km^2 of remotely sensed data interpretation (2 phases), 377 survey points, 60 water level simultaneous observation points (240 points in total, two times per point during the dry and rainy seasons, respectively), 10 sets of pumping tests, 45 sets of conventional water quality analysis, 82 sets of samples for isotope analysis and 600 m depth for hydrogeological drilling.

2.2 Water−quality Data Acquisition

Samples for conventional water quality analysis and for analysis of δD、$\delta^{18}O$ and ^{3}H isotopes were tested using conventional testing methods in the Groundwater, Mineral Water and Environmental Monitoring Center, Ministry of Natural Resources (MNR). Samples for analysis of $\delta^{34}S-SO_4^{2-}$ and $\delta^{18}O-SO_4^{2-}$ isotopes were tested in the Analytical Laboratory of the Beijing Research Institute of Uranium Geology, China National Nuclear Corporation (CNNC).

2.3 Data Acquisition on Groundwater Flow Field and Unwatering Zone

2.3.1 Groundwater Flow Field

Following the principle of "Evenly deploy points and consider every aquifer", within Huojitu, 60 pumping and domestic wells were chosen for simultaneous−measurement of groundwater levels during the rainy season (end October) and the dry season (end April) of the same year. The map shows underground water level contours for the dry season.

Software Surfer 8.0 was used to plot; the gridding method Kriging was applied. The interval between groundwater levels was 30 m and the groundwater isoline map was further improved based on the hydrogeological conditions.

2.3.2 Groundwater Unwatering Zone

The groundwater unwatering zone was mainly delineated on the basis of the range of a goaf, while taking into account the dry pumping (domestic) wells and springs surveyed in the field. The border of the groundwater unwatering zone was further refined.

2.4 Data Acquisition on Goafs

The type of goaf is divided by the exploited horizon of coal seams, including 1^{-2}, 2^{-2} and 3^{-1} coal goafs. While performing the field survey, the general distribution characteristics of goafs (including coal pits) were first worked out by visiting, surveying and collecting information in situ. Secondly, key sections were selected by using four geophysical prospecting methods: shallow 2D seismic testing, transient electromagnetic method, high density resistivity method, and apparent resistivity symmetric quadrupole profiling method. Targeted test protocols were selected on the basis of technical difficulties in geological conditions and geophysical prospective areas and the aforementioned methods were combined to thoroughly understand spatial distribution, lithology, structure and water accumulation of goafs and open mine pits with accumulated water. Finally, one goaf was drilled for verification based on the interpretation results to geophysical prospecting.

2.5 Establishment of Groundwater Circulation Mode

By analyzing groundwater recharge, runoff and discharge conditions in the working area, the groundwater circulation of the working area was divided into three−level systems: 1) shallow groundwater system, which is closely related to rainfall and surface water, having short−distance runoff; 2) deep groundwater system, which is involved in groundwater circulation in the Erdos Basin, having long−distance and slow runoff; and 3) local groundwater system, of which the runoff has changed against that of the primary system due to influence of coal mining, forming multiple depression cones in the region, as well with a shorter−distance.

The circulation mode, as one of main hydrogeological survey results in the mine area, is indicated on the hydrogeological map in the form of a mosaic map.

3 Data Processing

3.1 Identification for Levels of Water Yield Property

3.1.1 Levels of Water Yield Property

According to the connotation of a groundwater system, groundwater within the same water–bearing system always has the same water–bearing medium and a common source of recharge. These entities undergo the same temporal and spatial evolutionary process. Therefore, the unified water–bearing formation having the same water–bearing medium and delineated with a fixed border is used as the basis to classify water–bearing systems. Based on the type of water–bearing medium, any groundwater–bearing system within the area can be identified as water in loose porous rock, clastic rock core fissure water or burnt rock pore fissure water. Here, the water yield property is divided into:

For loose rock pore water:

Medium water volume; water yield is 100~300 m^3/d per well.

Poor water volume; water yield is 10~100 m^3/d per well.

Very poor water volume; water yield is <10 m^3/d per well.

For Clastic rock pore fissure water:

Medium water volume; water yield is 50~100 m^3/d per well.

Poor water volume: water yield is 10~50 m^3/d per well.

Very poor water volume: water yield is <10 m^3/d per well.

Where the water yield per well is the unified, converted water yield per well is converted to the water yield in the case of a diameter of 200 mm (about 8 inches) and 10 m drawdown.

For burnt rock pore fissure water:

Water stored in the burnt rock bodies is recharged directly from rainfall and discharged in linear or concentrated ways in the form of a depression spring from the bottom of the escarpment that forms due to collapse. Therefore, the water yield property of a burnt rock aquifer is expressed by the spring flow rate.

3.1.2 Conversion

The conversion equation is:

$$Q' = q \times s' \times \frac{\frac{r'}{r} + 1}{2} \tag{1}$$

Where, Q' is the water yield from unified diameter and unified drawdown (m^3/d); q is the specific yield [m^3/(d·m)] during pumping in the original well; s' is the drawdown for conversion (unified to be 10 m); r' the converted well diameter (200 mm); r the diameter of the original well (mm) (Yuan JF et al., 2016).

3.1.3 Determination of Main Parameters

①Calculation of specific yield

The formula is: $q=Q/S$

Where, q: specific yield [L/(s·m)];

Q: the mean water yield at the stable section (L/s);

S: the mean drawdown at the stable section (m).

②Calculation of single–well steady flow

Parameters are calculated with the single well unconfined–water steady flow dupuit equation:

$$K = \frac{0.732Q\lg R/r}{H^2 - h^2} \tag{2}$$

$$R = 10S\sqrt{K} \tag{3}$$

Where, K: the permeability coefficient (m/d);

Q: the single well water yield (m^3/h);

H: aquifer thickness at the natural state (m);

h: aquifer thickness at the steady state (m);

S: drawdown during pumping test (m);

R: radius of influence (m);

r: the well diameter of the pumping section.

3.2 Evaluation of Groundwater Chemical Features and Quality

This survey took 13, 11, 15 and 6 groundwater samples from a Quaternary formation, a Cretaceous formation, the Jurassic Anding and Zhiluo formations, and the Jurassic Yan' an Formation, respectively. Indices tested include K^+, Na^+, Ca^{2+}, Mg^{2+}, Al^{3+}, NH_4^+, Cl^-, SO_4^{2-}, HCO_3^-, CO_3^{2-}, NO_3^-, F^-, Br^-, I^-, NO_2^-, total hardness ($CaCO_3$), total acidity ($CaCO_3$), metasilicic acid, free CO_2, Cu, ZN, Pb, Fe, Mn, Co, Ni, Cr(hexavalent), Cd, Li, Cr, Sr, Ba, Hg, Mo, As, V, Ag, Se, metaboric acid, oxygen consumption and pH value.

3.2.1 Groundwater Chemical Features

The Shukarlev classification is used to combine anions and cations that contain more than 20% mg equivalent, from eight main ion components in the groundwater, i.e. Na^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-}, HCO_3^- and CO_3^{2-}. In practical application, the hydro chemical type is first divided into three categories by anion: HCO_3^-, SO_4^{2-} and Cl^- (see Table 2). Each category is then further sub−divided by combination of cations.

Table 2 Groundwater hydrochemical categories at Shendong Coal Base

Groundwater type	Piper hydro chemical category		Number
Groundwater in unconsolidated formation and bedrock weathering zone	Category HCO_3	HCO_3	8
		HCO_3−SO_4	3
	Category SO_4	SO_4−HCO_3	1
		SO_4−Cl	1
	Subtotal		13
Bedrock fissure water of medium−deep Luohe Formation	Category HCO_3	HCO_3	9
		HCO_3−SO_4	1
	Category Cl	Cl−SO_4	1
	Subtotal		11
Fissure water in bedrock of medium−deep Zhiluo Formation	Category HCO_3	HCO_3	12
		HCO_3−SO_4	2
		HCO_3−Cl	1
	Subtotal		15
Fissure water in bedrock of medium−deep Yan'an Formation	Category HCO_3	HCO_3	1
		HCO_3−SO_4	2
	Category SO_4	SO_4−HCO_3	2
		SO_4−Cl	1
	Subtotal		6

The software AquaChem 3.70 is used to do this.

3.2.2 Evaluation of Groundwater Quality

Groundwater quality features are shown in Table 3. The groundwater in unconsolidated formations and bedrock weathering zones mainly occurs in the aquifer of the Quaternary Lawusu Formation and Bedrock weathering zone, with a general well depth ranging between 3 m and 30 m. Groundwaters in the medium−deep mainly occur in the aquifer of the Cretaceous Luohe Formation and the Jurassic Zhiluo Formation (including Anding Formation). Additionally, the aquifer of the Yan'an Formation mainly occurs in both sides of Wulanmulun River, where the general well depth ranges from 60 m to 150 m.

Table 3 Groundwater quality summary at Shendong Coal Base

Water quality index		Unit	Quality limit for groundwater class III	Groundwater in unconsolidated formation and bedrock weathering zone (*n*=13)		Fissure water in bedrock of medium−deep stratum(*n*=32)	
				Range	Number beyond limit	Range	Number beyond limit
General chemical index	pH value	–	6.5≤pH≤8.5	7.47~8.02	0	7.42~9.26	1
	Total hardness	(Calculated per $CaCO_3$)/(mg/L)	≤450	125.1~1551	2	9.01~681	2
	TDS	mg/L	≤1000	230.4~3205	2	193.6~3040	3
	Sulphate	mg/L	≤250	10.5~1417	2	9.92~1026	4
	Chloride	mg/L	≤250	4.51~621.3	1	3.52~816.9	3
	Iron	mg/L	≤0.3	<0.01~0.134	0	<0.01~0.485	1
	Mn	mg/L	≤0.1	<0.001~0.12	1	<0.001~0.279	2
	Cu	mg/L	≤1	<0.01	0	<0.01	0
	Zn	mg/L	≤1	<0.002~0.15	0	<0.002~0.116	0
	Al	mg/L	≤0.2	<0.02	0	<0.02	0
	Oxygen consumption	(COD_{Mn} method, calculated as O_2)/(mg/L)	≤3	0.52~2.20	0	0.45~1.42	0
	Ammonia nitrogen	(Calculated as N)/(mg/L)	≤0.5	<0.04~10.11	1	<0.04~0.51	1
	Na	mg/L	≤200	11.27~477.10	1	6.59~762.2	5
Toxicological index	Nitrite	(Calculated as N)/(mg/L)	≤1	<0.002~0.010	0	<0.002~0.002	0
	Nitrate	(Calculated as N)/(mg/L)	≤20	0.13~45.61	1	0.06~30.37	1
	Fluoride	mg/L	≤1	0.05~0.82	0	0.05~3.6	3
	Iodide	mg/L	≤0.08	<0.02	0	<0.02~0.03	0
	Hg	mg/L	≤0.001	<0.0001	0	<0.0001	0
	As	mg/L	≤0.01	<0.001~0.002	0	<0.001~0.005	0
	Se	mg/L	≤0.01	<0.001	0	<0.001~0.006	0
	Cd	mg/L	≤0.005	<0.002~0.002	0	<0.002~0.002	0
	Cr (hexavalent)	mg/L	≤0.05	<0.004	0	<0.004	0
	Pb	mg/L	≤0.01	<0.001~0.009	0	<0.001~0.012	1

The single factor evaluation is used in this quality evaluation: 23 indices are selected and divided into general chemical index, inorganic toxicological index and toxic heavy metal index. The general chemical indexes include pH, Fe, Mn, Cu, Zn, Al, chloride, sulphate, total hardness, TDS, oxygen consumption, ammonia, nitrogen and Na. The inorganic toxicological indexes include iodide, fluoride, nitrate and nitrite. The toxic heavy–metal indexes include As, Se, Cd, Cr (hexavalent), Pb and Hg. The evaluation indicators are set in accordance with the *Standard for Groundwater Quality* (GB/T14848-2017).

4 Description of Data Samples

The "Groundwater Water Yield Property Level Attribute of Huojitu, Shendong Coal Base" (see Table 4) includes: meta–map No., groundwater type, level of aquifer water–yield property, single well water yield (m^3/d) and survey date/time. The single well water yield at the groundwater unwatering zone is 0.

Table 4 Groundwater Water–yield property Level Attribute of Huojitu, Shendong Coal Bas

No.	Field name	Dimension	Field type	Real example
1	Meta–map No.		Character string	10
2	Groundwater type		Character string	Loose rock pore water
3	Level of aquifer water yield property		Character string	Poor water volume
4	Single well water yield	m^3/d	Character string	10~50
5	Date/time for survey		Character string	June 30 2015

The "Groundwater Water Level Contour Attribute of Huojitu, Shendong Coal Base" (see Table 5) includes: water level contour value (m), groundwater type and date/time of simultaneous observation of water level.

Table 5 Groundwater Water–level Contour Attribute of Huojitu, Shendong Coal Base

No.	Field name	Dimension	Field type	Real example
1	Water level contour value	m	Double precision mode	1260.00
2	Groundwater type		Character string	Fissure water in bedrock
3	Date for simultaneous observation of water level		Character string	Apr. 20 2015

The "Shendong Coal Base Goaf Attribute" (see Table 6) includes goaf (zone file) and survey points in old coal pits (dot file), where the goaf attribute sheet includes: meta–map No., goaf type, goaf area (km^2). The old coal pits' survey point attribute sheet includes: No. longitude, latitude, adit opening elevation (m), pit name, pit type, geographical location, reason for mining cessation, date/time for mining cessation, pit water–yield (L/s), date/time for sampling and date/time of survey.

Table 6 Shendong Coal Base Goaf Attribute

Type	No.	Field name	Dimension	Field type	Real example
Goaf	1	Meta–map No.		Character string	10
	2	Goaf type		Character string	2–2 coal goaf

Continued table 6

Type	No.	Field name	Dimension	Field type	Real example
Goaf	3	Goaf area	km^2	Double–precision mode	6.25
Old coal pits' survey point	1	No.		Character string	C174
	2	Longitude		Character string	
	3	Latitude		Character string	
	4	Adit opening elevation	m	Character string	1084.65
	5	Pit name		Character string	Tanyaomao Mine
	6	Pit type		Character string	Mining
	7	Geographical loca1		Character string	Tanyaomao Village, Zhongji Town, Shenmu County, Shaanxi Province
	8	Time for mining cease		Character string	Mining completed
	9			Character string	1–1
	10	Pit water–yield		Character string	Mining completed
	11	Sampling		Character string	C174(total analysis + trace + DOT)
	12	Date/time for survey		Character string	Aug. 10 2014

The "Groundwater Chemical Feature Attribute Sheet at Shendong Coal Base" (see Table 7) includes groundwater chemical type zoning (zone file) and groundwater chemical sampling points (dot file). Whereas, the groundwater chemical type attribute sheet includes: meta–map No., groundwater chemical type; the groundwater chemical sampling point attribute sheet includes: field No.; longitude, latitude, horizon for water sampling, TDS (mg/L), groundwater chemical type, water quality level, beyond limit component and concentration (mg/L), and date/time for sampling.

Table 7 Groundwater Chemical Feature Attribute at Shendong Coal Base

Type	No.	Field name	Dimension	Field type	Real example
Zoning by groundwater chemical type	1	Meta–map No.		Character string	10
	2	Groundwater chemical type		Character string	Ca Mg–HCO_3
Groundwater chemical sampling point	1	Field No.		Character string	F4
	2	Longitude		Character string	
	3	Latitude		Character string	
	4	Horizon for water sampling		Character string	J2y
	5	TDS	mg/L	Character string	450
	6	Groundwater chemical type		Character string	Ca Mg–HCO_3
	7	Water quality level		Character string	Ⅲ
	8	Beyond limit component and its concentration	mg/L	Character string	NO_3, F and TDS
	9	Sampling date		Character string	June 30 2015

5 Data Quality Control and Assessment

This project conducted the design of work plan, field survey, sample acquisition, analysis and testing as arranged by CGS. The workload reached or exceeded those required in the *Specification of the People's Republic of China for Hydrogeological Survey (1∶50 000)* (DZ/T 0282-2015). The project assured that its work meets the needs to solve practical problems in terms of precision.

The project was implemented strictly in accordance with national and industry specific standards and specifications. Identifying the aquifer's water–yield property level mainly depended on the pumping test which was done in accordance with the *Standard for Exploration and Evaluation of Hydrogeology, Engineering Geology and Environment Geology in* Coal Beds *(MT/T 1091-2008)*. During drawdown stabilization of the pumping test, the period was longer than 8 h, the water level change was < 1%, the water–yield change is < 3% and the specific yield q is < 0.01 L/(s·m), thus all these indicators are up to the standard. Groundwater hydro chemical samples were acquired, stored and transported in strict accordance with relevant clauses in the *Specification for Acquisition, Storage and Transportation for Testing of Water Samples (MGMR 1982-12)* and *Specification for Geotechnical Tests (SL237-1999)*.

To ensure data quality acquired, the project team strictly followed the "Three–level Quality Inspection System" in accordance with the *Rules for Geologic Project Management* of CGS, achieving data self–check and mutual check rate of 100%, check rate of project head more than 30% and random inspection rate of quality inspection group over 10%. All original data acquired in the project are rated as "excellent" in the stage of random inspection, quality inspection and quality acceptance.

All aforementioned measures and methods ensured originality and credibility of information obtained in the project, meeting requirements of relevant specifications and thus ensuring accurate results.

6 Practical Data Value

The dataset of the 1∶50 000 hydrogeological map of the mine area of Huojitu within Shendong Coal Base has the following practical values:

(1) This dataset has established the groundwater circulation pattern under impact of coal mining, and indicated the spatial evolutionary features of pore and fissure water fields, regional groundwater recharge, runoff and discharge under the influence of coal mining activities by attached maps. Thus, the data users can get a visual understanding of the hydrogeological structural features within Huojitu at first sight, enhancing the readability of the data.

(2) In this dataset, the water–yield property of the Quaternary aquifer, which is the main water source of the coal mines is refined into three levels: medium water volume (single well water yield: 100~300 m^3/d), poor water volume (single well water yield: 10~100 m^3/d), and very poor water volume (single well water yield: <10 m^3/d). The water–yield property of the Cretaceous Luohe Formation aquifer is divided into three levels: medium water volume (single

well water yield: 50~100 m^3/d), poor water volume (single well water yield: 10~50 m^3/d), and very poor water volume (single well water yield: <10 ^{3}/d). Such a division shows more accurately the water–yield property regularities in the main aquifers at the Shendong Coal Base and significantly increases the precision from the previous 1∶200 000 hydrogeological map, while filling the gap for parameters in hydrogeological conditions, spatial distribution and hydrogeology of the Jurassic Anding and Zhiluo formations in the region. The dataset can provide more detailed basic information and the data for natural resources, urban building, agricultural field and hydraulic engineering authorities to rationally develop, utilize and protect groundwater resources. It can also provide basic maps with higher precision for large coal SOEs to design their production and ensure production safety.

(3) In this dataset, secondary environmental geological elements associated with coal mining (e.g. goaf, unwatering zone, natural water discharge points of pits, collapsed mine pits and ground cracks) have been added, indicating the water discharge of pits, outcropping formations and hydrogeological indices and plotted groundwater chemical maps as a mosaic map. This then provides basic data for natural resources and environmental protection and disaster emergency authorities to aid them in their policy–making processes and deployment.

(4) Integrating the results from remote sensing, geophysical prospecting and field survey, this dataset has identified goaf types and distribution range and plotted the goaf distribution map as a mosaic map. It provides more detailed survey data for large coal SOEs and safety regulation authorities for dynamic information management, safety production and establishment of relevant information systems.

7 Conclusions

The dataset of the 1∶50 000 hydrogeological map of the mine area of Huojitu, Shendong Coal Base was practically conducted on the basis of summarizing the work of previous researchers and was built on summarizing and innovatively improving data from hydrogeological survey in the mine area. The work refined the level of water–yield property of pore fissure aquifers in the Quaternary and the Cretaceous Luohe Formation, and filled the gap in hydrogeological information on the Jurassic Anding and Zhiluo formations. In addition, it has added the secondary environmental geologic elements related to coal mining, highlighting the characteristics of hydrogeological survey in the mine area through a practically innovative approach. This dataset provides normal support to planning, deployment and summarization of hydrogeological survey in mine areas and has real value in guaranteeing national security of energy resources, ecology and production.

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