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陕西石泉-旬阳金矿带整装勘查区饶峰幅等 7 个图幅区 1: 50 000 水系沉积物测量原始数据集

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摘要:首次汇集了陕西石泉-旬阳金矿带整装勘查区内 7 个图幅 1: 50 000 水系沉积物测量 18 种元素 (Au、Cu、Zn、As、Sb、Hg、Bi、Ti、V、Ag、Sn、Pb、W、Mo、Ni、Co、Cr、Cd) 的测试数据, 共包含数据点 13 169 个, 数据 180 944 个, 第一次建立了该勘查区的地球化学数据库。在此基础上, 编制了 233 张各类地球化学系列图件, 并建立了空间数据库。通过本数据集在区内共圈定各类单元元素异常 2 083 处, 其中金元素异常 304 处; 圈定金找矿靶区 10 处, 金成矿远景区 12 处; 经过后期矿产综合检查, 整装勘查区内共发现金矿产 (点) 53 处, 其中, 中型规模金矿床 8 处, 小型规模金矿床 18 处, 金元素异常与金矿床 (点) 对应程度较好, 矿致异常达 189 处, 显示 1: 50 000 水系沉积物测量是勘查区内较好的找矿手段之一。

关键词:陕西石泉-旬阳金矿带; 整装勘查区; 水系沉积物; 地球化学数据; 空间数据库; 1: 50 000

数据服务系统网址: <http://dcc.cgs.gov.cn>

1 引言

石泉-旬阳金矿带整装勘查区 7 个图幅区 1: 50 000 水系沉积物测量始于 2013 年 (图 1), 其中饶峰幅、迎宾街幅和安康幅 1: 50 000 水系沉积物测量由中国地质调查局发展研究中心 2016—2018 年组织实施; 铁佛寺幅、汉阴幅、大河口幅和赵家湾幅 1: 50 000 水系沉积物测量由中国地质调查局西安地质调查中心 2013—2015 年组织实施, 承担单位均为陕西地矿第一地质队有限公司。

陕西石泉-旬阳金矿带整装勘查区位于秦岭造山带中部的南秦岭构造带, 在漫长地质历史演化中, 该区地层经历了多期变形, 构造样式以褶皱、滑脱和韧性剪切带最为典型。地层区划隶属于华南地层大区中的牛山地层小区 (韩芳林等, 2013) (图 2)。因

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盖层与基底间拆离滑脱，以出露滨海环境下形成的震旦纪—早古生代黑色浅变质强变形细碎屑岩系建造最为典型（张复新等，2009；唐永忠等，2012）。区内出露地层有古元古代杨坪岩组、耀岭河岩组中基性火山岩，古生代沉积—浅变质岩，中晚志留世—早泥盆世沉积地层发育不全（刘国惠和张寿广，1993）。

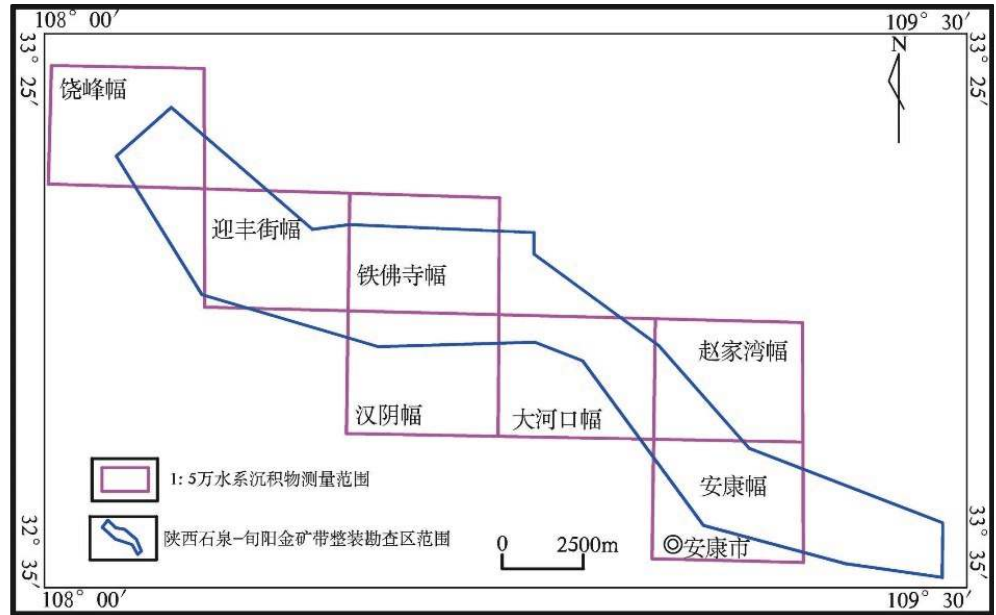


图1 陕西石泉-旬阳金矿带整装勘查区1:50 000水系沉积物测量范围

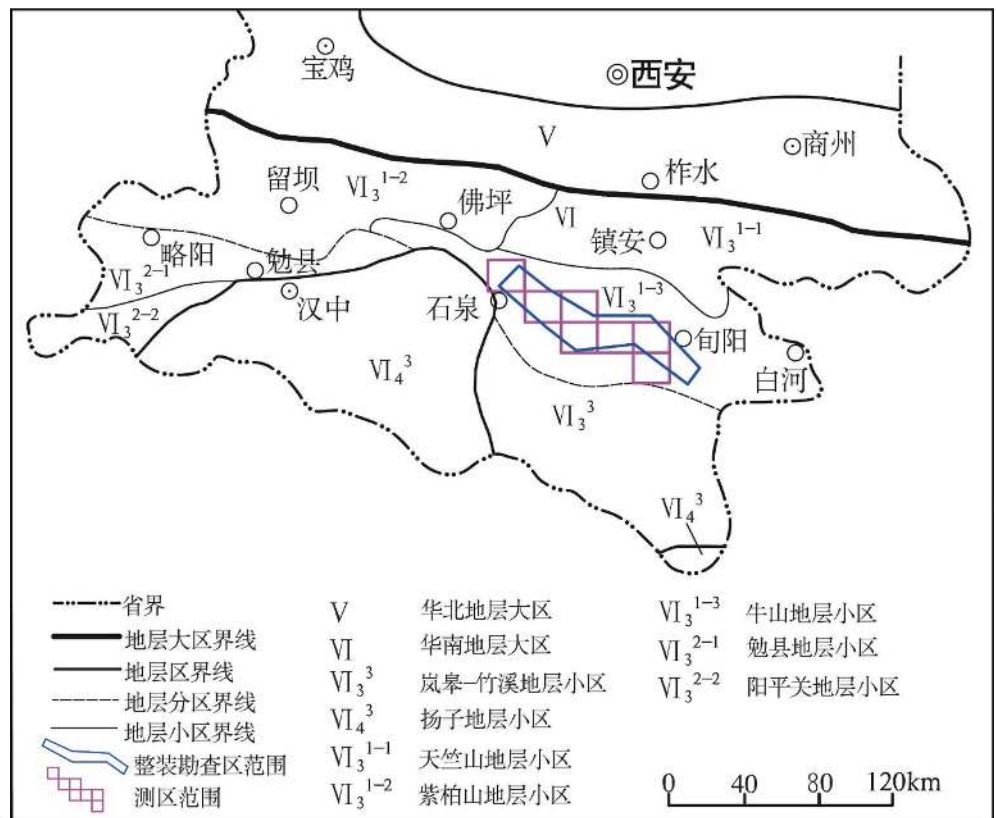


图2 陕西石泉-旬阳金矿带整装勘查区地层区划略图

石泉-旬阳金矿带整装勘查区1:50 000水系沉积物测量从2013年7月份编写项目设计书开始,各项工作均按相关技术要求执行。项目总体按三个阶段进行,第一阶段组织地球化学勘查技术人员进行1:50 000水系沉积物测量采样工作;第二阶段检查、核对、整理和处理数据,圈定地球化学异常;第三阶段编制地球化学系列图件,建立完善石泉-旬阳金矿带整装勘查区的区域地球化学数据库,筛选并进行异常查证工作。

陕西石泉-旬阳金矿带整装勘查区水系沉积物测量原始数据集元数据简表见表1。

表1 数据库(集)元数据简表

条目	描述
数据库(集)名称	陕西石泉-旬阳金矿带整装勘查区饶峰幅等7个图幅区1:50 000水系沉积物测量原始数据集
数据库(集)作者	谈乐, 陕西地矿第一地质队有限公司 张永强, 陕西地矿第一地质队有限公司 刘小朋, 陕西地矿第一地质队有限公司 李小明, 陕西地矿第一地质队有限公司 王才进, 陕西地矿第一地质队有限公司
数据时间范围	2013—2018年
地理区域	陕西省石泉县-旬阳县地区
数据格式	*.xlsx
数据量	2.01MB
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(121201004000150017-53、121201004000160901-54、121201004000172201-45、12120113048100)
语种	中文
数据库(集)组成	数据集为Excel表格,包括7个独立的工作表(sheet),分别为“饶峰幅采样点位及元素分析结果表”、“铁佛寺幅采样点位及元素分析结果表”、“汉阴幅采样点位及元素分析结果表”、“大河口幅采样点位及元素分析结果表”、“赵家湾幅采样点位及元素分析结果表”、“迎丰街幅采样点位及元素分析结果表”、“安康幅采样点位及元素分析结果表”

2 野外工作方法

2.1 方法选择

勘查区属湿润-半湿润中低山丘陵自然景观区(樊会民和李方周, 2013),湿润、多雨、强剥蚀、深切割,以物理风化为主,沟系冲、洪积物具粗岩屑性质(刘劲松等, 2016),适宜开展水系沉积物测量。根据《地球化学普查规范(1:50 000)》(DZ/T 0011-2015),结合勘查区地球化学景观特点,确定本次地球化学普查采样介质为水系沉积物,采样密度4~8点/km²,样品粒级选择-20目~+60目。

2.2 样品采集

2.2.1 采样部位

勘查区1:50 000水系沉积物测量采样部位均选择在河沟底部或河岸与水面接触处(张源等, 2018)。在间歇性水流地区或主干河道中,主要在河床底部采样;在水流湍急的河道中选择在水流变缓处、水流停滞处、转石背后、水流由窄变宽处,以及河道转弯内侧有较多细颗粒物聚集处采样。

2.2.2 采样物质

采样介质以代表原生地质找矿信息的基岩物质成分为原则, 采样物质为水系沉积物中的淤泥、粉砂或细砂。

2.2.3 采样方法

勘查区水系沉积物所采集的样品为粗-细粒级混合的粒级段, 有效地避开了腐植层取样, 样品采集过程中, 加强了对蚀变-矿化强烈或重点找矿地段的加密采样工作。采用的具体技术方法如下:

- ①采样前, 先用采样勺拨去地表浮土或腐植层, 再进行取样。
- ②每次装袋前, 首先检查布样袋, 看是否有开线或破洞。含水样品装袋时先用塑料袋分装后再装入布样袋中, 防止袋内水分相互淋滤造成湿样互相污染。
- ③为了提高样品的代表性, 样品采集均在采样点位上下游 20~30 m 范围内 3~5 处多点采集, 组合成一件样品。
- ④样品采集避开了矿山开发、村镇、水坝、淤地造田、交通要道和路口造成的污染物及岸边崩塌堆积物地段。

2.2.4 野外定点

陕西石泉-旬阳金矿带整装勘查区涉及 1:50 000 图幅共 7 幅 (表 2), 图幅坐标系采用 1980 西安坐标系, 中央经线为 111°, 图幅涉及地理数据均在陕西地理信息测绘局购买。

表 2 陕西石泉-旬阳金矿带整装勘查区涉及的 7 幅 1:50 000 地形图

图幅名称	图幅号
饶峰幅	I49E17001
迎丰街幅	I49E18002
铁佛寺幅	I49E18003
汉阴幅	I49E19003
大河口幅	I49E19004
赵家湾幅	I49E19005
安康幅	I49E02005

用 1:50 000 标准地形图作为水系沉积物测量野外工作手图, 采用手持 IGS-100 掌上机 (李超岭等, 2002) 结合地形图进行野外定点。定点实际距离误差均小于 30 m, 即在手图上均小于 1 mm。

2.3 采样点密度

本次共采集水系沉积物样品 13 169 件。根据勘查区地形地貌特点、景观条件、地质特征, 本次 1:50 000 水系沉积物测量分别采用了不同的采样布局和采样密度: 加密区 (即指 1:200 000 化探异常明显、矿化信息相对较多、基岩面积大、第四系分布面积较少的地区, 除正常布点外, 成矿有利地段适当加密) 采样密度为 5.18~5.46 点/km²; 一般工作区 (即指第四系分布面积相对较多, 基岩出露面积小或零星, 1:200 000 化探异常弱的地区) 采样密度为: 4.1~4.3 点/km²; 放稀区 (即山间盆地) 采样密度为 3.13~3.52 点/km²。该采样密度组合可有效地控制工作区内绝大多数汇水面积, 经济实用, 可有效地达到地球化学普查的目的。

2.4 样品加工

样品加工基本流程为：自然干燥→揉碎→过筛→混匀→称量缩分→填写标签→装袋→填写送样单→装箱（陈玉明和陈秀法，2018）。

样品干燥方式采取日晒风干。干燥过程中及时揉搓样品，防止结块，并用木槌适当敲打。

② 样品干燥后过-20目~+60目尼龙筛，对筛下样品用对角线折叠法混匀，缩分后装入纸样袋中，其重量均 ≥ 310 g。

③ 按样品缩分法将加工好的样品缩分成两份各 ≥ 150 g，一份装牛皮纸袋送检，另一份装塑料瓶封装当副样留存。

3 样品分析测试方法

样品分析测试工作先后由具备岩矿测试甲级资质的自然资源部西安矿产资源监督检测中心和陕西地矿局汉中地质大队有限公司实验室承担，严格执行《地球化学普查（比例尺1:50 000）规范样品分析技术的补充规定》。

3.1 实验室样品加工与制备

实验室配备有专职样品管理人员，负责样品的验收和保管，并严格按照规范要求办理样品交接手续。

以50件样品为一个分析批次进行编码和样品加工，每一个分析批次中随机插入4个国家一级标准物质，然后进入计算机，打印出分析号与送样号的对照表，以供样品管理人员在管理样品、填写汇总表等准备工作中使用，样品随后由样品管理人员下达至碎矿间进行无污染碎样。

化探样品在加工前均在60℃以下充分烘干。在大批量样品加工前，先对岩屑样分别进行玛瑙球数量、球磨时间的最佳条件试验，使其细磨后样品粒度满足1:50 000区域地球化学调查的要求为原则。要求细磨加工后样品粒度达到-0.074 mm（-200目）占90%以上。

样品管理人员对每批样品的加工粒度是否达到规定要求进行检查；检查合格后，按规定插入指定的监控样及国家一级标样，同时依照密码编号分出内检样，随后交由质量管理人员下达分析任务。

3.2 分析项目及分析方法

根据项目任务书、合同书及总体设计要求，2013—2015年度1:50 000水系沉积物测量分析项目为：Au、Ag、Cu、Pb、Zn、As、Sb、Hg、V、Mo、Ti、W共12种元素。2016—2018年度1:50 000水系沉积物测量分析项目为Au、Ag、Cu、Pb、Zn、As、Sb、Hg、Bi、Sn、W、Mo、Cd、Co、Cr、Ni共计16种元素。

采用光栅光谱仪（OES）、原子荧光仪（AFS）、等离子质谱仪法（ICP-MS）、发射光谱法（GF-AAS）等仪器进行分析测试，所有元素报出率均为100%。勘查区18种元素分析测试方法配套方案见表3。

表3 勘查区18种元素分析方法、检出限及报出率统计表

分析方法	元素含量	1:50 000地球化学测量规定检出限	所用方法检出限	报出率(%)
GF-AAS	w(Au)/10 ⁻⁹	0.3~1	0.23	100
F-AAS	w(Cu)/10 ⁻⁶	2	1.00	100
	w(Zn)/10 ⁻⁶	20	5.00	100
HG-AFS	w(As)/10 ⁻⁶	0.5~1	0.20	100
	w(Sb)/10 ⁻⁶	0.3	0.05	100
CV-AFS	w(Hg)/10 ⁻⁹	10~50	2.00	100
	w(Bi)/10 ⁻⁶	0.3	0.1	100
ICP-OES	w(Ti)/10 ⁻⁶	100	9.3	100
	w(V)/10 ⁻⁶	20	5	100
OES	w(Ag)/10 ⁻⁶	0.050	0.019	100
	w(Sn)/10 ⁻⁶	2	0.5	100
	w(Pb)/10 ⁻⁶	5~10	0.91	100
	w(W)/10 ⁻⁶	1	0.048	100
ICP-MS	w(Mo)/10 ⁻⁶	1	0.056	100
	w(Ni)/10 ⁻⁶	1	0.21	100
	w(Co)/10 ⁻⁶	1	0.10	100
	w(Cr)/10 ⁻⁶	10	1.00	100
	w(Cd)/10 ⁻⁶	0.2	0.02	100

4 数据样本描述

石泉-旬阳金矿带整装勘查区饶峰幅等7个图幅1:50 000水系沉积物测量原始数据集为Excel表格型数据,包括7个独立的工作表(sheet),分别为“饶峰幅水系沉积物测量采样点位及元素分析结果表”、“迎丰街幅水系沉积物测量采样点位及元素分析结果表”、“铁佛寺幅水系沉积物测量采样点位及元素分析结果表”、“汉阴幅水系沉积物测量采样点位及元素分析结果表”、“大河口幅水系沉积物测量采样点位及元素分析结果表”、“赵家湾幅水系沉积物测量采样点位及元素分析结果表”、“安康幅水系沉积物测量采样点位及元素分析结果表”(宋相龙等,2017)。每个工作表(sheet)包含如下内容:样品编号、高斯坐标、图幅号、地层、分析结果(铁佛寺幅、大河口幅、汉阴幅、赵家湾幅分析元素为Au、Hg、Ag、Cu、Pb、Zn、Mo、As、Sb、Ti、V、W;迎丰街幅、饶峰幅、安康幅分析元素为Au、Ag、Cu、Pb、Zn、As、Sb、Hg、Bi、Sn、W、Mo、Cd、Co、Cr、Ni)、备注。数据结构见表4。

表4 陕西石泉-旬阳金矿带整装勘查区水系沉积物测量数据结构表

序号	数据项名称	量纲	数据类型	字段长度	实例
1	样品编号	-	字符型	20	57C2
2	图幅号	-	字符型	20	I49E018002
3	地层	-	字符型	20	O ₃ -S _{1b}
4	高斯横坐标	-	字符型	20	255460
5	高斯纵坐标	-	字符型	20	3672075
6	经度	-	字符型	20	108°22'45"

续表 4

序号	数据项名称	量纲	数据类型	字段长度	实例
7	纬度	-	字浮型	20	33°08'48"
8	Au	10 ⁻⁹	浮点型	20	1.03
9	Ag	10 ⁻⁶	浮点型	20	42
10	Cu	10 ⁻⁶	浮点型	20	35.9
11	Pb	10 ⁻⁶	浮点型	20	35.9
12	Zn	10 ⁻⁶	浮点型	20	83.7
13	As	10 ⁻⁶	浮点型	20	3.88
14	Sb	10 ⁻⁶	浮点型	20	2.13
15	Hg	10 ⁻⁹	浮点型	20	49
16	Bi	10 ⁻⁶	浮点型	20	0.85
17	Sn	10 ⁻⁶	浮点型	20	3
18	W	10 ⁻⁶	浮点型	20	2.14
19	Mo	10 ⁻⁶	浮点型	20	0.93
20	Cd	10 ⁻⁶	浮点型	20	0.1
21	Co	10 ⁻⁶	浮点型	20	22.3
22	Cr	10 ⁻⁶	浮点型	20	94.6
23	Ni	10 ⁻⁶	浮点型	20	41.9
24	Ti	10 ⁻⁶	浮点型	20	-
25	V	10 ⁻⁶	浮点型	20	-

5 数据质量和评估

5.1 原始数据质量

铁佛寺幅、汉阴幅、大河口幅和赵家湾幅地球化学测量样品测试过程中以 50 件样品为一个分析批次进行编码和样品加工，每一个分析批次中随机插入 4 个国家一级标准物质，分别为 GBW07302a、GBW07304a、GBW07309、GBW07318，对分析过程的精密度进行监控。另外随机分段加入 12 件国家一级标准物（每 500 件样品插入一次），共插入 15 次，对分析过程的准确度进行监控，并对样品中部分高值和低值进行了抽查分析，抽查样品数量比例为 2.6%。

饶峰幅、迎丰街幅和安康幅地球化学测量样品测试过程中以 50 件样品为一个分析批进行编码和样品加工，共分为 243 批。每一个分析批次中随机插入购买于中国地质科学院地球物理地球化学勘查研究所的 4 个国家一级标准物质对分析过程的准确度进行监控。其中 Au、Ag、Hg、Pb、Sn、As、Sb 和 Bi 共 8 种元素插入 GSD-10、GSD-14、GSD-18、GSD-20 控制分析过程精密度；Cr、Co、Ni、Cu、Zn、Mo、Cd 和 W 共 8 种元素插入 GSD-8a、GSD-9、GSD-10、GSD-14 控制分析过程精密度，并对样品中部分高值和低值进行了抽查分析，抽查样品数量比例为 4.1%。

本次检测工作中，分析元素内检（重复样）合格率均在 95.00% 以上；元素报出率均达到 100%；元素异常复查合格率均为 97.5% 以上；所选用分析方法的检出限均满足 DZ/T0130.4-2006 中 1:50 000 化探样品标准要求。方法的精密度：对所选一级标准物质检测的 $\Delta \lg C$ 平均值在 (-0.099 ~ 0.099) 以内。方法准确度：对所选一级标准物质检测

的 $\Delta \lg C$ 平均值在(-0.099~0.099)以内。所选分析方法的检出限、精密度和准确度均满足《地球化学普查(比例尺1:50 000)规范样品分析技术的补充规定》的质量要求。

上述质量参数数据表明,本次检测的分析质量完全符合《地球化学普查(比例尺1:50 000)规范样品分析技术的补充规定》及DZ0130.4-2006的质量要求。

5.2 成果数据库建设质量

陕西石泉-旬阳金矿带整装勘查区饶峰幅等7个图幅区1:50 000水系沉积物测量成果数据库建设(万常选等,2009)均按照化探数据模型采用DGSS软件平台实现(庞健峰等,2017),样品中各分析元素属性结构均参照中国地质调查局固体矿产勘查数据库内容与结构(左群超等,2018;李超岭等,2013)填写,数据结构内容完整齐全。所形成的7幅1:50 000水系沉积物测量数据库已由中国地质调查局西安地质调查中心及中国地质调查局发展研究中心专家评审验收,评分93分,评为“优秀级”,已完成相关数据库汇交。

6 结论

本次数据集工作区范围是由中国地质调查局西安地质调查中心与中国地质调查局发展研究中心组织实施的陕西石泉-旬阳金矿带整装勘查区内饶峰幅等7幅图3 010 km² 1:50 000水系沉积物测量工作,是陕西石泉-旬阳金矿带整装勘查区内首次系统性的采用统一采样方法、分析测试方法、统一分析元素,也是本整装勘查区内首次规范化建立地球化学数据库,获得了珍贵的第一手地球化学测量资料。

本数据集成果指导在整装勘查区内圈定金找矿靶区10处,金成矿远景区12处^①,其中在圈定的陕西省汉阴县双河口一带金找矿靶区内新发现坝王沟金矿点,通过后期省地勘基金投入,金(333+334)资源量30吨;在圈定的陕西省安康市汉滨区将军山一带金找矿靶区内新发现早阳金矿点,通过后期省地勘基金投入,金(333+334)资源量20吨。另外运用本数据集成果新发现4处金矿点,分别为陕西省宁陕县堰沟金矿点、陕西省安康市汉滨区柳坑金矿点、陕西省石泉县石桥金矿点、陕西省石泉县栈房金矿点,均有一定的找矿潜力。另外,本数据集成果指导我省找到2~4处新的大型金矿产资源开发基地。

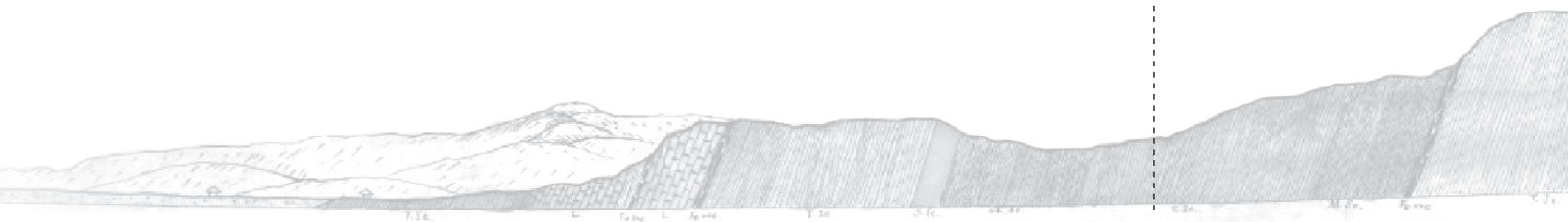
注释:

- ① 张永强,孙健,谈乐.2018.陕西石泉-旬阳金矿带整装勘查区矿产调查与找矿预测2016-2018年子项目总成果报告[R].安康:陕西地矿第一地质队有限公司,1-260.

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1-54, 121201004000172201-
45, 12120113048100)

The 1 : 50 000 Original Measurement Dataset on Stream Sediments for 7 Map Sheets including the Raofeng Map in the Integrated Survey Area of the Shiquan-Xunyang Gold Ore Zone, Shaanxi

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Abstract: This paper describes the collection of measured and tested data of 18 elements (Au, Cu, Zn, As, Sb, Hg, Bi, Ti, V, Ag, Sn, Pb, W, Mo, Ni, Co, Cr and Cd) in the stream sediments of seven 1 : 50 000 map sheets in the integrated survey area of the Shiquan-Xunyang gold ore zone, Shaanxi, including 13 169 data points and 180 944 total pieces of data, and the establishment of a geochemical database in the survey area for the first time. Building on this, 233 sheets of a variety of geochemical maps are developed and a spatial database established. Within the database, 2 083 places of various single-element anomalies are delineated in the area, including 304 Au anomalies; 10 Au prospecting target areas and 12 Au prospective areas are delineated; with subsequent comprehensive checking of minerals throughout the integrated survey area, there are 53 Au deposits (points), including 8 medium-scale Au deposits and 18 small-scale ones, indicating that Au anomalies correspond well with Au deposits (points), and there are 189 places of mineralized anomalies, indicating that the measurement of 1 : 50 000 stream sediments is one of the best means of prospecting in the survey area.

Key words: Shiquan-Xunyang Au Ore Zone; Shaanxi; Integrated Survey Area; Stream sediment; Geochemical data; Spatial Database; 1 : 50 000

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

1 Introduction

The measurement of 1 : 50 000 stream sediments across 7 map sheets of the integrated survey area of the Shiquan-Xunyang gold zone began in 2013 (Fig. 1), of which those in the

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Raofeng, Yingfengjie and Ankang map sheets were organized by the Development and Research Center of China Geological Survey in 2016–2018; those in the Tiefosi, Hanyin, Dahekou and Zhaojiawan map sheets were organized by the Xi'an Center of China Geological Survey in 2013–2015, and both were conducted by the Team No.1, Shaanxi Bureau of Geology and Mineral Resources Co. Ltd..

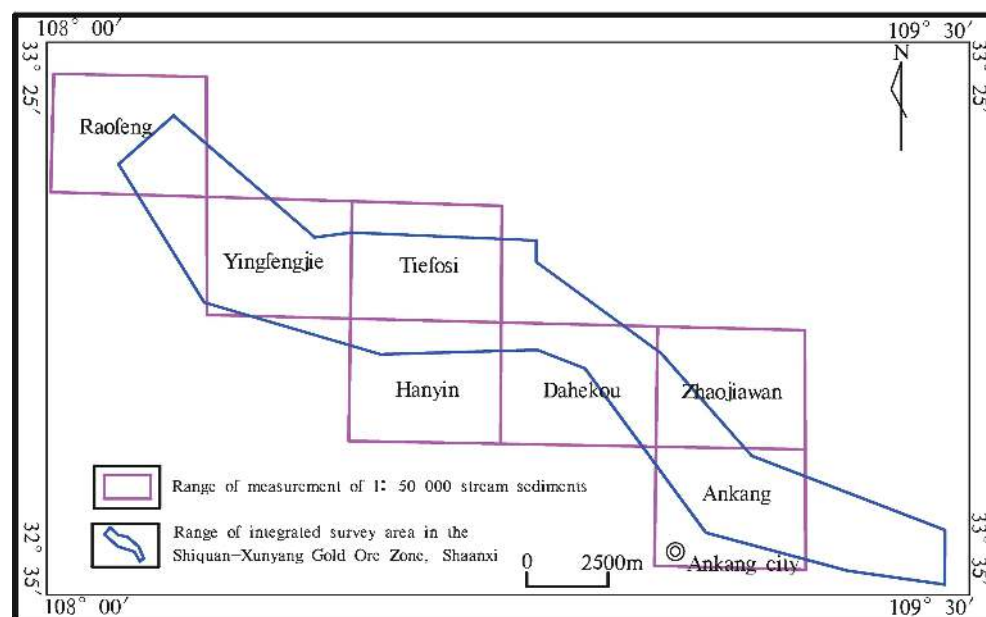


Fig. 1 Range for measurement of the 1 : 50 000 stream sediments of the 7 Map Sheets in the Integrated Survey Area of the Shiquan-Xunyang Gold Ore Zone, Shaanxi.

The integrated survey area of the Shiquan-Xunyang gold ore zone, Shaanxi, located at the South Qinling tectonic zone in the midst of the Qinling orogeny, has experienced multi-stage deformations in its long history of geological evolution, where the typical tectonic patterns are folding, detachment and ductile shearing zones. In terms of stratigraphic regionalization, it belongs to the Niushan stratigraphic sub-region of the South China stratigraphic super-region (Han FL et al., 2013) (Fig. 2). Due to decoupling detachment between the overlying strata and basement, the outcrop in the area is characterized by the formation of Sinian–early-Paleozoic, black, low-metamorphic, strongly-deformed fine clastic rock series, which were formed in the coastal sea environment (Zhang FX et al., 2009; Tang YZ et al., 2012). The outcropped strata within the area include the Paleoproterozoic Yangpingyan Formation, the basic volcanic rock of the Yaolinghe Formation and Paleozoic sedimentary–low-metamorphic rocks, where mid- and late-Silurian–early-Devonian sedimentary strata are poorly developed (Liu GH and Zhang SG, 1993).

The measurement of the 1 : 50 000 stream sediments in the integrated survey area of the Shiquan-Xunyang gold ore zone began with preparation of the project design in July 2013, all works being done in accordance with the relevant technical specifications. The project was completed in three stages: Stage 1, organization of the geochemical staff to take samples for the measurement of the 1 : 50 000 stream sediments; Stage 2, checking, verifying, collating

and processing data, and delineation of geochemical anomalies; Stage 3, plotting a series of geochemical maps, establishing and improving the regional geochemical database for the integrated survey area of the Shiquan-Xunyang gold ore zone, and screening and verifying anomalies.

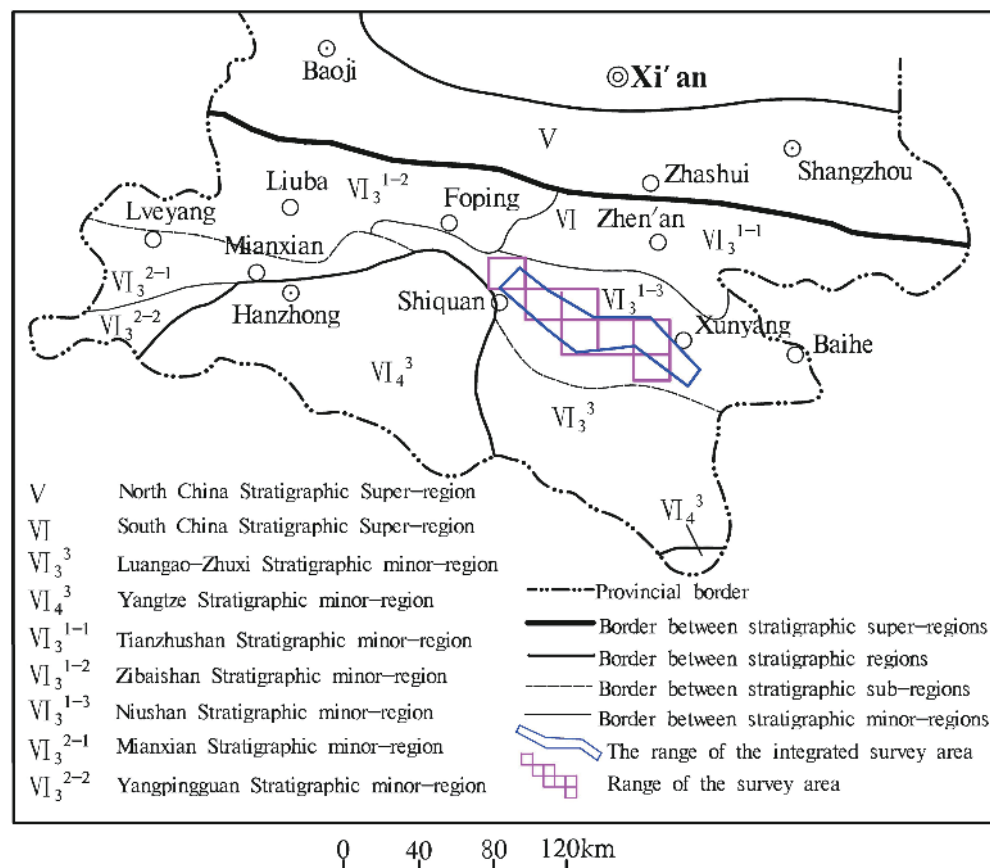


Fig. 2 Schematic diagram of the stratigraphic regionalization of the Integrated Survey Area of the Shiquan-Xunyang Gold Ore Zone, Shaanxi

Metadata for the measured original dataset of the stream sediments in the 7 map sheets of the integrated survey area of the Shiquan-Xunyang gold ore zone, Shaanxi, are shown in Table 1.

Table 1 Metadata Table of Database (Dataset)

Items	Description
Database (dataset) name	The 1 : 50 000 Original Measurement Dataset on Stream Sediments for 7 Map Sheets including the Raofeng Map in the Integrated Survey Area of the Shiquan-Xunyang Gold Ore Zone, Shaanxi
Database (dataset) authors	Tan Le, Team No.1, Shaanxi Bureau of Geology and Mineral Resources Co. Ltd. Zhang Yongqiang, Team No.1, Shaanxi Bureau of Geology and Mineral Resources Co. Ltd. Liu Xiaopeng, Team No.1, Shaanxi Bureau of Geology and Mineral Resources Co. Ltd. Li Xiaoming, Team No.1, Shaanxi Bureau of Geology and Mineral Resources Co. Ltd. Wang Caijin, Team No.1, Shaanxi Bureau of Geology and Mineral Resources Co. Ltd.

Continued table 1

Items	Description
Data acquisition time	2013–2018
Geographic area	Shiquan-Xunyang, Shaanxi
Data format	*.xlsx
Data size	2.01MB
Data service system URL	http://dcc.cgs.gov.cn
Fund project	China Geological Survey Project (121201004000150017-53, 121201004000160901-54, 121201004000172201-45, 12120113048100).
Language	Chinese
Database(dataset) composition	The dataset consists of 7 separate Excel sheets: <i>Raofeng Sampling Points and Element Analytical Result Sheet</i> , <i>Tiefosi Sampling Points and Element Analytical Result Sheet</i> , <i>Hanyin Sampling Points and Element Analytical Result Sheet</i> , <i>Dahekou Sampling Points and Element Analytical Result Sheet</i> , <i>Zhaojiawan Sampling Points and Element Analytical Result Sheet</i> , <i>Yingfengjie Sampling Points and Element Analytical Result Sheet</i> and <i>Ankang Sampling Points and Element Analytical Result Sheet</i> .

2 Field Work Methods

2.1 Selection Method

The survey area is a humid–semihumid mid-and-low hilly natural landscape area (Fan HM and Li FZ, 2013), humid, rainy, strongly denuded, deeply cut, mainly physically-weathered, where channel-system alluvium and diluvium have the properties of coarse debris, suitable for the measurement of the stream sediments (Liu JS et al., 2016). In accordance with the *Specifications of the Geochemical Reconnaissance Survey (1 : 50 000)(DZ/T 0011–2015)*, considering the geochemical landscape features of the survey area, it was decided to use stream sediment as the medium to be sampled for this geochemical reconnaissance survey, at a sampling density of 4–8 points/km², and –20 meshes ~ +60 meshes are selected for the sample's grain size.

2.2 Sampling

2.2.1 Sample Location

In the survey area, samples for measurement of 1 : 50 000 stream sediments are all taken from the river bottom or the contact between the riverbank and the water surface (Zhang Y et al., 2018). In intermittent or trunk river channels, samples are mainly taken from the bottom of the riverbed; in rivers with rapid flow, samples are taken at places where water flows slowly or stops, or behind a boulder, or where water flow widens, or at the inner side of the turn of the river channel, where much more fine-grained materials concentrate.

2.2.2 Sampling Materials

Following the principle that sampled media shall represent material components of bedrocks containing original geological prospecting information, sampling materials are sludge, silt or fine sand in stream sediments.

2.2.3 Sampling Methods

Samples taken from the stream sediments in the survey area are graded sections, mixing coarse–fine-grain sizes, care being taken to avoid sampling from the humus layer. During sampling, an emphasis was placed on taking more samples at places where alteration–mineralization is strong, or which are priorities for prospecting. Samples are taken using the specific technique below:

- ① Prior to sampling, the topsoil or humus layer is removed with a sampling spoon.
- ② The cloth bag used for housing samples is checked to ensure that it does not have split seams or broken holes before placing samples within it. Before putting moist samples in the bag, they were placed in a plastic bag and then in the cloth bag, to prevent samples from becoming wet and contaminated, due to mutual leaching.
- ③ To make samples more representative, samples were taken at multiple points of 3~5 places 20~30 m within upstream and downstream of the sampling points and then combined into one sample.
- ④ Sampling avoids locations where there are pollutants and accumulated collapses at the bank due to mine development, villages and towns, dams, field-making from silty land, traffic route or road junctions.

2.2.4 Point Fixation in the Field

The integrated survey area of the Shiquan-Xunyang gold ore zone, Shaanxi, involves seven 1 : 50 000 map sheets (Table 2) in which the 1980 Xi'an coordinate system is used and the central meridian is 111°, and geological data involved in the map sheets were purchased from the Shaanxi Geographic Information Survey Bureau.

Table 2 Topographic map of seven 1 : 50 000 Map Sheets involved in the Integrated Survey Area of the Shiquan-Xunyang Gold Ore Zone, Shaanxi

Map sheet name	Map sheet number
Raofeng	I49E17001
Yingfengjie	I49E18002
Tiefosi	I49E18003
Hanyin	I49E19003
Dahekou	I49E19004
Zhaojiawan	I49E19005
Ankang	I49E02005

The 1 : 50 000 standard topographic map is used as a base map for field measurement of the stream sediments to determine the sampling points in the field with a hand-held IGS-100 device (Li CL et al., 2002). Errors in point localization were less than 30 m from their actual locations, i.e. less than 1 mm on the base map.

2.3 Density of Sampling Points

During the project there were 13 169 samples in total taken from stream sediments. Based on topographic and landform characteristics, landscape conditions and geological features, for

the measurement of these 1 : 50 000 stream sediments, different sampling layouts and densities were used: at the densest area (i.e. referring to areas where at 1 : 200 000 a geochemical anomaly is obvious, there was more information on mineralization, larger in the bedrock area and distributed with less Quaternary strata, and in addition to normal point arrangements, sampling in sections favoring metallogenesis are undertaken to the standard density), the sampling density was 5.18~5.46 points/km²; at the ordinal work area (i.e. referring to areas where there are more Quaternary strata, smaller or sporadic outcropped bedrocks, and the 1 : 200 000 geochemical anomaly is weak), the sampling density was 4.1~4.3 points/km²; at the scattered area (i.e. intermountain basin), the sampling density was 3.13~3.52 points/km². The combination of these sampling densities allows the effective control of the vast majority of water catchment within the area, which is cost-effective and enables the effective meeting of the goal of the geochemical reconnaissance survey.

2.4 Sample Processing

The basic procedure to process samples: natural drying → trituration → sieving → mixing evenly → weighing and splitting samples → filling in the label → placing samples into bags → completing the sample delivery order → placing sampled bags into boxes (Chen YM and Chen XF, 2018).

Sample drying method: dried under sunlight and air. During drying, rub and knead samples regularly to prevent caking, and use a mallet to strike them properly,

② Dried samples were sieved with a -20~+60 mesh nylon sieve, samples under the sieve are mixed evenly through diagonal folding, split and then put into paper bags, their weight being ≥ 310 g.

③ Samples processed by sample splitting were divided into two parts, each part ≥ 150 g, one put into a kraft paper bag and sent for testing, and the other placed into plastic bottles, which were then sealed and kept as duplicate samples.

3 Sample Analysis and Testing

Samples were analyzed and tested by the Xi'an Center for Mineral Resource Supervision and Testing under the Ministry of Natural Resources and a laboratory of the Hanzhong Geological-Battalion Co., Ltd. under the Shaanxi Bureau of Geology and Mineral Resource, both of which possess Qualification A for rock and mineral testing, in strict accordance with the *Additional Rules for Regulating Sample Analysis Technologies of Geochemical Reconnaissance Surveys (Scale: 1 : 50 000)*.

3.1 Processing and Preparation of Lab Samples

Labs are provided with full-time staff to manage samples, receive, inspect and care for samples, as well as handle sample handover procedures strictly in accordance with requirements in the specifications.

The samples were coded and processed as an analytical batch of 50, each analytical batch also containing 4 randomly inserted level-1 national standard substances, the data sent to a

computer to print out a comparison table showing the respective numbers of samples analyzed and those delivered, which was then used by sample management staff in tasks such as managing samples and filling in the summary tables, and samples were subsequently sent by the sample management staff to the ore-crushing room where they were crushed without contamination.

Geochemical samples must be fully dried at a temperature below 60°C prior to processing. Before massive sample processing, debris samples should be tested for the best conditions for agate ball numbers and ball-milling time so that the particle size of the finely-ground samples meets the requirement for the 1 : 50 000 regional geochemical survey, that finely-ground samples with particle size reaching -0.074 mm (-200 mesh) accounted for at least 90% of the sample.

The sample management staff checked whether each processed batch of samples met the requirement for particle size; inserted designated control samples and Level-1 national standard samples into acceptable batches as required, whilst separating inner inspection samples based on their codes and numbers, and then delivering them to quality management staff to assign analysis tasks.

3.2 Items Analyzed and Analytical Methods

According to the Project Task, Contract and General Design Specification, in 2013–2015, the items to be analyzed during the measurement of the 1 : 50 000 stream sediments were the 12 elements: Au, Ag, Cu, Pb, Zn, As, Sb, Hg, V, Mo, Ti and W. In 2016–2018, the items to be analyzed for measurement of the 1 : 50 000 stream sediments totalled 16 elements: Au, Ag, Cu, Pb, Zn, As, Sb, Hg, Bi, Sn, W, Mo, Cd, Co, Cr and Ni.

Instruments such as Optical Emission Spectrometer (OES), Atomic Fluorescence Spectrometer (AFS), Inductive Coupling Plasma-Mass Spectrometer (ICP-MS) and Graphite Furnace-Atomic Absorption Spectrometer (GF-AAS) were used in analysis and testing, and all elements reported percentages were 100%. Schemes for testing and analysis of the 18 elements in the survey area are shown in Table 3.

Table 3 Analytical methods, detection limits and report percentages of the 18 elements in the survey area

Analytical method	Element content	Specified detection limit for the 1 : 50 000 geochemical measurement	Detection limit of the method used	Report percentage (%)
GF-AAS	$w(\text{Au})/10^{-9}$	0.3~1	0.23	100
F-AAS	$w(\text{Cu})/10^{-6}$	2	1.00	100
	$w(\text{Zn})/10^{-6}$	20	5.00	100
HG-AFS	$w(\text{As})/10^{-6}$	0.5~1	0.20	100
	$w(\text{Sb})/10^{-6}$	0.3	0.05	100
CV-AFS	$w(\text{Hg})/10^{-9}$	10~50	2.00	100
	$w(\text{Bi})/10^{-6}$	0.3	0.1	100
ICP-OES	$w(\text{Ti})/10^{-6}$	100	9.3	100
	$w(\text{V})/10^{-6}$	20	5	100

Continued table 3

Analytical method	Element content	Specified detection limit for the 1 : 50 000 geochemical measurement	Detection limit of the method used	Report percentage (%)
OES	w(Ag)/10 ⁻⁶	0.050	0.019	100
	w(Sn)/10 ⁻⁶	2	0.5	100
	w(Pb)/10 ⁻⁶	5~10	0.91	100
	w(W)/10 ⁻⁶	1	0.048	100
	w(Mo)/10 ⁻⁶	1	0.056	100
ICP-MS	w(Ni)/10 ⁻⁶	1	0.21	100
	w(Co)/10 ⁻⁶	1	0.10	100
	w(Cr)/10 ⁻⁶	10	1.00	100
	w(Cd)/10 ⁻⁶	0.2	0.02	100

4 Description of Data Samples

The measured original dataset on the 1 : 50 000 stream sediments in the 7 map sheets of the integrated survey area of the Shiquan-Xunyang gold ore zone contains data in Excel form, including 7 separate sheets: *Raofeng Sampling Points and Element Analytical Result Sheet*, *Tiefosi Sampling Points and Element Analytical Result Sheet*, *Hanyin Sampling Points and Element Analytical Result Sheet*, *Dahekou Sampling Points and Element Analytical Result Sheet*, *Zhaojiawan Sampling Points and Element Analytical Result Sheet*, *Yingfengjie Sampling Points and Element Analytical Result Sheet*, and *Ankang Sampling Points and Element Analytical Result Sheet* (Song XL et al., 2017). Each sheet contains the following: sample No., Gaussian coordinates, map sheet No., stratigraphy, analyzed result (elements analyzed in Tiefosi, Dahekou, Hanyin and Zhaojiawan map sheets are Au, Hg, Ag, Cu, Pb, Zn, Mo, As, Sb, Ti, V and W; elements analyzed in Yingfengjie, Raofeng and Ankang map sheets are Au, Ag, Cu, Pb, Zn, As, Sb, Hg, Bi, Sn, W, Mo, Cd, Co, Cr and Ni) and remarks. Dataset structure could be seen in Table 4.

Table 4 Dataset structure of the measured original data of the stream sediments in the integrated survey area of the Shiquan-Xunyang gold ore zone, Shaanxi

No.	Name of data item	Dimension	Data category	Field length	Real example
1	Sample No.		Character type	20	57C2
2	Map sheet No.		Character type	20	I49E018002
3	Stratigraphy		Character type	20	O ₃ -S _{1b}
4	Gauss horizontal coordinate		Character type	20	255460
5	Gauss vertical coordinate		Character type	20	3672075
6	Longitude		Character type	20	108°22'45"
7	Latitude		Character type	20	33°08'48"
8	Au	10 ⁻⁹	Floating-point type	20	1.03
9	Ag	10 ⁻⁶	Floating-point type	20	42
10	Cu	10 ⁻⁶	Floating-point type	20	35.9
11	Pb	10 ⁻⁶	Floating-point type	20	35.9

Continued table 4

No.	Name of data item	Dimension	Data category	Field length	Real example
12	Zn	10^{-6}	Floating-point type	20	83.7
13	As	10^{-6}	Floating-point type	20	3.88
14	Sb	10^{-6}	Floating-point type	20	2.13
15	Hg	10^{-9}	Floating-point type	20	49
16	Bi	10^{-6}	Floating-point type	20	0.85
17	Sn	10^{-6}	Floating-point type	20	3
18	W	10^{-6}	Floating-point type	20	2.14
19	Mo	10^{-6}	Floating-point type	20	0.93
20	Cd	10^{-6}	Floating-point type	20	0.1
21	Co	10^{-6}	Floating-point type	20	22.3
22	Cr	10^{-6}	Floating-point type	20	94.6
23	Ni	10^{-6}	Floating-point type	20	41.9
24	Ti	10^{-6}	Floating-point type	20	
25	V	10^{-6}	Floating-point type	20	

5 Data Quality and Assessment

5.1 Quality of the Original Data

In the process of analyzing and testing geochemical samples in the Tiefosi, Hanyin, Dahekou and Zhaojiawan map sheets, every 50 samples were grouped to be coded and processed as one analytical batch, each analytical batch being randomly inserted with 4 Level-1 national standard substances which were GBW07302a, GBW07304a, GBW07309 and GBW07318, in order to monitor and control the precision of the analytical process. In addition, 12 Level-1 national standard substances are added randomly in sections (once for every 500 samples) for 15 times in total, to monitor the accuracy of the analytical process, and some high and low values of samples were randomly inspected and analyzed, with 2.6% of samples receiving random inspection.

In the process of analyzing and testing geochemical samples in the Raofeng, Yingfengjie and Ankang map sheets, every 50 samples were grouped to be coded and processed as one analytical batch, 243 batches in total. Each analytical batch is randomly inserted with 4 Level-1 national standard substances purchased from the CAGS Geophysical & Geochemical Exploration Institute, in order to monitor and control the accuracy of the analytical process. Of these, to analyze the 8 elements Au, Ag, Hg, Pb, Sn, As, Sb and Bi, GSD-10, GSD-14, GSD-18 and GSD-20 were inserted to control the precision of the analytical process; to analyze the other 8 elements Cr, Co, Ni, Cu, Zn, Mo, Cd and W, GSD-8a, GSD-9, GSD-10 and GSD-14 were inserted to control the precision of the analytical process, and some high and low values of samples were randomly inspected and analyzed, with 1.4 % of samples receiving random inspection.

During this detection, the qualifying rate of element inner examination (duplicate sample)

was more than 95.00%; all elements' report percentages were 100%; the qualifying rate of element anomaly re-examination was at least 97.5%; the detection limits of analytical methods used all met the standard requirement on 1 : 50 000 geochemical samples in DZ/T0130.4-2006. Precision of methods: the mean $\Delta\lg C$ detected with Level-1 national standard substance was within $-0.099\sim+0.099$. Accuracy of methods: the mean $\Delta\lg C$ detected with Level-1 national standard substance was within $-0.099\sim+0.099$. The detection limit, precision and accuracy of the analytical methods selected met the quality-related requirements in the *Additional Rules for Regulating Sample Analysis Technologies of Geochemical Reconnaissance Surveys (Scale 1 : 50 000)*.

Above-mentioned figures concerning quality-related parameters indicate that this examination fully complied with the quality-related requirements in the *Additional Rules for Regulating Sample Analysis Technologies of Geochemical Reconnaissance Surveys (Scale 1 : 50 000)* and *DZ0130.4-2006*.

5.2 Quality in Establishing the Resulting Database

The measured results database of the 1 : 50 000 stream sediments in the 7 map sheets including Raofeng on the integrated survey area of the Shiquan-Xunyang gold ore zone, Shaanxi (Wan CX et al., 2009), was set up in accordance with the geochemical data model by using the software platform DGSS (Pang JF et al., 2017), properties and structures of all the elements analysed were completed by referring to the content and structure of the CGS's solid mineral survey database (Zuo QC et al., 2018; Li CL et al., 2013), to ensure that the data structure and content were complete and sound. The generated measurement databases of 1 : 50 000 stream sediments in the 7 map sheets have been reviewed and accepted by the experts from the Xi'an Center of China Geological Survey and the Development and Research Center of China Geological Survey, scoring 93, awarded "Excellence", and have thus been handed over.

6 Conclusions

The scope of the work area involved in this database was the measurement of the 1 : 50 000 stream sediments in the 7 map sheets including Raofeng in the integrated survey area of the Shiquan-Xunyang gold ore zone, Shaanxi, organized and implemented by the Xi'an Center and the Development and Research Center of China Geological Survey, covering 3 010 km². It is the first time that unified sampling, analytical and testing methods have been used to analyze elements in a systematic way in the integrated survey area of the Shiquan-Xunyang gold ore zone, Shaanxi. It is also the first time that a geochemical databases have been established in a standardized way in the integrated survey area, so as to obtain valuable first-hand geochemical measurement information.

With the results from the database, 10 Au prospecting target areas and 12 Au prospective areas were delineated in the integrated survey area^①, and at the newly-discovered Bawangou Au deposit from the Au-delineated prospecting target area at and around Shuanghekou, Hanyin

County, Shaanxi, with a subsequent provincial fund for geological exploration, it was found that the Au resource (333+334) was 30 tons; in the Au-prospecting target area at and around Jiangjunshan, Ankang city, Shaanxi, the Zaoyang Au deposit was recently found, and a subsequent provincial fund created for geological exploration, the Au (333+334) resource is 20 tons. In addition, 4 new gold ore occurrences were discovered in Shaanxi by using the results from this database, and they are located in Yangou, Ningshan County; Liukeng, Hanbin District, Ankang City; Shiqiao and Zhanfang, Shiquan County, all of which have a certain prospecting potential. Furthermore, the results from the database have guided Shaanxi to find 2–4 new large-scale Au resource development bases.

Notes:

- ① Zhang Yongqiang, Sun Jian, Tan Le. 2018. Comprehensive result report of sub-projects from 2016 to 2018 on mineral investigation and prospecting prediction in the integrated survey area of the Shiquan-Xunyang gold ore zone, Shaanxi[R]. Ankang: Team No.1, Shaanxi Bureau of Geology and Mineral Resources Co.Ltd., Ankang, Shaanxi, 1–260 (in Chinese).

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