

文章编号: 1001—1749(2011)02—0175—04

煤层采动裂隙与氦气浓度相关性研究

柏 强¹, 方 方¹, 李 翔²

(1. 成都理工大学, 四川 成都 610059; 2. 国家能源局煤炭司, 北京 100824)

摘 要: 煤层的开采极易导致采动裂隙直接连通地表, 引起煤层自燃、地下水流失等灾害现象。掌握煤层上表岩层中裂隙发育特征, 是解决上述问题的基础。将氦测量技术引入到煤炭采动裂隙发育研究中, 通过实验模型模拟, 分析得出了沙基型煤层采动裂隙分布与氦气浓度之间的相关规律。

关键词: 煤层; 裂隙; 氦气浓度; 相关性

中图分类号: P 631.6 **文献标识码:** A

0 前言

煤层开采, 极易导致覆岩采动裂隙直接沟通地表, 引起煤层自燃、地下水流失等灾害。而监测、掌握上覆岩层移动过程中的采动裂隙场的扩展与分布特征, 是有效解决上述难题的重要基础。但当前在覆岩采动裂隙动态演变过程的监测监控方面, 没有一种可靠、有效、易操作的方法和手段。因此, 迫切要求对煤层覆岩采动与裂隙扩展的监测, 进行机理研究与技术开发。

我们知道, 氦气测量技术是一种成熟有效的技术, 它在地质领域的应用已经相当广泛, 已取得了寻找铀矿、进行地质填图、探测隐伏构造^[1]、寻找基岩地下水和地热^[1]、解决有关工程地质问题^[1]、发现含金构造带、寻找石油天然气^[2]、探测煤田地下火区^[3]、寻探煤田陷落柱^[4]等的成功实例与经验。因此, 把氦气测量技术引入到煤炭开采与裂隙发育研究中, 具有一定的现实意义和可行性。

1 煤层采动裂隙模拟实验

为了分析沙基型煤层采动裂隙动态分布与氦气浓度之间的规律, 作者在实验中, 先后选取了具有沙基型浅埋煤层两种典型类型特征的, 国内某两

大煤矿为地质原型, 选择相应的岩石材料配比进行采动裂隙发育与氦气浓度变化物理模拟实验。实验模型为 2.5 m × 1.5 m × 2.0 m 的立方体, 模型底部为氦腔(向上供氦), 氦腔上部是各模拟岩层。在模型中, 各岩层的厚度与地质原型相应岩层厚度比为 1:100。在两个模型中, 都均匀分布了 48 个测点, 点距为 0.5 m × 0.42 m。其中, 基岩内有 36 个, 地表风积沙层内有 12 个, 模型正视、俯视简图和部份测点分布情况见下页图 1(48 个测点同时连续监测模型模拟煤层开采中, 不同岩层氦浓度随采动裂隙的变化情况)。

在布置测点的时候, 充分考虑到两模型的对比需要, 各测点相对模拟开采起始点的位置都是固定的, 这样开采进度对其氦气浓度影响便有了可比性。模拟材料配比见下页表 1 和后面表 2。

在第 I 类型中, 只有一个对覆岩运动起控制作用的关键层, 且位于裂隙带下部或垮落带内。

在第 II 类型覆岩中, 有一个以上对覆岩运动起控制作用的关键层, 其中主关键层位于裂隙带上部或弯曲下沉带内。

2 实验结果与分析

在模拟实验中, 作者采用了四川新先达测控技术有限公司生产的 KJD-2 000R 型连续测氦仪, 该仪器的测量范围在 4 Bq/m³ ~ 400 000 Bq/m³ 之

基金项目: 教育部博士点基金支持(20060616010)

收稿日期: 2010-12-24

改回日期: 2010-12-25

间;灵敏度为 $2.5\text{ count}\cdot\text{min}^{-1}/\text{Bq}\cdot\text{m}^3$ 。

由于在实验中涉及的监测点较多,故仅选择个别的测点加以说明。

2.1 沙基型煤层第 I 种典型类型

在实验模拟开采前,模型系统未连接氦源以及连接氦源平衡后接各测点的氦浓度情况,如下页图

2 所示。

从图 2 中我们可以看出,在未供氦时,模型系统的本底浓度较低,且低于 $1\,000\text{ Bq}/\text{m}^3$ 。而在连接氦源后,各测点的氦气浓度迅速升高,特别是“测点 1”,由于离氦源近,平衡时其浓度达到了 $8\,200\text{ Bq}/\text{m}^3$ 。

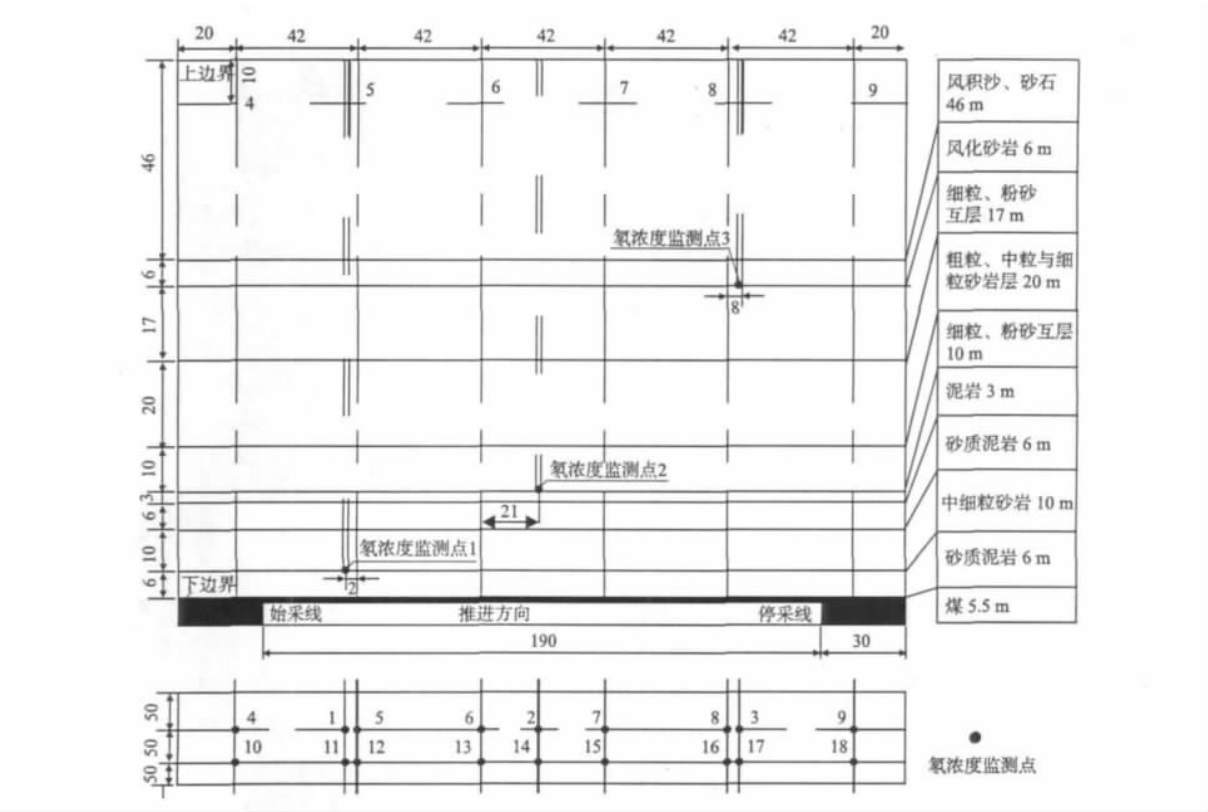


图 1 模型正视、俯视简图和部份测点分布情况

Fig. 1 Model from the front view and top view, and partial measuring points distribution

表 1 沙基 I 类型模拟材料配比

Tab. 1 Simulation material mixture ratio of sand - bedrock - coal I

序号	岩性	厚度 (cm)	配比号(砂子: 碳酸钙:石膏)	相似材料 质量(kg)	水 (kg)	砂 (kg)	碳酸钙 (kg)	石膏 (kg)
1	风积沙	30		607.50		607.50		
2	风化砂岩	5	40:7:3	101.25	11.25	72.00	12.60	5.40
3	粉砂岩	4	30:7:3	81.00	11.57	52.07	12.15	5.21
4	砂岩	4	60:7:3	81.00	9.00	61.71	7.20	3.09
5	砂岩互层	6	60:7:3	121.50	13.50	92.57	10.80	4.63
6	砂质泥岩	6	40:7:3	121.50	13.50	86.40	15.12	6.48
7	粉砂岩	4	30:3:7	81.00	11.57	52.07	5.21	12.15
8	粉砂岩	15	30:3:7	303.75	43.39	195.27	19.53	45.56
9	炭质泥岩	3	40:7:3	60.75	6.75	43.20	7.56	3.24
10	砂质泥岩	3	40:3:7	60.75	6.75	43.20	3.24	7.56

表 2 沙基Ⅱ类型模拟材料配比
Tab.2 Simulation material mixture ratio of sand – bedrock – coal Ⅱ

序号	岩性	厚度 (cm)	配比号(砂子: 碳酸钙: 石膏)	相似材料 质量(kg)	水 (kg)	砂 (kg)	碳酸钙 (kg)	石膏 (kg)
1	风积沙	46		931.50		931.50		
2	风化砂岩	6	40: 9: 1	121.50	13.50	86.40	19.44	2.16
3	细粒、粉砂互层	17	40: 7: 3	344.25	38.25	244.80	42.84	18.36
4	粗粒、中粒与 细粒砂岩互层	20	40: 3: 7	405.00	45.00	288.00	21.60	50.40
5	细粒、粉砂互层	10	60: 7: 3	202.50	22.50	154.29	18.00	7.71
6	泥岩	3	40: 7: 3	60.75	6.75	43.20	7.56	3.24
7	砂质泥岩	6	40: 7: 3	121.50	13.50	86.40	15.12	6.48
8	中细粒砂岩	10	30: 3: 7	202.50	28.93	130.18	13.02	30.38
9	砂质泥岩	6	40: 7: 3	121.50	13.50	86.40	15.12	6.48

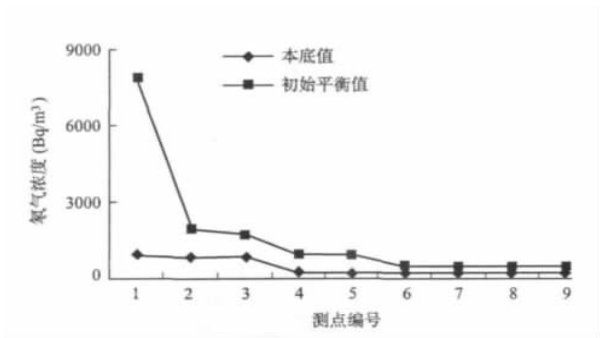


图 2 模拟开采前未供氡平衡时和供氡平衡时各测点氡气浓度
Fig.2 Radon concentration of measuring points at equilibrium both supplying radon and providing no radon before mining

在模拟开采过程中,“测点 2”随着开采的进行,其氡气浓度变化关系如图 3 所示。在初采时,该测点氡气浓度有小幅下降,这是由于开采扰动使原生的孔隙连通性增大,平衡时富集的氡气向上运移造成。而后随着开采推进,保持缓慢增长。当工

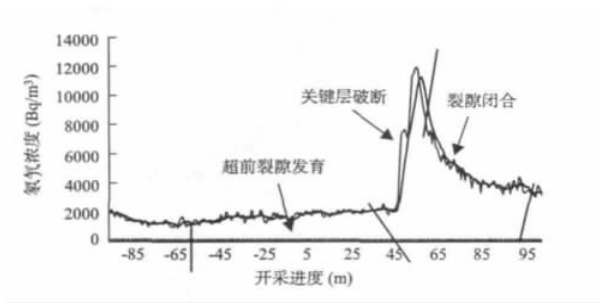


图 3 “测点 2”氡气浓度随开采进度变化情况
Fig.3 Changing situation of Radon concentration follow mining of point 2

作面推过该处约 50 m 时,氡气浓度突然增大,峰值逼近氡源浓度。当工作面推过该处约 60 m 后,氡气浓度迅速下降,最终趋于稳定,数值大约是初始平衡值的二倍。“测点 2”的氡气浓度变化过程,表现出了明显的因为覆岩裂隙发育,关键层破断,然后裂隙闭合而迅速增大再减小的规律,氡气浓度变化非常直观地显现出了该处的岩层运动情况。

2.2 沙基型浅埋煤层第Ⅱ种典型类型

在实验模拟开采前,模型系统未连接氡源以及连接氡源平衡后接各测点的氡浓度情况见下页图 4。从图 4 中可以看出,未供氡时,模型系统的本底浓度在 800 Bq/m³ 到 1 100 Bq/m³。连接氡源后,各测点的氡气浓度升高。

对比图 2 和图 4,由于沙基型煤层第Ⅱ种类型模型中有两个关键层的阻隔,各测点氡气浓度升高的幅度,相对于沙基型煤层第Ⅰ种类型中氡气浓度升高的幅度小。“测点 2”埋设于模拟开采起始点前方 95 m 处,在主关键层与亚关键层之间,距离煤层 25 m。在模拟开采过程中,“测点 2”随着开采的进行,其氡气浓度变化关系如图 4。随着开采推进,由于超前裂隙的产生,氡气浓度持续增大。工作面推过该处约 50 m 时,氡气浓度有一个急剧增大的过程,说明亚关键层破断了。与“测点 1”比较,由于“测点 2”埋设位置距离煤层更远,中间还有一层厚达 10 m 的中细砂岩亚关键层,所以氡气浓度要小得多。

2.3 两种典型类型的比较

实验分析了沙基型煤层的两种典型类型:
(1) 第Ⅰ类型中,由于基岩非常薄,均位于垮

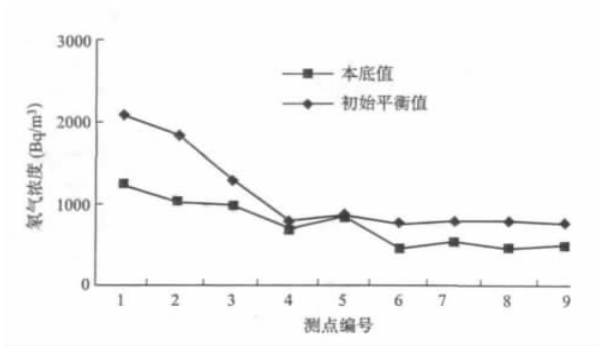


图4 模拟开采前未供氡平衡时和供氡平衡时各测点氡气浓度

Fig.4 Radon concentration of measuring points at equilibrium both supplying radon and providing no radon before mining

落带内,基岩内的测点氡气浓度值,均经历了一个从缓慢增长到急剧增加,而后压实浓度值回落的过程。有明显的峰值,压实后的稳定值与峰值差别较大,即压实率较大,如图3所示。

(2)第Ⅱ类型中,覆岩赋存了两个关键层,且主关键层位于裂隙带上部,位于主关键层上、下的测点氡气浓度变化情况表现出了明显差异。由于第Ⅱ类型中的“测点2”位于亚关键层与主关键层之间,当亚关键层破断时,浓度值都会有一次跃迁,岩层垮落裂隙沟通对增大氡气运移速度的意义非常明显,如图5所示。

第Ⅰ类型中,风化砂层中的测点距离煤层75 m,其中风化砂层30 m。第Ⅱ类型中,风化砂层中的测点距离煤层115 m,其中风化砂层46 m。

在第Ⅰ类型中,各测点氡气浓度表现出的规律是持续增加,超过初始平衡值3倍~5倍的时候,基岩裂隙即已经完全沟通。在第Ⅱ类型中,前三个表层测点,显现出了一致的变化规律,即在工作面推过相同的相对距离时,最大值出现。随后,由于裂隙压实闭合,稳定值和最大值略低。

需要指出的是,由于主关键层并未破断,压实的过程并不是太明显,压实率比较低,即最终稳定值仅仅是略小于最大值(见图5)。

3 结论

通过沙基型煤层的两种典型类型对比可以发现,在煤层中,可以建立基岩以及表土层中测点氡气浓度值与开采进度和裂隙发育情况的联系。氡气浓度的变化情况,可以揭示覆岩中岩层的移动情

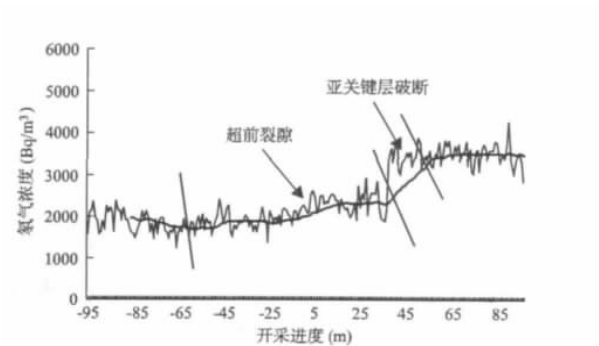


图5 “测点2”氡气浓度随开采变化情况

Fig.5 Radon concentration changing situation follow mining of point 2

况,不同的岩层赋存条件对应不同的变化规律。

参考文献:

[1] 孙东,王道永,王运生,等. 缅甸拉泰—其培河段恩梅开江断裂带氡气测量[J]. 水文地质工程地质,2010,37(4):107.

[2] 谷懿,葛良全,王广西,等. 汶川地震震后大成都地区断裂带活动性氡气测量分析评价[J]. 工程地质学报,2009,17(3):296.

[3] 张骏,高秀君,李侠,等. 霍州矿区隐伏断裂(带)活动性氡气测试成果解释分析[J]. 高原地震,2000,12(1):16.

[4] 邵永新,杨绪连,李一兵. 海河隐伏活断层探测中土壤气氡和气汞测量及其结果[J]. 地震地质,2007,29(3):627.

[5] 方方,贾文懿,周蓉生,等. 利用 α 测氡技术寻找地下水[J]. 物探化探计算技术,1996,18(增):103.

[6] 李奕霖,原观军,彭东,等. 油气化探异常预测油气藏埋藏深度探讨[J]. 物探化探计算技术,2006,28(4):367.

[7] 刘菁华,王兴泰,田钢,等. 放射性氡气测量动态监测煤炭地下气化燃空区[J]. 物探与化探,2000,24(2):92.

[8] 梅国栋,王云海,刘璐. 测氡法在探测浅埋煤层火源范围中的应用[J]. 煤炭科学技术,2007,35(10):42.

[9] 赵耀江,郭剑明. 测氡探火机理的研究[J]. 煤炭学报,2003,28(3):260.

[10] 泰峰,安海忠,亢俊健,等. 煤田陷落柱氡气场的数值计算及空间形态分布特征[J]. 地球物理学报,2004,47(1):171.

[11] 秦鹏. 利用氡气探测陷落柱初探[J]. 煤田地质与勘探,1999,24(3):173.

作者简介: 柏强(1984-),男,四川遂宁人,硕士,研究方向: 环境辐射场及辐射检测技术。

si-analytical solution of cube model. Due to the complex model decomposing into some cubes, the study of the cube model can pave way for the quasi-analytical method used in fast forward and inverse modeling of the complex model in the 3D D. C. electric field.

Key words: integration equation; the quasi-analytical method; D. C. electrical field; cube

DISCUSSION ON THE SENSITIVITY OF EACH MODE DISPERSION CURVES RAYLEIGH WAVE WITH THE SHEAR WAVE VELOCITY AND DEPTH OF STRATUM

ZHANG Ming-cai, XIONG Zhang-qiang, ZHANG Da-zhou, et al. (School of Info-physics and Geomatics Engineering, Central South University, Changsha 410083, China). *COMPUTING TECHNIQUES FOR GEOPHYSICAL AND GEOCHEMICAL EXPLORATION*, 2011, 33(2): 153

The exploration of Rayleigh surface wave aimed at effectively using dispersion curves to inverse the shear wave velocity and depth of stratum, but sensitivity of each mode with the shear wave velocity and depth of stratum are different. Frequency-phase velocity difference curve of each mode is obtained by subtracting the dispersion curve from the dispersion curve with one of the media parameter 10% changed. The sensitivity of each mode of Rayleigh wave with the shear wave velocity and depth of stratum of every layer is analyzed and discussed. Experimental results show that fundamental mode is more sensitive to the shear wave velocity and depth of stratum of shallow layer, and sensitive areas mainly concentrate on the narrow frequency range, while higher modes are more sensitive to the shear wave velocity and depth of stratum of deeper layer, and sensitive areas mainly concentrate on the wide frequency range, the distributions of frequency bands with strong sensitivity are scattered. The results can provide a theoretical basis for the multi-mode joint inversion of rayleigh surface waves.

Key words: dispersion curve of rayleigh wave; shear wave velocity; depth of stratum; sensitivity

APPLICATIONS OF STABILITY EXPLORATION WITH HIGH - DENSITY ELECTRICAL METHOD IN THE XILING SNOW MOUNTAIN RESERVOIR

TAN Da-long, TUO Xian-guo, ZHAO Si-wei (College of Information Engineering of Chengdu University of technology, Chengdu 610059, China). *COMPUTING TECHNIQUES FOR GEOPHYSICAL AND GEOCHEMICAL EXPLORATION*, 2011, 33(2): 159

According to the shallow survey on the constructing working area in Snow Mountain reservoir, the study on the covering layer of working area and the electrical differences of bedrock, the abnormal character-

istics of fracture and some comparing and correcting are carried out based on borehole data. The results show that there is obvious electrical differences among the bedrock, overburden rock and cracks and surrounding rock in working area. After the test line inversion of apparent resistivity anomalies and cross-section, a clear reflection of the up and down of bedrock and extension distribution of fracture underground rock and underground depth of the situation are showed, and thus the adverse geological scale can be delineated, and geological condition is provided to reservoir constructions.

Key words: high-density electrical method; cover layer thickness; crack

STUDY ON THE GEOLOGICAL CHARACTERISTICS IN THE PRIMARY MINING AREA OF SHARANG MOLYBDENUM DEPOSIT, TIBET

XU Yuan-ping^{1,2}, HE Zheng-wei¹, LIU Yan-song¹, et al. (1. College of Earth Science, Chengdu University of Technology, Chengdu 610059, China; 2. Hydro - engineering Team of Sichuan Metallurgical & Geologic Exploration Bureau, Chengdu 610501, China). *COMPUTING TECHNIQUES FOR GEOPHYSICAL AND GEOCHEMICAL EXPLORATION*, 2011, 33(2): 165

Sharang molybdenum deposit is magmatic hydrothermal mineral deposit, the molybdenum orebodies mainly occur as veinlet and netted venation within the plagioclase granite-porphyry fracture zone, and the general strike of the orebody is EW. The industrial type of the ore is primary molybdenum sulfide, the main metallic mineral are molybdenite, pyrite, ilmenite. Molybdenite occur as schistose, granular and powdered in the ore, and the grain size of molybdenite single crystal $\leq 0.1 \text{ mm} \sim 2 \text{ mm}$, the content of molybdenite in the ore is 0.1% ~ 3.35%. Based on the petro-chemistry analysis, the paper indicates that in the collision process and post-orogenic process, the magma hybridization is distinct from crustal matter, and the magmatic differentiation of anatectic magma is widely different. For that reason, the ore-bearing rock bodies in the Sharang deposit have the characteristic which is not only different from typical S-type granites, but also different from typical I-type granites.

Key words: granite-porphyry; primary sulfide deposit; geological character; sharang molybdenum deposit

STUDY OF CORRELATION OF FRACTURE CAUSED BY COAL MINE PRODUCTION AND RADON CONCENTRATION

BAI Qiang¹, FANG Fang¹, LI Xiang² (1. Chengdu University of Technology, Chengdu Sichuan 610059, China; 2. The National Energy Bureau, Beijing 100824, China). *COMPUTING TECHNIQUES FOR*

GEOPHYSICAL AND GEOCHEMICAL EXPLORATION, 2011, 33(2): 175

Coal production in seam mining can easily lead fracture in overlying stratum link up to the surface cracks directly, which could cause combustion, loss of groundwater and so on. An important basis to effectively solve the problems is to grasp the characteristics of distribution of mining fracture in overlying stratum. Radon measurement is introduced into researching on fracture development of seam mining, and the correlation of fracture and radon concentration in seam mining is analyzed by experimental simulation.

Key words: coal seam; fracture; radon concentration; correlation

THE GEOCHEMICAL DATA PROCESSING OF THE COKRIGING IN LINWANG MINERAL PROSPECTION

XU Yin-he, SUN Chun-yan, ZHU Wei-huang, et al. (School of Technology and Engineering, China University of Geosciences, Beijing 100083, China). *COMPUTING TECHNIQUES FOR GEOPHYSICAL AND GEOCHEMICAL EXPLORATION*, 2011, 33(2): 179

Cokriging is characterized by both multi-teity and kriging's advantages of representing the spatial attributes, which regionalizes two or more spatial attributions, and can improve the estimation accuracy in the geochemical data processing. Taken Lin Wang area as an example, the cokriging method is used to predict the reserve of gold element in the mineral area. The basal element combination of gold, silver, arsenic and mercury is showed by correlation analysis, which Au as the main variable element while Ag, As, Hg are the second elements. Compared with the traditional multivariate statistical methods of kriging, cokriging gets less estimated errors and high estimated accuracy. It is more superior than other methods in the predication of the mineral prospecting.

Key words: cokriging; correlation analysis; variogram; estimated accuracy

STATISTICAL RECOGNITION OF MOBILE ELEMENTS ANOMALY IN GEOCHEMICAL SOIL SAMPLES FROM CONCEALED DEPOSIT AREA

YANG Li-qin (Gold Geological Research Institute of CAPF, Langfang Hebei 065000, China). *COMPUTING TECHNIQUES FOR GEOPHYSICAL AND GEOCHEMICAL EXPLORATION*, 2011, 33(2): 184

The calculation method of mobile elements anomaly limit (T) in geochemical soil samples from concealed deposit area was developed. The contrast value ($C_i = x_i / T$) was defined and a statistical identifying mode of the anomaly was established (singular

date was picked out when $C_i > 1$). The method was applied in Jinchang gold deposit area which laid in the forest and black-land zone. The test result showed the mobile in Au anomaly values inosculated ideally with the Au deposits of known. Au anomaly scopes obtained corresponded with geology knowledge in the potential area, and some part was verified by the drill-engineering.

Key words: concealed deposit area; mobile elements; anomaly

DENUDATION RECOVERY OF HIMALAYAN PERIODS IN MIDDLE SECTION OF WESTERN SICHUAN DEPRESSION

SHEN Zhong-min¹, LIU Yang¹, LIU Si-bing² (1. State Key Lab of Oil – gas Reservoirs Geology and Exploitation, Chengdu University of Technology, Chengdu 610059, China; 2. Exploration and Production Research Institute of Southwest Branch Company, Chengdu Sichuan 610081, China). *COMPUTING TECHNIQUES FOR GEOPHYSICAL AND GEOCHEMICAL EXPLORATION*, 2011, 33(2): 189

Uplift and erosion of stratigraphy in a basin is a common phenomenon. Denudation Recovery of stratigraphy is the key and basis during the study of basin evolution and resource assessment. Tectonic movements have occurred frequently in the middle section of west Sichuan depression since the late Triassic, including the Indosinian movement, the Anxian movement, the Yanshan movement and the Himalaya movement. They are mainly caused by compressive stresses leading to many unconformity surfaces. Vitrinite reflectance distribution characteristics and the sonic velocity analysis method are used in this study to recover the denuded amount caused by three movements respectively. The erosion thickness is 844 m ~ 3 192.6 m which is restored by vitrinite reflectance, and the average thickness is 1 642.5 m; the erosion thickness is 1 015.5 m ~ 1 676.1 m which is restored by waves time law, and the average thickness is 1 386.4 m. The difference is produced by super pressure that generally exists in study area. The calculation results of the denuded amounts show that the thickness of erosion has decreased from north to south; The thickness has increased from west to east, in Yazihe region, the erosion is strong, smaller thickness of erosion decreased from east to the Majin regional. Then Zhongjiang erosion has become a large thickness.

Key words: west Sichuan depression; himalayan; erosion thickness; vitrinite reflectance; sonic time difference

STUDY ON RESERVOIR EVALUATION WITH WELL LOGGING DATA IN HORIZONTAL WELL OF HD OILFIELD