Progress with the Geological and Ecological Survey in the Critical Zone of the Global Black Soil Which is Linked with the Sky and Ground Monitoring Methods (ICGP665)

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The overall technical route of the project is based on field investigations and supported by remote sensing inversion and ground high precision testing and analysis. It gives full play of comprehensive, multidisciplinary research as an advantage from different scales and levels, and solves key scientific problems by comprehensive use of geology, geochemistry, remote sensing technology according to black soil globalization. The soil geological characteristics in black soil region are carried out from multi-angle, multi-scale, and multi-level, and abided by the research scope from region to local, the research content from shallow to deep, the research object from single element to element association, the analysis content from element content to element behavior.

1 Geological and ecological surveys supported by the sky and ground monitoring methods

1.1 Black land degradation survey

The specific contents of the black land degradation survey are as follows: (1) Dynamic monitoring of area in black soil region: change area, transformation grade, transformation intensity, etc. (2) Dynamic monitoring of soil erosion in black land: RULSE model, analytic hierarchy model, GIS-based integrated model, etc. (3) Study on the law of degradation of black land, including the relationship with land use, gully, elevation, slope length, slope and other aspects.

1.2 Black land fertility investigation and monitoring

The specific contents about land quality survey and monitoring of black land are as follows: Dynamic monitoring of land quality: soil geochemical properties, soil physical properties. Ground spectra mapping: horizontal, vertical. Land quality comprehensive evaluation model.

The specific contents about investigation and monitoring of black land capacity are as follows: net primary productivity (NPP), land use survey, planting structure analysis, crop growth survey, crop yield estimation analysis.

1.3 Black land ecological environment assessment

Guided by fragile ecological environment theory, landscape ecology and sustainable development theory, according to the "driving force-pressure-status-influence-response (DPSIR)" framework, based on remote sensing monitoring and ground survey data, the eco-environmental fragility is evaluated by using RS and GIS techniques to extract land use information, landscape indices, terrain factors, influence indices, etc. Taking city as the evaluated unit, combining the mathematical statistics and mathematical model, the landscape pattern in black soil region is carried out, and the landscape structural characteristics of the black soil region and the spatial distribution relationship of the black soil quality are quantitatively studied to reveal the law and degree of the spatial distribution about the ecological environment vulnerability in black soil region.

1.4 Construction and monitoring of long-term station in black land

Two purposes are as follows: (1) Establish a long-term station for soil carbon respiration. The basic monitoring data includes soil temperature, soil moisture, atmospheric temperature, atmospheric humidity and rainfall, providing basic data for studying black soil carbon cycle. (2) Establishing a long-term station for soil erosion monitoring, forming black soil erosion degradation process and its ecological environment impact monitoring ability, studying the spatial distribution characteristics of channel erosion and the formation mechanism of black soil erosion ditch landform, clearing the development process of gully erosion and its various erosion external force interaction, coupling and additive control, influencing factors, revealing the multi-external force driving mechanism of gully development under typical gully landforms in black soil region.

1.5 Black land database construction

The goal of database establishment comes from the demand for black soil which are linked with the sky and ground monitoring methods, and finally serves the comparative study of black soil and regional management decision-making. The data source and classification must be true, accurate, accordant with the current situation of resource utilization in black soil region, and really respond the spatial and distribution characteristics of the data. Data classification standards, scale divisions and data formats are consistent, ensuring that the same type of data from different regions have relatively consistent standards. The black soil basic information database should have dynamic, timely and scalable data.

2 Recent research work

2.1 China Geological Survey project

We continued with the integrated geological survey in
Northeast China in 2018. The budget was 500 million USD, the same amount that was stated in the IGCP project proposal. We have completed 44 960 square kilometers of the 1:250,000 geochemical survey, 100,000 square kilometers of the satellite remote sensing survey, and 1 500 square kilometers of the aerial hyperspectral survey.

2.2 Remote sensing survey

We collected Landsat8 satellite data and ASTER GDEM data in the black soil region of the Northern Hemisphere to form surface land use types with resolution of 30 m (including 9 first class land-use types and 25 second class land-use types), surface elevation maps, surface slope maps etc. A satellite remote sensing survey of 200,000 square was carried out in important arable areas in northeastern China, including three phases changes of land use (1985, 2000, 2015), three phases change monitoring of soil erosion (Fig.1), and three phases change monitoring of salinization and 3 phases change monitoring of erosion gully.

2.3 Aerial hyperspectral survey

For the first time, we used the method of aerial hyperspectral soil physicochemical properties survey on Qixing farm, using CASI/SASI/MAI/TASI aeronautical hyperspectral sensors to
form full-spectrum data from visible-near infrared-mid infrared-thermal infrared. Neural network, random forest, support vector machine, partial least squares and other methods were used to study the inversion of soil physical and chemical parameters, and the effects of different machine learning methods in spectral feature extraction and inversion were compared. The research contents include: organic carbon (Fig.2), soil total nitrogen, soil total phosphorus, soil total potassium, soil selenium and other soil chemical elements; soil pH, soil cation exchange capacity, soil texture, soil argillation, soil salinization and other soil physical structure. In addition, we constructed the relationship between leaf area index (LAI) and chlorophyll content of crops by spectral sampling and chlorophyll measurement of ground crops, and evaluate the spatial differences of crop growth, directly serving local agriculture.

2.4 Ground spectrum survey

Up to now, more than 40,000 ground spectra of soil samples which collected from Heilongjiang province, China, which is the typical black soil area. There were more than 40,000 soil samples with the exact geographical locations and geochemical analysis information which were processed in the laboratory according to the geochemical analysis standards. Soil samples were measured by two different spectrometers (ASD FieldSpec® 3 and ASD FieldSpec® 4) in the same laboratory condition. The ground-spectrum test results in Baqing County, Heilongjiang Province includes spectral classification of ground soil, soil absorption depth in different spectral ranges, soil organic matter evaluation, and soil pH evaluation, etc.

3 Upcoming research work

Multi-scale RS survey and monitoring of global black soil critical zone, Study on quaternary remote sensing geological mapping in the critical zone of the black soil and environmental driving mechanism of black soil evolution, Study on spectral characteristics of black soil and crops treated by different fertilizers for a long time, Effects of soil physical and chemical properties on crop productivity, Land use and crop spatial pattern on land quality of black soil, Application of satellite hyperspectral in soil properties, Study on interpolation method of organic matter and nutrient element in black soil based on geostatistics and remote sensing spectroscopy, Comprehensive modeling of global black soil critical zone, etc.

Key words: magmatic sulfide deposits, classification, small intrusions, metasomatism

Acknowledgments: This work is granted by the Land Resources Evolution Mechanism and Sustainable Use in Global Black Soil Critical Zone (IGCP665) and the Multi-target regional geochemical survey with standardised methods of 1:250,000 in Northeast China program (Grant No. DD20160316)

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