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Environment Geophysics on Environmental protection in China

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Abstract: The environmental problem conexists with the birth and development of human being. When people entered on the Industrial Revolution, especially the twentieth century, with the rapid improvement of the productivity level, the natural resources has been exploited and used at the unprecedented level. When people are creating the material wealth, they are also producing more and more pollution. The environmental problem has been more and more serious. This problem has already done harm to the human existence directly. In recent 20 years, the environmental problem has been one of the most important problems that people are concerned with. In China, there are also many environmental problems such as air pollution, water pollution, refuse treatment, desertification, sand calamity, soil erosion, drought, flood, biodiversity damage,and so on. Some of these problems have already affected the development of national economy and the living of people. So using the modern technology, uniting different subjects, studying these problems roundly and systematacially, and harnessing the pollution are important to the sustainable development of the society and economy.
Key words: Geophysics; Environmental protection; pollution

During the course of solving the environmental problem, a new subdiscipline, that is environment geophysics, came into being gradually. It also applies the theory and method of the geophysics to study and solve the environmental protection, improvement, and harnessing. It is a subdiscipline of geophysics as well as environmental science. The work of environment geophysics began in the 1950s, but its name didn't appear until the 1980s. In recent years, some progress has been made on the theory, technology, and instrument. Using different methods, the environment geophysics already has ability to monitor and interpret to solve the environmental problem. It will become more and more important.

At present, almost all the geophysical methods are used to solve the environmental problem in environment geophysics. All the geophysical methods in common use generally can be divided into electric-magnetic method, magnetic method, man-made seismic method ,radioactivity method,and the

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methods derivied from them. The work of the environment geophysics contains three aspects. Firstly, study the effect that the energy of the natural and the artificial physical field have on the environment and the biosphere of earth. Secondly, use the geophysical methods to monitor the pollution. Thirdly, use the geophysical methods to monitor and forecast the natural and artificial disaster.

In China, more and more attention has been paid to the environment geophysics. In 1993, the Environmental Geophysical Professional Committee was founded. In recent years, the Chinese geophysical society organize a lot of environmental geophysicists to engage in local environment , the engineering treat of water,engineering, and environment, the pollution of river,lake, and sea, and the detection of leakage on the field of garbage filling and burying.Its advantages bring into play better. The special science forum has been organized and convened many times successively by the national Natural science foundation of China (NSFC) and the Chinese geophysical society, which promote the development of subject.

As a subject, the environment geophysics is forming and developing, and is not very perfect. The environmental survey must be fine, tinily quantitative, and have less variety aroused by the anomalous field. So the detecting instrument must have high sensibility and the precise data processing technique. And there must be the talent who are familiar with environmental science and geophysics simultaneously. So the mature application of the environment geophysics is a development of geophysics, and need the support from environmental science and geophysics.

In this paper, according to the experience of the author's work, the main developments of the environment geophysics in China are presented. These main developments contain the detection of ground water pollution(the detection of the leakage on the field of garbage filling and burying, the detection of the underground establishment of gas and oil storage, the problem of dynamic inspection of groundwater pollution), the detection of seawater encroachment, the detecting methods on the radiation environment, the method of detecting and treating the alga inundation in river, lake and sea, the detection of ground subsidence, and the judgement of every kinds of insidious polluted body. Finally the perspective of this subject is indicated.

With the prosperity and development of environmental geophysics in our country, the difficulties of environmental science will be solved. This is a huge motive force that puts the environmental science to a new level. At the same time, it is a new developing direction on geophysics too.

1. THE DEVELOPING SITUATION OF ENVIRONMENTAL PROTECTION IN CHINA

With the sharp development of economics in our country, there is a trend that environmental quality went down gradually, especially, the eutrophication which occurred in river , lake and sea, groundwater pollution problem in city, regional ecosystem damage problem and so on . It is very difficult to the environmental management.

In the 1970s, in our country, the certain achievement was got in the harnessing of the industrial pollution castoff. In the 1980s, the experience in the comprehensive treatment that was carried out in city was groped, so that the control of environment pollution was gradually put into effect. And in the 1990s, on the side of large environment, that is to say the first kind of environment problems, people in our country have begun to be aware of the ponderance of these problems, such as desertification, sand calamity , grassland's perish and degradation, land subsidence and sinking, seawater encroachment, the pollution of offshore environment, earthquake ect.

In recent years, the manmade environment pollution is much more acute. For example, the release of a great deal of waste gas, waste water, and castoff has resulted in the climate anomaly, the ecological damage, and the waterbody and the soil pollution which impact on the health of human being directly, the continual development of the production and the economic, and the project of

vital and lasting of human being. But at the beginning of the environment subject, the general investigation of pollution and the programming were emphasized. It was a usually way that sampling and analyzing were made on the uncover polluted-carrier. However, it is helpless to know the distributing status of the regional zoology problem, and it is more difficult for the investigation of the deeply earth pollution. There must be profession skill. So using the modern technology, uniting different subjects, studying these problems roundly and systematacially, and harnessing the pollution are important to the sustainable development of the society and economy.

2. THE MAIN DEVELOPMENTS OF THE ENVIRONMENT GEOPHYSICS IN CHINA

During the course of solving the environmental problem, a new subdiscipline, that is environment geophysics, came into being gradually. It also applies the theory and method of the geophysics to study and solve the environmental protection, improvement, and harnessing. It is a subdiscipline of geophysics as well as environmental science. Comparing with others method of exploration, it has the advantages of inexpensiveness, quickness, and nondestructive test in situ, etc. At present, the work of the environment geophysics contains three aspects. Firstly, study the effect that the energy of the natural and the artificial physical field have on the environment and the biosphere of earth. Secondly, use the geophysical methods to monitor the pollution. Thirdly, use the geophysical methods to monitor and forecast the natural and artificial disaster. All the environment geophysical methods in common use generally can be divided into electric-magnetic method, magnetic method, man-made seismic method ,radioactivity method, and the methods derivied from them.

In recent years, in order to look after the integrated feature between geophysics and environment ,the Chinese geophysical society organize a lot of environment geophysicists to engage in the local environment, the engineering treat of water, engineering, and environment, the pollution of river, lake, and sea, and the detection of leakage on the field of garbage filling and burying. Its advantages bring into play better. The special science forum has been organized and convened many times successively by the national Natural science foundation of China (NSFC) and the Chinese geophysical society, which promote the development of this subject. And much more obvious developments which contain the following aspects are acquired.

2.1 The detection of groundwater pollution

People always think it is the most secure to embed the nocuousness waste underground, which make the groundwater that can be used directly and that occupy the great mass of fresh water increasingly be polluted. During the course of the prevention and cure of groundwater pollution, during whether the process of environment appraisal or the process of programming and harnessing, the position, the range, the direction of the polluted water, the polluted degree, and the distribution of the pollution source, ect. must be investigated clearly.

2.1.1 The detection of the leakage on the field of garbage filling and burying

Now, the pollution caused by the garbage filling and burying are increasingly serious in many cities of our country. A great deal of the extremely toxic substance or the toxic substance is mixed and buried together with the household garbage, which produces different effects on the surrounding soil, groundwater and environment. This makes the environment be destroyed and menaced largely. The result of investigation indicates that the leakage liquid caused by the garbage filling and burying can pollute the groundwater. In case the groundwater is polluted, it is very difficult and costly to clean up. In the United States, the percentage of the field of garbage filling and burying whose groundwater is polluted is about 86%. Now, the United States orders that the modern and advanced two-double field of

filling and burying must be used from 1996 and demands that the inspection-control and maintenance must be worked on for more than 30 years since it is closed.

As far as the garbage–body having tens hectares be concerned, when the seep liquid leaks towards underground and the groundwater is polluted, the accurate direction and leakage size usually must be known quickly so as to take the pertinence measure. For the problems above, the methods in common use are the ground probing radar (GPR), the electric magnetic method, the radioactivity method, and the measure temperature method. The methods which are used to decide the trend and the area of the groundwater polluted by the garbage are the induced polarization (IP) method and the ground probing radar (GPR). At the same time, the method that can be used must keep to the principles as follows:

a. The validity of the method. The selected method, which has been proved by practice, must be a valid way.

b. The feasibility of the technology. In order to get good effect, there should be the distinction of physical property between the polluted-body and background.

c. The contrastivity of the results. Two or more methods which have different principles should be chosen to survey the same section and the measured characters of abnormity should be compared, so that the results can validate one another. If two methods find the abnormity at the same time, that is to say, the survey result is highly reliable. It is avail to explain the result.

Now the environmental geophysicists in our country have obtained a great deal of information and accumulated experience. They have already fished out a well-rounded method of detecting the leakage of filling and burying of garbage from detecting the three biggest filling and burying of garbage fields in Beijing. Fig 1 shows that the monitoring of the area of the groundwater pollution. The drilling method was used to determine the area of the garbage. The GPR result is consistent with the drilling result. Furthermore, the actual area of pollution has already exceeded the drilling result.

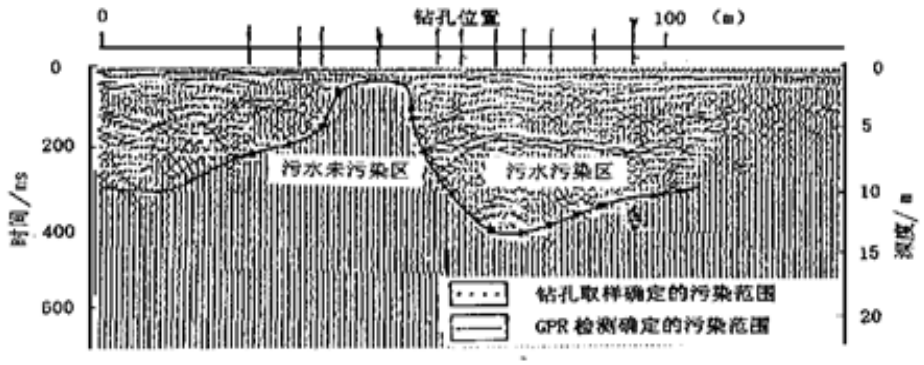

Fig 1. Constrast of drilling result and GPR result in the ground water pollution

2.1.2 The detection of the underground establishment of gas and oil storage

The leakage of underground establishment of gas and oil storage has a severe effect on the surrounding environment and causes a great loss. It can not only pollute the surrounding soil but also affect the earth's surface and groundwater and lead the surrounding vegetation to die. After the waterworks stops production or is discarded as useless, in case the oil and gas overflow and disperse from underground to the earth's surface, there might cause a fire or a blast. Therefore, it is very important to disclose, to detect, and to harness in time.

The corrosion and leakage that the oil tank of gas station and underground establishment of gas and oil storage are very common and difficult to discover in many cities such as Beijing, Shenyang, Xi'an, and Chengdu, ect. An accident of the leakage that took place in one gas station of Bejing had lead the waterworks to cut off the water supply and the underground construction to stop because the polluted acreage is quite large. There are much more this kind of accident in foreign country. It is reported that by

making an investigation on 210,000 gas stations in the United States, almost all the gas stations built before 1970s have leaked and 18000 gas stations have already polluted the groundwater.

There are many detection techniques of oil and gas leakage. The hydrocarbon detection technique and the GPR technique which are quick and convenient can offer the present measured result in situ. The absorbing hydrocarbon-hexane and the fluorescence-spectrum are highly accurate and the result is much more reliable.

2.1.3 The problem of dynamic inspection of groundwater pollution

The recently analyzing result of the information on the groundwater inspection which come from 118 large and middle cities in our country indicates that the groundwater of most cities has been polluted. Of all these cities, about 64% have been polluted heavily, 33% have been polluted lightly. The economic loss for the resource of water in our country caused by the pollution is about 337 hundred million yuan annually, in which 50% or so is due to the groundwater pollution. Cangzhou, in Hebei province, is located in the seashore plain. Because the groundwater was exploited excessively, the balance of the groundwater in Cangzhou is broken down and a huge filller of groundwater was formed. And the ground sewerage is speeded up pouring into the groundwater. The method of the environmental geophysics can locate the position of polluted groundwater and the direction of stream, determine the pollution intensity, trace the resource of pollution, and solve the problem of the forewarning and forecasting.

2.2 The detection of seawater encroachment

The water table has descended continually because the groundwater has been exploited excessively, which destroy the balance of the water line, the pressure, and the quantum of salt, and make the seawater encroach upon the layer of fresh water in inner-land. As a result, the polluted range is broadened gradually and the groundwater is lacking, which lead the salinization and effect the local environment directly. The seawater encroachment has taken place and developed since the 1970s in China. According to the preliminary investigation, the area of the seawater encroachment is about 1000 sq. kilometers. The longest distance of seawater encroachment is more than 10 kilometers. It is rather serious in Dalian, the Laizhou Bay, the coast of the Shandong Peninsula, and the coast of the Beidai River in Qinhuangdao in Hebei province. There are some small areal seawater encroachment in Beihai, the Weizhou Island, and the Qiong Harbor.

The resistivity method is often used to study the problem of the seawater encroachment. The emphases of study are the leading passage of seawater encroachment, the interface between salt and fresh water, the water storage structure of bedrock, and the size and range of seawater encroachment.

Table 1. Resistivity variation in the area of sea-water instrusion

Seawater encroachment	ρ_s /（$mg \cdot L^{-1}$）	$\rho(Cl^-)$ /（$mg \cdot L^{-1}$）	Resistivity（$\Omega \cdot m$）
Serious encroachment	＞2000	＞1000	2~17
Light encroachment	500~2000	300~1000	17~30
Non-encroachment	＜500	＜300	30~100

For example, Laizhou, in Shandong province, the aquifer consists of fine sand, medium coarse sand, and sandy gravel. The variation range of its resistivity is between 40 and 130 $\Omega \cdot m$. The rock formation is absolutely saturated when the seawater encroachment happens. Because the salt content of seawater is very high, the salt is dissolved in the groundwater and then amassed in the void of the bedrock. It makes the salt content of the groundwater increase sharply and the resistivity reduce relatively. According to the corresponding relation between the degree of seawater encroachment and the resistivity(Table 1), the symmetric four-pole resistivity method can be used to locate the interface between salt and fresh water. According to the contour map of the section of the apparent resistivity got from the resistivity sounding method, the passage and the section shape of the seawater encroachment can be reflected qualitatively

(Fig 2). The area of the contour line whose ρ_s is less than $25\,\Omega\cdot m$ is encroached by the seawater. According to the interpretation of different sections, the area that the ρ_s is less than $30\,\Omega\cdot m$ is encroached by the seawater (Fig 3). The time, velocity, size, and area can be determined by inspecting the different encroachment section dynamically.

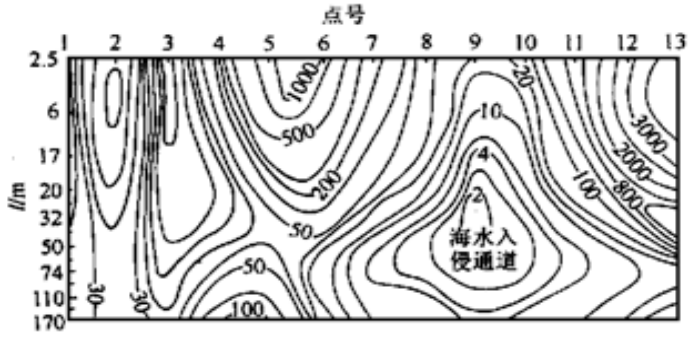

Fig. 2. Apparent resistivity pseusection of parallel seacoast line in the Sandong area

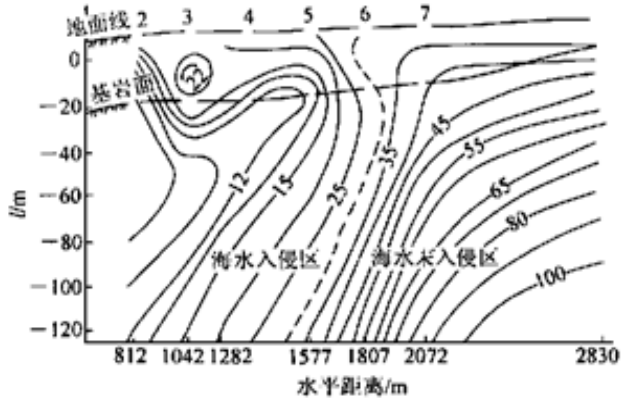

Fig. 3. Apparent resistivity pseusection of seawater encroachment in Sandong area

2.3 The detecting methods on the radiation environment

The radioactive nuclides that exist naturally produce radiance. They make human body receive the radioactive radiation.The natural radioactive radiation is mainly derived from the area of high radioactive strength such as the granite area in the south China, the metamorphite area with abundant uranium, the waste residue and mullock from factory, and the radioactive establishment, etc. The main monitoring methods are the airborne gamma-ray spectrometry and the ground gamma surveying. The main hazard to the human health is the indoor radon radiation. Most of the radon gas comes from all kind of granite, black shale, metamorphite with abundant uranium, phosphorite and the soil which is derived from them, the fluvial facies, marine facies and delta facies sedimentary rock with abundant uranium, and the recent drift sheet and lake clay layer. The radon radiation in water is mainly derived from the high Rn content groundwater of the area where the granite, black shale, and silicated limestone that contains Ra & U. The active carbon detector, α track detector, and the high sensitivity emanometer and so on are used to monitor the radon of the human living space and the water resource.

On the market, all kinds of the crude stone, encaustic brick, glazed brick, and artificial marble contain certain radioactive substance. In order to avoid the high radiation of crude stones to the human body, the national bureau of building materials industry（国家建筑材料工业局）stipulates the classified standard for the stone product. According to the radioactive level of stone in our country and the limiting level of

the natural radiation that the human body can receive, the stone product can be divided into A, B, and C, three types (Table 2). Only the type of A can be used indoors. Usually, the gamma energy spectrometer and the gamma ray surveying (60~3000kev) are used to divide the types of the stone.

Table 2. The classification standard of nuclear radiation of the building matcrial in China

Level	Equivalent concentration of radiation, *Bq / kg*	range of application
A	>350	All the buildings
B	351~700	Except the indoor facing
C	701~1000	Outdoor facing

2.4 The method of detecting and harnessing the alga inundation in river, lake and sea

In recent years, the eutrophication has taken place in most of river, lake and sea in our country. The alga overruns and becomes "zoology cancer " that it is difficult to harness. Some environmental geophysicists who co-operated with the environmental protection department in Yunnan province treated the blue algae pollution in Dianchi lake. They adopted a kind of fleet treating method, that is synthesis-removing alga. Harnessing work was divided into two stages.Firstly, the alga pollution material was disposed of in Dianchi. and a kind of "biochemical compound dose of inhibiting algae" was manufactured. Secondly, combined with the part zoology recovery measure, water control, and the periphery pollution abatement, some detection and treatment was done at the bottom of Dianchi.

The small field experiment and the separating experiment have been done. And the open and enlarge experiment has been done during the world horti-expo meeting , and the dredging of part of bed mud has been co-operated by the local. The test results showed that the No.355 biochemical compound dose of inhibiting algae has great capability to kill and control the alga. It has obvious clarificafion, it is safe, and it is helpful to resume the ecology in the lake. Some geophysical methods and technology will gradually be used to inspect.

These experiments are science experiments that the eutrophication of the typical plateau lake (it is drinking water too) is treated urgently. It has historical, pioneer, and far-reaching meaning.

2.5 The detection of the ground subsidence

The main reason of ground settlement is that the groundwater is exploited excessively, the water level is declining continuously, and the aquifer and the soil horizon above are compressed. If in the karat terrain of the limestone terrain or in the loessland, the falling of groundwater level can cause the ground subsidence. The detection on the ground subsidence must be paid highly attention. At present, there are the problems of the ground subsidence in 16 provinces, that is 46 cities and towns. The total area of the subsidence is 4870 hundreds sq. kilometers. According to the size (area) and the degree (the largest cumulative subsidence), the ground subsidence is the most serious in Tianjin, Shanghai, Suzhou, Wuxi, Changzhou, Cangzhou, Xi'an, Fuyang, and Taiyuan.

The detection on the ground subsidence must be paid highly attention. The main method to monitor the ground subsidence is the precise leveling survey. Because of its inefficiency, the cost is rather high. The gravity measurement can be used to monitor the ground subsidence. It can reduce the workload and know the change of the underground objects (especially the groundwater). The regional gravity monitoring net was arranged during the forecast of the earthquake. The trend of the gravity augment has been found in many areas because of the ground subsidence. The high precision gravity measurement is effcient and inexpensive. Therefore, it must have a good prospect.

2.6 The judgement of every kinds of insidious polluted body

Geophysical methods can be used to locate the accurate position, the size, and the polluting strength of a sort of solid waste and every kinds of unknown contamination. The range of this geophysical work contains determining the section and the depth of the polluted body, finding the larger object of the polluted body such as the slack tank and the container used to contain the waste materials, etc., measuring the area of the pollution and the geologic structure or the artificial works of the control of the pollution, and appraising the groundwater. All sorts of the electric-magnetic methods and the magnetic methods are often used to deal with these problems.

3. LOOK INTO THE FUTURE

In recent years, numerous Chinese geophysicists have done a large number of work to solve some important environmental problems and gained the delightful harvest. They are marching towards the depth and extent of environmental geophysics and working hard to probe into environmental geophysics.

Aroused by the activity of human being and the industrial production, the environmental problem, especially the pollution of groundwater is getting more and more serious and becomes the focus of the environmentalist and the geophysicists together. In our country, according to the existing information and practice, most of the fields of filling and burying of garage in all cities have occurred leakage; Most of all the gas station, the underground oil pipeline, and the oil storage facility have oil dripping; The alga overrun in most of lake and bay; The coastal area are short of groundwater severely because of the seawater encroachment, The ground fissure and the ground subsidence have appeared in many cities and towns; The indoor radon gas exceeds the standard in some zone. These giant hidden trouble may arouse the accident of disaster. In addition, there are the different degrees of leakage on all of the beatup underground steel tube, iron tube, and cement tube, so we must nip in the bud. During the course of solving these problem, environmental geophysics will take important effect. At the same time, it will promote the new development of environmental geophysics, so the environmental geophysicists will shoulder heavy responsibilities.

The principle of the existing geophysical survey methods, especially many applied geophysics methods can be used in environmental geophysics. But the environmental survey must be fine, tinily quantitative, and the less variety aroused by the anomalous field. So the detecting instrument must have high sensibility and the precise data processing technique. And there must be the talent who are familiar with environmental science and geophysics. So the mature application of the environmental geophysics is a development of geophysics, and need the support from environmental science and geophysics.

In a word, a strong procession of environmental geophysics, which will combine environment science and geophysics, is forming.

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