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Sustainable geology–Sociogeosciences

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Sociogeoscience, a new branch of geosciences and also a crossing subject, is proposed in this paper. The birth of sociogeoscience is inevitable in the process of the development of human society. Its mission is to deal with the difficulties faced by human beings and provide a solid scientific basis in order to realize the sustainable development. Sociogeoscience pays close attention to resources, population and environment.

As one of the basic subjects of the natural sciences, comparable to mathematics, physics, chemistry, astronomy and biology, geosciences have received great attention in history. Particularly, its significance for economic growth has become more and more conspicuous since the industrial revolution about two hundred years ago. As is known to everyone, geosciences laid a concrete foundation for the creation of the ever prosperous material civilization of human society. It can be said, without exaggeration, that the development of geosciences definitely goes hand in hand with industrial growth. In other words, industry can never expand fast enough to promote the economy of human society without sophisticated geosciences and relevant technology. Undoubtedly, geosciences have exerted an important influence on the progress of society.

Table 1 Status of China in world energy production in 1991

Output of coal (10 ⁷ t)	Output of crude oil (10 ⁷ t)	Output of natural gas (10 ⁸ m ³)	Power generation (TWh)
China 1087.4	USSR 513.0	USSR 8099	USA 2823.0
USA 901.4	Saudi-Arabia 407.9	USA 5285	USSR 1633.9
USSR 557.9	USA 368.6	Canada 1301	Japan 847.7
Germany 352.1	Iran 167.1	Netherlands 831	China 677.6
India 240.7	China 140.0	UK 552	Germany 617.1
Australia 225.9	Mexico 138.9	Algeria 458	France 499.8
Poland 209.7	Venezuela 117.1	Saudi-Arabia 450	Canada 489.9
South-Africa 171.4	UAE 97.3	Indonesia 385	UK 427.7
Czechoslovakia 98.1	Norway 93.2	Mexico 380	India 281.7
UK 91.3	Nigeria 92.9	UAE 332	Brazil 222.2*
	China 160.7**		
World gross output: 4440.4	2996.0	21639.0	11812.0

*data of 1991; **China ranking in the 20th, data adjusted

Source: «Oil Gas» USA, end of 1991, March, 1992; «Statistics Monthly Report of UN», June, July, 1992.

As chief supplier of raw material for industry and human life, mining of mineral resources plays an important role in the development of social civilization. 70%–90% of the raw material for industry is derived from mineral resources, while 90% of the energy in China arises from geological sources (Table 1). China's energy requirements will be higher in the year 2000 (Table 2).

Table 2 Predictions of China's energy requirements in 2000 (after Lei Shijun, et al. 1993)

	China National Statistics Bureau	Chinese Academy of Sciences	Ministry of Energy
Growth rate of GNP (%)	8	9	9
Gross energy requirement (10 ⁸ t)	15.4	16.1	14.8
Crude coal (10 ⁸ t)	16.0	16.7	15.7
Crude oil (10 ⁸ t)	2.0	2.0	1.65
Natural gas (10 ⁸ m ³)	300.0	300.0	250.0
Electricity (10 ⁸ kWh)	-	-	13600.0
Hydroelectricity (10 ⁸ kWh)	1400.0	2400.0	2300.0
Nuclear electricity (10 ⁸ kWh)	300.0	300.0	100.0

The output of mineral raw materials has been increasing in line with the development of the economy and living standard in most countries. Ever-increasing demand for energy, water resources and mineral raw material is keeping track with the expanding economy (Tables 3, 4, 5). Obviously, geological resources are not renewable, the proved reserves are limited (Table 6).

Table 3 Output values of mineral products in the world

Year	Output value of all mineral products (10 ⁸ USD)	Output value of 53 sorts of mineral products (10 ⁸ USD)
	constant dollar value in 1983	dollar value at present
1950	1179	259
1953	1553	370
1958	2085	500
1963	2353	590
1968	2698	779
1973	4300	1592
1978	8241	4770
1979	10065	6565
1980	12692	9512
1981	12263	10248
1982	9919	8926
1983	9887	9304
1984	10190	9950
1985	10540	10295

Source: «Minerals Yearbook», 1985.

Table 4 Proportion of output values of mineral products of different countries and organizations in the world total

Types of countries and organizations	Proportion (%)		
	1950	1978	1983
Developed countries	67.46	30.20	33.71
OPEC	9.98	30.56	22.02
Some developing countries	5.99	9.69	11.48
Countries with central planned economy	16.57	30.55	32.79

Source: «Minerals Yearbook», 1985.

About two thousand years ago, an ancient Chinese sage Lao Zi said dialectically that "It is upon bad fortune that good fortune leans, upon good fortune that bad fortune rests". Also, Friedrich Engels said that human beings, as conquerors, have been retaliated against by nature for their every victory. Mankind has achieved great success in the exploration and exploitation of natural resources and transformation of nature, but reprisal from nature closely follows. Up to the 1960s, environmental pressure brought about by the industrialization process in developed countries could no longer be tolerated by nature, resulting in serious environmental disasters, such as

planets and stars, searching for the origin of living organism, and last but not most important, protection of the living environment of mankind.

The exploitation and use of fossil fuels result in serious environment problems in the world. The atmospheric environment, especially with respect to air pollution from the burning of coal, is getting worse and worse in China. According to Chen Yaobang et al. (1996), coal provides about 75% of the energy in China. As the by-products of the combustion of coal, about 8.45 million tons of industrial smoke, 6.30 million tons of dust, 13.96 million tons of SO₂ (as well as a lot of CO, CO₂, NO, etc.), 600 million tons of solid wastes (the total amount of accumulated solid wastes is over 6,640 million tons), which covers over 50,000 hectares of farmlands are presently produced every year. Meanwhile, about 100 million tons of municipal refuse are produced every year.

Water pollution is also getting more and more serious in China. In 1995, waste water drained by the whole country was 35,620 million tons, of which 22,250 million tons was industrial waste and only 1/2 of the sewage was treated. Moreover, 850 of the 1200 rivers investigated in China are more or less polluted. About 6.36 million tons of solid industrial waste are directly poured into rivers. Two thirds of the cities in China are surrounded in garbage.

Table 5 Proportion occupied by the output values of minerals for different countries in their general domestic output in 1992 (%)

Country	Proportion (%)	Country	Proportion (%)	Country	Proportion (%)	Country	Proportion (%)
Australia	6.5	Mongolia*	40	Korea, D.P.R.	>50	India	2.2
Pakistan	0.8	Sri Lanka	1.8	Thailand	3	Korea, R.O.	0.5
Indonesia	14.5	Japan	0.3	The Philippines	1.6	Malaysia	10.3
Fiji	0.2						
Yemen	12	Israel	1.2	Oman	40.7	Cyprus	0.3
Syria	20	Turkey	18	Costa Rica	28	Bahrain	99
Iraq	25	Jordan	3.6	Saudi Arabia	23.8	Kuwait**	40
South Africa	14.7	Botswana	42	Zimbabwe	10.4	Angola	9
Swaziland	2	Namibia	22	Zambia	15.9	Gabon	3.5
Tanzania	0.6	Malawi	5.9	Central Africa	5	Kenya	0.2
Algeria	28	Libya	50	Mali	1.5	Guinea	12.9
Nigeria	28	Sudan	21	Ghana	26	Sierra Leone	17.9
Egypt	17	Mauritania	9.4	Niger	13.7	Liberia	13.4
Senegal	16	Togo	16	Morocco	3.4		
USA***	5.5	Canada	6	Mexico****	4	Chile	7.4
Brazil	2	Bolivia	13	Colombia	9.5	Peru	7.3
Venezuela	23.8	Argentina	15	Ecuador	7.6	Jamaica	6.5
Nicaragua	0.5	Paraguay	0.4				
England	3.1	Ireland	3	Portugal	<1	France	0.6
Austria	1.3	The Netherlands	3	Sweden	0.4	Finland	0.3
Yugoslavia	2.5	Albania	16.4				

Annotations: *Proportions occupied by exported values of minerals in the total; **Before the Gulf War in 1990;

Excluding fuel minerals; * Oil not calculated. (Source: *Mining Annual Review*, 1993)

the Hg and Cd pollution incidents in Japan, explosion of liquefied gas in Mexico, leakage of pesticide in Bhopal of India, etc. Air pollution, the greenhouse effect, enlargement of cavities in the ozonosphere above the Polar Regions, destruction of underground water, worsening of geological hazards, accumulation of industrial and living rubbish, harmfulness of poisonous remnants, desertification and salinization of farmland, decrease of forest and grassland, and quicker extinction of living species, etc., are getting more and more serious. This is the reason why population, resources and environment were treated as three key problems faced by our society. At the 26th International Geological Congress held in Paris in July, 1980, the tasks of geosciences were defined as follows: explaining the global tectonics and its evolution, dealing with the formation of

In China, because of waste water pollution, about 300 X 10⁹ m³ of fresh water is contaminated each year. It was reported that the economic loss due to waste water will be more than 273 billion RMB in China during 1985–2000 (Chen Yaobang et al., 1996).

Another critical problem challenging us is geological hazards, which occur more and more frequently. Property loss and casualties have doubled in recent decades (Table 7).

Since the 1970s, some scholars from both home and abroad have discussed deeply and broadly the relationship between geosciences and human society from various aspects. The most prominent representatives are Prof. P. J. Wyllie, Prof. W. S. Fyfe, Dr. Eder, Prof. G. M. Brown and Dr. V. Babuska. They stressed in a summary paper on IGCP progress that "various human activities have become

Table 6 Reserve base⁽¹⁾ of the major mineral resources in the world

Mineral resources	unit (ton)	1981	1994	I. R ⁽²⁾ (%)	Mineral resources	unit (ton)	1981	1994	I. R ⁽²⁾ (%)
Iron ore ⁽³⁾	10 ⁸	980	1000	0	Mn	10 ⁸	49	49	0
Chromite ⁽⁴⁾	10 ⁸	33.6	70	+5.8	Mo	10 ⁴	985.2	1200	+1.5
W	10 ⁴	290.5	330	+1.0	Co	10 ⁴	308.4	880	+8.4
Ni	10 ⁴	5423.9	11000	+5.6	V	10 ⁴	1852.3	2700	+2.9
Cu	10 ⁸	4.58	5.9	+2.0	Pb	10 ⁸	1.65	1.3	-1.8
Zn	10 ⁸	2.4	3.3	+2.5	Au ⁽⁵⁾	10 ⁴	3.73	6.0	+3.7
Ag	10 ⁴	26.2	42	+3.7	Pt group	10 ⁴	3.72	6.6	+4.5
REE ⁽⁶⁾	10 ⁴ , REO	701	4100	+14.5	Bauxite	10 ⁸	224	280	+1.7
Sn	10 ⁴	1000	1000	0	Nb	10 ⁴	345	420	+1.5
Ta	10 ⁴	2.18	3.5	+3.7	Bi	10 ⁴	10	25	+7.3
Sb ⁽⁷⁾	10 ⁴	453.5	470	+0.3	Hg	10 ⁴	15.3	24	+3.5
Zeolite	10 ⁴	4353.6	6200	+2.7	S	10 ⁸	22.75	35	+3.6
Potash	10 ⁸ K ₂ O	203.8	170	±4	Fluorite	10 ⁸	5.6	3.1	-4.8
Barite	10 ⁸	1.93	4.5	+6.7	Graphite ⁽⁸⁾	10 ⁸	1.54	3.8	+7.2
Magnesite	10 ⁸	25.2	34	+2.3	Diamond ⁽⁹⁾	10 ⁸ carat	6.2	19	+9.0
Trona ⁽¹⁰⁾	10 ⁸	391.8	400	0					

Annotation: (1) Reserve base of some mineral resources is not listed, (2) Average annual rate of increase, (3) Recoverable metallic content, (4) Commodity grade ores, content of Cr₂O₃ is generally 45%, (5) China and some other countries are not included, (6) The western countries, (7) China is not included, (8) Estimated value, (9) Industrial standard, (10) Being equivalent to that of Na₂CO₃.

Source: *Mineral Commodity Summaries*, 1982, 1985.

Table 7 Statistics of the direct economic loss due to the 15 major geological hazards in China (after Duan Yonghou et al., 1993)

Loss classification	Type of geological hazard	Annual average economic loss (¥100,000,000)	Remarks
Direct damage to available facilities (I)	Collapse, landslide and mudflow	36	Annual average economic loss due to the first class of geological hazard approximately totals ¥5.5 billion annually
	Ground collapse	4.39	
	Ground subsidence	1	
	Land cracking	0.4	
	Earthquake	10	
	Gas explosion	0.1	
Causing drop in social output value (II)	Water eruption in pit	3	
	Cold land	30	Annual average economic loss due to the first class of geological hazard approximately totals ¥5.5 billion annually
	Soil salinization	25	
Damage to environment and causing loss of resources (III)	Land desertification	45	Annual average economic loss due to the first class of geological hazard approximately totals ¥15.6 billion annually
	Soil erosion	96	
	Self-combustion of coal layers	15	
(IV)	Seawater intrusion	8	
totals		274	These data indicate economic losses in moderate disaster year

geological forces with significant impact on the Earth". The first two of the four goals for IGCP current research are "for the sake of improving human living conditions, understanding the factors controlling the environmental changes" and "searching for more efficient means in order to evaluate and explore natural resources, such as energy, underground water and minerals". Prof. L.R. Brown provocatively called for "Saving the Earth", which grasped the attention of various international scientific communities.

In China, Zhang Zongcheng (1989), Hu Angang and Wang Yi (1989), Li Jinchang (1990), Ma Zongjin et al. (1990), Hua Zepeng et

al. (1991), Xiao Zhuoji et al. (1994), Guan Fengjun et al. (1992), Duan Yonghou et al. (1993), Zhang Zonghu and Yuan Daoxian (1995), as well as some relevant institutes under different governmental departments completed many projects on the natural resource situation, environment, geological hazards and the relationship between them and the national economy and social development, while examining these issues from various angles. At the same time, they made related proposals and developed practical methods to deal with the above mentioned problems. These projects pursued models for sustainable development of human society based on domestic

resources and environment conditions macroscopically. In spite of the lack of concentration and nonsystematic approach, these pioneering achievements are undoubtedly of extreme significance.

From 1995 to 1996, Prof. Zhao Xun, Yin Jianzhao and Yang Yueqing have been doing detailed work on the subject of "Geosciences and Human Society" under the sponsorship of the State Planning Commission, which is a complete and systematic achievement. On the basis of this, Prof. Zhao Xun, Yin Jianzhao and Yang Yueqing released a new book "Geosciences and Human Society (1996)". Needless to say, this research project should go further as its result was restricted to some extent by the shortage of fund and limitation of time.

Generally speaking, the progress of human society, prosperity of the economy and the increase of material fortune, are all dependent on the development of production which relies on the exploitation and utilization of mineral resources. Moreover, more kinds of minerals are needed in social production, and many problems are encountered in the exploration of natural resources. In most countries, the economy grows approximately with the consumed volume of natural resources. At the same time, solid, liquid and gaseous waste materials have been generated along with the exploitation and consumption of natural resources. Although scientific development and technologic progress can promote the transformation of some waste to new raw materials, i.e., from waste to treasures, most of the waste material is abandoned in the open air, which results in not only destroying farmland but also damaging the environment and polluting the atmosphere and water resources. Additionally, the productive activities of human beings have also changed the Earth's surface, causing the intensification of natural hazards. When people were living in the primitive stage, with smaller productive scale and lower level of productive force, the environmental damages made by human beings were very small, and could be restored or disappeared gradually with time. To the contrary, large scale productive activities with high efficiency have deteriorated the environment day by day since the human society was industrialized on some parts of the Earth. But as soon as the Earth cannot tolerate the destructive accumulation caused by human activities, retaliation will definitely take place upon human beings, either violently or gently. Obviously, the exploitation and utilization of natural resources will never stop, as these activities are necessary for the development of human society. However, people have to change the short-sighted way in which the economy is developed, which disregards serious damage to the environment. A best balance point between the exploitation of mineral resources and environmental protection should be pursued, in order that contemporary people can promote economic development to meet the increasing demand for the improvement of current living standards, without damaging the potential of development for forthcoming generations as well, i.e. realizing sustainable development of human society, which is the splendid target of the whole world.

Geoscientists are an important force in the exploration and exploitation of natural resources. Also, geosciences are the key to preventing the deterioration of the environment and the practice of sustainable development of human society. Obviously, geoscientists have an obligation and are capable of searching for the balance point between exploitation of natural resources and environmental protection, so as to guarantee the realization of sustainable development of human society. In China, this practice has recently been encouraged with local people doing their best to lessen pollution during mining so as to gain biggest profits and suffer the least losses.

Actually, the balance point between the development of natural resources and environmental protection, like two sides of a coin, is controlled by various factors, such as natural conditions and social situations, economic development and scientific and technological level. It is quite understandable that this is not a simple problem which can be solved by geosciences solely. It requires the joint effort of different branches of the natural and social sciences. Sociogeoscience, as a new hybrid of sociology and geosciences, has developed in time to satisfy this purpose — solving this dilemma and seeking this balance point.

Recently, apart from some short-sighted politicians and entrepreneurs who disregard protection of the environment and neglect the practical value of geosciences, a large group of geoscientists and politicians in the international community, including those from China who are far-sighted, are really very worried about this situation. They proclaim that geosciences have greatly contributed to economic development in human history and will guarantee sustainable development of human society from the viewpoint of natural resources and environment. Hopefully, sociogeoscience, an interdisciplinary merger of geology with sociology, will bloom on the geoscientific system tree.

We have shown that sustainable development of human society is closely related to both geosciences and sociogeoscience, by scientifically reviewing contributions made by geosciences in order to promote the merger of geosciences and sociology to address the challenge faced by sociogeoscience in the next century. All of these are critical and significant for geosciences.

The goal of geosciences should reflect the needs of all human beings. The development of energy resources, mineral resources and water resources can notably improve the social economy, it exercises strong influence on the environment. Dealing with the causes and harmfulness of geological hazards, and last, designing countermeasures to cope with population expansion, resource shortage and environment damage, is necessary in order to make human society advance toward sustainable development.

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Hutchison 'Young Scientist' Fund

William Watt Hutchison, "Hutch" to his many friends around the world, was a Scots-born Canadian geologist who served Canada and the IUGS in myriad dynamic and creative ways. Most notably, he served as the IUGS Secretary General (1976-1980) at a pivotal time in its history, and as IUGS President (1984-1987). The same boundless energy, enthusiasm, skill in communications, and ability to foster teamwork that characterized his work with the IUGS also carried him to preeminent scientific administrative positions in the Canadian Government, where he served as Director General of the Geological Survey of Canada and as Assistant Deputy Minister of Earth Sciences. His distinguished career was terminated in 1987 by his untimely death at the age of 52, following a painful struggle with cancer.

One of Hutch's last wishes was to establish under IUGS auspices a memorial foundation intended to promote the professional growth of deserving, meritorious young scientists from around the world by supporting their participation in important IUGS-sponsored conferences. The first 3 beneficiaries of the Hutchinson "Young Scientist Foundation" attended the 28th International Geological Congress (IGC) in Washington, D.C., in 1989.

Currently, income earned as interest on the Hutchison fund is insufficient to sustain comparable grants every four years without seriously eroding the principal. For that reason, the IUGS made no grants from the fund for the 30th IGC, preferring instead to strengthen the fund by allowing it to earn interest for a longer period of time and by appealing for donations from the international geologic community. It is expected that grants from the fund will again support deserving young scientists to attend the 31st IGC in the year 2000. The Hutchison "Young Scientist Foundation" is a worthy cause that honors a fine, caring man and a distinguished, public-spirited scientist and administrator. The foundation also celebrates and promotes those things that gave Hutch the most professional satisfaction: geology, international scientific collaboration, and stimulating young minds.

The IUGS welcomes contributions to the Hutchison "Young Scientist Foundation." Please send donations to:

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