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Key Technology of Land Reclamation and Ecological Restoration in Large-scale Coal Mining Area on Loess Plateau During 30 years

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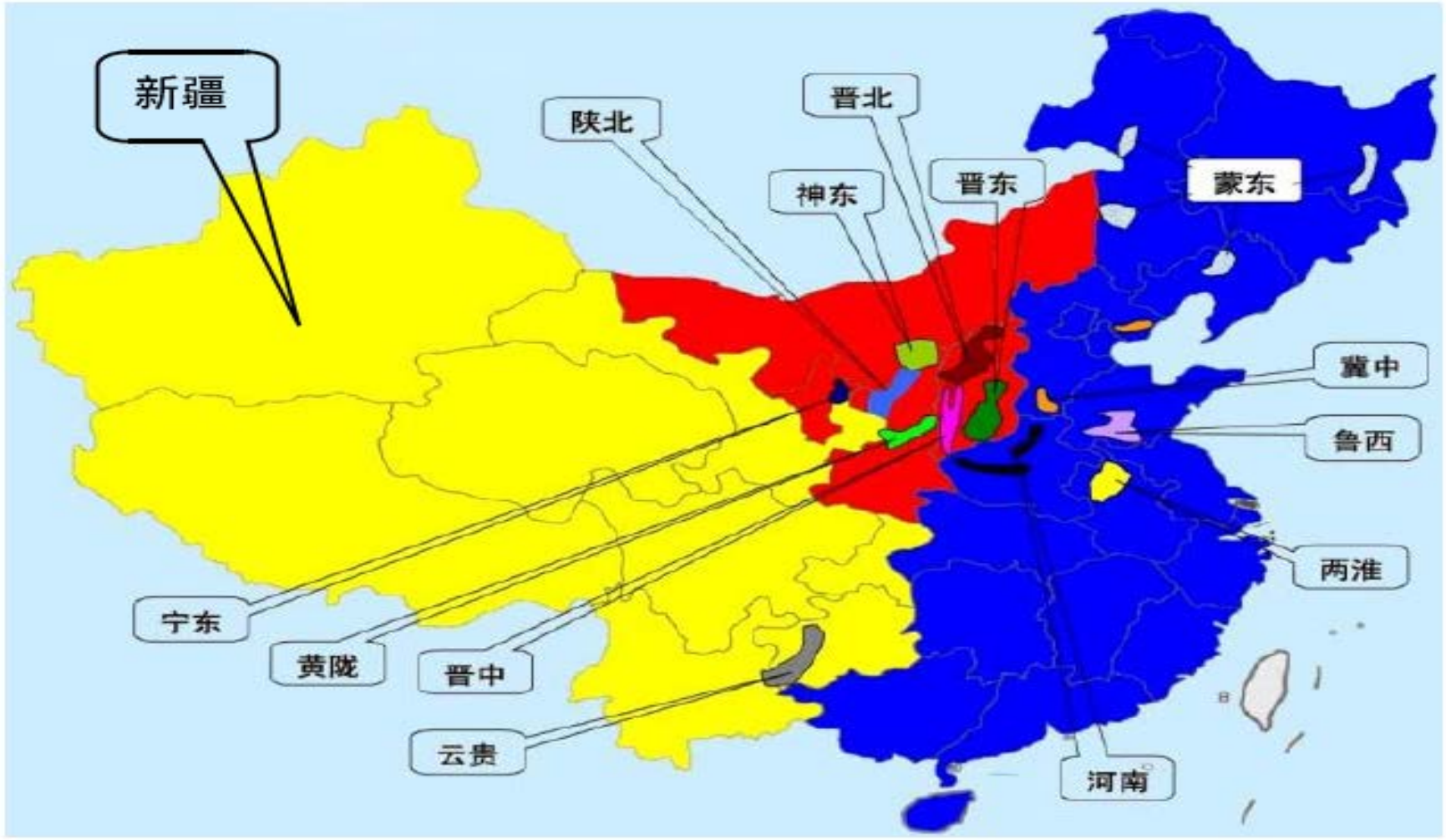
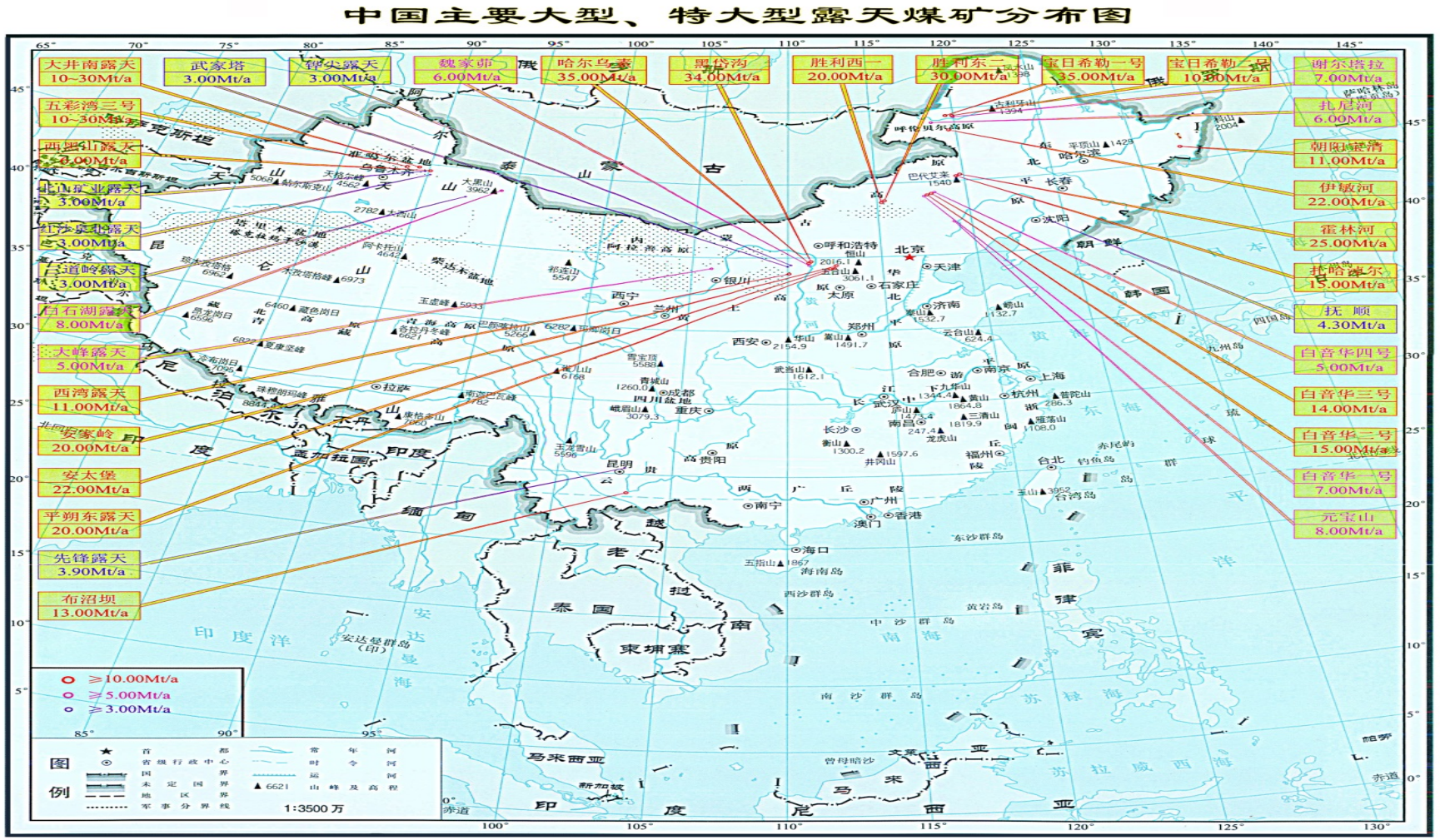
Funded by Basic Scientific Research of Central University

Distribution of Large-scale Coal Mining Bases Planned by Chinese Government

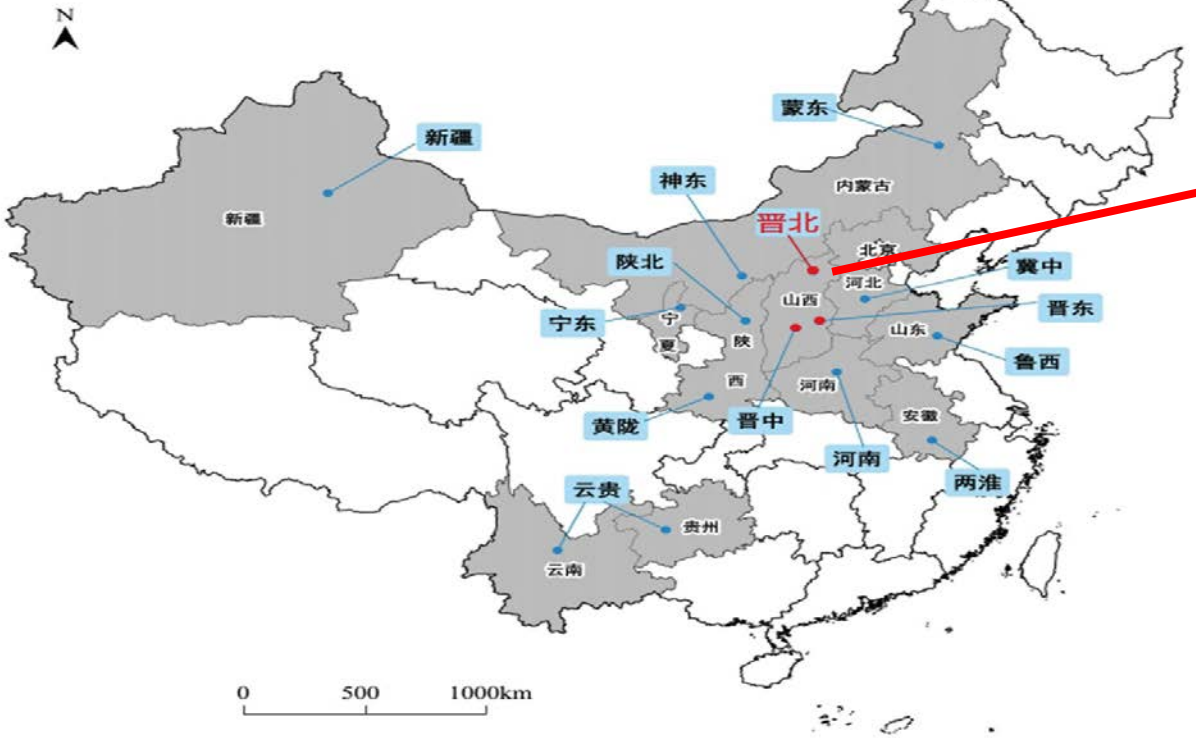


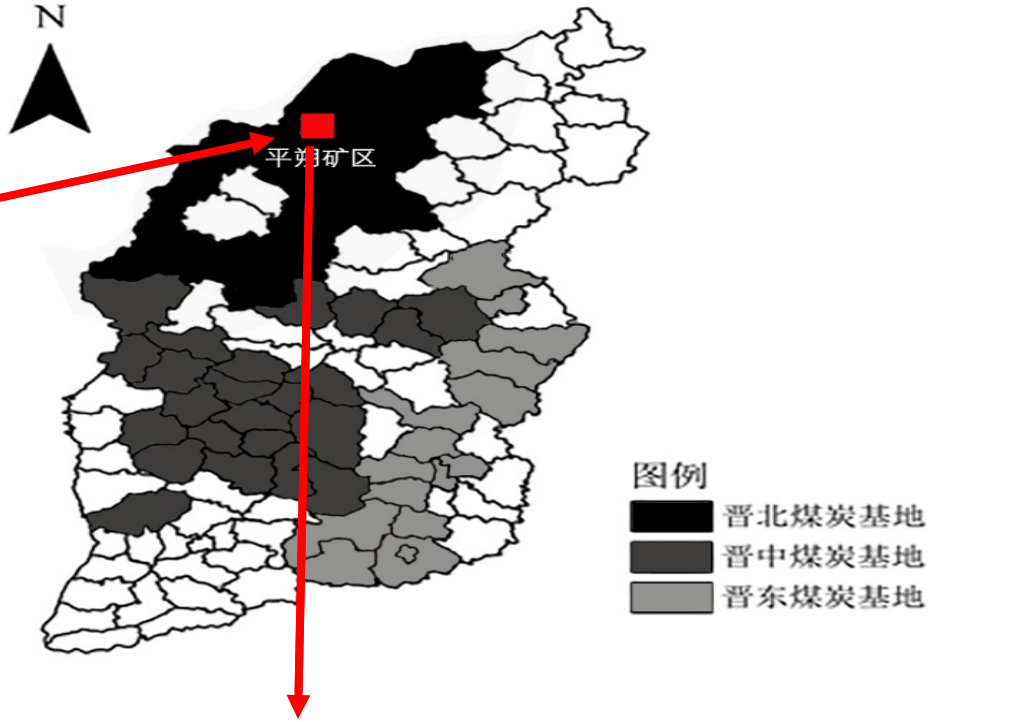
There are 14 coal mining bases in China, and most of them distribute in Inner Mongolia, Shanxi, Shann’xi, etc, where are ecological vulnerable regions in China.

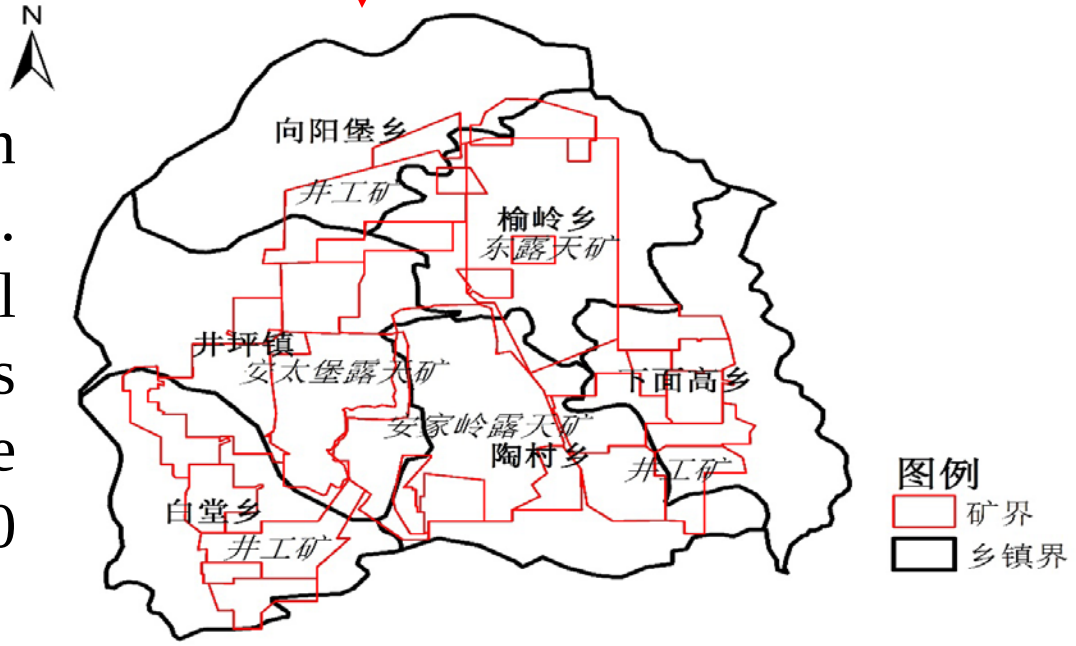
Distribution of Large-scale Opencast Coal Mines Planned by Chinese Government



Such as Heidaigou, Shengli, Baorixile, etc in Inner Mongolia, Antaibao, Anjialing, Donglutian in Shan xi. The coal production of each mine is more than 20 million ton per year.





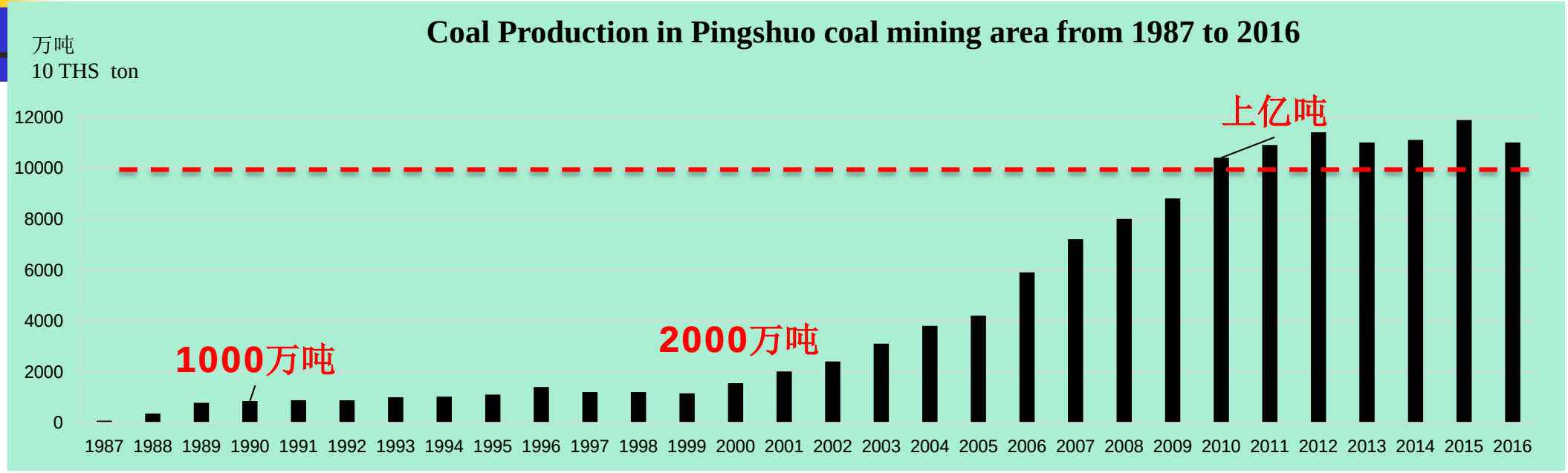


There are 14 coal bases in China, three of them are in Shanxi: Jinbei, Jinzhong and Jindong coal bases. Pingshuo is the major coal mining area in Jinbei coal base. Mining area has been 180 square kilometers since 1984. Area of 200 square kilometers will be disturbed in the future, which will impact 150 thousand people.

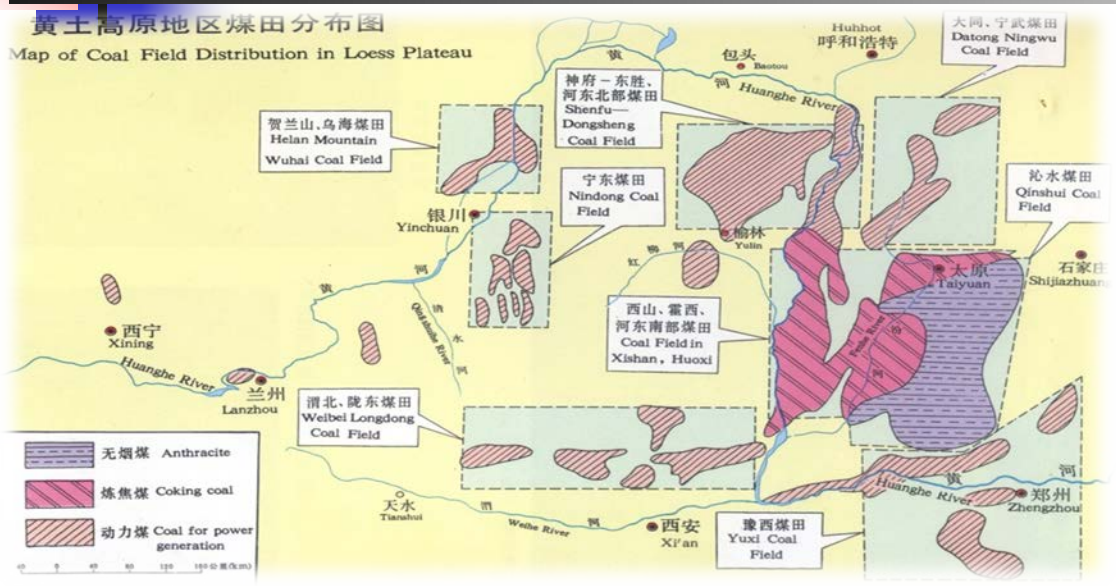
Development of Pingshuo coal mining area from 1984 to 2016 (point-line-area-net)

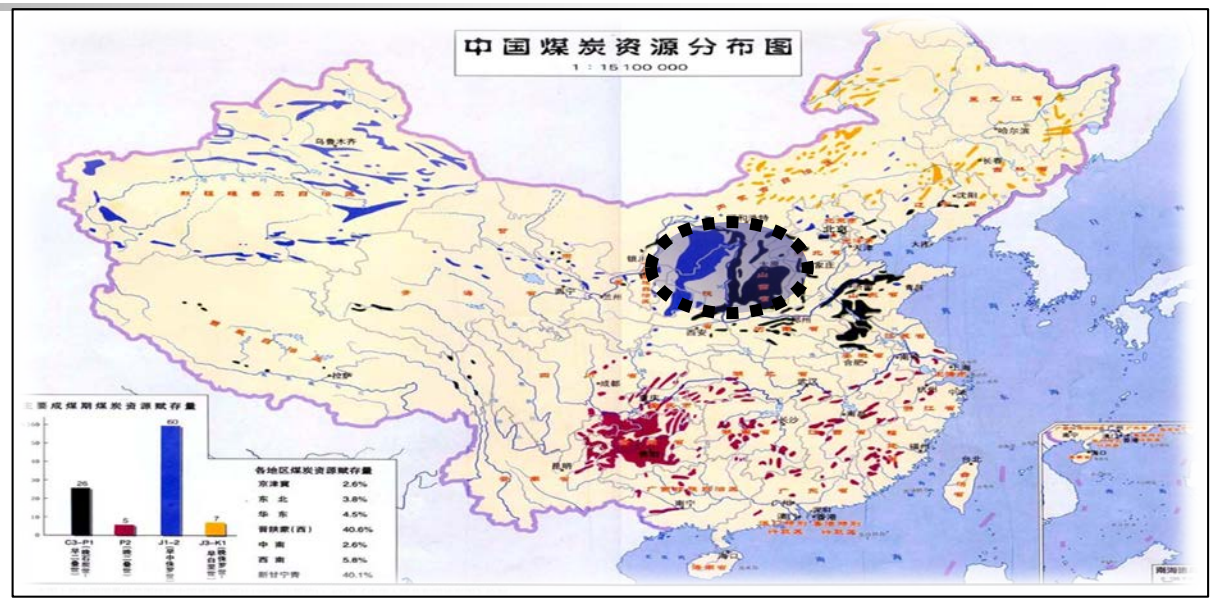
Xiaoping Deng and Armand Hammer

The first opencast coal mine in Pingshuo is Antaibao, which was constructed in 1984 by the cooperation between China and America after the Reform and Opening-up in China. It is a milestone for coal mining industry in China. The second opencast coal mine is Anjialing constructed in 1997, the third is Donglutian constructed in 2006. Besides, there are three large underground coal mines exploited after 2007. Currently, Pingshuo coal mining area is the largest one that combined opencast mines with underground mines in China. It is also the most modernized one with nearly one hundred years of life span and hundred million tons of production per year. The land and environment damage present the trend of point-line-area-net from 1984 to 2016.

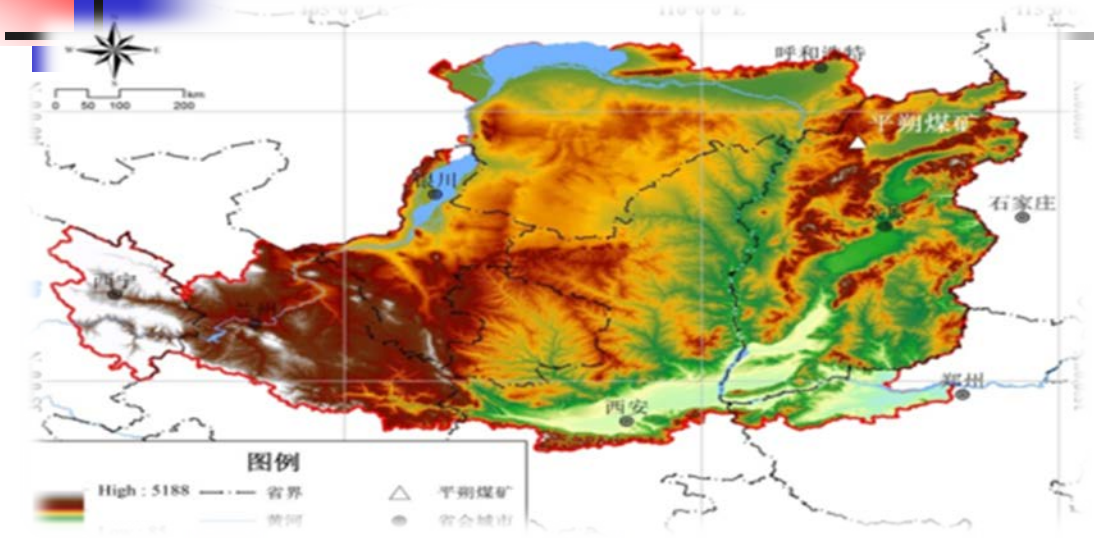


The coal production of Pingshuo coal mining area was 10 million ton in 1990, 20 million ton in 2000 and more than 100 million ton in 2010. 160 million ton of raw coal had been produced. At present, one-sixth of the coal production in Shanxi has contributed by Pingshuo coal mining area.

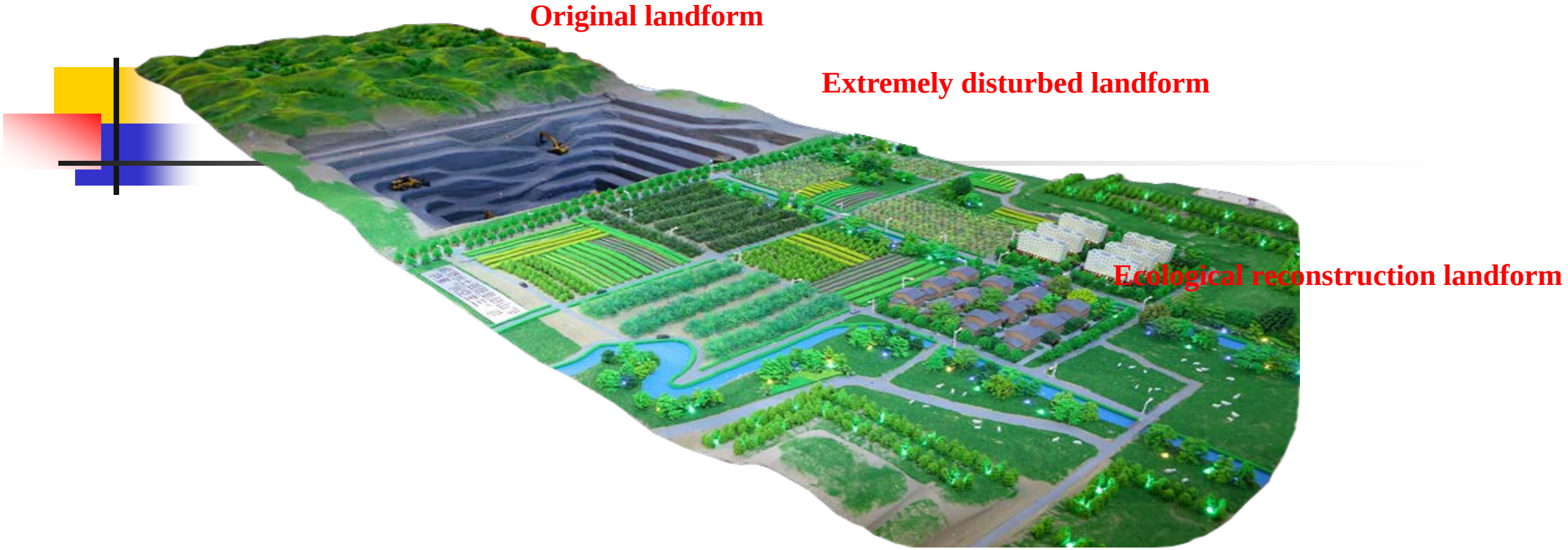




Pingshuo is located on the Loess Plateau. It is 640 thousand km^2 plateau and the area is less than one-fifteenth of the whole China. However, the proved raw coal reserves accounts for two-third of the whole China.



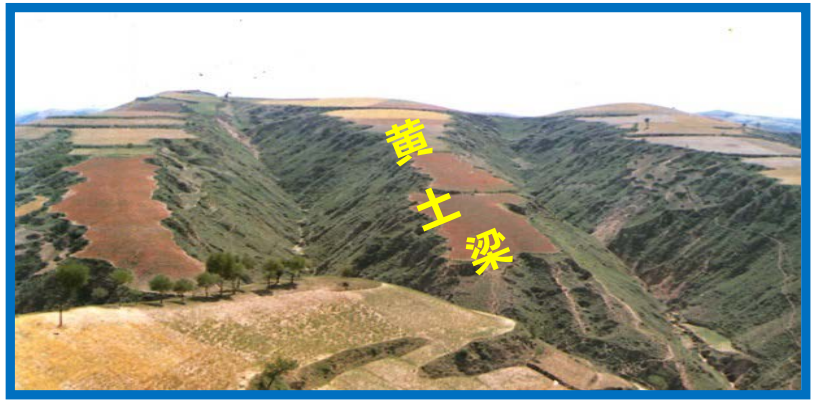
However, large scale coal mining in this area with such sever natural conditions (i.e. semi-arid climate, wind and water erosion, fragile ecological environment) may cause serious impact on the ecosystem. Meanwhile, some strict cultivated land protecting policies have been implemented in China, such as Balance of Cultivated Land Requisition and Compensation.



In the process of open-cast coal mining, the original landform and eco-system is strongly destructed, at the end, the new landform and eco-system is re-constructed. How are the landform, the soil, the vegetation and the living condition damaged? And how should we re-constructed these elements and eco-system?

Damaged Landform

Original landform



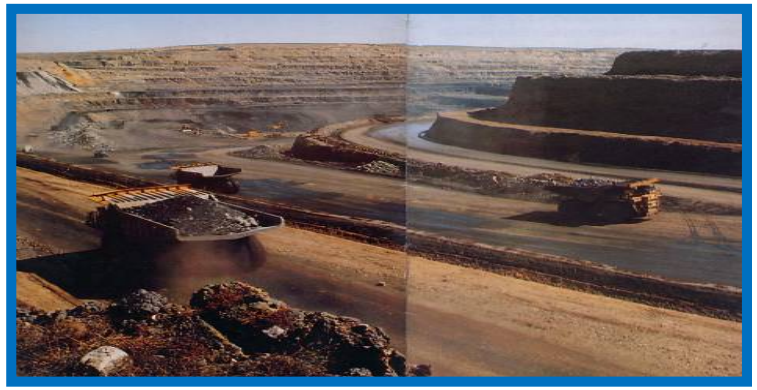
Damaged landform

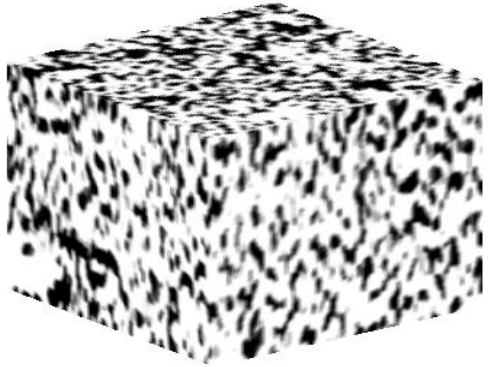
The original geological strata groups and landform disappear. During the past 30 years, original landform disappeared and artificial dumping sites were built in a 80km^2 area, and in the coming 60 years, 300km^2 original landform will disappear.

Damaged Soil

Original soil

Damaged soil





CT扫描
CT Scan

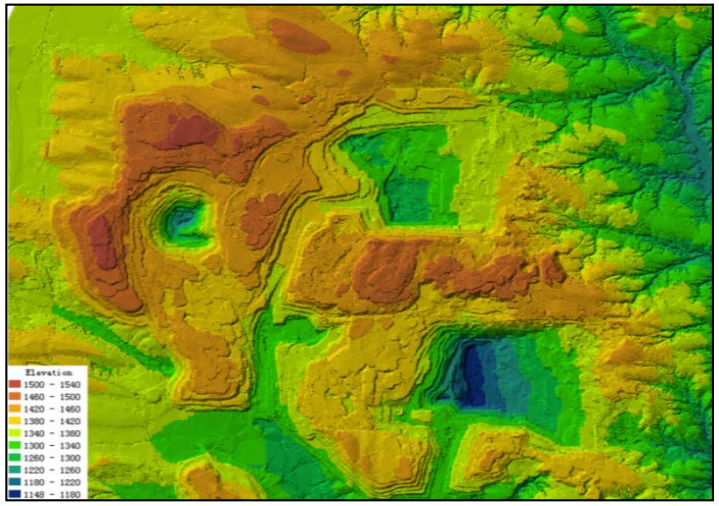
Soil damage include direct excavation, machine compaction and artificial displacement.

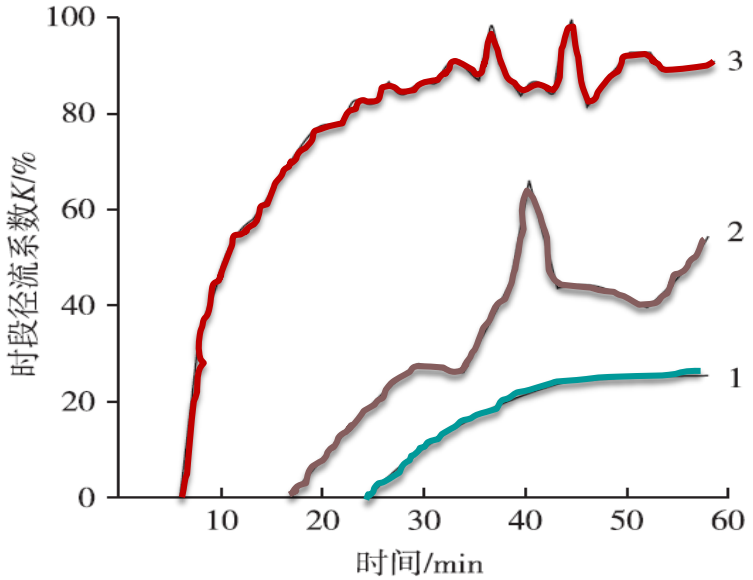
Especially, the off-road large trucks cause severe soil compaction, and the soil bulk density can be up to 1.7g/cm3-2.0g/cm3.

Damaged Vegetation and Reduced Biodiversity

During the past 30 years, 60 original species disappeared, and 98 species were planted. Over 20 pioneer and adaptive species were selected. Other 30 species degraded due to extreme weather conditions, spontaneous combustion or competition of species.

Ecosystem Functions Damaged





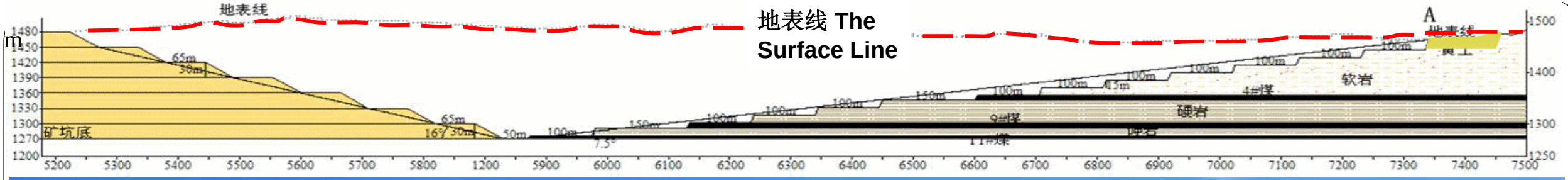
Newly built land

Original farmland

Original unused land

0.8 mm/min降雨强度下的径流变化过程
Changing process of runoff under 0.8 mm/min rainfall intensity

The soil erosion modulus of newly built land (dump site) raises from 5000t/km^2*a to 15000 t/km^2*a. Run off appears in 7min under intensive rainfall intensity, which is 10min earlier than original farmland and 18min earlier than original unused land.



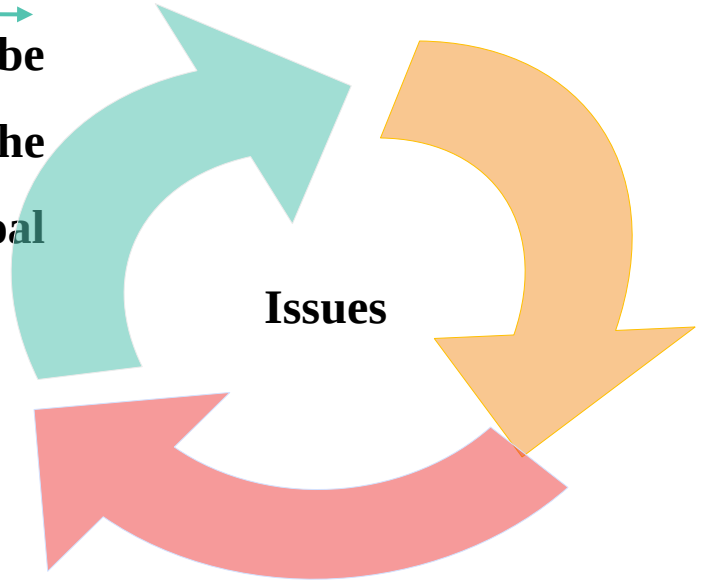
The Moving Pit

A coal pit with width of 200m and length of 2km was pushing forward 400m each year. There are three coal pits in Pingshuo coal mining area. All villages, schools and factories moved four times in 30 years, involving 16,000 people from 21 villages. The moving seemed to solve the problem that mining caused, but problems of production, living and ecology begin to appear gradually.

Scientific Issue

Issue 1

How much will the ecosystem be damaged and degraded under the disturbance of large-scale opencast coal mine?



Issue 2

What direction and how fast will developed ecological restoration technology promote ecosystem succession in mining area?

Issue 3

How is the resilience of the restored ecosystem under the extreme conditions? Whether it would be more resilience than the original ecosystem?

主要创新点 Main Innovation Point

创新点一

Innovation Point 1

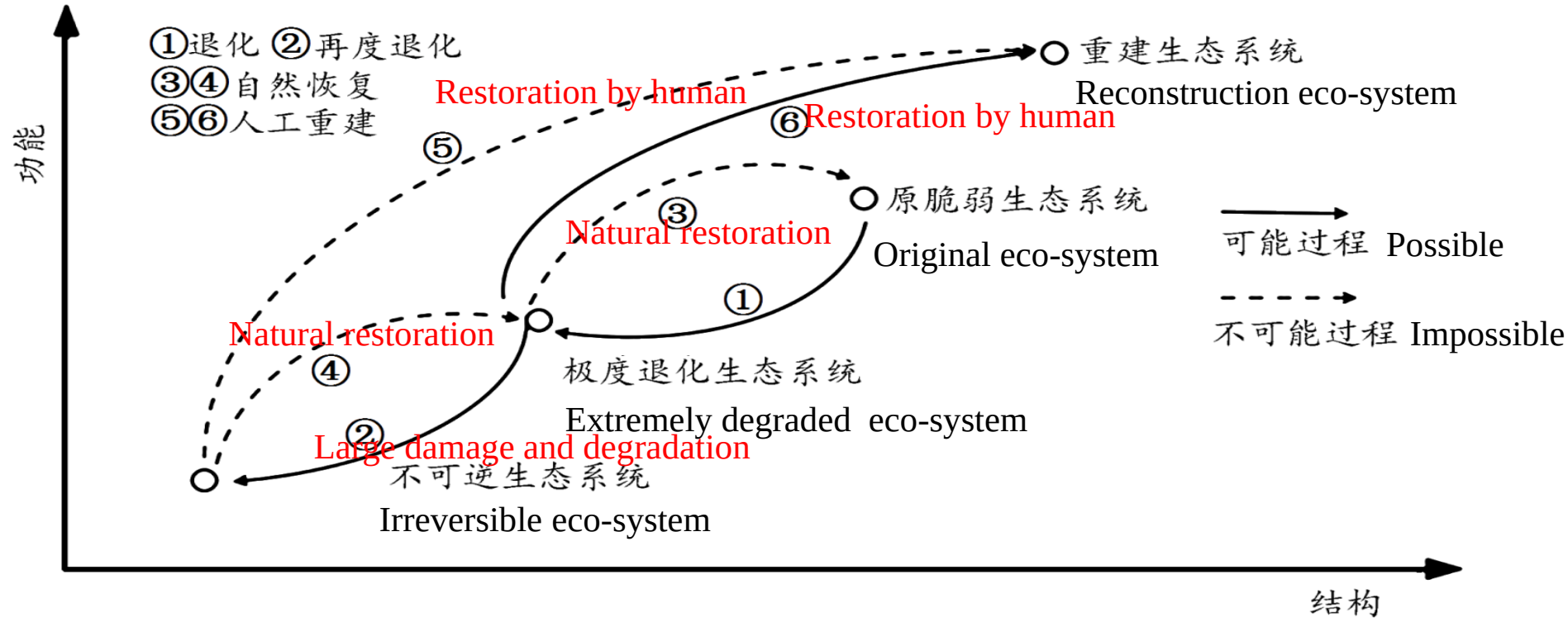
Proposed and verified the Five-Stage Theory of land reclamation and ecological restoration in severely damaged loess coal mining area

主要创新点 Main Innovation Point

创新点一

Innovation Point 1

1.1 Revealed ecosystem evolvement rule in large-scale coal mine area of loess plateau

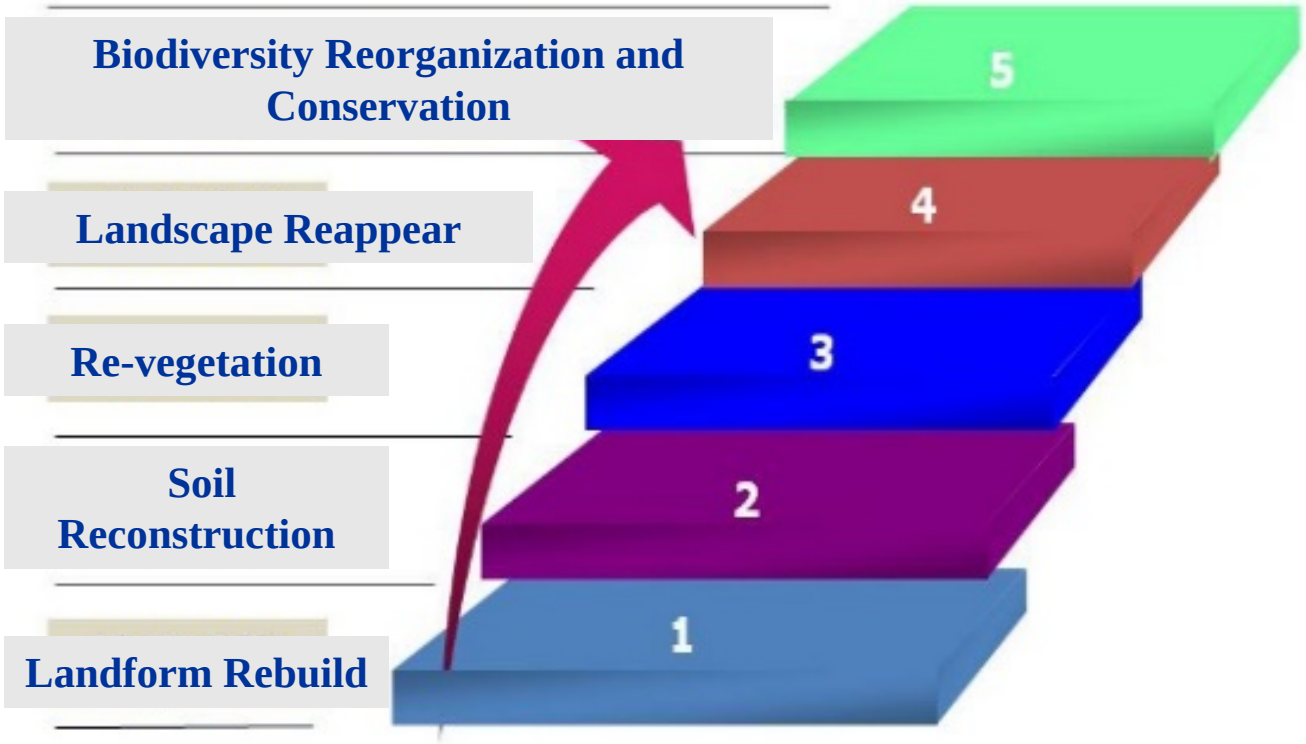


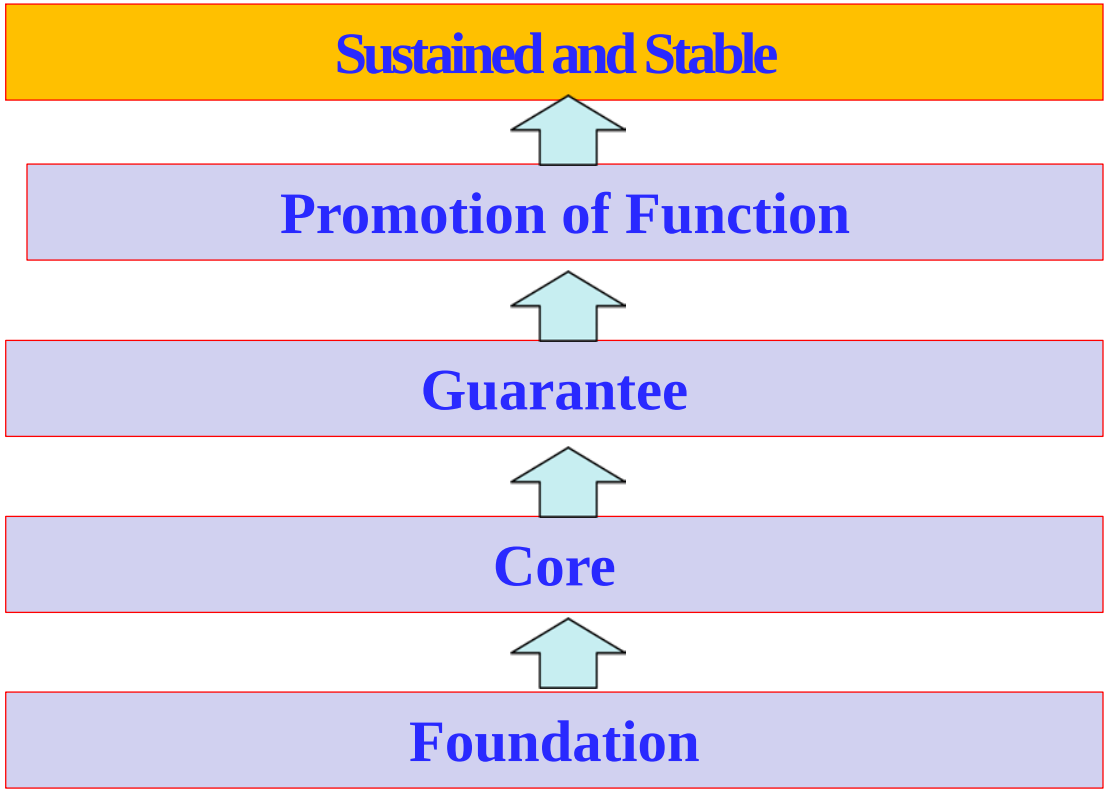
主要创新点 Main Innovation Point

创新点一

Innovation Point 1

1.2 proposed the five-stage theory of land reclamation and ecological restoration in mining area





主要创新点 Main Innovation Point

创新点二

Innovation Point 2

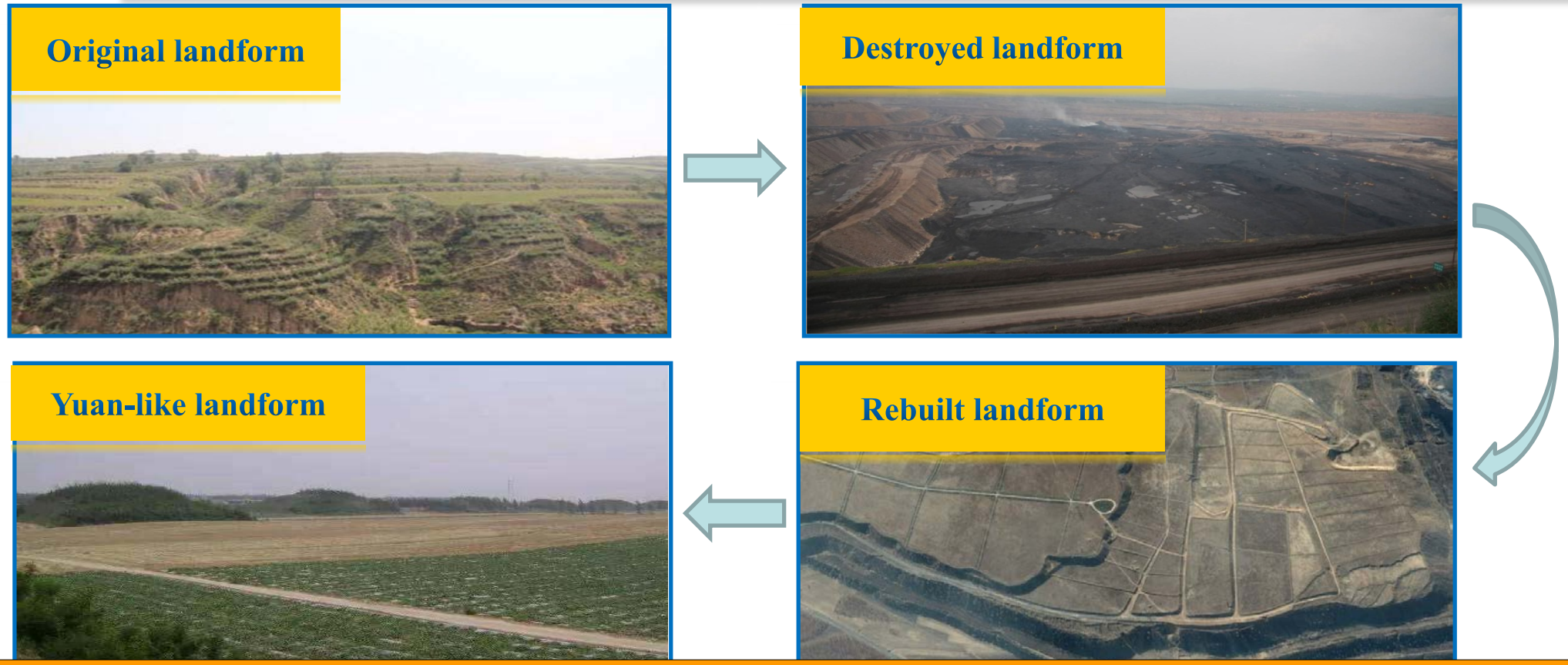
Researched technology of landform rebuilding and soil reconstruction in large-scale coal mine on Loess Plateau

主要创新点 Main Innovation Point

创新点二

Innovation Point 2

2.1 Technology of landform rebuilt combining platform and slope based on nature imitation theory



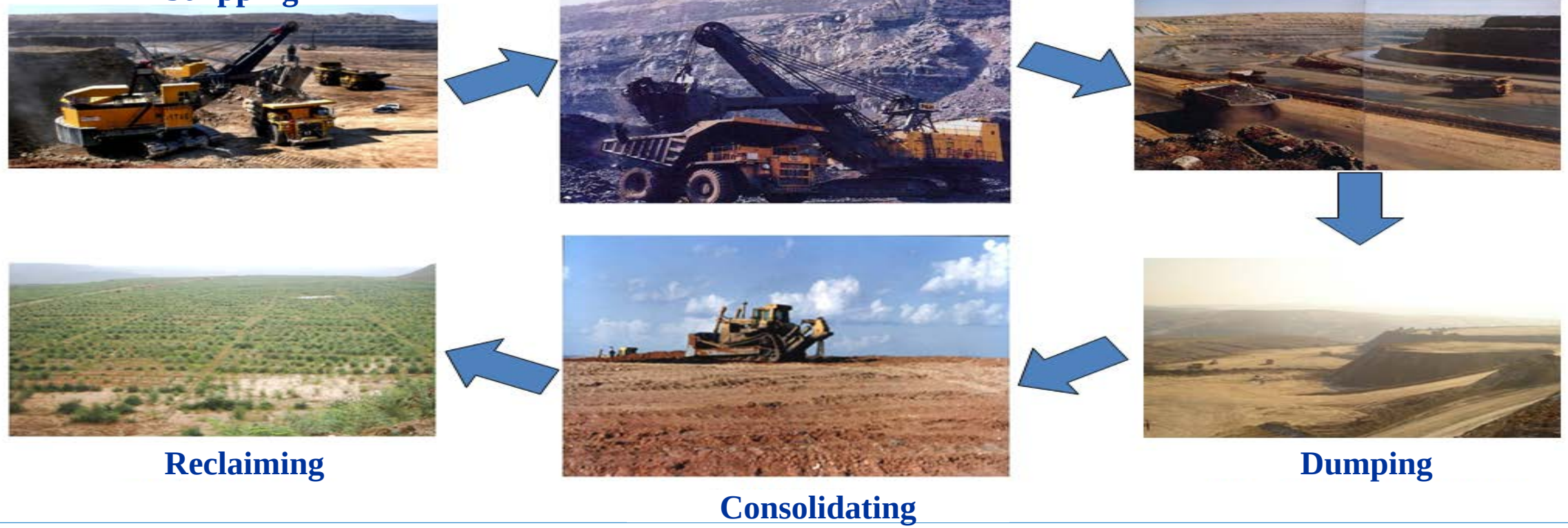
Reconstruction of ‘Yuan’-like landform, each cultivated plot is from 0.20 to 0.67km^2, and 10-30 times larger than the original plot.

主要创新点 Main Innovation Point

创新点二

Innovation Point 2

2.2 Land saving technology base on integrity of 'stripping-mining-transporting-dumping-reconsolidating-reclaming'



Land use rate increased to 70%-90%

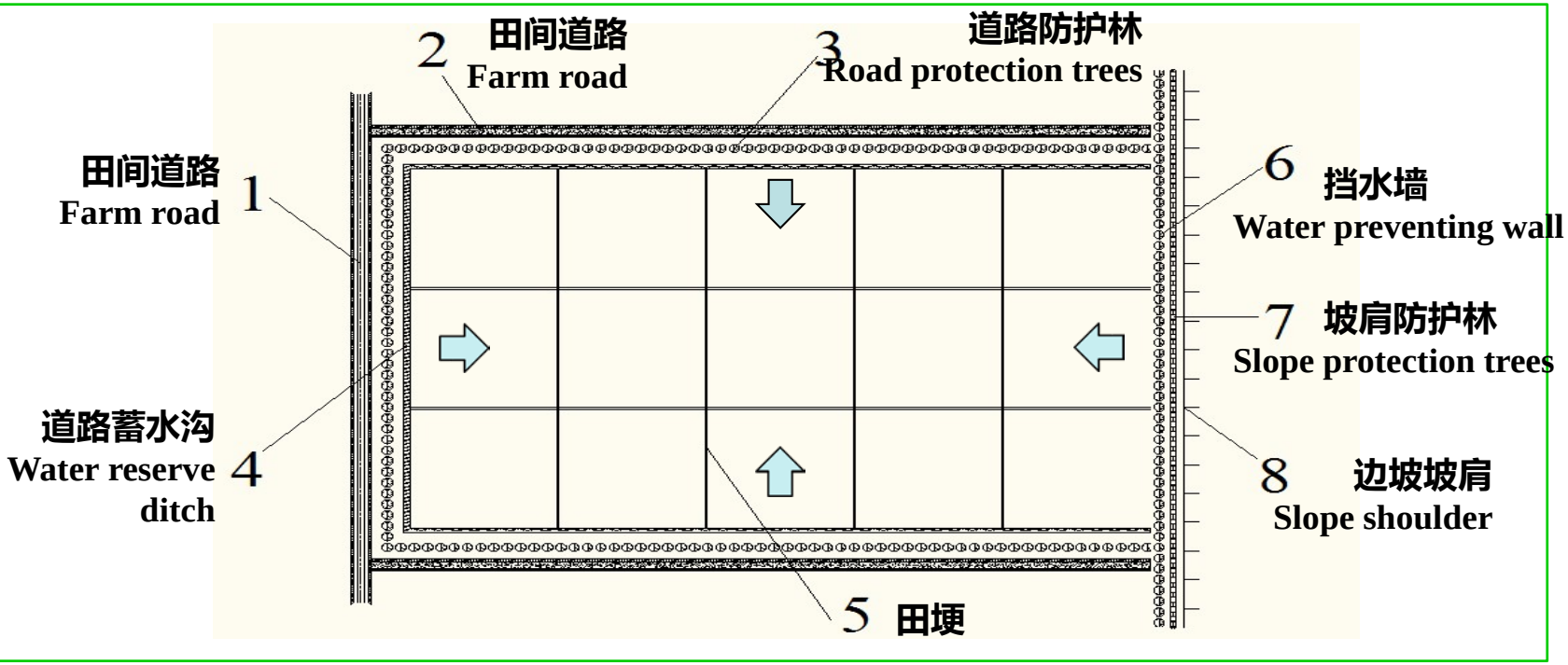
主要创新点 Main Innovation Point

创新点二

Innovation Point 2

2.3 Technology of reshaping micro landform to control erosion and promote water use efficiency

Scattering the run-off
Reserving water instead of draining



The annual soil erosion modulus is less than 1000 tons/km^2, 5-8 times less than that of the original land.

主要创新点 Main Innovation Point

创新点二

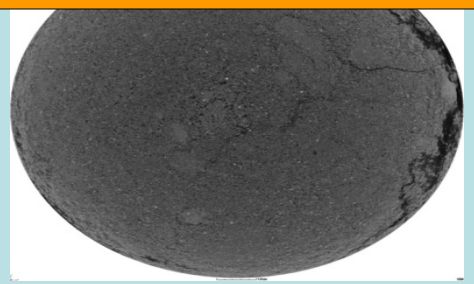
Innovation Point 2

2.4 Innovation of soil reconstruction and regulation for quantitative characterization (using CT scanning)

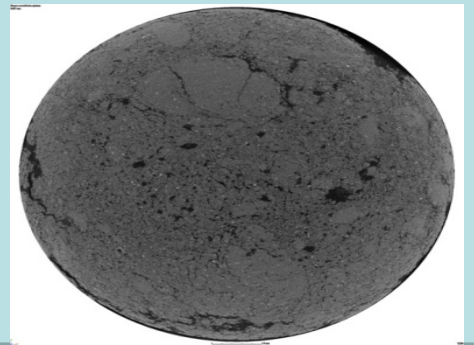
Original land

Enrichment of methods to test physical properties of highly compacted soil

After dumping



After 30 years reclamation

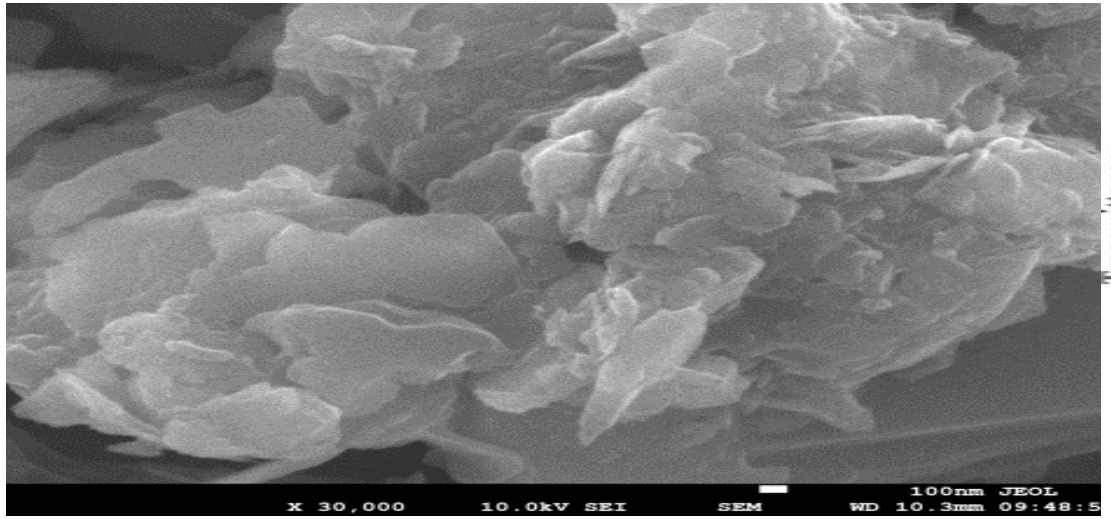


主要创新点 Main Innovation Point

创新点二

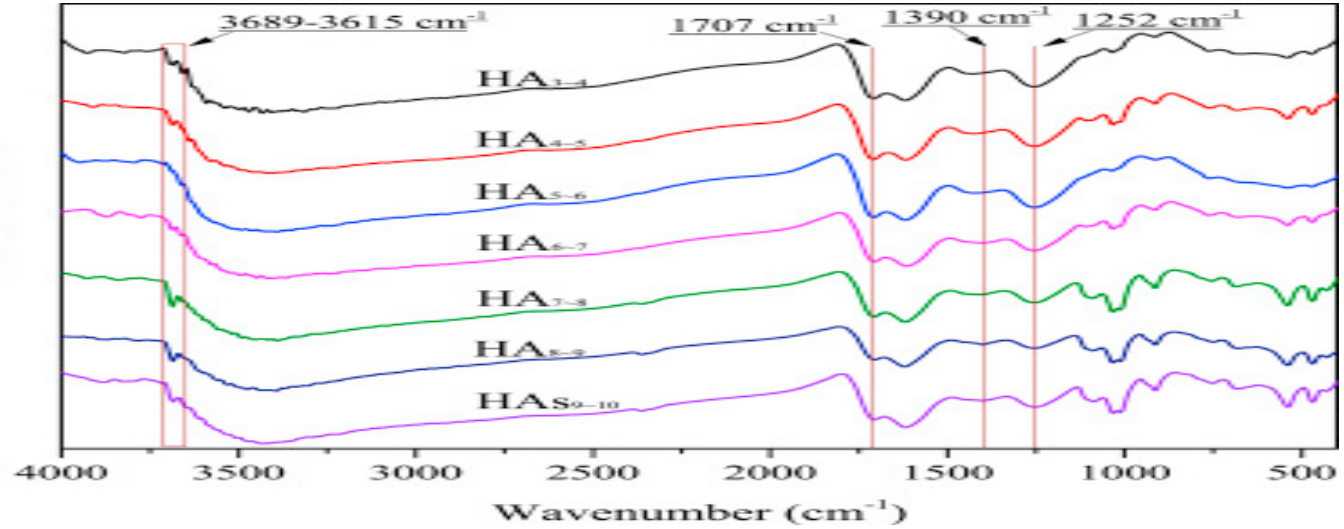
Innovation Point 2

2.5 Invention of using weathered coal to ameliorate artificial soil of coal mine in loess area



风化煤电镜图

Electron micrographs of weathered coal



风化煤腐殖酸FTIR光谱

FTIR spectrum of humic acid in weathered coal

Yield of reclaimed land increased by 10%-40% with no pollution

主要创新点 Main Innovation Point

创新点三

Innovation Point 3

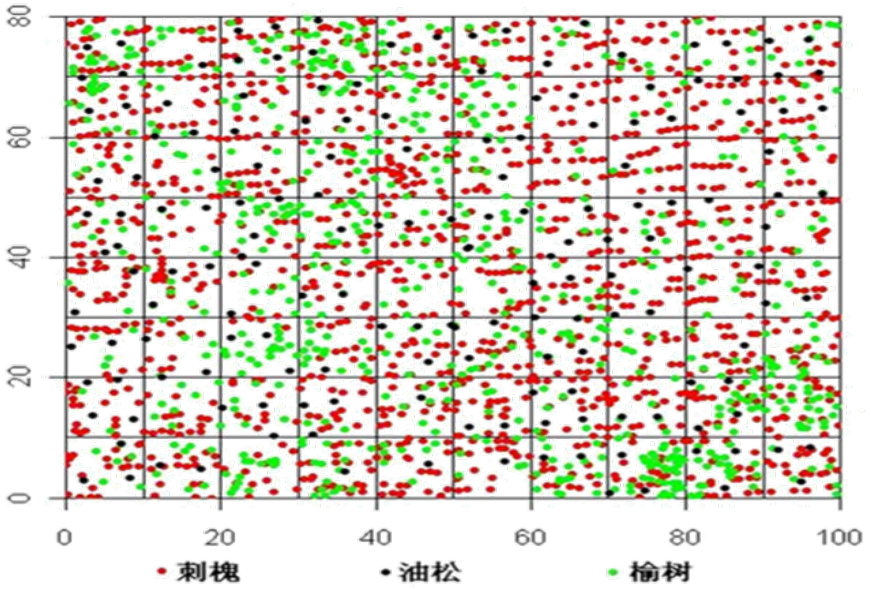
Researched technology of vegetation regeneration and ecological diversity reconstruction in large-scale coal mine on Loess Plateau

主要创新点 Main Innovation Point

创新点三

Innovation Point 3

3.1 100m*100m Perpetual Monitor Plot



Long-term and located observations based on sampling from point- quadrat- area- belt transect

主要创新点 Main Innovation Point

创新点三

Innovation Point 3

3.2 Screened Pioneer and Adaptive Species for Loess Coal Mining Area

10 Pioneer Species and 20 Adaptive Species

主要创新点 Main Innovation Point

创新点三

Innovation Point 3

3.3 Breaking the Tradition of Using Grass as the Pioneer Plants for Opencast Reclamation.

Vegetation cover increases more than 60, which is 50% higher than that of original land. Water conservation function has been improved greatly.

主要创新点

创新点四

Innovation point 4

Constructed optimizing technologies of spatial landscape pattern in compound area of mine-rural-urban

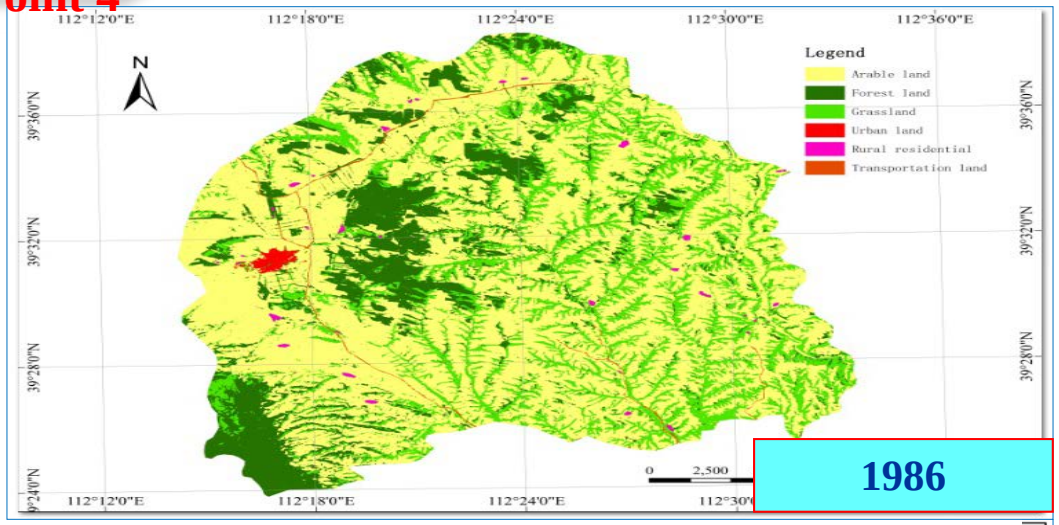
主要创新点

4.1 Monitoring Land Use and Environmental Effect During 30 years

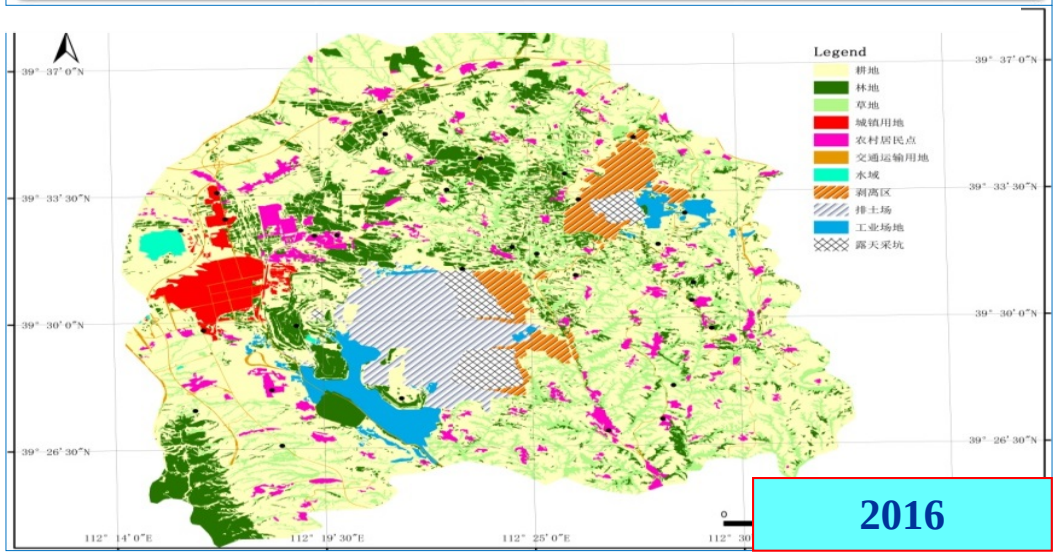
创新点四

Innovation Point 4

Land use changing maps

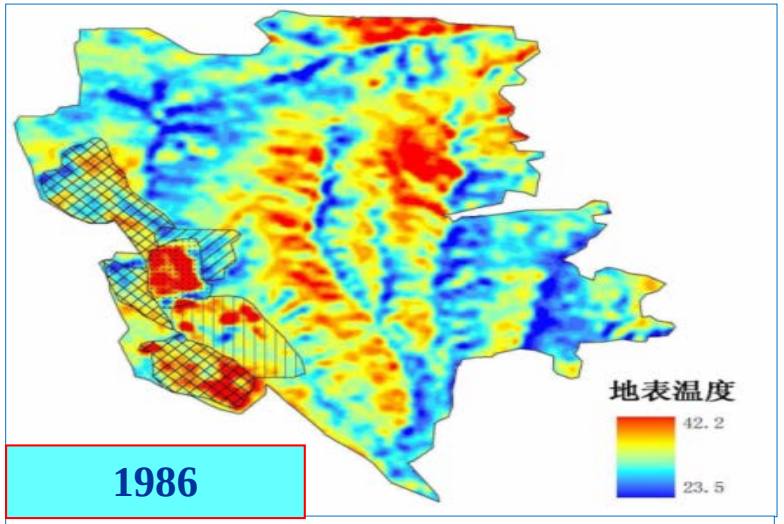


1986



2016

Temperature changing maps



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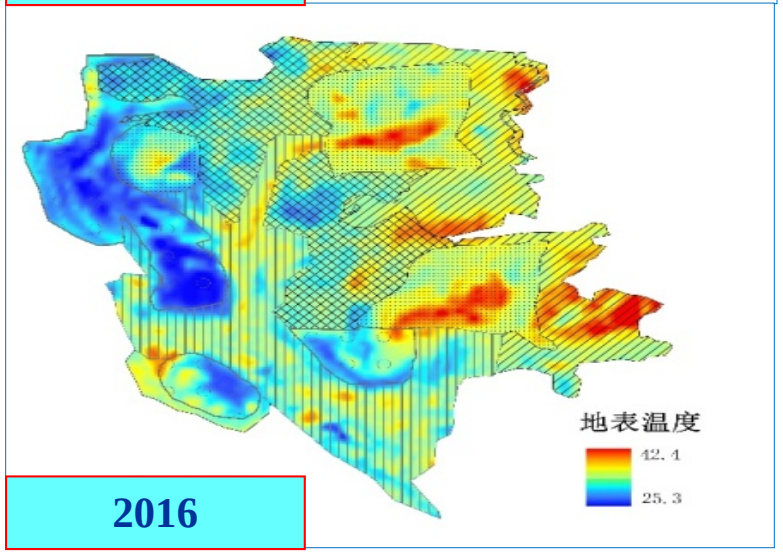


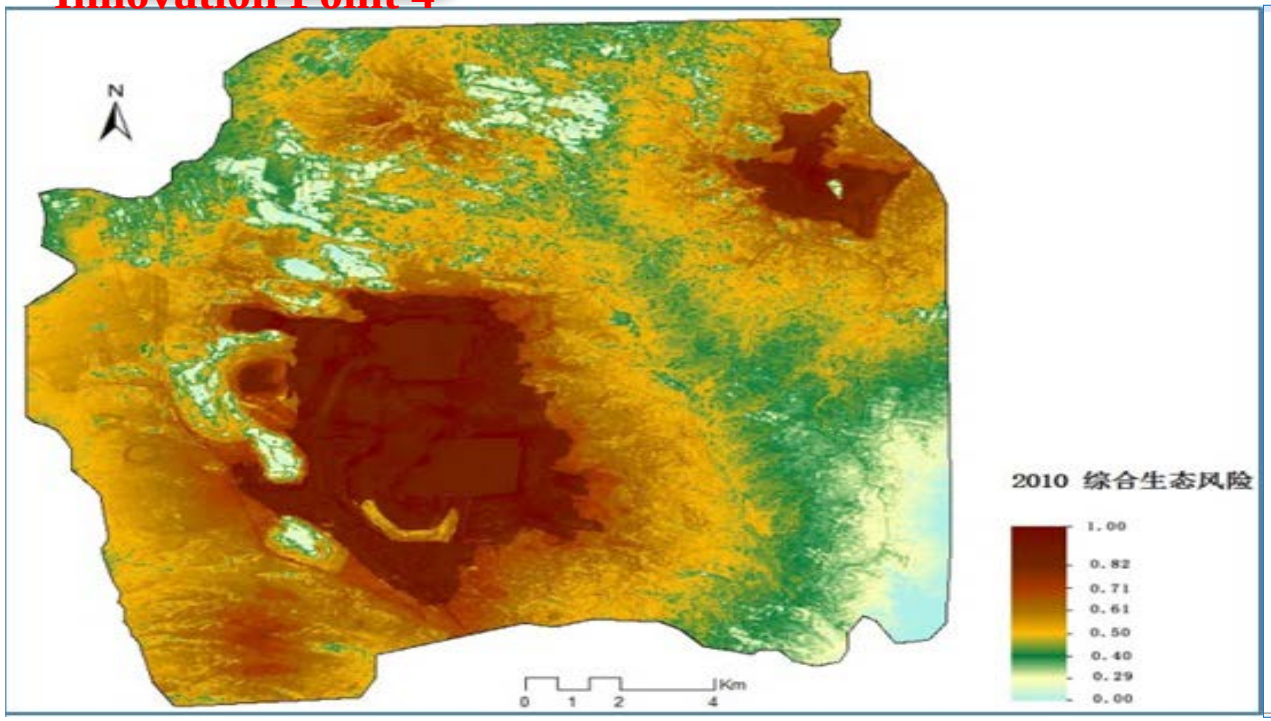
2016

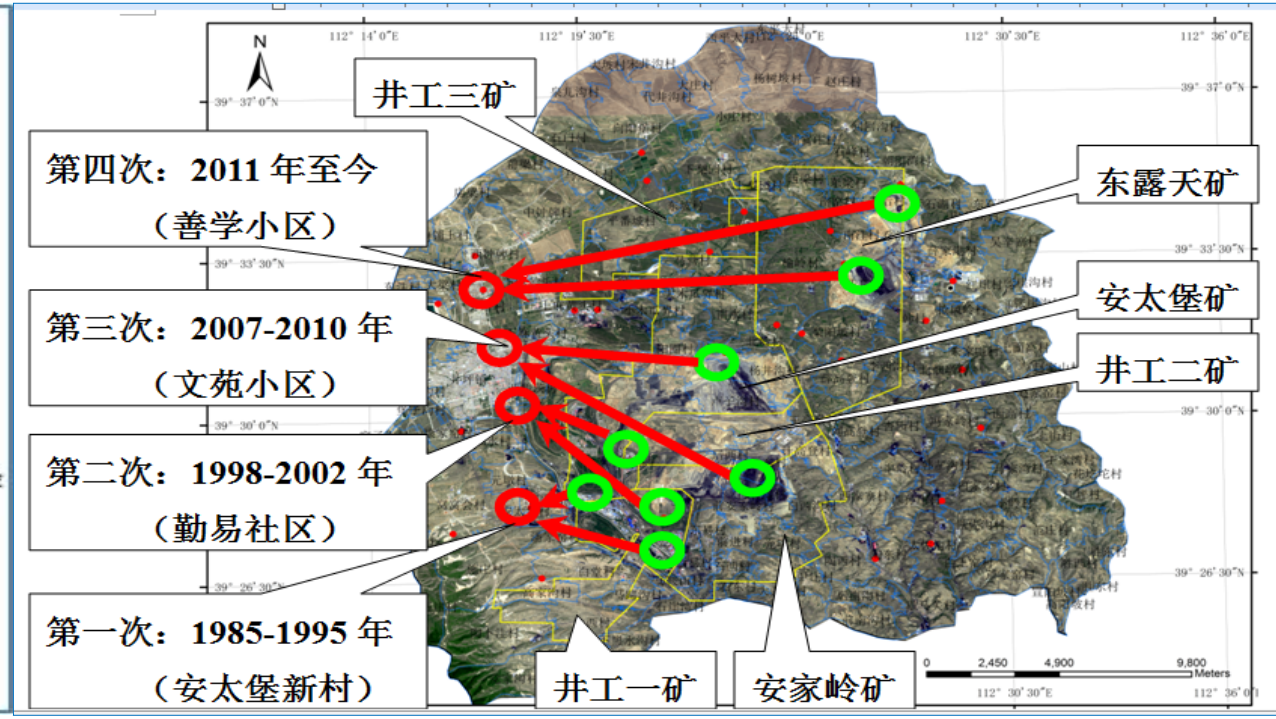
主要创新点

4.2 Technologies of Spatial Reconstruction and Ecological Risk Controlling

创新点四

Innovation Point 4





生态风险分布 Distribution of ecological risk

村庄搬迁方案 Planning of village moving

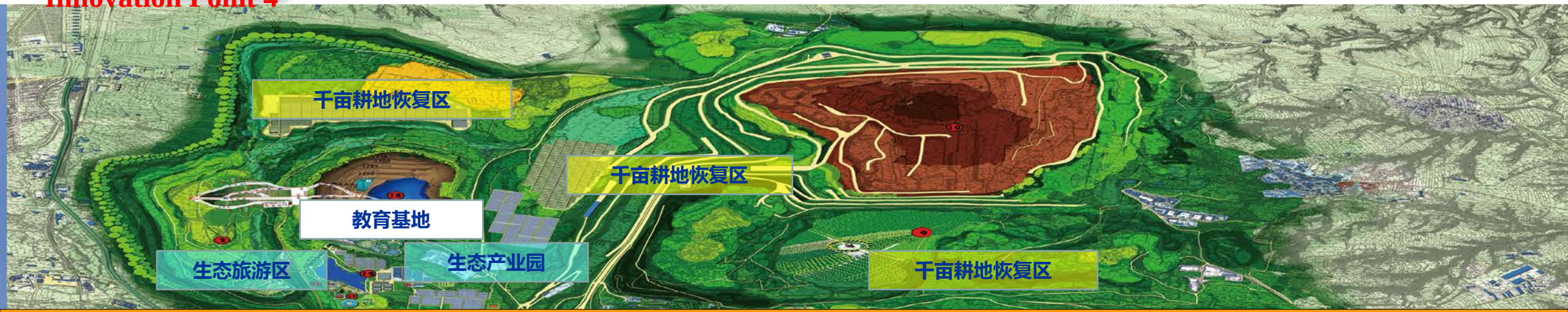
Ecological risk increased by 50% after mining, and it decreased by 70% after land reclamation and restoration

主要创新点

4.3 Constructing green ecological industrial chain and optimizing landscape pattern in compound area of mine-rural-urban

创新点四

Innovation Point 4



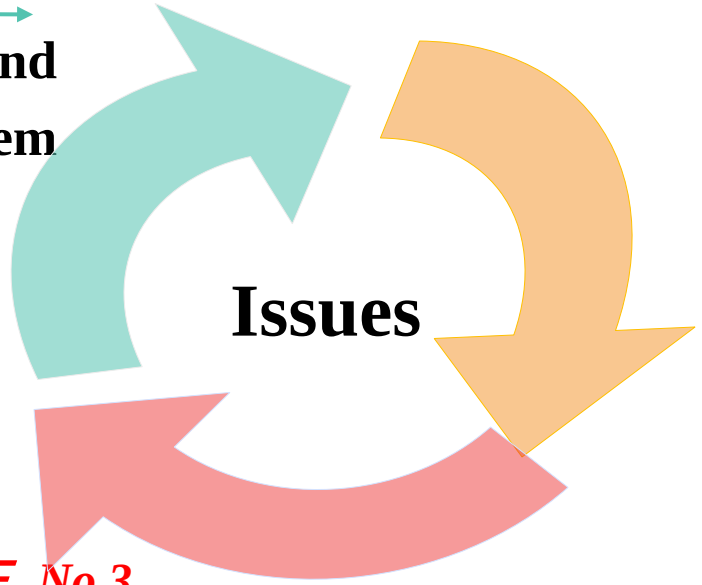
Reclaimed land is up to 3000 ha, and the reclamation ratio is up to 90%

Publications and appraisal from international experts

实践上回答了 **We have answered**

答案一 No.1

The extent of damage and degradation of ecological system under severe disturbance.



答案二 No.2

The reversing speed of damaged eco-system by the application of key technologies.

答案三 No.3

The intensity of defensing natural disaster under extreme climate conditions.

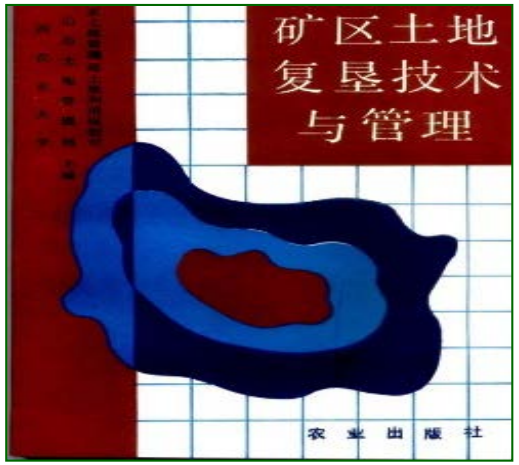
Publications and appraisal from international experts

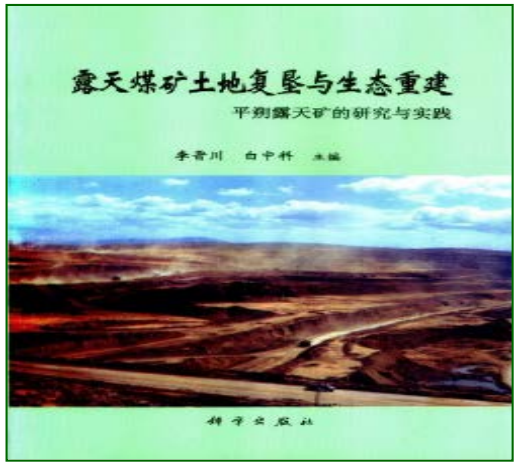
Papers with important impact in land reclamation and ecological restoration

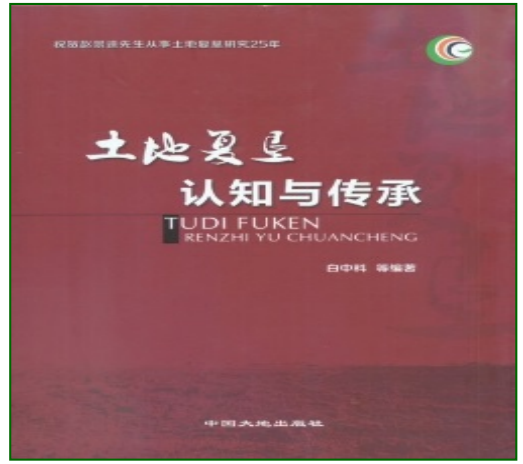
More than 200 papers were published on Ecological Engineering, CATENA, Transactions of the Chinese Society of Agricultural Engineering, etc, and there were 38 papers indexed by Science Index, 40 papers indexed by Engineering Index. These papers were referred more than 200 times by SCI/SSCI, and more than 2000 times by EI/CSCD/CSSCI.

Publications and appraisal from international experts

Series books published with high academic impact

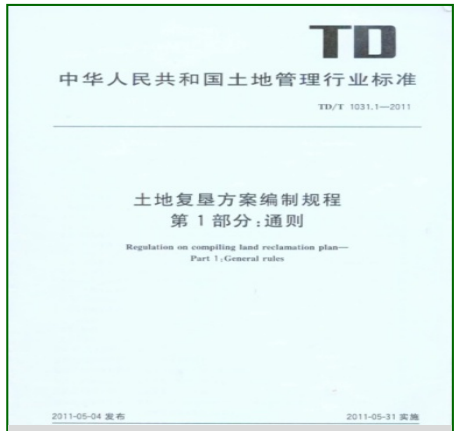






Applications and social-economic benefits

6 industry regulations and 1 enterprise regulation



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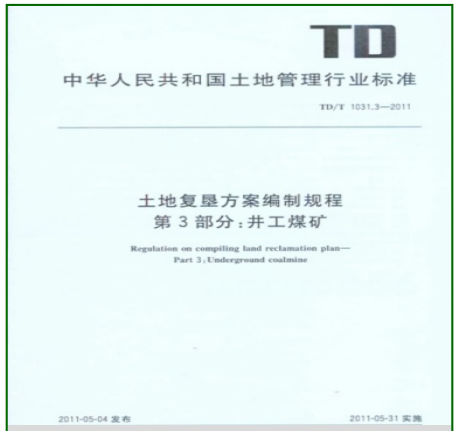
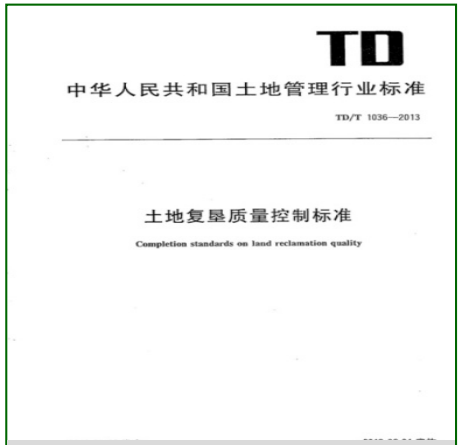


TD/T 1031.3-2011



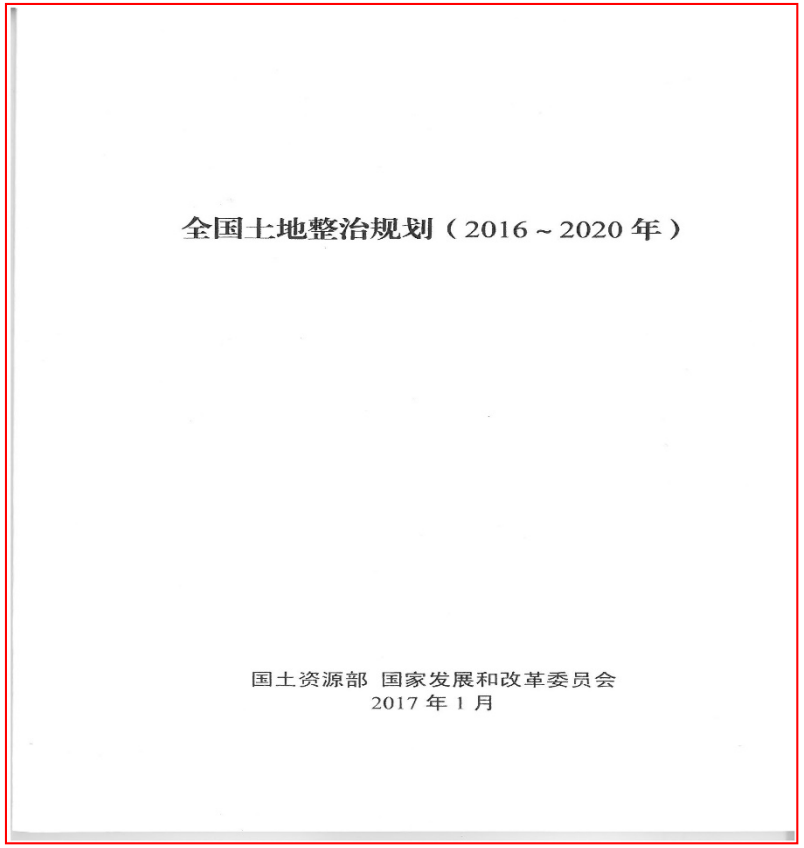
TD/T 1036-2013

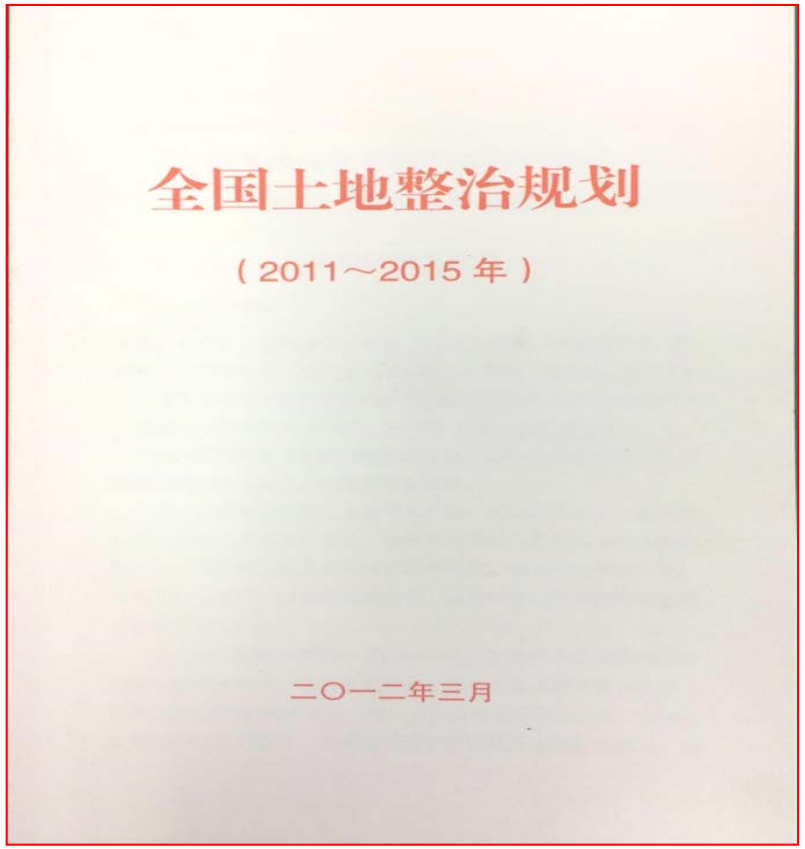
TD/T 1044-2014

It is effective for pushing ecological restoration engineering in different mines, and it is the important guide for the integration of land reclamation planning and geological environment restoration planning in mines.

Contributions to land reclamation

- **Become reference and supporting documents for related laws and regulations (i.e. *Regulation on Land Reclamation*)**





Applications and social-economic benefits

2017年8月12日 央视新闻直播间、东方时空进行相关报道 Achievement on the news on Aug 12th,2017

山西朔州·绿色发展、绿色生活、让绿水青山成为金山银山 Green development in Shuozhou, Shanxi

- Exploring the method of “Theory-Technology-Demostration-Standard-Regulation-Application” in 30 years.
- The reclaimed land stands the tests of 9 droughts, 3 floods, 2 fires and 4 plagues of insects in 30 years.
- The method provides experience for local construction of green mining of ecological fragile area, and industrial transformation of resource based cities in 30 years.

Key Technology of Land Reclamation and Ecological Restoration in Large-scale Coal Mining Area on Loess Plateau During 30 years

Thank you very much.
Welcome to China University of Geosciences and Pingshuo of China Coal.

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