Chapter 4

Natural Resources

Mineral Resources

The research region is located at the southern end of the N-S Tectonic Zone which is well-known for its geological structures in the context of the tectonic and magmatic movements to which the area has been subjected. The geological study shows that a paleo-rift zone occurred in the region from the Paleozoic era to the Triassic period. The tectonic evolution of the paleo-rift provided favourable conditions for the formation of various metallic mineral deposits of magmatic origin (Lu Binguang et al. 1988) (Figure 11). Therefore, the region is one of the main bases for mineral resources in southwestern China. The principal types of mineral deposit discovered in the region are iron, copper, lead, zinc, nickel, tin, gold, and rare earth elements.

Iron Deposits

Iron deposits are among the richest deposits in the region. The main type of iron deposit is associated with vanado-titano-magnetite. The mines (Plate 6) are distributed along the deep-seated Anninghe Fault belt. The largest vanado-titano-magnetite mine now being exploited is located near the Panzhihua Metallurgic Company.

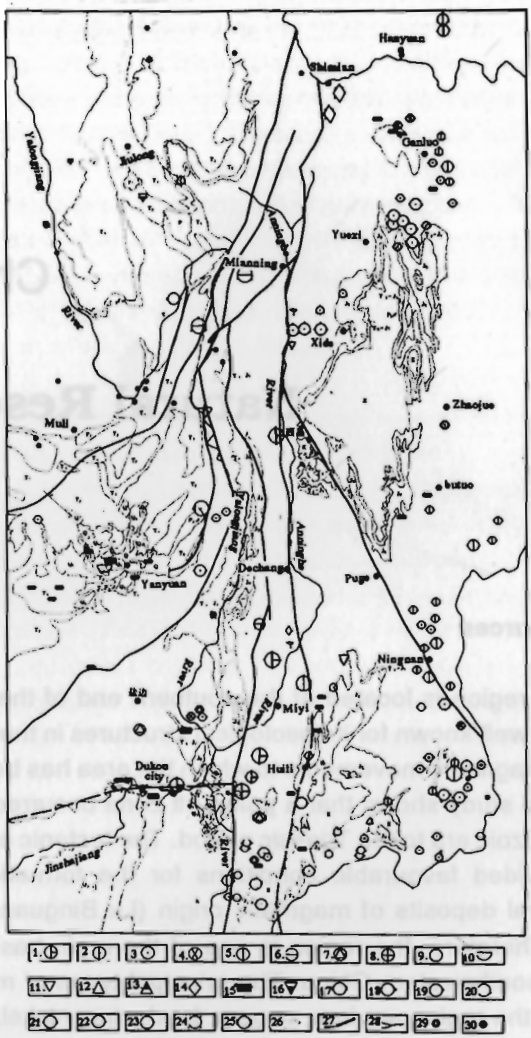

Fig. 11: Distribution of Mineral Resources in Panxi Region (after Lu Binguang et al., 1988)

1. Vanadic titano-magnetic deposit 2. Manganese-cobalt deposit 3. Iron, containing iron ore deposit 4. Bauxite deposit 5. Lead-zinc deposit 6. Rare earth element deposit 7. Copper-nickel deposit 8. Gold deposit 9. Copper deposit 10. Halite salt deposit 11. Tin deposit 12. Sulpho-iron deposit 13. Tungsten deposit 14. Asbestos deposit 15. Coal deposit 16. Beryllium deposit 17. Sedimentary type 18. Sedimentary and metamorphic type 19. Volcanic rock type 20. Hydro- thermal type 21. Silica rock type 22. Eluvial type 23. Magma condensation type 24. Sandstone silt type 25. Magma differential condensation type 26. Sedimentary strata 27. Regional fault 28. River 29. County town 30. City

The ore-containing body is a basic and ultrabasic complex composed of gabbro-diorite. The ore deposit formation is considered to be a late differentiation of magma. The ore-containing body intruded into the Denying limestone of the Sinian system in monoclinal layers and beds. The ore layers or lenses are 50 to 100m thick, and the main mineral composition of the ore is titano-magnetite with 25 to 30 per cent of iron. The associated elements are titanium, vanadium, chromium, cobalt, nickel, copper, manganese, sulphur, and platinum. Resources such as vanadic oxide, titanic oxide, and metallic cobalt were perhaps explored first of all here. There are large-scale deposits of metallic nickel, copper, and chromium oxide.

In addition to vanado-titano-magnetite, there is a large number of iron deposits of other origins, such as hydro-thermal and contact metamorphism. The iron mines of Tiekuangshan and Lugu are located on the outer contact between the granite massive and the Precambrian metamorphic strata. The ore is mainly composed of magnetite with rich iron content. The ore body is associated with veins of metallic sulphide which mainly consist of tin ore. The content of the latter reaches 0.579 to 0.7 per cent.

The iron ore deposits in Huili and Yanyuan counties were formed in connection with the hydro-thermal processes of volcanism. The iron content is quite high in deposits of such origin. Some iron deposits are associated with basic magmatism during metasomatic processes.

The iron deposits in the Manyinggou Mine were caused by regional metamorphism. The ore bodies exist in the lower part of the Shuanshuijin series of the Precambrian group of hematite and limestone. The average content of iron in the ore reaches 52 to 62 per cent. Iron deposits of this type are found in many areas of the region, for example, Xichang, Huidong, and Huili.

Copper Deposits

Copper deposits are found in the region; the salient characteristics are given below.

A. Lalachang Mine in Huili County. The Lalachang copper mine is large. The ore bodies are associated with the metamorphic volcanic strata

of the Huili system of the Precambrian group. The length of ore strata controlled by fractures and layers stretches from several hundred to a thousand metres; showing stability of the ore-containing body. The total thickness of the ore bodies reaches more than 80m. The ore contains contaminated or laminated copper masses, associated with molybdenite. The copper content on average is 0.88 per cent. Besides copper, there are several other components, such as Au, Ag, and Ni.

B. Liwu and Tongan Copper Mines. These two mines are a result of hydro-thermal enrichment in metasedimentary rocks. Deposits of this type have prospects for further exploration.

C. Datongchang Copper Mine. The Datongchang copper deposits with ore bodies in the Cretaceous sandstone and conglomerate are of sedimentary origin. There are six ore layers in the mine, including 13 ore blocks in lengths of up to 2,000m and thicknesses of from 1.86 to 5.43m. The copper content ranges from one to 2.13 per cent with associated elements such as Ag, Se, and Au. The basins of Cretaceous sediment in the region may well contain this type of copper deposit.

Other Metallic Deposits

The geological formations in the region are rich in mineral deposits of many metallic elements such as lead-zinc, copper-nickel, tin, gold deposits, and deposits of rare earth elements.

A. Lead-Zinc Deposits. The Dalianzi Mine in Huidong County and the Tianbaoshan Mine (Plate 7) in Huili County are the main lead-zinc deposits of hydro-thermal origin in the region. The metal content is high. Some rare and dispersed elements are associated with lead-zinc ore. Among them are Cd, Ag, and Ce.

B. Copper-Nickel Deposits. Copper-nickel deposits are found in southern Huili County. The largest one is the Tongmahe copper-nickel mine. The deposits were formed in the late magmatic stage. The intrusion of basic and ultrabasic magma containing nickel was controlled by the faults striking from north to south. The ore bodies occur at the bottom of the intrusive mass and on outer contact with

altered limestone. In addition to copper and nickel, the ore contains dispersed components of cobalt.

C. Lead Deposits. The lead deposits found in the region are mainly of contact-metasomatic and hydrothermal origin, for example, Zhahe Mine in northern Huili County. The ore body occurs in the skarn on the outer edge between granite massive and limestone of the Pre-cambrian Tianbaoshan group. The content of tin in the ore is high and is found in association with tungsten, beryllium, copper, and bismuth.

D. Gold Deposits. Gold deposits are distributed widely throughout the region. Gold placers are found in the Yalongjiang and Jinshajiang river valleys. In the Wali district of Yanyuan County, a gold nugget weighing 2,560g was found. Vein gold deposits are found in Mianning County.

E. Rare Elements and Rare Earth Elements. Mineral deposits of rare elements, rare earth elements, and dispersed elements are found in several districts in the region. Beicao and Lugu districts of Huili County are prospective mining areas for pegmatite and albite which are found sandwiched between basic and ultrabasic rocks and syenite and granite dykes. The ore bodies mainly contain Nb and Ta, associated with Zr and Bi. The contents of these elements are high and can be extracted for industrial use.

Deposits in the Deyizite district are composed of placer yttrium of deluvial and alluvial origin. The country rocks are granites with relevant minerals. The associated mineral is zircon.

The deposits in the Mulo and Sanchaohe districts of Mianning County are composed of light rare earth minerals of hydro-thermal metasomatic origin. The ore bodies are located in marble or diabase at the outer contact with granite massives. Sometimes deposits are in the form of vein nets. Since the deposits are spread over a large area, this district has prospects for mining light, rare earth elements.

Non-metallic Deposits

The region is rich in coal resources. There are several coal mines in the Panzhihua, Ertan, and Yimen districts. The largest one is Baoding Coal

Mine (Plate 8) located near Panzhihua city. The coal seams are found in the Baoding series of the Triassic system. The total thickness of the coal series reaches 1,800m with 111 coal seams with a total thickness of 60.25m. The structure of coal seams is simple and stable, with a low content of mud, sulphur, and phosphor. The coal can be used for production of coke in steel metallurgy. Rock salt deposits are rich in the Yanyuan Basin with its thick Triassic system which contains salt seams.

Land Resources

The research region is located on the south-eastern boundary of the Tibetan Plateau and on the northern border of the Yunnan Plateau. The geomorphology of the region is characterised by higher and middle mountains with deep valleys. The typical plateau monsoon is predominant with distinct dry and wet seasons.

The landscape and agricultural production as well are affected by vertical differentiation. In general, three different types of landscape and agricultural land use can be classified, ranging from deep valleys to mountains.

A. *Areas Having Elevations of Less than 1,300masl*

A southern subtropical climate prevails in these low elevation areas. The climate is typical of deep valleys. The annual average temperature ranges from 19.5°C to 20.5°C. The accumulated temperature of 10°C is as high as 6,500 to 7,500°C. The annual precipitation ranges from 800 to 1,000mm.

The main vegetation consists of grassy slopes with sparse woods and thick bushes (Plates 9). The valley slopes are covered by reddish soil which is typical of mountain areas. There are three harvests a year. Rice (Plate 10) is harvested twice. Sugarcane (Plate 11) and tropical plants can be cultivated. Temperate vegetables (Plate 12) and temperate and subtropical fruits (Plates 13 to 16) are grown.

B. *Areas Having Elevations Ranging from 1,300 to 2,200masl*

The areas with elevations of from 1,300 to 2,200m range from high mountain slopes to middle mountain plateaux. The climate is warm

and subhumid and typical of middle subtropical zones. The average annual temperature is from 13.5 to 19.5°C. The accumulated temperature of 10°C is 4,500 to 6,500°C. Occasionally, frost appears in winter. Annual precipitation is from 800 to 1,000mm. The vegetation consists mainly of mixed pine with oak and Yunnan pine as well. The soil is red. There are two harvests a year. Vegetables suitable for cool climates and temperate fruits can be cultivated.

C. *Areas Having Elevations Higher than 2,200masl*

There are high mountain slopes in these areas where northern subtropical and temperate humid climates are prevalent. The annual average temperature is 9.5 to 13.5°C. The accumulated temperature of 10°C is as low as 2,500 to 4,500°C. The frost period is relatively long. The annual precipitation reaches 1,000 to 1,400mm. The vegetation consists mainly of green wide-leaved oak, i.e., evergreen chinquapine and mixed pine and oak. The natural slopes are covered by yellow-brown soil. There is one harvest a year. The crops are usually dryland grains rather than wheat and rice.

Land use in the region is controlled by the geomorphological and climatic conditions and can be classified into 10 types, i.e., farmlands, vegetable gardens, forests, grasslands, urban and rural towns, mining and industrial areas, land for transportation, water surfaces, and land for other uses.

The distribution of different types of land use and land combinations is uniform and depends on the land characteristics of the region.

(1) The Broad Valley and Inter-Montane Basin Area. The broad valleys of the Jinshajiang, Yalongjiang, and Anninghe rivers and some of the inter-montane basin and lake areas come under this landform category. The valley beds, basins, and terraces are usually composed of alluvial sediments which provide thick and fertile soils. The slopes are gentle and farmland is concentrated in this area. The population density is also relatively high and the most important agricultural land is located in this area. Irrigated rice fields and sugarcane are cultivated on the low terraces, while vegetables and southern tropical fruits grow on high terraces and hill slopes. Towns and industrial lands are situated on the high

terraces and in the hills along the Jinshajiang and Anninghe rivers.

(2) The Narrow Valley and Canyon Area. The area of narrow valleys and the canyons of the Jinshajiang, Yalongjiang, and Anning rivers are characterised by steep slopes and intensive erosion. The soil in this area is very thin. The grass slopes are usually covered by sparse woods and thick bushes. Exposed deluvial and proluvial sands and rock fragments from rockfalls and landslides are often found on the river banks. Therefore, it is difficult to use the land in this area.

(3) The Hilly Land Near the River Valley Area. The hilly land area is usually located near broad valleys and is characterised by grass slopes and mountain rice fields. The forest cover is sparse and the slopes are mostly covered by bushes, sparse wood, and middle hill forests. Usually the southern slopes are covered with woodlands and the northern slopes with grasslands. Farmland is sparse and consists of gentle slopes and terraced land. The irrigated rice land areas are usually hot in winter and productivity is low. There is limited cultivation of tea, fruit, and shellac.

(4) The Middle Mountain and Continental Plateau Area. The middle mountain and continental plateau area on high elevations is located far from the river valleys. The climate is cool and wet. The most important forest is located in this area. The plantations are well preserved and forest cover is dense. The vegetation mainly consists of mixed pine with oak, broad-leaved, and coniferous trees. Farmlands are usually on steep slopes (25^{o}) and on marginal land.

(5) The High Mountain Area. The high mountain area is unsuitable for forestry and agriculture. Most parts of the area are waste, mountainous land covered with snow and ice or exposed rocks.

Water Resources

Water resources are plentiful in this area. The average runoff into the rivers is 622mm and the total annual amount of water is $1.7262 \times 10^{11} m^3$, of which

$3.3688 \times 10^{10} m^3$ is obtained from this area and $1.3674 \times 10^{11} m^3$ from outside.

The area is very rich in hydropower resources. The Jinshajiang and Yalongjiang rivers flow rapidly over precipitous terrain and thus are sources of abundant hydropower resources. In this area, the mainstream of the Yalongjiang River has a natural drop of 1,290m and the Jinshajiang River, 667m. The precipitation of their branches ranges from 500 to 2,000m. The hydropower storage in this area reaches 3.69678×10^7kW, of which 3.10248×10^7 kW can be exploited giving an electrical capacity of 1.80694×10^{11} kW-hour/year. The hydropower which can be exploited per square kilometre in this area totals 2.8×10^6 kW-hours/year.

The advantages of the exploitation of hydropower resources in this area are little submergence loss, little investment, advantageous dynamic indexes, and coordinative distribution with large-scale mines and smelting bases which can meet not only the national, large-scale strategic energy needs but also medium and small-scale energy needs for development of the local economy. At present, the energy resources have not been exploited and therefore prospects are quite substantial. The mainstreams have not been exploited and their branches have been under-utilised. For example, only 1.2 per cent of the hydropower potential of the branches of the Jinshajiang River has been exploited. The Yalongjiang accounts for only 0.4 per cent. Hydropower stations in this area not only supply electricity to Sichuan Province but also actively contribute to the development of energy resources in southwest China and the country as a whole.