Triassic Sedimentary-Tectonic Evolution in Western Sichuan and Eastern Xizang Region

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(Abstract)

The Yidun, Yajiang (western Sichuan) and eastern Xizang (Tibet) areas occupy the eastern part of Qinghai-Xizang Plateau, and are a well-developed and well-preserved position in the Tethyan Tectonic Domain. The Triassic sequence in these areas is well-developed, and the related mineral resources is very abundant. Through the detailed observations of representive Triassic sections in these areas, combining with analyses of sedimentary facies, formations, syn-sedimentary volcanic accumulations and related mineralizations, stratigraphical succession and units are further definited, and regionarly changing sedimentary environment, associated mineralizations and its relationship to plate tectonics during Triassic time are discussed and illustrated. This work is part of the scientific item"Tectonic Evolution and Distribution Regularity of Major Ore Deposits in The Qinghai-Xizang Plateau".

This study was carried out in 1980—1985. Three route geological observations across the studied area, measuring of 47 representive stratigraphical sections, and collecting and determining of abundant samples have been completed. On the basis of lithostratigraphy, biostratigraphy, chronostratigraphy and facies analysis for the representive sections, stratigraphical division and classification were modified, stratigraphical correlation between the studied and adjacent areas was discussed, sedimentary facies and environments in different segments, sections and sedimentary stages were recognized, sedimentary-tectonic formations during different stages in the studied and adjacent areas were established, and mineralizing condition, distribution regularity and prospecting were analyzed and concluded.

A formation and evolution of sedimentary basins are controlled by a development of plate tectonics, and consequently sedimentary process, volca-

nism and related mineralizations are controlled in varying degrees. The Triassic sedimentary history of western Sichuan-eastern Xizang area may be divided into five stages, based on lithofacies and formations of Triassic sequence, composition and origin of volcanic rocks, changing palaeogeographical environment and tectonic development.

1. Early Triassic

It is suggested from this study that during late Variscan-early Indosinian period, a continental-margin volcanic arc developed along Jiangda (eastern Xizang)-Deqin (Yunnan) zone. Because westward subduction occurred subsequently along Jinshajiang zone, assembly of eastern Xizang and Zhongza continental fragments (western Sichuan) has been completed during Triassic time. An area from east of Jiangda to west of Ganzi-Litang zone was then within the limits of an active continental margin during Early Triassic time. Near Jiangda and along Gongjue-Mangkang zone, there are eluvial-backshore shallow water depression-shore volcanic accumulation or dispersal facies and semi-closed bay facies represented by volcaniclastics and carbonates (Pushuiqiao Formation), and semiclosed bay-shore volcanic flood accumulation-beach facies and semiclosed bay facies represented by intermediate-acidic volcanics, volcaniclastics and clastics (Malasongduo Formation). In Zhongza area, Batang, carbonates intercalated with clastics (Cigong Formation) indicate an open-semiclosed platform facies. In Gongna (Baiyu)-Yidun (Batang) area, silty mudstones intercalated with a small amount of carbonates and metamorphosed basic volcanic rocks (Dangen Formation) represent a marginal platform-outer shelf bathyal basin facies. A sequence of basic pillow lava, basic-ultrabasic cumulates and radiolarian cherts (Lower Reshuitang Group), exposed intermittently along Ganzi-Litang fault zone, represent remains of oceanic basin. This shows that from west to east, unstable polygenetic terrigenous volcaniclastic-internal source carbonate formations——→stable-substable internal source carbonate formations——→unstable impure shale-internal source allochthonous carbonate formations——→unstable volcanic-chert-ophiolite formations appear successively.

From east of Ganzi-Litang zone to Xikang-Yunnan oldland, a passive continental margin appeared during Early Triassic time. In western part, Dahe-Mula area in the eastern side of Ganzi-Litang zone, there are variegated slates intercalated with thin-bedded limestones and radiolarian cherts, indicating an abyssal basin facies. In eastern margin, Baoxing-Kangding-Jiulong area, there are nearshore-outershore clastics and carbonates (Bocigou

and Hengyakuang Formations). The both represents unstable red micritic carbonate-radiolarian chert formations and substable variegated polygenetic terrigenous clastic-internal source carbonate formations, respectively.

In Early Triassic time, this basin was predominated by spreading and subsiding. Original mid-oceanic ridge basalts are preserved along Ganzi-Litang zone, and intermediate-acidic and minor basic volcanic rocks are often found in eastern Xizang continental-margin arc and forearc zone.

2. Middle Triassic

In the studied area, and adjacent Yajiang and eastern Xizang areas, there generally is a continuous relationship between Lower and Middle Triassic successions. A deepening-upward transgressive sequence appears in a vertical direction. However, a space distribution of this transgressive sequence is sporadical, because of the regional tectonic event and erosion process, which affected a wider area, during Middle-Late Triassic boundary time. Thus, it is difficult to reconstruct original sedimentary framework. There is a similarity between Middle and Lower Triassic successions in a general way. In this stage, semiclosed bay-shallow shelf facies clastics and carbonates (Jielong Group), and nearshore-shelf-marginal shelf basin facies clastics and deep trough facies turbidity flysch (Walasi Formation) occurred in depression basins on southern Qinghai and eastern Xizang continental arc; deep-sea basin turbidity flysch facies clastics (Leiyi Formation) in a forearc basin along Baiyu-Yidun zone; oceanic basin facies represented by cherts and basic volcanic rocks (Middle Reshuitang Group) along Ganzi-Litang zone; and deep water shelf-bathyal trough facies clastics and intercalated carbonates (Zagunao Formation) to east of the studied area. Generally, from west to east, substable variegated polygenetic terrigenous clastic-internal source carbonate formations——→unstable sandy-silty flysch formations——→unstable volcanic chert-ophiolite formations——→substable gray or variegated polygenetic terrigenous clastic formations may be successively established.

3. Late Triassic Carnian

Occurrences of oceanic fragments along Ganzi-Litang zone show a main spreading phase of Bayan Har Sea in Early and Middle Triassic time (initial spreading might begin at late Variscan time). Up to Late Triassic, a significant change of geological evolution arrived in Yidun area of western Sichuan. The superimposed Yidun island-arc was initiated in the eastern flank of

original Jiangda-Deqin continental arc, because of westward subduction of oceanic crust along Ganzi-Litang zone. In this tectonic framework, further uplift of eastern Xizang has resulted in, except for the limited local basins, absence of early Late Triassic sediments. Jinshajiang zone might then be an interarc block-faulted basin zone. A new Yidun volcanic arc began to establish and develop. Yajiang area was still under sea-waters.

An active continental margin developed still in eastern Xizang and to west of Ganzi-Litang zone. In eastern Xizang, early Late Triassic is represented by alluvial-littoral facies sandstones, conglomerates and shales (Dongdu Formation), and littoral or shore lagoon facies carbonates, cherts, clastics and evaporites (Yaoyelong Formation). In Baiyu-Yidun zone, western Sichuan, there mainly are composite sedimets of shore-open bay (Qugasi Formation) and deep trough (Tumugou Formation) facies carbonates and clastics. In Derong-Xiangcheng area to the south, the equivalents are characterized by deep-water cliffed coast collase deposits, indicating a deepening-upward overlapping transgressive succession in a vertical direction. In Dege-Xiangcheng area (eastern Zengke-Daocheng zone), Genlong and Gacun Formations, first established by this study, are represented by basic or intermediate-basic——→acidic and basic——→intermediate——→acidic volcanic rocks and volcaniclastics, which can be divi ded into two volcano-sedimentary cycles. Because of a frequency of volcanic eruption, volcanic accumulation masses in various size and shape have resulted in changing of paleogeographical enviranment, and there was different facies, including volcanic accumulation, top volcanic accumulation, circum-volcano accumulation and inter-volcano basin facies. However, in Zhuoxi-Daocheng area (western Zengke-Daocheng zone), the equivalents are poorly preserved and consist of basic volcanic rocks, minor acidic volcanic rocks, calcareous-argillaceous rocks and carbonates. Along Ganzi-Litang zone, there is"melange"consisting of basic lava, intermediate-basic volcanic breccia-aes, tuffes, and various size of lenticular limestone and slate blocks (Upper Reshuitang Group). These accumulations are considered to be products of continental-margin subsiding basin, intra- or inter-arc basin, island-arc volcanic zone, fore-arc basin——trench and oceanic basin, respectively. Generally, a sequence of unstable volcanic mollasse (or mollasse)-terrigenous polygenetic clastic and internal source allochthonous carbonate formations——→substable polygenetic terrigenous clastic-internal source carbonate(unstable polygenetic terrigenous clastic-collapse rock) formations——→unstable sandy flysch formations——→unstable volcanic flysch and unstable polygenetic terrigenous clastic formations——→unstable volcanic melange formations can be established.

To east of Ganzi-Litang zone, a passive continental margin developed

during this time. In Yajiang area of western Sichuan, there lithologically is a sequence of metamorphosed sandy slates, intercalated locally with metamorphosed basic volcanic rocks and carbonates (including Zhuwo, Waduo and Lianghekou Formations), which is considered to be substable sandy-silty flysch formations consisting of abyssal or bathyal contourites and turbidity flysch. Eastward to Xikang-Yunnan oldland, there was a narrow continental shelf. The composite tidal flat facies sediments occurred in Yanyuan-Lijiang area, constructing substable gray polygenetic terrigenous clastic-allochthonous carbonate formations.

4. Early Norian

A development of Yidun volcanic arc continued. With westward subduction of oceanic crust along Ganzi-Litang zone, a great number of arc-related intermediate, intermediate-acidic and acidic erupsives and reworked granitic plutons were formed in Queershan-Daocheng and Dege-Xiangcheng areas (eastern flank of Yidun zone, western Sichuan), Jinshajiang, Deyigou-Lanashan area (to east of Jiaduoling-Jiangda zone, eastern Xizang), and Chezhulin(Deqin) and Lancangjiang areas.

In Deyigou (eastern Xizang)-Lanashan (Batang)-Riyu(Derong) zone and western backarc area, Tongka (Jiapila), Bolila and Adula Formations are characterized by shore lacustrine swamp-fluviolacustrine-littoral-closed or semiclosed platform-shore lagoon, bar and swamp facies, in which a large number of calc-alkali high-alumina basalt and andesite, alkaline basalt-dolerite and soda or high-K rhyolite occurred. They are considered to be substable and unstable mollasse (or volcanic mollasse)—polygenetic terrigenous volcaniclastic and internal source carbonate—evaporite—(coal-bearing)polygenetic terrigenous clastic formations. In Gongna (Baiyu)-Haizishan (Yidun) area, the equivalents, i.e. the first—established Haizishan Formation, is represented by back-volcano deep-water trough—semiclosed shallow trough facies and inter-volcano valley facies, which is considered to be unstable polygenetic terrigenous clastic formations, and locally internal source carbonate—evaporite formations (Gongna) and spilite—keratophyre formations (Zhandouxiang of Xiangcheng). The island-arc volcanic zone occurred along Dege-Xiangcheng fault zone and both sides, and is characterized by complex lithological associations, generally constructing volcanic flysch formations. The formations consists of back-volcano trough facies; eruptive-flood accumulation facies, circum-volcano volcanic-sedimentary facies, and its relationship to western and eastern sides is interfingering. Along western side of Ganzi-Litang fault

zone, in Zhuoxi(Xinlong)-Daocheng area, the accumulations of predelta—delta-front facies, circum-volcano facies, inter-volcano basin facies and deep trough—marginal shelf basin facies (Miange Formation and equivalents) were deposited in a fore-arc basin, without or with a few of acidic volcanic rocks. They construct unstable flysch—polygenetic terrigenous clastic formations.On the other hand, a passive continental margin basin, located in Yajiang area of western Sichuan, came into a late stage of evolution, in which substable polygenetic terrigenous clastic formations consisting of marginal shelf basin flysch facies-shelf bar and shallow shelf facies (Yajiang Formation) was established. Farther eastward to western margin of Xikang-Yunnan oldland, composite tidal-flat-shore swamp facies appeared, which constructs allochthonous carbonate and polygenetic terrigenous clastic—coal-bearing polygenetic terrigenous clastic formations.

5. Late Norian—Rhaetian

In this stage, the passive continental margin to east (Yajiang area) has been collided with Yidun island-arc along Ganzi-Litang zone. This has caused the entire uplift of eastern Xizang-western Sichuan area. A sedimentation occurred only in a relict basin (Ganzi-Litang zone) and original back-arc basin (eastern Xizang).

Along the front of collided zone, in Zhuoxi (Xinlong), Reke (Litang), Xiaoxueshan (Xiangcheng) and Panghe (Daocheng) areas, Lamaya Formation is represented by delta-front—delta plain facies, indicating to be unstable mollasse—polygenetic terrigenous clastic formations. In Jiangda-Qamdo area, eastern Xizang, Duogaila Formation is characterized by shore-swamp facies, indicating to be substable gray polygenetic terrigenous clastic—coal-bearing polygenetic terrigenous clastic formations.

Up to terminal Triassic, the entire western Sichuan-eastern Xizang area has been transformed into a single Indosinian fold system. Since Yenshanian-Himalayan or Tertiary, although intensive tectonism (including uplift, thrust, strike-slip and crustal shortening) and magmatism occurred in this area, the general sedimentary-tectonic framework has been still preserved.

On the basis of Triassic lithofacies, formations and tectonic analyses, Yidun (western Sichuan)-eastern Xizang area can be divided into the following tectonic-formation zones, Ganzi-Litang trench-ophiolite melange zone, Queershan (eastern flank) -Daocheng fore-arc basin, Dege-Xiangcheng main volcanic arc zone, Baiyu-Yidun-Derong interarc(intraarc) basin and Jiangda-Deqin continental-margin volcanic arc—back-arc basin zone. Different sedime-

ntary formations, magmatism and mineralizations have been established during different evolutional stage in different tectonic background.

In Ganzi-Litang ophiolite melange zone, the known mineralizations include chromites, asbestoes and gems associated with basic-ultrabasic rocks, Cu associated with basalts, and Mn associated with deep-water cherts.

In Queershan (eastern flank)-Daocheng fore-arc basin, the known mineralizations associated with early Carnian Genlong Formation and early Norian Miange Formation include volcanogene hydrothermal polymetal occurrences (for example, Cuoalangba, Baiyu), and subvolcanic-hydrothermal Cu deposits (for example, Changdagou Cu deposit, Dege).

In Dege-Xiangcheng main volcanic arc zone, the known mineralizations associated with Late Triassic acidic volcanism include volcanic exhalation-sedimentary type Au and Ag-bearing polymetal deposits (for example, Gacun deposit occurred in Gacun Formation) and volcanogene hydrothermal Hg deposits (for example, Kongmasi deposit in Baiyu occurred in Miange Formation). The Gacun polymetal deposit is very similar to the Kuroko deposit of Japan.

In Baiyu-Yidun-Derong interarc (intraarc)basin zone, the mineralizations are represented by stratabound-type polymetal (for example, Ganriluo Pb-Zn deposit, Batang) and sedimentary Fe-Mn deposits.

In Jiangda-Deqin continental-margin arc-backarc basin zone, major mineralization period is limited to Late Triassic Norian. The known mineralizationsinclude Jiaduoling porphyrite type-like iron deposit (occurred in Tongka Formation), and cupreous sandstones and shales, gypsums and coals in Qamdo, Mangkang and Riyu (Derong).

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