

幔枝构造成矿 及深部找矿预测

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内 容 提 要

在系统总结课题组近年来研究成果及借鉴大量有关文献的基础上,应用幔枝构造理论重新评价了张宣地区金银多金属矿的找矿远景。特别是通过解剖东坪、黄土梁、中山沟等金矿,万全寺金银矿、相广锰银矿、蔡家营铅锌矿等金银多金属矿,深入探讨了张宣幔枝构造区的成矿作用、成矿规律,归纳了成矿模式,评述了找矿潜力,确定了远景找矿方向。对张-宣地区开展新一轮地质找矿,特别是已有矿床的深部和外围找矿新突破具有很好的指导作用。

本书可供广大地质科技工作者及地矿类高等学校有关专业师生参考。

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前 言

金银多金属矿产是我国现今,乃至 21 世纪中叶的急需矿种。随着国民经济的快速发展,矿产品的需求量越来越大,而相应的找矿难度却日益增大。因此,隐伏矿体、盲矿体及其深部矿床的寻找就更显重要。虽然近年来地质找矿已取得较大进展,但已探明储量仍不能满足国民经济建设的需求,寻找和勘查一批规模大、品位高、经济效益和社会效益好的金银多金属矿产地,特别是加强深部地质找矿仍是我国目前地质勘查工作的首要任务。

“冀西北黄土梁金矿区深部与外围找矿勘查研究”项目是“河北省地质勘查专项计划项目”,于 2006 年 12 月 28 日以冀国土资勘便字〔2006〕122 号下达。拟从黄土梁地区金矿成矿、控矿构造的典型解剖,探索幔枝构造形成、演化及其对成矿物质迁移、聚集、成矿的控制作用,研究其成矿规律,总结幔枝构造成矿、控矿模式,指导新一轮地质找矿。2007 年,牛树银教授又获得了河北省自然科学基金项目“冀西北赤城黄土梁地区成矿规律及找矿方向研究”(编号: D2007000751)的资助,得以从更大范围开展幔枝构造成矿控矿作用研究。基金项目侧重幔枝构造成矿控矿作用的理论探索;地质勘查专项计划项目侧重总结成矿规律,指出找矿方向,指导进一步地质找矿勘查工作。两者相辅相成,互为依托,互为支持,力争在理论探索和引导地质找矿实践两方面均取得重要进展。

1 目的任务

“幔枝构造”是近年来兴起的一种区域地质构造理论,它不仅很好地解释了中生代以来的构造地质演化特征,而且在指导深部地质找矿方面取得了一系列重要进展。

张(张家口)宣(宣化)地区是金银多金属矿产的成矿集中区。张宣幔枝构造是其主要的成矿控矿构造,控制着一系列金银多金属矿床(矿点)。其中,东坪金矿、小营盘金矿是大型矿床;黄土梁金矿、赵家沟金矿、水晶屯金矿、中山沟金矿、张全沟金矿等是中小型矿床。外围还有蔡家营、相广、万全寺、青羊沟等大中型银铅锌矿床。值得指出的是,通过石家庄经济学院与河北省国土资源厅、河北省地质矿产勘查开发局及其下属地质勘查单位和矿山企业密切合作、共同攻关、深入研究,黄土梁金矿深部及其外围地质找矿取得了突破性进展,使黄土梁金矿一跃成为大型,甚至有望成为超大型金矿。外围金银多金属矿的勘查与采矿也取得了新的进展。但仍急需进一步加强有关科研工作,归纳成矿模式,指出找矿方向,为进一步指导新一轮地质找矿作出应有贡献。2007 年 10 月在合肥召开的“全国深部找矿研讨会”上,国土资源部、中国地质调查局在充分调研的基础上,适时提出了开展 500~1500 m 的深部地质找矿工作的意见。很多专家认为:①积极开展与深部矿产勘查相关的深部成矿与找矿理论研究;②高精度深部矿产勘查地球物理、地球化学探测;③大功率深部钻探验证。上述是深部找矿工作应遵循的主要方法。之所以强调深部成矿与找矿理论研究,是因为理论研究是地质找矿工作的先导。特别是新中国成立以

来，随着科学技术的发展和人类社会的进步，人们对矿产资源的需求量越来越大，但人们获取矿产资源的主要渠道——地表矿、浅部矿和易开采矿已渐趋枯竭，这就要求在新的成矿理论指导下开展新一轮找矿，而新一轮找矿的方向必然转向地壳深部。然而深部矿的找寻显然难度很大，只有在新的理论指导下，通过大量有效信息的总结、综合，才能浓集资料，去伪存真，总结成矿、控矿作用的规律，才能有效地指导深部和外围地质找矿工作，实现地质找矿新突破。

幔枝构造是成矿控矿作用的主导因素。因此，张宣幔枝构造区金银多金属矿产资源的勘查、评价应从新的视角来考虑、研究和评价。

本项目实施的目的是用幔枝构造理论重新评价张宣地区金银多金属矿的找矿前景，特别是通过解剖东坪金矿、黄土梁金矿、中山沟金矿、万全寺银金矿、相广锰银矿、蔡家营铅锌矿，客观地认识张宣幔枝构造区的成矿作用、成矿规律、找矿方向，归纳成矿模式，发掘找矿潜力，确定找矿远景区，选择找矿有利地段，圈定找矿靶区，实现张宣地区地质找矿新突破。

2 以往工作简述

张宣幔枝构造区位于河北省的西北部，首都北京的近邻，历来受到地质学家的广泛关注。特别是新中国成立以来，各地质勘查单位做了大量工作。

张宣地区是我国地质工作研究程度较高的地区之一。该区 1:20 万及 1:5 万区域地质调查，1:100 万和 1:20 万区域重力调查，以及 1:20 万航磁和 1:20 万化探已全部完成。1:5 万及更大比例尺的化探多在重点矿产勘查区开展过。这些成果为本课题研究奠定了基础。

张宣地区开展矿产地质工作较早，新中国成立以来在多数成矿区带开展过大量矿产地质勘查工作。发现并评价了一批金银矿床，积累了丰富资料。同时，地矿、冶金、有色、化工及有关科研院所、大专院校亦开展了大量有关区域地质或不同矿种的研究工作，这些矿产研究成果多数具有重要的参考价值。

3 存在问题分析

毋庸讳言，张宣地区的地质研究及矿产勘查均具很高的程度，但仍存在一些重要地质问题尚待探索。在有关理论指导方面，以往的研究多以地台观点为主，对强烈的区域变形变质作用重视不够；在成矿作用方面多以围岩萃取为主，花费很多精力去寻找矿源层，找矿效果不佳；在找矿方法上，多注重地球物理、地球化学异常的检查上，而对典型矿区解剖不够。

研究发现，中生代以来，华北东部盆岭区发生了翻天覆地的巨变，并且以典型的陆内造山带为特征。应该思考：中生代大规模的成矿作用（有人称成矿大爆发）背景是什么？为什么成矿如此集中？其主要成矿机制是什么？很显然，急需用新的成矿理论建立适合本区的成矿模式及找矿模型，进而对本区金银多金属找矿前景进行预测、评价，筛选出一批找矿靶区。

4 取得的主要成果

通过校、队的密切合作,采用野外地质调研与室内测试、综合分析相结合,开展了多学科综合研究,取得了多方面的探索性、开创性成果。

1) 从地球圈层结构的形成与地幔热柱多级演化这一对立统一矛盾的双方,阐述了成矿物质的反重力迁移,探讨了金银等重元素在长期的重力分异作用下沉向地心成核,而某些局部在地幔热柱多级演化过程中,又可以气态→气-液态→流体的形式向上迁移,并在地壳的有利构造扩容带中成矿的辩证统一关系。

2) 以地幔热柱多级演化及幔枝构造理论为指导,详细解剖了黄土梁地区的地质演化与成矿控矿的关系。将其成矿作用与张宣幔枝构造演化联系起来,探讨了幔枝构造各单元的成矿作用和成矿控矿特征。

3) 从硫、铅、氢、氧、碳、氮、氩同位素特征,以及稀土、包裹体等方面,探讨了成矿物质来源问题。总体特征表明,成矿物质主要来自深部,在其向上迁移过程中,加入了部分变质水和大气降水。成矿物质的贯入特征明显。

4) 在成矿机理探讨的基础上,总结归纳了区域成矿规律、矿区成矿规律和矿体深部变化规律,并提出了区域找矿方向、矿区找矿方向、矿脉深部找矿方向等建议。基于成矿物质核幔源来源、幔枝构造成矿控矿作用以及成矿分带规律,指出万全寺银金矿区,随采矿深度的加深,矿脉的深部会发生规律性变化,银矿化向深部仍会保持一定富集,而同时金品位会逐渐升高,由浅部的银金矿变为深部的金银矿。

5) 在探讨成矿时代、矿质来源、成矿作用、成矿特征的基础上,总结了成矿规律,归纳了成矿模式,指出了找矿方向,为新一轮地质找矿奠定了基础。

由于河北省地质勘查专项计划项目和河北省自然科学基金项目研究各有侧重,不仅研究区域有所扩大,研究矿种有所增加,而且地质理论研究与地质实践找矿也结合得更加紧密,归纳了张宣地区的成矿模式。特别是指出了该区深部找矿的前景,分析了找矿潜力,提出了找矿方向,并在黄土梁金矿、中山沟金矿、水晶屯金矿、万全寺银矿、蔡家营铅锌矿等矿山取得了很好的实践效果。同时,可以考虑在冀东地区、太行山地区等相类似地质条件的矿集区推而广之。

此外,考虑到研究地区的扩大、研究矿种的增多以及研究成果的推广,征得河北省国土资源厅有关领导的同意,提交送审报告更名为“张宣地区金银多金属矿成矿规律与找矿方向研究”,书名精简为《幔枝构造成矿及深部找矿预测》。

2008年12月2日,受河北省科技厅委托,由河北省自然科学基金委员会主持,在石家庄召开了科研成果鉴定会,以裴荣富院士、祁兰夫前厅长为鉴定委员会正、副主任,梅燕雄研究员、许清海教授和杨志宏、马友谊、郭庆十等教授级高级工程师为委员的鉴定委员会给予了很高的评价,认为:“该成果内容丰富、资料翔实、立论有据、观点新颖,重点突出,具有很高的学术水平和实用价值,总体达到了国际先进水平。”

研究工作中得到了河北省国土资源厅、河北省地质矿产勘查开发局、石家庄经济学院以及河北省地质三队、张家口地区各有关矿山领导和科技人员的热情指导和大力支持,在此谨表衷心感谢。

作者还要特别感谢在项目研究和资料总结中李廷栋院士、陈毓川院士、翟裕生院士、裴荣富院士等，张洪涛研究员、叶天竺研究员、于海峰研究员、毛景文研究员、侯增谦研究员、聂凤军研究员、吕古贤研究员、杜建国研究员、李俊建研究员、谷永昌研究员、张维亮副厅长、冯建雄总工程师、陈华山总工程师、蒋威总工程师、马友谊处长、裴晓东院长、毕伏科总工程师、谢汝斌教授级高级工程师、郝东恒教授、张举钢教授、闫军印教授、张建珍教授等所给予的热情指导和鼓励，同时感谢王自力、赵莎、吴珊珊、王晓枝、谢新梅、刘亚明等研究生协助做了大量工作；在此还要向中国地质科学院地质研究所、矿产资源研究所等岩矿样品测试单位表示诚挚的谢意。

作 者

2010年6月6日

Preface

Gold and silver polymetal is an urgent kind of minerals for our country at present and will be more urgent in need by the mid-century. With the rapid development of the national economy, the quantity of mineral demand get growing while the corresponding difficulty for prospecting is more and more increasing. Therefore, the search for concealed orebodies, blind orebodies and the deep deposits becomes even more important. Although the geological prospecting has made great progress in recent years, proving reserves still can't satisfy the demands of national economy construction. At present, it is still our primary task for seeking and exploring a number of large scale, high grade, economic benefit and social benefit silver and gold polymetallic deposits and especially strengthen the deep geological prospecting in China.

The program about research on prospecting exploration for deep and periphery of Huangtuliang gold deposit in northwest Hebei, which came from the geological survey special program of Hebei province, was issued by the [2006] 122 document of Hebei Department of Land and Resource on December 28, 2006. Through typically studying the mineralization and ore-controlling structures of gold deposit in Huangtuliang area, we probed how to control ore-forming materials' migration, gather and mineralization by the formation and evolution of mantle branch structure, studied its metallogenic regularities, summarize mantle branch tectonic mineralization and ore-controlling mode in order to guide new geological prospecting better. In 2007, professor Niu Shuyin was awarded The National Natural Science Foundation of Hebei Province (Research on metallogenic Regularities and Prospecting Direction of Huangtuliang area in Chicheng country, Heibei Province < Grant No. D2007000751 >) so as to studying the ore-forming and ore-controlling roles with mantle branch structure in more broad areas. It focused on theoretical research in founding program while emphasized on practice in special program. these two programs complemented, relied on and supported each other in the two methods, strived to make important progress in guide geological prospecting in both theory and practice.

1 Purpose and Task

The mantle branch structure which is a new kind of regional geological structure theory at present, not only explained geological characteristics of the Mesozoic tectonic evolution and but also made a series of important progress in the guiding deep geological prospecting.

There are metallogenic clusters of gold and silver metallic deposits in Zhangjiakou-Xuanhua region and they are mainly controlled by Zhangjiakou-Xuanhua mantle branch structure in metallogenic conditions, for example the distribution of deposits. Among them, the Dongping gold

deposit and Xiaoyingpan gold deposit are large-scale mines, and Huangtuliang gold deposit, Zhaojiagou gold deposit, Shuijingtun gold deposit, Zhongshangou gold deposit and Zhangguangou gold deposit and so on are small and medium-scale deposits as well as Caijiaying, Xiangguang, Wanquansi and Qingyanggou large and medium-sized silver-lead-zinc deposits in the periphery. In particular, through close cooperation, joint tackling and thorough research among Shijiazhuang University of Economics Hebei Department of Land and Resource, Hebei Bureau of Geology and Mineral Resource Exploration and its subordinate unit of geological exploration, as well as mining enterprise, it made great breakthrough progress in geological prospecting in the deep and periphery of Huangtuliang gold deposit, jumped Huangtuliang gold deposit into a large-scale gold mining and even expected to become super-large gold deposit. Not only that, it also made great new progress in peripheral gold and silver polymetallic ore exploration and mining, but we still need to further strengthen the researching work, summarize metallogenetic model and point out prospecting direction in order to make due contributions to new geological prospecting.

In October 2007, the Ministry of Land Resources and China Geological Survey put forward some opinions about timely launching task of 500 ~ 1500m deep exploration on the basis of fully investigation when the National Seminar about deep exploration was held in Hefei. At the meeting, many experts think that ①actively researching on theories and methods related to deep mineral exploration and prospecting; ②developing the high-precise geophysical and geochemical methods about deep mineral exploration; ③Carrying on high-power deep drilling verification. The above methods should be mainly followed in deep ore-prospecting work and the reason that we stress the importance of studying deep mineralization and prospecting is because theory is the precursor of geological ore-prospecting work. Especially since the liberation, with the scientific and technological development and progress of human society, people have the growing demand for mineral resources, but people have access to the main channel of obtaining mineral resources-surface mining, the shallow ore and open mining, which has gradually exhausted. Therefore, this requires a new kind of theory to guide a next round of prospecting and exploration and it is inevitable to turn the direction of exploration into deep crust under the new theories' guidance. As is known to all, the deep deposits are obviously difficult to be found clearly, and only under the guidance of the new theory, through summarizing and synthesizing a large number of effective information, we can concentrate data, eliminate the false and retain the true, summarize ore-controlling and metallogenetic regularities and effectively guide the deep and peripheral geological prospecting in order to achieve new breakthrough for geological prospecting work.

The mantle branch structure is the dominant factor of ore-forming and ore-controlling. Therefore, a new point of view should be adopted for exploring gold and silver polymetallic mineral resources to be considered, studied and evaluated in Zhangjiakou-Xuanhua mantle branch structure region.

The purpose of this project was to re-evaluate the ore-prospecting of gold and silver polymetallic deposits in Zhangjiakou-Xuanhua district by adopting the theory of mantle branch.

Especially through studying Dongping gold deposit, Huangtuliang gold deposit, Zhongshangou gold deposit, Wanquansi silver-gold deposit, Xiangguang manganese-silver deposits and

Caijiaying lead-zinc deposit, we objectively knew the mineralization, ore-forming regularity and prospecting direction in Zhangjiakou-Xuanhua mantle branch district, generalized metallogenetic models, discovered and determined prospecting potential area and chose favorable ore-prospecting sectors to delineate the ore-prospecting target area, in order to make new breakthrough for geological prospecting work in Zhangjiakou-Xuanhua region.

2 Brief description of previous work

Zhangjiakou-Xuanhua mantle branch district which located in northwest Hebei province and also close to Beijing, has always received extensive attention from geologist. Especially, the geological exploration units have done a lot of work since the liberation.

Zhangjiakou-Xuanhua region in geological work is one of the high degree researching areas. In the district, the 1:200000 and 1:50000 regional geological survey, 1:1000000 and 1:200000 gravity survey, 1:200000 aeromagnetic and geochemical prospecting have also been completed and in the key mineral exploration area, the method has been developed in 1:50000 and more large scale of geochemical prospecting. The above results laid the foundation for this research.

Geological work in Zhangjiakou-Xuanhua area was developed earlier. People have done much geological work in the most mining areas since 1949, discovered and evaluated a number of gold and silver deposits, and accumulated rich material. Meanwhile, surveying, metallurgy, non-ferrous, chemical industry and related scientific research institutes and universities have also carried out a large number of the studying work about regional geology and different types of minerals, most of these mineral research is of very important referable value for us today.

3 Analysis of present problems

Needless to say, regional geology and mineral exploration were studied with a high degree in Zhangjiakou-Xuanhua region, but there are still some important geological problems remaining to be explored. In the aspect of relevant guiding theory, previous studies were mostly guided by platform view and they didn't pay enough attention to research the regional deformation and metamorphism; In the aspect of studying mineralization, they thought the mine is mainly extracted from surrounding rock, spent a lot of energy to actively look for the layer of mining source and the prospecting effect was ineffective; In the aspect of prospecting methods, they had more emphasis on geophysical and geochemical anomalies in the examination while didn't study the typical mining enough.

It was found that the Basin and Range area in the eastern part of North China has undergone earth-shaking changes with the characteristics of typical intercontinental orogenic belt since the Mesozoic. We should consider: what is the background of large-scale mineralization in the Mesozoic (known as the ore-forming outbreak)? Why did the mineralization break in such a focus forming? What is the main ore-forming mechanism? Obviously, It was very urgent to establish the met-

allogenic models and prospecting models by adopting a new forming theory and then forecast, evaluate the prospecting of gold and silver polymetallic deposits and screen out a number of prospecting targets for the area.

4 The main achievements made in the research

Through close cooperation between schools and geological teams and using the combining methods between field geological investigation and indoor testing, the comprehensive analysis, we carried out multidisciplinary research and gained many exploratory and creative understanding:

1) From the counterparts of the formation of circling structures and the multiple evolution of mantle plume in the Earth, we expounded that ore-forming materials migrate in anti-gravity and discussed that the heavy elements such as gold and silver tend to sink towards the core during long-term gravitational differentiation. However, during some local process of multiple evolution of mantle plume, they can move up as gaseous state→gas-liquid →hydrothermal fluid and deposit as economic deposit in favorable structures.

2) Taking the multiple evolution theory of mantle plume as the guidance, we studied the relationship between geologic evolution and ore-forming and ore-controlling structures in Huangtuliang area at length. We also linked tectonic evolution and mineralization in Zhuangjiakou-Xuanhua mantle branch area together and then, discussed the mineralization and the ore-forming and ore-controlling features of various tectonic units in mantle branch.

3) Based on studying characteristics of the sulfur, lead, hydrogen, oxygen, carbon, helium, argon isotopes as well as rare earth element and inclusions etc, we discussed the source of ore-forming materials. General features showed that ore-forming materials came from the deep and were jointed some metamorphic water and atmospheric water in the process of migrating upward. In addition, the ore-forming materials had obvious characteristics with penetrating to the wall rock.

4) We summarized the regional metallogenetic regularity, the mining metallogenetic regularity and the deep orebodies' changing regularity on the basis of discussing ore-forming mechanism, and put forward the prospecting direction in region, mining, deep and ore-veins, etc. Based on studying the source of ore-forming materials, the ore-forming and ore-controlling of mantle branch and the regularity of metallogenetic zoning, we indicated that the rules of ore-vein' occurrence would change and silver's mineralization would remain certain depth getting along with mining to the deep and also pointed out that the gold grade would gradually increase and the shallow silver-gold deposit would change to a deep gold-silver deposit from the shallow to the deep in Wanquan-shi silver-gold deposit area.

5) On the basis of discussion on the age of mineralization, mineral sources, mineralization and metallogenetic characteristics, we summarized the mineralization, generalized the metallogenetic model and pointed out the direction of prospecting so as to lay a foundation for a new geological prospecting.

Due to the different research emphases between the national natural science foundation of Hebei province and the geological survey special program of Hebei province, it made not only the re-

search area and the types of studying minerals increased, but also the theory of geological research and the practice of geological prospecting integrated more closely. We summarized the metallogenic models of Zhangjiakou-Xuanhua area, especially, pointed out the deep prospecting, analyzed the prospecting potency and put forward ore-searching direction for the area. This understanding was made very good test of practice in Huangtuliang gold deposit, Zhongshangou gold deposit, Shuijingtun gold deposit, Wanquanshi silver deposit, Caijiaying Zinc -Lead deposit, et al. Then, we can consider making it spread in the east area of Hebei province, Taihang Mountain area and other similar geological conditions. In addition, considering the expansion of the studying area, the increasing species of studying minerals and the promotion of researching achievements, we submitted researching report renamed as < Research on Mineralization and Prospecting Direction of Gold and Silver Polymetal in Zhangjiakou-Xuanhua Area > and simplified the publishing book's name as < Mantle Branch Structures Mineralization and depth prospecting prediction > after obtaining relevant leaders' consent from Hebei Department of Land and Resource.

Because of the Science and Technology Department of Hebei Province's delegation, the Committee of Natural Science Foundation of Hebei Province presided a appraisal meeting of scientific research achievements in Shijiazhuang on December 2, 2008, with Academician Pei Rongfu as director, Former Director-general Qi Lanfu as vice-director, Professors Mei Yanxiong, Xu Qinghai and Professor-level Senior Engineers Yang Zhihong, Ma Youyi, Guo Qingshi et al. as Committee member. They give the achievements a high evaluation and said: "the achievements with rich and informative content, well-supported arguments, new theoretical view and prominent highlight, are of high academic standards and practical value and generally reached the international advanced level."

Many helps have been got from Hebei Department of Land and Resource, Hebei Bureau of Geology and Mineral Resource Exploration, Shijiazhuang University of Economics, Hebei province No.3 Geological Team and the leadership and technical personnel of relevant mining in Zhangjiakou area, etc. We express our acknowledgements to them.

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第 1 章 研究区地质特征

张宣幔枝构造位于张家口—宣化—赤城一带，东经 $114^{\circ}50'$ ~ $115^{\circ}50'$ ，北纬 $40^{\circ}30'$ ~ $41^{\circ}15'$ ，在行政区划上包括张家口市所辖各区县，其西、北、东分别与山西省、内蒙古自治区和河北省承德市接壤。原大地构造划分为北部的内蒙地轴和南部的燕山台褶带。

1.1 张宣幔枝构造区的地质背景

张宣幔枝构造由核部岩浆—变质杂岩、外围拆离滑脱带和上叠构造盆地等 3 部分组成（图 1.1）。

1.1.1 核部岩浆—变质杂岩

张宣幔枝核部岩浆—变质杂岩较为特殊，它跨越燕山台褶带和内蒙地轴两个构造单元。尚义—赤城—平泉深大韧性剪切（断裂）带在太古宙就已存在，是一条重要的地质单元界线。中新元古代深大韧性剪切（断裂）带北侧长期隆升，处于剥蚀状态；南侧则大幅度拗陷，接受了中新元古界的沉积，继而，形成了燕山台褶带。古生代为稳定地台型造陆阶段。中生代以来，甚至更早可追溯到华力西晚期，华北地区进入了强烈的地幔热柱多级演化阶段。由于地幔拆离体的深部作用，加之尚义—赤城韧性剪切带与乌龙沟—上黄旗韧性剪切带叠加切割，导致地幔上隆，岩浆活动加强，并带动变质围岩一起隆升而形成张宣幔枝构造。

核部岩浆活动以水泉沟—大南山岩浆岩带最为明显，岩体呈透镜状沿尚义—崇礼—赤城韧性剪切带展布，属于岩浆侵入、蚀变交代、混合岩化多种地质作用形成的杂岩体，其出露面积达 400 km^2 。据遥感解译，深部为一浑圆状的大岩基。强烈的岩浆活动是张宣幔枝构造隆升的深部机制。

韧性剪切（断裂）带北侧为红旗营子群变质岩系，主要由浅粒岩、变粒岩、片麻岩和大理岩组成，其原岩以碎屑岩和碳酸盐岩为主。变质程度为低角闪岩相或高绿片岩相。韧性剪切（断裂）带的南侧分布有时代最老、变质程度最深的古—中太古代迁西群变质岩系。迁西群以含各种辉石为特点，由各种麻粒岩、片麻岩、斜长角闪岩和磁铁石英岩组成。下亚群为麻粒岩相，上亚群为麻粒岩相—角闪岩相。原岩以基性和中基性火山岩为主，其次为碎屑岩和含铁硅质岩。

1.1.2 外围拆离滑脱层

如前所述，张宣幔枝横跨在内蒙地轴和燕山台褶带两个大地构造单元之上。在幔枝构