塔里木盆地
西北缘中、新生代构造特征及演化

钱俊锋　肖安成　杨树锋　编著

Research on Mesozoic-cenozoic Structural Characteristics and Evolution in Northwestern Margin, Tarim Basin




浙江工商大學出版社
ZHEJIANG GONGSHANG UNIVERSITY PRESS

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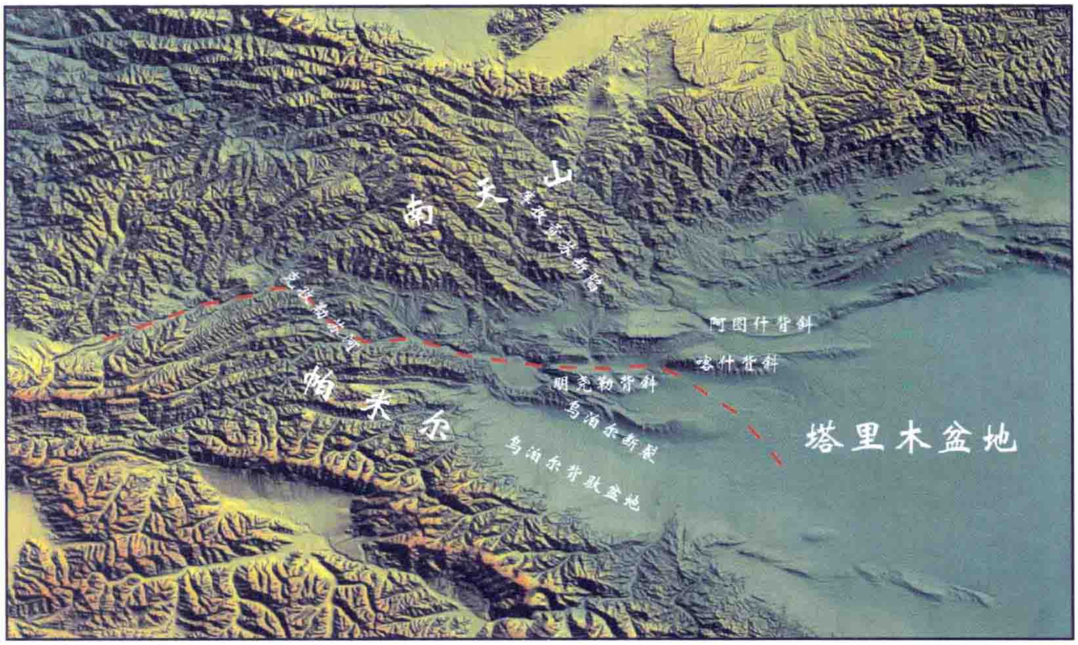
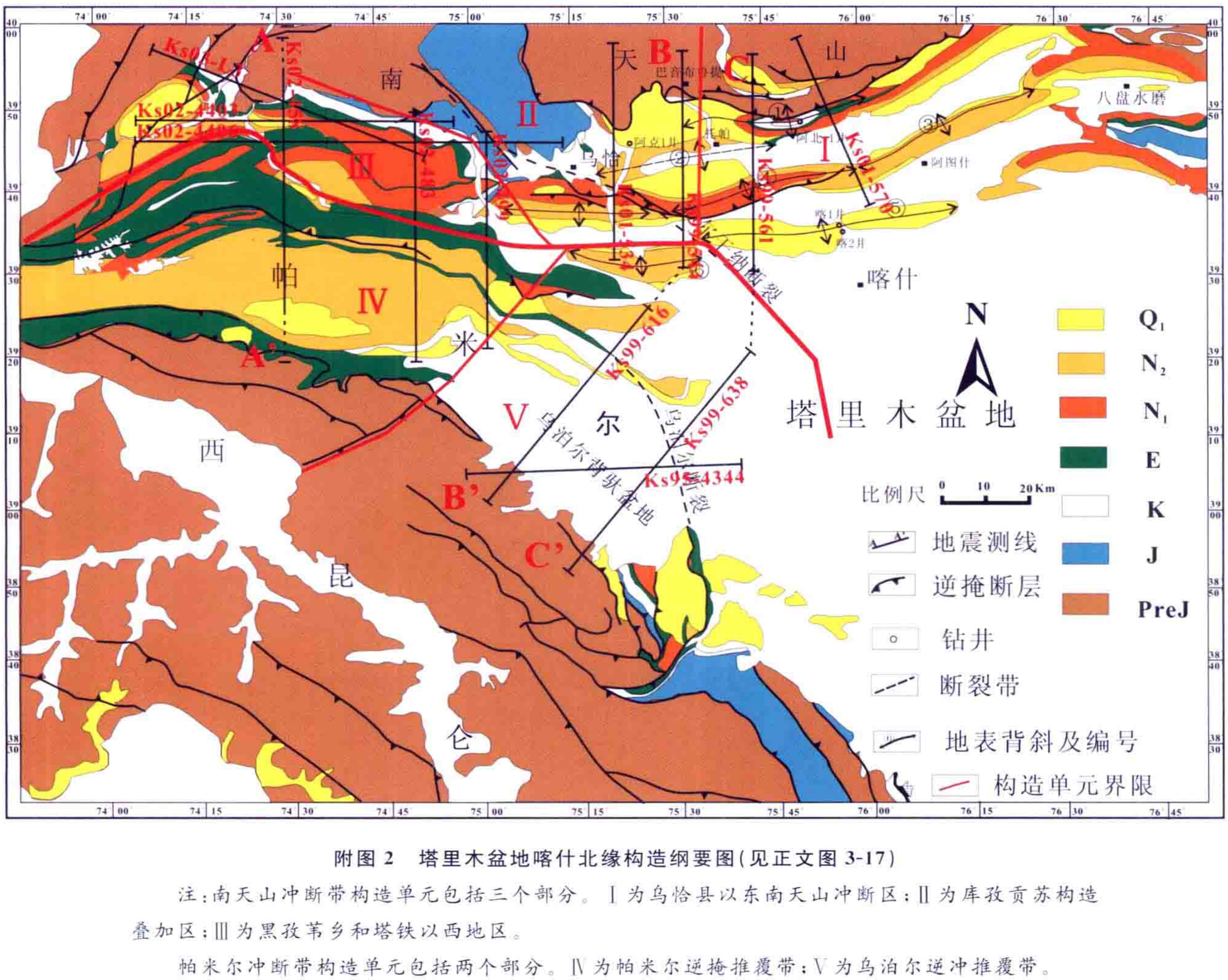


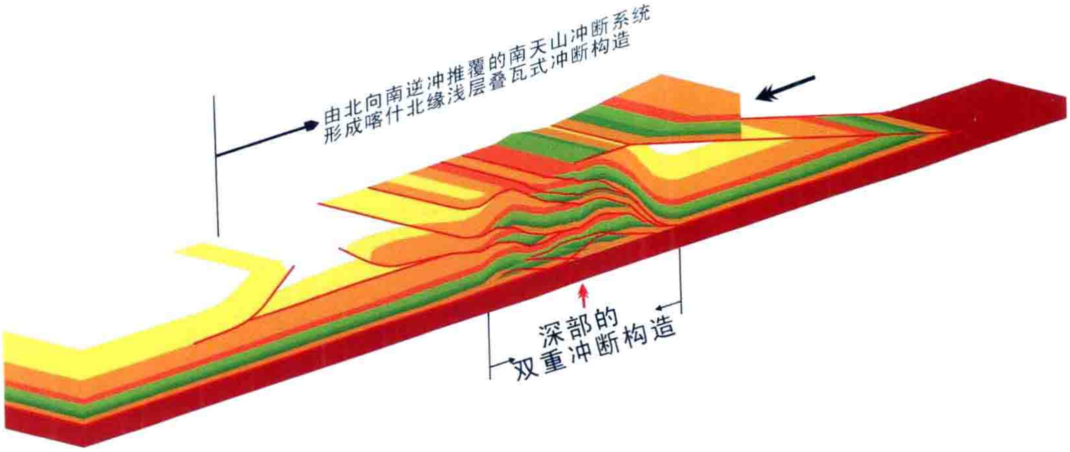
附图 1　南天山西段冲断带南缘边界分布(见正文图 3-10)



附图 2　塔里木盆地喀什北缘构造纲要图(见正文图 3-17)

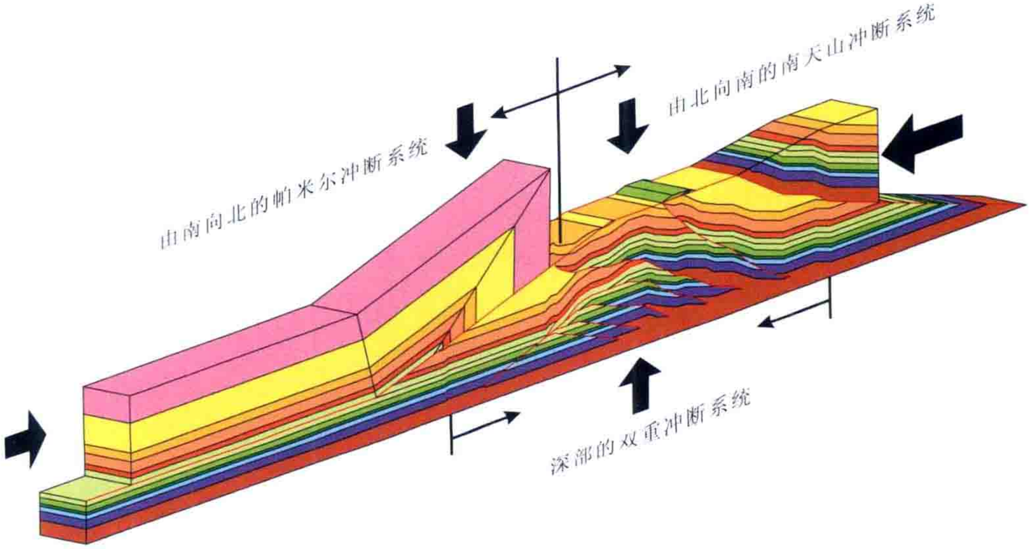
注:南天山冲断带构造单元包括三个部分。Ⅰ为乌恰县以东南天山冲断区;Ⅱ为库孜贡苏构造叠加区;Ⅲ为黑孜苇乡和塔铁以西地区。

帕米尔冲断带构造单元包括两个部分。Ⅳ为帕米尔逆掩推覆带;Ⅴ为乌泊尔逆冲推覆带。



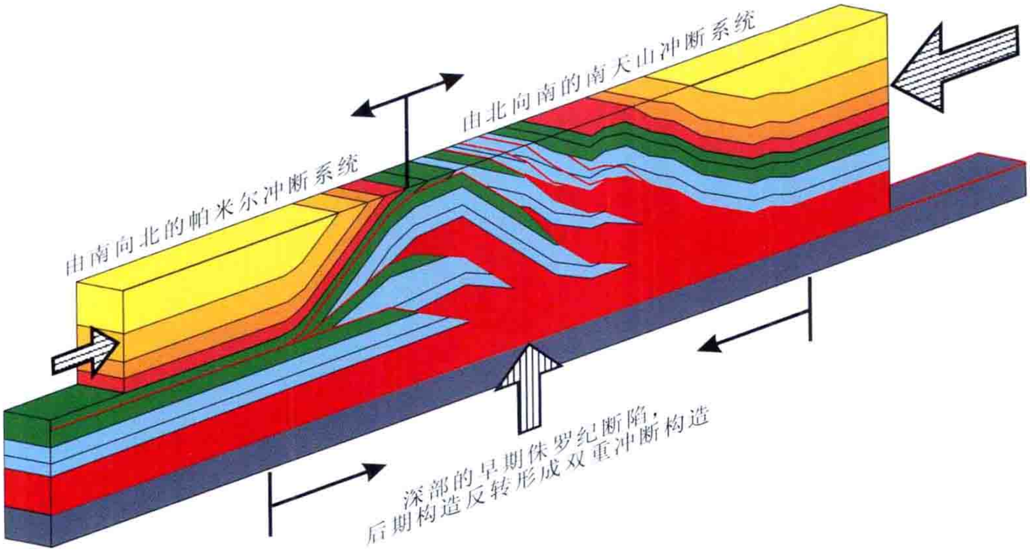
附图 3　南天山冲断带东段的变形模型(以 Ks99－561 剖面为例,见正文图 3-20)

注:主要的变形来自于南天山由北向南的冲断作用,浅层形成叠瓦式冲断构造,深层形成双重冲断构造和反冲系统。



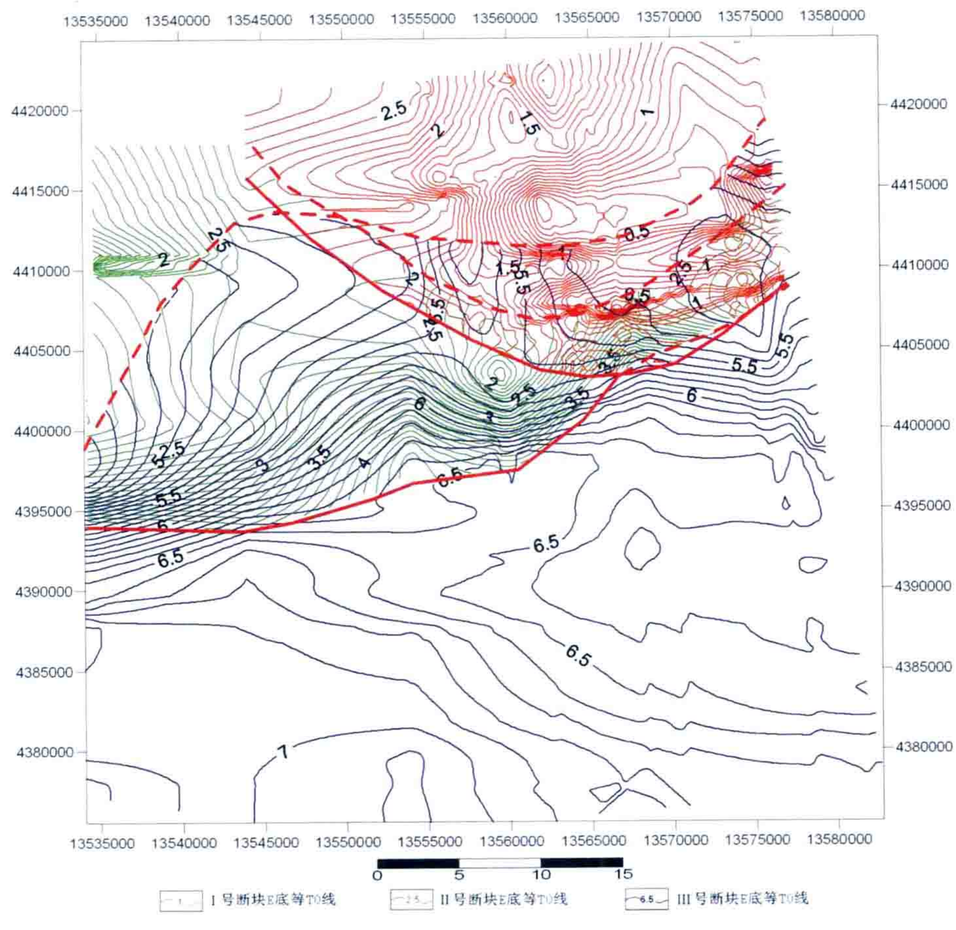
附图 4　喀什北缘中段的南天山冲断带的变形模型一(以 Ks01－544 剖面为例,见正文图 3-23)

注:变形来自于南天山由北向南地冲断作用,浅层形成叠瓦式冲断构造深层形成双重冲断构造和反冲系统。南侧形成由南向北的冲断作用。

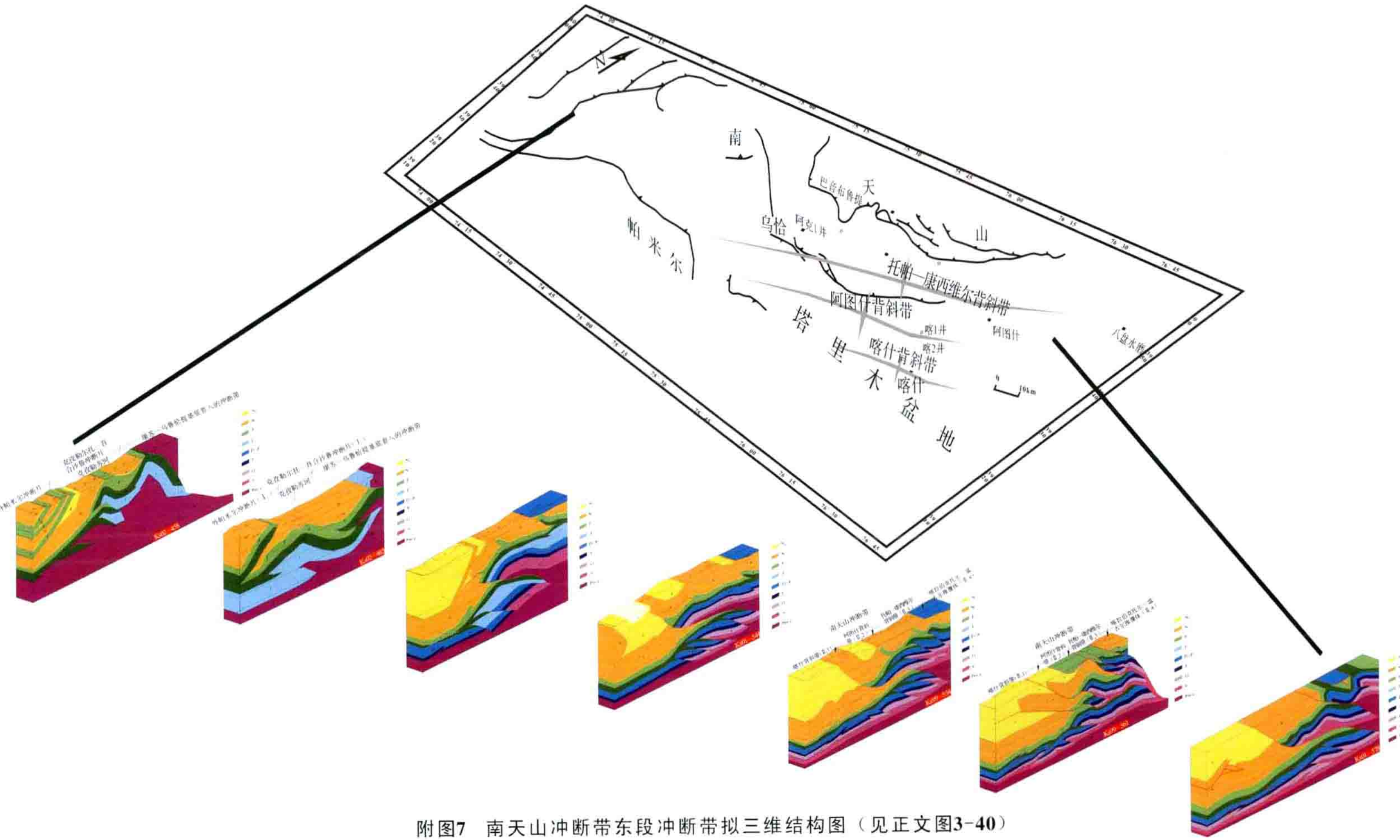


附图5　喀什北缘中段南天山冲断带的变形模型二(以Ks01－534剖面为例，见正文图3-24)

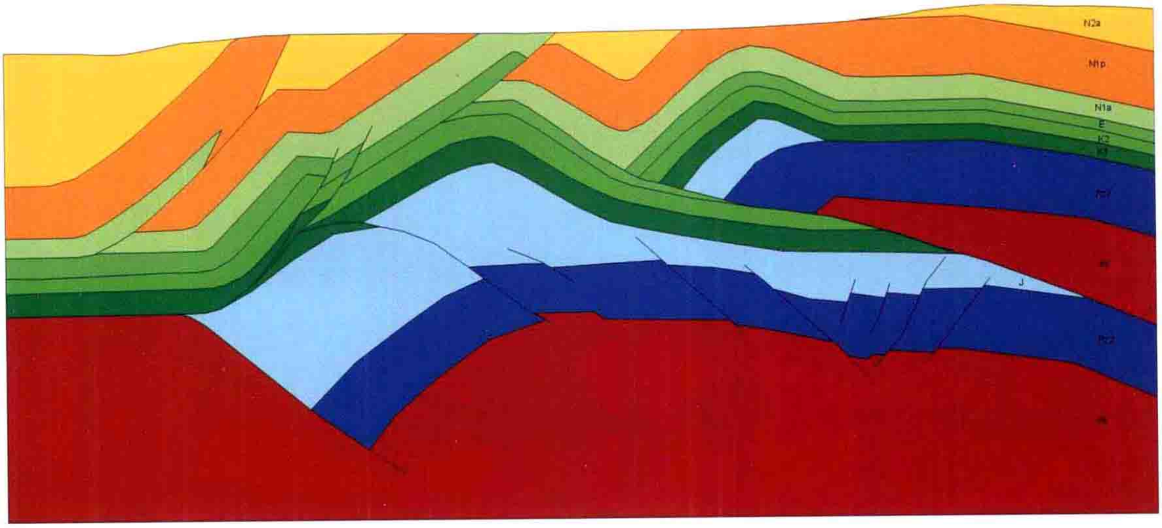
注：重点在于深部早期侏罗纪断陷盆地的后期构造反转作用。



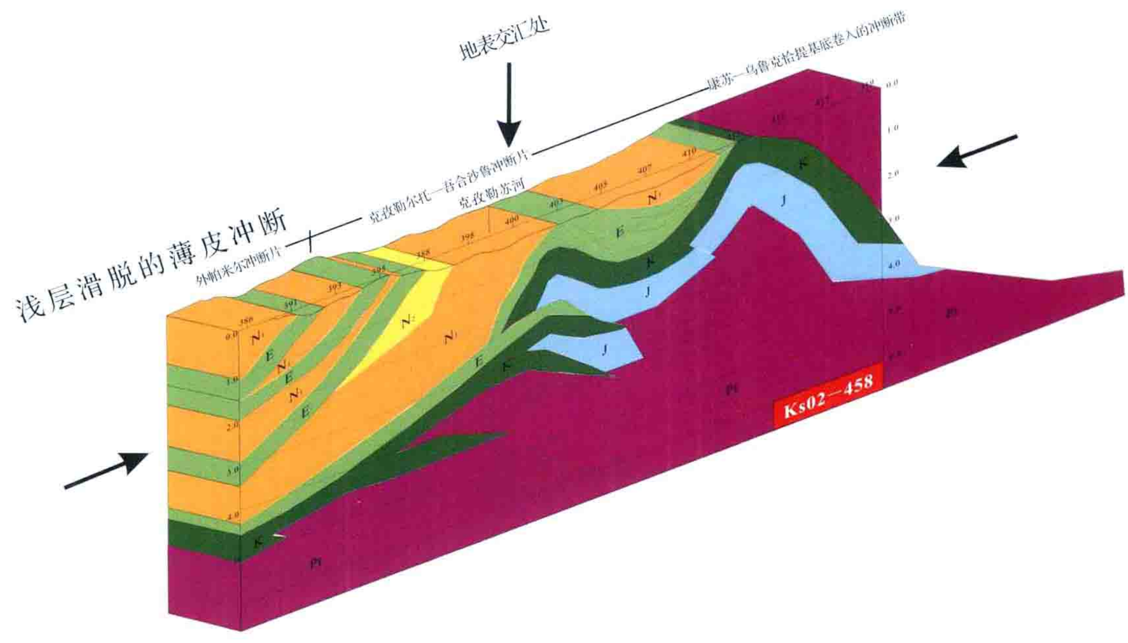
附图6　南天山冲断带东段三个断片的空间叠置图(见正文图3-39)



附图7　南天山冲断带东段冲断带拟三维结构图（见正文图3-40）



附图 8　ks01-L1 测线的地质解释剖面(见正文图 3-41)



附图 9　帕米尔逆掩推覆带的构造模型(以 Ks02—458 剖面为例,见正文图 4-9)

A

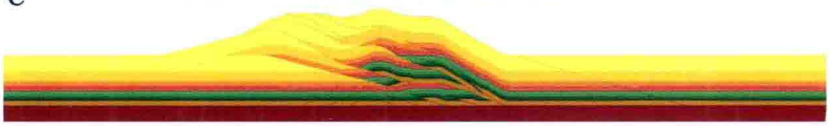
原始沉积层序

B

后缘叠瓦式冲断片形成

C

向前缘另外一个叠瓦式冲断片(喀什背斜)形成



D

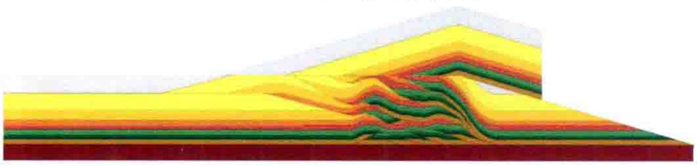
深部的双重冲断构造形成，浅层的叠瓦式冲断片最终形成
(喀什背斜和阿图什背斜形成)

E

深浅层构造变形的最终结果

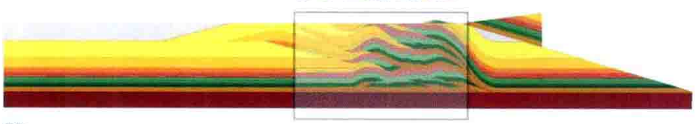
F

构造主体顶部的夷平作用



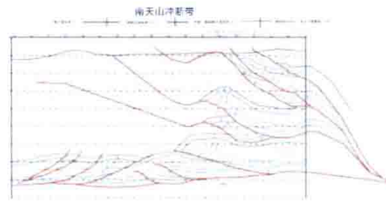
G

后缘冲断片的掩覆

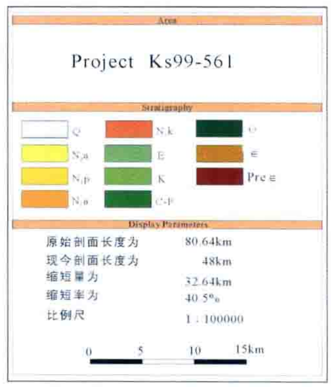


H

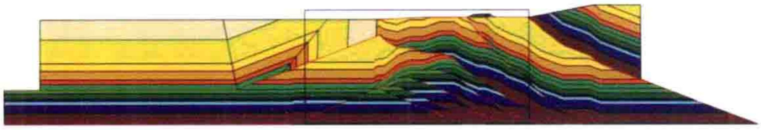
后缘大型推覆体的被剥蚀，飞来峰形成



原始剖面的解释结果

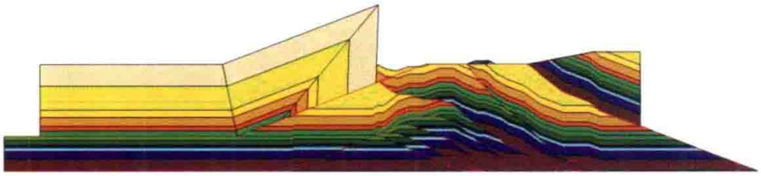


附图 10　ks99－561 剖面演化历史(见正文图 5-10)

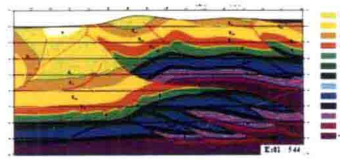


A　现今区域大剖面

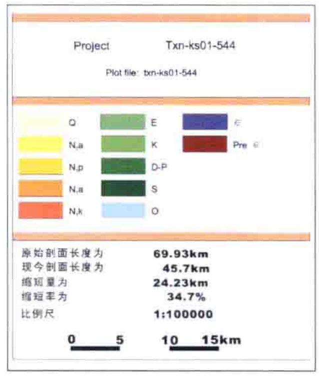
原始地震剖面

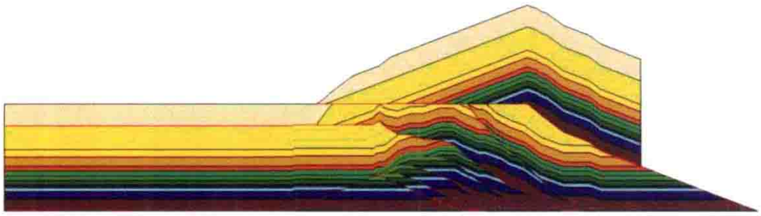


B　克拉托一明尧勒反向冲断片形成



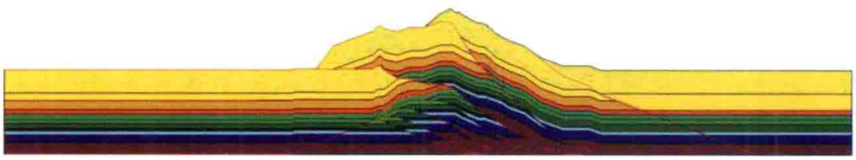
原始剖面的解释结果



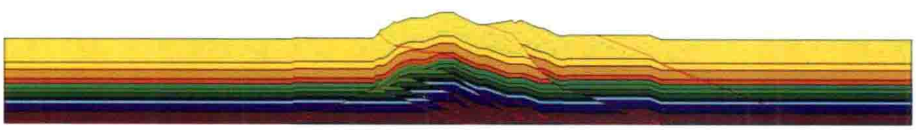


C　喀拉伯克托尔一温古尔推覆体形成

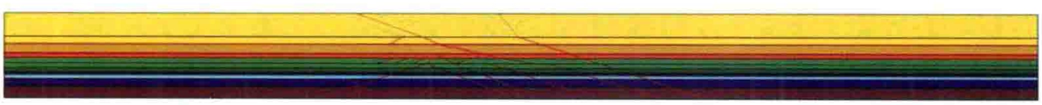
D　阿图什背斜带形成后的剥蚀夷平



E　阿图什背斜带形成

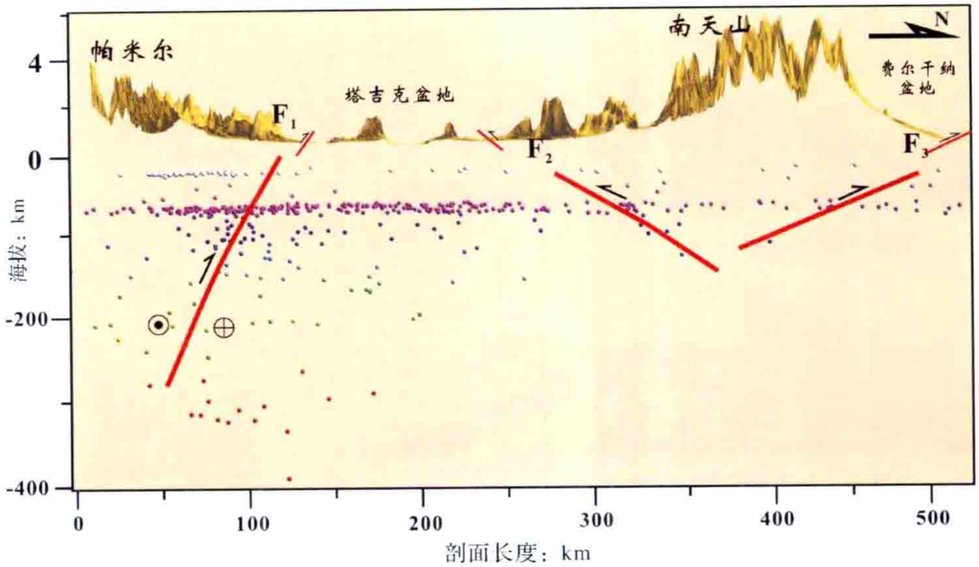


F　深部双重冲断构造形成

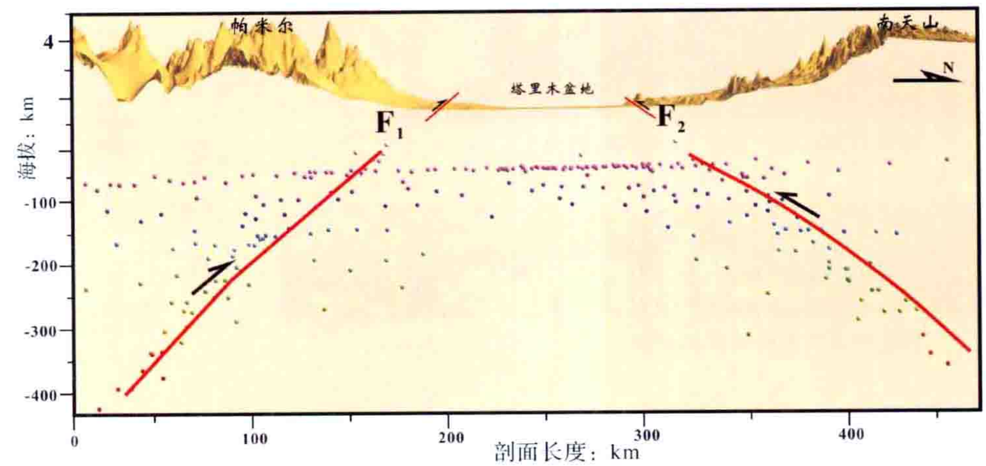


G　变形以前的原始沉积层序

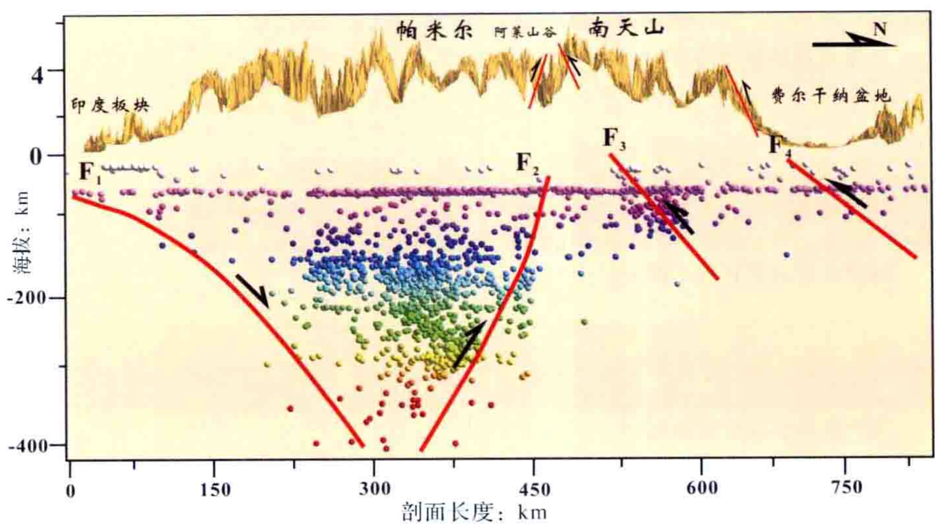
附图 11　Ks01－544 剖面演化历史图(见正文图 5-11)



附图 12　A—A′剖面天然地震震中分布图(剖面位置见图 6-9、图 6-10,见正文图 6-12)



附图 13　C—C′地震剖面及解释结果(剖面位置见图 6-9、图 6-10,见正文图 6-13)



附图 14　B—B′地震剖面及解释结果(剖面位置见图 6-9、图 6-10,见正文图 6-14)

序　言

塔里木盆地地处中国西北边疆，是我国最大的中、新生代陆相盆地，同时它又是一个叠加于古生代克拉通盆地之上的复合盆地，蕴藏着丰富的油气资源，是中国石油工业的重要战略基地之一。塔里木盆地西北端处于天山造山带与帕米尔造山带的对接部位，是研究新生代中亚大陆构造变形最为关键的地区，对于陆内造山和大陆动力学研究意义深远，因被视为学科的前沿领域而备受国内外学者关注。该地区是近年来油气勘探的主要目标之一，在我国的能源战略中的地位举足轻重。因此，本专著《塔里木盆地西北缘中、新生代构造特征及演化》具有重要的理论和实践意义。

本专著作者基于野外地质调查，对塔里木盆地西北缘南天山西段冲断带和西昆仑帕米尔冲断带的地质结构及演化历史进行了研究，综合地球物理、天然地震及钻井等大量实际资料，运用现代构造解析和地质建模理论，再现了南天山和西昆仑两大冲断体系的空间结构和彼此叠置关系，并在浅层构造解析的基础上，通过对天然地震资料的数据分析，进而完成了西昆仑(帕米尔)与南天山两大造山带深部俯冲和浅层推覆的空间大地构造模型，从而为该区中、新生代的盆地演化、基底结构分析研究和油气勘探实践建立了较可靠的依据和标准。

作者所研究的新生代浅层次地壳压缩、折叠及陆内山间盆地向两侧山带的深俯冲现象，曾经在20世纪初古地中海盆地向阿尔卑斯造山带潜没消减中得到最初的认识(Ampfere，1911)，即今之“A”型俯冲，并由此而感悟陆内造山的动力学来源。但在我国大陆山带陆间盆地研究中，大多以拉伸裂陷及继后褶皱隆起作解。本专著研究所揭示的塔里木盆地基底向山带俯冲现象及“盆—山”耦合体系，为当前发展中的陆内造山和动力学机制探索提供了新的启示，或也可“由浅及深”并“将今论古”而推及古大陆山间海盆向山根的深俯冲及引致其陆内深部流变结构的改变，从而有益于对陆内造山动力源和后造山变形活动的认知，此或正是本专著潜在的理论意义。而其对盆地结构构造的精细化勾画和描绘，对现今石油能源开发的规划、设计也当有现实的参考意义。因此，本专著的出版应受到欢迎。

本专著第一作者是一名年轻的地学博士，未来求索之路漫长，发展前景可期。谨望作者以本专著中的挽近地质浅层地壳变形研究为起点，进而深化和涉猎更为复杂的古造山带变形和深部结构以及大陆造山动力学问题。对于年轻的学者，野外地质调研实践和系统的多学科知识积累，将为迈步前进和不断跨越，提供坚实的、无尽的动力。

水　涛

2012 年 4 月 25 日

前　言

南天山西段冲断带和帕米尔冲断带形成于新生代晚期，并在塔里木盆地西北缘的喀什地区西部交接，彼此叠加以后导致各自构造要素发生交切、叠置、干涉和转换，冲断带结构异常复杂，使其成为前陆冲断带构造变形分析和叠加构造解析的最有利地区，深部地震资料的成像品质较差以及地质结构研究程度低下是制约该区油气勘探的主要因素。因此，对这两个冲断体系的空间结构和形成过程进行研究，再现其中、新生代的构造演化历史，是塔里木盆地乃至中亚地区非常重要的科学问题，并对油气勘探具有重要的指导意义。

本专著在结合野外地质调查、地球物理、天然地震及钻井等大量实际资料分析的基础上，运用现代构造解析和地质建模理论，对塔里木盆地西北缘南天山西段冲断带和西昆仑帕米尔冲断带的地质结构及演化历史进行了研究，并建立起研究区的构造地质模型，再现了两大冲断体系的空间结构和彼此叠置关系，为中、新生代的盆地演化历史提供了分析基础和初步结论。在浅层构造解析的基础上，通过对天然地震资料的数据分析，完成了西昆仑（帕米尔）与南天山两大造山带深部俯冲和浅层推覆的空间大地构造模型。

通过研究，作者认为，造成南天山西段冲断带横向差异性的主要控制因素有两点：一是中生代形成的控制断陷分布的断裂系统（费尔干纳断裂的一部分）的展布规律，这些断裂控制了侏罗纪沉积的分布；二是南天山和帕米尔构造系统空间对接位置在各个不同区域会改造南天山冲断系统的平面、剖面形态和构造体系的分布。据此将南天山西段冲断带的构造变形划分为东段、中段和西段三个区段，并综合利用多种资料，对其进行了详细的中尺度构造解析。在多条件约束下，通过多剖面的解析和结构分析，建立了塔里木盆地西北缘不同区段的2D构造变形模型，为本区的基础结构分析研究和油气勘探实践建立了较可靠的依据和标准。对研究区各个构造单元的重点剖面进行了正演模拟和反演恢复，计算出南天山西段冲断带各构造单元的缩短量和平均缩短速率，同时，作者认为，库孜贡苏断陷盆地自西向东发育了多个不对称的侏罗纪箕状断陷，断陷结构为西断东超，说明该盆地形成时主要物源来自于西部的"乌拉根隆起"，由此揭示了南天山西段冲断带东西部分古生界分布差异性的原因。新生代以来盆地受印藏碰撞的影响发生了构造反转。

本专著完成了三条穿过南天山和西昆仑（帕米尔）两大冲断体系表现浅层冲

断结构的区域地质剖面，认为帕米尔冲断系统的前锋为一弧形构造带，类似于一个表层的推覆体直接覆盖在南天山冲断带的冲断片之上，两者形成了交错叠置的关系；而南天山冲断带则大多形成深层次的冲断褶皱作用。从而在地理上划分了南天山和帕米尔冲断系统的构造分界线，即西部帕米尔冲断系统前锋弧形构造带以北的克孜勒苏河，往南沿克拉托—明尧勒背斜带以北断裂至喀什背斜带南侧恰克乌克达里亚河一线。

专著最后通过对天然地震剖面的解释，探索了南天山造山带、西昆仑（帕米尔）造山带和塔里木（塔吉克）地块的岩石圈大地构造关系。认为在东西两侧，塔里木（塔吉克）地块为南北直接俯冲于西昆仑（帕米尔）造山带和南天山造山带之下的双向俯冲模式；在中部地区，西昆仑造山带在帕米尔地区形成构造结并仰冲于南天山造山带的前陆冲断带之上，形成了两个新生代复活的巨型造山带，以及两大造山带与塔里木（塔吉克）地块之间的俯冲和对接关系，形成了独特的“盆—山”耦合体系。

钱俊锋

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Preface

The western segment of South Tienshan and Pamir foreland fold and thrust belts were formed during Late Cenozoic. They met with each in Kashi area, northwest of Tarim basin, causing the overlapping, cutting, interfering and transforming of structures with each other, which resulted in a more complex system. Because of the complexity in structure in Kashi area, it became one of the best places for structural analysis of the foreland fold and thrust belts and overlapped structures. However, the restriction of low quality of seismic profiles in the deep part and less knowledge of the subsurface structure makes the exploration of oil and gas in this area still in a lower level. Hence, researches of spatial structures, formation processes and Mz-Kz tectonic history of these two fold and thrust systems play an important role in the researches of Tarim basin and central Asia and can also guide the exploration of oil and gas.

Based on analysis of field-survey geological data, geophysical data, natural earthquakes and well data, the writer applied modern theories of structural analysis and geological modeling to the Kashi area, and established structural geological model. From the model, it is ready to see the spatial structures and overlapping relationship of the two fold and thrust systems. It is also a basis for research of Mz-Kz tectonic evolution history of the basin. After detailed structural analysis of the shallow part and the natural seismic data, a tectonic model of the West Kunlun (Pamir) and South Tienshan, from deep-level subduction to shallow-level thrusting was established. After this study, some innovative results are listed below.

(1) There are two main factors that might take responsibility for the lateral variability of the western segment of Southern Tienshan fold and thrust belt. One is the Mesozoic fault system (a part of Feierganna fault) which controls the distribution of fault subsidence and the Jurassic sequence. The other factor that causes the lateral variability is the spatial relationship of South Tienshan and Pamir. That is, in different parts of the western segment of South Tienshan, Pamir would influence the thrust pattern of South Tienshan differently, including the pattern in map view, the cross-section structures and the structural domains. Based on those, the authors divided the western segment of South Tienshan into three different parts from east to west, integrating and synthesizing all kinds of

data available, detailed medium-level structural analysis are done to different part of western segment of South Tienshan.

(2)Constrained by several conditions, structural analysis is made to build a 2D structural model for the different parts of the northwestern margin of the Tarim basin. This provides a basis for the structural analysis and oil and gas exploration in the study area as detail as possible. The author chose several important cross sections through each tectonic unit for forward modeling and inversion modeling and calculated the structural shortening amounts and shortening rates of the different parts of the western segment of South Tienshan and Wuboer fold and thrust belts. The shortening amount of the east part is 32.64—49.1 km, with a 40.5%—50.51% shortening ratio. The S-N shortening rate of the crust in Cenozoic is 9.12—13.72 mm/a. The shortening amount of the middle part is 24.23 km, with a 34.7% shortening ratio and a S-N 6.77 mm/a shortening rate of the crust in Cenozoic. The shortening amount, ratio, rate of Wuboer area is 32 km, 40.2%, 7.17 mm/a, respectively.

(3) The Kuzigongsu fault subsidence has several asymmetric half-graben depressions from west to east. These half grabens are characteristic of west-faulting and east-overlapping. According to this phenomenon, the source of the sediments may be mainly from "Wulagen Uplift" to the west when the basin formed. During the Cenozoic, the basin was inversed affected by India-Tibet collision.

(4)Three long cross-sections across the two fold and thrust belts that reveal the shallow structural of the thrusting were constructed. It seems that the frontier of Pamir fold and thrust belts is an arcuate structural belts, which is a surficial nappe overlapping the thrust sheets of the South Tienshan that formed the overlapping relation. The South Tienshan fold and thrust belts mostly have deep-level folding and thrusting. The geographic boundary of South Tienshan and Pamir fold and thrust belts is plotted: in the west it is along Kezilesu River north to the arcuate frontier of Pamir fold and thrust belts, then the north fault of Kelatuo-Minraole anticline belts, finally along the Qiakewukedaliya River that separates the Kelatuo-Minraole anticline belts and Kash anticline belts.

(5) After interpreting natural earthquakes since 1953, the author also did a exploratory research on the lithospheric tectonic relationship of South Tienshan orogen, and considered in west and east side, West Kunlun (Xindukushi) orogen and Tarim (Tajike) block, and considered that Tarim (Tajike) block subducts beneath the West Kunlun (Pamir) orogen and South Tienshan orogen in two direction; In Pamir area, a syntaxis formed with the West Kunlun (Pamir) orogen obducts upon the South Tienshan orogen, and result in the two great orogens that rejuvenated during Cenozoic and the subduction and jointing relationship of the two orogens and Tarim (Tajike) block, showing a specific basin-and-range coupling system.