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The journal is also included in the Emerging Sources Citation Index (ESCI) of the Web of Science platform (Clarivate Analytics, since 2018).

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«Қазақстан Республикасы Ұлттық ғылым академиясының Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналы 2016 жылдан бастап халықаралық реферативтік және ғылымиметриялық Scopus дерекқорында индекстеледі және тұрақты библиометриялық көрсеткіштерді көрсетіп келеді.

Сонымен қатар журнал Web of Science платформасының (Clarivate Analytics, 2018) халықаралық реферативтік және наукометриялық дерекқоры Emerging Sources Citation Index (ESCI) тізіміне енгізілген.

ESCI дерекқорында индекстелуі журналдың халықаралық ғылыми рецензиялау талаптары мен редакциялық этика стандарттарына сәйкестігін растайды, сондай-ақ Clarivate Analytics компаниясы тарапынан басылымды Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) және Arts & Humanities Citation Index (AHCI) дерекқорларына енгізу қарастырылуда.

Scopus және Web of Science дерекқорларында индекстелуі жарияланымдардың халықаралық деңгейде жоғары сұранысқа ие болуын қамтамасыз етеді, олардың дәйексөз алу көрсеткіштерінің артуына ықпал етеді және редакциялық алқаның геология мен техникалық ғылымдар саласындағы өзекті, бірегей және ғылыми тұрғыдан маңызды зерттеулерді жариялауға ұмтылысын айқындайды.

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Журнал также включён в международную реферативную и наукометрическую базу данных Emerging Sources Citation Index (ESCI) платформы Web of Science (Clarivate Analytics, 2018).

Индексирование в ESCI подтверждает соответствие журнала международным стандартам научного рецензирования и редакционной этики, а также рассматривается компанией Clarivate Analytics в рамках дальнейшего включения издания в Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI) и Arts & Humanities Citation Index (AHCI).

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GEOTHERMAL REGIME AND CONTEMPORARY TECTONICS OF THE SOUTH TORGAI SEDIMENTARY BASIN

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Abstract. *Relevance.* The South Turgay Sedimentary Basin occupies a transitional position between the Turan Plate and the Kazakhstan Fold Belt. Its geothermal field and Neogene–Quaternary crustal movements provide important evidence for evaluating the present energy state, inherited structure, and geodynamic evolution of the lithosphere. *Objective.* The study aims to determine how the regional thermal field and recent crustal movements reflect the deep structure and rift-related evolution of the South Turgay Sedimentary Basin. *Methods.* Published and archival borehole-temperature and heat-flow data were integrated with rock thermal-conductivity estimates, crustal-temperature maps at depths of 10 and 30 km, neotectonic maps, seismic data, gravity and magnetic-field transforms, and laboratory core analyses. Local heat-flow anomalies were smoothed within 20–30 km neighbourhoods, and recent crustal movements were interpreted using a modified morphostructural mapping approach. *Results.* Heat flow within most of the basin is 40–50 mW/m², decreasing to 40–45 mW/m² in its southern part. Temperatures are generally 200–250 °C at 10 km depth and 700–800 °C at 30 km depth. Neogene–Quaternary uplift amplitudes are predominantly +50–150 m, which are lower than in the adjacent Shu–Sarysu Depression and Lower Syrdarya Uplift. The Moho occurs at depths of 40–48 km and locally coincides with a tectonically active mantle layer 10–16 km thick. *Conclusions.* The South Turgay Sedimentary Basin is characterized by a relatively cold upper crust, a warmer and dynamically active lower crust, and weak recent uplift. The combined geothermal, gravimetric, magnetic, and neotectonic evidence supports its inherited riftogenic origin and indicates that deep faults exert spatially variable control on heat and fluid transfer.

Keywords: Modern Earth crust movements (MECM), heat flow, geothermal anomalies, thermal conductivity, South Turgay Sedimentary Basin, Regional Thermal Field, rifting

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ОҢТҮСТІК ТОРҒАЙ ШӨГІНДІ БАССЕЙНІНІҢ ГЕОТЕРМИЯЛЫҚ РЕЖИМІ ЖӘНЕ ЕҢ ЖАҢА ТЕКТОНИКАСЫ

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Аннотация. *Өзектілігі.* Оңтүстік Торғай шөгінді бассейні Тұран плитасы мен Қазақстан қатпарлы облысының аралығындағы өтпелі аймақта орналасқан. Оның геотермиялық өрісі мен неоген-төрттік жер қыртысы қозғалыстары литосфераның қазіргі энергетикалық күйін, мұраланған құрылысын және геодинамикалық эволюциясын бағалаудың маңызды көрсеткіштері болып табылады. *Мақсаты.* Аймақтық жылу өрісі мен ең жаңа жер қыртысы қозғалыстарының Оңтүстік Торғай шөгінді бассейнінің терең құрылысын және рифтогендік эволюциясын қалай бейнелейтінін анықтау. *Әдістері.* Ұңғымалық температуралар мен жылу ағыны жөніндегі жарияланған және мұрағаттық деректер, тау жыныстарының жылу өткізгіштігін бағалау нәтижелері, 10 және 30 км тереңдіктердегі жер қыртысы температурасының карталары, неотектоникалық карталар, сейсмикалық материалдар, гравитациялық және магниттік өрістердің трансформанттары, сондай-ақ кернді зертханалық зерттеу нәтижелері біріктірілді. Жергілікті жылу ағыны аномалиялары 20–30 км аралығында тегістеліп, ең жаңа қозғалыстар модификацияланған морфоқұрылымдық карталау әдісімен түсіндірілді. *Нәтижелері.* Бассейннің басым бөлігінде жылу ағыны 40–50 мВт/м², ал оңтүстік бөлігінде 40–45 мВт/м²-ге дейін төмендейді. Температура 10 км тереңдікте негізінен 200–250 °С, ал 30 км тереңдікте 700–800 °С құрайды. Неоген-төрттік көтерілу амплитудалары көбіне +50–150 м болып, іргелес Шу–Сарысу ойысы мен Төменгі Сырдария көтеріліміндегі мәндерден төмен. Мохо шекарасы 40–48 км тереңдікте орналасып, кей жерлерде қалыңдығы 10–16 км тектоникалық белсенді мантия қабатымен сәйкес келеді. *Қорытындылар.* Оңтүстік Торғай шөгінді бассейні салыстырмалы түрде салқын жоғарғы қыртыспен, неғұрлым қызған және динамикалық белсенді төменгі қыртыспен, сондай-ақ әлсіз ең жаңа көтерілулермен сипатталады. Геотермиялық, гравиметриялық, магниттік және неотектоникалық деректер жиынтығы бассейннің мұраланған рифтогендік табиғатын растап, терең жарылымдардың жылу мен флюидтерді тасымалдаудағы рөлінің кеңістікте әркелкі екенін көрсетеді.

Түйін сөздер: жер қыртысының соңғы қозғалысы, жылу ағындары, геотермиялық ауытқулар, эндогендік режим, Оңтүстік Торғай шөгінді бассейні, рифтогенез

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ГЕОТЕРМИЧЕСКИЙ РЕЖИМ И НОВЕЙШАЯ ТЕКТОНИКА ЮЖНО-ТОРГАЙСКОГО ОСАДОЧНОГО БАССЕЙНА

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Аннотация. *Актуальность.* Южно-Торгайский осадочный бассейн занимает переходное положение между Туранской плитой и Казахстанской складчатой областью. Его геотермическое поле и неоген-четвертичные движения земной коры являются важными индикаторами современного энергетического состояния литосферы, унаследованного тектонического строения и геодинамической эволюции региона. *Цель.* Установить, каким образом региональное тепловое поле и новейшие движения земной коры отражают глубинное строение и рифтогенную эволюцию Южно-Торгайского осадочного бассейна. *Методы.* Обобщены опубликованные и архивные скважинные данные о температуре и тепловом потоке, оценки теплопроводности горных пород, карты распределения температур в земной коре на глубинах 10 и 30 км, неотектонические карты, сейсмические материалы, трансформанты гравитационного и магнитного полей, а также результаты лабораторного изучения керна. Локальные аномалии теплового потока сглаживались в радиусе 20–30 км, а новейшие движения земной коры интерпретировались с применением модифицированного метода морфоструктурного картирования. *Результаты.* На большей части территории бассейна тепловой поток составляет 40–50 мВт/м², снижаясь в южной части до 40–45 мВт/м². Температура земной коры преимущественно составляет 200–250 °C на глубине 10 км и 700–800 °C на глубине 30 км. Амплитуды неоген-четвертичных поднятий в основном достигают +50–150 м и являются более низкими, чем в прилегающих Шу-Сарысуйской впадине и Нижнесырдарьинском поднятии. Поверхность Мохоровичича залегает на глубине 40–48 км. На отдельных участках её положение пространственно совпадает с тектонически активным мантийным слоем мощностью 10–16 км. *Выводы.* Южно-Торгайский осадочный бассейн характеризуется относительно холодной верхней корой, более прогретой и динамически активной нижней корой, а также слабо выраженными новейшими поднятиями. Совокупность геотермических, гравиметрических, магнитных и неотектонических данных подтверждает унаследованную рифтогенную природу бассейна и указывает на пространственно неоднородную роль глубинных разломов в процессах переноса тепла и флюидов.

Ключевые слова: Современные движения земной коры (СДЗК), тепловой поток, геотермические аномалии, теплопроводность пород, эндогенный режим, Южно-Тургайский осадочный бассейн

Introduction. The study of temperatures as an indicator of the current energy state of the lithosphere aims to identify anomalies that characterize its endogenous regime, thereby enhancing the understanding of the causes of contemporary geodynamic processes, particularly in regions with intense neotectonic movements.

This research focuses on study the geological structure, thermal regime, and Modern Earth crust movements (MECM) of the South Torgay Sedimentary Basin (STSB) to identify endogenous processes influencing the region's geodynamic evolution and to assess their impact on the present state and formation of the lithosphere.

To achieve this goal, three objectives have been set:

1. Comprehensive geothermal studies were conducted at various depth intervals, and evaluation of the thermal conductivity of rocks. These data will enable the creation of detailed thermal regime models for the crust of STSB, which can be used for both applied and scientific purposes.

2. Identification of active tectonic processes that have occurred during the most recent geological periods, with a particular focus on their direct influence on the formation of Earth's crustal relief. This includes an in-depth analysis of

fault structures, uplifts, subsidence zones, and other morphostructures shaped by contemporary tectonic activity.

3. Valuable insights into deep geothermal, density, geomagnetic, and structural heterogeneities at various lithospheric levels were obtained through the comprehensive interpretation of seismic, gravity, magnetic, and geothermal data. These insights were correlated with the current tectonics and geological history of the STSB, providing a foundation for further research into geodynamic processes in this region of Kazakhstan.

The resolution of these above-mentioned objectives holds significant importance for planning geological exploration, the discovery and assessment of mineral deposits, and for understanding both the current and past geological processes in the STSB.

Study Area and Geological Setting. Structurally, STSB is bounded to the east and southeast by the submeridionally oriented Ulutau mega-anticlinorium and the mountain-fold structures of the Greater Karatau, which separate it from the Shu-Sarysu Depression (SSD). To the west, the STSB adjoins the subsidence zone of the Lower Syrdarya Uplift (LSU), while to the north, it transitions into the Zhylanshik Depression. In the south and southwest, the basin is delineated by the Great Karatau Fault (MKF).

The present structural configuration of the submerged horizons in the STSB has been well-defined through seismic surveys. These data reveal that the basin consists of the Zhylanshik Depression in the north and the Aryskum Depression in the south, separated by the Mynbulak Saddle (Fig. 1).

These three major structures are further complicated by higher-order structural elements. According to geological and geophysical data, as well prospecting, exploration and production drilling, the STSB is characterized by the presence of uplifted horst-anticlines and subsided basement blocks-graben-synclines.

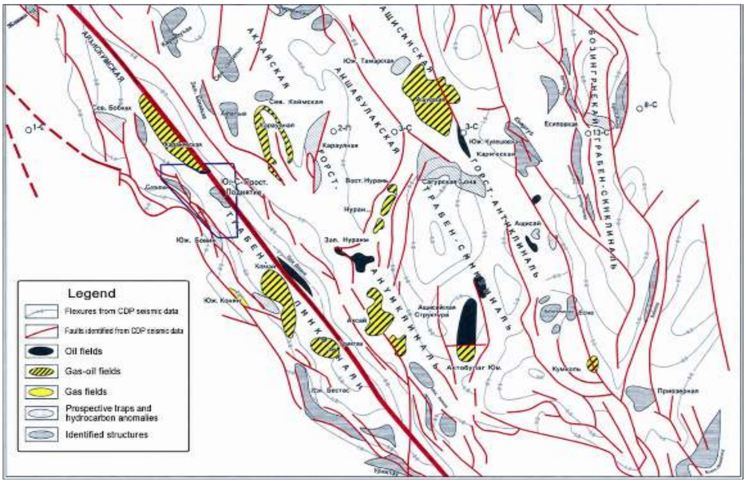

Figure 1. Tectonic Map of the South Turgay Basin.

The basin fill comprises Meso-Cenozoic sedimentary strata, which can be subdivided into two structural levels: a taphrogenic (riftogenic) Jurassic system and a platform-type Cretaceous–Paleogene system, as suggested by some researchers (Cook et al., 1995). Alternative interpretations propose a threefold subdivision, distinguishing the lower basement, the middle quasi-platform level, and the upper platform level (Zholtaev et al., 1998).

The origin and formation conditions of occurring the crystalline basement rocks in the STSB remain a subject of debate.

The basement is composed of various deeply metamorphosed Precambrian rocks, analogous to the Bekturgan and Maitobe series of the Ulutau region, which are of Proterozoic age, locally extending into the Lower Paleozoic (Cambrian-Ordovician), (Daukeev et al., 2002; Paragulgov et al., 2013).

The origin and formation processes of the crystalline basement rocks in the STSB remain a topic of ongoing discussion. The basement consists of deeply metamorphosed Precambrian rocks, correlated with the Bekturgan and Maitobe series of the Ulutau region, predominantly of Proterozoic age, with local extensions into the Lower Paleozoic (Cambrian-Ordovician) (Daukeev et al., 2002; Paragulgov et al., 2013).

In this context, the basement rises stepwise toward the east. Its greatest depth occurs in the central part of the basin and within the MKF zone. To the east, basement outcrops are exposed in the Ulutau mega-anticlinorium. The axes of anticlinal structures align with the strike of horst-anticlines and graben-synclines, confirming the crucial role of these structures in their formation.

It is assumed that the block structure of the STSB basement was generated in the Lower Paleozoic along deep faults.

In the Middle Paleozoic, such tectonics led to the accumulation of formations of various thicknesses. For this reason, the overlying Mesozoic sediments sometimes lie on the Precambrian folded basement, and in some places on the quasi-platform structural level. (Daukeev et al., 2002; Paragulgov et al., 2013).

The heterogeneous basement of the STSB is submerged at depths of 6,500–7,000 m in the Aryskum Depression (in the south-western part of the STSB). Consequently, the sedimentary cover here reaches a maximum thickness of up to 7,000 m and is predominantly composed of by terrigenous sediments.

The petrographic composition, degree of metamorphism, and age of the basement formations were determined thtough the core samples. The oldest rocks, dated to the Lower Proterozoic, include grayish granito-gneiss complexes, comparable to the leucocratic gneisses of the Bekturgan series in Ulutau. The series were identified in several areas of the Aryskum Depression (Kumkol, Takyrsai field, Doshan, Akshabulak, Aryskum HC fields, and others).

In the basement of the Zhylanshik Depression (in the northern STSB), amphibolitized gabbros were discovered in the Uzynshik structure at a depth of 2,924–2,931 m in well 1-G (Paragulgov et al., 2013).

Analogs of the pre-Vendian formations of the B. Karatau Range include quartz-muscovite schists encountered in wells 14-S, 2p-Sazymbay, and others. The main rocks are composed of quartz, plagioclase, and chloritized muscovite and chloritized muscovite, with secondary epidote, dolomite, and minor inclusions of apatite and ore minerals. In some areas, microfracture cavities are filled with calcite (Li et al., 2017).

The Vendian rock complex comprised with greenish-gray and black siliceous schists and siltstones, penetrated in several wells (Kyzylkiya- 4-s, 6-s, 6, etc.). These rocks correlate with the Ulutau series of the Greater Karatau region.

The overlying intermediate (quasi-platform) structural level, according to (Zholtaev et al., 1998), has a potential for hydrocarbon exploration. It consists of Upper-Middle Paleozoic rocks and has a sporadic distribution.

This structural level has been extensively studied through deep drilling and geophysical studies, at least in its upper part. It is characterized by a drastic angular and stratigraphic unconformityrelative to the overlying and underlying rock assemblages. Boreholes have explored it in the northwestern part of the Aryskum Depression and the western half of the Mynbulak Saddle.

The structural differentiation of the intermediate structural level is quite distinct, allowing for the confident delineation of a system of submeridionally oriented, predominantly linear graben-synclines, extending for distances of up to 100–150 km and with widths ranging from 20 to 30 km.

In the STSB, three major deep-seated, linear, and fan-shaped grabens can be confidently traced from west to east: the Aryskum, Akshabulak, and Bozingen. Additionally, and three smaller grabens-Sarylan, Arys, and Dautskaya-are identified. These structures are bounded at the bottom of the sedimentary cover (Pz basement) by high-amplitude tectonic faults (Figure 1).

The upper structural level, comprising the entire Mesozoic-Cenozoic sediments, is divided into two levels: the lower- rift level and the upper - epirift (orthoplatform) level. The structural level has been most thoroughly studied through deep drilling and geophysical exploration. Its structural separation is well-defined, allowing for the confident delineation of a system of sub-meridionally oriented, predominantly linear grabens separated by horsts (Paragulgov, 2013; Konyrbekov, 2015; Abetov, 2023; Zholtaev, 1996).

In the grabens, the base of the sedimentary cover descends to depths of 5–6 km, whereas on horsts, it rises to 1–2 km, and along the margins of the STSB, it reaches a first few hundred meters. Faults with amplitudes of up to 1–1.5 km contribute to the asymmetry of graben-synclines, particularly in the Aryskum and Bozingen grabens.

A relatively high degree of drilling exploration, considering the structural characteristics of the Mesozoic section of the sedimentary strata, allows for the identification of several characteristic stratigraphic sections that provide the most comprehensive understanding of the geological parameters of the STSB. Notable examples include the Ariskum, Sarylan, Akshabulak, Bozingen, and Mynbulak reference sections.

The STSB that control the distribution of hydrocarbon accumulations across the area and within the stratigraphic sections allow the identification of two key petroleum systems: the regionally oil-gas play within the Jurassic and Neocomian strata, and the zonal petroleum play associated with the weathered crust of pre-Mesozoic formations.

To date, 17 oil and gas fields have been discovered in the STSB. Among these, two fields—Arys and South Konys—are gas-condensate fields, while the rest are oil or gas-condensate-oil fields. The largest fields in terms of oil reserves are Kumkol, Akshabulak, and Konys.

Vintage data. The main results of Heat flow (HF) studies across Kazakhstan, including the STSB, have been presented in publications by T. Ashirov, Yu. N. Zuev, B. B. Tal-Virsky, and others (Akhmetova et al., 1993; Ashirov, 1985; Ashirov et al., 1975; Ashirov et al., 1976; Zuev et al., 1977; Zuev et al., 1983; Kropotkin 1983; Vilyaev et al., 1994) HF values were determined in approximately 250 boreholes.

Thermal conductivity, a key parameter for HF calculations, was measured using various methods (Gordienko et al., 1990; Tleubergenova et al., 2022) leading to significant variations (up to 30%) for rocks of similar age and composition by different authors. These discrepancies might reflect actual differences in the formation conditions of the Paleogene-Neogene sedimentary sequences.

The results of HF studies in Kazakhstan were incorporated into the 1991 HF map of the former USSR, scaled at 1:5,000,000, edited by V. V. Gordienko and U. I. Moiseenko. The Kazakhstan section of this map was compiled by Yu. A. Kalashnikov and Yu. G. Schwartzman (1991).

Regional HF and crustal-temperature maps of Kazakhstan at a scale of 1:500,000 were subsequently compiled by A.U. Abdullayev (2002). The maps were prepared by refining earlier cartographic materials and synthesizing available geothermal, hydrogeothermal, and thermal-water data (Zhevago, 1972; Kalmurzaev et al., 1981; Moiseenko et al., 1982, 1983; Duchkov et al., 2003; Vilyaev et al., 2004). The dataset included direct borehole HF measurements from boreholes at depths of approximately 300–400 m to more than 3,000 m.

MECM of the Earth's crust and the role of deep faults in the geodynamics of the STSB during the Neogene-Quaternary have long been the focus of attention for many researchers, including V.S. Burtman (1964), L.B. Wongaz (1956), N.P. Kostenko (1964), Rantsman (1967), N.M. Sinitsyn (1960), V.N. Ogneva (1964), A.I. Suvorov (1968), N.I. Nikolaeva (1988), V.I. Popov (1972), V.G. Trifonov (1988), and others.

Their studies resulted in tectonic and geodynamic maps to classify various geodynamic systems, including the features of neotectonics and contemporary tectonic processes. Key maps include the Map of Modern Tectonics of Southern USSR (Scale: 1:1,000,000, edited by L.P. Polkanova, published in Moscow, 1972), the Geodynamic Map of the USSR and Adjacent Offshore Areas (Scale: 1:10,000,000, edited by A.A. Smyslov et al., published by All-Russian Geological

Research Institute of A.P. KarpinskyLeningrad, 1982), the Map of Quaternary Sediments of Kazakhstan (Scale: 1:1,500,000, edited by N.N. Kostenko, published in Alma-Ata, 1978), and the Map of Active Faults of Southeastern Kazakhstan and Their Seismic Potential, sourced from Map and Quantitative Characteristics of Active Fault Zones of the USSR by A.V. Timush (presented in the abstracts of the XXV All-Union Tectonic Conference, Moscow, 1991). Additionally, a map referenced under number (Smyslov et al.,1982) (Geodynamic map of the USSR territory and adjacent water areas]. VSEGEI, Leningrad, 53 p.) is mentioned.

Despite a substantial amount of G&G knowledge, the creation of detailed geodynamic maps for modern stages of evolution remains underexplored. Many existing maps depict tectonic and structural processes at global or regional scales, which complicates their application at the local level.

Nevertheless, the methodological approaches developed for the Geodynamic Map of the USSR and Adjacent Offshore Areas (in Scale: 1:10,000,000, edited by A.A. Smyslov, published by All-Russian Geological Research Institute of A.P. Karpinsky, 1982) have served as a basis for the creation of similar maps adapted to modern tectonic processes in Kazakhstan.

According to V.G. Trifonov et al (1988), who focuses on neotectonics and modern geodynamics, the relationships between modern structures and the specific features of the lithosphere in certain regions are analyzed. This approach examines tectonotypes, which represent various geodynamic conditions for the formation of structures.

A significant, if not defining, role in newest crustal movements is attributed to deep faults. The works of V.N. Ognev (1939–1954), V.S. Burtman (1961–1964), T.A. Dodonova (1962), and V.G. Korolev (1962) highlighted right-lateral strike-slip movements along the Talas-Fergana Fault and its northwestern extension, the Great Karatau Fault (MKF), which began in the Late Paleozoic and continue to the present day.

The concept of right-lateral strike-slip movements was further developed in the studies of V.S. Burtman, L.B. Wongaz, E.Ya. Rantsman (1967), and other researchers. These movements have persisted into the modern era, as confirmed by the work of N.I. Nikolaeva and colleagues (1962, 1988).

At the same time, an alternative perspective exists. For instance, N.M. Sinitsyn (1960) argued that strike-slip displacements along the Talas-Fergana Fault were not significant and suggested that the fault is more appropriately classified as a marginal structure.

According to N.P. Kostenko (1961, 1964), structural elements along the northwestern extension of the Talas-Fergana Fault can be traced without significant horizontal displacement, which does not support the concept of right-lateral strike-slip movement of crustal blocks along the MKF.

A similar conclusion was reached by V.I. Popov and colleagues (1955, 1972), who classified the MKF and the Talas-Fergana Fault as discordant faults. These are defined as major faults that are syngenetic with sedimentation processes, dividing areas of conform and unconform sediment accumulation on either side of the fault. These areas show no significant differences in thickness or facies composition.

A.I. Suvorov (1968), analyzing the Neogene-Quaternary deep faults of Central Asia and recognizing the significant role of vertical, primarily uplift movements over large areas, against which subsidence of individual blocks occurred, noted that the origin of the vast majority of Neogene-Quaternary faults in Kazakhstan and Central Asia can be fully explained by meridional compressional stresses.

At the same time, according to A.I. Suvorov, horizontal displacements became widespread only to the southwest of the Talas-Fergana Fault, in the Central Tien Shan region.

Materials and methods. *Thermal conductivity of rocks.* The key parameter characterizing the geothermal field and reflecting the intensity and direction of geodynamic processes in the lithosphere is the *HF*—the most informative geothermal characteristic. It represents the power of heat sources and the amount of heat loss from the Earth's surface. Data on HF enable the assessment of the distribution of subsurface temperatures and the thermal lithosphere's capacity.

Thermal conductivity of rocks is typically determined under laboratory conditions using rock core samples obtained from deep and ultra-deep boreholes.

In practice, HF is predominantly measured vertically in boreholes that have been "at rest" for at least 30–50 days after the completion of drilling. This period allows for the dissipation of thermal disturbances caused by drilling and mud circulation, enabling the borehole fluid temperature to approach the temperature of the surrounding rocks.

The values of this parameter depend on the composition of the rocks, as noted by Bashenina, (1977).

However, it should be noted that the accuracy of HF determination remains low, primarily due to two factors: the widespread use of temperature data obtained by geophysical organizations for various industrial purposes and the very limited volume of thermal conductivity measurements of rock samples from boreholes.

Under these circumstances, the authors of the study had to largely extrapolate thermal conductivity data obtained from outside the STSB to rocks of similar composition formed under comparable geological conditions.

Observations of regional HF (HF) are often distorted by numerous local anomalies, many of which are represented by only one or two measurements. The causes of these disturbances are generally unknown. Only confinement to certain structures of small size indicates possible sources of the anomalies. They are probably related to convective heat transfer.

Therefore, smoothing of local anomalies was carried out by filtering them at nearby observation points within distances of 20–30 km. This smoothing, while necessary for filtering local anomalies that distort the regional HF background, inherently reduces the density of observational networks and may exclude valuable information.

However, such adjustments are essential when addressing the impact of local anomalies on the interpretation of regional HF patterns (Bashenina, 1976).

The averaging process provides a means to assess the accuracy of HF values by incorporating not only instrumental and methodological errors but also unaccounted disturbances in the form of local anomalies. The deviation from the mean HF value is approximately 20%, though in one-third of the observation points, deviations can reach up to 30%. Consequently, strict standards are required for drawing HF isolines on maps.

Considering the number of observational points and the averaged HF values for each, the overall mean error is approximately 17%. This emphasizes the importance of maintaining high-quality data for regional HF studies and ensuring precise methodologies in the creation of HF maps.

Modern Earth crust movements (MECM). The data also underscore the importance of considering neotectonic activity, which can introduce additional variability and affect the interpretation of regional and local HF anomalies.

The formation of the current relief is closely tied to *Alpine tectogenesis,* including modern tectonic movements. There were two fundamentally different points of view on the process of landform formation.

According to N.G. Kassin (1960), the primary cause of formation of large landforms (morphostructures) is clastic movements along faults, and according to S.S. Shultz (1948) - the latest fold deformations. He identified the modern ridges with the latest anticlines and troughs with synclines. The folded structures of Cenozoic (Paleogene-Neogene and Quaternary) sediments are a reflection of deformations of the Paleozoic basement surface (epihertzinic leveling surface).

In our studies, the *Late Alpine tectonic stage (Late Oligocene–Quaternary)* was taken as the basis for understanding relief formation. This stage is responsible for an independent cycle of erosion and denudation geomorphology, during which the modern relief of *STSB* evolved, strongly associated with modern morphostructures.

The general principles of mapping MECM have been addressed by many geologists, primarily due to their importance in resolving issues related to modern tectonics. The diversity of methodologies and principles for compiling maps of modern movements has resulted in a wide variety of map legends. These principles provide a critical framework for understanding the dynamic consolidation of the Earth's surface and the interplay between tectonic activity and geomorphic processes.

Therefore, referring all interested parties to the works of well-known specialists, (Polkanova, (Ed.), 1972; Kostenko, 1978; Ganeshin, 1970; Bashenina et al., 1977); it should be noted that our research was based on the methodology of *Bashenina (1976)* with certain modifications. The core principle of this methodology is that *morphogenetic types of relief* are mapped, and their combinations reflect the regime and direction of neotectonic movements. Additionally, it focuses on *morphostructural elements* of mountainous, fluvial, and azonal relief, which help identify anomalous structural features, their connection with fault zones, and the structure of the consolidated crust.

This approach allows for a comprehensive analysis of modern tectonic processes by integrating geomorphological observations with structural geology, providing insights into the dynamics of crustal deformation and its influence on surface features.

Research finding. Regional Thermal Field. The nature of changes in the observed heat flow allows us to determine the deep processes occurring in the lithosphere within large tectonic blocks, which in turn helps to better understand the geothermal regime and temperature distribution in them.

The results of the analysis of the regional thermal field in the study area indicate its rather high heterogeneity in plan. The anomalies here map heterogeneities differing in thermophysical properties in the basement and overlying formations.

Heat flows. The HF distribution across the structural elements of the STSB demonstrates clear zonal contrasts. Most of the basin exhibits HF values ranging from 40 to 50 mW/m², with the lowest values (40–45 mW/m²) recorded in its southern parts.

In the adjacent eastern regions of the northern part of the SSD and the Ulutau Uplift, the heat flow values exhibit extreme increases, reaching levels of 60–80 mW/m², with localized peaks of up to 100 mW/m² (Abetov et al., 2019).

To the west of the SSTB, in the LSU, HF acquires intermediate values, which are 50-60 mW/m2 (Figures 2 and 3).

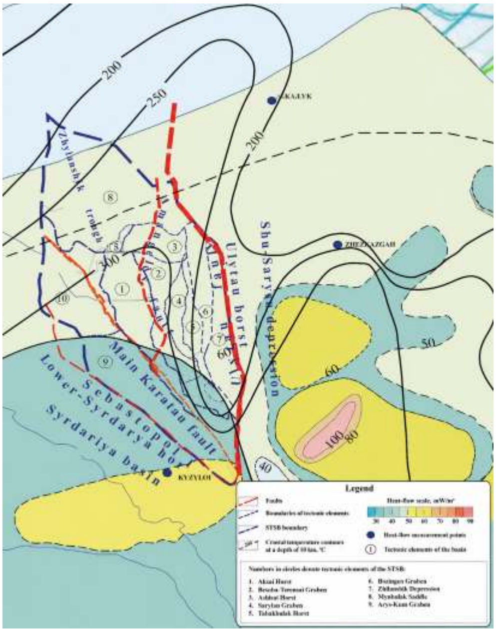

Figure 2. HF and Crustal Temperature Map to a Depth of 10 km in the South Turgay Basin (STSB) (Based on data from Nusipov et al.,2007).
Legend: Numbers in circles denote tectonic elements of the STSB:Aksai Horst; 2. Besoba-Terensai Graben; 3. Ashisai Horst; 4. Sarylan Graben; 5. Tabakbulak Horst; 6. Bozingen Graben; 7. Zhylanshik Depression; 8. Mynbulak Saddle; 9. Aryskum Graben.

Consequently, the STSB is marked by significantly lower values of heat flow compared to the adjacent structures of the SSD, Ulutau Uplift and LSU is observed.

Apparently, a "cold" consolidated crust formed in the upper part of the STSB, lacking significant heating by endogenous thermal fluids. In contrast, the elevated values observed in the Shu-Sarysu Depression and the LSU indicate increased endogenous activity in the upper part of the consolidated crust.

In this context, it is necessary to mention the perspective presented in (Abetov et al., 2019), which suggests that the anomalously high heat flow values in the Shu-Sarysu Depression are not attributed to deep heat and mass transfer along major fault planes but rather to heat sources located in the upper part of the consolidated crust. These sources are genetically associated with radioactive ores of the Betpak-Dala–Chu-Ili uranium ore province.

It is assumed that a similar effect is present in the LSU, where uranium deposits are explored in the Central Kyzylkum located to the south.

Most likely, the deep HF is the sum of the radiogenic HF and the HF coming from the Earth's crust.

Isolines of the HF do not quite agree with the orientation of tectonic structures and deep faults. Perhaps this circumstance is related to the density of borehole measurements, to the accuracy of calculations or to the nature of deep thermophysical heterogeneities. Within the framework of the present paper its authors only emphasize this phenomenon, which needs additional study.

The distribution of HF is consistent with the thermal conductivity of rocks that are part of the consolidated crust. Heat conductivity increases with the age of rocks from Neogene to Archaean.

The distribution of HF in the STSB, in our opinion, reflects the formation in the granite-gneiss layer of the consolidated crust of the STSB of acidic and medium-sized rocks (with thermal conductivity of 0.2-1.5 kJ/(kg*K)), which contributed to the formation here of minimum values of HF.

In the direction of SSD and LSU in the consolidated crust increases the content of basic and ultrabasic rocks with thermal conductivity of 0.6-1.1 kJ/(kg*K), which is associated with an increase in HF readings (Moiseenko, 1982).

The obtained values of thermal conductivity are somewhat less than in (Shvartsman 1990; Yudakhin et al., 1991), in which the values of the thermal conductivity coefficient of the sedimentary layer for the south of Kazakhstan and Northern Tien Shan were determined as 1.5-1.7 vT/m-K, granitic - about 2.6, dioritic - 2.2-2.3, basaltic - 3-3.1 vT/m-K. For the upper mantle of the region the thermal conductivity coefficient is assumed to be 3.4 wT/m-K. The reasons for the discrepancy need additional study.

Geothermal anomalies in the consolidated crust at a slice of depth of 10 km. Geothermal anomalies in the consolidated crust at slice of depths of 10 km and 30 km in Kazakhstan are key indicators of geothermal activity within the STSB and surrounding regions.

At a slice of depth of of 10 km, temperature measurements in the STSB generally align with the trends observed in the spatial distribution of HF values.

In the eastern part of the study area, the orientation of isotherms roughly corresponds to the orientation of regional tectonic elements. However, inconsistencies are noted between the morphology of isotherms and the orientation of deep faults.

In the SSD and the LSU, areas of elevated temperatures exceeding *300°C* are recorded at a slice of depth of 10 km. These high-temperature anomalies are indicative of localized geothermal activity, potentially driven by tectonic processes, magmatic intrusions, or variations in lithospheric structure.

Actually, STSB is distinguished by reduced temperature values ranging between *200–250°C* at a depth of 10 km. This low-temperature zone encompasses key structural elements, including the Zhylanshik Depression, Aksai Horst, Zhinishkekum Graben, and Besoba-Terensai Graben. At the same time, temperature values in the STSB increase from east to west, which generally characterizes this sedimentary basin as a boundary element between the northeastern Turanian Platform and the Paleozoic folding of Central Kazakhstan.

Morphologically, the low-temperature zone forms a northward-expanding, elongated cone-like structure oriented in a meridional direction.

Thus, the temperature distribution at a slice of depth of 10 km clearly shows a trend, in accordance with which the SSD and the LSU show areas of elevated temperature values, while the STSB shows decreased temperature, indicating that there are no clear boundaries of tectonic elements in the regional thermal fields.

Geothermal anomalies in the consolidated crust at a slice of depth of 30 km. The regional trend of temperature values slightly changed its signature at the 30 km depth slice of the consolidated crust

The *highest temperatures*, ranging from *800–1000°C*, are observed in the SSD. This depression demonstrates a petrophysical anomaly where both HF and temperature values at depths of 10 km and 30 km reach anomalously high levels.

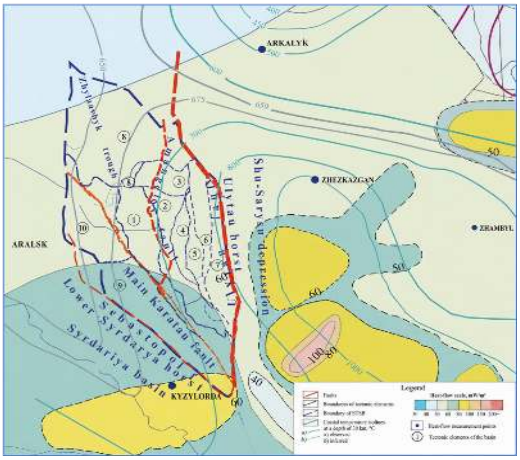

Figure 3. HF and Crustal Temperature Map to a Depth of 30 km in the South Turgay Basin (STSB) [Based on data from Nusipov E., Uzbekov N.B. (2007) (Nusipov 2007)]. Legend: Numbers in circles denote tectonic elements of the STSB (refer to Figure 2).

In the LSU, isothermal values at a depth of 30 km reach their minimum (650–700°C), which contrasts with the increased isothermal readings at a depth of 10 km and the elevated HF values.

Moreover, it cannot be ruled out that the identified trend in the distribution of geothermal anomalies in the lithosphere may be influenced by the background created by radioactive ores in the SSD and LSU. Investigating this geological phenomenon represents a crucial problem for the near future.

STSB, comprising the Zhylanshik Depression, Aksai Horst, Aryskum, Zhinishkekum, and Besoba-Terensai Grabens, is characterized by *intermediate temperature values* at 30 km depth, ranging between *700–800°C*. This thermal signature contrasts significantly with the distributions observed at a slice of depth of 10 km and the Earth's surface HF.

In the lower part of the consolidated crust, there is a clear transition from the *epicaledonian folded basement* in the SSD to the northeastern flank of the Turan Platform, where the LSUis delineated.

The orientation of faults does not align with the morphology of isotherms at a slice of depth of 30 km, suggesting that deeper geothermal processes operate independently of surface tectonic structures.

Thus, the study of geothermal anomalies at different depths provides important information on geothermal activity and crustal structure in the region, which is important for geologic studies and prediction of geologic processes.

According to all three qualitative criteria - heat flow, values of isotherms at depths of 10 and 30 km in the SSD, LSU and STSB differ cardinally from each other, which emphasizes their different degree of involvement in the regime of endogenous activation.

At the same time, it is possible that the detected trend in the distribution of geothermal anomalies in the lithosphere was superimposed on the background created by radioactive ores in the SSD and the and the LSU. The study of this geological phenomenon is the objective of the near future.

*Modern Earth Crust Movements (MECM)***.** Research focused on tectonic processes that caused significant changes to the Earth's surface relief during the Neogene-Quaternary period, driven primarily by internal crustal and upper mantle processes.

As numerous studies have shown, the activation of tectonic processes cannot be accurately dated everywhere and is not always synchronous, but in the vast majority of cases fits within the framework of the Neogene and Quaternary periods (Yudakhin et al., 1991).

Consedimentary folds generally conformal to large structures of the consolidated basement are formed in the SEB cover. The Karatau and Ulutau meganticlines are rising, and the Chu-Sarysu and Syr Darya syneclises associated with them are sinking, which are usually located discordant to the transregional subtransform faults (Main Karatau and others).

In the Neogene-Quaternary, the Karatau and Ulutau meganticlines rise and the Chu-Sarysu and Syr Darya syneclises associated with them descend, usually located discordant to transregional subtransformational shifts *MKF.*

The manifestation of multiscale and multidirectional processes resulted in the differentiation of key geomorphological structures in the STSB.

The sedimentary cover of the STSB exhibits an asymmetric structure, with the top of the folded basement gradually subsiding from its margins toward the submerged axial zone, ranging in depth from 0–50 m to approximately 7000 m.

The *western margin* is relatively steep, while the *eastern* is more gently sloping but is locally complicated by steep escarpments with amplitudes of *300–400 m****,*** likely formed by tectonic movements along meridional faults during the Mesozoic-Cenozoic era (Agafonov, 1971).

LSU adjoins the Turgay Syneclise from the southwest and west. The flanks of the uplift are generally gentle and smooth, except for the northeastern flank, which is bounded by the MKF**.**

The depth of pre-Mesozoic sediments in this area ranges from 550 to 900 m. The latter are represented here mainly by Permo-Triassic effusive deposits.

The uplift was formed mainly in the Oligocene-Quaternary, although its growth began in the Cretaceous. The modern outlines of the uplift are delineated by 200-300 m isobases., reflecting repeated tectonic movements that controlled the deposition of both Mesozoic and Cenozoic strata (Kunin, 1971).

The *SSD****,*** located to the east of the *Ulutau Basement High* and separated from it by the *Ulutau Fault****,*** has experienced *MECM with amplitudes of +200 to +500 m* (Figure 4). During the Neogene-Quaternary period, this structure underwent relative uplift. The signature of isobases has a linearly elongated appearance, oriented in the northeastern direction. In the same direction, isobases of the latest crustal movements are revealed.

The northeast orientation also marks the widening of newest crustal movement isobases, which correlate with deep-seated faults.

In the *LSU****,*** the isobases of MECM exhibit a *closed configuration****.*** The *maximum amplitudes* of Neogene-Quaternary uplifts are observed in the apical part of the uplift, reaching *+300 to +400 m or more****,*** indicating significant growth during this period. (Figure 4).

Thus, in the lower part of the consolidated crust there is a consecutive transition from the area with Epicaledonian folded basement in the SSD to the northeastern flank of the Turan Platform.

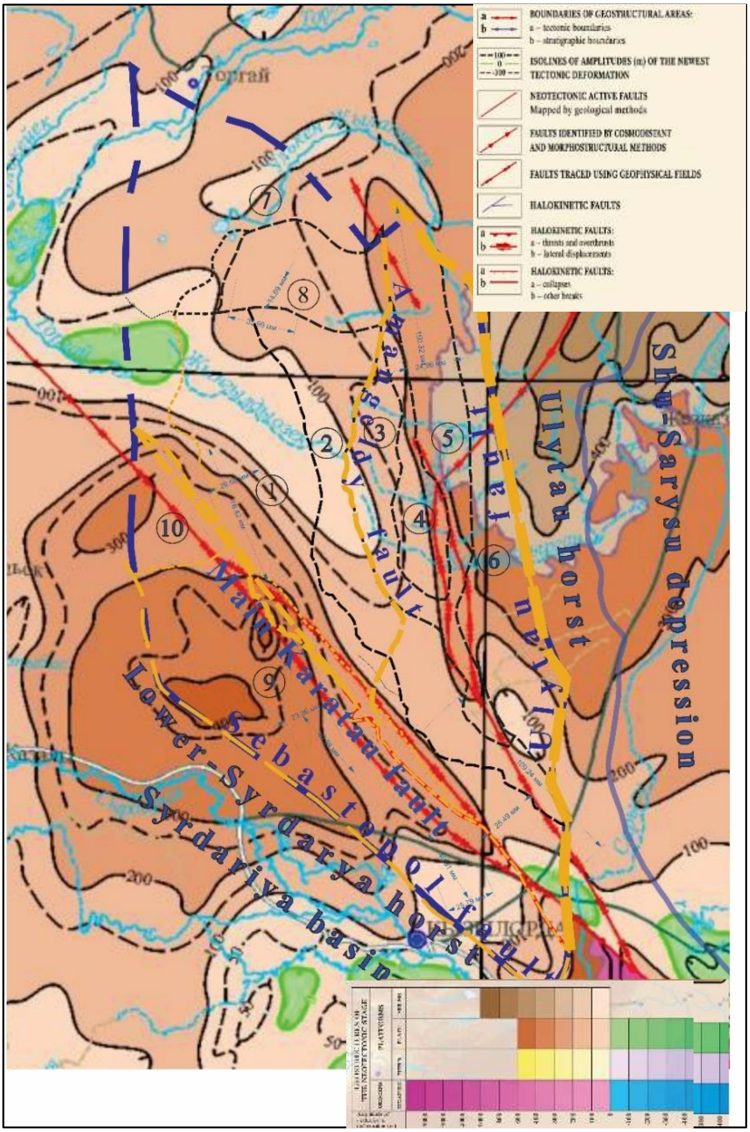

Figure 4. Fragment of the Neotectonic Map of the Republic of Kazakhstan Featuring Fault Tectonics and Seismicity (Compiled using data from Timush et al., 2012). Legend: Numbers in circles denote tectonic elements of the STSB (refer to Figure 2).

In the *LSU,* the amplitudes of MECM decrease to *+100 m or less* toward the periphery, indicating diminishing tectonic activity.

Within the *STSB,* the amplitude of upward MECM ranges from *+50 to +150 m,* with minimum amplitudes recorded in the western part of the basin. This correlates well with the relief of the basement top and the quasi-platform sedimentary cover.

The isobases of MECM exhibit *northwestward divergence,* aligning with the orientation of deep-seated faults. Isobases of the newest crustal movements are revealed in the northwestern direction. Correlation of isobases and deep faults is observed.

Thus, *STSB* demonstrates the *lowest amplitudes of MECM* during the Neogene-Quaternary compared to the *LSU* to the west and the *SSD* to the east.

In conclusion, the analysis of the spatial distribution and interactions of Neogene-Quaternary geomorphostructures in the study region reveals the heterogeneity of the lithosphere. This heterogeneity is expressed through multidirectional tectonic dislocations with differentiated amplitudes.

The *LSU* and the *northwestern SSD* are undergoing uplift, whereas the STSB exhibits *minimal positive MECM amplitudes***.**

A correlation is observed between the isobases of MECM and deep-seated faults, indicating a *paragenetic relationship***.** Consequently, we can speak about the connection of the MECM with the regmatic fault network of the faults of the region under consideration.

Discussion. Comprehensive geothermal studies at depths of *10 km* and *30 km***,** combined with evaluations of HF and rock thermal conductivity, have significantly enhanced the understanding of geodynamic processes within the *STSB* lithosphere. These investigations revealed substantial heterogeneity in the thermal and physical properties of the region.

Additional studies were conducted in combination with *seismic surveys***,** *gravity and magnetic surveys, and laboratory analyses of core samples* to validate these findings. These efforts refined the geological parameters of the STSB, providing valuable data on deep geothermal, velocity, density, geomagnetic, and structural heterogeneities across different lithospheric levels. The results were integrated with the region's *modern tectonics* and *geological evolution history*, encompassing genetic, tectono-magmatic, historical-geological, and structural-formational aspects.

In the STSB, MECM exhibit *minimal positive amplitudes***,** with isobases showing northwestward divergence. In the *LSU***,** the isobases form a *closed configuration*, reflecting *intermediate positive amplitudes* of modern movements. In contrast, the *SSD* demonstrates *maximum positive amplitudes of neotectonic uplift*, with isobases extending in a *northeastward linear pattern*.

These observations highlight the dynamic interplay between tectonic movements and subsurface heterogeneities, providing deeper insights into the tectonic formation and structural complexity of the region. This multidisciplinary approach underscores the importance of integrating geothermal, geophysical, and geological data to advance the understanding of lithospheric processes in the STSB and adjacent areas.

The *spatial distribution of HF reveals minimum values in STSB, maximum values in the northern SSD, and intermediate values in the LSU.*

At at a slice of depths of *10 km,* a clear trend emerges where the *SSD* and

LSU exhibit *increased temperatures*, while the *STSB* is characterized by *lower temperatures*.

At at a slice of depths *of 30 km*, the *STSB* shows *intermediate temperature values*, while the *highest temperatures* are recorded in the SSD. In contrast, the *LSU* displays *the lowest isothermal values* at this depth.

Thus, based on all three qualitative criteria—*HF, isotherm values at 10 km*, and *isotherm values at 30 km*—the SSD, LSU, and STSB exhibit *distinct thermal regimes*, reflecting their varying geodynamic and structural characteristics. These differences highlight the lithospheric heterogeneity and the unique geothermal dynamics of each region.

The *STSB* displays geomagnetic anomaly morphologies that are intermediate between those of the *LSU* and the *SSD*. In the LSU, geomagnetic anomalies (ΔTa) are characterized by *polygonal and sub-isometric shapes*, whereas in the SSD, these anomalies are predominantly *linear and elongated***.** This suggests a transitional structural complexity within the STSB.

Regarding the regional transformed gravity field (Δg_{reg}), the STSB displays *weakly intensive minima* that differ significantly in morphology, sign, orientation, and gradient from those observed in the adjacent structures. The LSU is marked by *polygonal gravity anomaly maxima*, while the SSD features *intense negative linear-elongated gravity minima*. These distinctions in gravity anomalies reflect underlying differences in tectonic processes and crustal compositions among these regions.

Based on the depths of the Curie point in the STSB, the crust is characterized by increased thermal maturity, as indicated by weak negative anomalies in the vertical component (Bz) of the geomagnetic field. (Nusipov, 2007).

In contrast, the crust of the LSU and the SSD is less affected by endogenous heat and mass transfer, evidenced by significant positive Bz anomalies. Therefore, less heated crustal rocks generate positive magnetic anomalies by acquiring magnetization in response to the dipolar current component of Earth's main planetary magnetic field (Timush, 2012).

STSB demonstrates intermediate characteristics in the morphology of geomagnetic anomalies when compared to the LSU and the SSD.

Specifically, while LSU is characterized by polygonal and sub-isometric ΔTa anomalies, the SSD displays linear-elongated anomalies. In contrast, the STSB features weakly intense minima in the regional gravity field transformant (Δg_ reg), which differ significantly in morphology, sign, orientation, and gradient from those observed in the adjacent structures. These distinctions suggest that the STSB occupies a transitional position between the LSU and the SSD in terms of both geomagnetic and gravity field characteristics.

Furthermore, the depth to the Curie point within the STSB indicates an increased thermal state of the crust, as evidenced by weak negative anomalies in the vertical component (Bz) of the magnetic field. Conversely, the crusts of the LSU and the SSD are less thermally active, exhibiting significant positive Bz anomalies. This suggests that cooler crustal rocks in these regions generate positive magnetic fields due to their magnetization in the Earth's main planetary field.

The Moho discontinuity is a principal boundary within the lithosphere, demarcating the Earth's crust from the upper mantle. Its depth, characterized by seismic velocities of 8.1–8.2 km/s, defines the crust's thickness. In the STSB, the Moho is situated at depths of 40–48 km**.**

In contrast, the depth of Moho decreases to 38–40 km beneath the LSU and to 40–42 km under the SSD**.** Consequently, the STSB features a Moho, while adjacent areas like the SSD and the LSU exhibit relative elevations of this boundary, suggesting that the STSB's Moho delineates the LSU and SSD.

Notably, in the southern part of the STSB, an active mantle layer up to 10–16 km thick extends in a northwest direction along the Moho. Regions where the Moho reaches its maximum depth (up to 48 km) correspond to areas with an increased thickness of this active mantle layer (up to 14–16 km). This correlation indicates a significant relationship between the Moho's relief and the underlying mantle dynamics. These observations are detailed in the study by (Sherman, 1977).

Further, to the north, west and east the thickness of the tectonically active mantle layer decreases from 10 to 0 km Zhumagulov et al., 2022; Abetov et al., 2023; Abetov et al., 2024.

The absence of this active mantle layer in the western part of the SSD and eastern areas of the LSU, generally characterized by a relatively elevated position of the Moho discontinuity (Moiseenko, U.I., Smyslov, A.A.,1983, Abetov, A.E., Uzbekov, A.N.,2023). Shvartsman, Yu.G., 1990, Sherman, S.I., 1977).

The next geologic phenomenon we have identified is the overlap of the areas with an increased horizontal gradient of the crustal basement (Aryskum graben, Aksai horst, Bozingen graben) with the areas of active mantle (Abetov et al., 2023), which indicates intensive geodynamic processes occurring in the lower crust at the present stage of the STSB evolution.

STSB demonstrate intermediate characteristics in the morphology of geomagnetic anomalies between the LSU and the SSD. Specifically, while the LSU is characterized by polygonal and sub-isometric anomalies shapes, and the SSD by linear-elongated anomalies, and the STSB displays a combination of these forms.

In terms of the regional gravity field transformant structure, the STSB is marked by weakly intensive minima (Δg_reg), which differ significantly in morphology, sign, orientation, and gradient changes from those observed in the adjacent regions. LSU is characterized by polygonal gravity anomaly maxima, whereas the SSD features intense negative linear-elongated gravity minima.

On the contrary, the LSU is distinguished by minimal horizontal gradient values at the Earth crust bottom, while the SSD is characterized by intermediate gradient values (Abetov et al., 2023). This, to some extent, indicates relative geodynamic stabilization at the lower crustal levels of these regions.

Based on a synthesis of existing geological and geophysical data, coupled with our analytical findings, we conclude that in the STSB, the primary geonomic boundaries within the Earth's crust (e.g., Earth surface topography,Paleozoic and basement tops, and Moho) exhibit a generally conformal relationship.

Presence of an area of active mantle and with an increased horizontal gradient of the crustal basement, which convincingly demonstrate the rift nature of the STSB. (Abetov et al., 2023).

Furthermore, the structural, geothermic, velocity, geomagnetic, and density heterogeneities at various levels of the lithosphere in the South Torgay Basin are conditioned by its Vendian–Early Paleozoic and Jurassic geodynamic stages of riftogenesis development.

Additionally, a concept suggests that during the Late Early to Early Middle Devonian, a spreading zone formed in the Turkestan Palaeoocean, under the influence of which an active continental margin with the Turgay Devonian marginal volcanic belt emerged along the southern and southeastern periphery of the Kazakhstan paleocontinent (Dobretsov et al., 2005).

Consequently, STSB can be considered an inherited rifting-tectonic structure dating back to the Early Paleozoic, having undergone three distinct phases of rift formation: during the Late Proterozoic–Early Paleozoic, the Middle–Late Paleozoic, and the Jurassic.

In the presented model of the deep structure and stages of geodynamic development of the STSB, a special role belongs to the deep faults, along which the HF and endogenous fluids constantly moved in the past and circulate in the present.

Decoding of remote sensing data has refined the tracing and morphogenetic classification of faults within STSB and adjacent regions. Notably, the spatial arrangement of fractures of various orientations and morphokinematic types,

It should be noted at the outset that the systematic spatial distribution of faults of various orientations and morphokinematic types, as well as their consistent interrelationship, allows the existing rhegmatic network to be considered as a paragenesis of structural forms. These structures were formed under the influence of persistently and cyclically reactivated submeridional compression forces, which operated during the rifting stages of the STSB.

The analysis of the identified geophysical (thermal) anomalies allows them to be conditionally divided into two groups. The first group includes anomalies of considerable extension (hundreds of kilometers), which likely reflect deep suture zones in the lithosphere. These zones have been periodically reactivated and renewed through successive stages of ongoing tectogenesis.

The second group of faults, with few exceptions, is characterized by relatively shorter lengths. These faults are likely associated with the middle and upper sections of the Earth crust. Almost all of them, to some degree, correspond to faults identified through seismic and gravity surveys, with a lesser degree of correlation observed in magnetic survey data. Most faults from the first group coincide with previously identified faults based on geological, seismic, magnetic, and gravity data, and sometimes align with anomalies in the thermal field.

Our research demonstrates that, contrary to dogmatic assertions, some deep faults do not find reflection in geophysical data pertaining to the deep layers of the Earth's crust and upper mantle. For example, the MKF, likely due to the significant thickness of Meso-Cenozoic sediments in the Ariskum graben, is almost undetectable in thermal anomalies. The same situation may occur in fault zones where there are no conditions for migration of endogenous heat.

The absence of deep roots for the MKF is supported by the results of calculations and interpretations of the regional gravity field transformant. These results reveal a chaotic orientation of anomalies within the MKF zone (except for its southeastern segment) and a lack of influence on the morphology and intensity of regional gravity anomalies (Δg_reg). This evidence suggests that the fault does not extend to heterogeneities in the lower crust or upper mantle.

However, an alternative interpretation of the MKF exists. According to Timush (2012), it has been traced by seismic exploration to depths exceeding 60 km, indicating its transcrustal nature. In the Paleozoic, the vertical displacement amplitude of its northeastern wing reaches 8–19 km. During the Paleozoic, the vertical displacement amplitude of its northeastern flank is estimated to have reached 8–19 km.

At the same time, the tectonic activity of the MKF over a prolonged period (since the Riphean) influenced the distribution and thickness of sediments, their facies composition, the manifestation of metamorphism, and ultimately shaped the structure of the STSB.

According to (Lyubetskii et al., 1986; Abdulin et al., 1986), the MKF, as the northwestern extension of the Talas-Fergana deep fault, is characterized throughout its entire length by predominantly vertical dip and a left-lateral strike-slip movement that has been developing since the Proterozoic to the present. It is accompanied by a system of relatively extensive secondary faults, through which it influences the formation of Hercynian structures in the axial part of the Karatau Range.

An alternative perspective is presented in the works of Ognev V.N. (1939–1954), Burtman V.S. (1961–1964), Dodonova T.A. (1962), Korolev V.G. (1962), Nikolaev N.I., and others (1962, 1988). These studies noted right-lateral strike-slip movements along the Talas-Fergana Fault and its northwestern extension of the MKF, which began in the Late Paleozoic and continue to the present.

Thus, the nature of the MKF requires further in-depth study. At the same time, our studies based on integrated data from regional potential geophysical fields indicate significant differentiation in the depth and age of major faults in the STSB. For example, on the eastern periphery this basin, the Ulutau Fault is recognized as originating at the upper mantle level (Abetov, 2025), and is inferred to be of Early Paleozoic or Precambrian age. The MKF, Sebastopol Fault, and other similar structures show no expression within the regional geophysical transforms. This suggests a shallower depth of origin for these features.

And it is not by chance that in the development zone of one of the virgations of the Ulutaus fault, on the Sorbulak basement high of the basement in the north-east of the Aryskum trough, a large gas and oil field Kumkol was explored, which was put into expliotation in May 1990 and is still in operation.

The manifestation of the Ulutau Fault in thermal fields indicates the presence of geological conditions conducive to heat transfer. Such anomalies may be associated with regional geodynamic zones, which, in turn, could control regional-scale fluid dynamic systems. This relationship represents an important exploration criterion and should be considered in planning future prospecting and exploration activities.

Conclusions. The integrated analysis of geothermal, neotectonic, seismic, gravity, magnetic, and geological data demonstrates that the South Turgay Sedimentary Basin represents a distinct lithospheric domain at the boundary between the Turan Plate and the Kazakhstan Fold Belt. The principal conclusions are as follows.

1. The South Turgay Sedimentary Basin is characterized by a relatively low regional heat flow of 40–50 mW/m², including minimum values of 40–45 mW/m² in its southern part. These values are lower than those recorded in the adjacent Shu–Sarysu Depression (60–80 mW/m², locally up to 100 mW/m²) and the Lower Syrdarya Uplift (50–60 mW/m²). This distribution indicates a comparatively cold upper consolidated crust beneath the basin.

2. The crustal temperature pattern changes with depth. At 10 km, temperatures within the South Turgay Sedimentary Basin are generally 200–250 °C, whereas values above 300 °C occur in the adjacent structural domains. At 30 km, the basin is characterized by intermediate temperatures of 700–800 °C, compared with 800–1000 °C in the Shu–Sarysu Depression and 650–700 °C in the Lower Syrdarya Uplift. The contrast between the relatively cold upper crust and warmer lower crust indicates vertically differentiated thermal conditions within the lithosphere.

3. Neogene–Quaternary crustal movements within the basin have predominantly positive amplitudes of +50 to +150 m, which are lower than those observed in the adjoining regions. The northwestward divergence of the isobases broadly corresponds to the regional fault pattern, indicating a structural relationship between inherited basement discontinuities and recent crustal deformation. However, the local mismatch between thermal anomalies and mapped faults shows that not all deep faults currently act as pathways for heat and fluid transfer.

4. The Moho discontinuity occurs at depths of approximately 40–48 km beneath the South Turgay Sedimentary Basin. In its southern part, the deepest Moho sectors spatially coincide with a tectonically active mantle layer approximately 10–16 km thick and with increased horizontal gradients of the basement surface. Together with the gravity and magnetic-field characteristics, these features support

interpretation of the basin as an inherited rift-related structure formed through several stages of lithospheric reactivation.

Overall, the results show that the present structure of the South Turgay Sedimentary Basin reflects the combined influence of Paleozoic and Mesozoic rifting, heterogeneous crustal composition, lower-crustal and upper-mantle processes, and differentiated Neogene–Quaternary deformation. The basin therefore cannot be described using a simple model in which all major faults uniformly control geothermal activity. Further research should prioritize new equilibrium-temperature measurements in boreholes, direct laboratory determination of rock thermal conductivity, denser heat-flow observations, and integrated three-dimensional thermal–structural modelling to distinguish conductive, radiogenic, and fault-controlled components of regional heat transfer.

This version presents four principal theses, reports concrete numerical findings, avoids bibliographic citations and new unsupported discussion, and identifies a clear direction for further work, consistent with the journal's recommendation that the conclusion formulate approximately 2-4 main findings and indicate their potential application or development. The content also matches the journal's scope in original fundamental and applied geological research. The conclusions are based on the results presented in the manuscript.

References

Abetov A.E., Uzbekov N.B., Uzbekov A.N. (2023) Structure and interpretation of the anomalous geomagnetic field of Central Kazakhstan. News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences. – No. 5(461). – P. 8-21. DOI: 10.32014/2023.2518-170X.327 (in Eng.).

Akhmetova L.U., Egorov V.G. (1993) Teploprovodnost gornykh porod [Thermal conductivity of rocks]. Geothermics of seismic and aseismic zones. – Moscow: Nauka. – *P.* 197-204. (in Russ.).

Bashenina N.V. (Ed.). (1976) Melkomasshtabnoe geomorfologicheskoe kartirovanie [Small-scale geomorphological mapping]. Moscow State University Publishing House. – 185 p. (in Russ.).

Cook H.E., Zhemchuzhnikov V.G., Buvtyshkin V.M., Golub L.Y., Gatovsky Y.A., Zorin A.Ye. (1995) Devonian and Carboniferous passive-margin carbonate platform of southern Kazakhstan: Summary of depositional and stratigraphic models to assist in the exploration and production of coeval giant carbonate-platform oil and gas fields in the North Caspian Basin, western Kazakhstan. In Embry A.F., Beauchamp B., Glass D.J. (Eds.). Pangea: Global environments and resources. Canadian Society of Petroleum Geologists Memoir. – Vol. 17. – P. 363-381. (in Eng.).

Daukeev S.Zh., Uzhkenov B.S., Lyubetskii V.N., (2002) Glubinnoe stroenie i mineralnye resursy Kazakhstana [Deep structure and mineral resources of Kazakhstan]. – Vol. 1. Deep structure and geodynamics; – Vol. 3. – Almaty: Oil and gas. – 220 p. (in Russ.).

Duchkov A.D., Sokolova L.S., Lysak S.V. (2003) Teplovoi potok Tsentralnoi Azii [Heat flow of Central Asia]. In Geodinamika i geoekologicheskie problemy vysokogornykh regionov [Geodynamics and geoecological problems of high-mountain regions]. Proceedings of the 2nd International Symposium. Bishkek. (in Russ.).

Gordienko V.V. (Eds.) Tektonosfera Srednei Azii i Yuzhnogo Kazakhstana [Tectonosphere of Central Asia and Southern Kazakhstan]. – P. 148-153. Kyiv: Naukova Dumka. (in Russ.).

Gordienko V.V., Zunnunov F.Kh., Tal-Virsky B.B. (1990) Tektonosfera Srednei Azii i Yuzhnogo Kazakhstana [Tectonosphere of Central Asia and Southern Kazakhstan]. – Kyev: Naukova Dumka. – 232 p. (in Russ.).

Kassin N.G. (1960) Razvitie geologicheskih struktur Kazakhstana. [The Development of Geological Structures in Kazakhstan]. In: The Main Ideas of N.G. Kassin in the Geology of Kazakhstan. Alma-Ata: Publishing House of the Academy of Sciences of the Kazakh SSR. – P. 29-73. (in Russ.).

Konyrbekov, M. Z. (2015). Studying the features of livestock sector growth in Kazakhstan within market environment. Actual Problems of Economics, 169(7), 79–87. RL: http://nbuv.gov.ua/ UJRN/ ape_2015_7_12

Lyubetsky V.N. (1986) Glubinnoe stroenie zemnoi kory [Deep structure of the Earth's crust]. In the book: Geology and metallogeny of Karatau. – Alma-Ata: Nauka. – Vol. 1. – 180 p. (in Russ.).

Moiseenko Yu.I. (1982) Teplofizicheskiye svoistva gornykh porod i glubinnie temperatury zemnoi kory [Thermal physical properties of rocks and deep temperatures of the Earth's crust]. Yu. I. Moiseenko. Physical Processes of Mining Production. – Vol. 12. – P. 30-36. (in Russ.).

Nusipov E.N., Shatsilov V.I., Uzbekov N.B. (2007) Geodinamika i seismichnost lithosperi Kazakhstana [Geodynamics and seismicity of the Kazakhstan lithosphere]. – Almaty. – 390 p. (In Russ.).

Paragulgov T.Kh., Paragulgov Kh.Kh., Fazylov E.M., Musina E.S. (2013) Yuzhno-Torgaiskii osadochnyi bassein: Veshchestvennyi sostav i neftegazonosnost domezozoiskikh obrazovanii [South Turgay sedimentary basin: Material composition and petroleum potential of pre-Mesozoic formations]. News of the National Academy of Sciences of the Republic of Kazakhstan. Series of Geology and Technical Sciences. – No. 1. – P. 44-54. (in Russ.).

Paragulgov T.Kh., Paragulgov Kh.Kh., Fazylov E.M., Musina E.S. (2013) Yuzhno-Torgaiskii osadochnyi bassein: Veshchestvennyi sostav i neftegazonosnost domezozoiskikh obrazovanii [South Turgay sedimentary basin: Material composition and petroleum potential of pre-Mesozoic formations]. News of the National Academy of Sciences of the Republic of Kazakhstan. Series of Geology and Technical Sciences. – No. 1. – P. 44-54. (in Russ.).

Shvartsman Yu.G. (1990) Teplovoi rezhim litosfery Tyan-Shanya [Thermal regime of the Tien Shan lithosphere]. (in Russ.).

Smyslov A.A. (ed.). (1982) Geodinamicheskaya karta territorii SSSR i nekotorykh prilegayushchikh akvatorii.Masshtab 1:10,000,000 [Geodynamic map of the territory of the USSR and adjacent marine areas. Scale 1:10,000,000]. – Leningrad: VSEGEI. – 53 p. (in Russ.).

Timush A.V., Taradaeva T.V., Stepanenko N.P., Sadykova A.B., Sydykov A. (2012) Seismogeneriruyushchie zony Kazakhstana [Seismogenic zones of Kazakhstan]. – Almaty: High Technology. – 83 p. (in Russ.).

Yudakhin F.N., Chediya O.K., Sabitova T.M. (1991) Sovremennaya geodinamika litosfery Tyan-Shanya [Modern geodynamics of the Tien Shan lithosphere]. – Moscow: Nauka. – 192 p. (in Russ.).

Zholtaev G.Zh., Paragulgov T.Kh. (1998) Geologiya neftegazonosnykh oblastei Kazakhstana [Geology of Oil and Gas-bearing Areas of Kazakhstan]. – Almaty: Aikos. – P. 80-12. (in Russ.).

Zhumagulov A.S., Manzari M.T., Kezembayeva G.B., Nurmakova S.M., Mukanov D.B. (2022). Tectonic evolution and hydrocarbon accumulation controlling characteristics of the Shu–Sarysu Basin. News of the National Academy of Sciences of the Republic of Kazakhstan. Series of Geology and Technical Sciences. – Vol. 455. – P. 289-305. DOI:10.32014/2518-170X.2022.5.455.289 (in Eng.).