Natural - anthropogenous processes in Caspian Sea region of Western Kazakhstan (as exemplified by Emba Oil region)

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Abstract. Modern relief-forming processes which originated not earlier than 5-6 thousand years ago are still unfinished. They are determined by particularities of geological and geomorphologic structure of the territory, climate and a number of anthropogenic factors. All processes changing morphology of earth's surface can be divided into 3 groups: natural, natural-anthropogenic and anthropogenic. Natural (endogenous and exogenous) processes take place independently from man's activity. Natural-anthropogenic are processes which are caused by economic activity of man. Anthropogenic processes are those related to direct influence of a man on earth's surface which result in relief changes. In this work we consider only natural-anthropogenic processes in the limits of Emba oil region where anthropogenic activity is especially active, because most part of oil and gas deposits are located here (39 or 40% of deposits) and anthropogenic impact on natural exogenous processes and on environment has increased.

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Introduction

Emba oil and gas producing region (area of 118,6 km^2) is situated in the desert zone characterized by very unstable balance between climate changes and relief-forming processes.

In geo-morphological terms the region is situated on Caspian Sea depression - a see bed flatland of accumulation situated below zero horizontal. On the surface of the flatland inclined to the side of Caspian sea absolute height marks change in the range from minus 14 to minus 27,5 m (2005) [1] near Caspian coast, in western part of the region. The sediment's contents are mainly sand and clay rocks.

The plain is characterized by big number of sor-affected depressions in form of internal-drainage dents of stretched form (0,5-0,7 km) which were formed after sea withdrawal, thanks to unevenness of its bed [2].

On sandy sections the surface of the plain was subject to Aeolian processes, deep enough which resulted in formation of big sandy massives: Taisogan, Caspian Karakumy.

Section with Baer knolls near delta of Zhem river is located on a special place within analyzed region: these are ridges in parallel rows, in sub-latitudinal, rarely - in latitudinal direction. The surface of ridges is made of sands and sandy clays with broken shells. Inter-hill depressions during spring floods are covered with water and when they dry out they turn into sors and takyrs.

The sea plain encircles first oil deposits in the Republic: Dossor and Makat which are being explored for more than 100 years (since 1908) and one of the biggest deposits in the world - Tengiz deposit. On Caspian shelf included into the territory of the region the biggest deposit - Kashagan - was found. Side by side with these deposits there are more than 30 explored oil deposits [3] forming the economy of the Republic: Royal, Prorva, Koshkar, Baishonas, Kolsary, Besbolek, Tenteksor etc. That is why oil exploration and almost any kind of anthropogenic impacts activate many relief-forming processes and as a result, lead to great transformations of modern relief.

Methods and materials

The work is based on the results of many-year field surveys of the authors (2000-2012); we also used published and stock materials, the materials of Ecology department of Atyrau region, Kazgidromet, scientific and technical libraries of Atyrau, scientific results of Aristarkhova L., Faizov K., Abdullin A., S. Gorshkov, M. Diarov, Anhert F., Derbyshire E.E., Jahn A. and others.

In the course of our study we used comparative-geomorphological method of study of natural processes with the use of space images (Landsat-7, 2009, 2012) and the maps of different

years, topographic maps (1:50 000, 1:200 000, 1:500 000, 1:1 000 000), method of expert estimates of processes and phenomena, system analysis.

Main part

By character and intensity of manifestations the most common natural-anthropogenic process in the given region is Aeolian process. Key reasons of activity of this processes are anthropogenic impacts, determined by reconnaissance. and exploration of the deposits. Almost all oil deposits of the region are concentrated in central and coast parts of the territory formed predominantly by sandy and sand and clay sediments [2].

Because of exploration of oil deposits in accordance with current regulatory norms 2,5 hectares of land are taken out from agriculture in order to make wells [4]. In fact, taking into account transport ways, machinery and equipment allocation they exceed the norms by 10-20 times and more. In 2010 the area of intervened lands in Atyrau region including analyzed region was 2300 hectares. Most part of this area is under activity of Tengyzshevroil (area of intervened land - 1881,6 hectares, re-cultivated - 3,2 hectares), oil and gas company Kolsaryneft (14,1 and 7,929 hectares), oil and gas company Prorvaneft (14,02 and 2,7 hectares) [4].

While transporting drill equipment to these new sections mainly heavy vehicles are used (40-80 tons, the width of the track - 20-40 cm), producing load up to 12 kg/cm3, while bearing capacity of low-buffer desert soils is not more than 1,5 kg/cm3. This deforms and eliminates all humus horizon of soil in the depth of 20-40 cm in the radius of 50-100 m at the distance of several km. The result: constantly blowing strong winds, in winter and summer (average wind speed - 4,8-7,1 m/sec) blow away sandy materials [5, 6].

Illustration of Aeolian process is sections around Komsomolsk and Kosshagyl oil deposits and along liner facilities in central part of the region where not fixed barkhans (sand ridges) are spread. In the process of industrial exploration and taking out of crude hydrocarbons positive sand ridges were created, with length from 200 to 1000 meters and more and height about 1,5 m [7]. Total area of separate sections of Aeolian sands in the region of deposits is 2812 km^2 [8].

Activization of Aeolian process is facilitated also by building of new and use of already existing transport network, laying of oil and gas pipeline, hit-and-miss use of transport through little-bound and non-bound soils with rare vegetation. Such misuse resulted in increase in deflation of sand on the section of earth road, on the sor plain, at the distance of 20 km to north-west of former village Karaton, made with the purpose of reduction of the way to the Terenozek deposit. Deflation depth is 20-30 cm [7]. Here quick breakage of soil-vegetarian cover is determined by the fact that frequent traffic increased load on the soils, increasing the dust rate of the participles. Sometimes moving on such loosened and broken roads is not possible, in such case it is much easier to ride in parallel to main road on more dense soil with un-intervened soil cover. This way of transportation results in forming of several roads (the width of surfaced portion is 6-7 m), the area of intervened soils grows and further activation of wind erosion takes place. Finally relief forms look like cups and blowing-out streaks.

Anthropogenic intervention into soils and active deflation of sand is noticed also in South-East part of Kolsary station. In this region all populated places are connected with each other by dense piping network, automobile roads (mainly earth roads) which increase anthropogenic load on soil-vegetarian cover. The profile of soil is broken, its genetic features change, wind-dust blow-out of fine materials takes place, sand deflation increases. Every 100 km of oil and gas piping eliminate from 500 to 1000 hectares of soil cover. The zone of total elimination of soil-vegetarian cover due to traffic on the roads is 80%. The surface of soil is destroyed not only in the zone of direct impact, but in all zone of influence. On the pipelines the width of intervened zone varies from 40 to 400 m [8].

The deflation centers are most common along soil roads Kolsary-Zhem village, Kolsary-Kosshagyl, Turgyzba - Tasshagyl, Shockpartogai - Koisary. Such deflation sections can be met along track Karaton-Sarykamys, Makat-Kolsary-Oporny. The area of Aeolian transformation of sand is 3750 m^3 [9].

One of the factors influencing development of Aeolian process, side by side with exploration of deposits, is agriculture, namely, cattle-breeding. Proportion of pastures of season use in the region is rather high. They all-year use (overgrazing) resulted in their extreme exhaustion and pollution which increased the area of naked easily blown away sands. Area of lands imposed to wind erosion is 1,8 hectares [10].

So, Aeolian process is strongly activated because of increased anthropogenic load, which can be easily seen in the photos from space - most light, sometimes white spots. They go along railways and automobile roads (village and earth ones), especially at their crossing, along communication lines, oil-and gas pipelines and other engineering and technical facilities. Today process of intensive deflation is going on, and Aeolian process takes place in eastern and western direction, in accordance with dominated

winds (identified by wind diagram obtained by meteo-stations Oporny and Kolsary).

Analyzed region with strongly continental climate is characterized by process of salination of soils which is also spread everywhere. The key source of enhancing of this process is oil and drill storage pits, discharge of sewage waters on the fields of irrigation, accidents and ruptures of oil pipelines, accumulation of heavy oil polluted soils and crude oil on oil platforms. Natural development of this process is determined mainly by approximation of ground waters to the surface because of strong surface evaporation, by crystallization of salts produced by water from the rocks themselves, oncoming salts from eroded depths of massive-crystal rocks, and re-distribution and transportation of salts from sedimentary rocks, earlier accumulated salty masses [11].

Relief-forming role of this process is rather great. In relief depressions the saline lands form which made of clay, loamy, rarely sandy-loam and sand rocks near to the level of ground waters.

Availability of highly-mineralized stagnant solutions in upper layer of soil, especially in boundaries of local relief depressions occupied with takyrs and sors, to a great extent determines general level of high salination of soil-forming rocks. Low hypsometric situation of the territory turned it into the region of intensive salination. General level of salination is influenced by geo-chemical processes related to salt-dome structure.

Process of saltiness of soils is significantly strengthened. Main factors of activization of this process are discharge of wasted industrial waters on the evaporation fields and their accumulation, formation of oil storage pit, accumulation of oil products on industrial platforms, oil spills at accidents on the oil- and gas-pipelines and around the wells.

Absence of efficient system of utilization of spills of drill solutions and wasted waters at the oil-extracting enterprises results in formation on e-f (depressions, sors, saline land dents) of dead pools, containing solutions and toxic chemical substances. At average in the zone of deposits and oil pipelines every square km of territory is polluted with 0,02 ha of spilled oil per year [12].

Wasted waters are multi-ingrediented and manifest high geo-chemical activity and toxicity. They contain oil products, different mineral salts and mechanical admixtures which, while being absorbed by soil, change its chemical and physical-chemical properties – salt content, alkali content, structure of soil-absorbing complex, break its watery-airy mode and carbon-nitrogen balance. Wasted waters contain a lot of bromine, barium, boron, silicon, iodine and others salts. Content of chemical elements in wasted waters increase with degree of their mineralization. In all deposits wasted waters are characterized by their high mineralization. Sum of salts reaches 150-300%, contents of chloride ions - 60-100%, sulphates - 3-16% and general alkaline content - 0,02-06%. The water is carbonate, predominantly neutral and reveals lightly-acid reaction [12].

Mineralized wasted waters cause deep transformation of morpho genic profile of the soil. Under their influence specific anthropogenic and meadow saline lands and saline soils with modified morphological, chemical and physic-chemical characteristics in comparison with original soil. The sum of soils in the upper horizon of saline lands is higher than 5% and forms sulphate-cloride, calcium-sodium type of salination which, to a great extent, corresponds to primary salination of wasted industrial waters [9]. The soils have little humus, mineral elements (needed by plants) and is characterized by high carbonate content, availability of clay illuvial horizon.

When the wasted waters pools dry out the products of saline-dust erosion turn into toxic poisons. With desalting reclamation and taking solved with water salts out from the saline land profile secondary alkalization happens, the reaction of soil solution and the content of absorbed sodium increase, the process of saline land formation become more active [12]

In spite of limits of extracted water on oil-extraction places and oil-processing enterprises (there are 25 of them in this region) every year 22,9 million cubic meters of water. is damped onto the evaporation fields, rivers and underground horizons. For example, in *Embaneft company* 31,6 million tons of reservoir waters were extracted together with 4 million tons of oil - every ton of oil was accompanied with 8 million tons of water. In general, only *Embaneft company* in 1991 for maintenance of reservoir pressure pumped about 5 million m3 of water, while 25-27 million meters - 85% - of reservoir waters were spilled on the evaporation fields, causing great salination of soils and formation of saline lands (saline land Ole Koltyk in Southern part of the region with the area of 4225 square km).

Artificial saline lakes differ from normal ones by their edge stripe of brown colour with width of 15-20 cm. These are the traces of sediment and saturation of soil with mineral substances from reservoir waters (mainly iodine), further to the center of saline land strong saltiness is observed. This process is observed in all current oil and gas deposits areas of Emba region. Huge fields of salty soils and formation of saline lands are available in the sections

of Baer knoll, Tenteksor, Karaton, Tengiz, Prorva and other deposits.

In the northern part of the villages Dossor and Makat and in south-western part of Kolsary village the artificial saline lands cover big spaces which have already merged with natural saline lands because exploration of these deposits is carried out for long years - since 1913. Pollution of soils with heavy oil wasted materials is 9 meters deep - the soil is richly saturated with oil, increasing the process of salination When pollution is low soil profile is saturated with crude oil to the depth of not less than 5 cm, with medium pollution - 5-10 cm, with strong - 10-20 and with very strong - more than 20 cm [13].

Intensive manifestation of the salination process (on already available sors) and new sections of sors and artificial lakes is observed also around oil products, their sizes depend on the quantity of extracted reservoir waters and on depressions in which they accumulate. By our estimates, annual growth of small saline land near entrance to Karaton village was about 10-14 cm and in more lowered places - from 0,4 to 0,5 m, i.e. anthropogenic impact increase saline land formation by 3-5 times. Average speed of development of natural saline land with near laying of ground waters (0,5-3 m) with average wind speed 4,8-7,1 m/sec is about 3,3 cm per year [7,8].

Thus, "artificially" developed process of salination (due to reservoir waters, spills from drill-sites) not only forms relief but changes physical-mechanical characteristics of composing rocks making them more sensitive to other processes, including Aeolian processes.

Processes developing locally are not well-spread but in the same time they also play significant role in formation of general picture of spread of natural-anthropogenic processes.

Process of road erosion is strengthened along linear facilities where anthropogenic soils form. In this region the most loaded and often ridden track is Atyrau-Makat-Kolsary-Karaton-Tengiz where because of constant pressure produced by heavy vehicles erosion of road surface takes place everywhere, even resulting in blockage of traffic. And in this case an automobile leaves the main road and drives in parallel making another road which in turn enhances development of Aeolian process.

Anthropogenic gullies are also observed along the right side of railway line Komsomolsky-Kolsary. Here they reach depth of 2,5 m and the length of 10-12 m. [7]. The same picture is observed in 3 km to the south from Kolsary-Toles line, in mines located in 8 km to the east from Kolsary village and in 5 km to north-west from Makat village.

Along the whole coastline on the surface of new-Caspian Sea plain where most of oil wells are situated the process of anthropogenic underflood is observed. Anthropogenic underflood is understood as the process of lifting of the level of ground waters above certain critical position during influence of economic activity of a man on natural geo environment [14].

Underflood process on given territory happens because of bottom pressure on ground waters located in the depth of 0,5-1,5 m, produced by sea water, and from the top - by discharge of wasted waters on evaporation fields, anthropogenic leakages, oil spills in accidents etc.

Thus, inflow of water is much greater than its outflow, which results in surplus saturation of soil with water represented by sandy sediments with good water-absorbing ability [6].

The problem of underflood of the territories near the deposit was determined by lifting of the level of Caspian Sea which is taking place since late 70s. Recently some stability in regard to level point is observed: this point remains unchanged on the level of 27,1 m though most of 1,5 thousand plugged and abandoned wells are in the zone of underflood, many of them are under sea water for more than 30 years. Such potentially dangerous wells amount to 148 in the region [5]. Here ruptures of oil and gas are possible because of violation of exploration and technical columns under the influence of sea water.

Takyrs can be considered as another characteristic natural-anthropogenic process on this territory; takyrs are formed in flat looped relief depressions under the influence of anthropogenic pressure at discovery of dense clay soil horizons. Small sections can be met on the territory of almost all oil-gas deposits of the region, especially Tengiz deposit because extracted oil is characterized by high content of paraffin which quickly thikens on soil surface.

Paraffin is primary product of lipid-lipoid fraction of original biomass; it is not toxic for plants but in low temperatures crystallizes into solid mass, adsorbs resin substances and asphaltenes and in such a way strongly influences water-air exchange and compaction of soil, forms bitum crusts in the profile, which usually quickly degrade and ruin. In oil storage pits and during prolonged stagnation of big volumes of crude oil on the surface strong (20-30 and more cm) strongly bitumized crusts form. They are very dense (80-90%), inaccessible for micro-organisms, almost do not oxidize in the air: that is why they slowly de-integrate and easily kept in the profile of soil [9].

Main factor of takyr-formation process at this territory is pollution of soil cover after oil-spills around wells, storage of oil and oil-products in oil

storage pits, accidents in oil pipelines during oil transportation.

Pollution of soil cover with heavy oil, enriched with paraffins and epoxies leads to takyr-formation and tarring of surface with formation of dense bitum crust, with thickness of 15-20 cm and more which are regularly collected by bulldozer and taken to the landfills. In oil-polluted soils in comparison with original the thickness of fine soil decrease, bulk density and humidity increases, porosity and aeration decrease [13].

Anthropogenic takyrs are observed on the earth road to Kolsary village, the sizes of which are equal to the width of the road - 6 m. The same takyrs can be met in other roads to south-west and south from Kolsary village, south-east part of Kosshagyp deposit, in northern part of Karaton village. Takyr-formation results in gradual disappearance of vegetation and further turning of the territory into desert.

Thus, the processes of wind erosion and sor-formation, enhanced by economic activity of man produce strongest influence on the territory of Emba region of Western Kazakhstan. Other processes are manifested locally and in little-populated places, their link with anthropogenic activity of a man is not evident.

Of course, natural-anthropogenic processes are not restricted to above considered types. In this work we tried only to describe those which are most developed on this territory.

Inference

We see that modern relief-forming processes in Emba oil region are well-spread. Intensive exploration of oil and gas, especially in last decade resulted in activisation of many processes.

Performed study of modern exogenous processes gives grounds to finding ways of rational land use. These lands of geo-morpho-system are not resistant to anthropogenic loads and have low potential of self-recovery. Solution of this problem is not possible without complex system approach, methods of which are considered both by home and foreign scientists [15-24]. Proposed by us method suggests the following ways of solution of the problem:

1) Establishment of constant system of observation and monitoring over natural components: soil vegetation, underground and surface waters, atmosphere;

2) implementation of modern monitoring systems and qualitative and quantitative analyses of modern relief-forming processes in the region of oil explorations, especially of leading ones (study of the speed of their development, areal areas) - Aeolian processes, sor-formation, underflood and flood.

3) attracting of specialists' attention to study and cartography of relief-forming processes in the oil and gas extraction region;

4) implementation and acceleration of the works on mathematic modeling of the processes, especially of regional character of development: Aeolian process and processes of salination of soils;

5) study of modern processes with the use of materials of distant probing, geophysical, geo-chemical and other methods;

6) broadening of theoretical research to establish interrelations between modern relief-forming processes and anthropogenic factor in the oil and gas extraction regions for scientific prediction of changes in the surface under influence of economic activity of a man.

Of course, natural factors can not fully neutralize all progress of the processes triggered by anthropogenic impacts, which results in violation of ecological systems, breaking balance in nature. This process in some cases demands complex development and building of nature-protecting facilities, in other cases – immediate and significant financial costs. Because of the fact that the region is highly perspective in economic terms, such works are imperative, this will allow to take operative measures in future in regard to prevention and liquidation of the effects.

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