Introduction. Frost cracking process is widespread on the permafrost area on the Earth and is responsible to the formation of the ice wedges polygonal relief as the contraction cracks are repeated along the same fracture plane annually in the winter time. The frost cracks appears when the soil’s thermal tensions exceeds the threshold durability of the soil [1,2]. Typical polygons sizes on the Earth are in the diapason from 10 to 30 meters. Their sizes are depended on the amplitude and the temperature fluctuations, and also from durability and physical-chemical characteristics of the frozen sediments. The maximum size of the frost-cracking polygons on the Earth was observed on the surface of low sea terraces, where they reaches of up to 70-100 meters in diameter [3]. The salinity of the sea terraces deposits was suggested as possible reason of such large polygons formation [3].

The high-resolution MOC images [4] show multiple examples of the polygonal terrains. The terrains are located in the both hemispheres of Mars mostly on the latitudes higher than 40°, which is consistent with the modal prediction where they could be formed on the Mars [5]. The morphology of the polygonal features is very similar with the terrestrial ice wedges polygons, while their size range is some wider (~ 20-200 m). In our study we focus on comparative morphologic and morphometric analyses of the polygonal terrains on the Earth and Mars.

Observation. For comparison between Terrestrial and the Martian polygonal terrains we analyzed the images of the Yamal peninsula area (fig.1a) of the Western Siberia (71°N, 67°E) and the region of Utopia Planitia (43.5°N, 269.3°W) on the Mars (fig.1b, MOC image M02-02863). Terrestrial area is characterized by following permafrost and geological conditions: upper part of the frozen deposits is represented by sea loam-sandy loam sediments of the middle and the upper Pleistocene age which are recovered by sand with the thickness > 10 m; the ice-wedges polygons have been observed everywhere and their pattern occurrence results to formation of multiple-wedge ice and polygonal ridge micro relief; predominant polygon size is 20-40 meters in diameter and till 80 meters (fig.2a) on the flood plain of large rivers; the polygons of nonorthogonal and orthogonal form with three- and four-ray intersections of cracks (fig.3a); the orthogonal polygons with four-ray intersection are more typical for areas are close to the edge of the lake shore line, rowine and flood plain.

The Martian polygonal relief is located within the latitudes range (>43° N), where water ice is stable in the surface regolith under modern climate conditions of the planet [6]. By the reason, the patterns may to be suggested as the ice wedge polygons. The polygonal terrains on Mars are seen mostly on the darker surface, where the mantle layer of an aeolian material (or other later formed sediments) apparently is less or absent.
The size of Martian polygons varies from 20 meters to 200 meters and their average size is close to 80-90 meters (fig.2b). The geometry form the polygons patterns in the studied area is mostly regular orthogonal form and they have the intersections types like for the terrestrial ice wedge polygons (see fig.3).

As the first step of this work, we have try to value the size of the Martian polygons on the basis of the simpler thermo-elastic pattern. The last one is meaning that ice wedge is situated in the multi layers frost deposits massif, there are the upper layers, which are under the influence of the temperature fluctuations. The layer can to play the role of the insulation layer, like the snow layer on the Earth. The result of these frictions is the appearance of breaking stress. It takes place if the layer temperature is lower then the average winter temperature [2]. It is obviously that for the high longitudes with lower negative temperatures we can ignore the influence of the geological processes. The temperature regime of upper layers for the considered area was valuated under our program “Heat-Mars”, which get us satisfactory conformity with results from the “Marsterm” program [7]. The evaluations show the winter daily temperature fluctuates from minimum – 135°С to maximum -85°С, the average month temperature is from –98°С to –123°С for the area with the albedo value 0,25 ÷ 0, 5 at L s 300°С-360°С. We considered two-layer model. The upper layer consists of dry regolith (fine unconsolidated material) with thickness up to 0.20 m and very low thermal conductivity (λ=0.06-0.07 wt/m K), which annihilate considerable part of the temperature fluctuation. The layer fulfills the role of the snow cover under terrestrial conditions. The low layer was represent by different breaking rocks (basalt, andesite and other), with much higher thermal conductivity values (λ=1.2-1.3 wt/m K).

Mechanical and thermal-physic characteristics of rock and their coefficient of line expansion (ε=1.5x10^-6) have been chosen in the according to low temperature region.

Following to our modal calculation, the values of the polygon sizes on Mars may to be from 80 meters to 150 meters, which are consistent with the observing sizes of the polygons patterns on Mars. It could be proposed that the polygon size will be smaller for higher longitudes as it is followed from used pattern. Because of increase the temperature amplitude fluctuation on the surface and accordance increasing of the temperature gradient by the depth, and also effects of decrease of the rock thermal conductivity and increase their elastic module. At that, the coefficient of line expansion and strength of rocks characteristics changes negligible for this temperature level.

Conclusions. The conducted comparative analyses of the polygons terrains on the Earth and Mars show that the features have very similar morphology, the size distribution trend and in the both cases they characterized by 3-ray and 4-ray intersections. The notable similarity of the polygonal terrains let us to suggest that the features on Mars apparently were formed mostly by frost cracking process in ice-reaching sediments with following growing of the ice wedges. The calculated sizes values for the Martian polygon (on high longitude) show satisfactory conformity with values of polygon size, which are received from morphometric evaluations. The H2O and CO2 ice may to be as the main components for the ice wedge formation on Mars. It is probable that seasonal appearance of the salt solution in the upper surface layer [8] could be serving as source of water filling the frost cracks in the summer season.

Fig.3. The polygonal patterns set in Yamal Peninsula (a) and in Utopia Planitia on Mars (b). Bar plots in the left show the types of the polygons intersection.

References: