Terraforming the Aral Sea Basin

Geomorphological and Anthropogenic Foundations (first part)

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Abstract: This paper presents a study on ancient geographic maps of Central Asia in order to collect indications of geomorphological oscillations in the Aral Sea basin that consubstantiate the proposal of terraforming the region, currently dominated by a desert named *Aralkum*. The research was carried out on maps of renowned authors, following a chronology that began in the 16th century. The total information collected, including those of the actual situation, was organized in two parts, the first called "The Pre-Soviet Aral Sea" with the maps, the second called "The Post-Soviet Aral Sea" illustrated by high-quality NASA photos. Theoretical considerations about thermodynamic phenomena and thermal devices were organized from a perspective of control engineering. The concept of entropy was addressed as a keystone of the technical proposal for monitoring the region, if partially restored.

Keywords : Terraforming, Aral Sea, Aralkum, OTEC Device, Thermodynamics, Entropy.

My eyes are tired
Of this hopelessness
Seeing all my drying breasts
Covered with salty crystal grains
My ears are clogged with broken dreams.

Michael Flores Caasi

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Introduction

Present work intends to deepen the geomorphological foundations of the proposal to terraforming degraded regions of the Earth, especially the Aral Sea region, presented in previous article. Although the analysis of the natural and anthropogenic oscillations of the Aral basin has been done by a few authors, I have not found a geo-analysis illustrated by a sequence of maps, how far were my research on this issue. Now, a terraforming project shall be more feasible the more the knowledge of the facts that have altered the landscape over the centuries, and, thus, attesting the possibility of induced transformations. Then, I believe that an interesting contribution to consecrate a complete study as a historical subsidy of geomorphological events, whether of natural or anthropogenic origin, comes from the evolution of the geographic mapping of Central Asia. This analysis has to be very careful. For example, a nineteenth-century map showing the Aral Sea, exhibiting the conquests of Alexander the Great, does not mean that in the time of Alexander the Aral was there. If the goal was to show the conquered territories, perhaps the map author would not mind doing it on an updated map. Additional care must be taken with regard to the accuracy of the maps. Although the detailing is admirable from the eighteenth century, one cannot forget the imperfections arising from technological and observational limitations. Therefore, the geographic "comparative anatomy" that I intend to conduct also takes into account the geological and geomorphological analyzes already established on the region of the present Aralkum.

I PART: THE PRE-SOVIET ARAL SEA

By pre-Soviet period I understand all the time prior to Stalin's delusions. It may seem disproportionate, but I believe that, with the exception of the Mongol devastation, nothing really compares to what Stalinism has created in Central Asia.

1 Generalities on the Aral Basin and Central Asia

The Aral Sea has perhaps been one of the greatest targets of environmental scientific research during the last decades ([1], [3], [4], [5], [9], [14], [16]). I do not intend to repeat what is already well known. On the contrary, I shall concentrate in consolidating my thesis on the terraforming of degraded regions from a geographic-geomorphological documentary analysis, improving some ideas presented previously.

The Aral Sea, as a terminal lake with no outfalls, is subject to strong evaporation during the hot summers of Central Asia. We may say that it is hydrologically a self-contained lake, since in normal conditions of water volume there are no outflows to external water bodies. Therefore, if there is no constant inflow of water from the two great rivers that fill the lake, the Amu Darya and the Syr Darya, both supplying the lake from the mountainous regions of Tajikistan, Kyrgyzstan, and Afghanistan, the Aral simply disappears. This is what happened throughout the history, whenever the water supply was interrupted by anthropogenic actions or climate changes.

In scale of hundreds and thousand years, the unstable climate of Central Asia led some researchers to define arid and pluvial phases in the region, doing estimations of drains of paleochannels on the ancients Amu Darya, Sir Darya and Uzboy. Judging by what we have today in terms of historical records, the Aral Sea is known as a salt lake from the ancient world, having received different denominations (*Oxiana Palus, Lacus Aral, Lacus Chorasmia, Buhayrat Khwarazm, Sine More*), as we shall have opportunity to verify in the maps. In weighing accuracy features, roughly its shape seems to have changed over the time, judging by periods when it does not appear on the maps, suggesting precisely an oscillation in the flow of the tributary rivers as anthropogenic interventions occurred. The Amu Darya (sometimes Red River), the major affluent river, was known by the Greeks as the *Oxus*. This river contributes to the Aral Sea with a flow between two and three times greater than the flow of the Syr Darya. The Syr Darya is the second major affluent river of the basin, named by the Greeks the *Jaxartes* (Pearl River). The Arabs called it the *Sayhun* or *Sihun*. The Syr

Darya has only one flood season, because there are not enough glaciers in the Tien Shan mountain system to produce a significant second flood season. Of course, climate changes across the globe have dramatically altered these proportions. The region between the Amu Darya and the Syr Darya has been known as *Transoxiana*, a Latin term certainly created to refer to the region beyond the *Oxus* for those who headed from the Caspian, or, by extension, the region beyond the *Oxiana Palus*. (this is even more confirmed from the Arabs, who called the region north of the Amu Darya *Mawaran-nahr*, that is, "the land beyond the river").

At the end of the first half of the last century, and until 1960, the annual water balance of the Aral Sea used to be around 9 km^3 from precipitation and 55 km^3 from river flow, having a full accounting for water surface evaporation around 64 km^3, with average salt percentage of 10-11%. From then on, the amount of water due to the flow of the Amu Darya and Sir Darya rivers has decayed alarmingly to the present almost complete desertification state of the basin. It is not worth here to extend this subject, practically exhausted by so many authors. The main thing is to document that the geomorphologic and geographic evidences bring indication of a seasonality of the Aral throughout the ages, whether by anthropogenic events or by natural events. From both cases we can extract information and insights that show us how to monitor a possible anthropogenic new Aral Sea, capable of bringing environmental balance to this so desolate region.

1.1 Central Asia at the 16th and 17th centuries

I started with the *Orbis Ptolomæi* from the 1541 edition (Figure 1), and the famous first 1570 edition of the Ortelius's *Orbis Terrarum* (Figure 2), considered the former world map in a standard Atlas, with a deformed Caspian Sea named *Mar de Bachu* and two eastern rivers reaching it, certainly the *Oxus* and the *Jaxartes* according to the *Orbis Ptolomæi*. Further DeWitt' *Magna Tartaria*, 1680, of the Mongol Empire, confirms this reading with more precision (Figure 3), but introduces a suggestive small "salt" lake, the *Saluna Lacus*, probably an embryonic Aral sea. I repeat here that the absence of the Aral Sea in some maps does not necessarily means the inexistence of the lake at the time of the Mongol empire, or even before. However, this absence seems symptomatic of a plausible drying phase, since already in 1873 Tissandier [15] and Reclus [11] warned about the strangeness caused by the inexistence of references to the Aral Sea in ancient maps, when it was known that the Greeks were aware of the Bactriana and the Sogdiana ([15], [11]). In addition, Marco Polo, Tissandier continues, "makes no mention of this inland sea"[15]. In view of these observations, Tissandier concluded

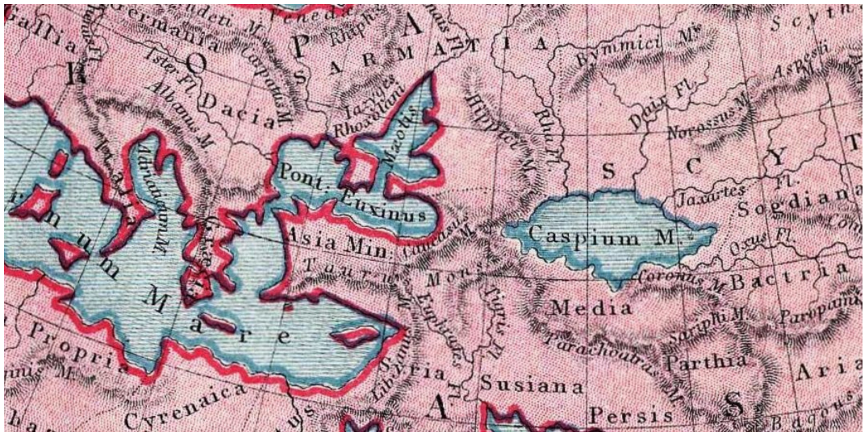

Fig. 1. *Orbis Ptolomæi*, 1541 (private collection fragment).

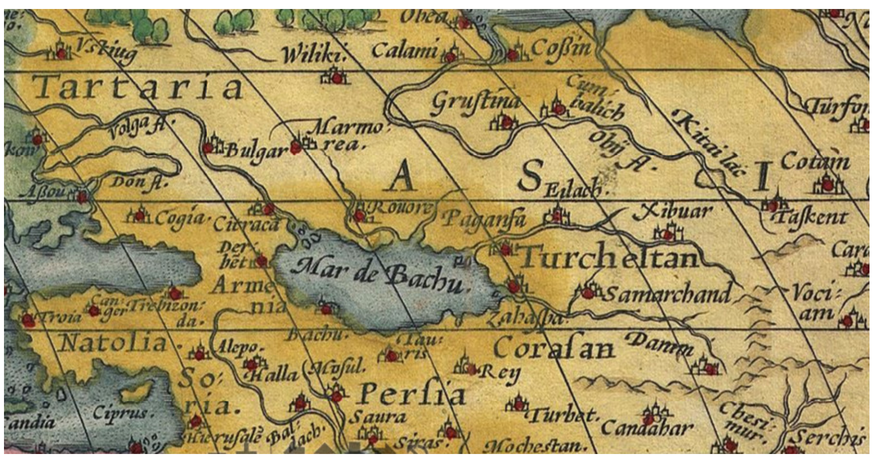

Fig. 2. Ortelius's *Orbis Terrarum*, 1570 (private collection fragment).

that "It is probable that the Aral Sea was desiccated at these times because the *Oxus* had been thrown into the Caspian for some centuries. According to these facts, the Aral should be regarded as an intermittent sheet of water which would have been dried several times in the course of the historical period, and which would soon dry up if the Russians take back from the Amu Darya the bed through which it has already poured its water"[15], as if anticipating the final tragedy.

Fig. 3. DeWitt's *Magna Tartaria*, 1680 (private collection fragment).

1.2 Central Asia at the 18th century

Several maps of this century present contradictory information and oscillate in quality, mainly because they depended on expeditions to be updated, so that many were edited before the information was made public. So, I tried to select those which, by degree of detail, mirrored the real geographical knowledge of the academic community. They are, in general, consistent with the main points discussed here.

In the 18th century, Lake Aral was already well documented in the major global charts, as shown in Figures 4, 5, 6 and 7. In these maps it is possible to see a clear evolution in the form and dimensions of the lake. Since the contour of the Caspian Sea was presented with a reasonable approximation to the current shore line, we can rule out a question of imprecision regarding the contour of the Aral Sea, and it is very probable this was really its approximate shape at that times. The representation of two *Oxus* alternative courses towards the Caspian Sea is noteworthy mainly in the Santini Map, 1778, of Persia, Arabia and Turkey (Figure 7). From this map, it is understood that the main stream of the *Oxus* flowed into the Aral.

Fig. 4. Herman Moll's Independent Tartary, 1728 (private collection).

1.3 Central Asia at the 19th century

From the nineteenth century, the great maps already showed in definitive a large Aral Sea (while at first with little precision of form), as well as the principal courses of the two major rivers of the basin. To give no more than one example, on the beautiful map of John Thomson, edited in 1817, one clearly reads "Antient Course of the Amu Daria" (Figure 8), showing that not only was this course well known, but also the real course at that time. Among many wise men, this century knew the foresight of Gaston Tissandier and the genius of Élisée Reclus, both with important legacies for the understanding of the Earth.

Fig. 5. Johann Homann's Aral, 1743 (private collection fragment). Compare this map with the previous one.

Fig. 6. Priest Robert de Vaugondy's Central Asia, 1749 (private collection fragment).

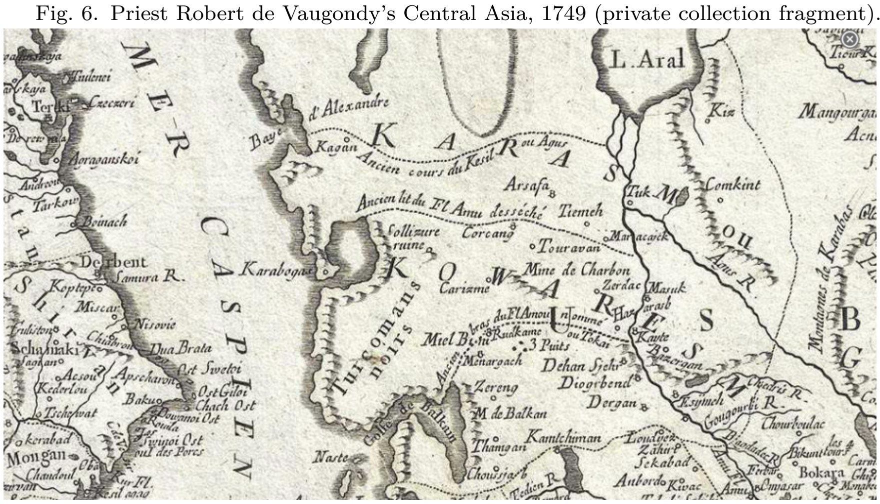

Fig. 7. Santini's map, 1778 (private collection fragment).

Fig. 8. John Thomson's Tartary, 1817 (private collection fragment).

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