

**THE POSSIBLE FLUVIOGLACIAL-TECTONIC ORIGIN
OF THE PYRAMIDAL HILLS AND ASSOCIATED FEATURES,
BOSNIA AND HERZEGOVINA**

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Reconnaissance field study and interpretation of satellite image of Bosnian valley of the "pyramids" and surrounding areas reveal several evidences of fluvio glacial-tectonic origin of the pyramidal hills of Visočica and Plješevica Hrašće as well as the associated features (e.g. what are called tilled terraces, beds of concrete like stone and stone spheres). These evidences could be discussed on the following topics

1- Sides of Visočica and Bosnian Valley :

The setting of Visočica sides and distribution of the other pyramidal hills (ten hills) along the Bosnian valley may show the effects of tectonic movement (mainly faulting and tilting) during uplifting of Miocene clastic-carbonate inclined beds comprising the Visočica hill. The trend of right angles meandered Bosnian Valley seems to be controlled mainly by N-S and E-W major fault trends which are parallel to the northern and eastern sides of not only the Visočica hill but also such sides of the other hills.

2- Pyramidal sharp edged hill of Visočica :

The obvious pyramidal sharp edges with triangular sides particularly within the tops of the northern and eastern faces of the Visočica hill seem to have been developed during intense glaciation of dissected valley mountainous region of appropriate structure. The heavy glaciation by valleyward moving ice of sufficient thickness may facilitate plucking and "cirques" (corries) erosion. The upland of the mountainous region seems to be subjected to successive glacial erosion processes from several sides at once, and so reduced to a series of sharp-edged precipitous ridges known as "arêtes" radiating like a starfish from a central summit. At a later stage the "arêtes" themselves are worn back, and the central mass where the head of three or more corries come together, remains isolated as a conspicuous pyramidal peak. In this way, most probably, the Bosnian pyramidal shaped tops of hills, like horns of the Alps, have been formed.

3- "Tilled Terraces" of Plješevica Hrašće:

The presence of numerous series of polygonal cracks on surface of multilayered tectonic benches at foundation of the Plješevica Hrašće hill may indicate another evidence of regional glacial traces. The region seems to have been affected by cold climatic conditions causing ice to accumulate in high altitudes. The successive freezing and thawing actions have effected the upper surface of partially consolidated wetted muddy fine sandstone crusts on the

benches, may resulted in the formation of regularly repeated polygonal cracks like "tiles". The difference in sizes, patterns, thicknesses and multi-colouration of these polygons may depend mainly on the amount of mud contents, types of clay minerals, texture and primary structure (e.g. graded bedding) of the sediments as well as paleo-tectonic relief, paleoclimatic condition, frequency of glacial freezing and thawing, the rate of cooling and actual stresses distribution of ice sheets at the time of shrinkage. In this respect the study phenomenon may be similar to the ice-wedge and frost crack polygons of the tundra.

4- Beds of "concrete like stone":

The foundation of some exposed sides of Visočica hill is paved with jointed slopping beds of brecciated conglomerate which are also roofing of tunnel "KTK" that located within the southern river Bosna bank. The distribution and textural properties of these conglomeratic beds may indicate their glacial origin as tillite terraces covering different levels of the exposed (dis-vegetated) side of the hill. The glacial sediment (till) seems to originally polymictic glacio-clasts that deposited by immediate release from transporting ice by ablation and melting in which the clasts might have fluviually reworked. Such sediments are extremely poorly sorted pebbles and boulders embedded in coarse to fine grained sand mud matrix and occasionally showing primary graded bedding structure. The occurrence and lithification of these sediments are depend on pre-glacial relief and local glacio-fluvial and paleo-climatic condition.

5- Stone spheres :

The occurrence of scattered granitic spheres with rough or polished or scratched surfaces along some nearby steep slopped valleys and their concentration within their down streams is considered as typical characteristic features of glaciated regions of Bosnia. These stone spheres are boulders or blocks of granitic composition which lithologically are foreign to the place where they have been dropped, and therefore they are considered as glacial "erratic" spheres. The internal characteristics and distribution of these spheres may decisive evidence for rafting in a high altitude subaquatic glacio-lacustrine environment at first phase. The rolling and rotating of such rafted clasts on steep rocky slopes of braided channels running in different direction may lead to formation of spherical reworked grains.

In conclusion, in spite of all these evidences of appropriate tectonic structures in upland region of the Bosnian valley and heavy regional glaciation within the study area, much is still to be done to get satisfactory explanation for all geological features in the region.