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TECTONIC GEOMORPHOLOGY OF SERIFOS (CYCLADES, GREECE)

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Introduction

For several reasons the central Aegean region of Greece represents an attractive field laboratory for the studies of geological processes. Besides its beauty, the region exposes spectacular poly-metamorphic rocks, a plethora of viscous and frictional deformation structures, and one of Europe's most active places concerning earthquake and volcanic activity. This study focuses on the landscape evolution of Serifos Island that lies in the western Cyclades, north of Sifnos and Milos, in the backarc region of the hellenic arc. It belongs to the Attic Cycladic crystalline belt, an Eocene high pressure unit with famous blueschist occurences. The exhumation of the HP/LT rocks in the Cyclades involved crustal scale exhumation processes, possibly in a exhumation wedge geometry (Grasemann & Vannay 1999). During the Miocene the island formed a just recently recognized (Grasemann et al. 2004) metamorphic core complex (MCC) among several already well-studied MCCs in the Aegean (e.g. Naxos and Ios; Lister et al. 1984). The post-Miocene to recent evolution of this area is characterized by extensional tectonics and the formation of horst - graben type structures.

Tectonic Setting

Several models were proposed for the tectonic history of the Aegean area. The three main hypotheses are (i) syn-compressional uplift and continuous underplating, (ii) extensional metamorphic core complexes and (iii) direct influence of the Anatolian extrusion. Attempts to combine the first two of them have been made by Coney & Harms (1984) and Platt (1986) proposing compression and extension taking place at different structural levels (see Boronkay & Doutsos 1994 and references therein). While classical models suggest movements perpendicular to the strike of the subduction zone, recent ideas consider the influence of tectonic escape models with a more realistic model for the recent plate configuration (Boronkay & Doutsos, 1994). The extrusion-model (iii) has been questioned by GPS measurements of recent plate movements, indicating slower movement of Anatolia compared to the Aegean area (e.g. McClusky et al. 2000).

There was a strong debate about age of the onset of extension in the Aegean area and its interdependance with the lateral extrusion of Anatolia. The metamorphic core complexes and basins in the Aegean are dated back to the late Oligocene - earliest Miocene. In this case subduction related extension migrated southward at a rate of ~ 3 cm/yr. Deriving ages from the metamorphic core complexes between 18 Ma (e.g. Naxos) and around 8 Ma (e.g. Serifos), the complexes show younger ages towards the west. A possible link between extension and the subduction zone is further supported by recent extension concentrating in the Gulf of Corinth above the Hellenic subduction zone. The speculated roll-back of the subducting plate possibly started due to the slowing down of absolute plate convergence rate between Africa and Eurasia. This model is attractive, because it would also explain the shift from a compressional Andean - type regime to an extensional Mariana - type regime (Jolivet & Faccenna, 2000).

Geomorphology

Todays topography of the Cycladic islands is characterized by Pleistocene - Holocene geomorphologic processes superimposed on remnants of preceeding landforms, some of them possibly related to above mentioned tectonic processes. A system of subhorizontal planation surfaces are common on most of the islands (see Riedl 1995 and references therein). Well documented planation surfaces are missing on Serifos, although in the southern part of the island an area significantly low gradient values appear at a height of 450 to 500 m above sea level (Hejl, 2002). Mean elevation is not very high, but slope angles are rather steep mostly around the plateau in the W and SW of the island.

The central and south-eastern parts of Serifos are dominated by an Upper Miocene granodioritic pluton intruding into greenschist to amphibolite facies metamorphic rocks (Altherr et al. 1982, Henjes-Kunst et al. 1988). Biotite Rb-Sr whole rock ages of the granodiorite yield around 8 Ma constraining the upper time limit for MCC formation (Grasemann et al. 2004). While the central part of the pluton is relatively undeformed, the deformation intensity gradually increases towards the hanging wall forming several tens of meters thick top to south directed mylonites, which mark the main ductile detachment of the Serifos MCC (Grasemann et al. 2004).

The topographic evolution of the island is strongly influenced by the strong seasonal variations in runoff characteristics and lithologic contrasts between the granodioritic southern part - resulting in hilly, undulous landscapes and the gneissic and schisteous northern part - showing V-shaped valleys. Previously existing forests have been exploited for ship industries and ore mining purposes since prehistoric times. Fertile soil and fine grained sediments of the weathering zone have been eroded by wind and rainfall.

The whole island is protected by low stonewalls, so called "Xerolithies" against erosion indicating the unstability of the deforested slope (Lambrakis et al., 2000).

Methodology

The source of the geomorphometric evaluation of the island is a conventional DEM, which is mainly based on isohypse data provided by ANAVASI (originally derived from Hellenic military maps 1:50 000). Because of the statistical and spatial properties of the dataset ridge and valley line corrections proved to be necessary to improve the slope distribution properties avoiding artificial flat areas.

The island topography is presented combined with a 1:100 000 scale bathymetry containing isopachs every 50 metres.

Hierarchical classification of geomorphometric parameters and objects and a divide into methods deriving primary geomorphometric parameters and geomorphometric objects is attempted. The hierarchy starts with geomorphometric points that can be visualized by XYZ triples and their attributes (e.g. slope and curvature). Geomorphometric points are clustered to geomorphometric objects (Schmidt & Dikau in Dikau and Saurer 1999).

Two derivatives of geomorphometric points and their implementations have been found useful to describe the altitude surface. Slope, the first derivative is a vector with two components, expressed by two angles: gradient and aspect .

The second derivative is the surface curvature, adding two of its components: profile (vertical) and plan (horizontal) convexity. Where convexity to the atmosphere is positive and concavity is negative (Evans, 1999).

To create a comparable basis, the dataset was roughly divided into a part containing mainly the granodiorite and a part occupied by the wallrock gneisses and schists. Since the dataset provided by ANAVASI also contained isolines of the island of Naxos, a comparison between these MCCs seems to be of interest.

Conclusions

The boundary between the landforms dominated by the granodiorite in the southern part of Serifos and the gneiss and schist lithologies in the northern part is formed by a local drainage divide, about 150 m above the contact of the granodiorite to the wallrock. The difference in drainage is explained by differences in slope hydrology. While the discharge in the granodiorite areas is dominated by interflow and subsurface flow in the strongly weathered regolith and tectonic fractures (Lambrakis et al. 2000), all other areas of the island are dominated by direct runoff (Selby 1993). The weathering provides loose material for the torrential runoff erosion.

Since surface equilibrium may not be assumed, the slope angles are likely related to surface uplift (Székely B., 2001). Rapid doming of the island above present day sea level causes strong erosion and high relief. Besides of these natural reasons the afforementioned anthropogenic deforestation plays also a major role.

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