Introduction

Thracian tombs are important part of the cultural and architectural heritage of the ancient Thracians on the territory of Bulgaria. The Thracian tomb in “Shushmanets” mound (IV–III century B.C.) excavated in 1996 near the town of Shipka at the foot of the Stara Planina mountain, consists of wide corridor (dromos) bordered by boulder masonry, rectangular in plan antechamber with a semi-cylindrical vault and Ionic column, and round chamber with dome pillared by Doric column. All the premises (their walls, floors and ceilings) and columns are built up of dressed granite blocks and plastered with fine mortar. Today the plaster in many places of the tomb is seriously deteriorated and detached from the walls. The conducting nowadays conservation-restoration works on the tomb need an actual information on the construction technology of the ancient builders including their recipes for the used mortars (binder, aggregates and raw materials). In the present communication, the authors report their primary results on mineralogy and chemistry of the plaster from the “Shushmanets” tomb.

Materials and methods

Series of samples of plaster from the main chamber (floor and wall), antechamber (inner wall and facade wall) as well as samples of granite from the building blocks of the “Shushmanets” tomb were provided by the Center for Restoration of Art Work (Sofia, Bulgaria). Manually picked fragments of the materials, polished specimens and thin sections were studied using optical microscopy (Leitz – Orthoplane), scanning electron microscopy and electron probe micro-analysis (ZEISS SEM EVO 25LS equipped with an EDAX Trident system). A part of the materials was studied by X-ray powder diffraction using D2 Phaser Bruker AXS.

Results and discussion

General characteristics of plasters. The principle feature of the studied plasters is that they are composed of two mortar coats of different chemical and mineral composition. This is distinctly visible in the plasters of the antechamber walls (Fig. 1): the outer layer is macroscopically lighter being composed of aggregates of limestone particles and calcite crystals cemented by fine disperse lime binder; the lower coat consists mainly of granite fragments (grains of plagioclase, quartz, potassium feldspar, biotite, epidote, muscovite, zircon, sercite, chlorite) in lime binder. Samples from the main chamber turn out to be either the upper part (sample from the floor) or the lower part (sample from the wall) of the respective two-layered plaster. In the all studied plasters, the size of aggregates (mineral and rock fragments) is similar varying between 0.01 and 4 mm (~2 mm in average), and the volume occupying by the lime binder is the same 30–50 vol.%. The width of each plaster varies between 3 and 8 mm. Optical microscopy examination of granite...
from the building blocks specifies the rock as porphyritic after feldspars biotite granite with weak hydrothermal alteration. This granite corresponds well to the granite fragments in the studied plasters. The petrographic characteristics of the granite are close to those used in other Thracian tombs in the region as in the “Golyama Kosmatka” tomb (Yaneva et al., 2006). It is assumed that the rocks have a local origin and correspond to the so-called “South Bulgarian granites” outcropping to the east of the tombs (Tsankov et al., 1995).

**Chemical composition of binder.** Binders of the external plaster coats are almost entirely composed of calcium carbonate (calcite) with variable MgO content. The lower coats, besides CaO and MgO, contain variable quantities of SiO₂, Al₂O₃ and Fe₂O₃, and sporadically Na₂O, K₂O and Cl. The binders in each of the studied samples are nearly homogeneous in their chemical composition. An exception is the sample from the antechamber facade showing high variation in the content of SO₃ (corresponding to gypsum). The obtained chemical compositions of the studied binders are recalculated and plotted in two ternary diagrams: CaO+MgO (carbonate) – Al₂O₃+Fe₂O₃+SiO₂ – CaO (sulphate) and CaO+MgO (carbonate) – SiO₂ – Al₂O₃+Fe₂O₃ (Fig. 2a, b). As is seen in Fig. 2b the binder compositions are grouped in almost linear trend from essentially carbonate to carbonate-alumosilicate composition (from a nearly pure common lime to a comparatively high hydraulic lime in the original mortars). The Devonian rocks of the limestone-pelitic suite – limestones, marls and argillites (Tsankov et al., 1995) outcropping nearby the studied tomb seem to be appropriate raw materials for the production of limes (by burning) for the studied tomb. The presence of gypsum in some of the studied binders (Fig. 2a) is most probably due to the additives of calcium sulphate in the original ancient mortar recipes (this assumption is valid at least for the binder of wall of the main chamber with 4–7 mol.% of gypsum). The calculated values of hydraulicity index (HI = (SiO₂+Al₂O₃+Fe₂O₃)/(CaO+MgO)) of the hydraulic lime used in the studied mortars correspond well to the published data for ancient mortars (Elsen et al., 2012) being: 0.75–1.29 (0.94 in average, close to HI of binder of the so-called “Rome concrete”) – for main chamber wall (first coat), 0.52–0.96 (0.74) – for antechamber facade wall (first coat), 0.22–0.47 (0.33) – for antechamber inner wall (first coat), 0.13–0.15 (0.14) – for antechamber facade wall (external coat).

**Conclusion**

It is shown that the studied plasters consist of two coats corresponding to two different types of mortar. The first one, related to the first (lower) coat, is a stronger mortar with hydraulic lime as binder and fragments of granite as aggregates. The second type of mortar consisting of common lime as binder and grains of calcite and limestone as aggregates was used for the second coat. The so-called “South Bulgarian granites” outcropping to the east of the studied tombs and the local Devonian rocks of the limestone-pelitic suite are assumed to be raw materials used for the tomb construction.

**References**

