EAGE

ENGINEERING & MINING GEOPHYSICS 2018

У01-08 46412

Methodical Guide in the Study of Hard to Access Geologic Cross-sections With Using of SUAV at the Pechishi Stratotype As an Example

A. Starovoytov* (KFU), E. Korolev (KFU), A. Eskin (KFU), I. Chernova (KFU), T. Rahmatullin (KFU)

Summary

The method of studying hard to access geologic cross-sections using unmanned aerial vehicles in combination with ground-based photometry is presented in the article. Model of textural ortho-section and the surface relief model in the plane of exposure were constructed based on Upper-Kazanian stage sediments of the Pechishi stratotype. The lithostratigraphic breakdown of section was carried out based on raster data obtained.

Introduction

Geological cross-sections at many times are headlong rock escarpment, approaches to which involve risks to the life and health of geologists-researchers. At the same time distant visual observations are often difficult by local talus accumulations, which hiding individual layers of rocks. Another reason is the remoteness of research objects which excludes the detailed study of rocks structural and texture features. To solve these problems we propose to use SUAV (Small Unmanned Air Vehicle) and photogrammetric method for describing of hard to access geologic cross-sections (Wrobel, 1991). We used drones for the Pechishi stratotype Upper-Kazanian stage sedimets description, to show SUAV potential for using at rock massive scarp study. This stratotype is a cliff (about 100 m high) with steep walls, stretched along the banks of the Volga River. Its lower rock layers are available for direct study by geological methods, at the same time upper layers available only for visual observation. For their detailed elaboration, the drone was involved.

Equipment

For the photogrammetric survey was used combined technology includes SUAV and techniques of ground-based close range photogrammetry (Starovoytov and Chernova, 2015). We were used several drones to study upper layers of the Pechishi stratotype with purpose of further the comparative analysis: quadcopters Mavic, DJI Phantom 3 and DJI Phantom 2. As the main source of data from the air was used drone DJI Phantom 3 equipped with superwide-angle camera, FPV-mode aerial survey and remote control (Figure 1b). Technical specifications: flying range – at least 2 km at a working altitude of flight - 50-500 m; flight time – 20 minutes at a speed of up to 16 m/s; camera lens resolution – 12 mpx; video recording quality – 2K. The Canon Mark II D5 camera with the EF 24-70 F / 2.8L USM lens was used as the ground-based photographing equipment.

Figure 1 *SUAVs used: a) Mavic; b) DJI Phantom 3; c) DJI Phantom 2*

Technique of photographing

The photos of the outcrop walls were carried out using techniques of perspective route photography shooting (Starovoytov and Saifutdinova, 2015). The changes in the position of photographic equipment were carried out along height and along cut. The distance from cliff wall for most photographing points varied within 5-10 m. Also, some frames were shooted from a longer distance to cover entire surveyed area and simplify the further equalization of the scene during processing. The overlap of neighboring images varies between 60-85%, which corresponds to the requirements for using this method (Krasnopevtsev, 2008).

The length of the study interval was about 280 m. The amount of photos taken during shooting from the drones are varies. For Mavic quadcopter their number is 60 frames, DJI Phantom 2 – 89 frames, DJI Phantom 3 – 172 frames. During the ground photographing was obtain 191 high-resolution photos.

On all investigation object area were placed control picture points for the subsequent binding of the photo data. As external orientation elements, markers were used which are a white A3 format sheet (297×420 mm) with special codes printed on them (Figure 2). Use of such markers is necessary for their automatic detection at pictures in the processing software. This removes the need to manually set snapping points. In total, 12 markers were put up on the area.

The Trimble M3 5 " total station and the Trimble R8 GNSS receiver have made it possible to obtain good geodetic connection of marks positions. The determination of the target point and the location of total station base were carried out using GNSS receiver at RTK mode. Corrections with sub-cm precision accuracy were obtained from a base station located at Kazan University at a distance of 10.1 km from the site of the study. After installing the total station, all markers were shot in the following modes: section marks on a vertical surface – reflectorless; for horizontal markers on the ground – using a geodetic prism. As a coordinate system was used WGS84 UTM Zone 39. It allowed obtaining data about position of orientation external elements. The position data of shooting points for UAV Mavic and Phantom 3 were recorded as geo-tag an image at metadata.

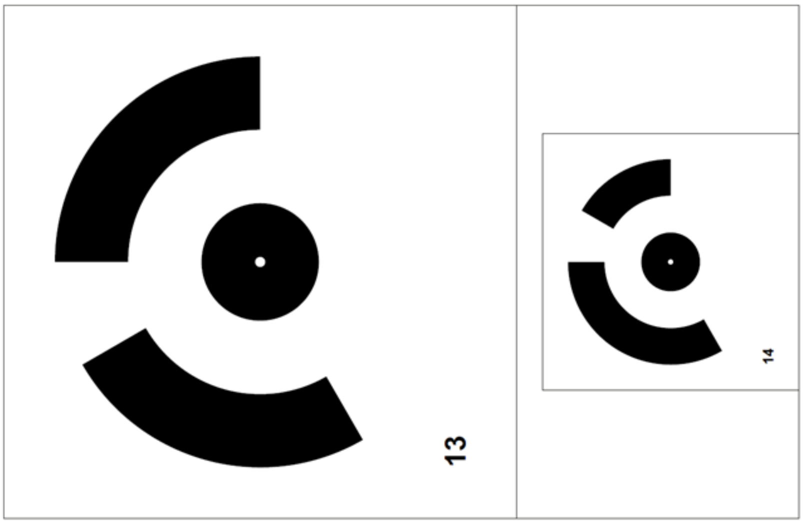

Figure 2 *Elements of external orientation (markers)*

The photogrammetry data was processed using the Agisoft Photoscan software (Agisoft LLC, 2016) using the following algorithm:

- The photogrammetry data was processed using the Agisoft Photoscan software (Agisoft LLC, 2016) using the following algorithm:
- Color correction of images;
- Adding photos to the project and aligning the scene, taking into account the GPS binding from the EXIF metadata for each frame;
- Searching for markers and determining their coordinates according to geodetic survey data;
- Removal of incorrect alignment points, optimization of the scene and determination characteristics of the internal orientation of the cameras, conducted in several iterations;
- Construction of a dense cloud of points (fine grid) (Figure 3);
- Construction a three-dimensional polymesh model with a texture from a points cloud;
- Generate derived data.

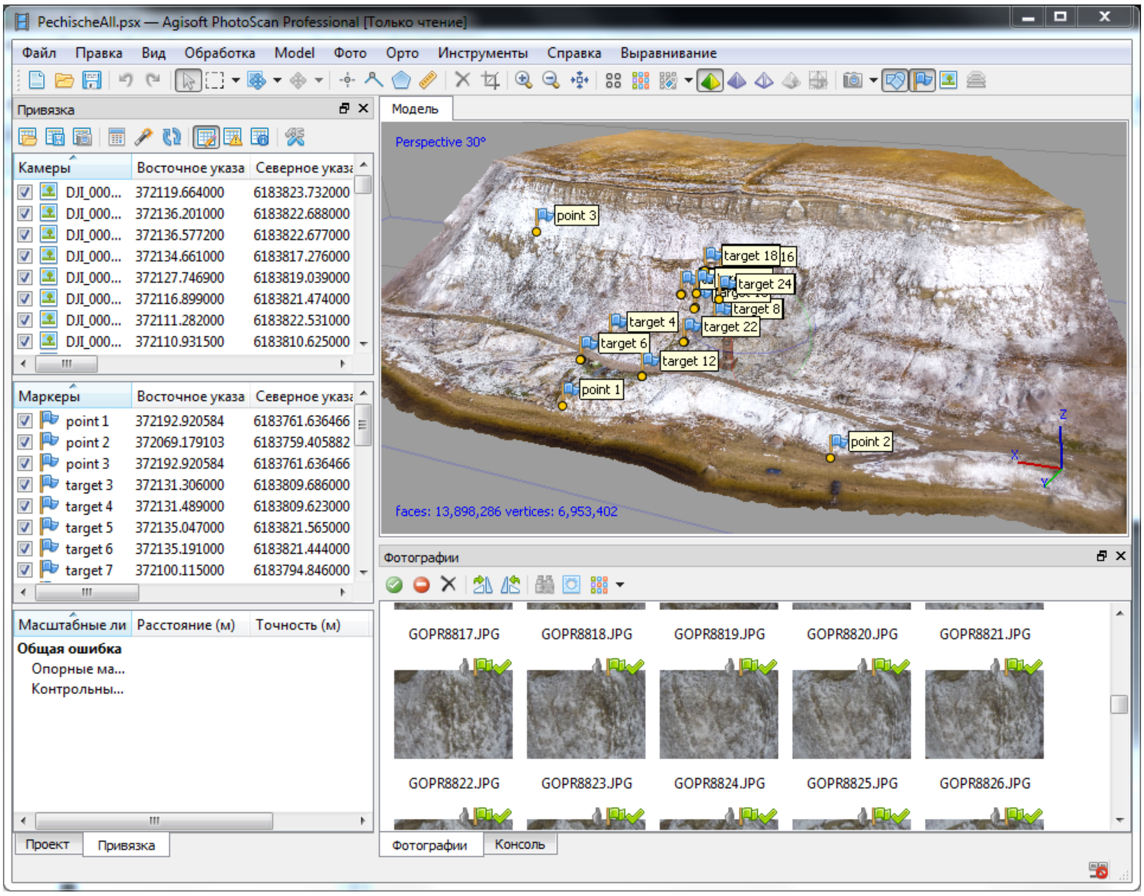

Figure 3 *Three-dimensional section model in the Agisoft Photoscan program*

Result of derived processing data is a digital relief model and location orthophotomap, also the ortho-section (Figure 4) and the surface relief model in the plane of exposure. The latter are raster data for further lithological analysis and have a spatial ortho-section resolution of 0.0056 m for the texture cut and 0.022 m for the surface relief.

The obtained panoramic image of the Pechishi stratotype makes it possible to carry out section upper part lithostratigraphic breakdown with a high degree of detail. As a basis for isolating stratigraphic geological unit, various rock stability to weathering. In this case, all laterally continuous facies on images are marking boundaries between the packs which composed of rocks of different composition.

Image analysis of relief shows the presence in the middle part of section a clear boundary between the "shihany" pack and the "opoka" pack. On the photo, it stands out by snow cover. The dense dolomites of the "shihany" pack form sheer rocky protrusions on which snow cover holds. The snow cover itself covers the more intensively weathered carbonate-terrigenous flat pitch layer of the "opoka" pack. Above the marls, clays and siltstones of the "opoka" pack, begins almost vertical slopes of light gray, dense dolomites of "podlyjnik" pack. This boundary coincides with the boundary of the end of the snow field. The dolomites are resistant to weathering and retain the primary deposit at lithological section, without hiding under sand talus. With an increase in the raster panoramic image, it is possible to clearly observe how an eluvial-soil horizon develops along the top of "podlyjnik" pack dolomite layer. At ortho-section of the Pechishi stratotype it is separated by fluffy consistence, a rusty color and the presence in the upper part of a black humus layer.

Conclusions

The main advantages of using UAV as a source of information for a photogrammetric measurement are:

- Use for photographing a hard to access geologic cross-sections areas;
- Wide areal coverage of the territory or photogrammetric measurement object;
- A high photo resolution allows to high degree of detail of section lithostratigraphic breakdown for hard to access geologic territory;
- Ability to install sensors and sensing elements for the purpose of geophysical research.

Figure 4 *Investigation object ortho-section)*

Acknowledgements

This study was funded by the subsidy allocated to Kazan Federal University as part of the state program for increasing its competitiveness among the world's leading centers of science and education.

References

1. Wrobel, B.P. [1991] The evolution of digital photogrammetry from analytical photogrammetry. *The Photogrammetric Record*, 13(77), 765-776.

2. Starovoytov, A.V. and Chernova, I.Y. [2015] Creation of a local infrastructure of the spatial data for conducting archaeological research on the basis of modern geodetic and GIS technologies. *Fundamental science and technology - promising developments V*, North Charleston, 2, 18-29. (in Russian)

3. Starovoytov, A.V. and Saifutdinova, G.M. [2015] Spatial information recording procedure involving methods of close range photogrammetry as applied to archaeological researches. *International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management. SGEM*, 1, 801-806.

4. Krasnopevtsev, B.V. [2008] *Photogrammetry*. Reprographiya, Moscow. (in Russian)

5. Agisoft LLC [2016] *Agisoft PhotoScan User Manual Professional Edition (Version 1.4)*, Saint Petersburg.