Determination Surface Characteristics and Alteration of Koru Mining Area (NW Turkey) by UAV Photogrammetry

Oya ERENOGLU, R. Cuneyt ERENOGLU and Ozgun AKCAY, Turkey

Key words: Mine surveying, Photogrammetry, Positioning, Remote sensing

SUMMARY

Biga Peninsula is a rich region in view of current mineral exploration in Turkey. The study area is located near the Koru (Lapseki/Çanakkale) village, in northeastern part of the Biga Peninsula. Koru deposit is hosted by volcanic rocks which are directly related to economically significant mineralization such as Pb-Zn. This deposit is shaped by Tertiary volcanic units including rhyolitic lava and tuffs. In this study, we used ortho-mosaics derived from Unmanned Aerial Vehicle (UAV) based photogrammetry provide opportunities to analyze materials of natural and artificial the objects on surface, to produce maps of study areas, to determine litological differences of geological units, to introduce their contact relations, and finally to detect alteration characteristic on concerning rocks. For this purpose, we employed air imagery using high resolution digital camera integrated to UAV. In this context, UAV technology would be first used to geological researches for producing thematic maps (the rock classifying maps). The lava and tuff lithologies in the Koru mining area have been successfully distinguished using the imagery obtained from UAV. Severe rhyolitic lava, andesitic lava and rhyolitic tuff are classified and zoned in the map by image processing techniques in addition to the surface topography. As a result, lithology and mineralization maps can be produced in short time especially for the local areas using UAV technology and image processing.

Determination Surface Characteristics and Alteration of Koru Mining Area(NW Turkey)by UAV Photogrammetry

Oya ERENOGLU, R. Cuneyt ERENOGLU and Ozgun AKCAY, Turkey

1. INTRODUCTION

1.1 Study Area

The study area is located near the Koru (Lapseki/Çanakkale) village, in northeastern part of the Biga Peninsula. Koru deposit is hosted by volcanic rocks which are directly related to economically significant mineralization such as Pb-Zn. This deposit is shaped by Tertiary volcanic units including rhyolitic lava and tuffs.

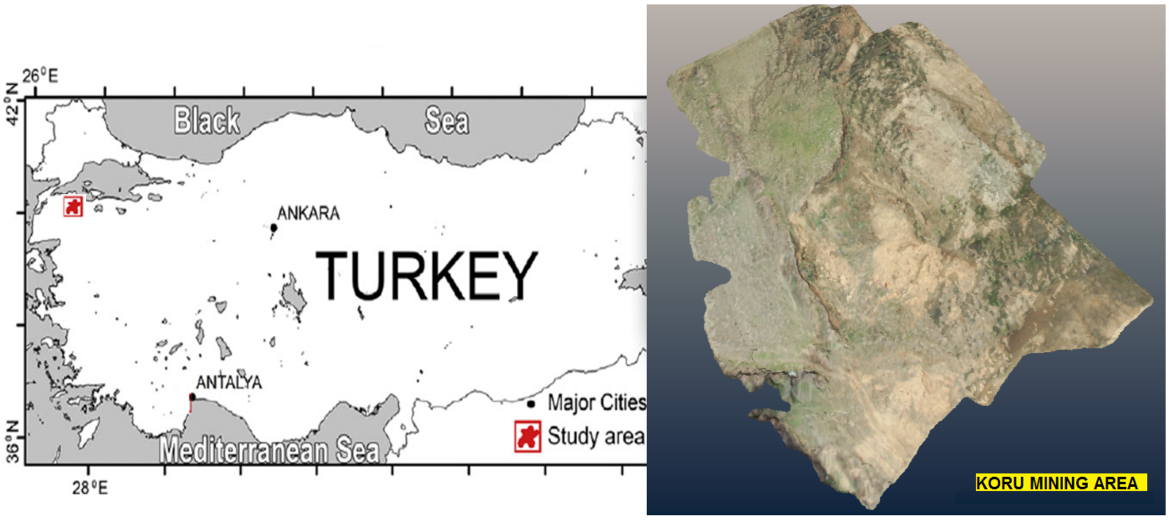

Fig. 1: Studying Area

1.2 UAV-based Remote Sensing for Geological Classification

Many scientists have been performed UAV-based photogrammetry and remote sensing for many decades. As the first motorized UAV photogrammetry workings, fixed wing remote controlled air vehicles have been developed in 1970's (Przybilla and Wester-Ebbinghhaus, 1979). The first high-resolution digital elevation models was produced by Eisenbeiss et al. (2005) using autonomously UAV helicopter. Nowadays, there are many other UAV-systems for using (Jütte, 2008, Gomez-Lahoz and Gonzalez-Aguilera, 2009, Fotinopoulos, 2004, Aber et al., 2002). The use of high resolution digital photogrammetry based on UAV technology for classifying of surface geology is tested in this study.

2. UAV SYSTEM

2.1 Eight-Rotor Oktokopter UAV

When compared to conventional helicopters, quad-rotor systems are more stable in flight with reduced vibration and have the mechanical advantage of not requiring a large, variable pitch rotor-unit. Our in-house developed quad-rotor system is stabilized by inertial measurement units (IMU), including three acceleration sensors, three gyroscopes, a three-axis compass, a pressure sensor, and is regulated by basic PID (proportional integral differential) loops. A quad-rotor open source project (Mikrokopter, 2009) has been used and improved by modifications of the software and the electronic circuit in order to comply with the requirements for landslide studies. Technical data of Oktokopter XL can be summarized as follows:

- Dimensions 73x73x36 (BxLxH)
- Payload: recommended max. payload = 2500g
- Max. altitude: Line of sight (several 100m)
- Max. distance: Line of sight (several 100m)
- Flight time: max. 45min at full battery load (30Ah)
- Realistic flight time: 18-28Min (10Ah) See tables below
- Telemetry with speech: Voltage, capacity, current, altitude, distance, direction, speed, temperature

Fig. 2: UAV Okto XL Mikrokopter Full Ready to Fly

2.2 Camera- Systems

For optimum flight time, the eight-rotor UAVs should be equipped with lightweight low-cost digital compact camera, which support manual camera settings. In this study, we used Canon EOS-M Mirrorless Digital Camera, see Fig 3. For all flights the camera settings were fixed to ISO 200 at F2.8 and a focus of 18 mm. These settings enabled an average shutter speed of 1/800 s which was necessary to avoid blurred photographs.

Fig. 3: Canon EOS-M Mirrorless Digital Camera

Specifications:
Type: Digital single-lens non-reflex, AF/AE camera
Image Format: 22.3 x 14.9 mm (APS-C size)
Compatible Lenses: Canon EF-M lenses, Canon EF lenses including EF-S lenses
(35mm-equivalent focal length is approx.1.6x the lens focal length)
Lens Mount: Canon EF-M mount (Canon EF-M lenses can be mounted directly to the camera. Canon EF lenses (including EF-S lenses) can be attached by using the optional Mount Adapter EF-EOS M.)

Lens System:
Type: Wide-angle lens - 22 mm - F/2.0 STM Canon EF-M
Focal Length Equivalent to 35mm Camera: 35 mm
Focus Adjustment: Manual/Automatic
Min Focus Range: 5.9 in
Max View Angle: 63.5 degrees
Lens Construction: 6 groups / 7 elements
Filter Size: 43 mm
Lens System Mounting: Canon EF-M

3. CAMERA CALIBRATION SCHEME

Camera calibration determines information about the camera that improves accuracy in subsequent studying projects. Calibration process calculates the camera's focal length, lens distortion, format aspect ratio, and principal point. The resulting calibration data file can be saved on disk for use in all the projects that involve photos taken by that camera. High accuracy works, e.g., digital surface modeling, require a well calibrated camera. Various calibration algorithms have been developed and improved over a period of more than decades. Some automatic camera calibrator are fully automated and very accurate, plus it is included at no extra charge as part of the basic software package. It is designed to be so practical to use and suitable for the broadest range of automatic camera calibrator users. In this study, we used PhotoModeler's camera calibrator. To do it, we have performed the field calibration project using calibration sheets including the coded targets, see Figure 4. The calibration status report is given in Figure 5.

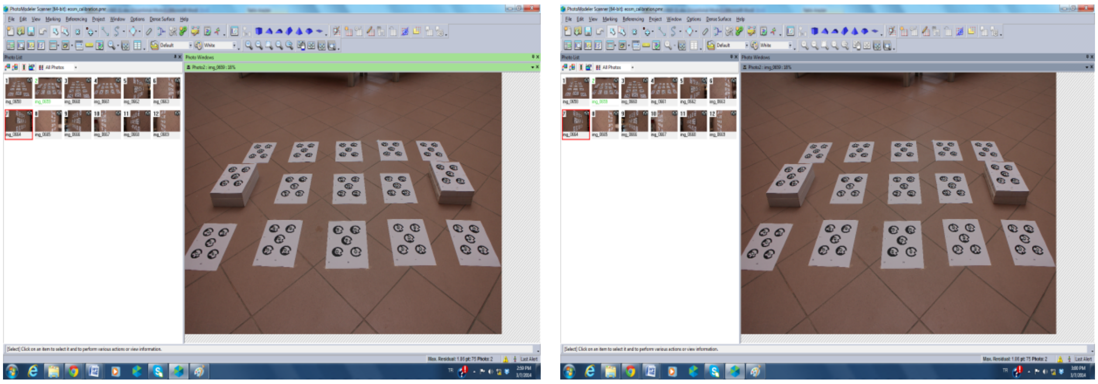

Fig. 4: Calibration process using calibration sheets.

```
Status Report Tree
   Project Name: eosm_calibration.pmr
   Problems and Suggestions (1)
      Project Problems (1)
   Information from most recent processing
      Last Processing Attempt: Fri Feb 07 16:23:40 2014
      PhotoModeler Version: 2014.0.0.1302 - final,full (64-bit)
      Status: successful
      Processing Options
         Orientation: on
            All photos oriented.
            Number of photos oriented: 12
         Global Optimization: on
         Calibration: on (full calibration)
         Constraints: off
      Total Error
         Number of Processing Iterations: 4
         Number of Processing Stages: 2
         First Error: 41.112
         Last Error: 4.548
      Precisions / Standard Deviations
         Camera Calibration Standard Deviations
            Camera1: Canon EOS M [18.00]
               Focal Length
                    Value: 18.697047 mm
                    Deviation: Focal: 0.003 mm
               Xp - principal point x
                    Value: 11.632606 mm Deviation: Xp: 0.005 mm
               Yp - principal point y
                    Value: 7.782084 mm  Deviation: Yp: 0.006 mm
               Fw - format width
                    Value: 22.768255 mm Deviation: Fw: 0.003 mm
               Fh - format height
                    Value: 15.163800 mm
               K1 - radial distortion 1
                    Value: 4.947e-004   Deviation: K1: 3.9e-006
               K2 - radial distortion 2
                    Value: -8.669e-007  Deviation: K2: 2.9e-008
               K3 - radial distortion 3
                    Value: 0.000e+000
               P1 - decentering distortion 1
                    Value: -6.402e-005 Deviation: P1: 3.7e-006
               P2 - decentering distortion 2
```

Fig. 5: Calibration status report

4. IMAGE ACQUISITION

A set of UAV-acquired photographs covering the whole mining area in Koru (Lapseki/Çanakkale) village were taken. The achievable altitude over ground was in the range between 40 m and 70 m. All photographs were taken manually using shooter of remote controller and First Person View (FPV) flying mode. In a first in-situ flight planning step, the desired area and suitable locations for starting and landing were chosen. Then the quadrotor was launched to the maximum flight altitude of about 70 m. At this location the UAV was hovered for about 45 seconds. Note that the pilot initiated vertical landing. After each flight, we downloaded and checked the covered area of the acquired photographs on-site, see Fig. 6.

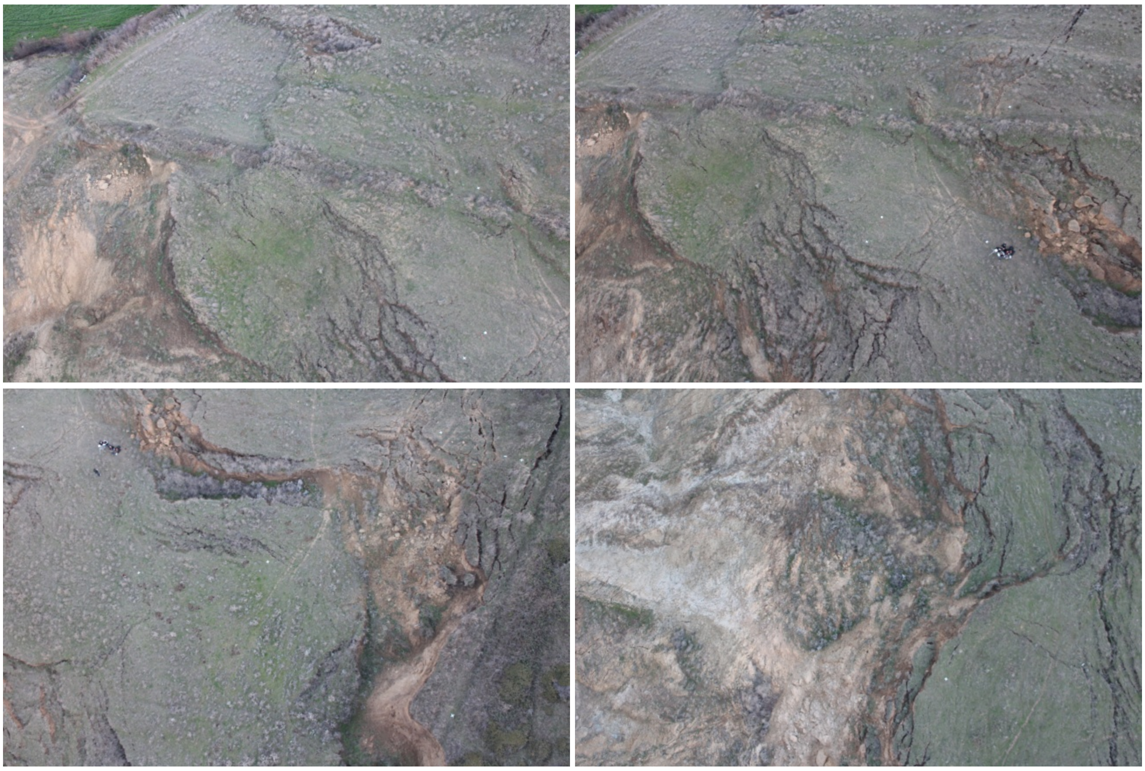

Fig. 6: Some examples of taken aerial photos by UAV

5. DIGITAL SURFACE MODEL PROCESSING

In order to produce digital surface model, we processed the data in PhotoModeler Scanner software. The photographs of the entire mining area (manually pre-selected by criteria like image quality and covered area size) were computed to digital surface models in 4 sub-areas. First, all photographs were processed to get the image planes from UAV photos and camera positions, see Figures 7 (a) and (b). Then, these data were supplied to the patch based multi view stereo procedure of the software which finally computed a dense point cloud for all supplied photographs. Thereby, we obtained 3D digital surface model including point cloud with single color and point cloud with exact color from photo as seen in Figures 7 (c) and (d). Furthermore, the largest residual for each photo in Figure 8 clearly shows photo quality production of digital surface models during software process.

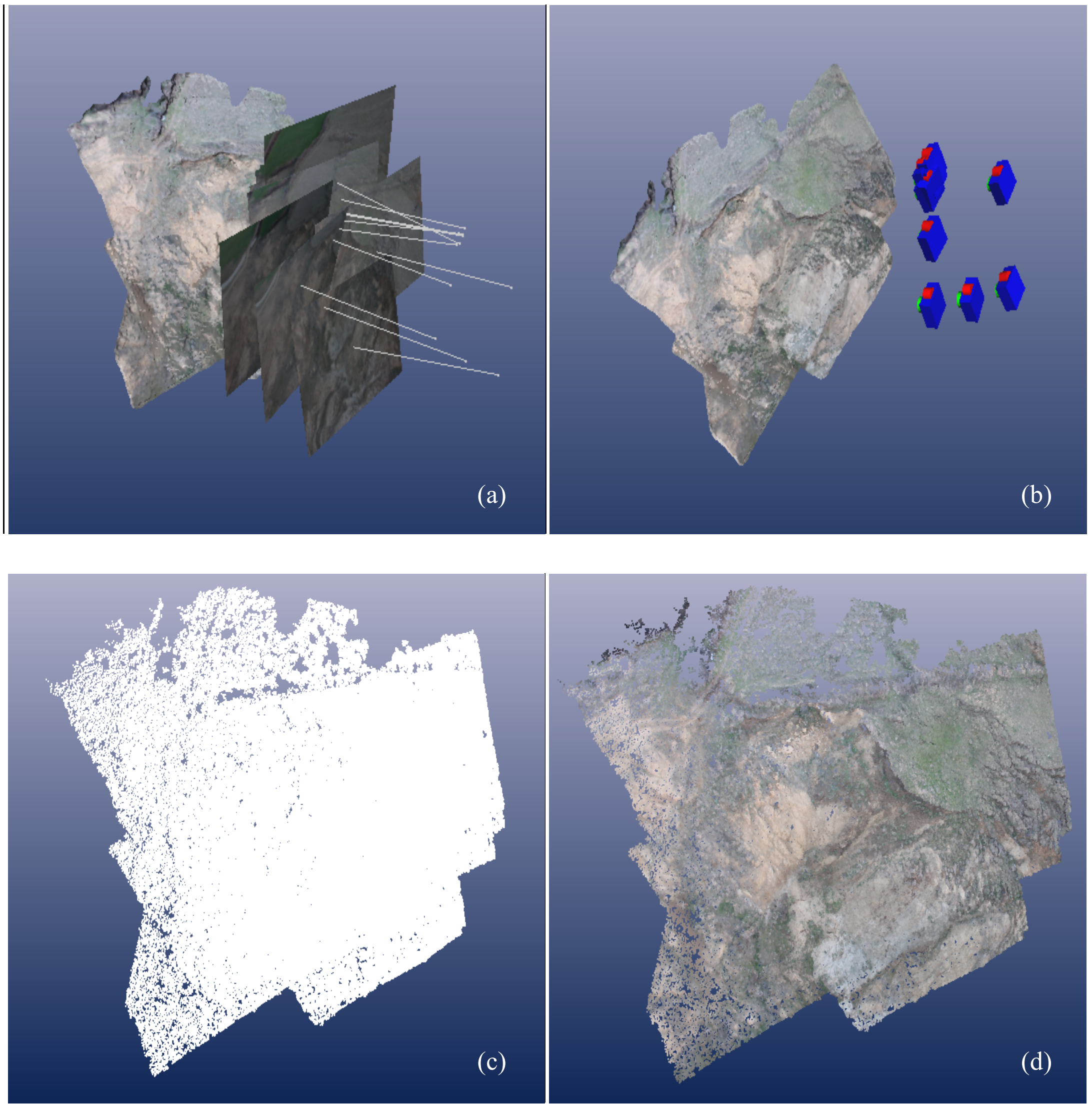

Fig. 7: (a): Image planes from UAV photos. (b): Image frustum plane. (c): Point cloud with single color. (d): Point cloud with exact color from photo.

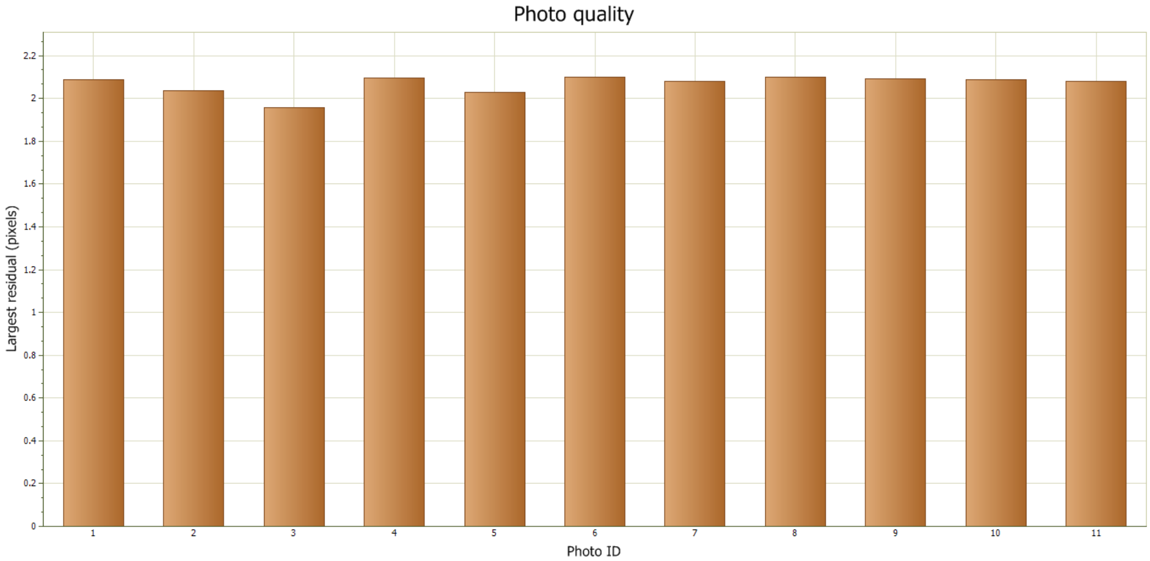

Fig. 8: Largest residual vs photo id

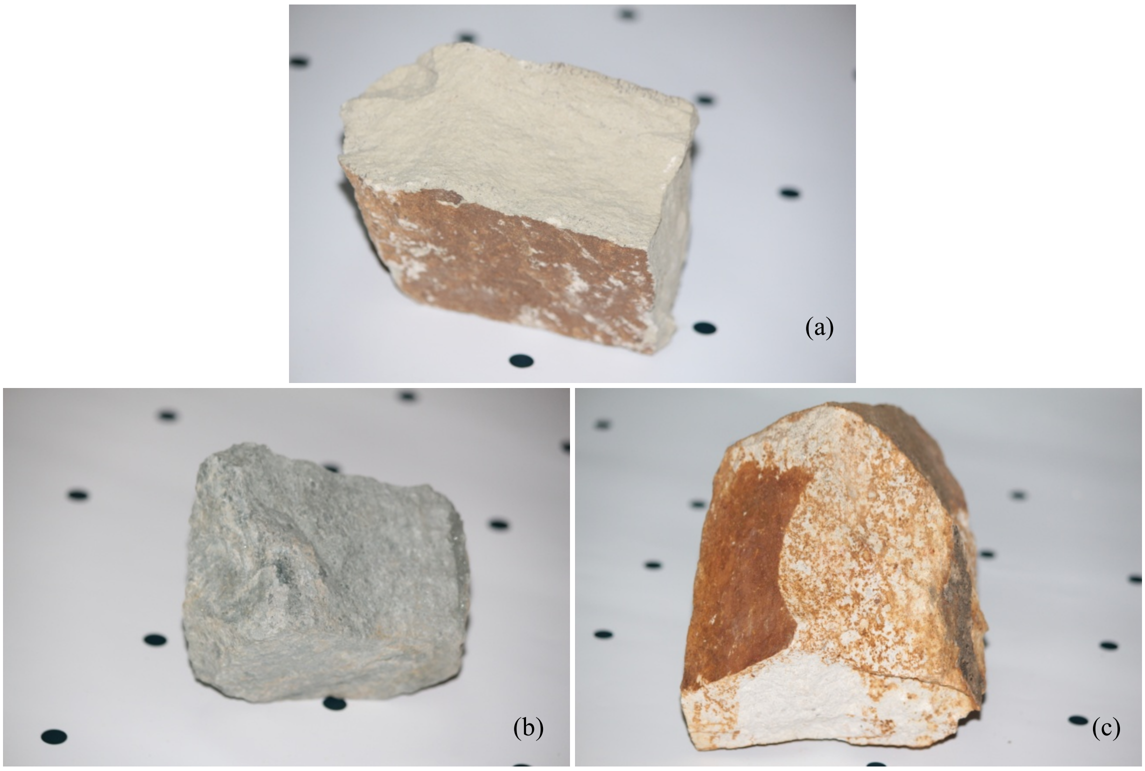

Fig. 9: Taken rock samples from the study area; (a): Rhyolitic lava. (b): Andesitic lava. (c): Rhyolitic tuff.

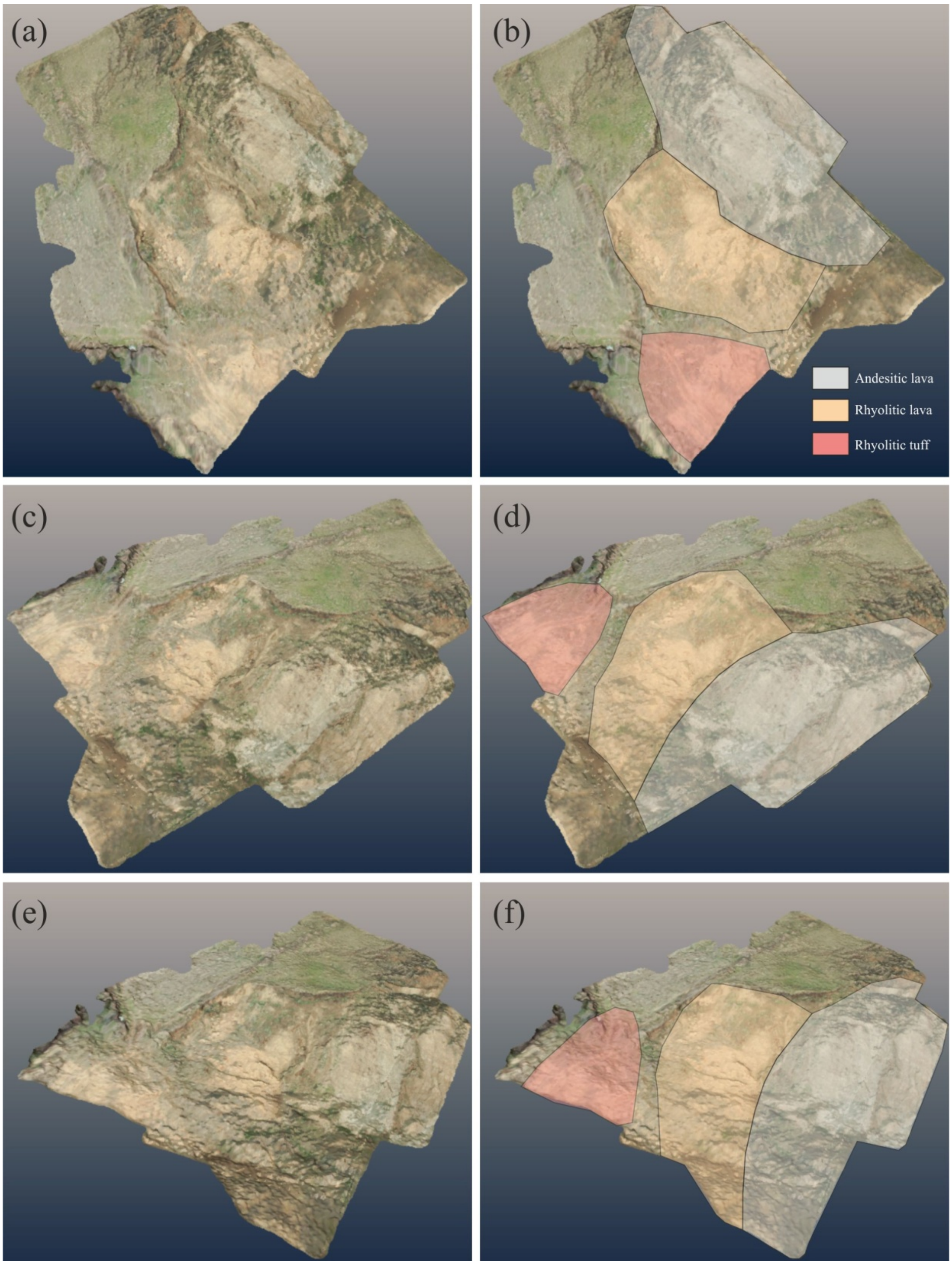

Fig. 10: 3D model of landslide showing the sub-areas

In study area, we get some rock samples from the region. You can see them from Figure 9. The photos of rhyolitic lava, andesitic lava and rhyolitic tuff are given in Figures 9 (a), (b) and (c), respectively. A histogram is a graph that can help you evaluate a digital image.

Histograms can be found on digital cameras and in computer software. We used Photomodeler software. From the RGB histograms of these rocks, the values are regionally averaged for the actual RGB colors (Lichti, 2005, Bachmann et al., 2010, Buckley et al., 2010). The average RGB values of the rocks are obtained. Figures 10 (a), (c) and (e) shows the 3D surface models using UAV- remote sensing from three different aspects. Finally, we searched for 3D surface models according to the averaged RGB colors of sampled rocks in order to classify surface characteristics of the study area. The matched areas are covered with related colors. Figures 10 (b), (d) and (f) indicate good matching for landing classifications. Moreover field observations also confirm this.

6. CONCLUSIONS

In this study, for surface characterization, we showed that a low-cost UAV-based remote sensing approach reveals high-resolution digital surface models. To do it, terrestrial and aerial photos were taken, and their RGB values are compared with each other. Finally, the matched areas, e.g. rhyolitic lava, andesitic lava and rhyolitic tuff, are successfully determined, classified and zoned. We propose to use the UAV remote sensing for classifying geological characterization. As a future work, we plan to extend this approach using geological spectrometer tools for increasing inner reliability of the used approach.

ACKNOWLEDGMENTS
This work partly was supported by the Scientific and Technological Research Council of Turkey (TUBITAK) with Project Number 112Y336.

REFERENCES

Bachmann, C.M., Nichols, C.R., Montes, M.J., Li, R.-R., Woodward, P., Fusina, R.A., Chen, W., Mishra, V., Kim, W., Monty, J., Mcilhany, K., Kessler, K., Korwan, D., Miller, W.D., Bennert, E., Smith, G., Gillis, D., Sellars, J., Parrish, C., Schwarzschild, A., Truitt, B., 2010. Retrieval of substrate bearing strength from hyperspectral imagery during the virginia coast reserve (VCR'07) multi-sensor campaign. Mar. Geodesy 33 (2-3), 101–116.

Buckley, S.J., Enge, H.D., Carlsson, C., Howell, J.A., 2010. Terrestrial laser scanning for use in virtual outcrop geology. Photogram. Rec. 25 (131), 225–239.

Eisenbeiss, H., Lambers, K., Sauerbier, M., (2005), Photogrammetric recording of the archaeological site of Pinchango Alto (Palpa, Peru) using a mini helicopter (UAV). In: Proc. of the 33rd CAA Conference, Tomar, Portugal.

Fotinopoulos, V., (2004), Balloon photogrammetry for archaeological surveys. In: International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XX ISPRS Congress, Istanbul, Turkey, XXXV-B5, pp. 504-507.

Gomez-Lahoz, J. and Gonzalez-Aguilera, D., (2009), Recovering traditions in the digital era: the use of blimps for modelling the archaeological cultural heritage. Journal of Archaeological Science, 36(1), pp. 100-109.

Jütte, K., (2008), Vergleich verschiedener low-cost Luftbildaufnahmesysteme sowie Einsatz von Drohnen: Grenzen und Möglichkeiten. In: Bayerische Landesanstalt für Wald und Forstwirtschaft. Der gepixelte Wald - Fachtagung zur Forstlichen Fernerkundung

Lichti, D.D., 2005. Spectral filtering and classification of terrestrial laser scanner point clouds. Photogram. Rec. 20 (111), 218–240.

Mikrokopter Drohne (2009) RobinSchneider.

Przybilla, H.-J. and Wester-Ebbinghaus, W., 1979. Bildflug mit ferngelenktem Kleinflugzeug. Bildmessung und Luftbildwesen, Zeitschrift fuer Photogrammetrie und Fernerkundung, 47(5), pp. 137-142.

BIOGRAPHICAL NOTES

Oya Erenoglu is an research assistant at the COMU. She has a degree of PhD. She has been academic staff at the university since 2005. Her search interests focus on mineorology and petrography.

R. Cuneyt Erenoglu graduated from the Department of Geodesy and Photogrammetry Engineering of YTU in 1999. He has a degree of PhD. His work focuses on robust statistics. Moreover, he works on statistics, GPS and geodesy. He is an assistant professor at the DGPE of COMU.

Ozgun Akcay graduated from the Department of Geodesy and Photogrammetry Engineering of ITU in 1998. He has a degree of PhD. His work focuses on photogrammetry.

CONTACTS

Oya ERENOGLU
Department of Geological
Canakkale Onsekiz Mart University,
17100 Canakkale
TURKEY
Tel. + 90 286 218 00 18 (ext. 2135)
Fax + 90 286 218 05 41
Email: o_turkdonmez@comu.edu.tr

R. Cuneyt ERENOGLU
Tel. + 90 286 218 00 18 (ext. 2206)
Fax + 90 286 218 05 41
Email:ceren@comu.edu.tr

Ozgun AKCAY
Tel. + 90 286 218 00 18 (ext. 2201)
Fax + 90 286 218 05 41
Email:akcay@comu.edu.tr