

ISSN 2518-170X (Online),
ISSN 2224-5278 (Print)

ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
ҰЛТТЫҚ ҒЫЛЫМ АКАДЕМИЯСЫ
Satbayev University

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
РЕСПУБЛИКИ КАЗАХСТАН
Satbayev University

N E W S

OF THE ACADEMY OF SCIENCES
OF THE REPUBLIC OF KAZAKHSTAN
Satbayev University

SERIES
OF GEOLOGY AND TECHNICAL SCIENCES

3 (447)

MAY – JUNE 2021

THE JOURNAL WAS FOUNDED IN 1940

PUBLISHED 6 TIMES A YEAR

ALMATY, NAS RK

NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

НАН РК сообщает, что научный журнал «Известия НАН РК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАН РК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.

Бас редактор

ЖҰРЫНОВ Мұрат Жұрынұлы, химия ғылымдарының докторы, профессор, ҚР ҰҒА академигі, Қазақстан Республикасы Ұлттық Ғылым академиясының президенті, АҚ «Д.В. Сокольский атындағы отын, катализ және электрохимия институтының» бас директоры (Алматы, Қазақстан) Н = 4

Редакциялық алқа:

ӘБСАМЕТОВ Мәліс Құдысұлы (бас редактордың орынбасары), геология-минералогия ғылымдарының докторы, профессор, ҚР ҰҒА академигі, «У.М. Ахмедсафина атындағы гидрогеология және геоэкология институтының» директоры (Алматы, Қазақстан) Н = 2

ЖОЛТАЕВ Герой Жолтайұлы (бас редактордың орынбасары), геология-минералогия ғылымдарының докторы, профессор, Қ.И. Сатпаев атындағы геология ғылымдары институтының директоры (Алматы, Қазақстан) Н=2

СНОУ Дэниел, Ph.D, қауымдастырылған профессор, Небраска университетінің Су ғылымдары зертханасының директоры (Небраска штаты, АҚШ) Н = 32

ЗЕЛЬТМАН Реймар, Ph.D, табиғи тарих мұражайының Жер туралы ғылымдар бөлімінде петрология және пайдалы қазбалар кен орындары саласындағы зерттеулердің жетекшісі (Лондон, Англия) Н = 37

ПАНФИЛОВ Михаил Борисович, техника ғылымдарының докторы, Нанси университетінің профессоры (Нанси, Франция) Н=15

ШЕН Пин, Ph.D, Қытай геологиялық қоғамының тау геологиясы комитеті директорының орынбасары, Американдық экономикалық геологтар қауымдастығының мүшесі (Пекин, Қытай) Н = 25

ФИШЕР Аксель, Ph.D, Дрезден техникалық университетінің қауымдастырылған профессоры (Дрезден, Берлин) Н = 6

КОНТОРОВИЧ Алексей Эмильевич, геология-минералогия ғылымдарының докторы, профессор, РҒА академигі, А.А. Трофимука атындағы мұнай-газ геологиясы және геофизика институты (Новосибирск, Ресей) Н = 19

АБСАДЫКОВ Бахыт Нарикбайұлы, техника ғылымдарының докторы, профессор, ҚР ҰҒА корреспондент-мүшесі, А.Б. Бектұров атындағы химия ғылымдары институты (Алматы, Қазақстан) Н = 5

АГАБЕКОВ Владимир Енокович, химия ғылымдарының докторы, Беларусь ҰҒА академигі, Жаңа материалдар химиясы институтының құрметті директоры (Минск, Беларусь) Н = 13

КАТАЛИН Стефан, Ph.D, Дрезден техникалық университетінің қауымдастырылған профессоры (Дрезден, Берлин) Н = 20

СЕЙТМҰРАТОВА Элеонора Юсуповна, геология-минералогия ғылымдарының докторы, профессор, ҚР ҰҒА корреспондент-мүшесі, Қ.И. Сатпаев атындағы Геология ғылымдары институты зертханасының меңгерушісі (Алматы, Қазақстан) Н=11

САҒЫНТАЕВ Жанай, Ph.D, қауымдастырылған профессор, Назарбаев университеті (Нұр-Сұлтан, Қазақстан) Н = 11

ФРАТТИНИ Паоло, Ph.D, Бикокк Милан университеті қауымдастырылған профессоры (Милан, Италия) Н = 28

«ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы».

ISSN 2518-170X (Online),

ISSN 2224-5278 (Print)

Меншіктенуші: «Қазақстан Республикасының Ұлттық ғылым академиясы» РҚБ (Алматы қ.).

Қазақстан Республикасының Ақпарат және қоғамдық даму министрлігінің Ақпарат комитетінде 29.07.2020 ж. берілген № **KZ39VPY00025420** мерзімдік басылым тіркеуіне қойылу туралы куәлік.

Тақырыптық бағыты: *геология және техникалық ғылымдар бойынша мақалалар жариялау.*

Мерзімділігі: жылына 6 рет.

Тиражы: 211 дана.

Редакцияның мекен-жайы: 050010, Алматы қ., Шевченко көш., 28, 219 бөл., тел.: 272-13-19, 272-13-18
<http://www.geolog-technical.kz/index.php/en/>

© Қазақстан Республикасының Ұлттық ғылым академиясы, 2021

Типографияның мекен-жайы: «Аруна» ЖК, Алматы қ., Муратбаева көш., 75.

Главный редактор

ЖУРИНОВ Мурат Журинович, доктор химических наук, профессор, академик НАН РК, президент Национальной академии наук Республики Казахстан, генеральный директор АО «Институт топлива, катализа и электрохимии им. Д.В. Сокольского» (Алматы, Казахстан) Н = 4

Редакционная коллегия:

АБСАМЕТОВ Малис Кудысович, (заместитель главного редактора), доктор геолого-минералогических наук, профессор, академик НАН РК, директор Института гидрогеологии и геоэкологии им. У.М. Ахмедсафина (Алматы, Казахстан) Н = 2

ЖОЛТАЕВ Герой Жолтаевич, (заместитель главного редактора), доктор геолого-минералогических наук, профессор, директор Института геологических наук им. К.И. Сатпаева (Алматы, Казахстан) Н=2

СНОУ Дэниел, Ph.D, ассоциированный профессор, директор Лаборатории водных наук университета Небраски (штат Небраска, США) Н = 32

ЗЕЛЬТМАН Реймар, Ph.D, руководитель исследований в области петрологии и месторождений полезных ископаемых в Отделе наук о Земле Музея естественной истории (Лондон, Англия) Н = 37

ПАНФИЛОВ Михаил Борисович, доктор технических наук, профессор Университета Нанси (Нанси, Франция) Н=15

ШЕН Пин, Ph.D, заместитель директора Комитета по горной геологии Китайского геологического общества, член Американской ассоциации экономических геологов (Пекин, Китай) Н = 25

ФИШЕР Аксель, ассоциированный профессор, Ph.D, технический университет Дрезден (Дрезден, Берлин) Н = 6

КОНТОРОВИЧ Алексей Эмильевич, доктор геолого-минералогических наук, профессор, академик РАН, Институт нефтегазовой геологии и геофизики им. А.А. Трофимука СО РАН (Новосибирск, Россия) Н = 19

АБСАДЫКОВ Бахыт Нарикбаевич, доктор технических наук, профессор, член-корреспондент НАН РК, Институт химических наук им. А.Б. Бектурова (Алматы, Казахстан) Н = 5

АГАБЕКОВ Владимир Енокович, доктор химических наук, академик НАН Беларуси, почетный директор Института химии новых материалов (Минск, Беларусь) Н = 13

КАТАЛИН Стефан, Ph.D, ассоциированный профессор, Технический университет (Дрезден, Берлин) Н = 20

СЕЙТМУРАТОВА Элеонора Юсуповна, доктор геолого-минералогических наук, профессор, член-корреспондент НАН РК, заведующая лабораторией Института геологических наук им. К.И. Сатпаева (Алматы, Казахстан) Н=11

САГИНТАЕВ Жанай, Ph.D, ассоциированный профессор, Назарбаев университет (Нурсултан, Казахстан) Н = 11

ФРАТТИНИ Паоло, Ph.D, ассоциированный профессор, Миланский университет Бикокк (Милан, Италия) Н = 28

«Известия НАН РК. Серия геологии и технических наук».

ISSN 2518-170X (Online),

ISSN 2224-5278 (Print)

Собственник: Республиканское общественное объединение «Национальная академия наук Республики Казахстан» (г. Алматы).

Свидетельство о постановке на учет периодического печатного издания в Комитете информации Министерства информации и общественного развития Республики Казахстан № KZ39VPY00025420, выданное 29.07.2020 г.

Тематическая направленность: *публикация статей по геологии и техническим наукам.*

Периодичность: 6 раз в год.

Тираж: 211 экземпляров.

Адрес редакции: 050010, г. Алматы, ул. Шевченко, 28, оф. 219, тел.: 272-13-19, 272-13-18

<http://www.geolog-technical.kz/index.php/en/>

© Национальная академия наук Республики Казахстан, 2021

Адрес типографии: ИП «Аруна», г. Алматы, ул. Муратбаева, 75.

Editor in chief

ZHURINOV Murat Zhurinovich, doctor of chemistry, professor, academician of NAS RK, president of the National Academy of Sciences of the Republic of Kazakhstan, general director of JSC "Institute of fuel, catalysis and electrochemistry named after D.V. Sokolsky" (Almaty, Kazakhstan) H = 4

Editorial board:

ABSAMETOV Malis Kudysovich, (deputy editor-in-chief), doctor of geological and mineralogical sciences, professor, academician of NAS RK, director of the Akhmedsafin Institute of hydrogeology and hydrophysics (Almaty, Kazakhstan) H = 2

ZHOLTAEV Geroy Zholtaevich, (deputy editor-in-chief), doctor of geological and mineralogical sciences, professor, director of the institute of geological sciences named after K.I. Satpayev (Almaty, Kazakhstan) H=2

SNOW Daniel, Ph.D, associate professor, director of the laboratory of water sciences, Nebraska University (Nebraska, USA) H = 32

Zeltman Reyman, Ph.D, head of research department in petrology and mineral deposits in the Earth sciences section of the museum of natural history (London, England) H = 37

PANFILOV Mikhail Borisovich, doctor of technical sciences, professor at the Nancy University (Nancy, France) H=15

SHEN Ping, Ph.D, deputy director of the Committee for Mining geology of the China geological Society, Fellow of the American association of economic geologists (Beijing, China) H = 25

FISCHER Axel, Ph.D, associate professor, Dresden University of technology (Dresden, Germany) H = 6

KONTOROVICH Aleksey Emilievich, doctor of geological and mineralogical sciences, professor, academician of RAS, Trofimuk Institute of petroleum geology and geophysics SB RAS (Novosibirsk, Russia) H = 19

ABSADYKOV Bakhyt Narikbaevich, doctor of technical sciences, professor, corresponding member of NAS RK, Bekturov Institute of chemical sciences (Almaty, Kazakhstan) H = 5

AGABEKOV Vladimir Enokovich, doctor of chemistry, academician of NAS of Belarus, honorary director of the Institute of chemistry of new materials (Minsk, Belarus) H = 13

KATALIN Stephan, Ph.D, associate professor, Technical university (Dresden, Berlin) H = 20

SEITMURATOVA Eleonora Yusupovna, doctor of geological and mineralogical sciences, professor, corresponding member of NAS RK, head of the laboratory of the Institute of geological sciences named after K.I. Satpayev (Almaty, Kazakhstan) H=11

SAGINTAYEV Zhanay, Ph.D, associate professor, Nazarbayev University (Nursultan, Kazakhstan) H = 11

FRATTINI Paolo, Ph.D, associate professor, university of Milano-Bicocca (Milan, Italy) H = 28

News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technology sciences.

ISSN 2518-170X (Online),

ISSN 2224-5278 (Print)

Owner: RPA «National Academy of Sciences of the Republic of Kazakhstan» (Almaty).

The certificate of registration of a periodical printed publication in the Committee of information of the Ministry of Information and Social Development of the Republic of Kazakhstan **No. KZ39VPY00025420**, issued 29.07.2020.

Thematic scope: *publication of papers on geology and technical sciences.*

Periodicity: 6 times a year.

Circulation: 211 copies.

Editorial address: 28, Shevchenko str., of. 219, Almaty, 050010, tel. 272-13-19, 272-13-18,

<http://www.geolog-technical.kz/index.php/en/>

© National Academy of Sciences of the Republic of Kazakhstan, 2021

Address of printing house: ST «Aruna», 75, Muratbayev str, Almaty.

NEWS

OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN

SERIES OF GEOLOGY AND TECHNICAL SCIENCES

ISSN 2224-5227

Volume 3, Number 447 (2021), 53-58

<https://doi.org/10.32014/2021.2518-170X.62>

**Fitryane Lihawa¹, Ahmad Zainuri¹, Indriati Martha Patuti², Aang Panji Permana¹,
I Gusti Nyoman Yuda Pradana¹**

¹Earth Science and Technology Department, Faculty of Mathematic and Natural Science,
Universitas Negeri Gorontalo, Gorontalo, Indonesia

²Civil Engineering Department, Faculty of Engineering, Universitas Negeri Gorontalo,
Gorontalo, Indonesia

E-mail: aang@ung.ac.id

**THE ANALYSIS OF SLIDING SURFACE IN ALO WATERSHED,
GORONTALO DISTRICT, INDONESIA**

Abstract. Alo watershed is the sub-watershed within the system of Limboto watershed which directly disembogues to Limboto Lake. Land degradation happened in the Alo watershed is caused by the agricultural system that does not apply land conservation techniques such as terracing and mounds and it triggers erosion and landslide. The method used in this research is geoelectric method with Wenner Alpha configuration; while the data analysis utilizes resistivity imaging method which produces two-dimensional cross-sectional images. In total, there are seven trajectories with a length of 170-180 meters each. The result of the research presents the slip surfaces of 7 locations are located in 3-17 meters depth with the inclination of 11° -79° trending dominantly northwest and one location trending southeast.

Keywords: Alo Watershed, Gorontalo, Sliding Surface

Introduction. There are not many pieces of research covering landslides in Gorontalo province. The latest research shows that the landslides occur in there are rotational slide, planar slide, slide flow, and rock block slide. The landslides are commonly affected by the slope and surface shape of the slope [1]. Alo watershed is the sub-watershed located in Limboto basin system which directly disembogues into Limboto Lake. Alo watershed is one of the largest sediment contributors to Limboto Lake of 0.0342 kg/sec. According to the latest survey conducted by JICA study team, annual sediment volume is estimated around $5.04 \times 10^6 \text{ m}^3/\text{year}$ (or $5,500 \text{ m}^3/\text{km}^2/\text{year}$). Therefore, if the incoming sediment volume cannot be controlled, it is predicted that within 25 years the Limboto Lake will be filled with sediment [2]. Alo watershed has the biggest sediment contribution of 947,187.87 ton and its SDR reaches 0.59. It reveals that 59% of the eroded sediment will get into Limboto Lake. As the result, the lake will be a land because of silting process. Alo watershed located on Tibawa sub-district has various levels of erosion ranging from very low, low, medium, and high risk. The trigger of these levels of erosion risk is inappropriate utilization of the land [3].

According to the Regional Geological Map of Tilamuta Sheet, scale 1:250,000 [4], Alo watershed is composed from tertiary and quaternary rocks. The rock formations in the Alo watershed are Diorite Bone (Tmb), Bilungala volcanic rock (Tmbv), Dolokapa Formation (Tmd), Pinogu Volcanic Rock (TQpv), and Reef Limestones (Q1). Referring to the

latest research, the name of new limestone formation is Limboto Limestone Formation. This formation consists of two to three microfacies with shallow marine paleobathymetry that have undergone tectonic uplift [5,6]. The slope on Alo watershed is dominated by gentle slopes with slopes ranging from 8 – 15% with a percentage area of 3.14%, and slopes of 15 – 25% are 25.74%. Land usage in Alo watershed is dominated by arid agricultural land with an area percentage of 38.07%, secondary forest of 21.29%, plantation of 14.78%, shrubs of 20.30%, paddy field of 4.17%, and residential area of 1.38%. In general, the practice of agricultural land management in this area has not applied a land conservation technique. The social condition of Alo watershed community in terms of educational level, education level of people residing in Alo watershed is said to still low. Many people agree that farming areas are open. In addition, many people do not quite know about erosion, but many claims to know about erosion. Habits are carried out from generation to generation in cultivations / agricultural practices. There are 78% of the people living in the Alo watershed who agree to log to create farming areas. In cultivating agricultural area, 86% of farmers do not make changes in land cultivation practices and only 14% of farmers follow the advancement of land processing techniques [7].

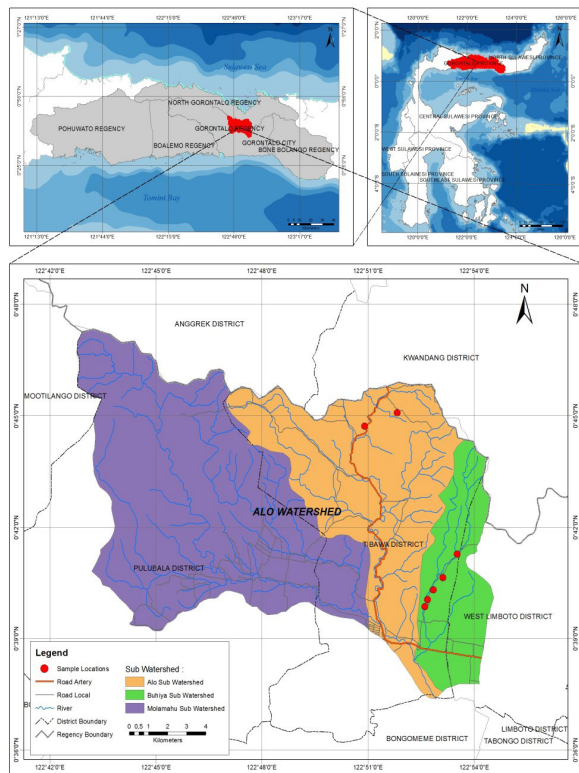


Figure 1. Map of research location in Alo Watershed, Gorontalo District

Methodology. The Alo watershed in the Gorontalo district, with an area of 24,222.41 acres, located at the coordinates of N 00o44' 52.715" and E 122o 49' 33.206" to N 00o 39'59.192" and E 122o 49'12.778" shall be chosen as the research site. The sampling location is in the Tibawa and Limboto sub-districts (Figure 1). Research data is a slip surface that occurs in the Alo sub- watershed. The measurement itself is conducted in seven locations, namely North Isimu Village and Labanu Village, Tibawa Subdistrict, Gorontalo District. Geoelectric measurements are carried out using the Electrical Resistivity Tomography (ERT) method to estimate the boundary or sliding surface below the surface. The ERT method is often used for landslide investigations because the main factors affecting resistance are soil type, porosity and water content [8,9,10,11].

ERT can present 2D and 3D cross-sections of soil and rock resistance distribution, with maximum resolution and depth of measurement depending on the configuration of the electrode [12]. The depth measurement target that can be achieved is approximately 1/5 of the maximum stretch length, i.e. the distance from the first electrode to the last electrode in one line [13]. One measurement line uses the Wenner-Alpha electrode configuration with a stretch length of 180 m for a depth target of about 35 m. Additionally, the acquisition of ERT measurements uses the Wenner-Alpha electrode configuration. The data analysis technique used in this study was a 2D inversion using the 3.54.44

version of RES2DINV based on the least - squares optimization method [14]. Landslide field analysis was performed by adding topographic data to the 2D inversion model using the RES2DINV program [15]. In addition, drill holes BH-01 and BH-02 were added for the calibration and correlation of subsurface resistance prices.

Result and Discussion. The measurement result of the resistivity value and rock type at the research location are shown in Table 1. The data in Table 1 shows that the rock types at 7 locations consist of clay, gravel, sand, limestone and dacite. Geoelectric measurement in research area refers to the inversion result of 2D resistivity imaging on the lines in seven location shown in Figure 2.

Location 1: Geoelectric measurements at location 1 are in North Isimu Village, 180 meters long, with a southwest-northeast trend. The slip plane is usually characterized by a contrasting field between high and low resistance values. Based on the rock resistance value, the slip plane at location 1 is estimated to be in the limestone layer as a layer with a high resistance value. The upper layers of the slip plane with resistance values of less than 674 Ωm were detected or suspected to be clay, gravel and sand layers. The limestone layer, which is a boundary plane or a slip plane, is detected at a depth of about 5-7 meters and has a high resistance of between 674-10,950.5 Ωm with an apparent slope of about 8° to the southwest. On the basis of the apparent slope, the actual slope is 47° to the northwest.

Location 2: Geoelectric measurement at location 2 is at North Isimu Village, 180 meters long, with a south-north trend. Based on the rock resistance value, the slip plane at location 2 contains layers of clay, gravel, sand, limestone and dacite. The slip plane at location 2 is estimated to be in the plane of contrast between low and high resistance values. The upper layers of the slip plane with resistance values of less than 692 Ωm are thought to be rock layers, i.e. clay, gravel and sand layers. The limestone layer, which is a slip plane, was detected at a depth of about 3 meters and has a high resistance of 692-9,479 Ωm with an apparent slope of about 11° southwest. Based on the apparent slope, the actual slope to the northwest is 79°.

Location 3: Geo-electric measurement at location 3 North Isimu Village with a length of 170 meters trending southwest – northeast. Based on the rock resistance value, the slip plane at location 3 is estimated to be in the contrasting plane between low and high resistance values, i.e. in the limestone layer. A layer of clay, gravel, and sand is thought to be the upper layer of the slip plane, which has a resistance value of less than 796 Ωm . The limestone layer, which is a slip plane, is detected at a depth of about 5-8 meters and has a high resistance of 796-10,552.5 Ωm with an apparent slope of about 7° to the southwest. Based on the apparent slope, the actual slope is 74° to the northwest.

Table 1. Electrical Resistance Value and Types of Rock Layers at the Research Location

No	Location 1 North Isimu Village 1 (0°39'52.6" N, 122°52'41.4" E) - (0°39'55.5" N, 122°52'41.6" E)		Location 2 North Isimu Village 2 (0°40'3.5" N, 122°52'41.4" E) - (0°40'9" N, 122°52'43.3" E)		Location 3 North Isimu Village 3 (0°40'19.6" N, 122°52'51.26" E) - (0°40'24.9" N, 122°52'55.19" E)		Location 4 North Isimu Village 4 (0°40'39.1" N, 122°53'7.1" E) - (0°40'36" N, 122°53'1.89" E)		Location 5 North Isimu Village 5 (0°41'17.41" N, 122°53'31.6" E) - (0°41'21.4" N, 122°53'28.2" E)		Location 6 Labuan Village 1 (0°44'43.3" N, 122°50'57.2" E) - (0°44'45.3" N, 122°50'51.8" E)		Location 7 Labuan Village 2 (0°45'05.2" N, 122°51'07.3" E) - (0°45'05.5" N, 122°51'01.7" E)	
	Electrical Resistance (Ωm)	Type of Layer	Electrical Resistance (Ωm)	Type of Layer	Electrical Resistance (Ωm)	Type of Layer	Electrical Resistance (Ωm)	Type of Layer	Electrical Resistance (Ωm)	Type of Layer	Electrical Resistance (Ωm)	Type of Layer	Electrical Resistance (Ωm)	Type of Layer
1	0 – 27.9	Clay	0 – 13.7	Clay	0 – 7.11	Clay	0 – 15.8	Clay	0 – 4.29	Clay	0.0.89	Clay	0.3.44	Clay
2	27.9 – 54.3	Clay	13.7 – 32.15	Clay	7.11 – 16.5	Clay	15.8 – 34.25	Clay	4.29 – 11.695	Clay	0.89.2.05	Clay	3.44.8.22	Clay
3	54.3 – 80.6	Clay	32.15 – 50.6	Clay	16.5 – 25.9	Clay	34.25 – 52.7	Clay	11.695 – 19.1	Clay	2.05.3.21	Clay	8.22.13	Clay
4	80.6 – 156.8	Clay	50.6 – 118.8	Clay	25.9 – 60.05	Clay	52.7 – 114.35	Clay	19.1 – 51.85	Clay	3.21.7.36	Clay	13.30.9	Clay
5	156.8 – 233		118.8 – 187		60.05 – 94.2	Clay	114.35 – 176		51.85 – 84.6	Clay	7.36.11.5	Clay	30.9.48.8	Clay
6	233 – 453.5	Gravel and Sand	187 – 439.5	Gravel & Sand	94.2 – 218.6	Gravel & Sand	176 – 381	Gravel & Sand	84.6 – 230.3		11.5.26.5	Loamy Sand	48.8-116.4	Gravel & Sand
7	453.5 – 674		439.5 – 692		218.6 – 343	Gravel & Sand	381 – 586		230.3 – 376	Gravel & Sand	26.5.41.5	Loamy Sand	116.4-184	Gravel & Sand
8	674 – 1,310.5	Limestone	692 – 1,122	Limestone	343 – 796	Limestone	586 – 1,269.5	Limestone	376 – 1,023		41.5.95.25	Gravel & Sand	184.438	Gravel & Sand
9	1,310.5 – 1,947	Limestone	1,122 – 2,562	Limestone	796 – 1,249	Limestone	1,269.5 – 1,953	Limestone	1,023 – 1,670		95.25-149	Gravel & Sand	438-692	Gravel & Sand
10	1,947 – 3,788	Limestone	2,562 – 6,020.5	Limestone	1,249 – 2,898.5	Limestone	1,953 – 4,233	Limestone	1,670 – 4,544.5		149.342.5	Gravel & Sand	692-1,649.5	Limestone
11	3,788 – 5,629	Limestone	6,020.5 – 9,479	Limestone	2,898.5 – 4,548	Limestone	4,233 – 6,513	Limestone	4,544.5 – 7,419	Dry Gravel	342.5-536	Gravel & Sand	1,649.5-2,607	Limestone
12	5,629 – 10,950.5	Limestone	9,479 – 22,277	Dacite	4,548 – 10,552.5	Limestone	6,513 – 14,113	Limestone	7,419 – 20,188		536.1,232.5	Limestone	2,607-6,214	Dacite
13	10,950.5 – 16,272	Dacite	22,277 – 35,075	Dacite	10,552.5 – 16,557	Dacite	14,113 – 21,713	Dacite	20,188 – 32,957	Dacite	1,232.5-1,929	Limestone	6,214-9,821	Dacite
14	16,272 – 31,656	Dacite	35,075 – 82,430	Dacite	16,557 – 38,418.5	Dacite	21,713 – 47,052.5	Dacite	32,957 – 89,681	Dacite	1,929.4,432.5	Dacite	9,821-23,406.5	Dacite
15	31,656 – 47,040	Dacite	82,430 – 129,785	Dacite	38,418.5 – 60,280	Dacite	47,052.5 – 72,392	Dacite	89,681 – 146,405	Dacite	4,432.5-6,936	Dacite	23,406.5-36,992	Dacite
16	> 47,040	Dacite	> 129,785	Dacite	> 60,280	Dacite	> 72,392	Dacite	> 146,405	Dacite	> 6,936	Dacite	> 36,992	Dacite

Source: Analysis Result in 2021

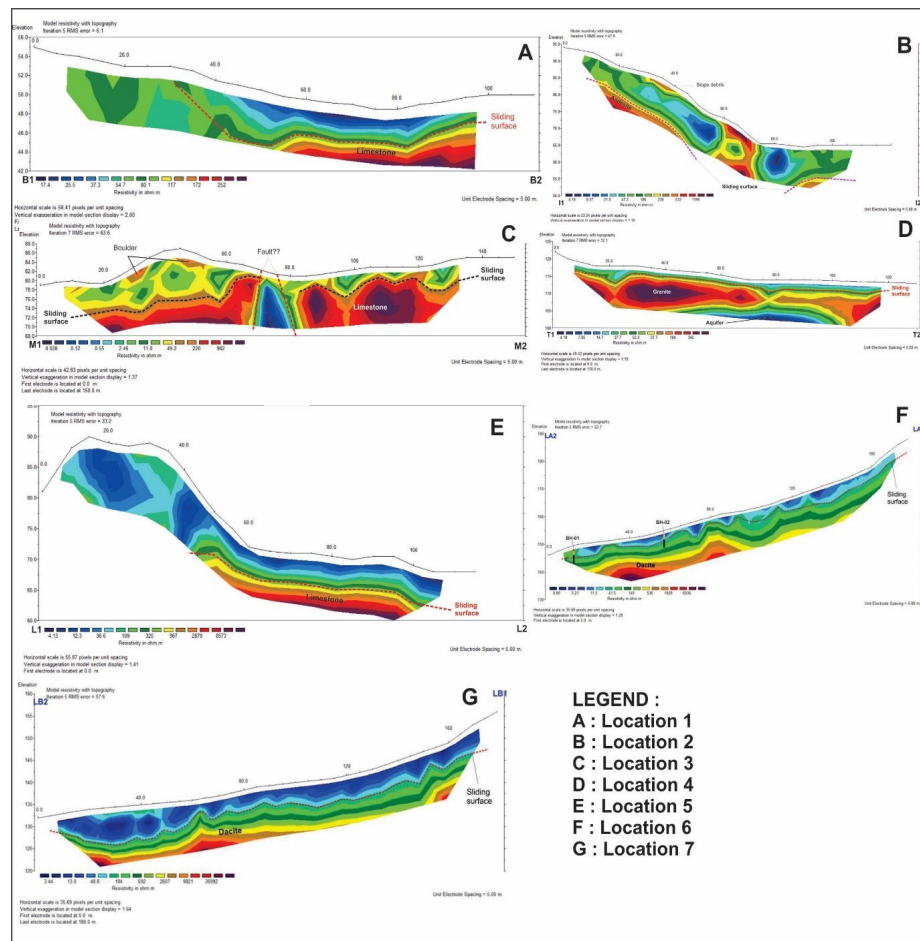


Figure 2. Cross section of 2D resistivity imaging at 7 lines at the research location

Location 4: Geo-electric measurement at location 4 in North Isimu Village with a track length of 180 meters trending northeast - southwest. The limestone layer which is a slip plane is detected at a depth of about 4-5 meters which has a high resistivity ranging from 586-14,113-m with an apparent slope of about 3° to the southwest. Based on the apparent slope, the actual slope is 56° trending the northwest.

Location 5: Geo-electric measurement at location 5 in North Isimu Village with a track length of 180 meters trendingsoutheast - northwest. The slip area is estimated to have low and high resistance values, namely in the dacite layer. The upper layers of the slip plane with resistance values of less than 20,188 -m are thought to be layers of clay, gravel, sand and dry gravel. The igneous rock layer of the dacite, which is a slip plane, was detected at a depth of about 17 meters, which has a high resistance of >20,188 -m, with a true dip of about 11° to the southeast.

Location 6: Geo-electric measurement at location6 in Labanu Village with a track length of 180 meters trendingeast - west. The slip area is estimated in low and high resistance values, namely in the dacite layer. The upper layers of the slip plane with resistance values of less than 536Ωm are thought to be layers of clay, loamy sand, gravel and sand. The limestone layer, which is a slip plane, was detected at a depth of about 2 meters, which has a

resistance of > 536Ωm, with a true dip of about 13° to the east.

Location 7: Geo-electric measurement at location 7 in Labanu Village with a track length of 180 meters trending east - west. The slip area is estimated in low and high resistance values, namely in the dacite layer. The upper layers of the slip plane with resistance values of less than 692Ωm are thought to be layers of clay, gravel and sand. The limestone layer, which is a slip plane, was detected at a depth of about 2-5 meters, which has a resistivity of > 692Ωm, with a true dip of about 11° to the east.

Conclusion. Based on the results of the interpretation and analysis, it can be concluded that the two-dimensional cross-section of the track at locations 1, 2, 3, 4 and 7 is thought to be the structure of the subsurface soil in the form of clay, gravel and sand. The line at location 5 has a subsurface layer of dry gravel under the sand. The track at location 6 has a sub-surface layer of loamy sand under the layer of clay. The slip plane is interpreted as a limestone layer in lines 1, 2, 3, 4, 6 and 7, while the slip plane in line 5 is assumed to be in a dacite igneous rock layer. The results showed that the landslide slip fields at 7 locations were approximately 3-17 meters deep with a slope angle of 11o -79° with trending dominantly northwest and one location with a southeast trend.

**Фитран Лихава¹, Ахмад Зайнури¹, Индриати Марта Патути²,
Аангпанжи Пермана¹ И Густу Ньоман Юда Прадана¹**

¹Жердегі ғылым және технология бөлімі, Математика және жаратылыстану факультеті,
Universitas Negeri Gorontalo, Горонтало, Индонезия

²Инженерлік факультеті, Universitas Negeri Gorontalo, Горонтало, Индонезия
E-mail: aang@ung.ac.id

АЛО СУ ҚОЙМАСЫНДАҒЫ СЫРҒАНАУ БЕТІН ТАЛДАУ, ГОРОНТАЛО АУДАНЫ, ИНДОНЕЗИЯ

**Фитряне Лихава¹, Ахмад Зайнури¹, Индриати Марта Патути², АангПанджи Пермана¹,
И Густу НьоманЮда Прадана¹**

¹Земное отделение науки и техники, Факультет математики и естественных наук,
Universitas Negeri Gorontalo, Горонтало, Индонезия

²Инженерный факультет, UniversitasNegeriGorontalo, Горонтало, Индонезия
E-mail: aang@ung.ac.id

АНАЛИЗ ПОВЕРХНОСТИ СКОЛЬЖЕНИЯ В ВОДОРАЗДЕЛЕ АЛО, РАЙОН ГОРОНТАЛО, ИНДОНЕЗИЯ

Аннотация. Водораздел Ало - это суб-водораздел в системе водораздела Лимбото, который непосредственно сливается с озером Лимбото. Деграция земель, произошедшая в водосборном бассейне Ало, вызвана сельскохозяйственной системой, которая не применяет методы сохранения земель, такие как террасирование и насыпи, что вызывает эрозию и оползни. Метод, используемый в этом исследовании, является геоэлектрическим методом с конфигурацией Альфа Веннера, в то время как анализ данных использует метод визуализации удельного сопротивления, который создает двумерные изображения поперечного сечения. Всего существует семь траекторий, длиной 170-180 метров каждая. В результате исследования представлены поверхности скольжения в 7 местах, расположенных на глубине 3-17 метров с наклоном 11о-79°, направленным преимущественно на северо-запад, и в одном месте, направленном на юго-восток.

Ключевые слова: водораздел ало, Гронтоло, поверхность скольжения.

Information about the authors:

FitryaneLihawa - Earth Science and Technology Department, Faculty of Mathematic and Natural Science, Universitas Negeri Gorontalo, Gorontalo, Indonesia (<https://orcid.org/0000-0002-9033-3057>)

Ahmad Zainuri - Civil Engineering Department, Faculty of Engineering, Universitas Negeri Gorontalo, Gorontalo, Indonesia: (<https://orcid.org/0000-0002-2020-6327>)

Indriati Martha Patuti- Civil Engineering Department, Faculty of Engineering, Universitas Negeri Gorontalo, Gorontalo, Indonesia (<https://orcid.org/0000-0002-3678-2564>)

AangPanjiPermana - Earth Science and Technology Department, Faculty of Mathematic and Natural Science, Universitas Negeri Gorontalo, Gorontalo, Indonesia (<https://orcid.org/0000-0002-6865-3564>)

REFERENCES

[1] Lihawa, F., Patuti, I. M., and Nurfaika. (2014) Sebaran Aspek Keruangan Tipe Longsoran di DAS Alo Provinsi Gorontalo [Distribution of Landslide Type Spatial Aspects in the Alo Watershed, Gorontalo Province]. Jurnal Manusia dan Lingkungan, Vol. 21(3) : 277-285.

[2] Japan International Cooperation Agency The Government of Indonesia. (2002)The Study on flood control and water management in Limboto-Bolango-Bone in the Republic of Indonesia. Gorontalo: Nikken Consultants Inc and Nippon Koei CO., LTD.

[3] Eraku, S. S., and Permana, A.P. (2020) Erosion Hazard Analysis in The Limboto Lake Catchment Area, Gorontalo Province, Indonesia. News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences. Vol. 3 (441): 110-116. <https://doi.org/10.32014/2020.2518-170X.61>.

[4] Bachri, S., and Apandi, T. (1993)Peta Geologi Lembar Tilamuta [Geological Map of Tilamuta Sheet]. Bandung: Pusat Penelitian dan Pengembangan Geologi.

[5] Permana, A.P., Pramumijoyo, S., Akmaluddin and Barianto, D.H. (2021) Planktonic foraminiferal biostratigraphy of the Limboto Limestone, Gorontalo Province, Indonesia. Kuwait Journal of Science. Vol. 48 (1): 116-126.<https://doi.org/10.48129/kjs.v48i1.6916>.

[6] Permana, A.P., Pramumijoyo, S., and Eraku, S. S. (2021) Microfacies and Depositional Environment

of Tertiary Limestone, Gorontalo Province, Indonesia. News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences, Vol. 2 (446). 15-21. <https://doi.org/10.32014/2021.2518-170X.29>.

[7] Haspiah. (2015) Sebaran Aspek Sosial Ekonomi Masyarakat DAS Alo di Provinsi Gorontalo [Distribution of Socio-Economic Aspects of the Alo Watershed in Gorontalo Province]. Essay, Universitas Negeri Gorontalo.

[8] Reynolds, J. M. (1997) An Introduction to Applied and Environmental Geophysics. Chichester UK: J. Wiley and Sons.

[9] Park, S. G., and Kim, J. H. (2005) Geological Survey by electrical resistivity prospecting in landslide area. Geosyst Eng, VIII(2): 35-42.

[10] Bievre, G., Jongmans, D., Winiarski, T., and Zumbo, V. (2012) Application of geophysical measurements for assessing the role of fissures in water infiltration within a clay landslide (Trieves area, French Alps). Hydrol Process, 2128-2142.

[11] Perrone, A., Lappena, V., and Piscitelli, S. (2014) Electrical resistivity technique for landslide investigation: A review. Earth Science Review, 65-82.

[12] Lowrie, W. (2007) Fundamental of Geophysics, Second Edition, Cambridge.

[13] Cervantes, B., Polacek, A., and Rysavka, J. (2012) Contribution of electrical resistivity tomography applied to the slope deformation survey in Lidecko. Geo Science Engineering, III(2): 7-15.

[14] Loke M. H. (2011) Tutorial: 2-D and 3-D Electrical Imaging Survey Manual.

[15] Loke M. H., Acworth I and Dahlin T. (2003) A comparison of smooth and blocky inversion methods in 2-D electrical imaging surveys. Explora. Geophysics, 34:183-187.

**Publication Ethics and Publication Malpractice
in the journals of the National Academy of Sciences of the Republic of Kazakhstan**

For information on Ethics in publishing and Ethical guidelines for journal publication see <http://www.elsevier.com/publishingethics> and <http://www.elsevier.com/journal-authors/ethics>.

Submission of an article to the National Academy of Sciences of the Republic of Kazakhstan implies that the described work has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint, see <http://www.elsevier.com/postingpolicy>), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder. In particular, translations into English of papers already published in another language are not accepted.

No other forms of scientific misconduct are allowed, such as plagiarism, falsification, fraudulent data, incorrect interpretation of other works, incorrect citations, etc. The National Academy of Sciences of the Republic of Kazakhstan follows the Code of Conduct of the Committee on Publication Ethics (COPE), and follows the COPE Flowcharts for Resolving Cases of Suspected Misconduct (http://publicationethics.org/files/u2/New_Code.pdf). To verify originality, your article may be checked by the Cross Check originality detection service <http://www.elsevier.com/editors/plagdetect>.

The authors are obliged to participate in peer review process and be ready to provide corrections, clarifications, retractions and apologies when needed. All authors of a paper should have significantly contributed to the research.

The reviewers should provide objective judgments and should point out relevant published works which are not yet cited. Reviewed articles should be treated confidentially. The reviewers will be chosen in such a way that there is no conflict of interests with respect to the research, the authors and/or the research funders.

The editors have complete responsibility and authority to reject or accept a paper, and they will only accept a paper when reasonably certain. They will preserve anonymity of reviewers and promote publication of corrections, clarifications, retractions and apologies when needed. The acceptance of a paper automatically implies the copyright transfer to the National Academy of Sciences of the Republic of Kazakhstan.

The Editorial Board of the National Academy of Sciences of the Republic of Kazakhstan will monitor and safeguard publishing ethics.

(Правила оформления статьи для публикации в журнале смотреть на сайтах:

[www:nauka-nanrk.kz](http://www.nauka-nanrk.kz)

<http://www.geolog-technical.kz/index.php/en/>

ISSN 2518-170X (Online), ISSN 2224-5278 (Print)

Редакторы: *М. С. Ахметова, Р. Ж. Мрзабаева, Д. С. Аленов*
Верстка на компьютере *В.С. Зикирбаева*

Подписано в печать 15.06.2021.
Формат 60x881/8. Бумага офсетная. Печать – ризограф.
4,6 п.л. Тираж 211. Заказ 3.

Национальная академия наук РК
050010, Алматы, ул. Шевченко, 28, т. 272-13-18, 272-13-19