Application for a Minor Modification to the Boundaries of the Jeju Volcanic Island and Lava Tubes

2018. 1.

REPUBLIC OF KOREA

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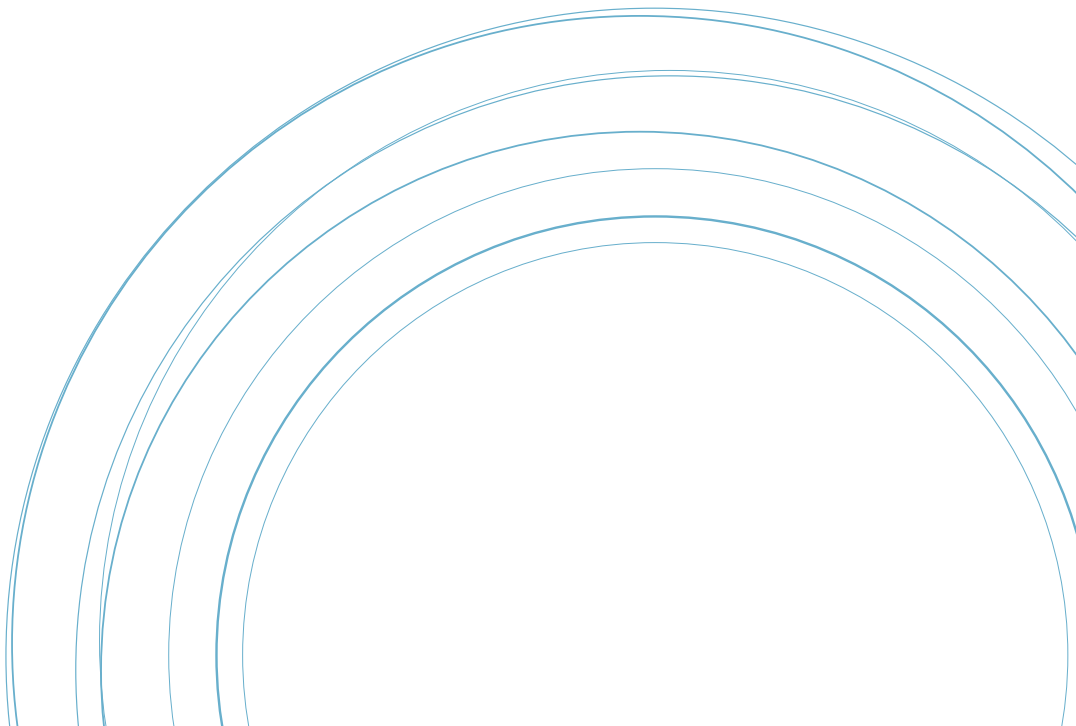


1. Area of the Property

The area of the proposed minor boundary modification to extend the Jeju Volcanic Island and Lava Tubes World Heritage property is 1,102 ha, including 201.1 ha of property zone and 900.9 ha of buffer zone. The modification will result in a 2.1% increase of the core zone from 9,475.2 ha to 9,676.3 ha and a 5.8% increase of the total area, including the buffer zone, from 18,846 ha to 19,948 ha (Table 1).

Table 1. The size and coordinates of the sites inscribed in 2007 and proposed minor modification sites.

Names of sites	Coordinates	Area (ha)	Area of buffer zone (ha)	Remark
Hallasan Nature Reserve	N 33° 19′ 10″ E 126° 27′ 50″	9,093.1	7,347.4	Inscribed in 2007
Geomunoreum Lava Tube System	N 33° 31′ 30″ E 126° 46′ 21″	330.3	1,906.4	
Seongsan Ilchulbong Tuff Cone	N 33° 27′ 19″ E 126° 56′ 46″	51.8	117.0	
Suwolbong Tuff Ring	N 33° 17′ 56″ E 126° 10′ 03″	21.1	360.3	Minor Boundary Modification sites
Chagwido Tuff Cone Complex	N 33° 18′ 40″ E 126° 08′ 57″	120.2	461.7	
*Upper Geomunoreum Lava Tube System	N 33° 06′ 41″ E 126° 08′ 48″	46.6	300.9	
Socheongul Lava Tube	N 33° 21′ 53″ E 126° 15′ 37″	13.2	125.5	
Total property		9,676.3	10,271.7	

* Overlap with the existing buffer zone

2. Description of the Modification

Jeju Island has a great geologic diversity because it was formed by both magmatic and phreatomagmatic explosive volcanic activity, lava effusion, and attendant volcaniclastic sedimentation in continental shelf to coastal settings under the influence of fluctuating Quaternary sea levels, so Jeju Island is unitary volcanic complex (Sohn et al., 2008). Of these diverse volcanic formations, Mount Hallasan, Seongsan Ilchulbong Tuff Cone, and the Geomunoreum Lava Tube System were inscribed on the World Heritage list in 2007.

The four minor boundary modification sites are added to reinforce the OUV of the World Heritage sites inscribed in 2007. The details are belows.

2-1. Suwolbong Tuff Ring

Suwolbong is a low-relief mount of volcaniclastic deposit located at the western margin of Jeju Island (Fig. 1). Present topographic contours of the mount together with sedimentological study suggest that the mount represents a partly preserved tephra ring of a phreatomagmatic volcano, shows similar formation process of the Seongsan Ilchulbong tuff cone, which vent lies about one kilometer seaward of the present shoreline (Sohn and Chough, 1989; Fig. 2).

Fig. 1. A distant view of the coastal exposures of the Suwolbong tuff ring from the west, consisting of near-horizontally bedded basaltic volcaniclastic deposits.

Seongsan Ilchulbong tuff cone, the eruptive activity involved mostly discrete, small-volume jetting and near-vent deposition of wet tephra, thereby resulting in a tuff cone with a high and steep profile. On the other hand, Suwolbong resulted from pyroclastic surges, which are

turbulent and fast-moving currents of gas, steam, and tephra that moves away from a vent at a subsonic speed (Sohn and Chough, 1989). The deposits of Suwolbong are therefore dominated by near-horizontal, well-bedded tuffs with abundant climbing megaripple bedforms and low-angle undulations as well as numerous impact sags and other current-related deposit structures (Fig. 3).

Fig. 2. Satellite image of the Suwolbong area, showing the inferred crater rim of the Suwolbong Tuff Ring.

The excellent and continuous coastal exposures of Suwolbong clearly reveal how pyroclastic surges evolve from the moment of eruption at the vent to the final moment of deposition of tephra in the distal margins of tuff rings. Summation of lateral facies transitions within the Suwolbong volcaniclastic deposits show that massive or crudely stratified lapilli tuff occurs in the most proximal part, which transforms downcurrent into either planar-stratified, undulatory-stratified or climbing megaripple-bedded (lapilli) tuff. Further downcurrent, the tuff becomes mostly thinly and planar-stratified with subdued bedforms. Such lateral facies transitions, which are hardly observable at other tuff rings outside Jeju Island, suggest that a pyroclastic surge is highly concentrated near the vent and deposits its load rapidly from

suspension with meager tractional transport, resulting in the generally unstratified deposits in the proximal area (Fig. 3). As the surge becomes diluted downcurrent through fallout of suspended loads and mixing of ambient air, it becomes turbulent and segregated into coarse-grained bedload and overlying fine-grained suspension, forming thinly stratified units with diverse bedforms. Suwolbong thus remains the world-famous type locality of phreatomagmatically generated pyroclastic surges deposits in the volcanological communities, and more located on the western coast of the Jeju Island, is composed of beautiful seneries of the island.

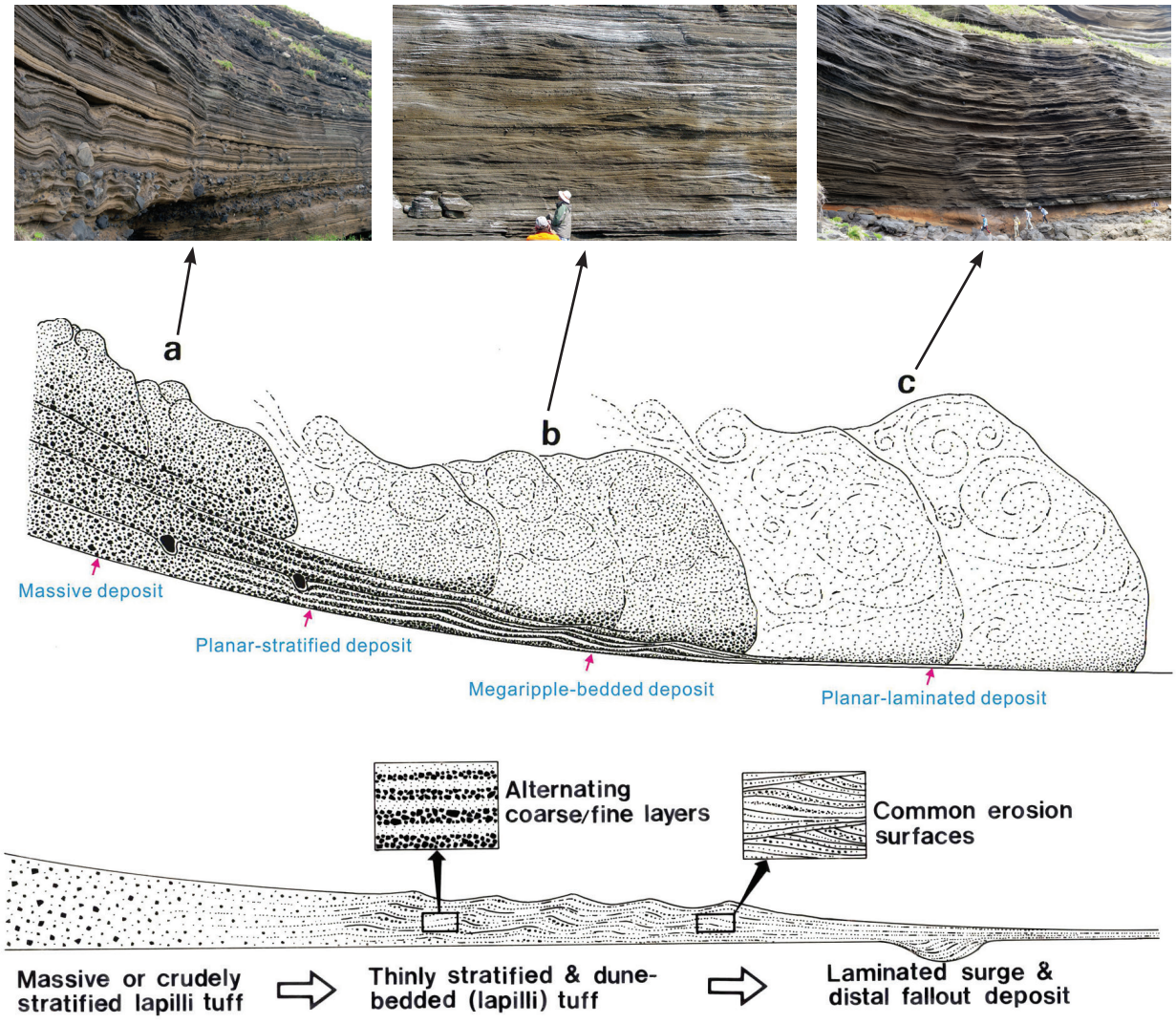


Fig. 3. Diagrammatic illustration of a pyroclastic surge at three stages (a, b, c) of development. The pyroclastic surge expands, decreases in particle concentration and develops large-scale turbulent structures in the downcurrent direction (after Sohn and Chough, 1989).

2-2. Chagwido Tuff Cone Complex

Chagwido consists of three small islands and rocks off the western coast of Suwolbong (Fig. 4). The island is about 900 m long and 400 m wide. The highest point of the island is a 67-m-high semicircular ridge top in the northeast, which is interpreted to be a tuff cone, similar to the Seongsan Ilchulbong tuff cone. The central portion of the island is a flat-topped region composed of lava flows. A number of small islets and rocks composed of basaltic tuffs, lavas, and scoria/spatters are scattered around the islands.

Chagwido exposes evidence of two eruptive episodes (Brenna et al., 2015). The first episode took place on the eastern side of the island. It formed a tuff cone followed by a scoria and spatter cone produced within the centre. The second eruption occurred approximately 400 m to the west of the first eruptive center, forming the western Chagwido. The second eruption involved a sequence of phreatomagmatic to magmatic eruption style, resulting in another set of a tuff cone, a scoria cone, and lava flows (Fig. 5). A prominent erosional surface with a well-developed weathering zone and paleosol is observed between the two tuff/scoria sequences, suggesting a long time gap between the two eruptions (Fig. 6).

Chagwido reveals that seemingly simple and small volcanic centers in monogenetic volcanic fields may hide great stratigraphic and chemical complexity, consisting of two overlapping volcanic centers separated by a break of over 200,000 years. The second eruption occurred at least 200,000 years later. Chagwido thus provide an unusual example of the recurrence of volcanism associated with different magma types within a spatially constrained portion of monogenetic volcanic field. This finding at Chagwido has significant implications regarding not only understanding of the magmatic processes but also the forecasting of volcanic hazards in monogenetic volcanic fields. These aspects of Chagwido eruption are quite unique and distinctively different from the archetypal but relatively simple cone-forming Surtseyan eruption of the Seongsan Ilchulbong Tuff Cone and the pyroclastic surge-dominated and ring-forming eruption of the Suwolbong tuff ring.

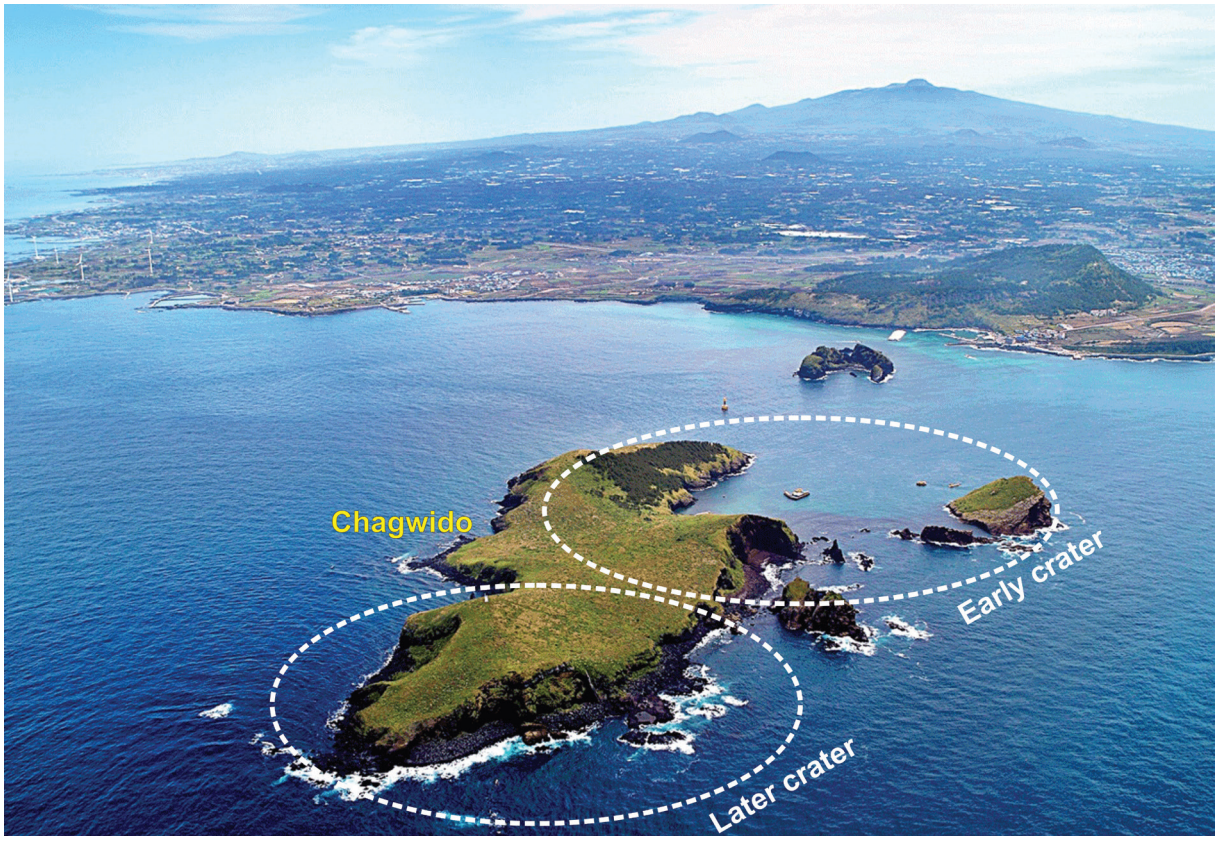


Fig. 4. Aerial view of Chagwido with Mt. Hallasan, the 1,950 m central peak of Jeju Island, in the background. Chagwido consists of small islands and rocks, which resulted from two episodes of phreatomagmatic to magmatic eruptions. Chagwido thus comprises two overlapping craters.

Fig. 5. Exposure on the western side of Chagwido, showing a gradual transition from yellowish basaltic tuff in the lower part to reddish to black scoria/spatter deposits in the upper part, indicating a change in eruption style from phreatomagmatic to magmatic during the eruption of the later tuff cone.

Fig. 6. Exposure on the southern side of Chagwido, showing a contact between the tuff cone deposit from an earlier eruption and the lava from the later eruption. The contact is characterized by an erosion surface with reddish paleosol layer, indicating a long time gap between the two eruptions.

2-3. Upper Geomunoreum Lava Tube System

The Upper Geomunoreum Lava Tube System denotes the upstream part of the Geomunoreum Lava Tube System. This system is composed of three lava tube caves (Utsanjeongul, Bukoreumgul and Daerimgul lava tube caves) and is located between Geomunoreum cone and the World Heritage Lower Geomunoreum Lava Tube System (Fig. 7). The discovery of the Upper Geomunoreum Lava Tube System provided essential evidence that the Lower Geomunoreum Lava Tube System was formed by the lava flows erupted from Geomunoreum volcanic cone.

Fig. 7. Location of the Upper Geomunoreum Lava Tube System.

2-3-1. Utsanjeongul Lava Tube

Utsanjeongul Lava Tube is located on the northeastern part of the island, has a multi-leveled passages that meanders along the lava flow direction. The total length of the cave is 2,385m. Due to collapse of ceiling and wall in the cave, many rockfalls are present on the floor, which give various forms of transverse sectional views along the passage (Fig. 8). Several stages of lava flows can be observed due to collapsed walls and ceilings. Multi-leveled passages, linings in the wall and thermally eroded features help to understand the formation process. The most prominent microtopographic features are a lava bridge in the middle level. In addition, linings, lava rafts, tube-in-tube, lave benches, lava flowlines and scraped marks are present. Lava speleothems such as lava stalactites, lava straws, lava stalagmites, lava blisters, lava flowstone and so on are found. Cave corals and cave powders formed by secondary mineralization.

Fig. 8. Various features in Utsanjeongul Lava Tube.

2-3-2. Bukoreumgul Lava Tube

Bukoreumgul Lava Tube was originally connected to Utsanjeongul Lava Tube, however they were separated due to the collapse of the ceiling. Between Utsanjeongul and Bukoreumgul, a collapsed valley is present and this should represent the old cave passage. The cave is 221m long and it extends northeast from the entrance to a site at 100m downstream and north-northeast beyond that site. Bukoreumgul Lava Tube is a simple unitary passage that meanders along the lava flow direction. This cave also shows collapsed feature from ceiling and wall. Various lava microtopographic features such as pahoehoe lavas, tube-in-tubes, lava linings, lava seals, lava shelves and lava flowlines are present (Fig. 9). Lava speleothems such as lava stalactites and lava flowstones and secondary speleothems (white and yellow cave corals) on the rockfall near the entrance can be found. Numerous lava stalactites are distributed on the ceiling and aa lava is present on the floor at 165m.

Fig. 9. Main passage of the Bukoreumgul Lava Tube and tube-in-tube.

2-3-3. Daerimgul Lava Tube

The Daerimgul Lava Tube is 173m long and is characterized by two adjacent skylights and lava bridge between the skylights (Fig. 10). The cave has an overall sinuous passage and includes a variety of microtopographic features such as lava rafts, ropy lava (pahoehoe), lava levees, lava aprons, tube-in-tubes, scraped marks, contraction cracks and lava linings, etc. At the end of the passage, ropy lava which flowed upstream can be found. Lava speleothems such as lava stalactites and lava flowstones, and the same secondary minerals as in Bukoreumgul Lava Tube can be also found.

Fig. 10. Two skylights of the Daerimgul Lava Tube and pahoehoe lava on the floor.

2-4. Socheongul Lava Tube

Socheongul Lava Tube is located in the western part of Jeju Island. The cave is about 4,040 m long (Fig. 11). The cave is developed northwest to north-northwest toward the upstream direction. Together with the Socheongul Lava Tube, some other lava tube caves nearby also contain carbonate speleothems due to the presence of carbonate sand dunes overlying the lava tube caves (Fig. 12).

Socheongul Lava Tube includes well preserved lava speleothems such as lava stalactites, lava flowstones and lava stalagmites. It is a wonderful lava tube cave, but it is also very special due to a wide distribution of diverse and spectacular array of carbonate speleothems in the lower half of the cave. Above the cave, sand dunes that are composed of thick carbonate sands as dunes which were transported from the coast by northwesterly winds. Gradually, the carbonate sediments have been dissolved by rain water to make the secondary mineralization. As a result numerous spectacular carbonate speleothems have formed such as rimstones, soda straws, cave popcorn, flowstones, carbonate powders etc.

There are numerous significant microtopographic features in the cave, a tube-in-tube, lava bench and lava fall ,lava aprons, lava levees, lava linings, lava bridges and lava pillars are present (Fig. 13).

Fig. 11. The main passage (left) and the branch (right) of the Socheongul Lava Tube.

Flowstone on the wall

Soda straw

Fig. 12. Carbonate speleothems in Socheongul Lava Tube.

Tube-in-tube

Lava table

Lava stalactites

Lava stalactites

Fig. 13. Various microtopographic features and lava speleothems in Socheongul lava Tube

3. Justification for the minor modification

Jeju Island is regarded as a peculiar intraplate volcano built upon a continental crust that preserves unique records of volcanic activity associated with and/or affected by Quaternary environmental changes.

Of these diverse volcanic formations, Mount Hallasan, Seongsan Ilchulbong Tuff Cone, and the Geomunoreum Lava Tube System were inscribed on the World Heritage list in 2007. The World Heritage Committee evaluated that Jeju has a distinctive value as one of the few large shield volcanoes in the world built on a stationary continental plate. It is distinguished by the Geomunoreum Lava Tube System, which is the most impressive and significant series of conserved lava tube caves in the world and includes a spectacular array of secondary carbonate speleothems (stalactites and other decorations), with an abundance and diversity unknown elsewhere within lava caves making them unique. The Seongsan Ilchulbong tuff cone was evaluated to have exceptional exposures of its structural and sedimentological characteristics, making it a world-class location for understanding Surtseyan-type volcanic eruptions.

Suwolbong and Chagwido not only provide world-class exposures of tuff rings and tuff cones, but also offer additional aspects of hydrovolcanic processes and landforms that cannot be seen in the Seongsan Ilchulbong Tuff Cone. Decades of studies of hydromagmatic (Surtseyan to phreatomagmatic) volcanoes in the world show that hydrovolcanic processes are extremely diverse and result in contrastingly different volcanic landforms because they are controlled by a number of factors such as surface environments and geological and hydrological conditions in the subsurface in addition to the physical and chemical properties of the magmas (Sohn, 1996; White and Houghton, 2000; Sohn and Park, 2005; White and Ross, 2011). Jeju Island is regarded as a world-class showcase of hydromagmatic volcanoes, which show clear evidence for contrastingly different eruption and depositional styles of these volcanoes and the controls of surface to subsurface geological/hydrological conditions on the eruption styles. The great diversity and variability of these volcanoes cannot thus be represented by the Seongsan Ilchulbong Tuff Cone alone. Inclusion of additional hydrovolcanic sites to the Jeju World Heritage property is therefore crucial for strengthening the integrity of the whole property and for enhancing and reinforcing the Statement of Outstanding Universal

Value for the property as adopted by the World Heritage Committee in its decision in 2007.

The Geomunoreum Lava Tube System justified its Outstanding Universal Value in 2007. The discovery of additional three lava tube caves of the Upper Geomunoreum Lava Tube System clearly confirms that the Upper and Lower Geomunoreum Systems were formed by the continuous lava flows from the Geomunoreum scoria cone. After excavating the third entrance of the Socheongul Lava Tube, numerous carbonate speleothems were discovered in the cave under overlying carbonate sediments. The young age of carbonate speleothems clearly show complete growth stages of carbonate speleothems in Jeju Island, thus supporting and justifying the Outstanding Universal Values of the Yongcheondonggul and Dangcheomuldonggul lava tube caves.

The proposed areas of modification have been protected as national monuments of Korea for decades and managed mainly for conservation under the Cultural Heritage Protection Act and for education and careful sustainable development. The inclusion of these areas into the Jeju Volcanic Island and Lava Tubes World Heritage property will strengthen the wholeness of geological integrity of the previously inscribed property, and enhance and reinforce the Statement of Outstanding Universal Value for the property as adopted by the World Heritage Committee in its decision in 2007.

4. Contribution to the Maintenance of the Outstanding Universal Value

In 2007, the World Heritage Committee assessed that Jeju has a distinctive and unique value as one of the few large shield volcanoes in the world built on a stationary continental plateand more, recognized that Jeju Island has a great geologic diversity that cannot be represented by the nominated sites alone, and made a recommendation to "consider the potential for extension of the nominated property to include other significant lava tube systems and volcanic features on Jeju". Ongoing geoheritage assessment of Jeju Island since 2007 reveals that the most outstanding geoheritage values of the island are:

1) the diversity of dimensions and internal features of lava tube caves, including unique and aesthetic carbonate speleothems as well as pristine internal microtopographic features of lavas, and
2) the excellent exposures of various types of Surtseyan to phreatomagmatic volcanoes along the coast of Jeju Island, which were dissected by coastal erosion for millennia and provide excellent sea-cliff exposures that are unsurpassed by any other similar volcanoes in the world.

Therefore the inclusion of additional lava tube caves and Surtseyan to phreatomagmatic volcanic formations to the World Heritage property will not only contribute to the maintenance of the Outstanding Universal Value of the Jeju World Heritage property but also to strengthen and complete the geological integrity of the whole property. Referbelows how the criteria (vii and viii) under which the property has been inscribed in 2007 also apply to the proposed areas of modification. For criterion (vii), the Upper Geomunoreum Lava Tube System and the Socheongul Lava Tube display a fantastic internal landforms of lava tube caves with various volcanic features along with secondary carbonate speleothems. The coastal sea cliff exposures of basaltic volcanic rocks and well-bedded tuff with diverse structures of the Suwolbong Tuff Ring and the Chagwido Tuff Cone Complex also provide scenic values.

Table 2.

Property name		Outstanding Universal Value	Remarks
Seongsan Ilchulbong Tuff Cone		Composed of a mix of breccia, lapilli tuff, stratified tuff and bedded tuff, castle-like feature,. Wave erosion has exposed the internal sedimentary structures and stratification., one of the phreatomagmatic' volcanoes,	Inscribed in 2007
	Suwolbong Tuff Ring	One of the phreatomagmatic' volcanoes, basic formation process is similar to the Seongsan Ilchulbong Tuff Cone, and also represents the diversity of the phreatomagmatic' volcanoes, shows the complete cross section of tuff ring	**Minor Boundary Modification**
	Chagwido Tuff Cone Complex	One of the phreatomagmatic' volcanoes, basic formation process is similar to the Seongsan Ilchulbong Tuff Cone and Suwolbong Tuff Ring, and moreover represents the diversity of the phreatomagmatic' volcanoes, shows the complexities of volcano formation with chronological flow	
Geomunoreum Lava Tube System		The lava tube caves of the Geomunoreum system are, however, regarded as internationally important due to their length, massive volume, intricate passage configuration, well preserved internal lava features, abundant and spectacular secondary carbonate formations, ease of access, and their scientific and educational values.	Inscribed in 2007
	Upper Geomunoreum Lava Tube System	The discovery of the Upper Geomunoreum Lava Tube System provided essential evidence that the Lower Geomunoreum Lava Tube System was formed by the lava flows erupted from Geomunoreum volcanic cone, so fully complete the Geomunoreum Lava Tube System.	**Minor Boundary Modification**
	Socheongul Lava Tube	The age of the nearby sand dune of Socheongul Lava Tube implies that they are probably less than 1,000 yr BP. Therefore, carbonate speleothems in Socheongul Lava Tube provide excellent and unique growth history of carbonate speleothems in lava tube caves in Jeju Island as well as in the world.	
Hallasan Natural Reserve		The Hallasan Natural Reserve comprises a substantial part of the summit area of the primary volcano. The diverse volcanic landscape includes a 1.6 ha lake-filled crater, 550m in diameter and 108 m deep, a younger (circa 25,000 years in age) intruded trachyte dome, and a series of columnar jointed basalts forming prominent cliffs.	Inscribed in 2007

4-1. Suwolbong Tuff Ring

Suwolbong is a 'phreatomagmatic' volcano produced by the interaction of magma with groundwater, about 18,000 years ago when the global sea level was much lower than at present. Explosive magma-water interaction occurred more than 300 m below the surface, excavating abundant basement rocks and incorporating them as 'accidental' materials in the tuff beds. The eruption also generated abundant pyroclastic surges, which is a variety of pyroclastic density currents and defined as turbulent and swift, ground-hugging currents of gas, steam, and tephra that moves away from a vent at a subsonic speed. The tephra could thus be dispersed relatively far away from the vent, thereby resulting in the "ring" morphology of the volcanic edifice rather than the "cone" morphology typified by the Seongsan Ilchulbong tuff cone. The internal structures of the volcano or the tuff ring are some different from the tuff cone, characterized by near-horizontal-bedded tuffs with abundant climbing megaripple bedforms and low-angle undulations, all of which indicate the action of the pyroclastic surges

Suwolbong is one of few places in the world where a near-complete, continuous cross-section of a tuff ring is available from near the crater rim to the distal margins of the tuff ring. Suwolbong therefore provides clues to multitude of phreatomagmatic volcanic processes, including pyroclastic surge processes in particular. Suwolbong thus fulfills the criterion viii in that it is an outstanding example of significant geological (volcanological) process in the development of (phreatomagmatic volcanic) landforms in the world.

4-2. Chagwido Tuff Cone Complex

Recent studies of tuff rings and cones in Jeju Island clearly demonstrate, that there is a great complexity in monogenetic eruptions, being controlled by a number of factors such as the access of water to rising magma and the possibility for rise of multiple magmas successively or in a parallel fashion during a single eruption (Brenna et al., 2010, 2011; Sohn et al., 2012). The changes of these factors lead to complex changes in eruption style and to vent migration and establishment of multiple eruption sites. The eruption of the Seongsan Ilchulbong Tuff Cone, for example, occurred in three separate phases with shifts in eruption chemistry and vent location. The eruption break between phase I and II was "long", i.e., days to weeks; the

long break led to the formation of a volcano-wide discontinuity surface and cooling and solidification of the initial shallow conduit system and the resumption of phase II eruption from a new vent location ~600 m away (Sohn et al., 2012).

Chagwido is another peculiar example of monogenetic volcanoes that had experienced complex changes in eruption style and the migration of vent (Brenna et al., 2015). As already described in a preceding chapter, Chagwido exposes clear evidence of two eruptive episodes: the first eruption in the Middle Pleistocene about 450,000 years ago followed by the second eruption at least 200,000 years later. These two eruptions were also fed by chemically distinct magmas from two separate vents a few hundred meters apart. The 200,000 year-long time gap between the two eruptions, represented by a prominent paleosol, is incomparably long for monogenetic volcanoes because an eruption break of even days to weeks is regarded to be "long" in monogenetic volcanism. Chagwido is thus regarded as an unusual example of the recurrence of volcanism associated with different magma types within a spatially constrained portion of monogenetic volcanic field. This finding in Chagwido has significant implications regarding not only understanding of the magmatic processes but also the forecasting of volcanic hazards in monogenetic volcanic fields. Chagwido therefore meets the criterion viii in that it is an outstanding example of significant geological (volcanological) process in the development of (Surtseyan to phreatomagmatic volcanic) landforms.

4-3. Upper Geomunoreum Lava Tube System

The Geomunoreum Lava Tube System displays evolutionary history of volcanic eruption as well as the formation processes of the lave tube caves. The system was formed by the lava flows from the Geomunoreum Cone which is one of over 360 volcanic cones that erupted on the wide epicontinental margin. The basaltic lavas that erupted from the Geomunoreum formed extensive inflated pahoehoe lava flows and produced several lava tube caves as they flowed downstream. This feeder system operated down the axis of the flow and extended perhaps as long as about 14 km from the source to the terminal front of the lava flow, now lying beneath the sea. Following cessation of vent activity, the liquid lava in parts of the tube system continued to drain downslope, leaving substantial elongated lava tube caves. The lava flow contains a series of individual caves, each separated from its neighbour upflow or

downflow by either a lava seal or debris resulting from roof collapse. The system is composed of five lava tube caves. These are the most voluminous 7,416 m long Manjanggul Lava Tube, Gimnyeonggul Lava Tube which is likely to be extension of Manjanggul, the 4,481 m long Bengdwigul Lava Tube which is a labyrinth-type cave, and Yongcheondonggul and Dangcheomuldonggul lava tube caves with numerous secondary carbonate speleothems. The caves are magnificent because of their great dimensions, the fantastic passage configurations, the wonderful conservation state of their internal lava features, and the presence of abundant secondary carbonate speleothems in two caves (Yongcheondonggul and Dangcheomuldonggul lava tube caves) at downstream end. The presence of such speleothems is not comparable in any other lava tubes in the world. Additionally, the recently discovered caves of the Upper Geomunoreum Lava Tube System provide substantial evidence to understand the formation process of the Geomunoreum Lava Tube System by adding more to the Outstanding Universal Value of the system. The various geological features in three caves of the Upper Geomunoreum Lava Tube System thus complete the already proven Outstanding Universal Values.

4-4. Socheongul Lava Tube

Jeju Island is surrounded by shallow epicontinental sea areas on broad continental shelf. Because Jeju Island is a volcanic island, perennial streams from mountainous are to the sea are very rare and stream waters only flow during rainy seasons ephemerally only in northern and southern parts of the island. This has provided perfect conditions for the deposition of temperate carbonate sands in shallow seas only in eastern and western parts. This kind of temperate carbonate deposits on shallow broad continental shelf are very rare in the world. It is estimated that these shallow marine carbonate sediments were transported onto land during the Holocene when sealevel was temporarily lower. The oldest age of carbonate sand dunes is about 5,000 yr BP and the age becomes younger toward the land, implying that carbonate sand started to be deposited when sea level reached the present-day level due to deglaciation since the Last Glacial Maximum. Obviously calcium and carbonate ions dissolved by rainwater were transported into the caves, resulting in carbonate speleothem formations in already inscribed Yongcheondonggul and Dangcheomuldonggul lava tube caves. The Socheongul lava tube cave is an extension to the suite of lava tubes with carbonate speleothems. The ages of carbonate

speleothems in Yongcheondonggul and Dangcheomuldonggul lava tube caves are almost the same as those of carbonate sand dunes over the carbonate speleothems(Fig. 14). The age of the nearby sand dune of Socheongul Lava Tube implies that they are probably less than 1,000 yr BP. Therefore, carbonate speleothems in Socheongul Lava Tube provide excellent and unique growth history of carbonate speleothems in lava tube caves in Jeju Island as well as in the world. Thus the early stage of carbonate speleothem growth in Socheongul Lava Tube make a complete story of the secondary carbonate mineralization in Jeju lava tube caves by adding higher Outstanding Universal Values and by increasing the wholeness for geological integrity.

Fig. 14. Carbonate speleothems in Socheongul Lava Tube.

5. Implications for legal protection

All the serial sites proposed for the Minor Boundary Extension are protected as Natural Monuments under the Cultural Heritage Protection Act and also protected by National Park Act and other acts. The Cultural Heritage Protection Act is the highest protection measure in Korea and the Act is applied to both core and buffer zones of the extended property. No activity is permitted in the core zones, and any artificial activities must be approved by the Cultural Heritage Administration and the Natural Committee in Cultural Heritage Administration. More detailed information on the Cultural Heritage Protection Act is provided in Annex.

Table 3. Legal status of laws governing the candidate properties.

Classification	Legal status	Relevant law	Designation
Suwolbong Tuff Ring	Natural monument No. 513	Culture properties protection act	2009
	National park	Natural parks act	2010
	Absolute preserved area	SPECIAL ACT ON THE ESTABLISHMENT OF JEJU SPECIAL SELF-GOVERNING PROVINCE AND THE DEVELOPMENT OF FREE INTERNATIONAL CITY	2006
Chagwido Tuff Cone Complex	Natural monument No. 422	Culture properties protection act	2000
	Absolute preserved area	SPECIAL ACT ON THE ESTABLISHMENT OF JEJU SPECIAL SELF-GOVERNING PROVINCE AND THE DEVELOPMENT OF FREE INTERNATIONAL CITY	2006
Upper Geomunoreum Lava Tube System	Natural monument No. 552	Culture properties protection act	2017
	Absolute preserved area	SPECIAL ACT ON THE ESTABLISHMENT OF JEJU SPECIAL SELF-GOVERNING PROVINCE AND THE DEVELOPMENT OF FREE INTERNATIONAL CITY	2006
	Urban area	NATIONAL LAND PLANNING AND UTILIZATION ACT	2009
Socheongul Lava Tube	Natural monument No. 236	Culture properties protection act	1971
	Absolute preserved area	SPECIAL ACT ON THE ESTABLISHMENT OF JEJU SPECIAL SELF-GOVERNING PROVINCE AND THE DEVELOPMENT OF FREE INTERNATIONAL CITY	2006

6. Implications for management arrangements

The Cultural Heritage Administration and Jeju Special Self-governing Provincial Government will assume de facto responsibility for the conservation and management of natural heritage properties in Jeju Province by fully abiding by the basic principles of conservation prescribed in the UNESCO World Heritage Convention. Moreover, Jeju Provincial Government will oversee and control matters relating to conservation and management in accordance with the relevant laws. Jeju Provincial Government will strengthen networks with relevant agencies to conserve and manage the resources while ensuring practical coordination to prevent conflicts arising from developments and environmental pollution. The Government will prepare a report every three years for the consideration by the Management Committee and the World Heritage Committee of Cultural Heritage Administration outlining the progress in achieving the goals and objectives of the action plans. The Jeju Provincial Government's management structure is shown in the Annex.

Jeju World Natural Heritage Management Committee is wholly responsible for preserving the value of and efficiently managing, natural heritage properties in Jeju Province. This Management Committee was established in by consolidation and enforcement of existing related organizations and it commenced in January 2006. A number of other committees were created under the Management Committee but as of June 2016 all committees have been consolidated into one under the title of World Heritage Management Committee. Key functions and roles of the committee include:

1) Providing support and advice to the Jeju Provincial Government,
2) Formulating and implementing management plans and strategies that conform to the principles for conservation and management of natural heritage properties,
3) Promoting constant monitoring and research of the resources and set up and run an organization in charge of monitoring and research,
4) Contributing to conserving and enhancing the value of the properties by developing programs to train experts and educate local residents and visitors,
5) Promoting efficient management of nominated areas by coordinating between the relevant localities, local communities, and government agencies, and

6) Reflecting the opinions of the local communities in policy decisions by gathering their views regarding conservation of nominated areas.

Ownership: The ownership status of the minor boundary modification areas is listed in the Annex. The core areas which are private lands will be progressively purchased by the state.

Education: There are many programs in progress to raise the awareness of preservation and maintenance of natural heritage and environment. Education is conducted by the Cultural Heritage Administration, the Jeju Special Self-governing Province, NGOs and schools at large. In the Cultural Heritage Administration, public officials in charge of cultural assets, related experts, and technicians often receive training. The Jeju Special Self-governing Province has been educating employees and volunteer heritage workers. The Promotion Committee for the inscription of Jeju's Sites on the World Natural Heritage List provided education to local residents and World Heritage supporters. Schools and NGOs offer environment education, including field trips, on natural environment values and preservation.

Visitor facilities and infrastructure: Jeju Island has a very large range of natural and cultural resources together with very many developed visitor attractions. Visitor numbers have increased in recent years. There are enough information centers, accommodation, and transportation systems to provide satisfactory facilities for the increasing tourist numbers. Suwolbong and Chagwido Island do not have enough facilities such as parking lots, restaurants, and toilets. Such facilities will be built to accommodate the increase in visitor numbers.

Specific action plans for each site are as follows:

(1) Suwolbong Tuff Ring

- Suwolbong will be under the care control and management of the Suwolbong and Chagwido Tuff Cone Complex Management Team.
- Additional staff will be hired to act as interpreters and patrollers;
- Visitors will be strongly encouraged to stay on paths and observation platforms by signage and patrol;
- Formal guided tours will be implemented;
- Further pathways and observation platforms are required and will be installed under guidelines outlined in "General Provisions" above;

- A large parking lot is needed and will require purchase of private land adjacent to the proposed visitor center site;
- The pathway from the present visitor center to the northern end of the outcrop will be extended under the guidelines outlined in "General Provisions" above;
- Investigations of the vegetation overtaking the outcrop will be carried out to see if there are rare and endangered species present; and
- Invasive vegetation will be removed under permit from the National Monument Committee, and methods of preventing plant invasion will be investigated.

(2) Chagwido Tuff Cone Complex

- Chagwido Tuff Cone Complex will be under the care control and management of the Suwolbong and Chagwido Tuff Cone Complex Management Team;
- Further infrastructure will not be permitted unless it is to improve interpretation; to better manage the walking courses already developed or to upgrade safety measures;
- The adequacy, environmental impact and safety of the trail already established and remedial measures taken as necessary; and
- A small information center is already present on the island. The adequacy of this building will be assessed. It may be augmented to provide for emergency accommodation and equipment; and
- The need for and adequacy of small information center at Chagwido Port in Chagwido will be assessed.

(3) The Upper Geomunoreum Lava Tube System

- Special care will be given within the core zone of the tube for 100 m either side of the cave survey centerline and cave ends to avoid possible contaminated water entering the cave
- The buffer zone will extend 500 m around the perimeter of the core zone as shown on the map
- The tube will generally remain closed to the public except for research and monitoring activities under a permit from the Geomunoreum Management Team; and
- Guided "wild" cave tours will be considered only for Utsanjeongul Cave, Daerimgul and Bukoreum caves and they will not be open to public and will be protected.

(4) Socheongul Lava Tube

- Special care will be given within the core zone of the tube for 100 m either side of the cave survey centerline and cave ends to avoid possible contaminated water entering the cave;
- The tube will generally remain closed to the public except for research and monitoring activities under a permit from the Management Team;
- Future use of the tube will be considered by the Management Team after consultation;
- Scientific research will be carried out to understand the age of carbonate speleothems and carbonate sand dunes as well as archaeological heritage values; and
- Guided bat-watching tours to the cave entrance to view the evening fly-outs may be permitted and conducted by and under a permit from the Geomunoreum Management Team following research and monitoring of bat behavior.

7. Maps

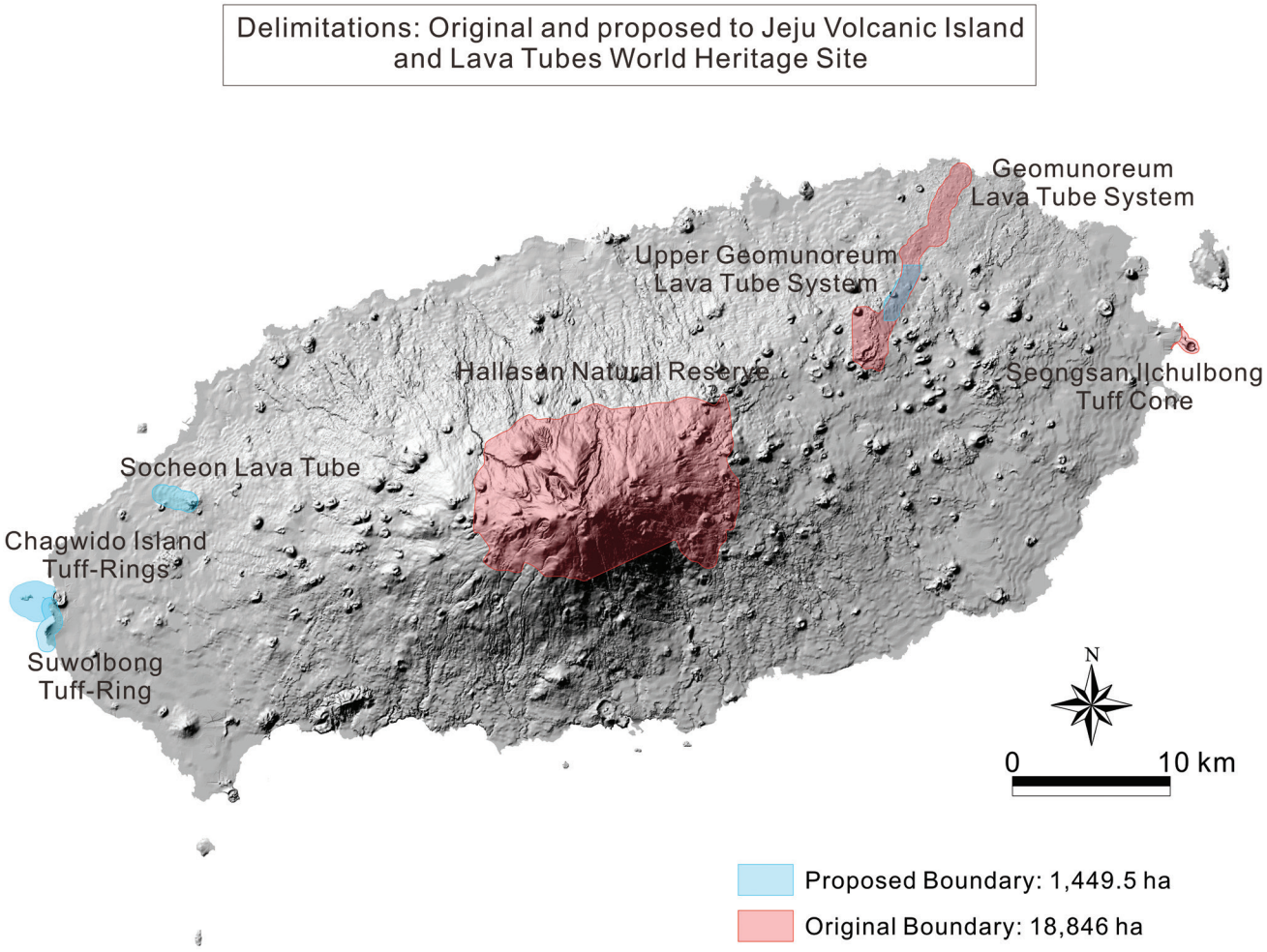


Fig. 15. Delineation of the original and proposed areas of the Jeju Volcanic Island and Lava Tubes World Heritage Site.

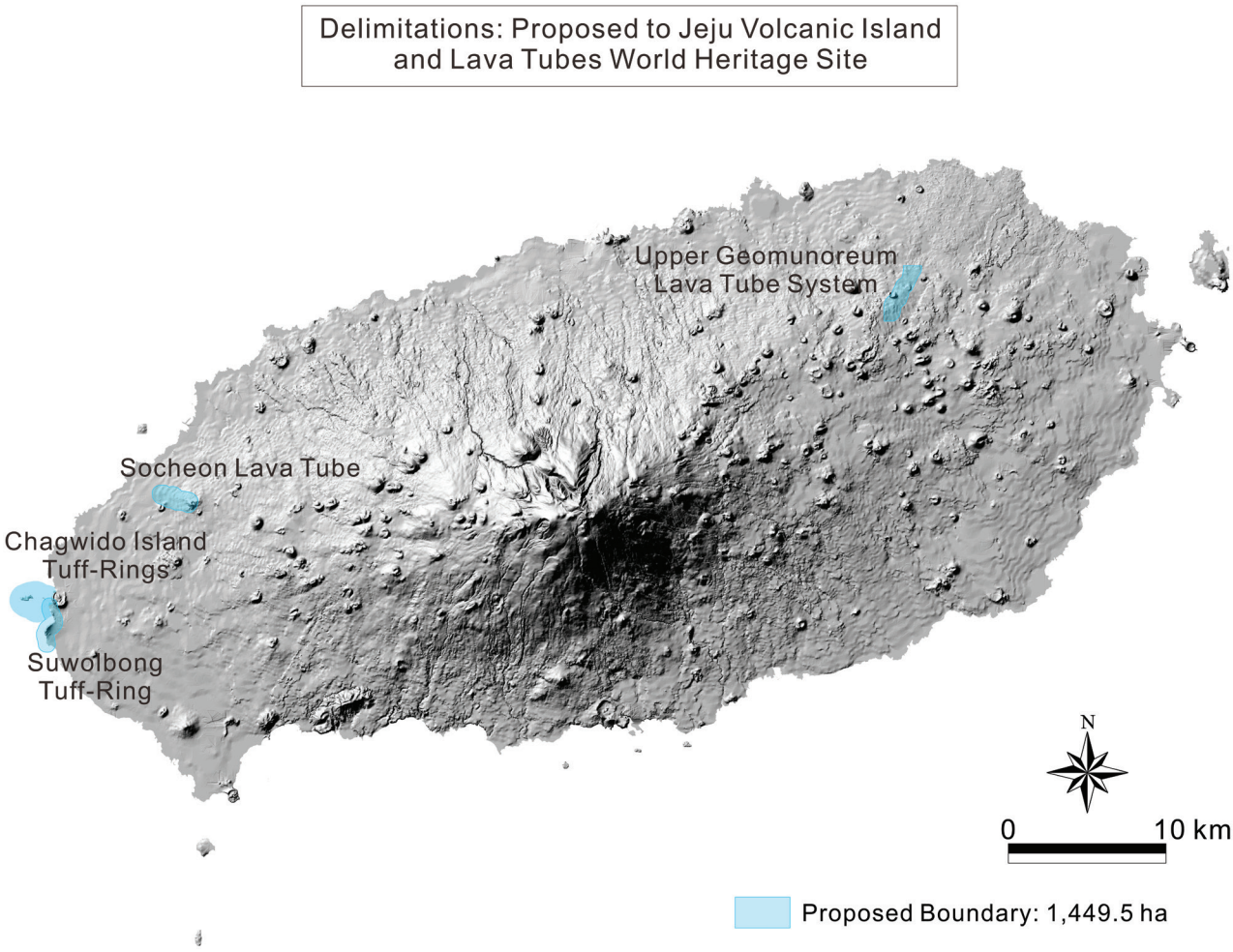


Fig. 16. Delineation of the proposed areas of Jeju Volcanic Island and Lava Tubes World Heritage Site.

Fig. 17. Topographic map of the Suwolbong Tuff Ring, showing the proposed boundary modification area.

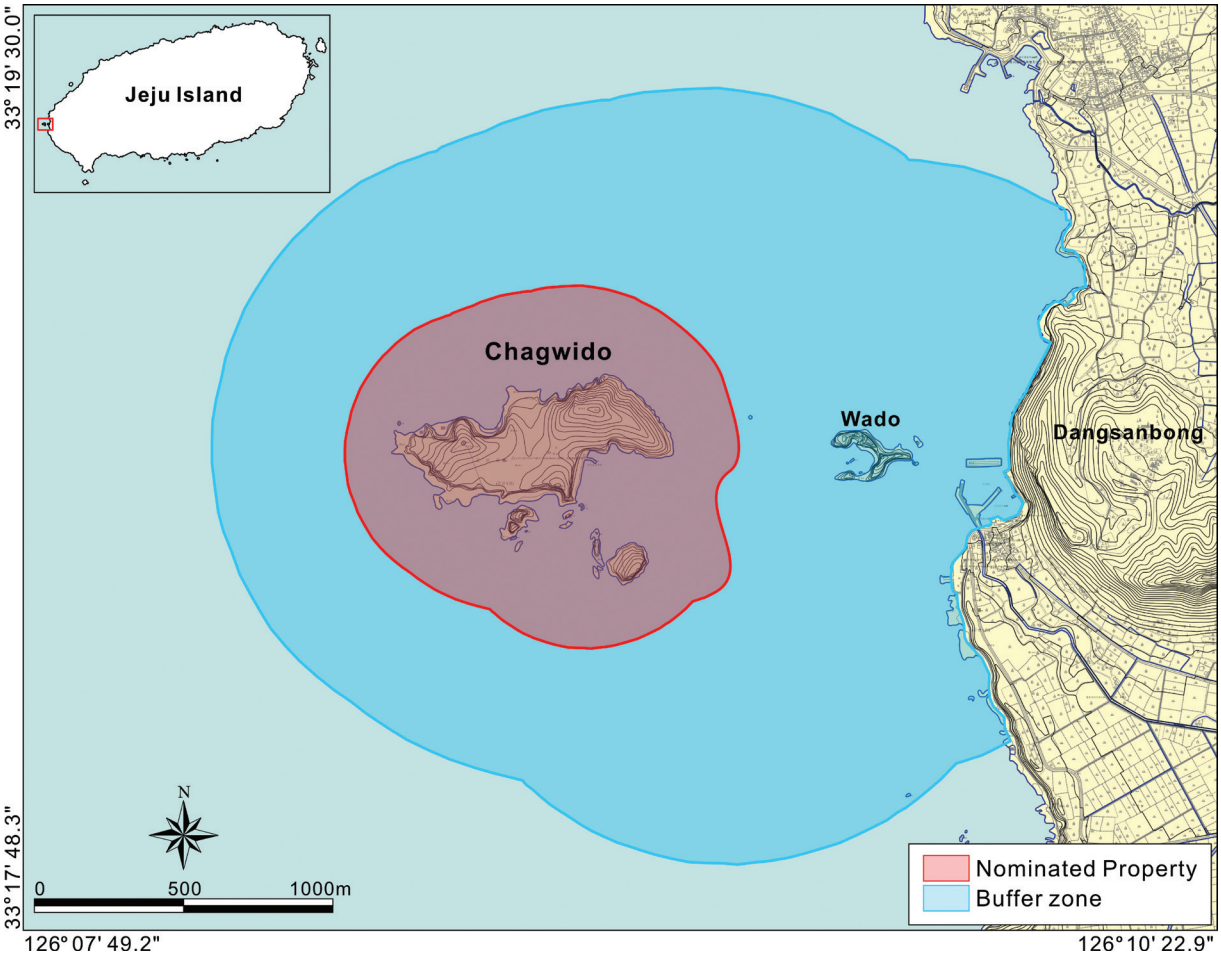


Fig. 18. Topographic map of the Chagwido Tuff Cone Complex, showing the proposed boundary modification area.

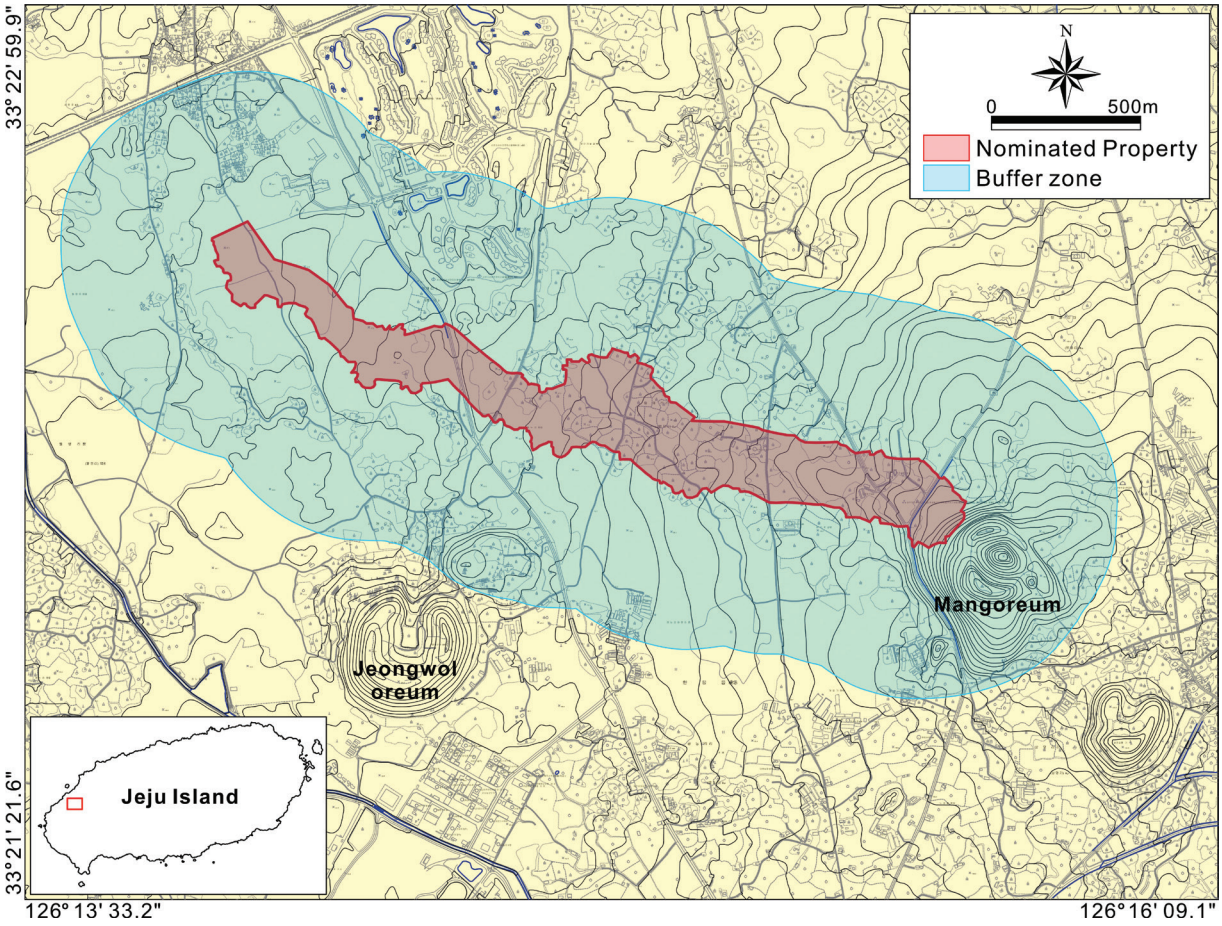


Fig. 19. Topographic map of the Socheongul Lava Tube, showing the proposed boundary modification area.

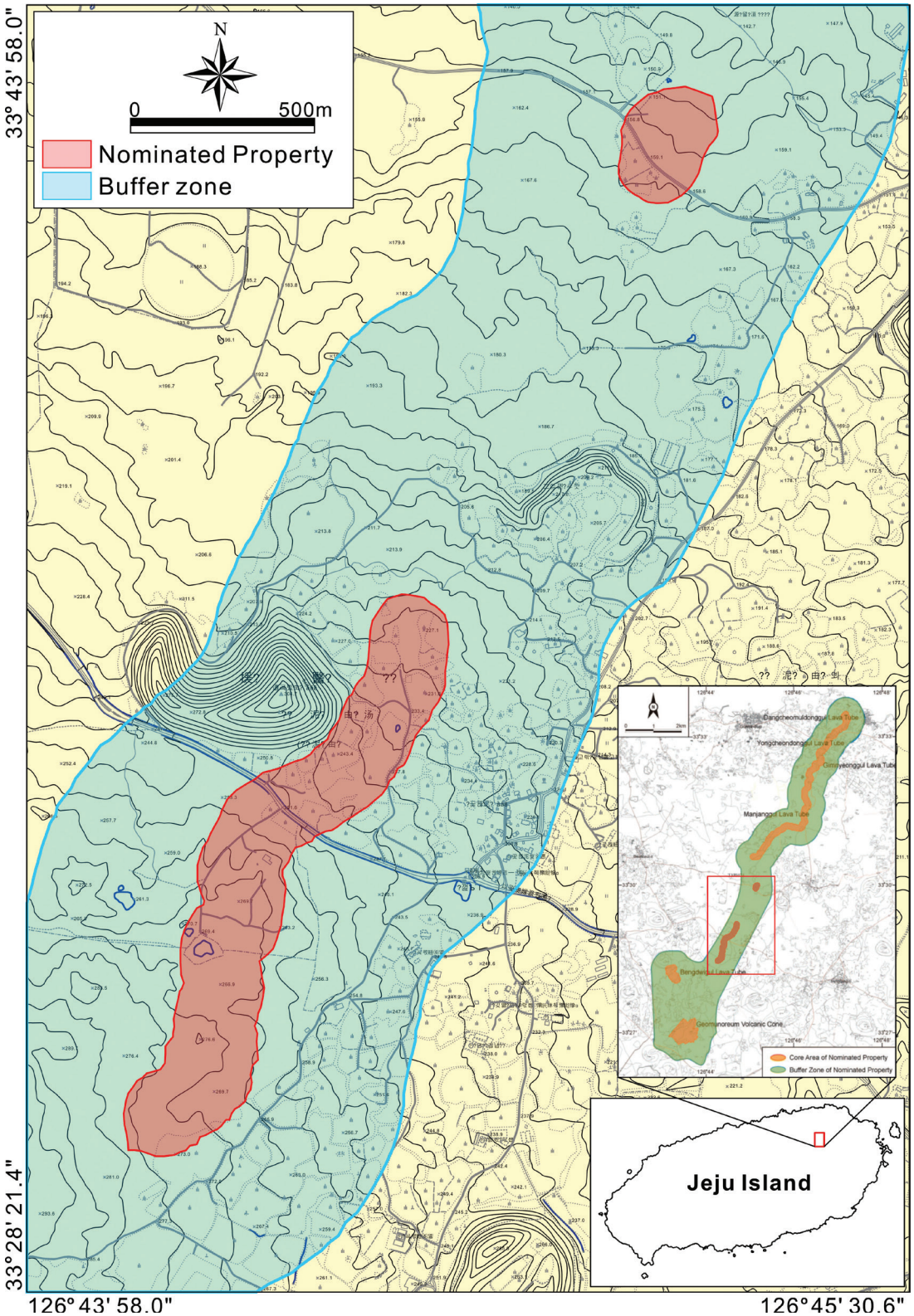


Fig. 20. Topographic map of the Upper Geomunoreum Lava Tube System, showing the proposed boundary modification area.

8. Additional information

8-1. Cultural Heritage Protection Act

Table 3. The Cultural Heritage Protection Act which will be applied to all the serial sites for Minor Boundary Modification of the 'Jeju Volcanic Island and Lava Tubes'.

Legal status	Relevant law	Important act
Natural monument No. 513	Culture properties protection act	Article 3 (Basic Principle of Protection of Cultural Heritage) The basic principle for the preservation, management, and utilization of cultural heritage is to preserve them in their original state. Article 35 (Matters to be Permitted) (1) A person who intends to perform any of the following activities for State-designated cultural heritage(excluding important intangible cultural heritage; hereafter the same shall apply in this Article) shall obtain permission from the Administrator of the Cultural Heritage Administration, as prescribed by Presidential Decree. The same shall also apply where he/she intends to change any permitted matter: 1. Altering (including making a specimen of or stuffing a natural monument) the current state of State-designated cultural heritage (including its protective facilities and protection zone, and a dead natural monument), as prescribed by Ordinance of the Ministry of Culture, Sports and Tourism; 2. Performing activities determined by Ordinance of the Ministry of Culture, Sports and Tourism which could affect the preservation of State-designated cultural heritage (excluding cultural heritage that can be categorized as movable property); 3. Taking a rubbed copy, a photoprint, or a photograph of State-designated cultural heritage in a manner that could affect the preservation of the cultural heritage; 4. Capturing or collecting an animal, a plant, or a mineral within an area designated or provisionally designated as a scenic area or a natural monument or within its protection zone, or removing the captured or collected animal, plant, or mineral from such spot or protection zone; (2) Where permission from the Administrator of the Cultural Heritage Administration is granted pursuant to paragraph (1) 2 in an area where the preservation area of a historic and cultural environment of State-designated cultural heritage overlaps with that of City/Do-designated cultural heritage, permission from the relevant Mayor/Do Governor under Article 74 (2) shall be deemed to have been granted. (3) The Administrator of the Cultural Heritage Administration may entrust the Mayor/Do Governor with affairs concerning permission for changes to insignificant matters determined by Ordinance of the Ministry of Culture, Sports and Tourism, among permitted matters concerning activities which could affect the preservation of State-designated cultural heritage under paragraph (1) 2.

Legal status	Relevant law	Important act
Natural monument No. 513	Culture properties protection act	Article 51 (Subsidies) (1) The State may fully or partially subsidize the following expenses: 1. Expenses incurred in managing cultural heritage by a management organization under Article 34 (1); 2. Expenses incurred in taking measures stipulated under Article 42 (1) 1 through 3; 3. Expenses incurred in managing, protecting, repairing, utilizing State-designated cultural heritage or in preparing records thereon, in addition to cases under subparagraphs 1 and 2; 4. Expenses incurred in protecting and developing important intangible cultural heritage. (2) The Administrator of the Cultural Heritage Administration may supervise the repair of cultural heritage or any other works where he/she grants subsidies pursuant to paragraph (1). (3) Subsidies under paragraph (1) 2 through 4 shall be granted through the Mayor/Do Governor, and shall be managed and spent in compliance with the instructions of the Mayor/Do Governor: Provided, That such subsidies may be directly granted to an owner, holder, custodian or management organization, and may be managed and spent in compliance with the instructions of the Administrator of the Cultural Heritage Administration where he/she deems it necessary to do so. Article 48 (Public Disclosure of Cultural Heritage) (1) State-designated cultural heritage(excluding important intangible cultural heritage; hereafter the same shall apply in this Article) shall be publicly disclosed if any extenuating circumstance exists, except where public disclosure of cultural heritage is restricted pursuant to paragraph (2). (2) Where necessary to preserve cultural heritage and to prevent its damage, the Administrator of the Cultural Heritage Administration may fully or partially restrict the disclosure of the relevant cultural heritage. In such cases, the Administrator of the Cultural Heritage Administration shall hear the opinion of the owner (referring to a management organization where such organization is designated) of the cultural heritage in question. (3) Where the Administrator of the Cultural Heritage Administration places a restriction on public disclosure of State-designated cultural heritage pursuant to paragraph (2), he/she shall give public notice on the location of the area where the cultural heritage is located, the period during which public disclosure is restricted, the area subject to the restriction, and other relevant matters, as determined by Ordinance of the Ministry of Culture, Sports and Tourism, and shall inform an owner, holder, custodian, or management organization of the relevant cultural heritage, the competent Mayor/Do Governor, and the head of the competent Si/Gun/Gu thereof.

Legal status	Relevant law	Important act
Natural monument No. 513	Culture properties protection act	(4) The Administrator of the Cultural Heritage Administration shall promptly lift the restriction measure as soon as the grounds for a restriction on public disclosure of State-designated cultural heritage under paragraph (2) cease to exist. In such cases, the Administrator of the Cultural Heritage Administration shall give public notice thereon, as determined by Ordinance of the Ministry of Culture, Sports and Tourism, and shall inform the owner, holder, custodian, or management organization of the relevant cultural heritage, the competent Mayor/Do Governor, and the head of the competent Si/Gun/Gu thereof. (5) A person who intends to enter a restricted area pursuant to paragraphs (2) and (3) shall obtain permission from the Administrator of the Cultural Heritage Administration by clearly stating the reason therefor. Article 19 (Registration and Protection of World Heritage Site, etc.) (1) The Administrator of the Cultural Heritage Administration may file an application with UNESCO for the registration of Korea's important cultural heritage being as a World Heritage Site, Intangible Cultural Heritage of Humanity, or Memory of the World in accordance with the Convention Concerning the Protection of the World Cultural and Natural Heritage, the Convention for the Safeguarding of the Intangible Cultural Heritage or UNESCO's programs. In such cases, the Administrator of the Cultural Heritage Administration shall determine procedures, etc. for selecting those to be applied for, in consideration of UNESCO's regulations. <Amended by Act No. 10562, Apr. 6, 2010> (2) The Administrator of the Cultural Heritage Administration shall actively endeavor to preserve not only cultural heritage registered with UNESCO as a World Heritage Site, Intangible Cultural Heritage of Humanity, or Memory of the World (hereafter referred to as "World Heritage Site, etc." in this Article), but also cultural heritage of humanity, and to enhance the prestige of cultural heritage around the world. <Amended by Act No. 10562, Apr. 6, 2010> (3) The State and a local government shall maintain, manage and support a World Heritage Site, etc. to the level equivalent to the State-designated cultural heritage from the date on which they are registered, and the Administrator of the Cultural Heritage Administration may order any person who engages in any activity that could affect a World Heritage Site, etc. or its historic and cultural environment to take necessary measures for the protection of a World Heritage Site, etc. and its historic and cultural environment, as prescribed by Presidential Decree.

Legal status	Relevant law	Important act
Absolute preserved area	SPECIAL ACT ON THE ESTABLISHMENT OF JEJU SPECIAL SELF-GOVERNING PROVINCE AND THE DEVELOPMENT OF FREE INTERNATIONAL CITY	Article 315 (Organization, etc. of Groundwater Management Committee) The Governor shall establish a groundwater management committee for seeking advice on the following matters, and matters necessary for the organization and management of the groundwater management committee shall be prescribed by Provincial Ordinance: <Amended by Act No. 8586, Aug. 3, 2007; Act No. 10154, Mar. 22, 2010> 1. Basic surveys on groundwater and the establishment and revision of the comprehensive water resources plan; 2. Examination of groundwater impact survey reports under Article 312 (4) or environmental impact survey reports under Article 13 of the Drinking Water Management Act; 3. Designation and change of special control areas for groundwater resources designated under Article 312; 4. Management of the special account for management of groundwater established under Article 318; 5. Establishment of the comprehensive plan for agricultural water under Article 319 (1); 6. Other matters concerning the development, utilization, conservation, and management of groundwater and alternative water resources. Article 355 (Penalty Provisions Applicable to Immigration Control) (1) Any of the following persons who engage in a corresponding activity for profit-making purposes shall be punished by imprisonment with or without labor for not more than seven years, or by a fine not exceeding 50 million won: 1. A person who moves, or arranges to move, a group of foreigners to other area within the territory of the Republic of Korea in violation of Article 158 (1); 2. A person who provides a ship, etc. or a passport to move a group of foreigners to other area within the territory of the Republic of Korea in violation of Article 158 (2); 3. A person who hides a group of foreigners who has moved or is moving to other area within the territory of the Republic of Korea, assists such group of foreigners to escape, or provides a ship, etc. for such purposes in violation of Article 158 (3). (2) A person who engages in any of the activities under the subparagraphs of paragraph (1) not for gain shall be punished by imprisonment with or without labor for not more than five years, or by a fine not exceeding 30 million won. (3) Any of the following persons shall be punished by imprisonment with or without labor for not more than three years, or by a fine not exceeding 20 million won: 1. A person who moves to other area within the territory of the Republic of Korea without the permission for extension of his/her sojourn area under Article 157 (1); 2. A person who violates Article 158, but does not fall under paragraph (1) or (2). (4) A person who violates Article 159 shall be punished by a fine not exceeding five million won. (5) A person who refuses a just demand of an immigration control official or a public official with due authority in the course of performing his/her duty to verify whether a person has permission for extension of his/her sojourn area under Article 157 (5) shall be punished by a fine not exceeding one million won.

Legal status	Relevant law	Important act
Urban areas	NATIONAL LAND PLANNING AND UTILIZATION ACT	Article 7 (Management Obligation by Special-Purpose Area) In order to efficiently utilize and manage special-purpose areas determined pursuant to Article 6, the State or a local government shall take necessary measures for maintenance and preservation of special-purpose areas, as prescribed in the following: 1. Urban areas: It shall formulate a plan in advance and implement it in order for the relevant areas to be systematically and efficiently developed, maintained and preserved, as stipulated in this Act or related Acts;

8-2. Ownership status

Table 4. Ownership status of minor boundary modification properties (unit : ha, %).

		Total	Province	City/County	Private
Suwolbong Tuff Ring	area	4.7034	0.2438	0.6201	3.8665
	%	100	5	13	82
Chagwido Tuff Cone Complex	area	16.2932	0.0760	13.3263	2.8909
	%	100	0.1	82	17.9
Upper Geomunoreum Lava Tube System	area	347.5252	39.1992	7.5145	300.8115
	%	100	11	2	87
Socheongul Lava Tube	area	138.7352	62.8148	28.8886	47.0318
	%	100	45	21	34

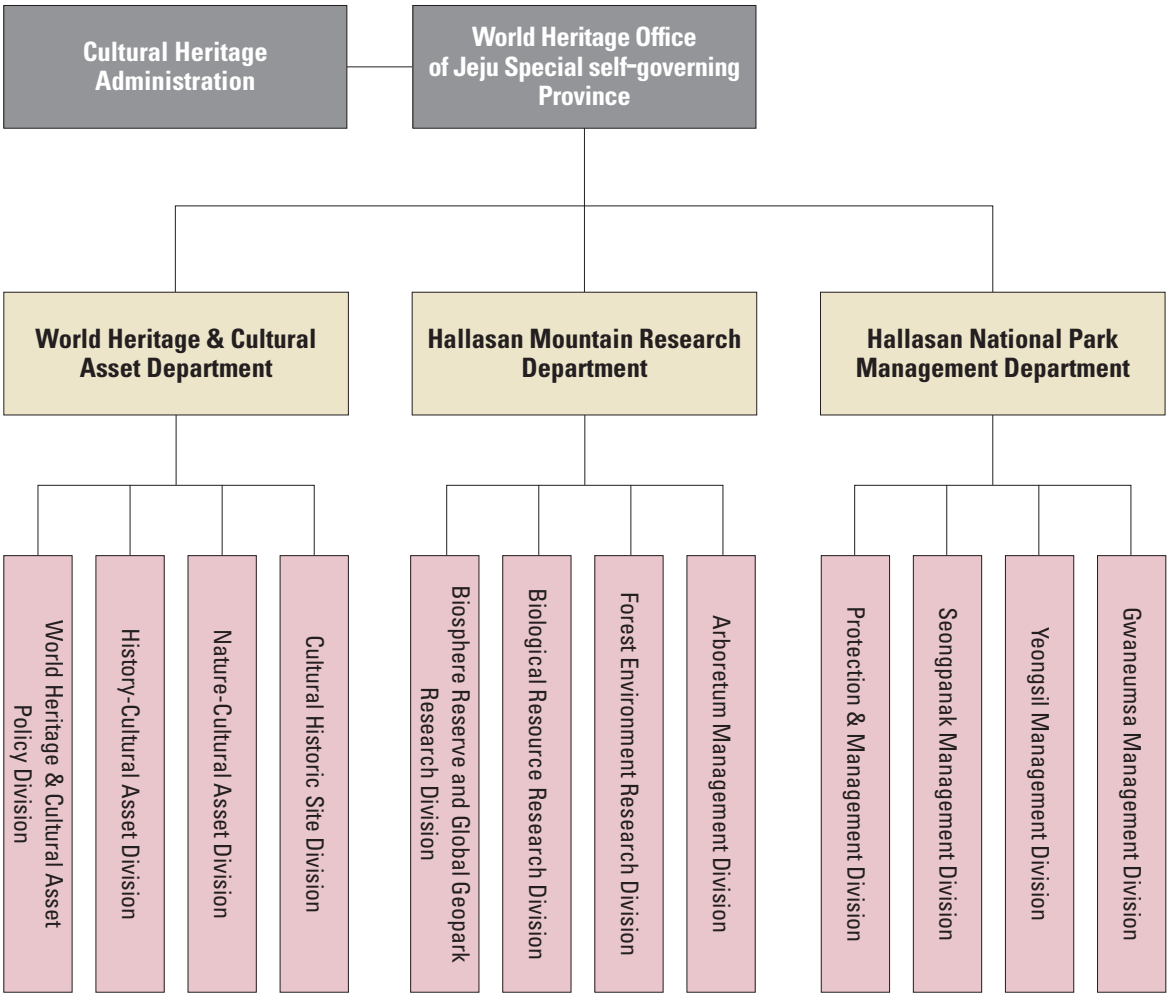
Table 5. Ownership status of core area by minor boundary modification properties (unit : ha, %).

		Total	Province	City/County	Private
Suwolbong Tuff Ring	area	4.3292	1.467	0.5592	3.6233
	%	100	3	13	84
Chagwido Tuff Cone Complex	area	16.2932	0.0760	13.3263	2.8909
	%	100	0.1	82	17.9
Upper Geomunoreum Lava Tube System	area	44.6189	1.0841	5.6050	37.9298
	%	100	2	13	85
Socheongul Lava Tube	area	13.0199	0.7857	4.7092	7.5250
	%	100	6	36	58

Table 6. Ownership status of buffer zones by minor boundary modification properties (unit : ha, %).

		Total	Province	City/County	Private
Suwolbong Tuff Ring	area	0.3742	0.0971	0.0609	0.2432
	%	100	24	15	61
Chagwido Tuff Cone Complex	area	-	-	-	-
	%	-	-	-	-
Upper Geomunoreum Lava Tube System	area	302.9063	38.1151	1.9095	262.8817
	%	100	12	1	87
Socheongul Lava Tube	area	125.7153	62.0291	24.1794	39.5068
	%	100	49	19	32

8-3. Administrative structure



8-4. Bibliography

Brenna, M., Cronin, S.J., Nemeth, K., Smith, I.E.M. and Sohn, Y.K., 2011. The influence of magma plumbing complexity on monogenetic eruptions, Jeju Island, Korea. Terra Nova, 23(2): 70-75.

Brenna, M., Cronin, S.J., Smith, I.E.M., Sohn, Y.K. and Nemeth, K., 2010. Mechanisms driving polymagmatic activity at a monogenetic volcano, Udo, Jeju Island, South Korea. Contributions to Mineralogy and Petrology, 160(6): 931-950.

Brenna, M., Németh, K., Cronin, S.J., Sohn, Y.K., Smith, I.E.M. and Wijbrans, J., 2015. Co-located monogenetic eruptions ~200 kyr apart driven by tapping vertically separated mantle source regions, Chagwido, Jeju Island, Republic of Korea. Bulletin of Volcanology, 77: 43.

Cheong, C.S., Choi, J.H., Sohn, Y.K., Kim, J.C. and Jeong, G.Y., 2007. Optical dating of hydromagmatic volcanoes on the southwestern coast of Jeju Island, Korea. Quaternary Geochronology, 2(1-4): 266-271.

Sigurdsson, H., Houghton, B.F., McNutt, S.R., Rymer, H. and Stix, J., 2000. Encyclopedia of Volcanoes. Academic Press, San Diego, 1417 pp.

Sohn, Y.K. and Chough, S.K., 1989. Depositional processes of the Suwolbong tuff ring, Cheju Island (Korea). Sedimentology, 36(5): 837-855.

Sohn, Y.K. and Chough, S.K., 1992. The Ilchulbong tuff cone, Cheju Island, South Korea: depositional processes and evolution of an emergent, Surtseyan-type tuff cone. Sedimentology, 39(4): 523-544.

Sohn, Y.K. and Park, K.H., 2005. Composite tuff ring/cone complexes in Jeju Island, Korea: possible consequences of substrate collapse and vent migration. Journal of Volcanology and Geothermal Research, 141(1-2): 157-175.

Sohn, Y.K., 1996. Hydrovolcanic processes forming basaltic tuff rings and cones on Cheju Island, Korea. Geological Society of America Bulletin, 108(10): 1199-1211.

Sohn, Y.K., Cronin, S.J., Brenna, M., Smith, I.E.M., Nemeth, K., White, J.D.L., Murtagh, R.M., Jeon, Y.M. and Kwon, C.W., 2012. Ilchulbong tuff cone, Jeju Island, Korea, revisited: A compound monogenetic volcano involving multiple magma pulses, shifting vents, and discrete eruptive phases. Geological Society of America Bulletin, 124(3-4): 259-274.

Sohn, Y.K., Park, K.H. and Yoon, S.H., 2008. Primary versus secondary and subaerial versus submarine hydrovolcanic deposits in the subsurface of Jeju Island, Korea. Sedimentology, 55(4): 899-924.

Walker, R.G. and James, N.P., 1992. Facies Models: Response to Sea Level Change. Geological Society of Canada, 409 pp.

White, J.D.L. and Houghton, B., 2000. Surtseyan and related phreatomagmatic eruptions. In: H. Sigurdsson, B.F. Houghton, S.R. McNutt, H. Rymer and J. Stix (Editors), Encyclopedia of Volcanoes. Academic Press, San Diego, pp. 495-511.

White, J.D.L. and Ross, P.-S., 2011. Maar-diatreme volcanoes: A review. Journal of Volcanology and Geothermal Research, 201: 1-29.

Woo, K.S., Sohn, Y.K. and King, L.M., 2010. Jeju: South Korea's premier island geotourism destination. In: P.E. Cooper and M. Cooper (Editors), Volcano and Geothermal Tourism: Sustainable Geo-Resources for Leisure and Recreation. Earthscan Publications Ltd., pp. 276.

Woo, K.S., Sohn, Y.K., Ahn, U.S. and Yoon, S.H., 2013. Jeju Island Geopark—A Volcanic Wonder of Korea. Springer, Berlin, 90 pp.