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## A first step towards the inference of geological topological operations

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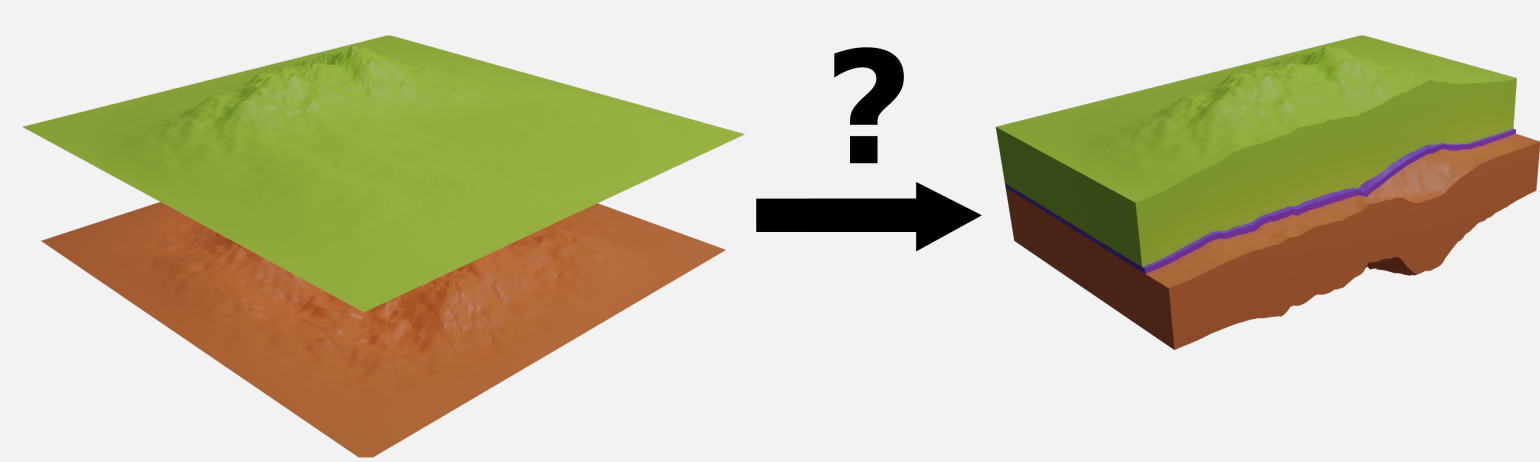
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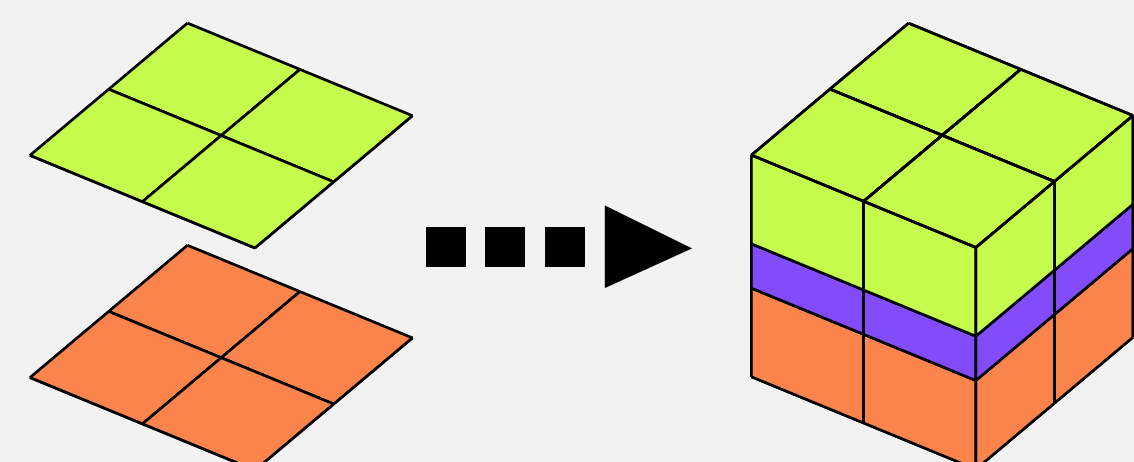
## 1. Problematic and motivating context

Question: How to obtain this operation ?



Before: 2 surfaces, 64516 faces, and 258064 vertices.  
After: 48387 volumes, 290322 faces, and 2322576 vertices.

Intuition: It is a layering operation !



Before: 2 surfaces, 8 faces, and 32 vertices.  
After: 12 volumes, 72 faces, and 288 vertices.

We offer to infer operations from a representative example.

- Applicability:** Should produce a valid operation.
- Robustness:** Should yield an operation usable in a broader context.
- Simplicity:** Should not require user knowledge of the data structure.
- Time efficiency:** Should infer in an acceptable amount of time.

Exploiting Jerboa's platform, we can use objects created in various software.

## 2. Topological structure

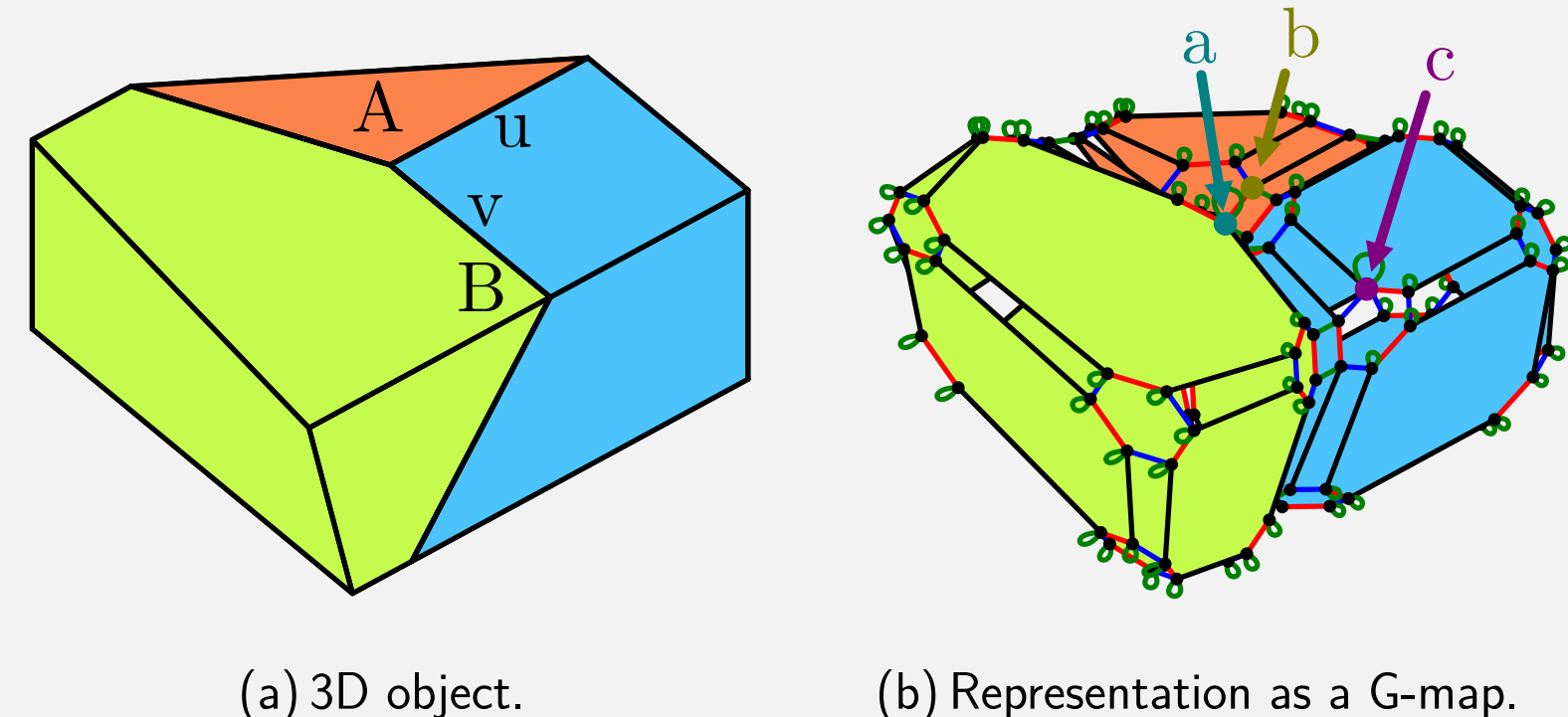


Figure 1: Generalized maps (G-maps) [DL14] as an arc-labeled graph encode the object's topological cells.

## 3. Modeling operations

We developed a dedicated tool with Jerboa's platform [BALGB14] supporting imports from common file formats.

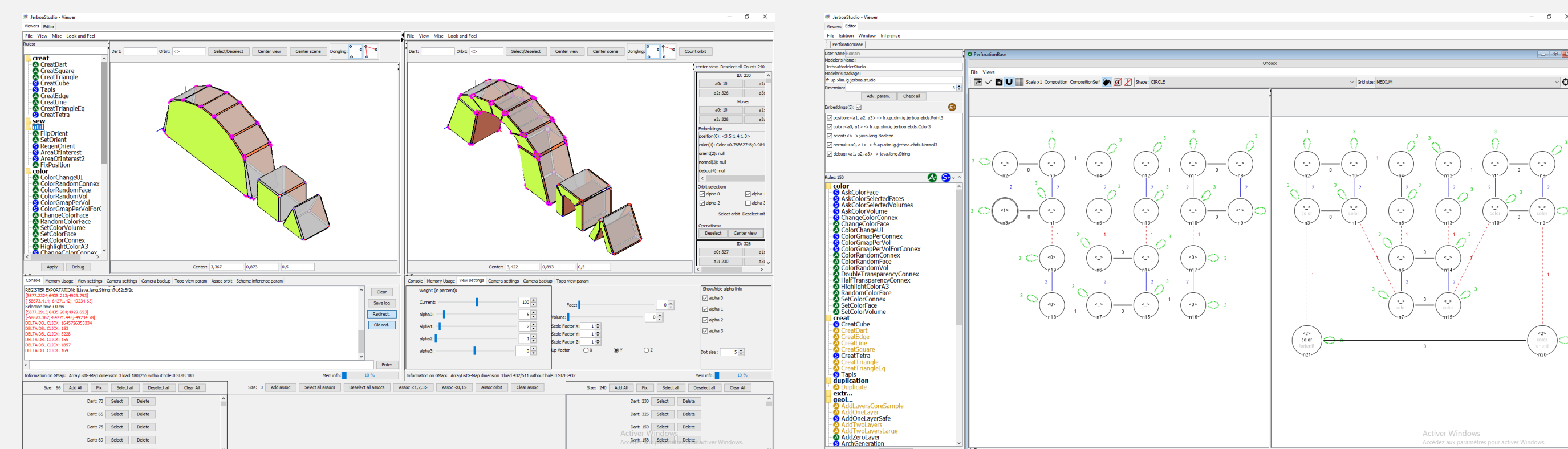


Figure 2: Viewer tab.

Figure 3: Editor tab.

The viewer tab (Fig. 2) contains both instances used for the inference. The editor tab (Fig. 3) allows visualizing the inferred operations and adding missing geometric computations.



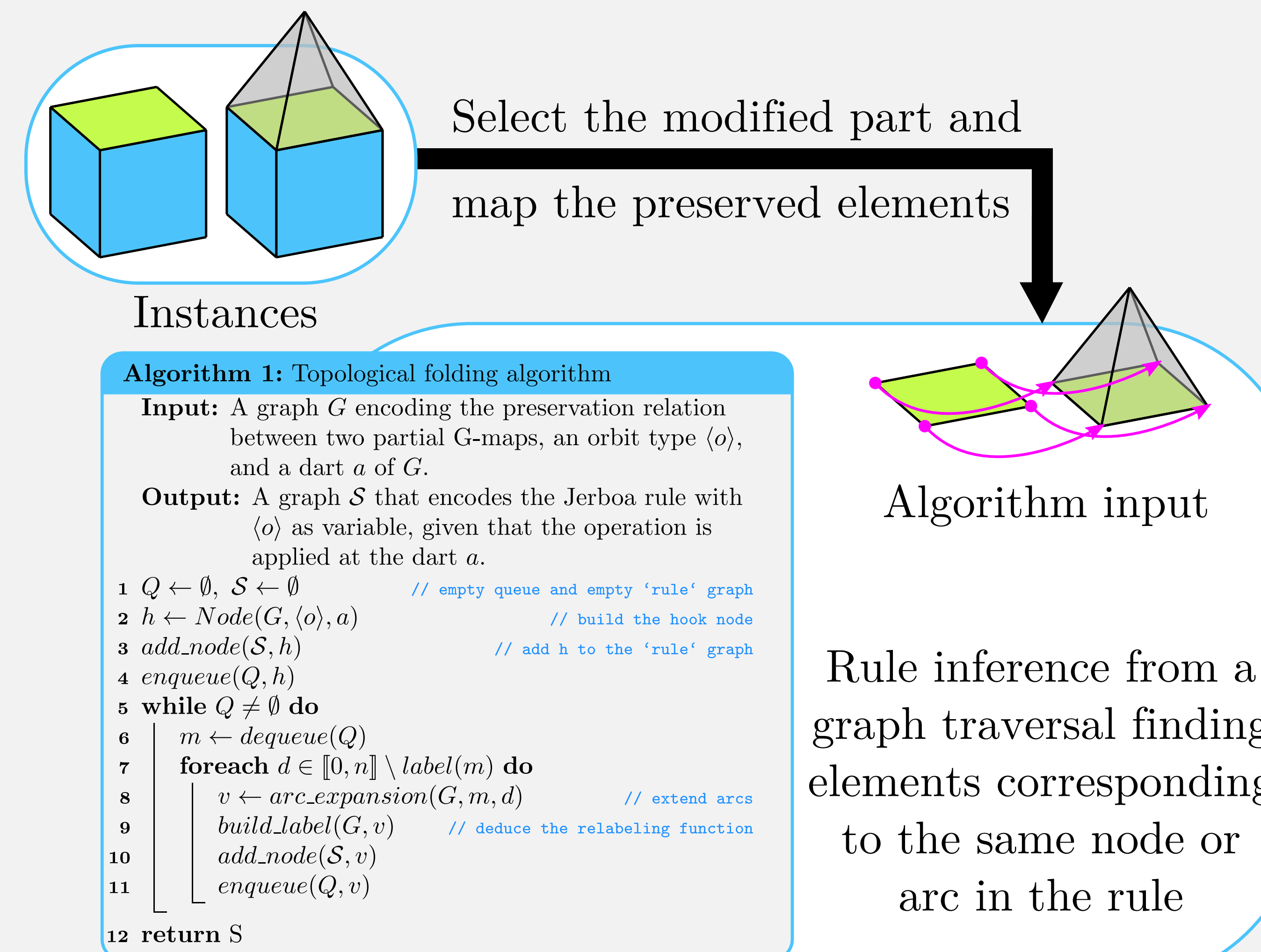
Take a picture to access the demo

[BALGB14] BELHAOUARI H., ARNOULD A., LE GALL P., BELLET T.: Jerboa: A Graph Transformation Library for Topology-Based Geometric Modeling. In *Graph Transformation (ICGT)* (2014), Giese H., König B., (Eds.).

[DL14] DAMIAND G., LIENHARDT P.: *Combinatorial Maps: Efficient Data Structures for Computer Graphics and Image Processing*. 2014.

## 4. Method

We reverse the instantiation process by folding a graph that encodes the elements modified by the operation.



```

Algorithm 1: Topological folding algorithm
Input: A graph G encoding the preservation relation between two partial G-maps, an orbit type (o), and a dart a of G.
Output: A graph S that encodes the Jerboa rule with (o) as variable, given that the operation is applied at the dart a.
1 Q ← ∅, S ← ∅ // empty queue and empty 'rule' graph
2 h ← Node(G, (o), a) // build the hook node
3 add_node(S, h) // add h to the 'rule' graph
4 enqueue(Q, h)
5 while Q ≠ ∅ do
6   m ← dequeue(Q)
7   foreach d ∈ [0, n] \ label(m) do
8     v ← arc_expansion(G, m, d) // extend arcs
9     build_label(G, v) // deduce the relabeling function
10    add_node(S, v)
11    enqueue(Q, v)
12 return S
    
```

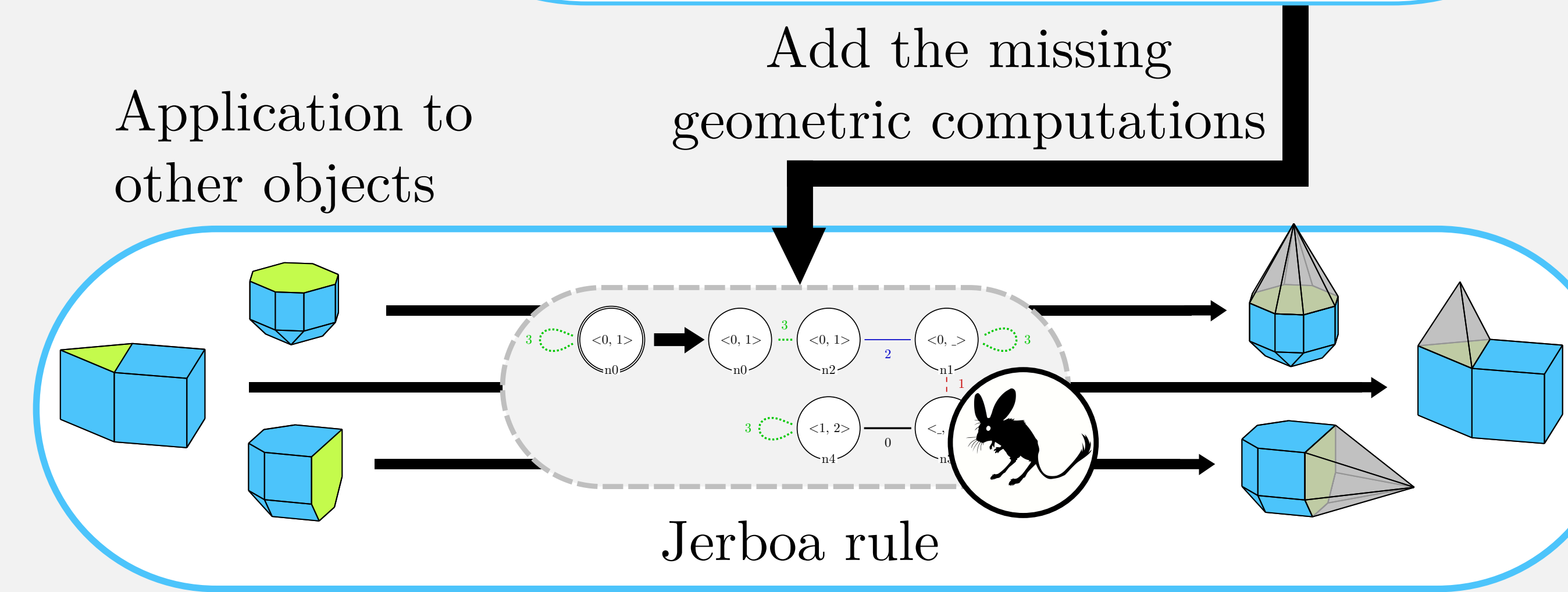


Figure 4: How to obtain a topological operation from an example.

## 5. Applications for procedural modeling (geology)

Layering: (a) no inter-layer, (b) one inter-layer, (c) two inter-layers, (d) six inter-layers and their inferred operations.

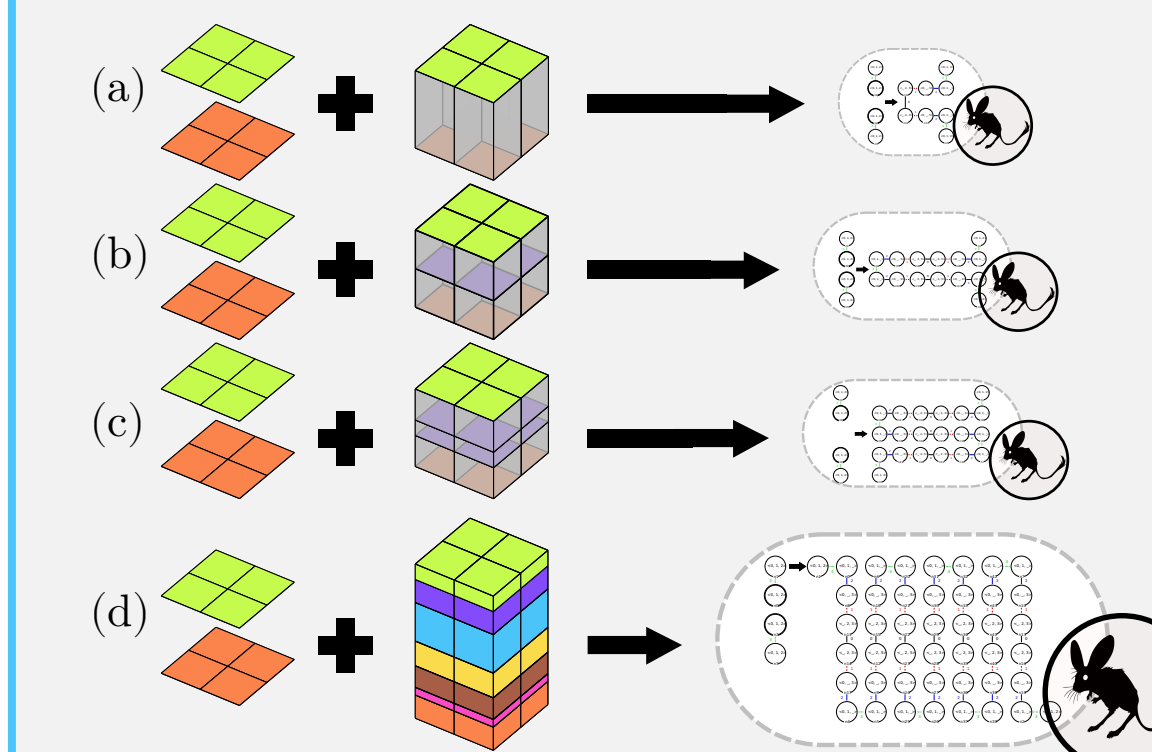


Figure 5: Layering inference.

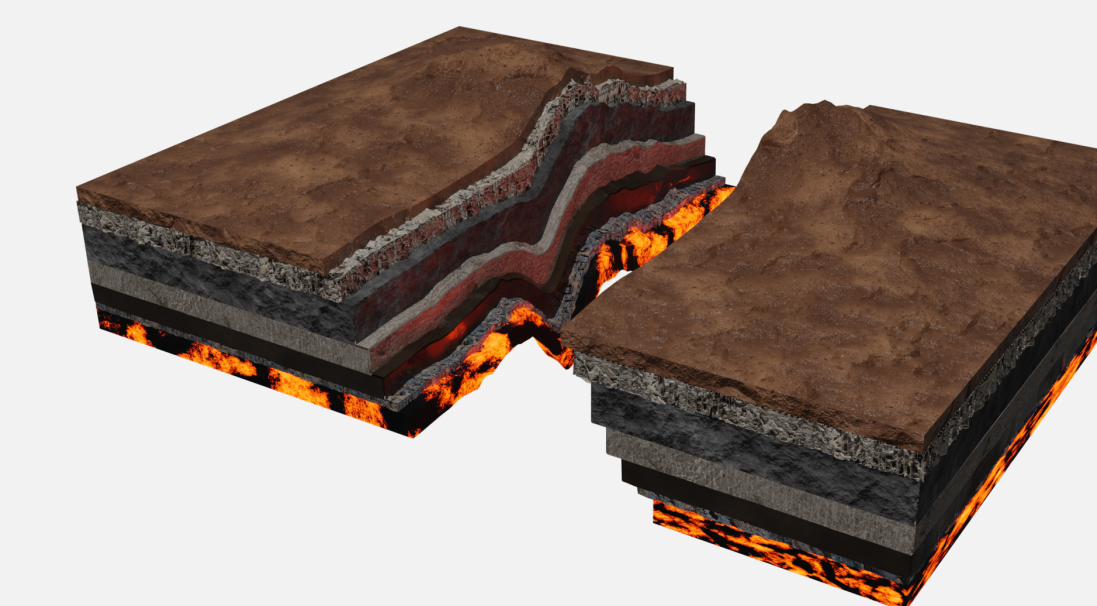


Figure 6: Final rendered subsoil.

Arch generation: (a) three-step and (b) one-step procedure by removing the base of a prism, and (c) two-step procedure by hole perforation.

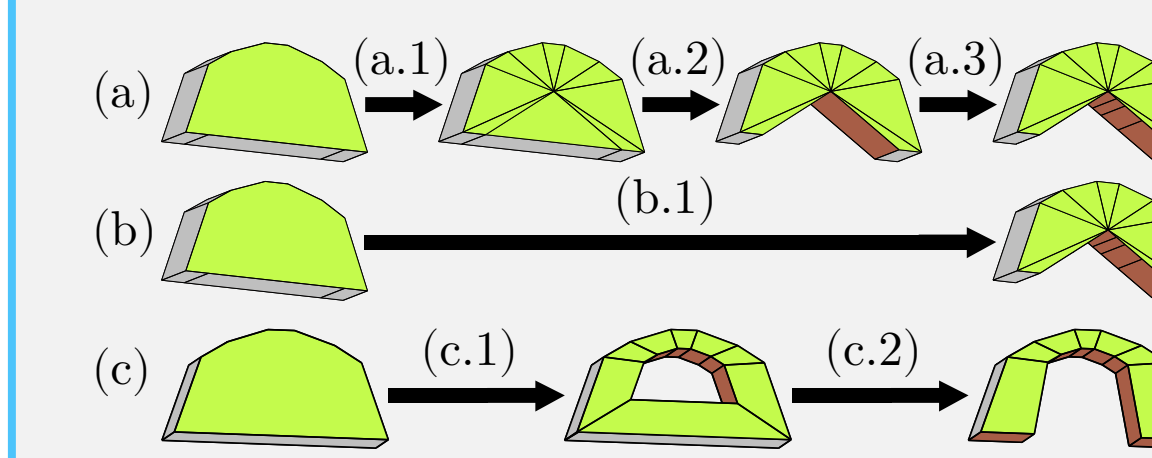


Figure 7: Arch generation inference.



Figure 8: Rendered arches in water.

The operations presented here are part of a larger procedural workflow and were obtained through our inference mechanism. We can either refine the generation by inferring simpler operations (line (a)) or realize a single step generation with the threat of inferring an operation that completely fixes the topology (line (b)).

## 6. Results and conclusion

Inference time:

Time in ms for the inference of the operations from applications of section 5.

Operation	Figure 5				Figure 7					
	a	b	c	d	a.1	a.2	a.3	b.1	c.1	c.2
Time (ms)	3	4	4	4	2	5	2	28	4	5

Limitations:

- The operation should modify a connected part of the object for the algorithm to work.
- When the algorithm does not find regularities, it produces an operation tailored to the instance given as input (e.g. operation (b) from Fig. 7).

Conclusion:

We infer any constructive or destructive topological operations from their description on a representative example (facilitated by the regularity of generalized maps and the genericity of graph-based rules).