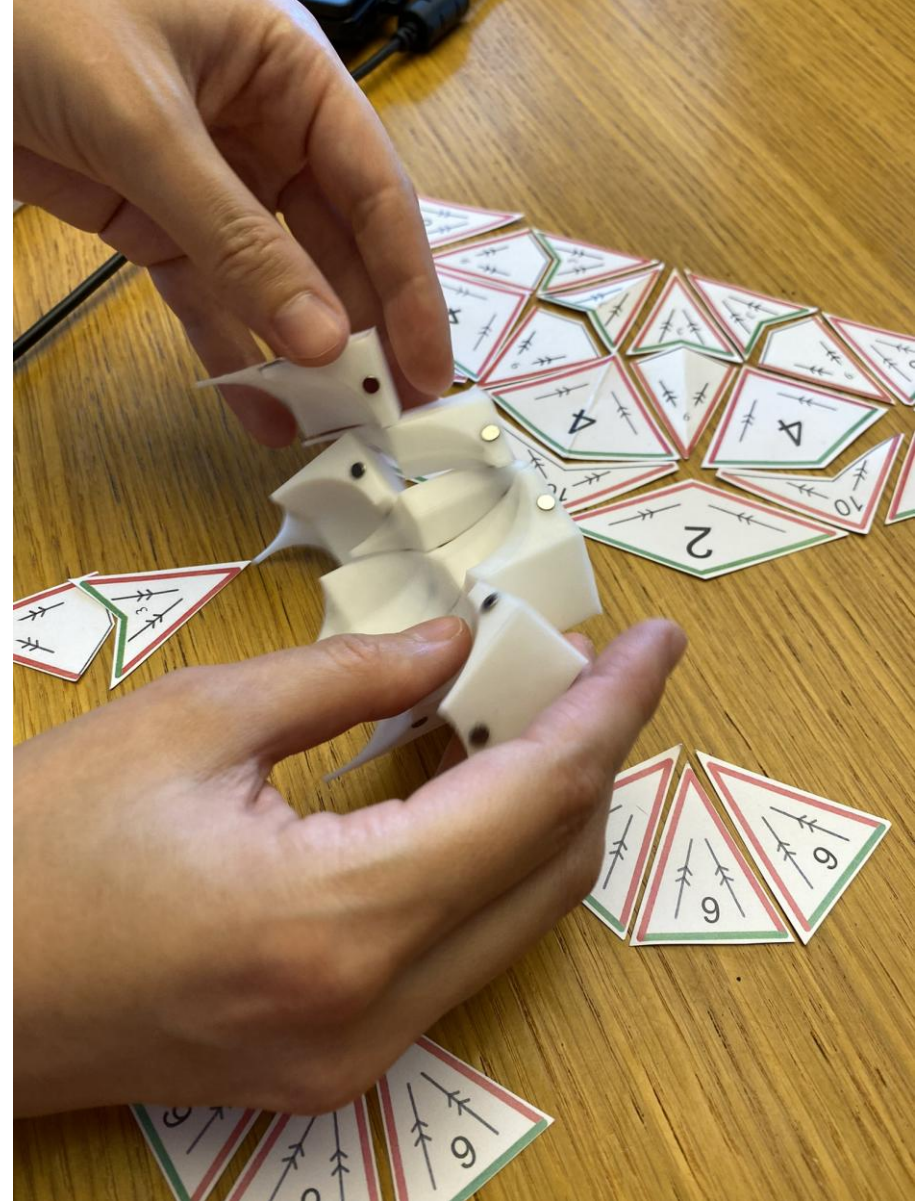
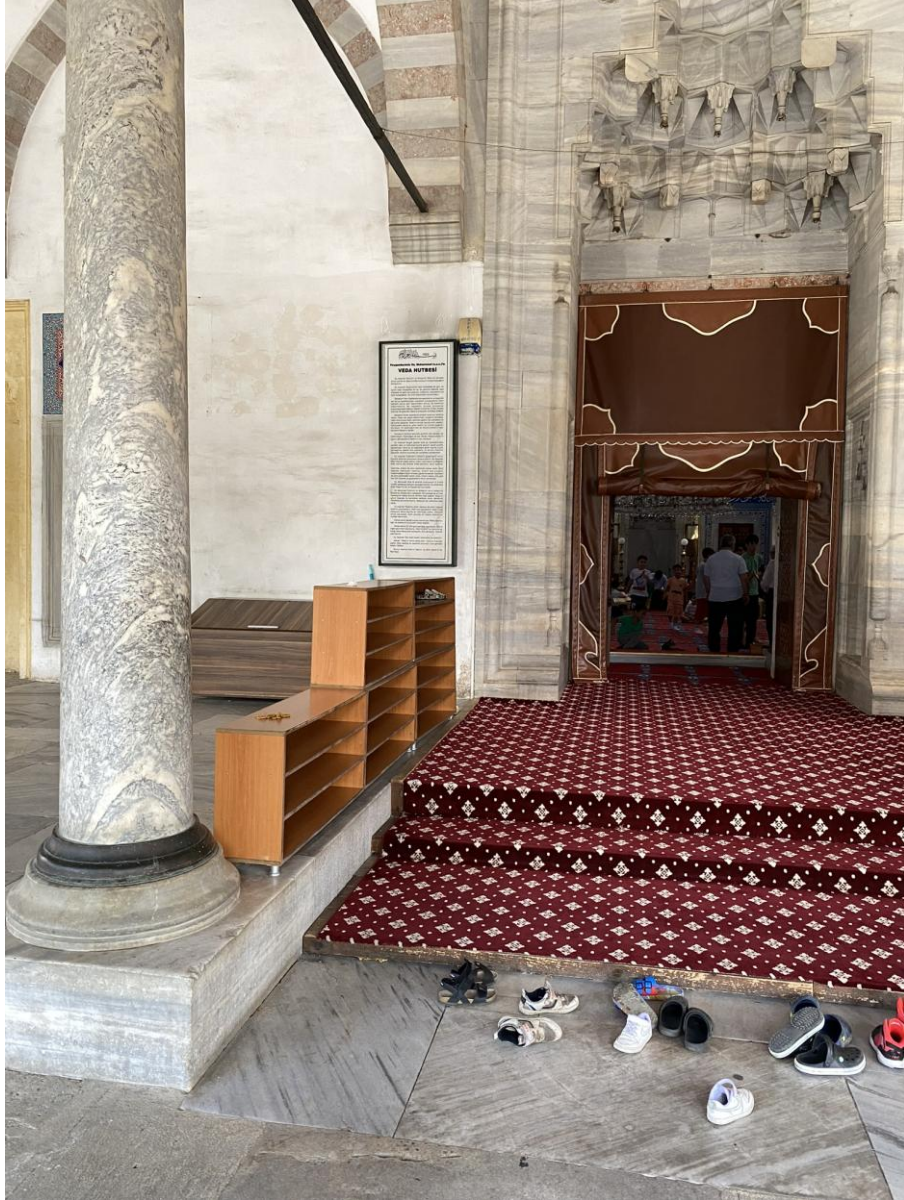


The Beauty of a Muqarnas

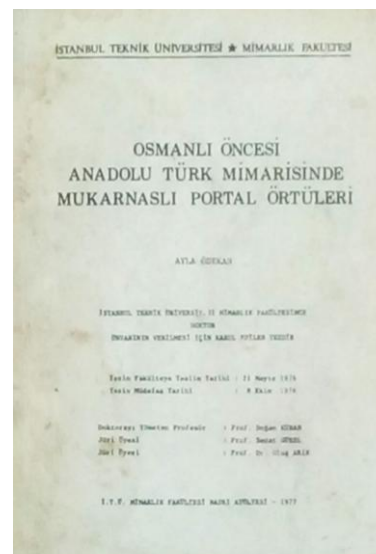
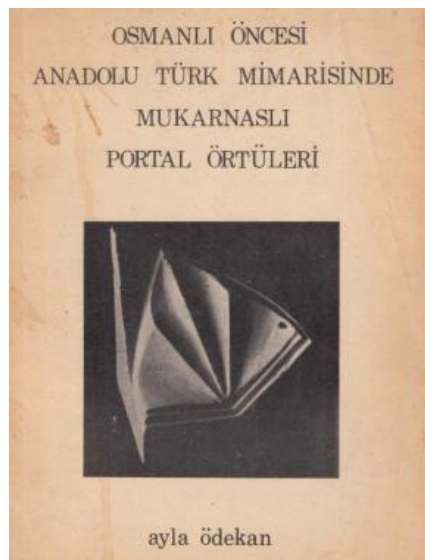
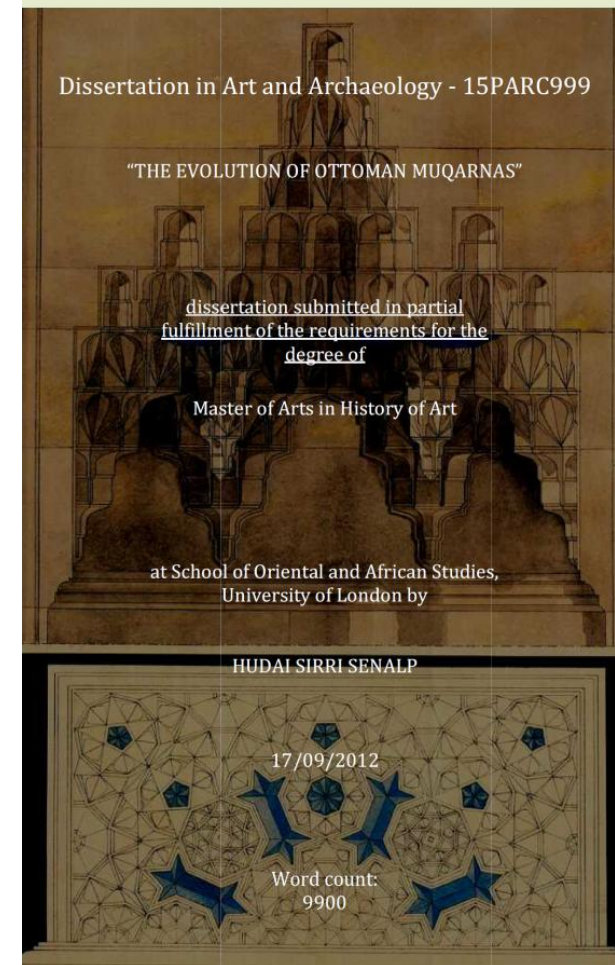
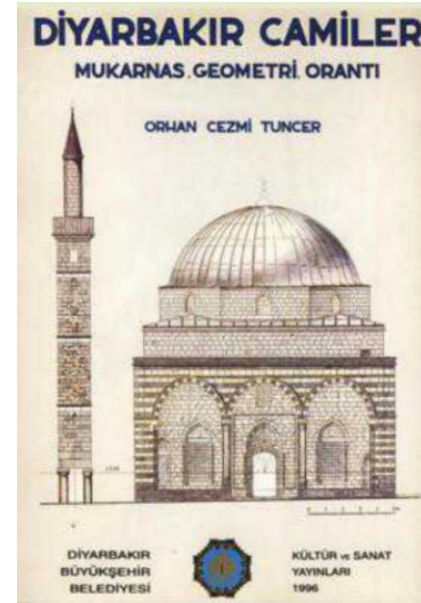
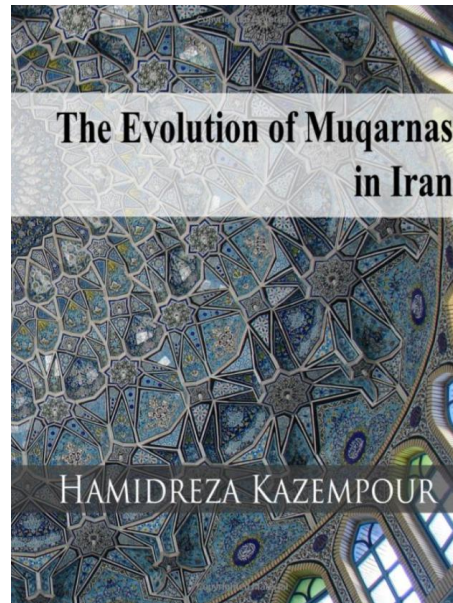
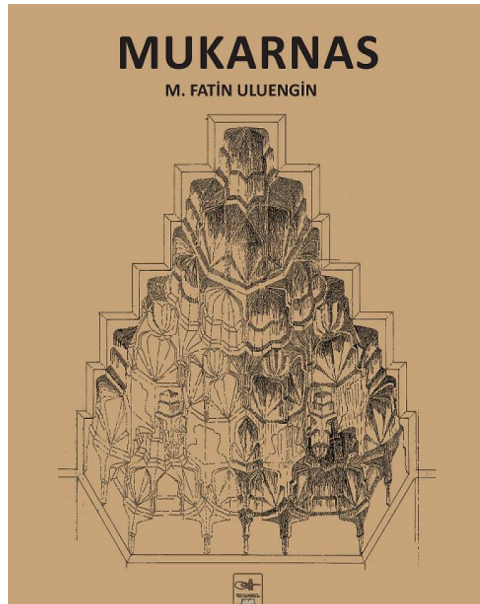


[www . henk hietbrink . nl / muqarnas](http://www.henk hietbrink . nl / muqarnas)

Istanbul Üsküdar Atik Valide Cami



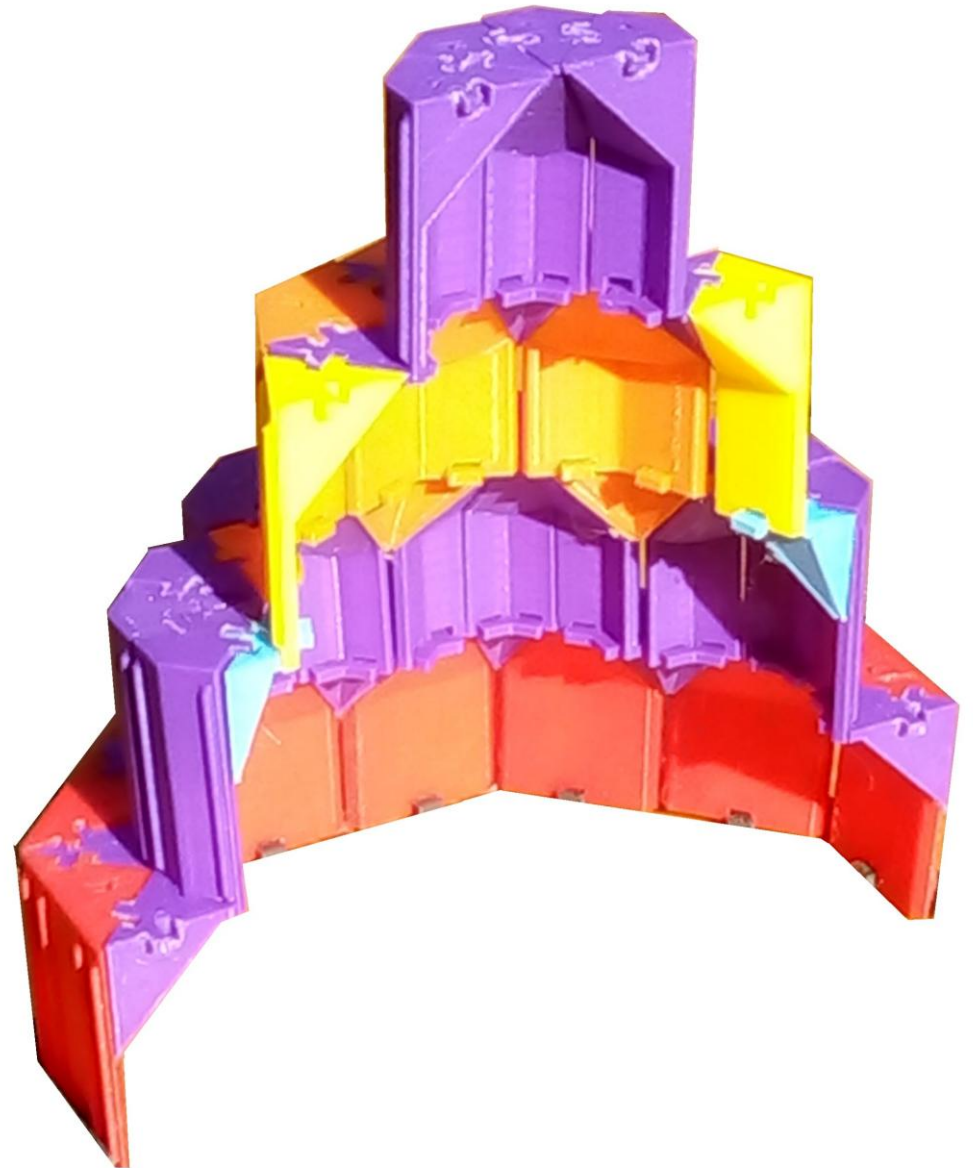
Study muqarnas: read a book



Click on a figure to open the corresponding webpage at www.henkietbrink.nl/muqarnas

Lego like units

Fun for children



Workshops in Istanbul

Fatih Sultan Mehmet Vakıf Üniversitesi
Prof. Dr. Fuat Sezgin İslam Bilim Tarihi
Enstitüsü



DESIGN A MUQARNAS YOURSELF

Atölye: Henk Hietbrink

Koordinatör: Nihal Fırat
Özdemir

Simultane Çeviri:
Rana Kahraman Duru
Rabia Odabaşı

28 Nisan Cuma

Saat 16.00

Yer: Prof. Dr. Fuat
Sezgin İslam Bilim
Tarihi Enstitüsü
Gülhane

Hemen kaydolun:
nozdemire@fsm.edu.tr



Click on a figure to open the corresponding webpage at www.henkhietbrink.nl/muqarnas

Workshops in the Netherlands

Foto: Jameh Moskee, Isfahan, Iran, schilderij: Joshe Lansdaal (2018), ontwerp: Tom Gons

NWD31

4 en 5 april 2025
Noordwijkerhout



aanmelden van 9-12 tot 6-1

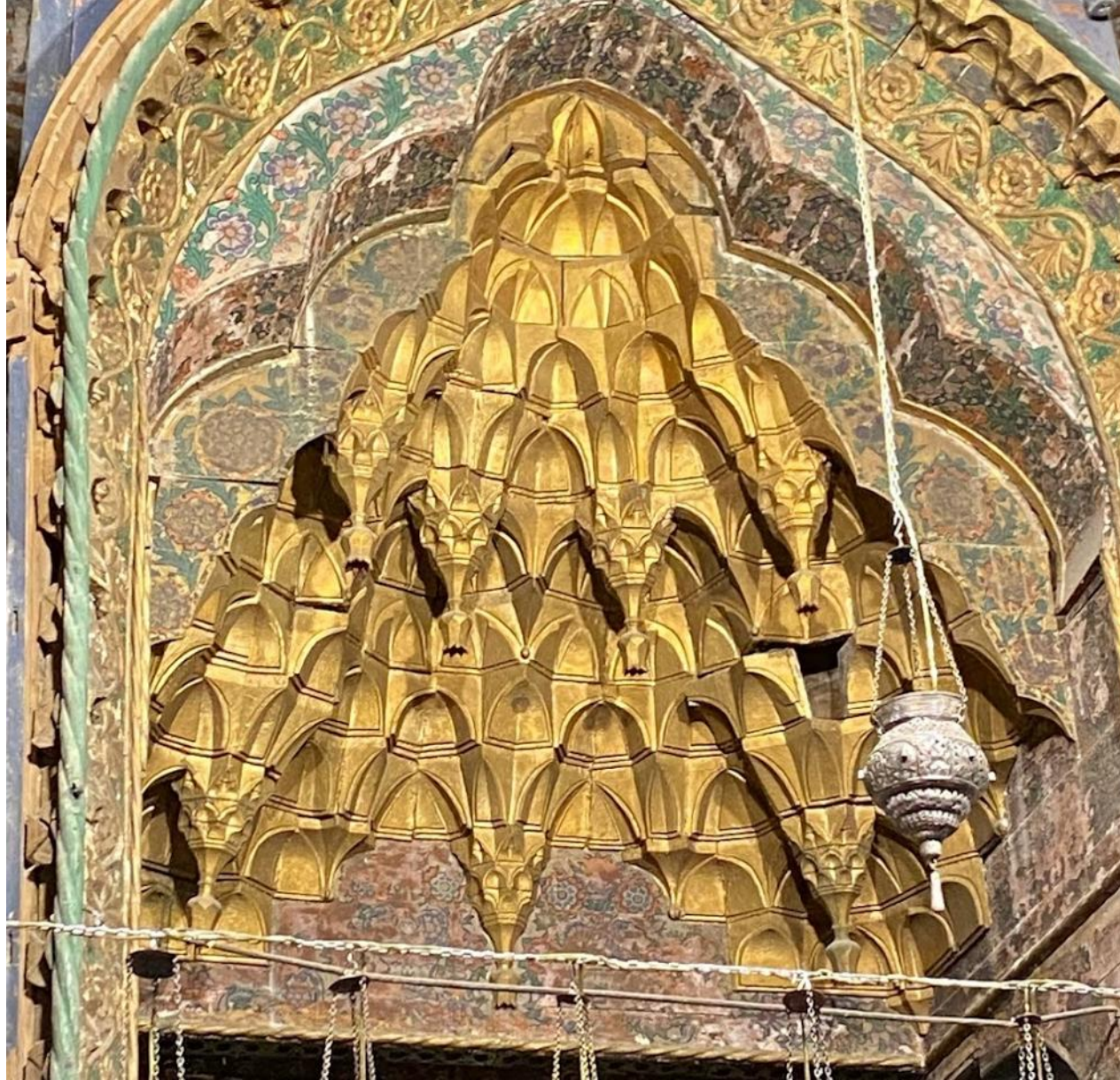
Workshops at a highschool

Sacha kept going

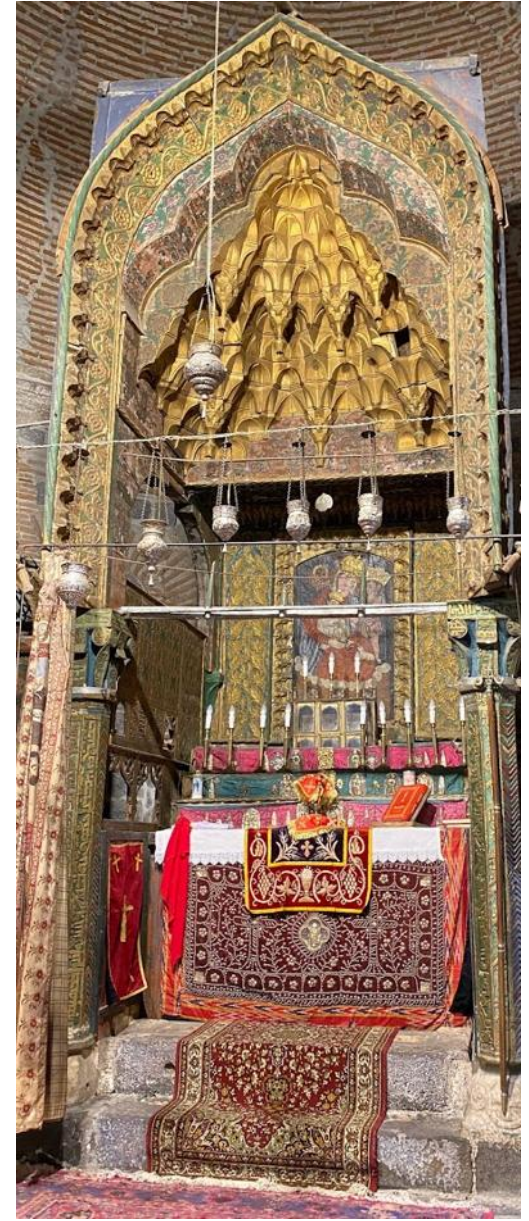
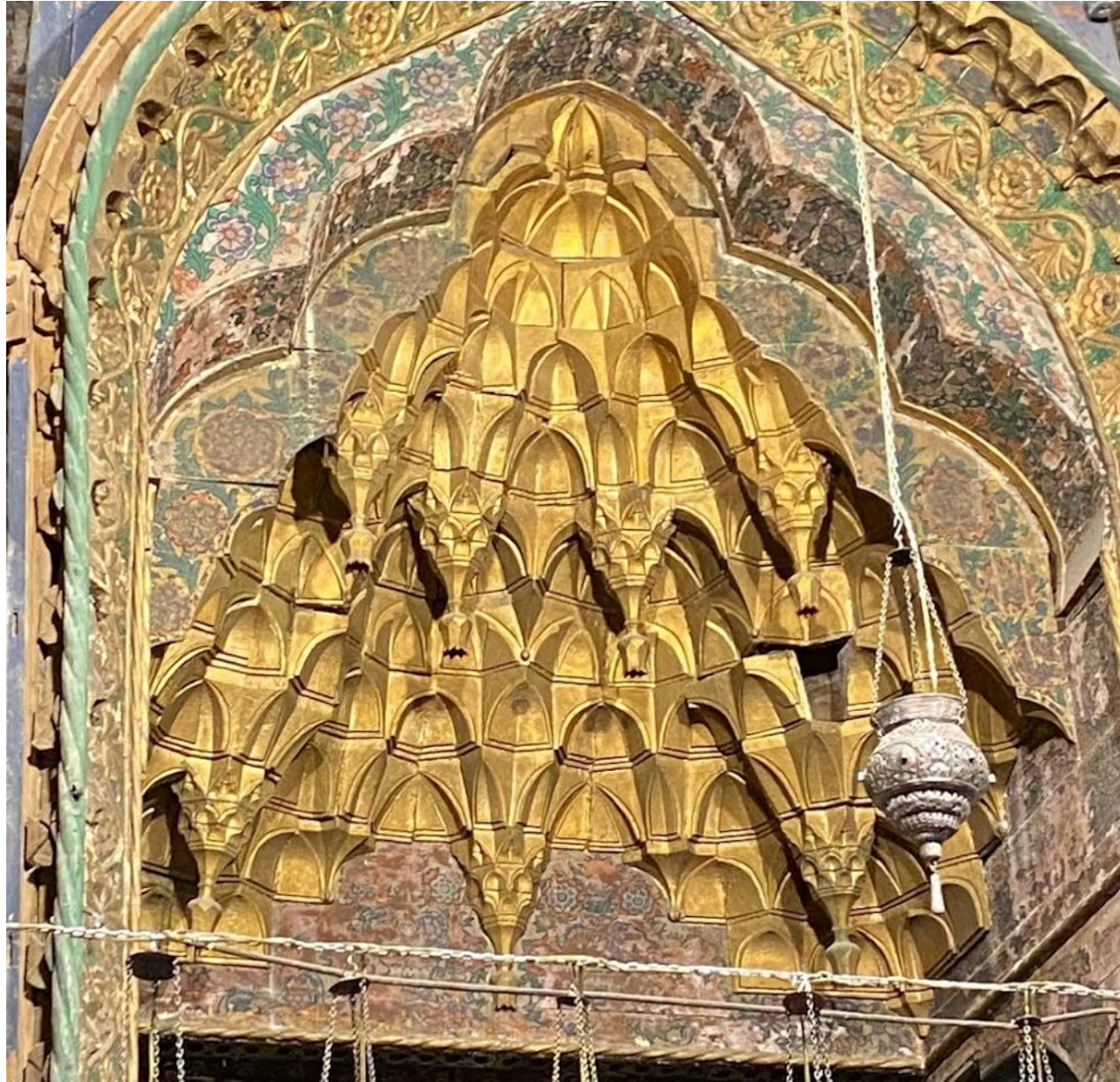


Click on a figure to open the corresponding webpage at www.henkhetbrink.nl/muqarnas

Surprising Muqarnas



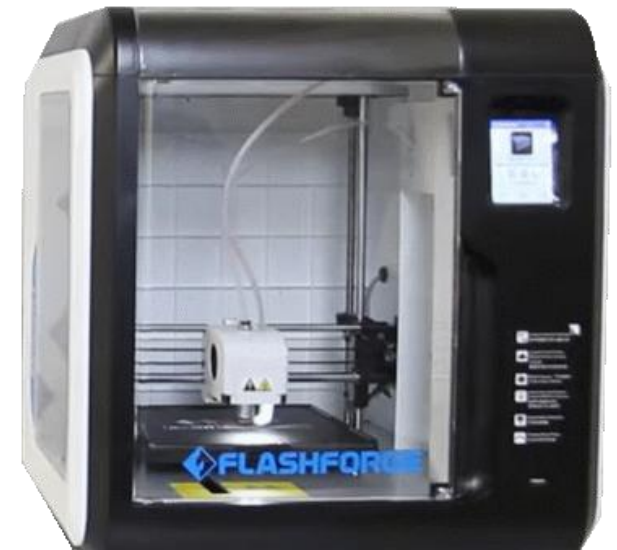
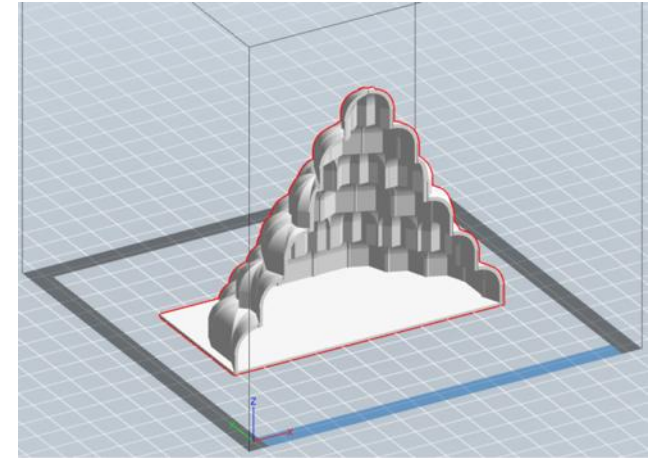
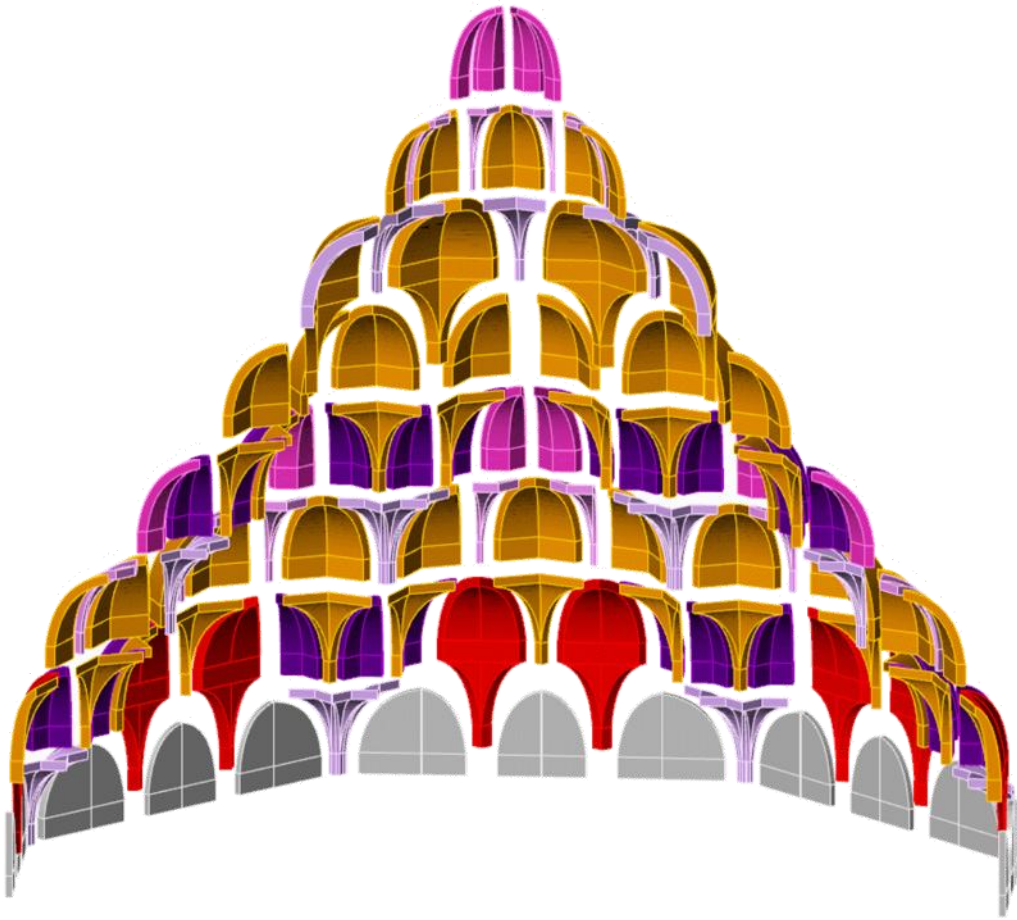
Welcome to St. Mary Church, Diyarbakır (a Syriac Orthodox church)



Welcome to Diyarbakır Behram Pasa (a Mimar Sinan mosque)



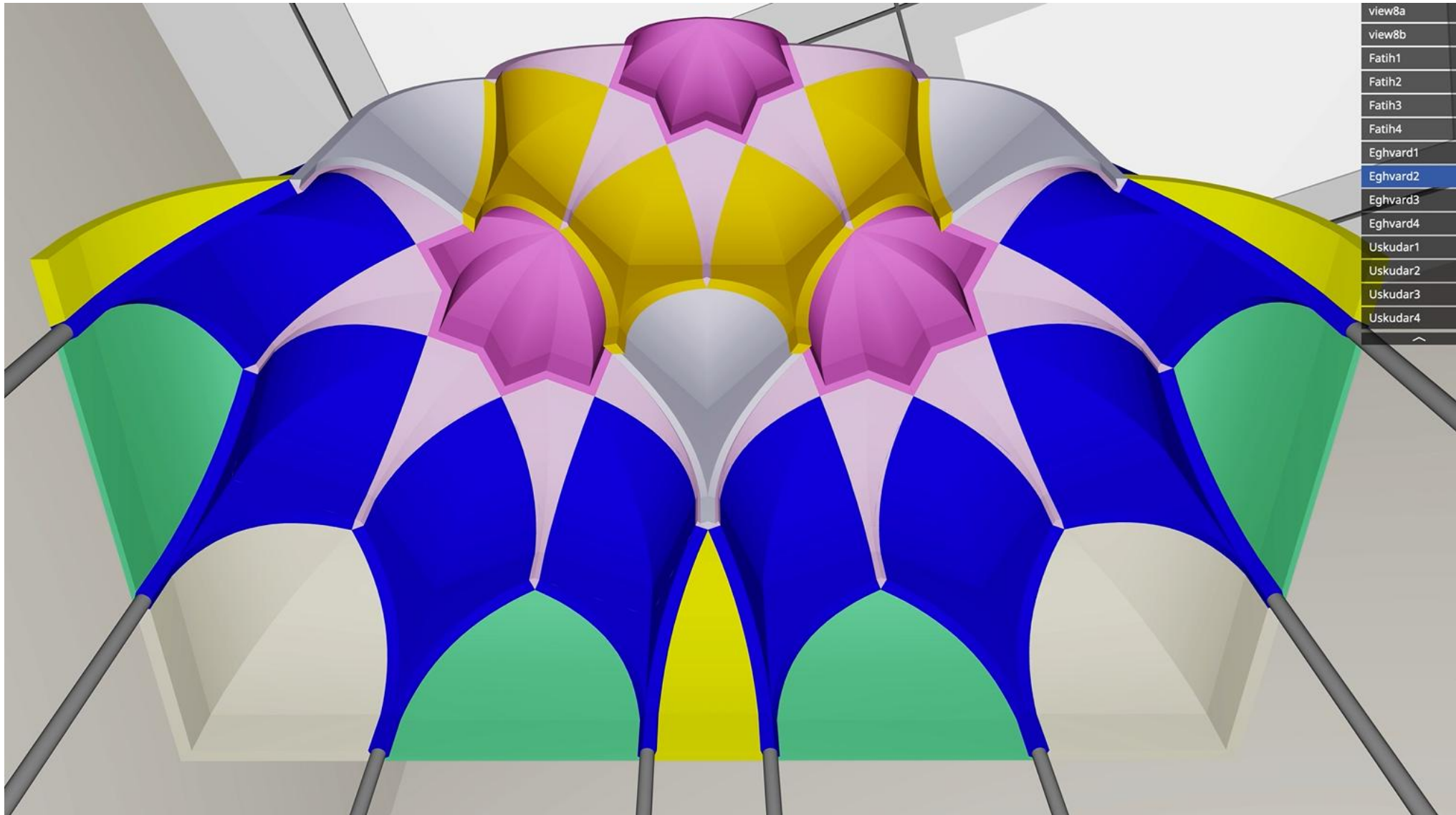
A visual interpreter



Click on a figure to open the corresponding webpage at www.henkhetbrink.nl/muqarnas

Parametric Design in Rhino Grasshopper

https://www.fransvanschooten.nl/muqarnas/museum_muqarnas.mov



Click on a figure to open the corresponding webpage at www.henkhetbrink.nl/muqarnas

An introduction to muqarnas

- **Discussion on Program**
- **Playful introduction**
- **Advanced course**
- **Questions and answers**

Henk Hietbrink

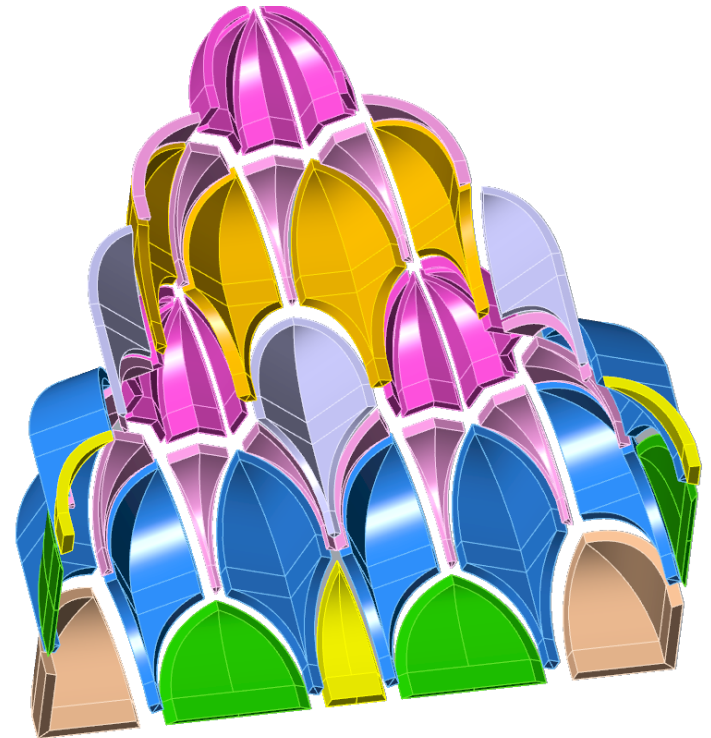
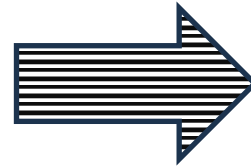
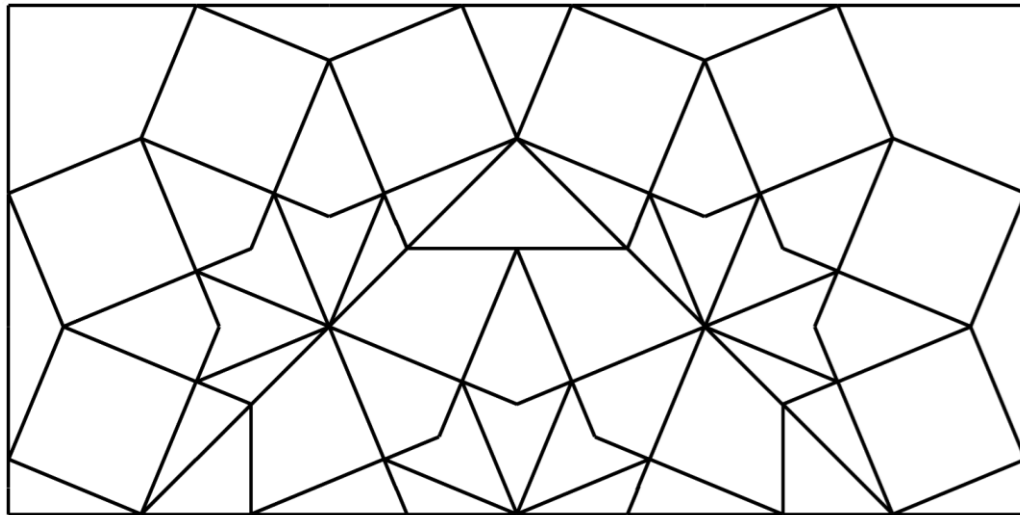
Fascination for muqarnas

- **Decorative art**
- **Symmetry and similarity**
- **Order and disorder**
- **Unity, multiplicity, and diversity**
- **Many styles, regional preferences**
- **Mathematicians stick to formal rules**
- **Artists break the rules**



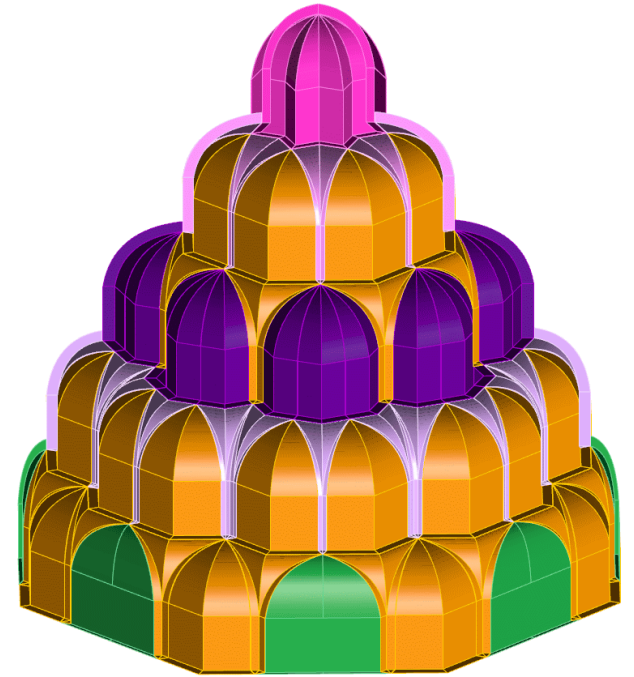
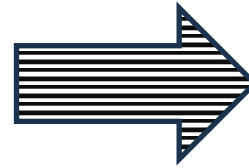
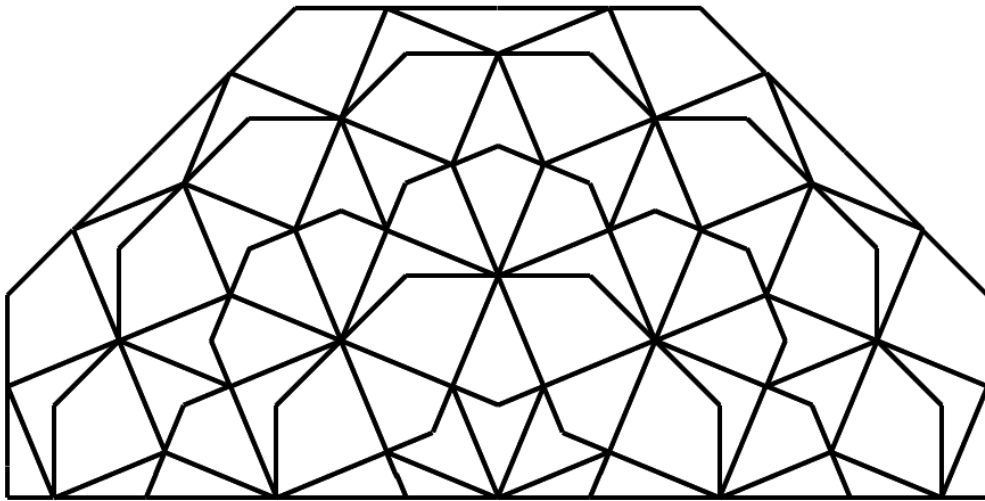
Understanding floor plans

**Can you elevate
a 2D tessellation plan
into 3D muqarnas ?**

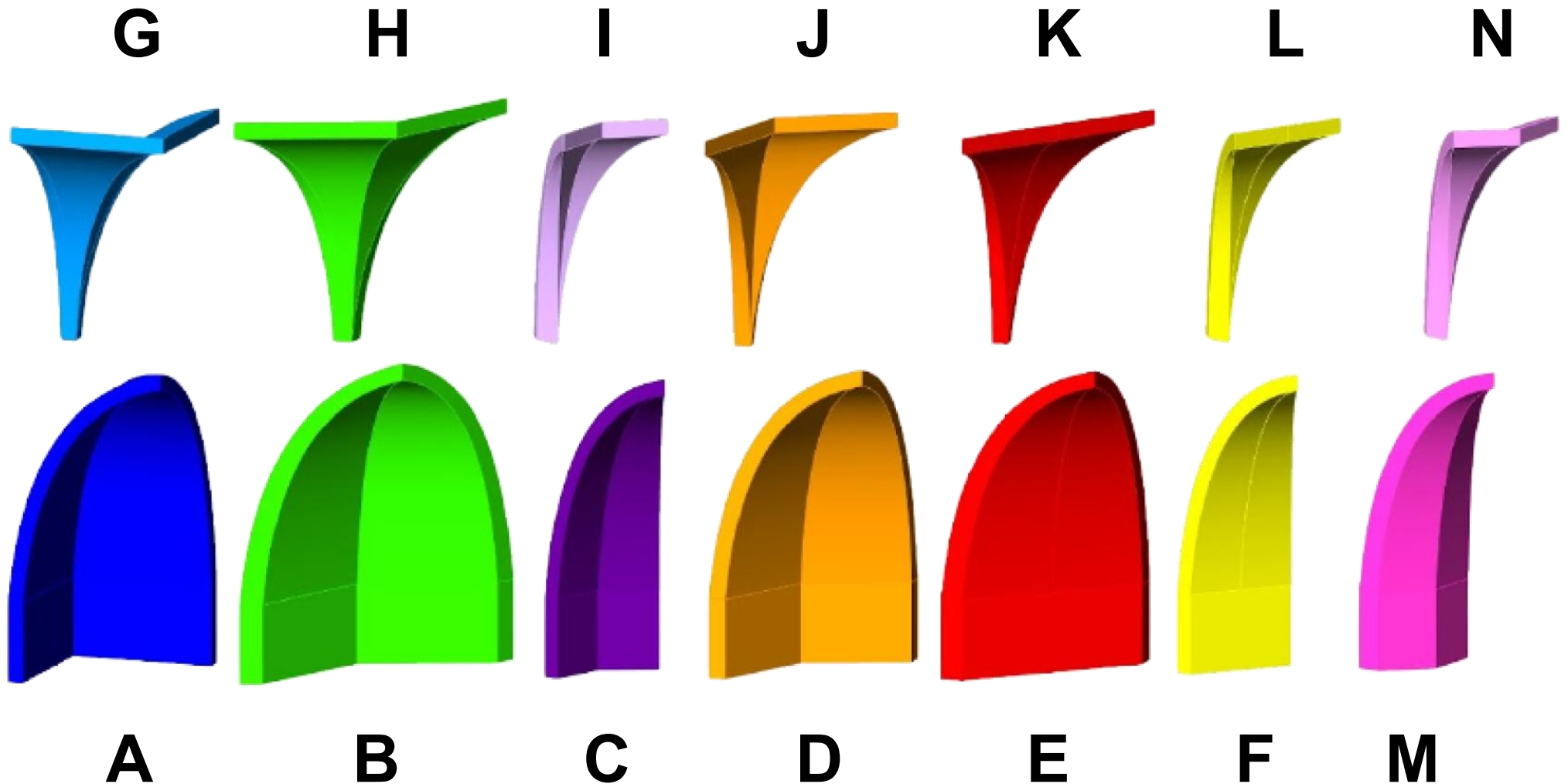


Understanding muqarnas

**Can you elevate
a 2D tessellation plan
into 3D muqarnas ?**



Predefined Units from A to Z (and even more)



Pre-defined Units

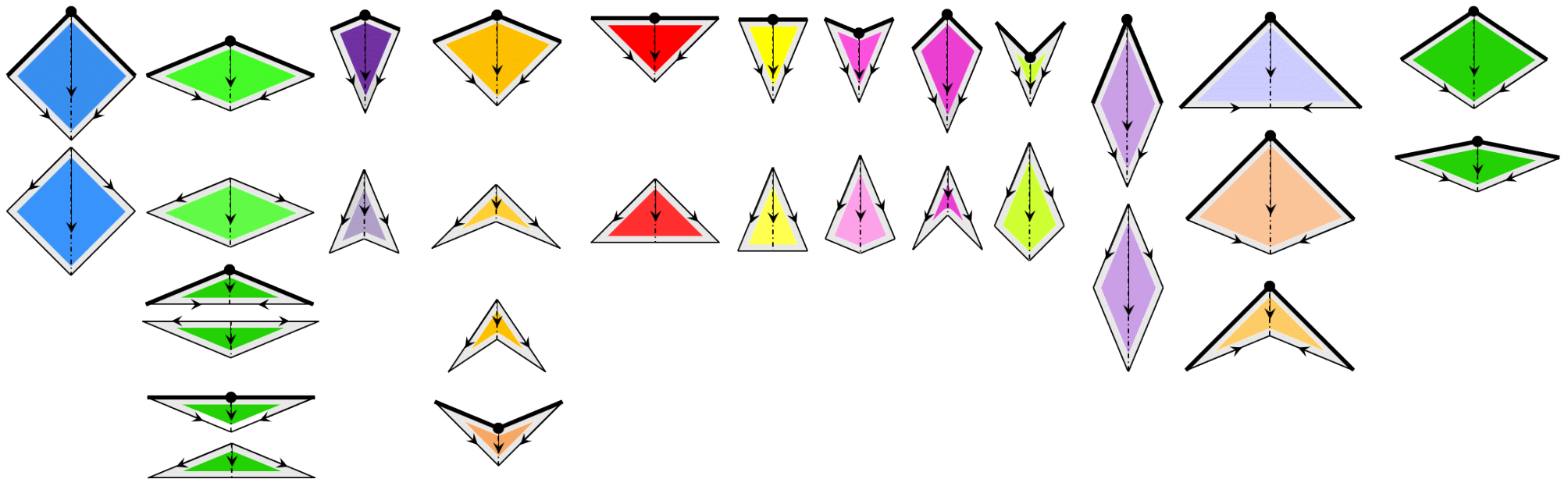


Table 1 of Pre defined Units

Is twelve enough? Yes we need M and N too

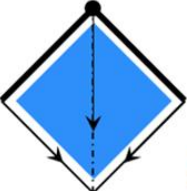
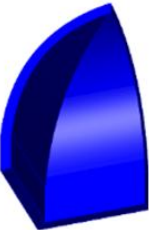
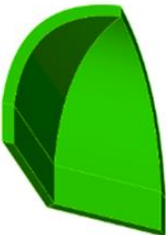
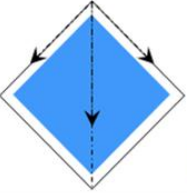
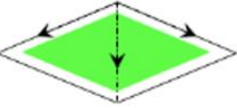
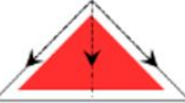
 A	 B	 C	 D	 E	 F	 M
						
						
 G	 H	 I	 J	 K	 L	 N

Table 2 of Pre defined Units

Write down all permutations

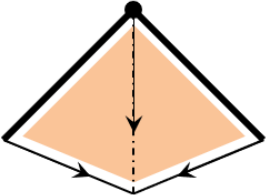
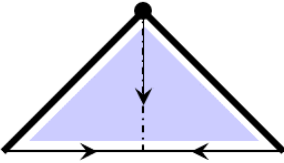
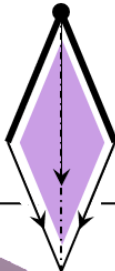
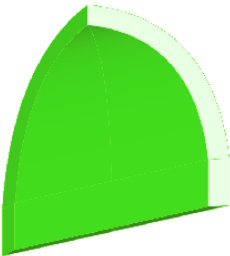
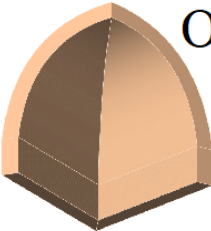
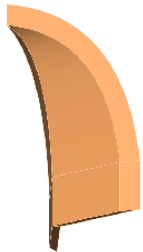
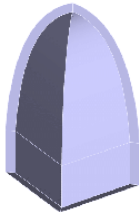
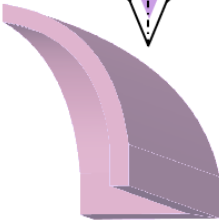
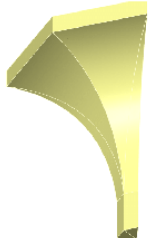
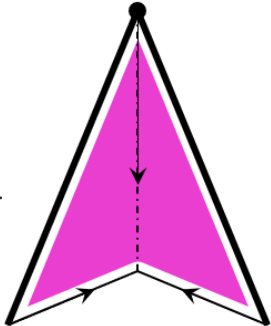
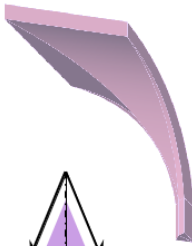
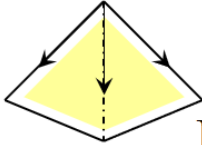
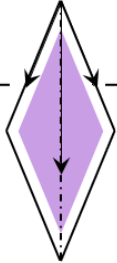
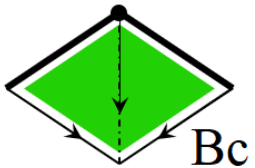
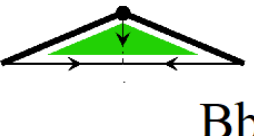
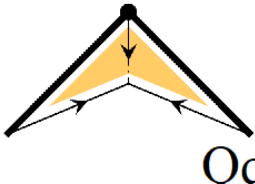
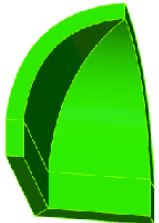
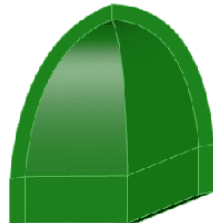
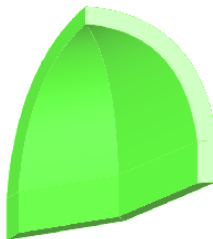
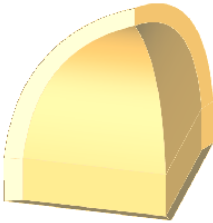
 Rr	 O	 O	 Q	 R	 T	 V
	 Oo		 Q			
			 Qn			
 Ss	 Jj	 P		 S	 U	 W

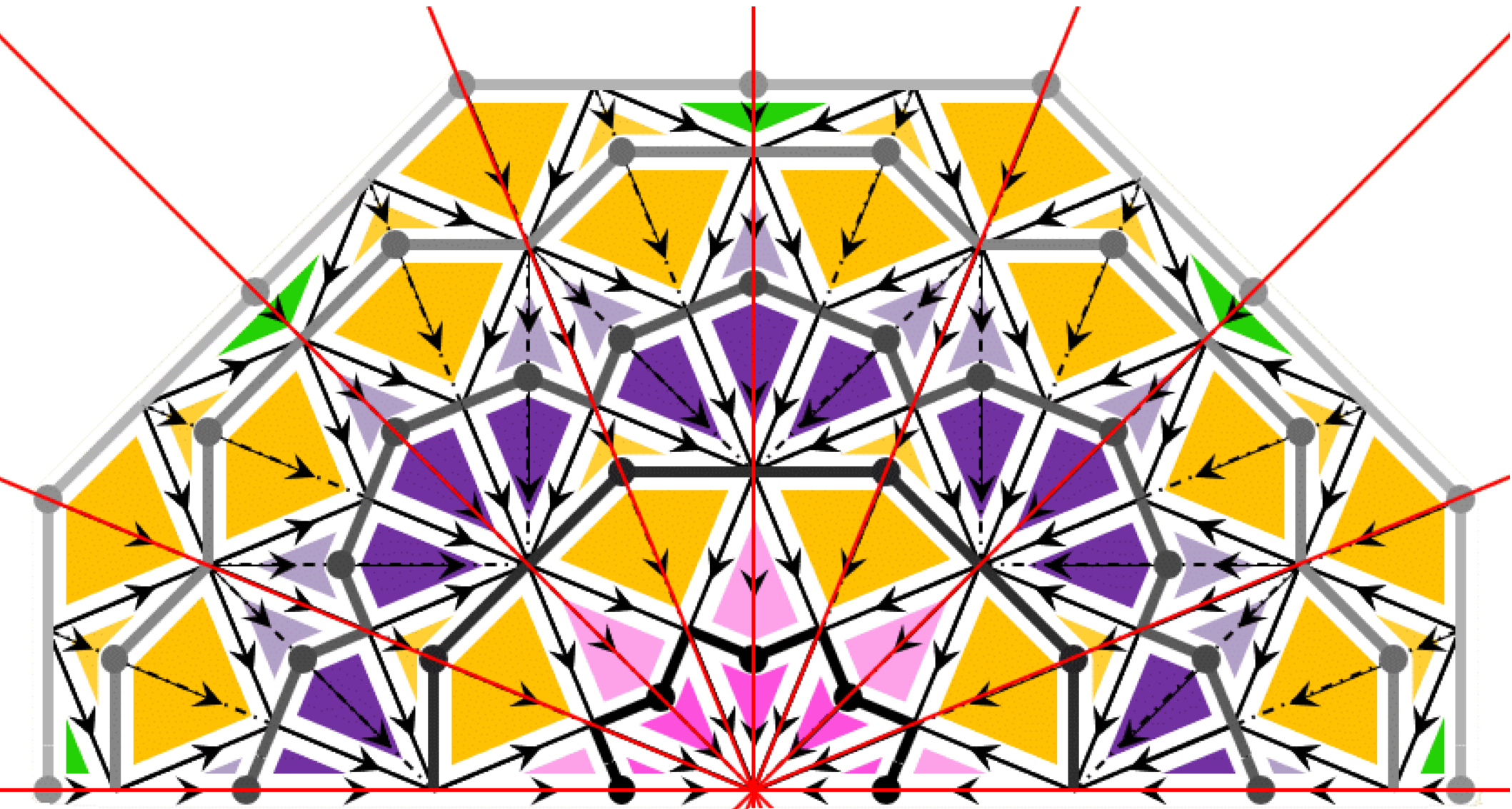
Table 3 of Pre defined Units

Parametric design: front angle, back angle

 Bc	 Bb	 Rb	 Qq			
						

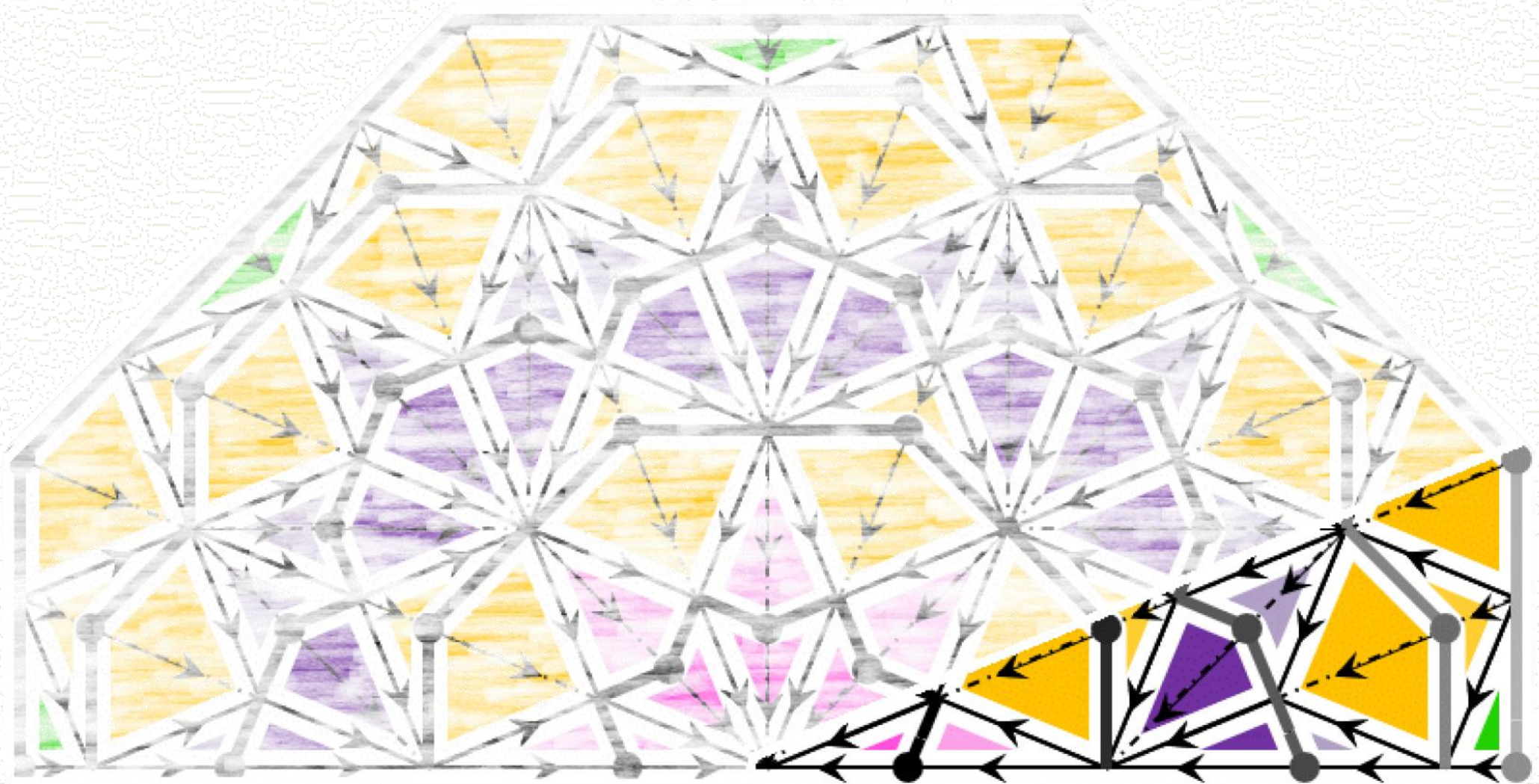
Example: Fatih, Istanbul

Muqarnas with a lot of symmetry



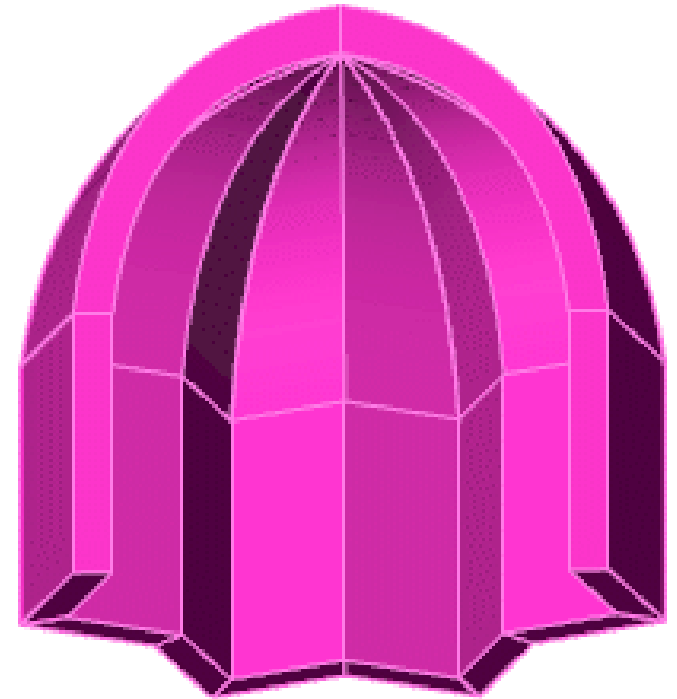
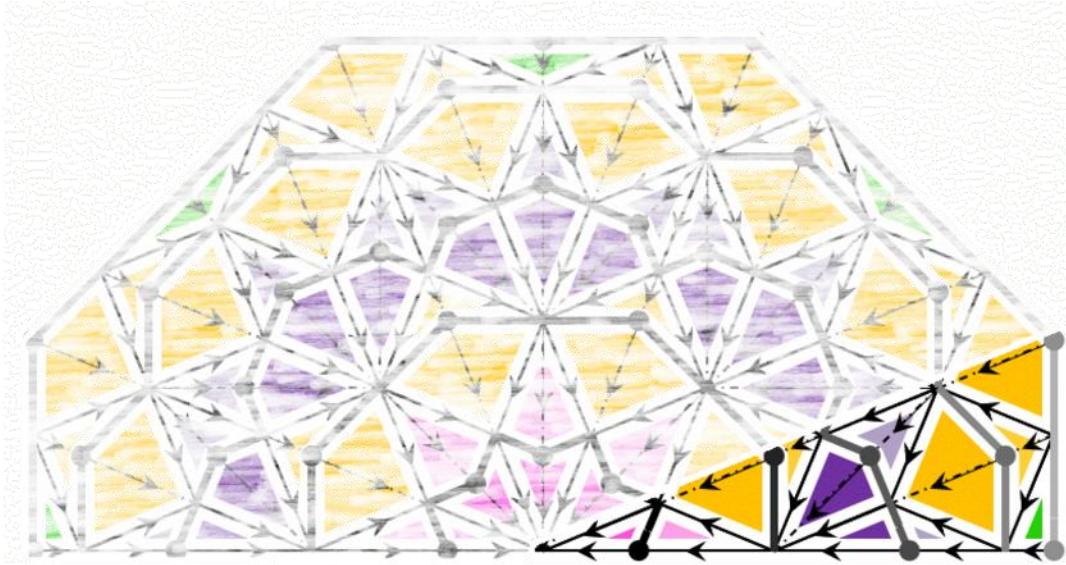
Click on a figure to open the corresponding webpage at www.henkietbrink.nl/muqarnas

Code single segment in Excel Interpreter does the reflection



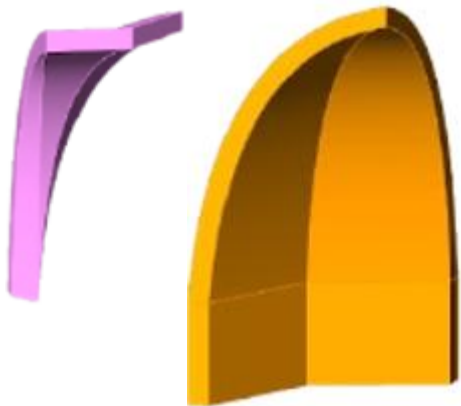
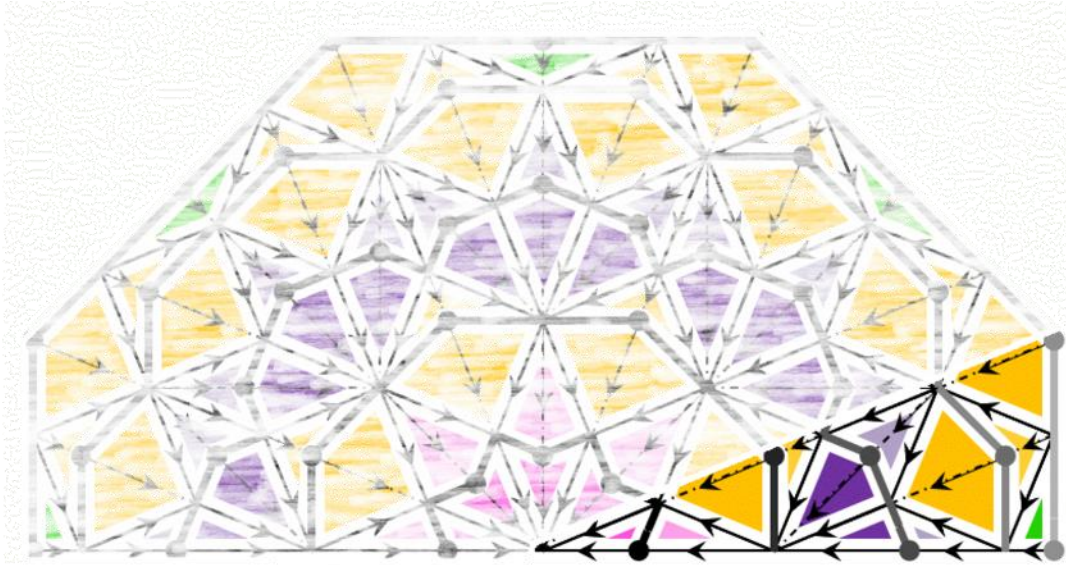
Click on a figure to open the corresponding webpage at www.henkhetbrink.nl/muqarnas

Step one: top layer pink M

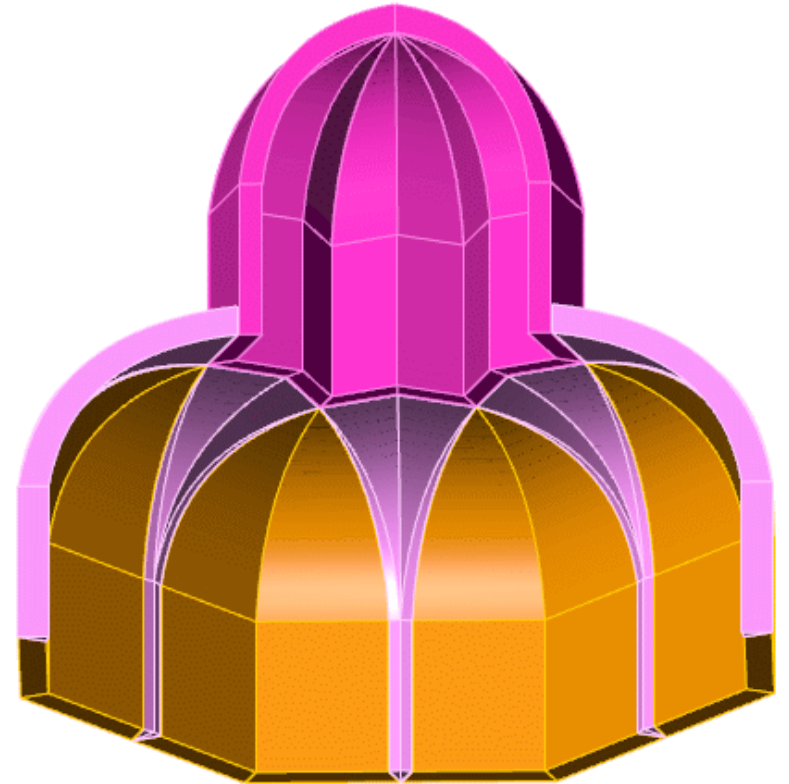


	A
1	Fatih Istanbul
4	M_left

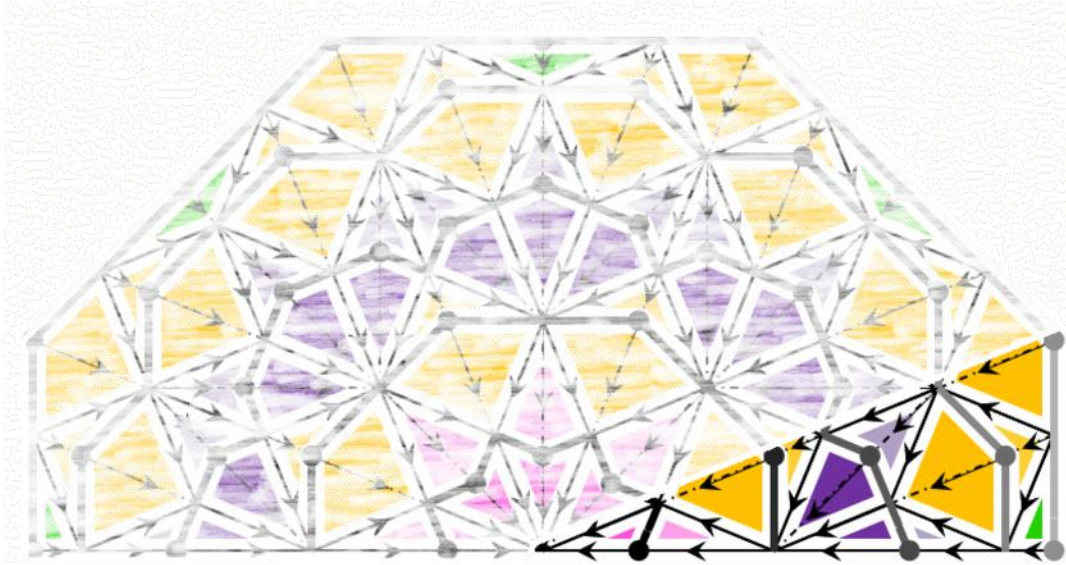
Step two: second layer from top pink N , orange D



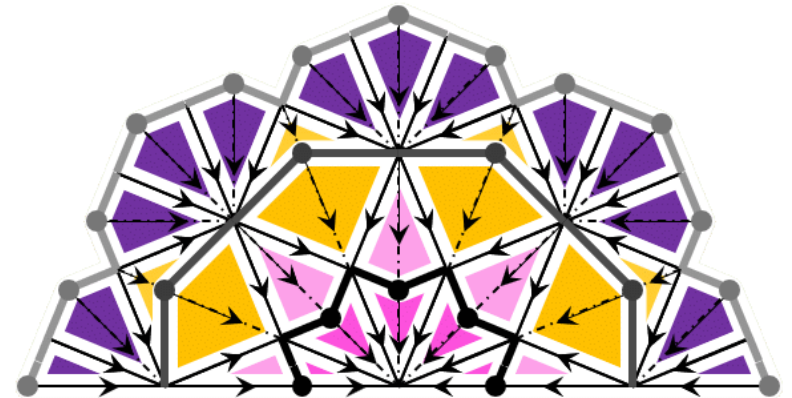
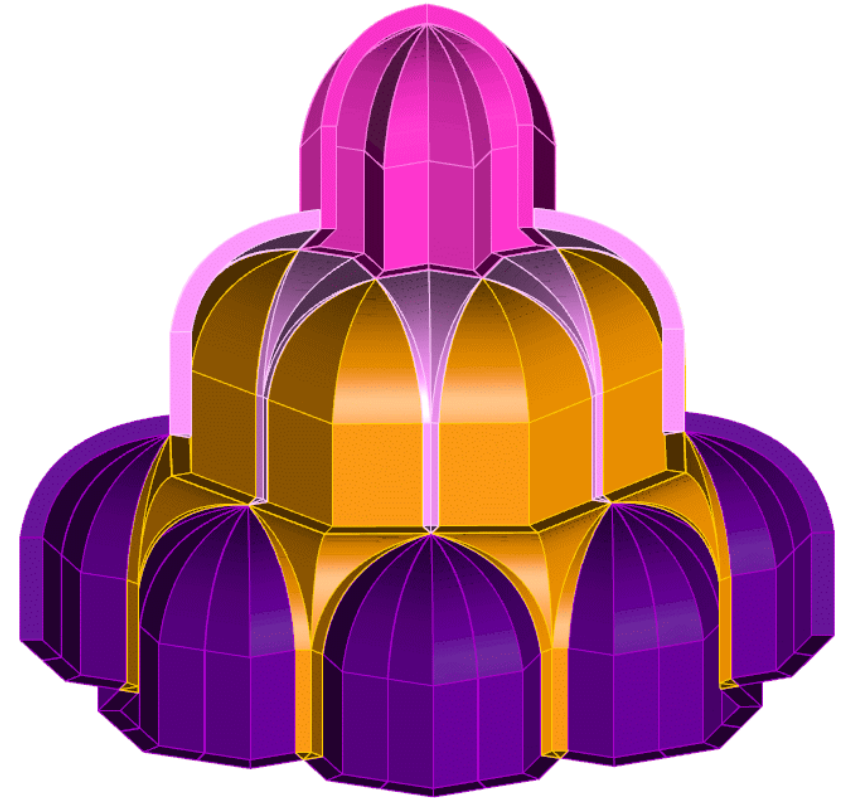
	A
1	Fatih Istanbul
4	M_left
5	N_left D_right



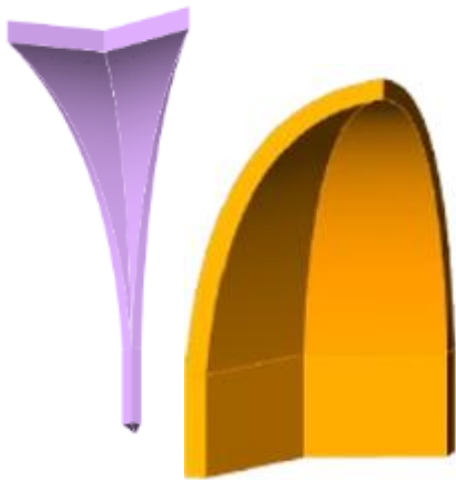
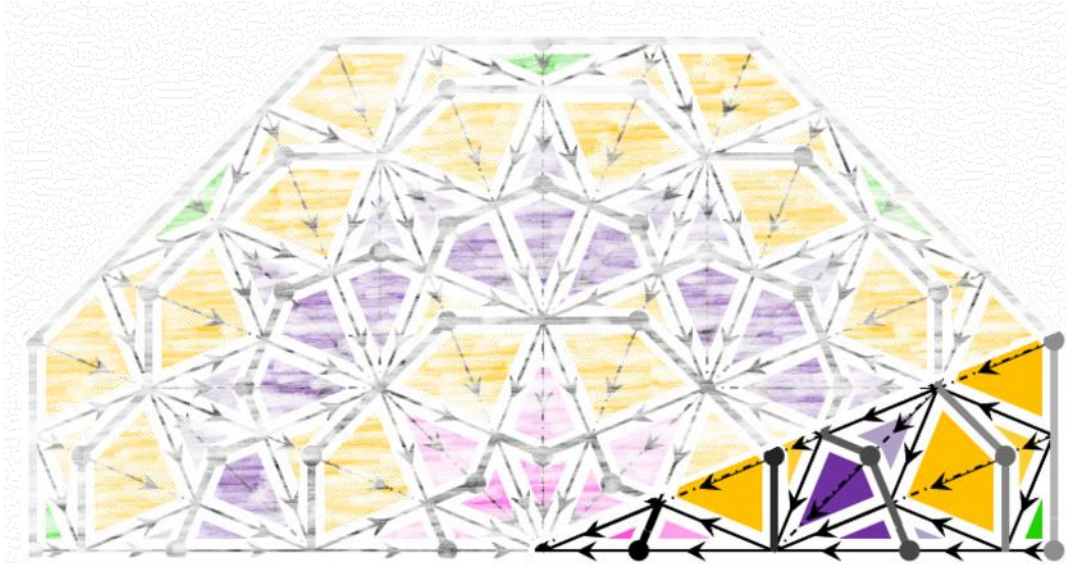
Step three: third layer from top purple C , orange J



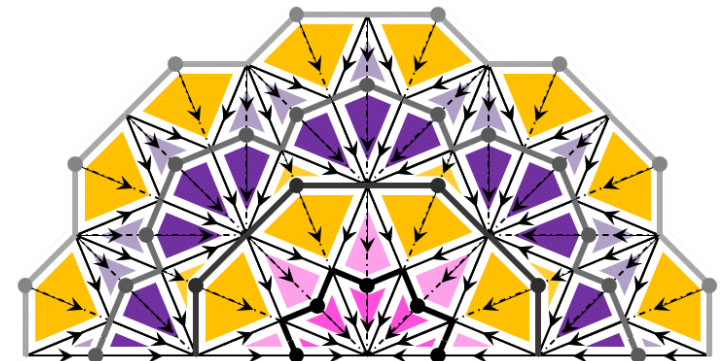
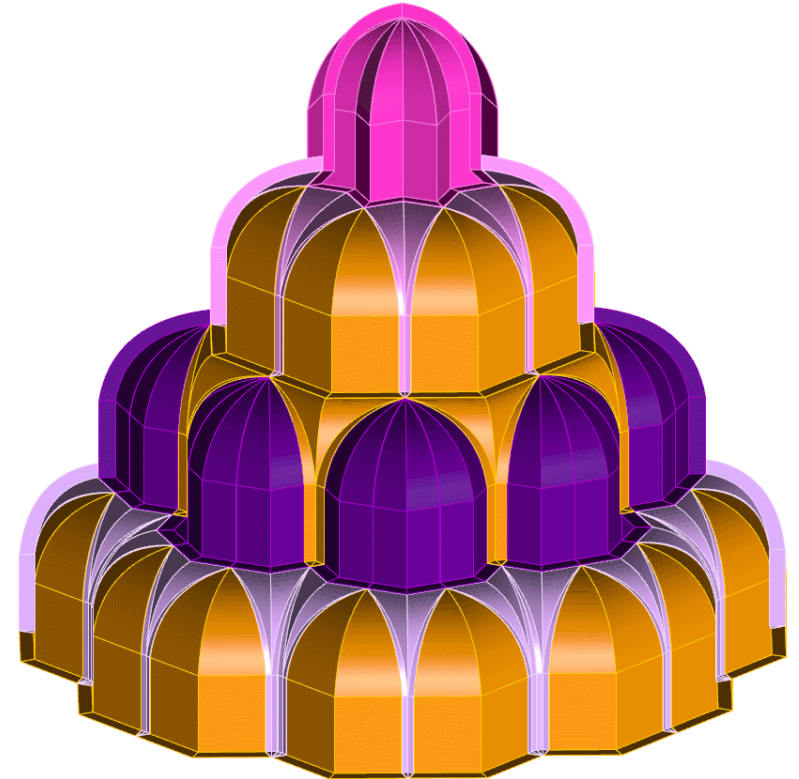
A	
1	Fatih Istanbul
4	M_left
5	N_left D_right
6	C_left C J_right



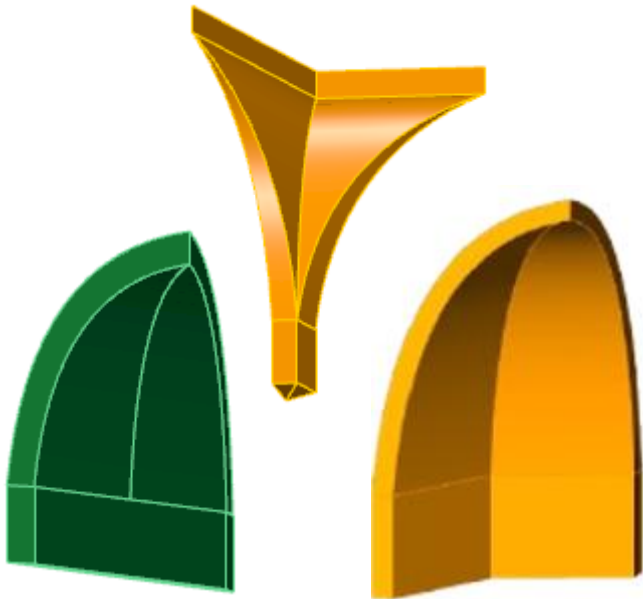
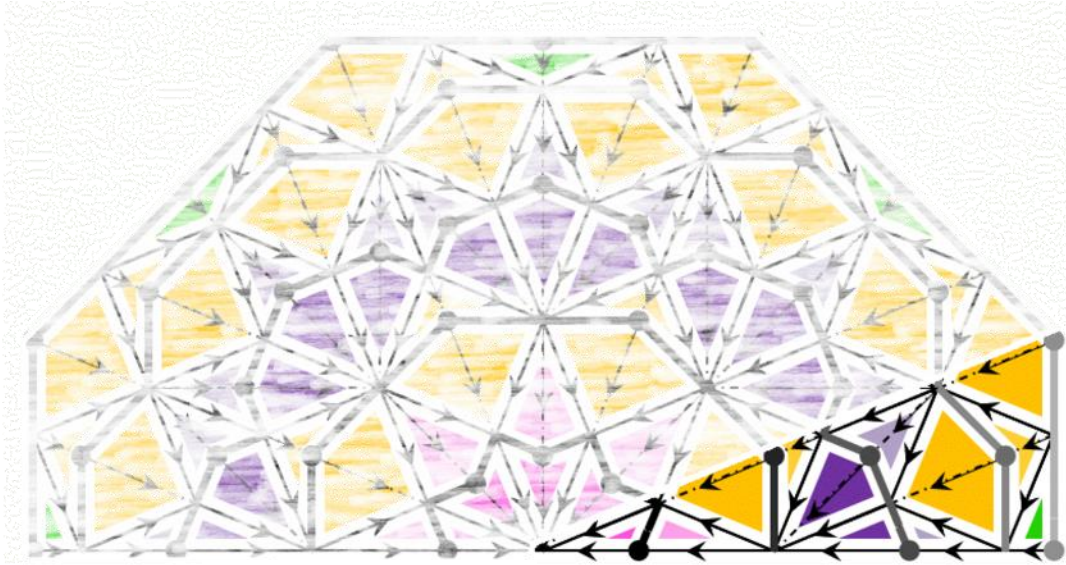
Step four: second layer from bottom purple I , orange D



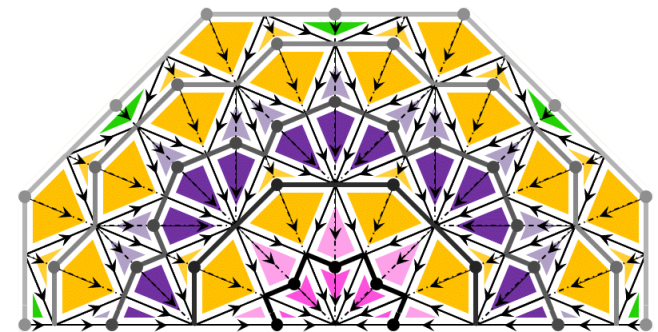
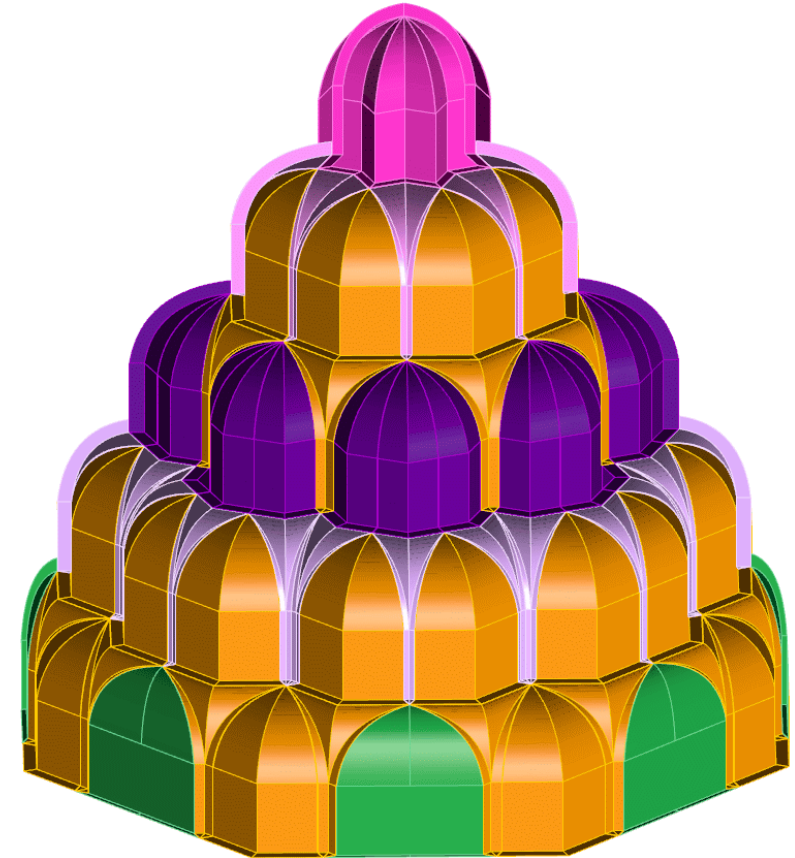
	A
1	Fatih Istanbul
4	M_left
5	N_left D_right
6	C_left C_right
7	I_left D I



Step five: third layer from top green Rr , orange J , orange D

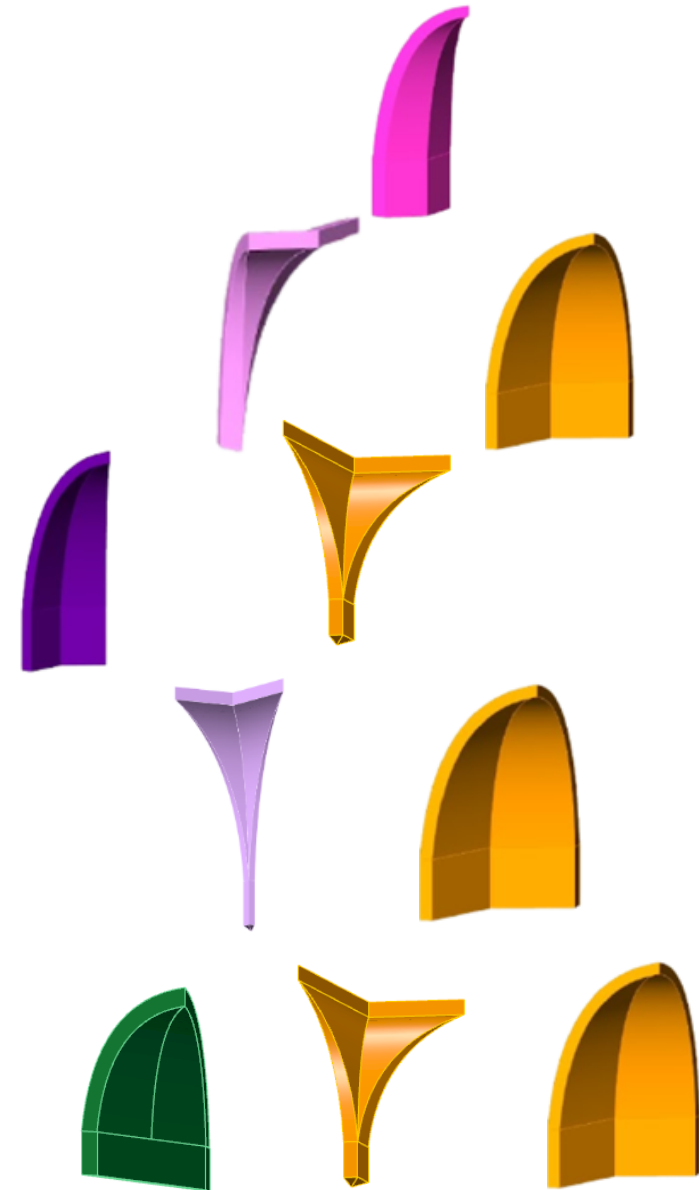


4	M_left
5	N_left D_right
6	C_left C J_right
7	I_left D I
8	Rr_left J D_right

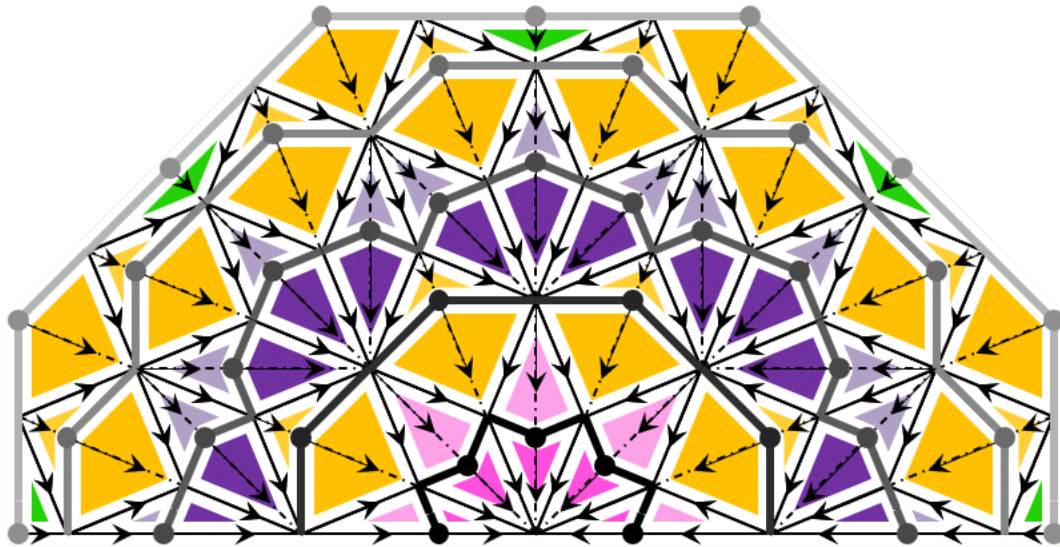


Input into Excel

4	M_left
5	N_left D_right
6	C_left C J_right
7	I_left D I
8	Rr_left J D_right



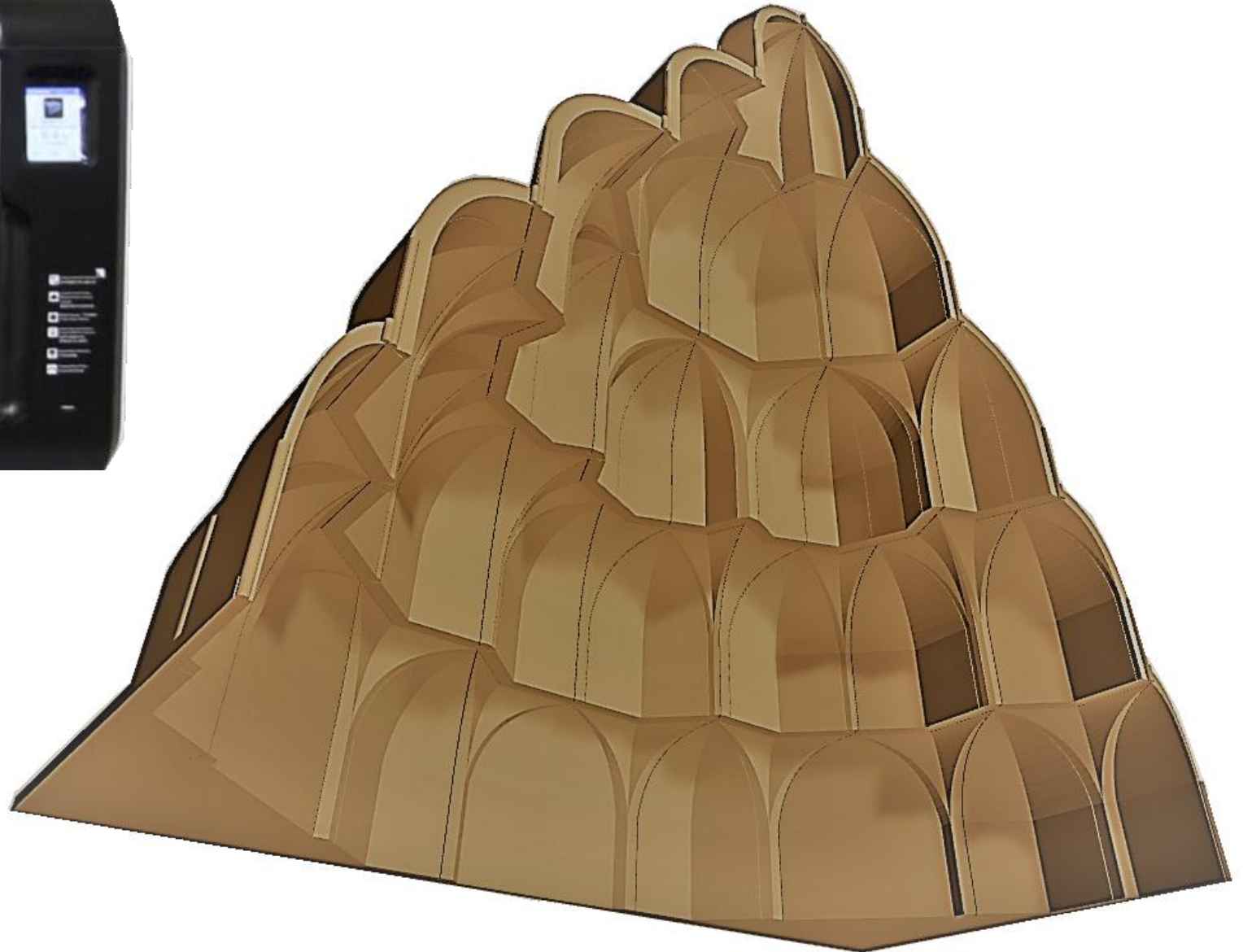
Output of Excel → 2D floorplan → CSV for Rhino/Grasshopper



```
1 Z2_{16-2};Z;Full;4.720777;0.809957;0;0.35;1.4;180;2;0.707107;0.35;1.05;0;0;16;Diyarbakir Melek Ahmet
2 Z1_{16-3};Z;Full;4.720777;0.809957;0;0.35;1.4;180;1;1;0.35;1.05;0;0;16;
3 I_{16-5};I;Intermediate;4.720777;1.95541;0;0.35;1.4;-202.5;0;1.145452;0.35;1.05;0;0;16;
4 I_{16-6};I;Intermediate;4.720777;1.95541;0;0.35;1.4;-247.5;0;1.145452;0.35;1.05;0;0;16;
5 I_{16-7};I;Intermediate;4.720777;1.95541;0;0.35;1.4;-292.5;0;1.145452;0.35;1.05;0;0;16;
6 Z2_{16-9};Z;Full;3.910819;2.765367;0;0.35;1.4;-135;2;1;0.35;1.05;0;0;16;
7 Z1_{16-10};Z;Full;3.910819;2.765367;0;0.35;1.4;-135;1;0.707107;0.35;1.05;0;0;16;
8 Z2_{16-11};Z;Full;2.765367;3.910819;0;0.35;1.4;-135;2;0.707107;0.35;1.05;0;0;16;
9 Z1_{16-12};Z;Full;2.765367;3.910819;0;0.35;1.4;-135;1;1;0.35;1.05;0;0;16;
10 I_{16-14};I;Intermediate;1.95541;4.720777;0;0.35;1.4;-157.5;0;1.145452;0.35;1.05;0;0;16;
11 I_{16-15};I;Intermediate;1.95541;4.720777;0;0.35;1.4;-202.5;0;1.145452;0.35;1.05;0;0;16;
12 I_{16-16};I;Intermediate;1.95541;4.720777;0;0.35;1.4;-247.5;0;1.145452;0.35;1.05;0;0;16;
13 Z2_{16-18};Z;Full;0.809957;4.720777;0;0.35;1.4;-90;2;1;0.35;1.05;0;0;16;
14 Z1_{16-19};Z;Full;0.809957;4.720777;0;0.35;1.4;-90;1;0.707107;0.35;1.05;0;0;16;
15 Z2_{16-20};Z;Full;-0.809957;4.720777;0;0.35;1.4;-90;2;0.707107;0.35;1.05;0;0;16;
16 Z1_{16-21};Z;Full;-0.809957;4.720777;0;0.35;1.4;-90;1;1;0.35;1.05;0;0;16;
17 I_{16-23};I;Intermediate;-1.95541;4.720777;0;0.35;1.4;-112.5;0;1.145452;0.35;1.05;0;0;16;
18 I_{16-24};I;Intermediate;-1.95541;4.720777;0;0.35;1.4;-157.5;0;1.145452;0.35;1.05;0;0;16;
19 I_{16-25};I;Intermediate;-1.95541;4.720777;0;0.35;1.4;-202.5;0;1.145452;0.35;1.05;0;0;16;
20 Z2_{16-27};Z;Full;-2.765367;3.910819;0;0.35;1.4;-45;2;1;0.35;1.05;0;0;16;
21 Z1_{16-28};Z;Full;-2.765367;3.910819;0;0.35;1.4;-45;1;0.707107;0.35;1.05;0;0;16;
22 Z2_{16-29};Z;Full;-3.910819;2.765367;0;0.35;1.4;-45;2;0.707107;0.35;1.05;0;0;16;
23 Z1_{16-30};Z;Full;-3.910819;2.765367;0;0.35;1.4;-45;1;1;0.35;1.05;0;0;16;
24 I_{16-32};I;Intermediate;-4.720777;1.95541;0;0.35;1.4;-67.5;0;1.145452;0.35;1.05;0;0;16;
25 I_{16-33};I;Intermediate;-4.720777;1.95541;0;0.35;1.4;-112.5;0;1.145452;0.35;1.05;0;0;16;
26 I_{16-34};I;Intermediate;-4.720777;1.95541;0;0.35;1.4;-157.5;0;1.145452;0.35;1.05;0;0;16;
27 Z2_{16-36};Z;Full;-4.720777;0.809957;0;0.35;1.4;0;2;1;0.35;1.05;0;0;16;
28 Z1_{16-37};Z;Full;-4.720777;0.809957;0;0.35;1.4;0;1;0.707107;0.35;1.05;0;0;16;
29 E_{15-0};E;Full;4.720777;0;1.4;1.75;2.8;292.5;1;1.145452;0.35;1.05;-1.4;15;
30 C_{15-1};C;Full;4.385281;1.145452;1.4;1.75;2.8;337.5;0;1.145452;0.35;1.05;0;0;15;
31 J_{15-2};J;Intermediate;3.910819;1.145452;1.4;1.75;2.8;135;0;1.145452;0.35;1.05;0;0;15;
32 C_{15-3};C;Full;3.910819;1.619914;1.4;1.75;2.8;292.5;0;1.145452;0.35;1.05;0;0;15;
33 J_{15-4};J;Intermediate;3.575324;1.95541;1.4;1.75;2.8;90;0;1.145452;0.35;1.05;0;0;15;
34 C_{15-5};C;Full;3.910819;2.290905;1.4;1.75;2.8;247.5;0;1.145452;0.35;1.05;0;0;15;
35 E_{15-6};E;Full;3.338093;3.338093;1.4;1.75;2.8;315;0;1.145452;0.35;1.05;-1.4;15;
36 C_{15-7};C;Full;2.290905;3.910819;1.4;1.75;2.8;22.5;0;1.145452;0.35;1.05;0;0;15;
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38 C_{15-9};C;Full;1.619914;3.910819;1.4;1.75;2.8;337.5;0;1.145452;0.35;1.05;0;0;15;
39 J_{15-10};J;Intermediate;1.145452;3.910819;1.4;1.75;2.8;135;0;1.145452;0.35;1.05;0;0;15;
40 C_{15-11};C;Full;1.145452;4.385281;1.4;1.75;2.8;292.5;0;1.145452;0.35;1.05;0;0;15;
41 E_{15-12};E;Full;0;4.720777;1.4;1.75;2.8;0;0;1.145452;0.35;1.05;-1.4;15;
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43 J_{15-14};J;Intermediate;-1.145452;3.910819;1.4;1.75;2.8;-135;0;1.145452;0.35;1.05;0;0;15;
44 C_{15-15};C;Full;-1.619914;3.910819;1.4;1.75;2.8;22.5;0;1.145452;0.35;1.05;0;0;15;
45 J_{15-16};J;Intermediate;-1.95541;3.575324;1.4;1.75;2.8;-180;0;1.145452;0.35;1.05;0;0;15;
46 C_{15-17};C;Full;-2.290905;3.910819;1.4;1.75;2.8;-22.5;0;1.145452;0.35;1.05;0;0;15;
47 E_{15-18};E;Full;-3.338093;3.338093;1.4;1.75;2.8;45;0;1.145452;0.35;1.05;-1.4;15;
48 C_{15-19};C;Full;-3.910819;2.290905;1.4;1.75;2.8;112.5;0;1.145452;0.35;1.05;0;0;15;
49 J_{15-20};J;Intermediate;-3.575324;1.95541;1.4;1.75;2.8;-90;0;1.145452;0.35;1.05;0;0;15;
50 C_{15-21};C;Full;-3.910819;1.619914;1.4;1.75;2.8;67.5;0;1.145452;0.35;1.05;0;0;15;
```

Rhino Grasshopper

→ STL file → 3D printer



Agenda for a next meeting

- **Try to identify the tiers and allocate the units accordingly.**
 - Be aware that you can find unacceptable alternatives
- **Rare units**
- **Multiple solutions**
- **Incorrect drawings**
- **Size matters**
- **Non-monotony (up or down)**
- **Pentagons in an octagonal grid**
- **Graph theory runs in trouble due to flat panels**
- **Püskül (tassels) and other ornaments**

!! Encourage you to read Turkish literature !!

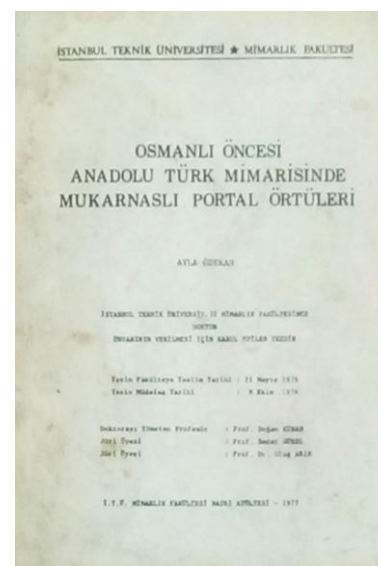
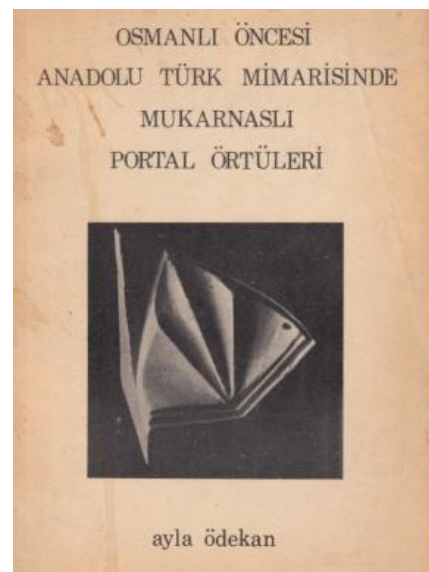
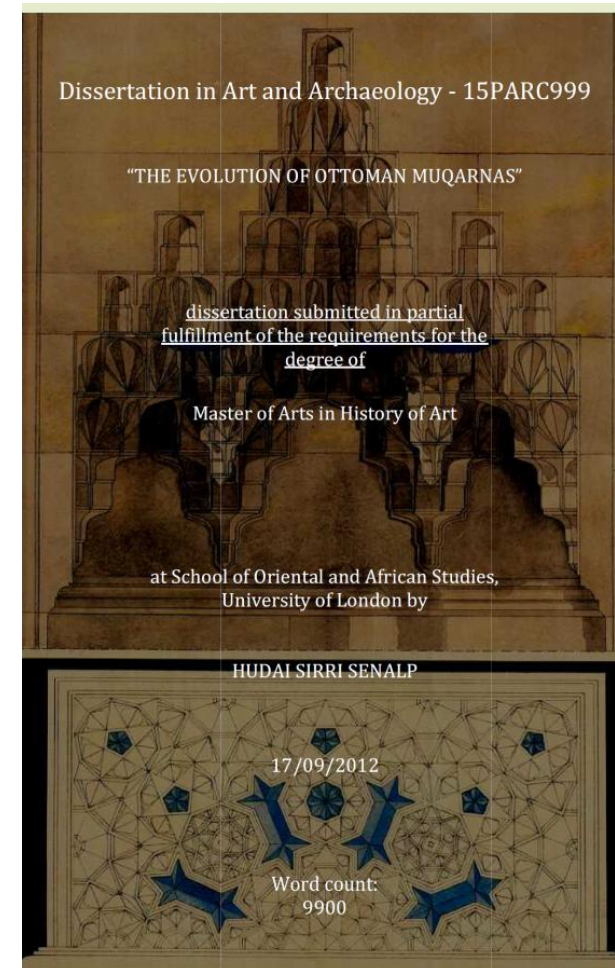
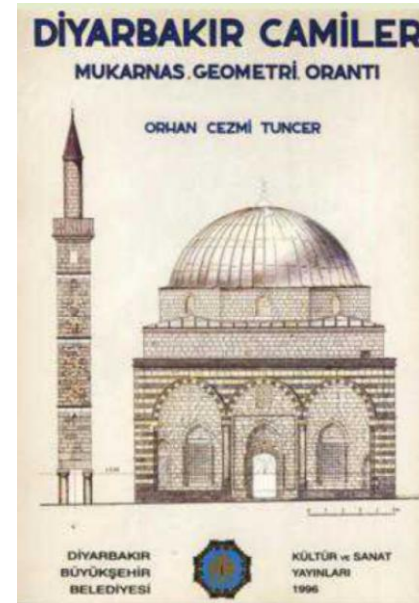
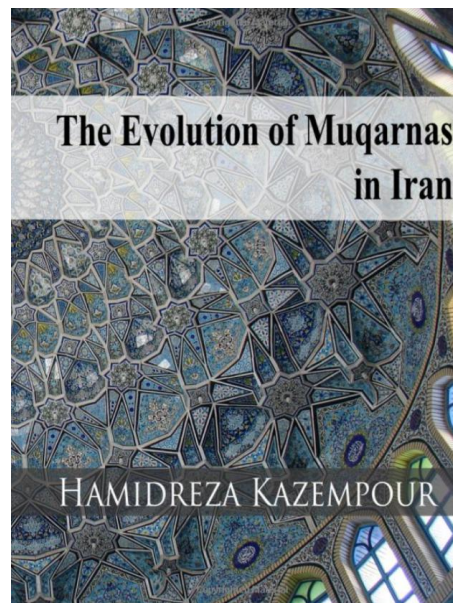
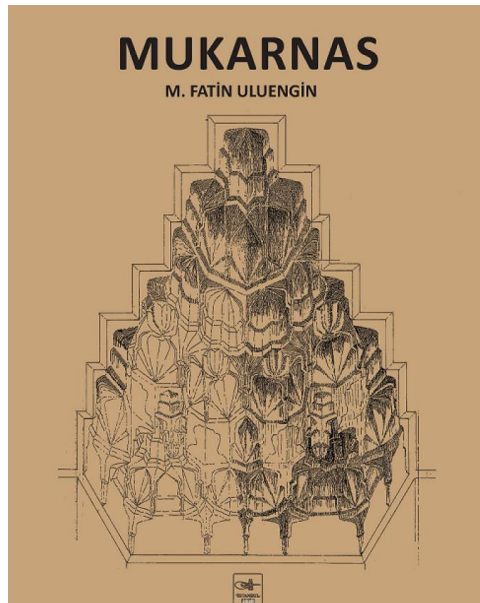
On Tour

- **Marmara University Theology Faculty Mosque**
- **Takht-i Sulayman Southern Octagon**
- **Takht-i Sulayman Central Dome**
- **Diyarbakır Kasim Padisah**
- **Mardin Kasim Padisah**
- **Mardin Sultan Isa Medresesi**
- **Diyarbakır Iskender Pasa**
- **Kayseri Sultan Han**
- **Afyon Tas Medrese**
- **Bursa Muradiye Complex**
- **Istanbul Üsküdar Atik Valide**

Conclusion

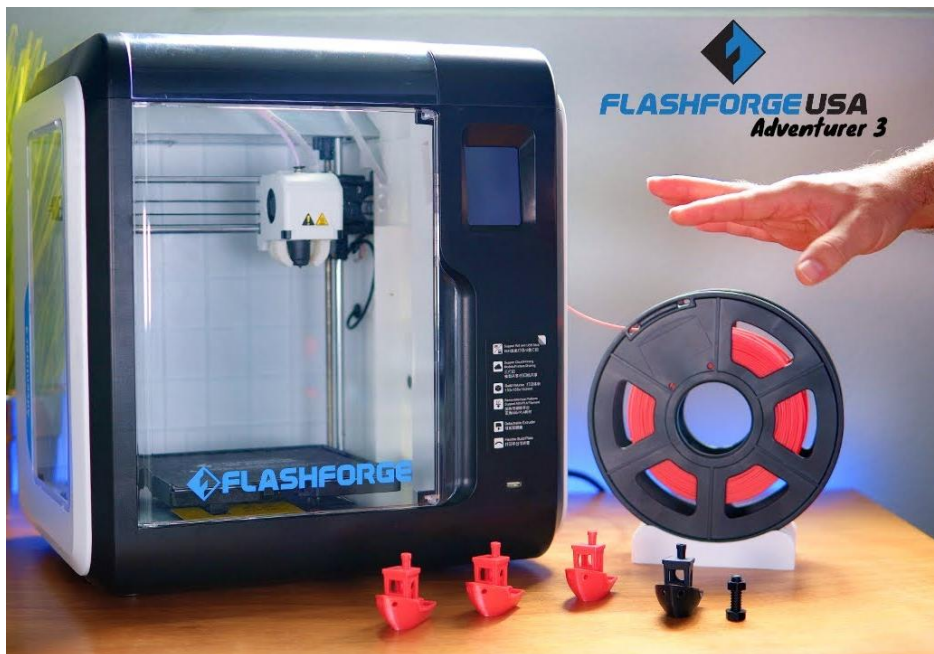
- **Muqarnas are complex ornaments**
 - Huge variety
 - Exceptional constructions
 - It's art, architecture, not mathematics
 - Family tradition
- **Parametric software is a powerful tool**
 - 2D and 3D
 - Engineers use Rhino
- **3D animations are essential**
 - to find correct interpretation of floor plans

Study muqarnas: read a book



Production Costs

- Printer takes up to 30 min. for a single piece
- 1000+ pieces after two months



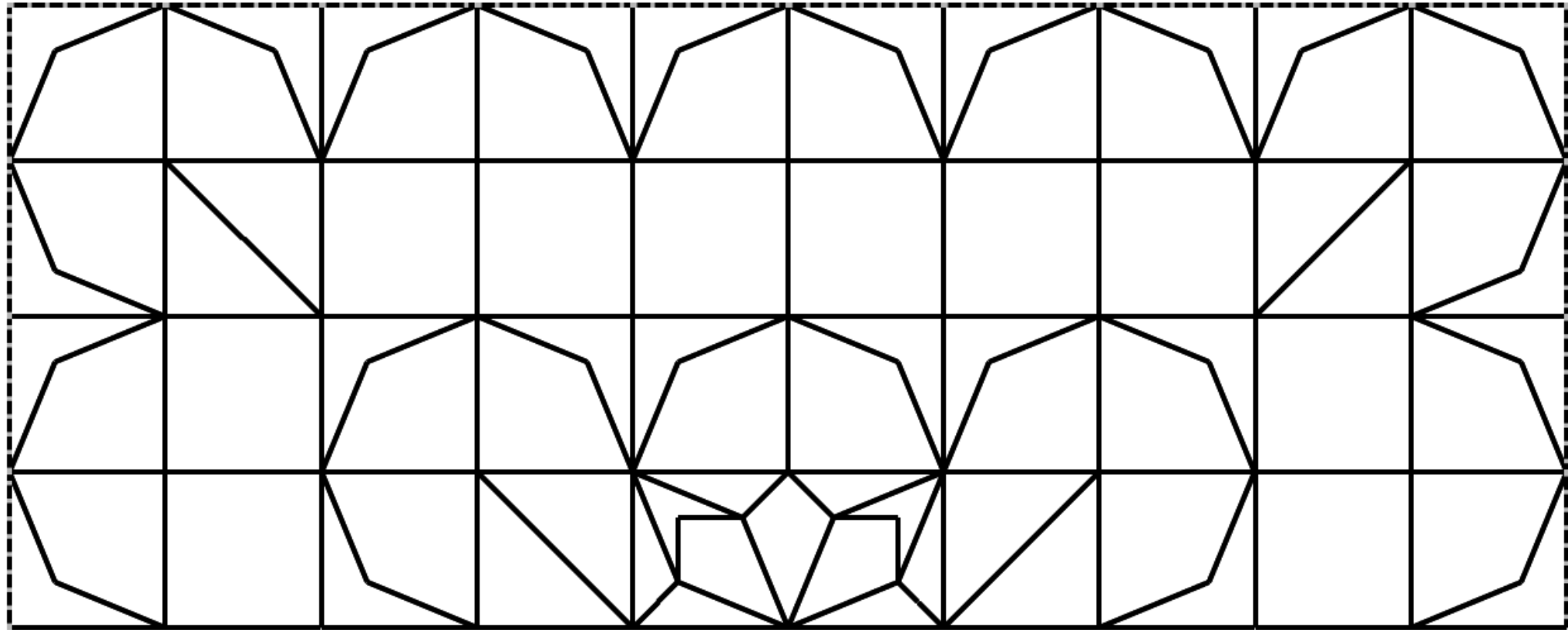
Tour starts now

- **Marmara University Theology Faculty Mosque**
- **Takht-i Sulayman Southern Octagon**
- **Takht-i Sulayman Central Dome**
- **Diyarbakır Kasim Padisah**
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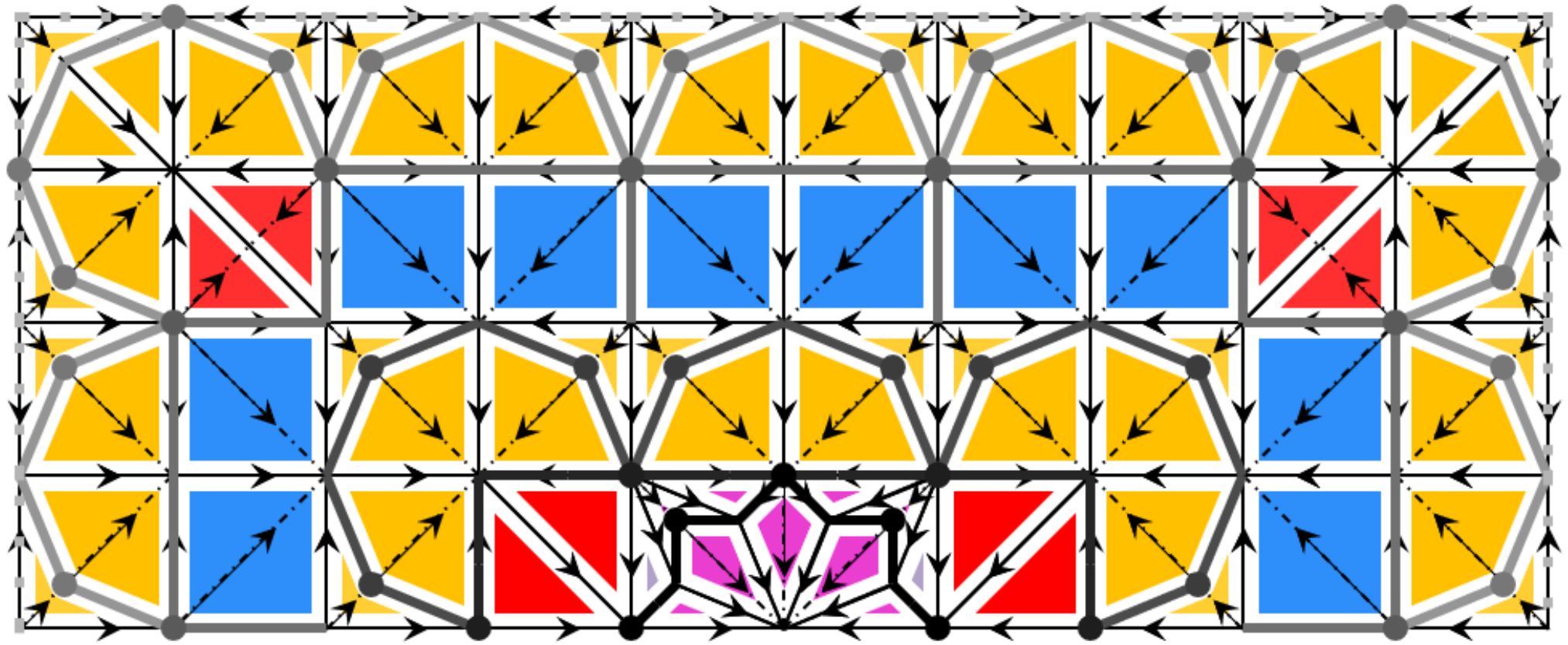
Istanbul Üsküdar Marmara University Theology Faculty Mosque



Find the tiers and assign the units



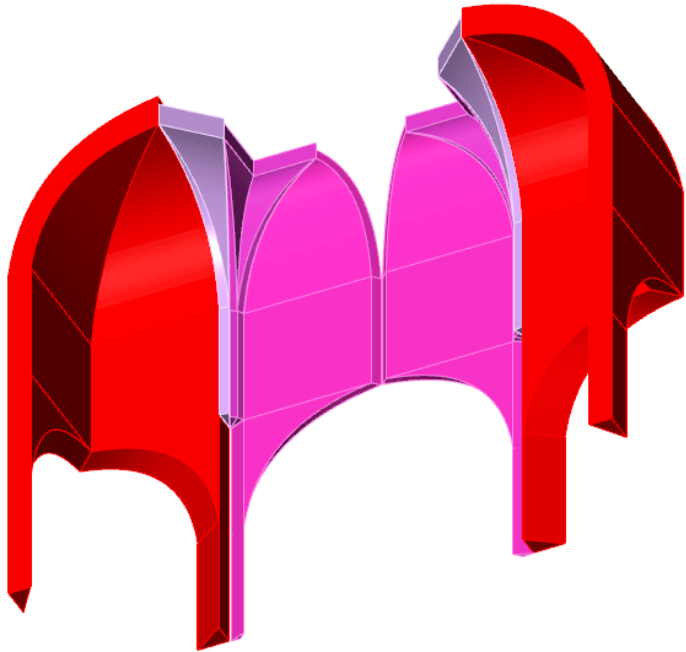
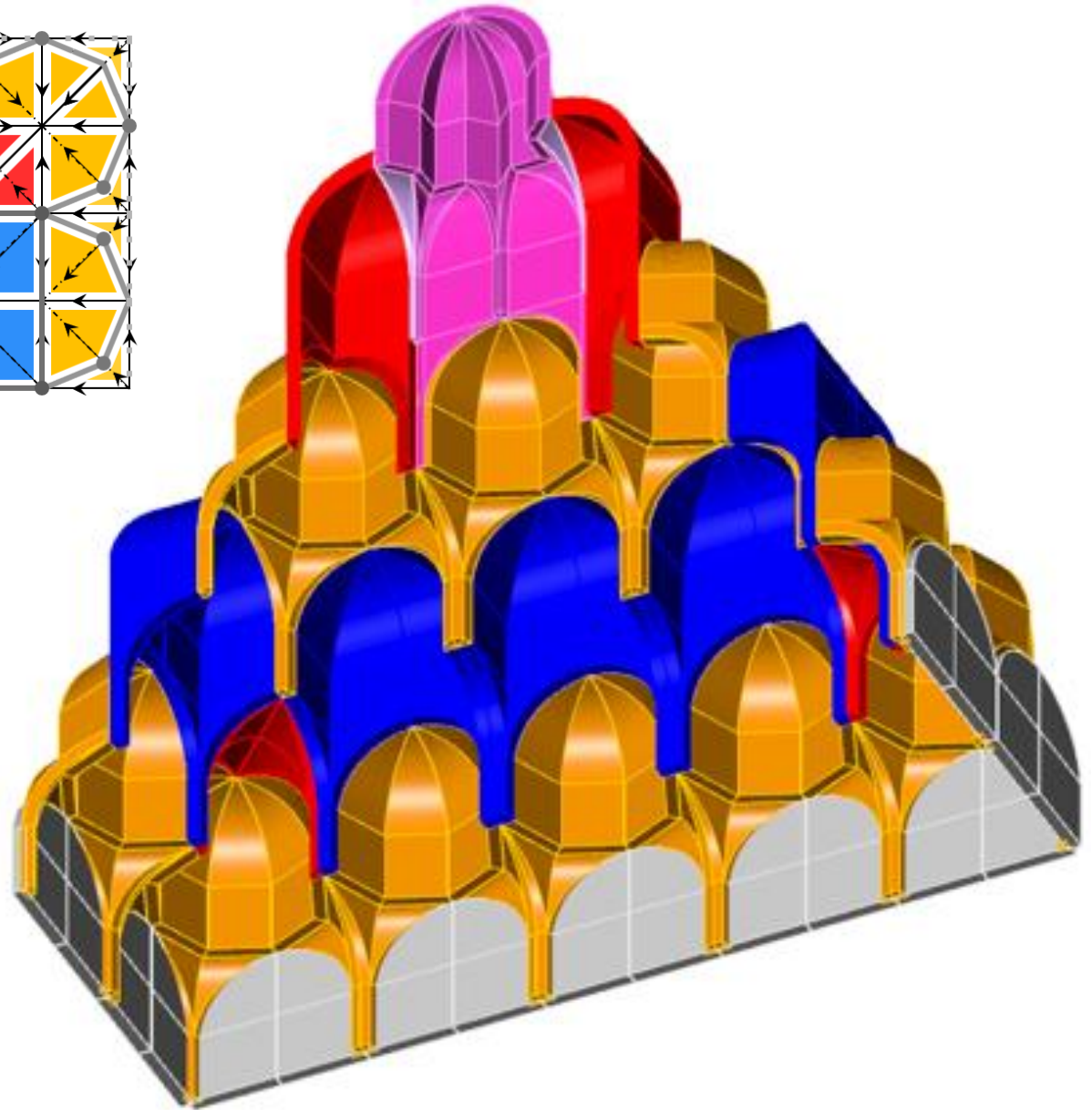
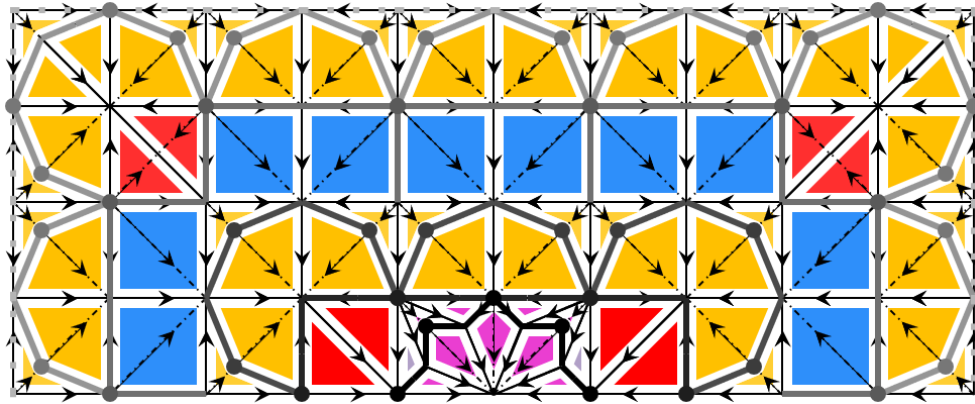
Systematic approach of all configurations



Click on a figure to open the corresponding webpage at www.henkhietbrink.nl/mugarnas

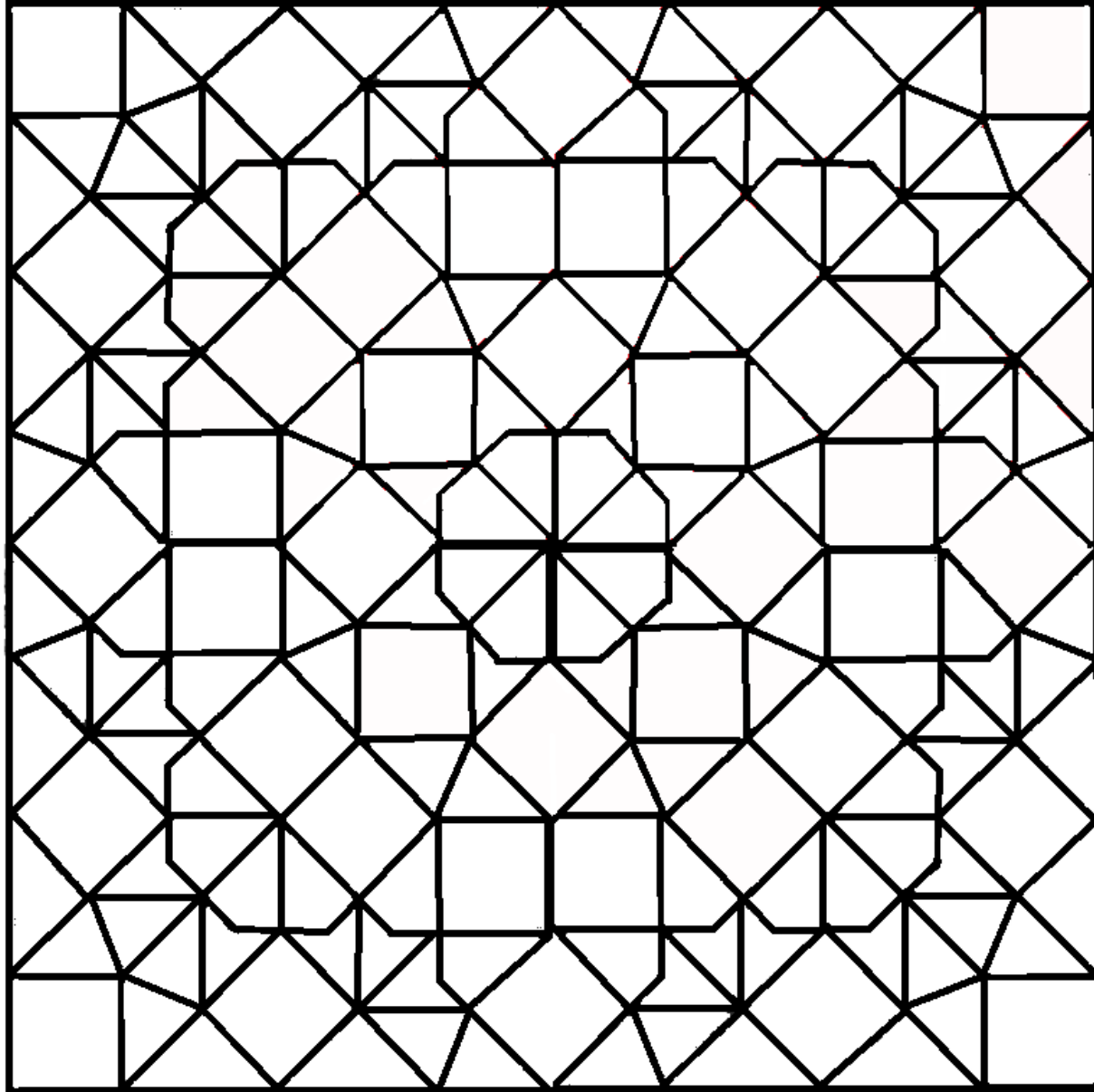
Quest for new pre-defined units

Systematic approach of all configurations

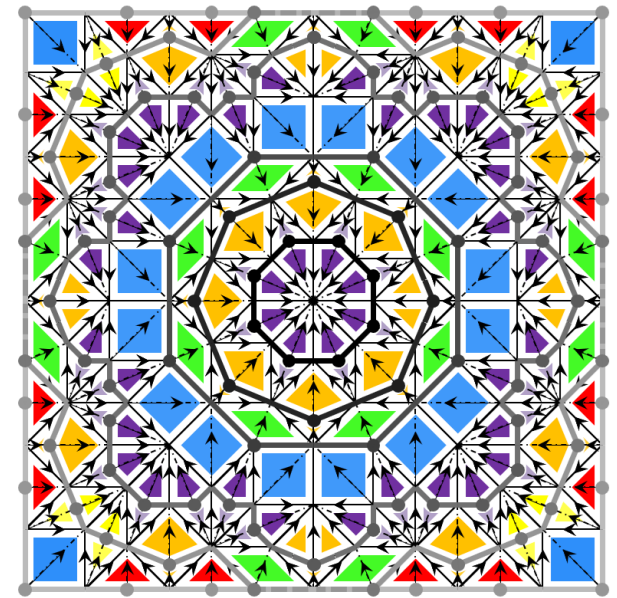
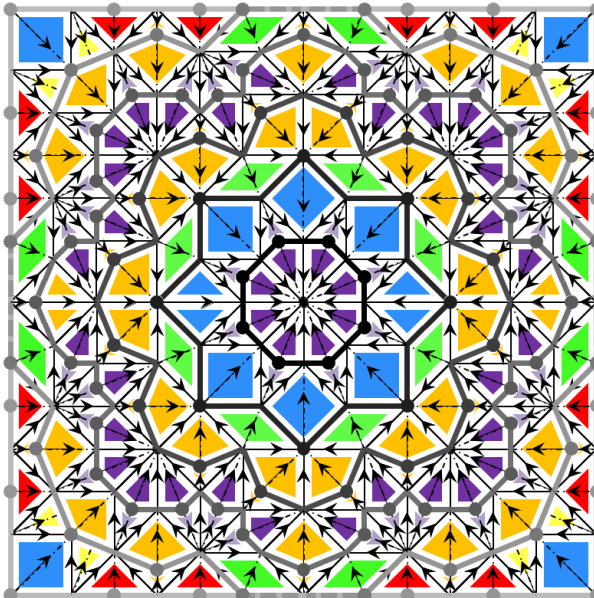
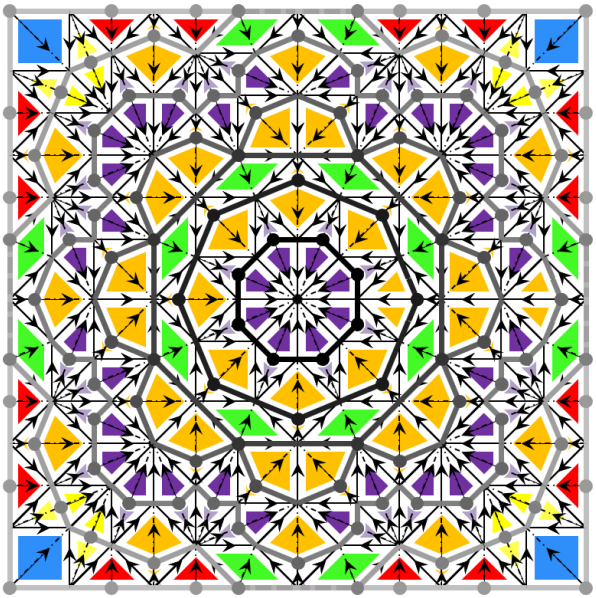
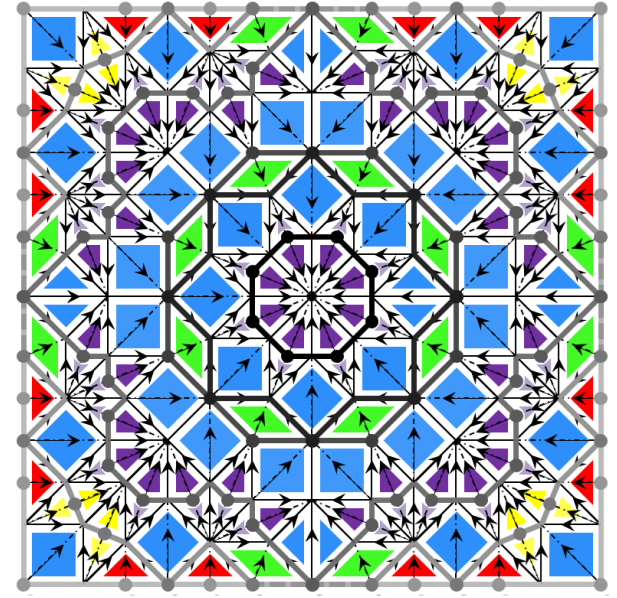
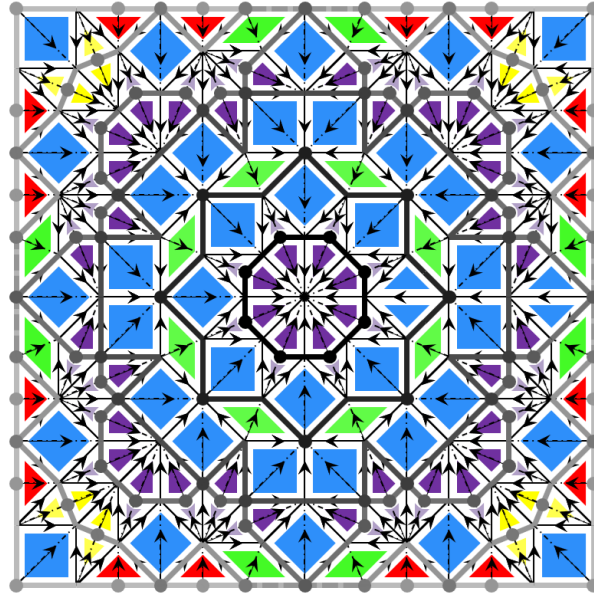
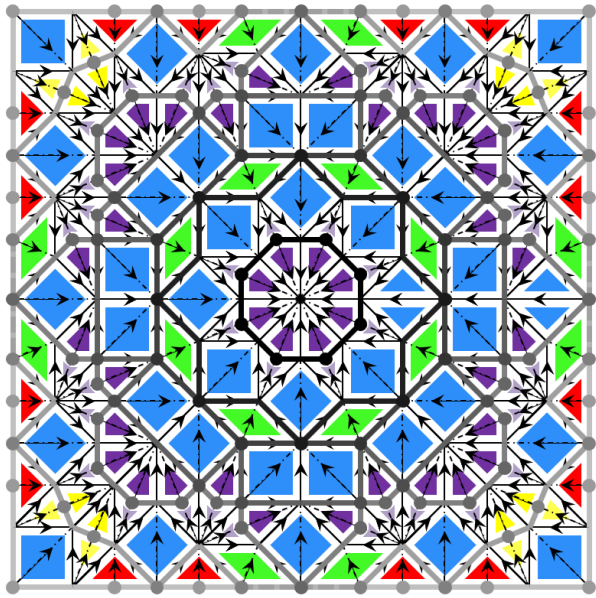


How to elevate this design from 2D to 3D

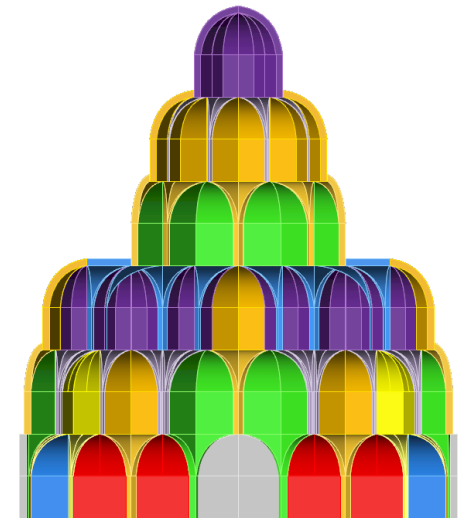
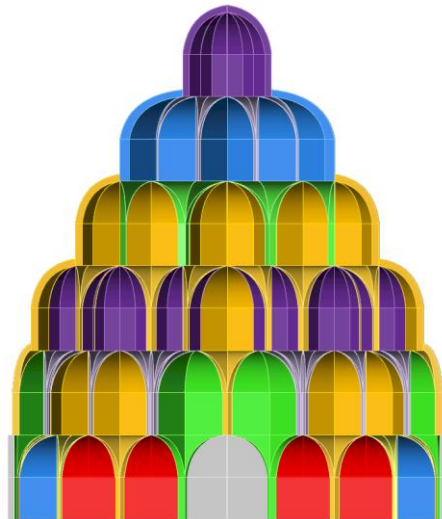
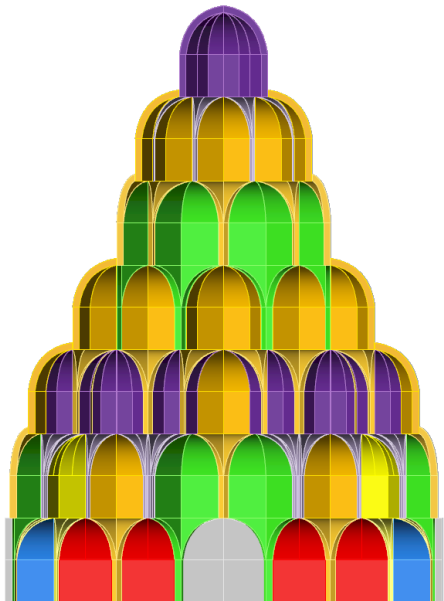
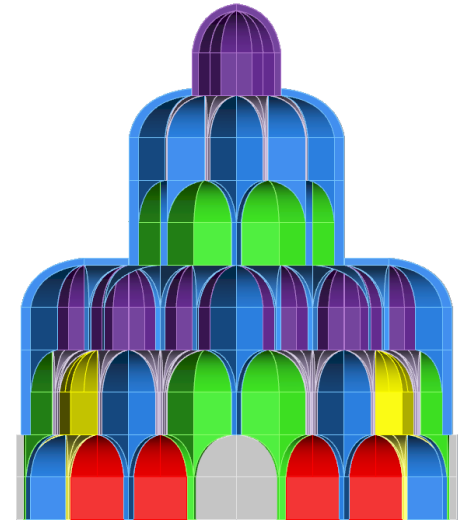
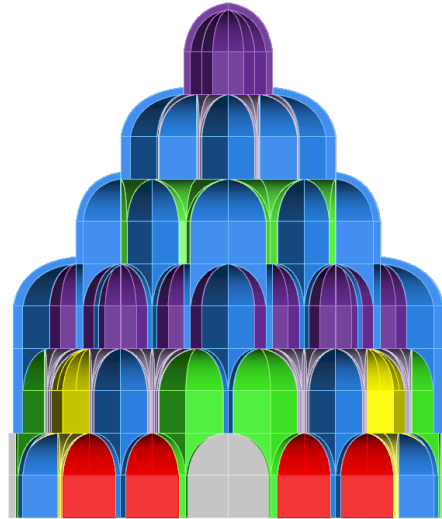
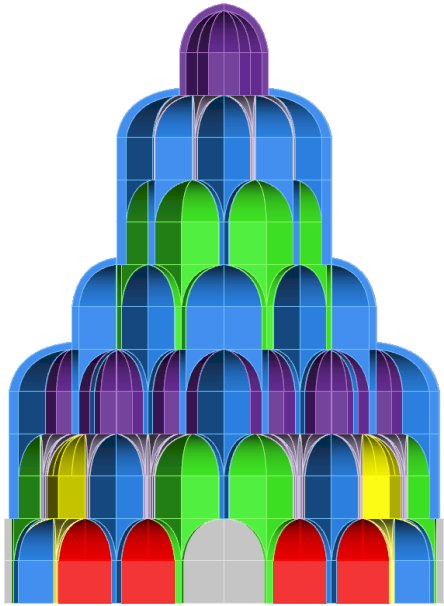
Takht-i Sulayman Southern Octagon



Six possibilities (of many more) to identify tiers and assign units

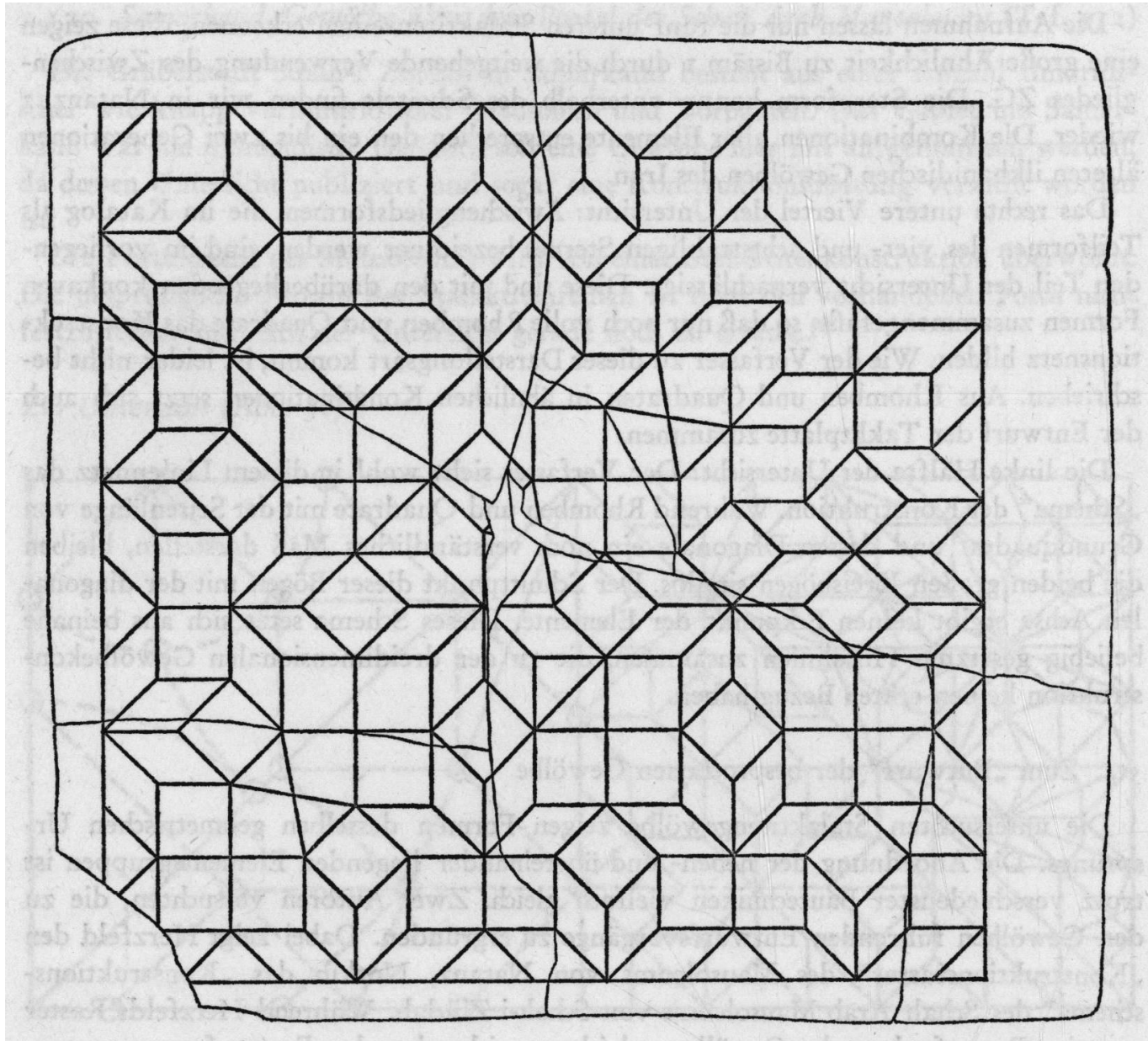


Six possibilities result in six different muqarnas



How to elevate this design from 2D to 3D

Takht-i Sulayman Central Dome



Some possibilities

Quarter of the vault

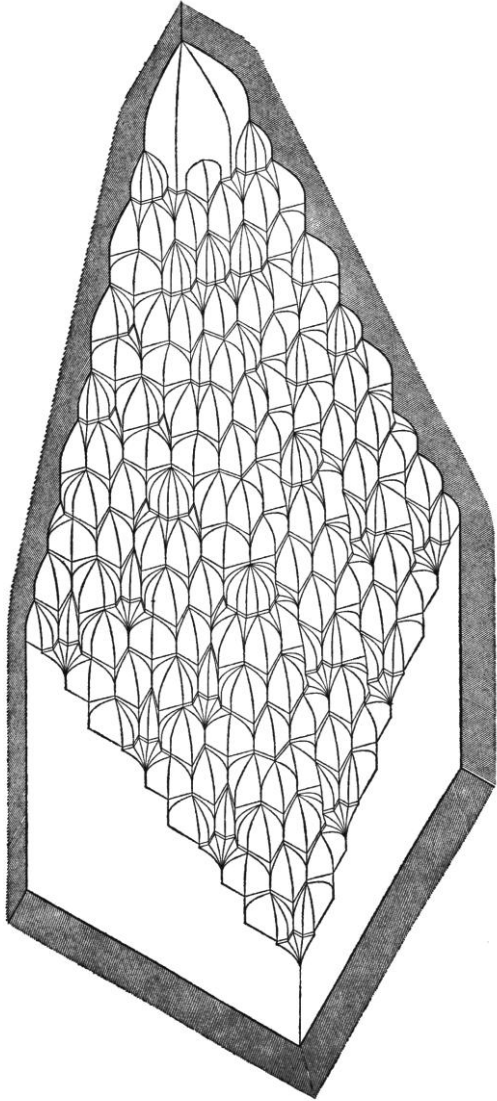
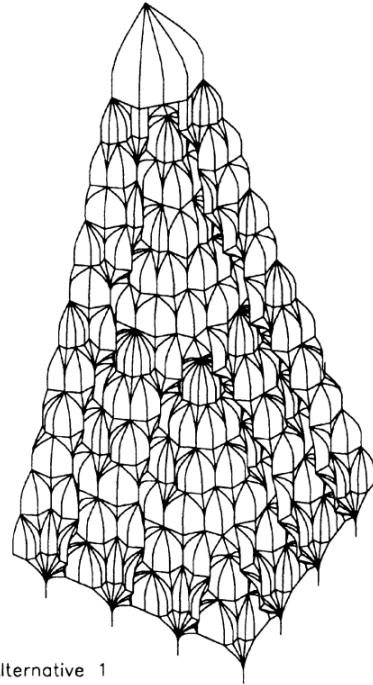
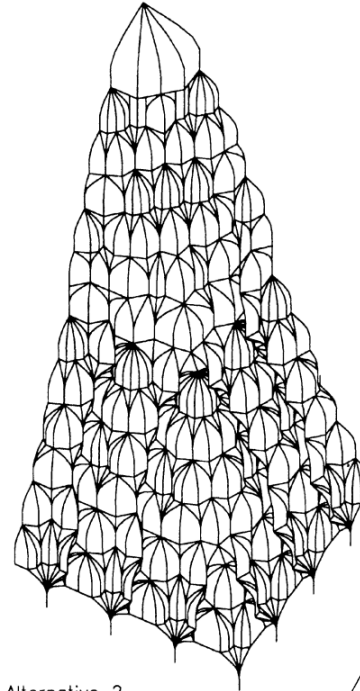


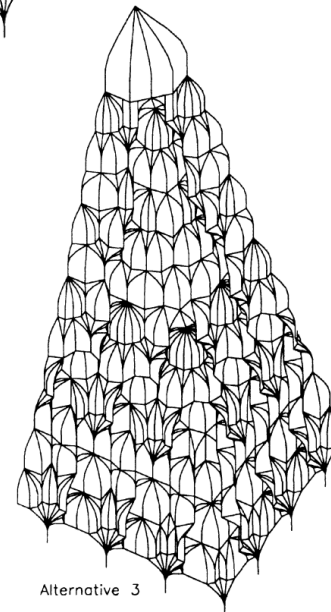
Abb. 33. Rekonstruktionsvorschlag zur Entwurfsplatte
des Takht-i Suleiman, Axonometrie



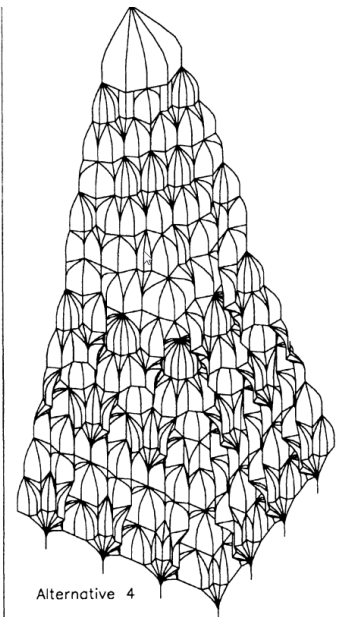
Alternative 1



Alternative 2



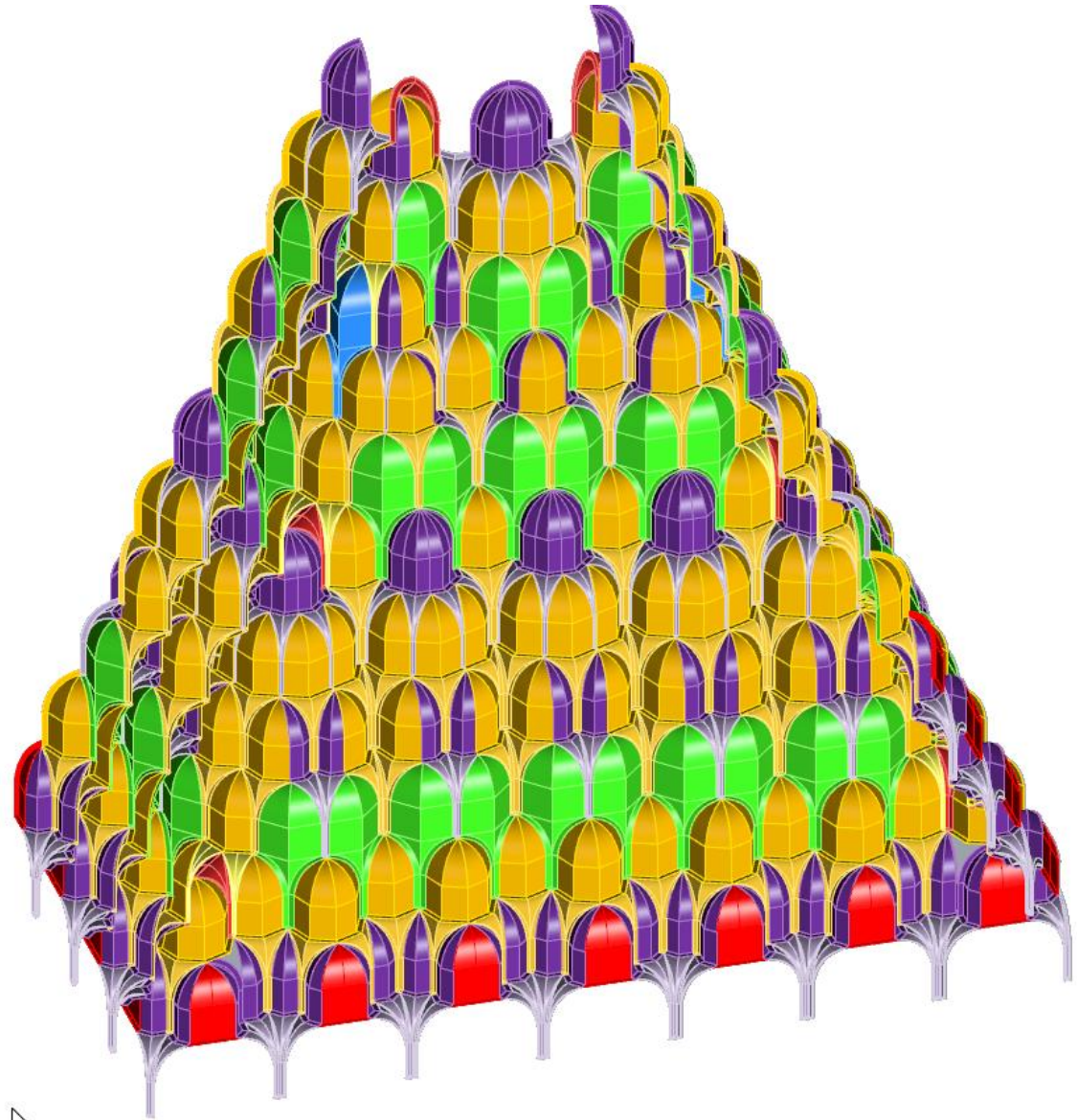
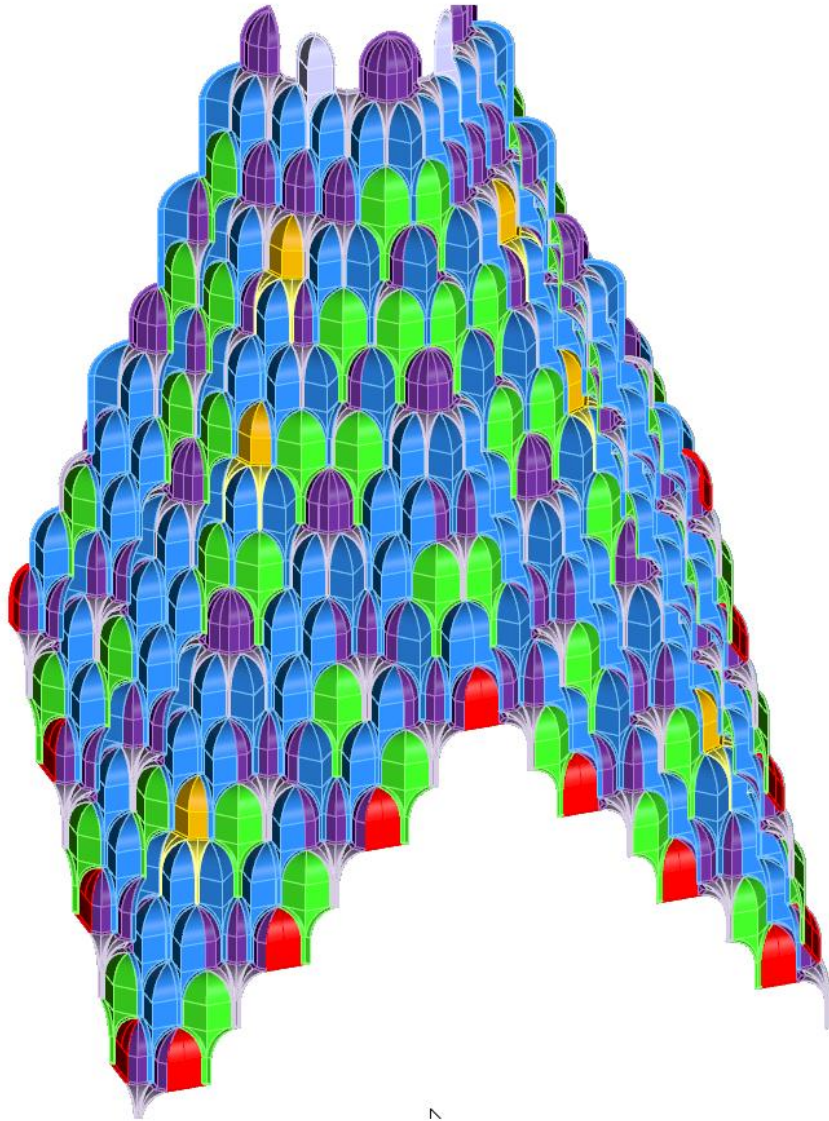
Alternative 3



Alternative 4

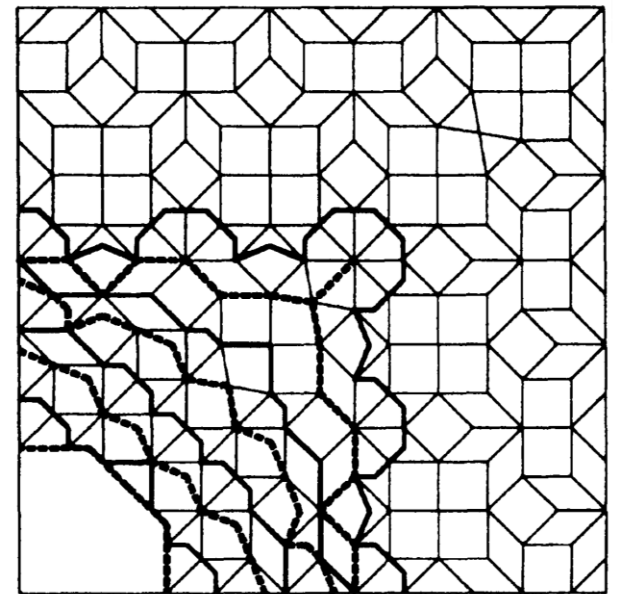
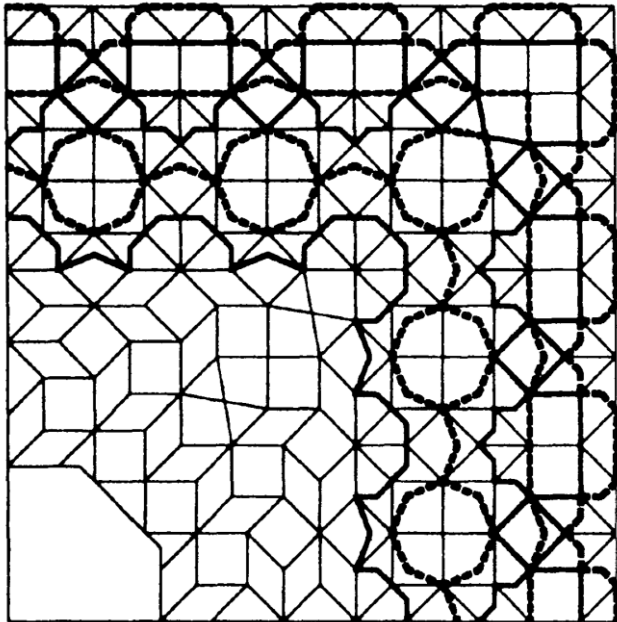
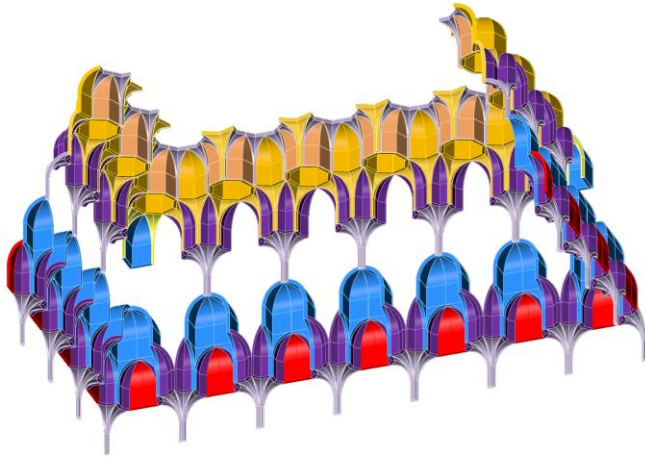
My interpretations of Half of the vault

Only two make sense.



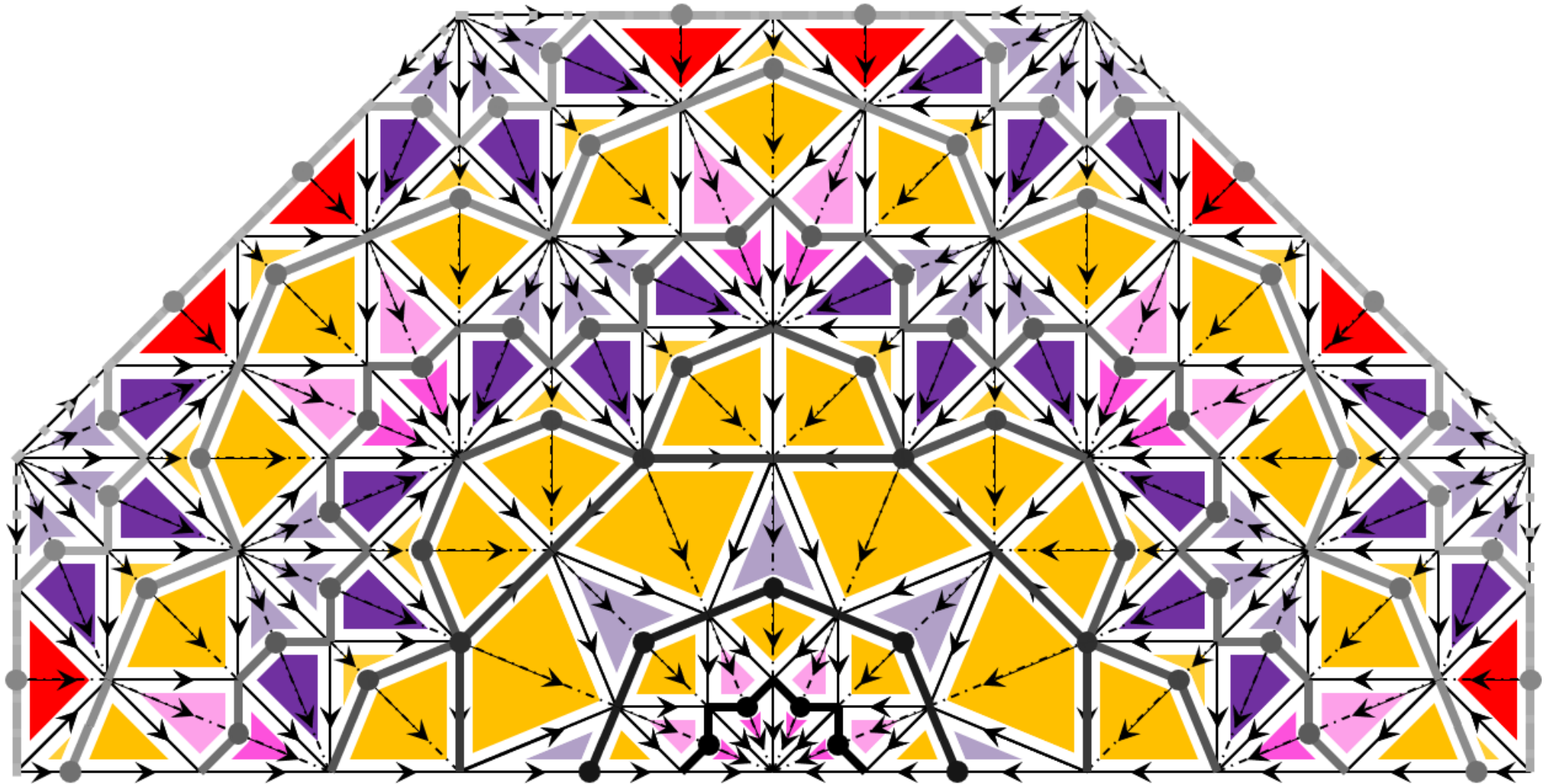
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**There are gaps in the others.
I didn't understand the floor plan**



Diyarbakir Kasim Padisah

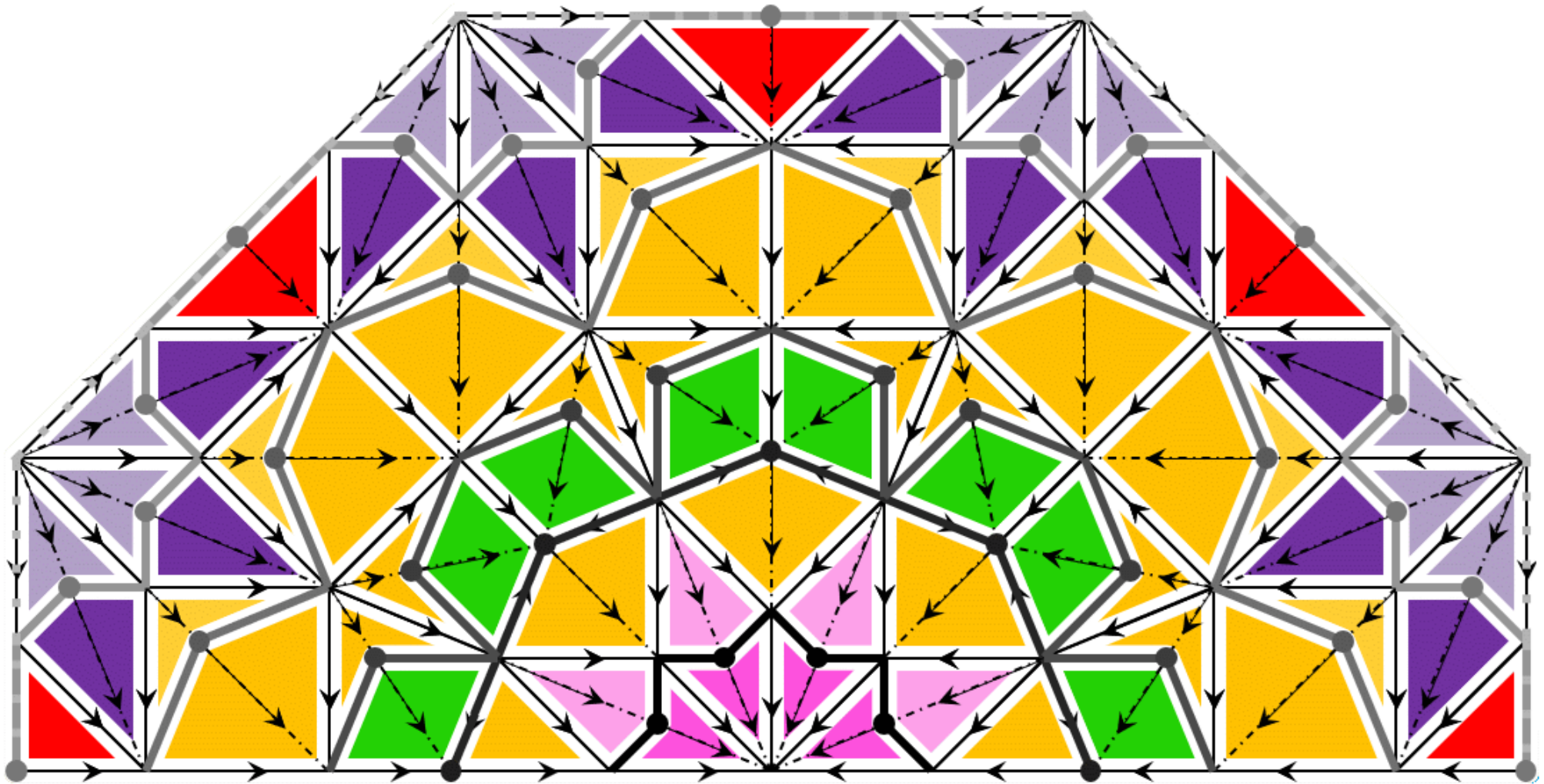
Same shape, different sizes



Click on a figure to open the corresponding webpage at www.henkhetbrink.nl/muqarnas

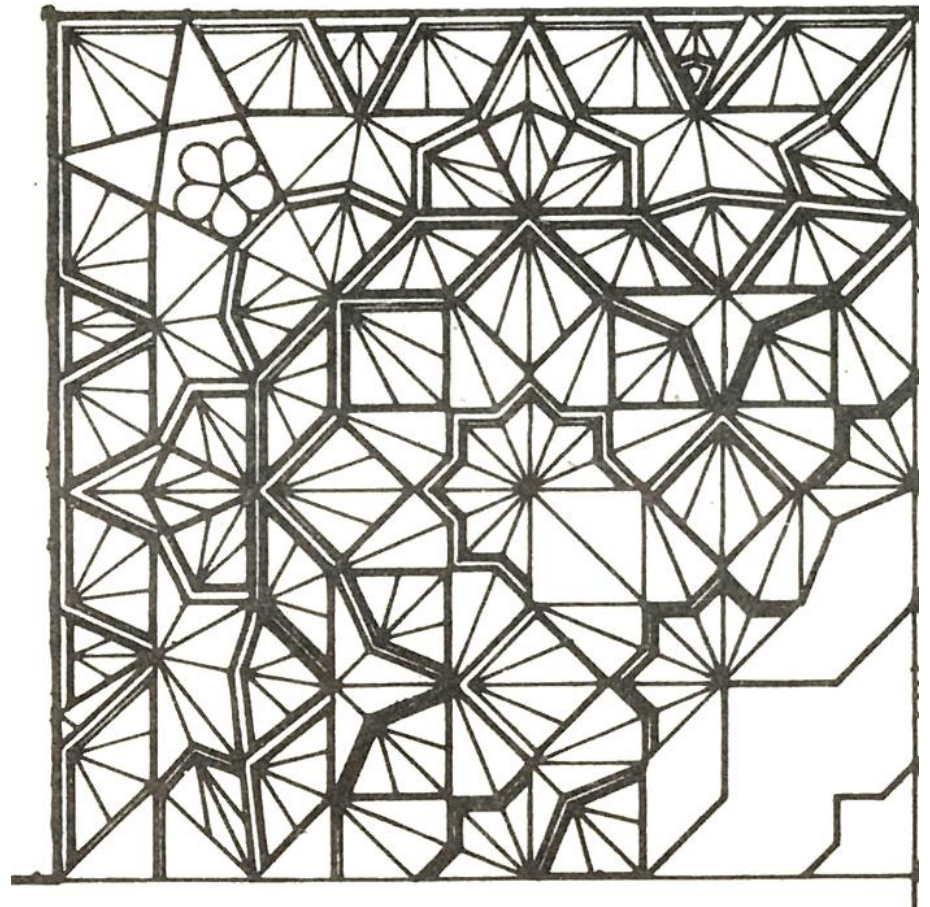
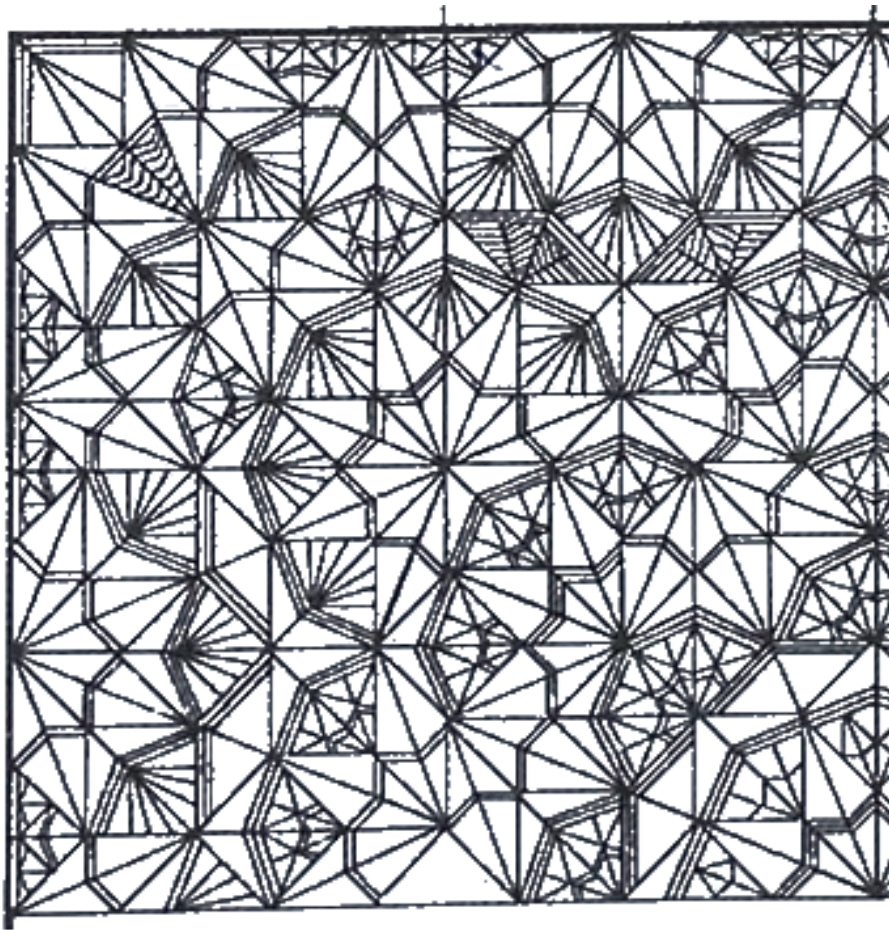
Diyarbakir Kasim Padisah (portal niche)

New rhombuses



Click on a figure to open the corresponding webpage at www.henkhetbrink.nl/muqarnas

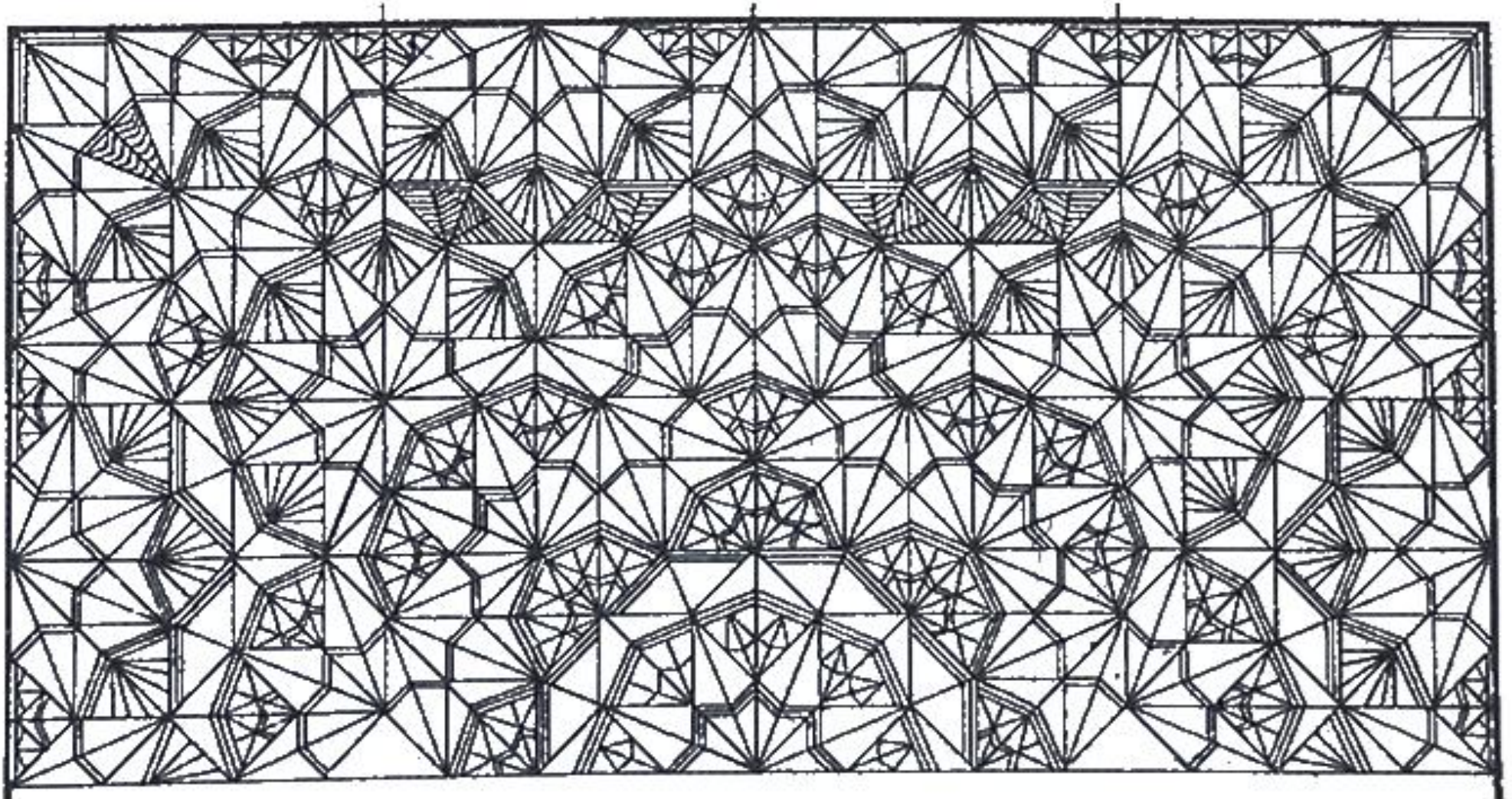
Up or down ?



Mardin Kasim Padisah Up or down

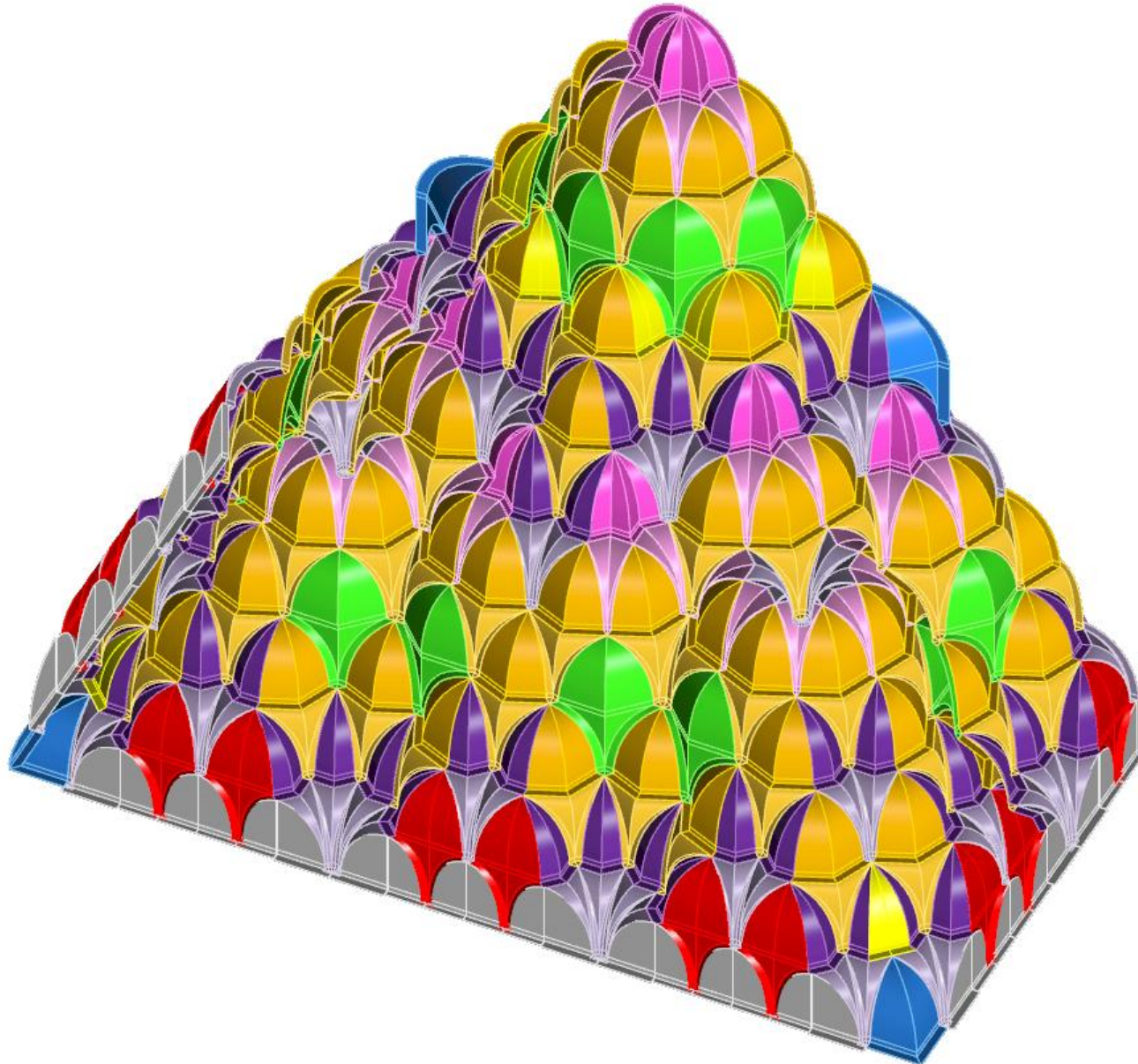
© Prof. Dr. Orhan Cezmi Tuncer

MARDİN KASIM PADİŞAH (KASİMİYE) MEDRESESİ TAÇKAPISI MUKARNASI



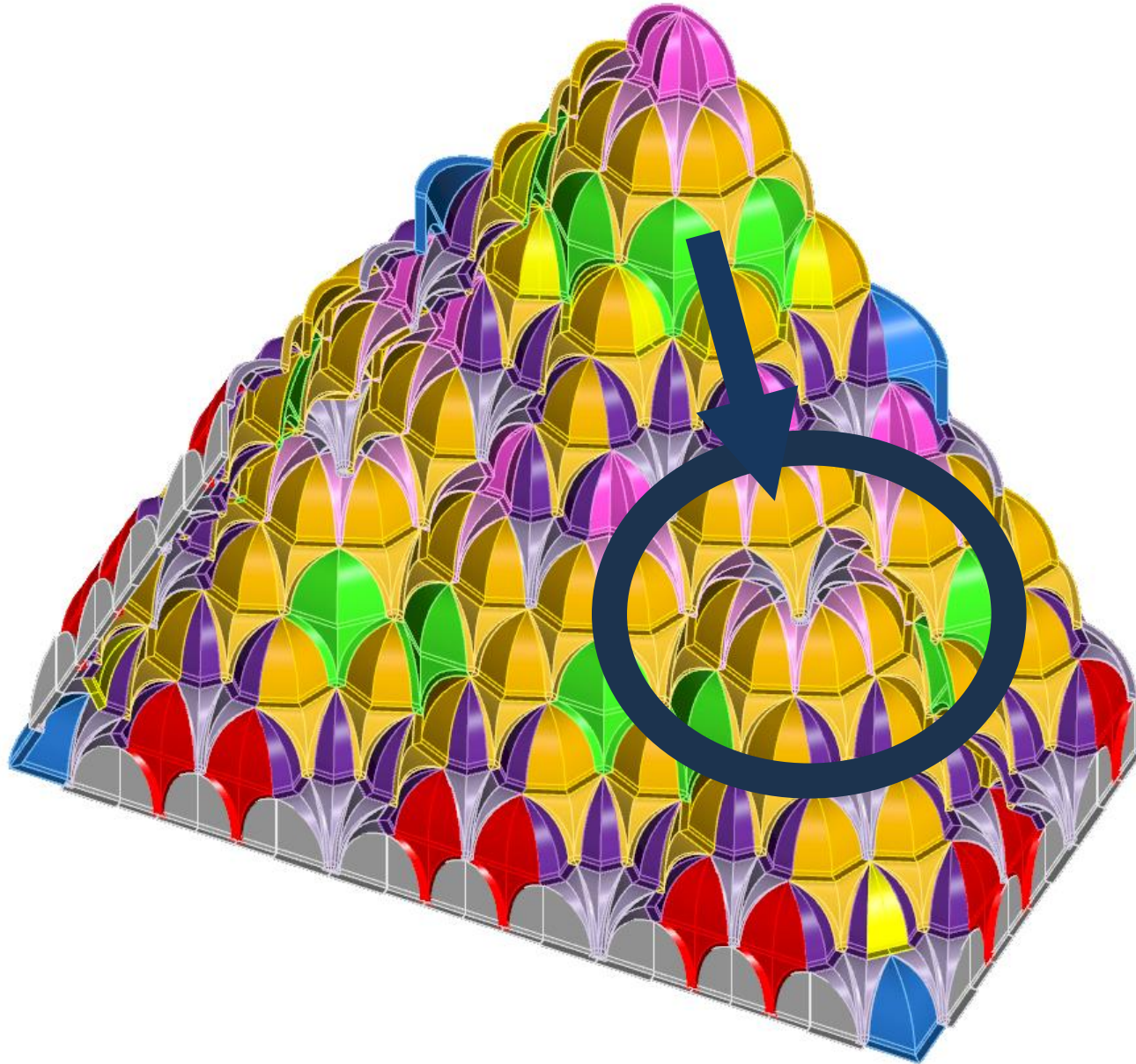
Click on a figure to open the corresponding webpage at www.henkietbrink.nl/muqarnas

Mardin Kasim Padisah goes Down

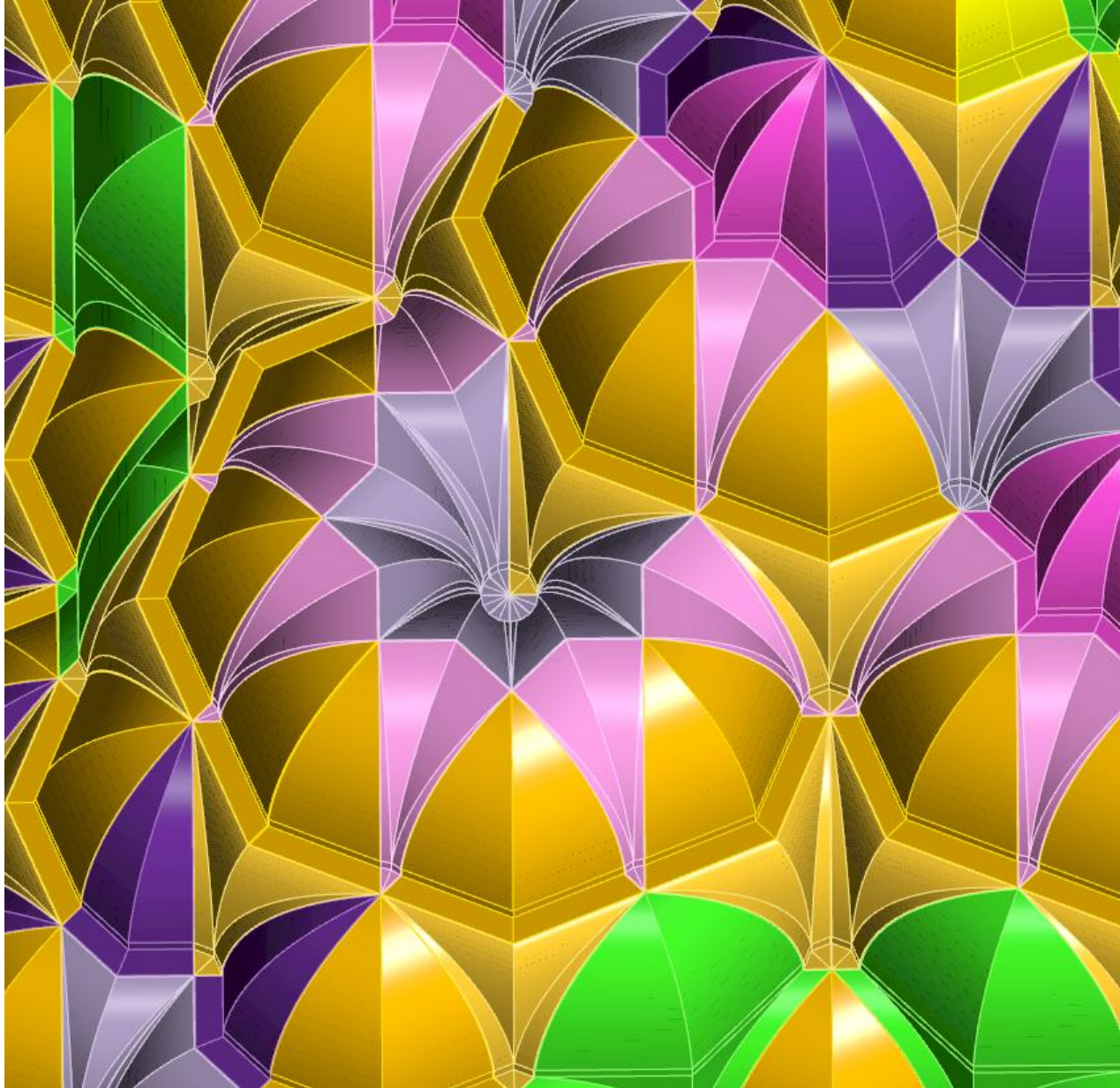


Click on a figure to open the corresponding webpage at www.henkhetbrink.nl/muqarnas

Mardin Kasim Padisah goes Down



Mardin Sultan Isa Medresesi → Down too



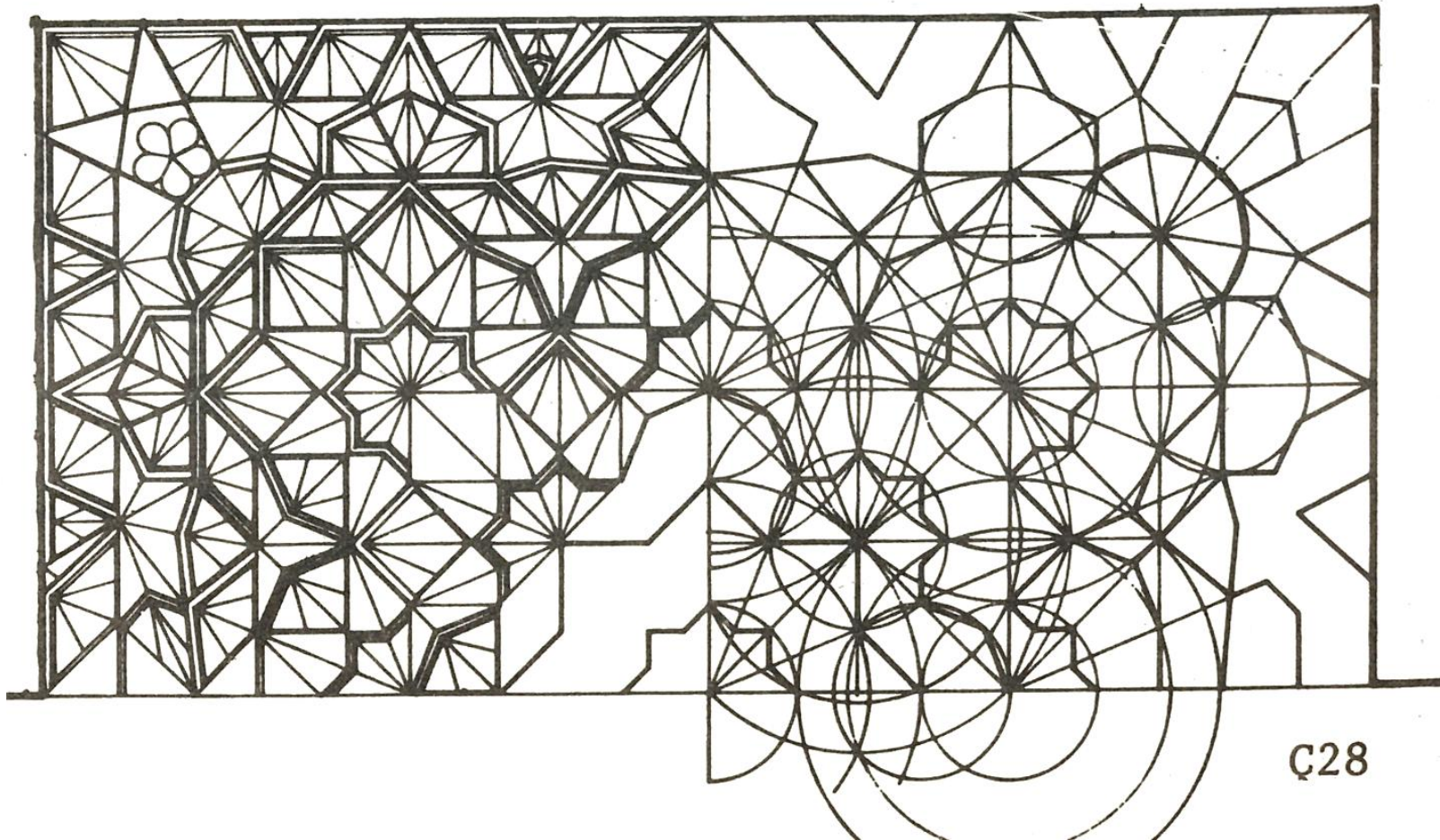
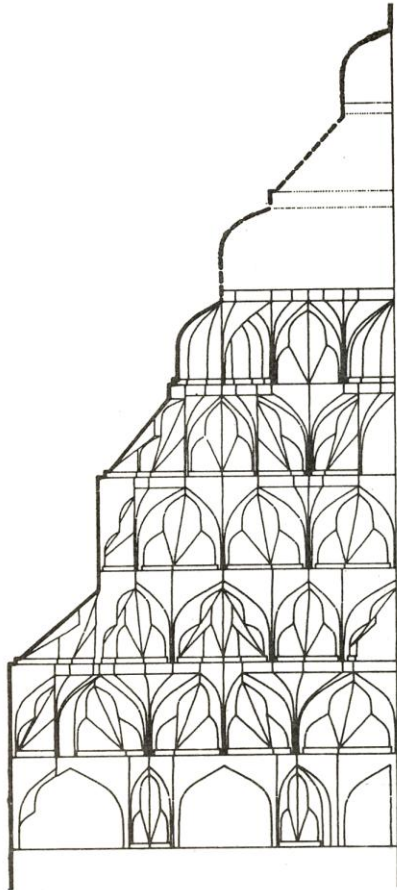
Example

Diyarbakır Iskender Pasa



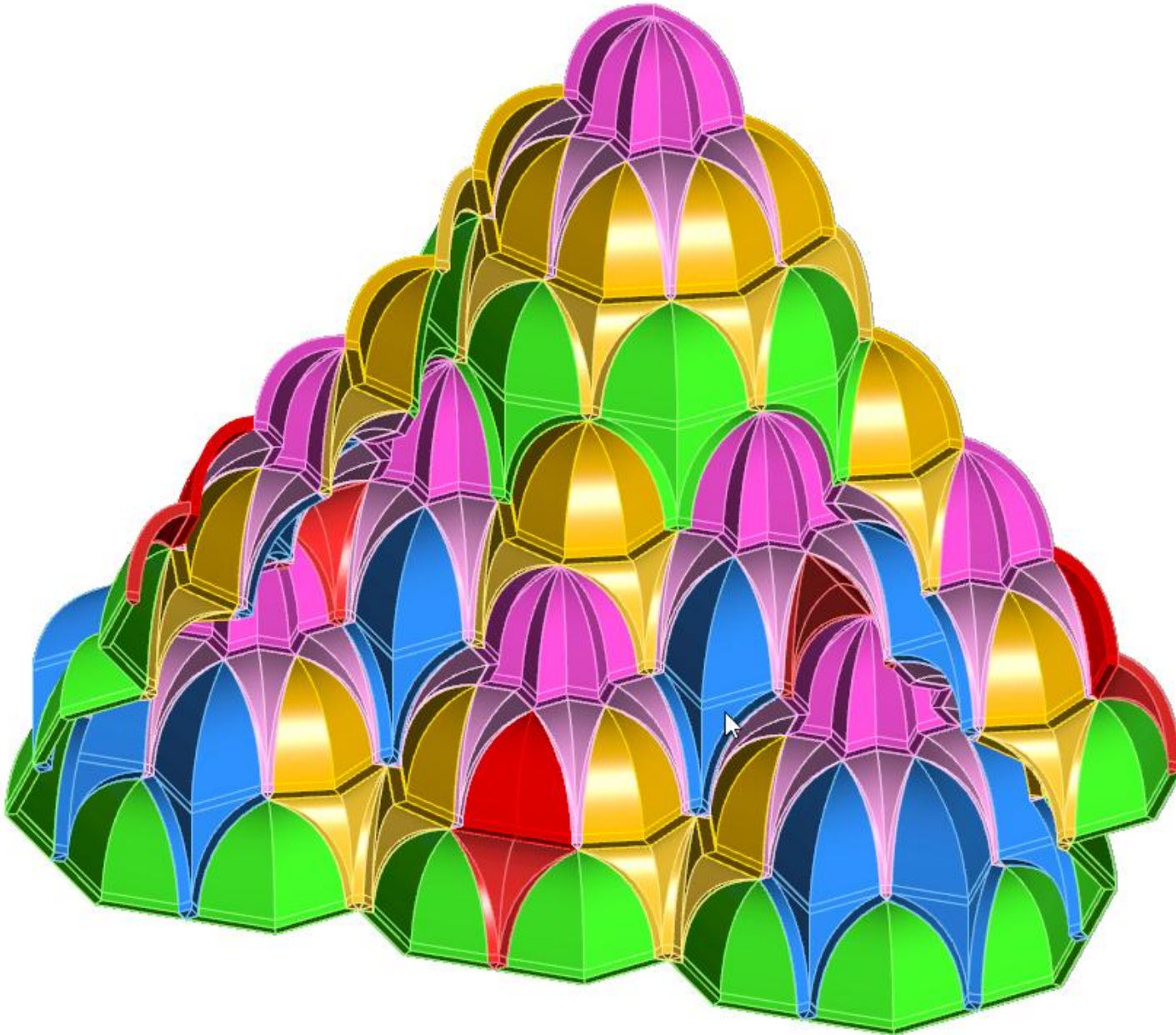
Kayseri Sultan Han on the Kayseri Sivas Road

Up or down © Prof. Dr. Ayla Ödekan



Ç28

Kayseri Sultan Han goes Up



Kayseri Sultan Han goes Up



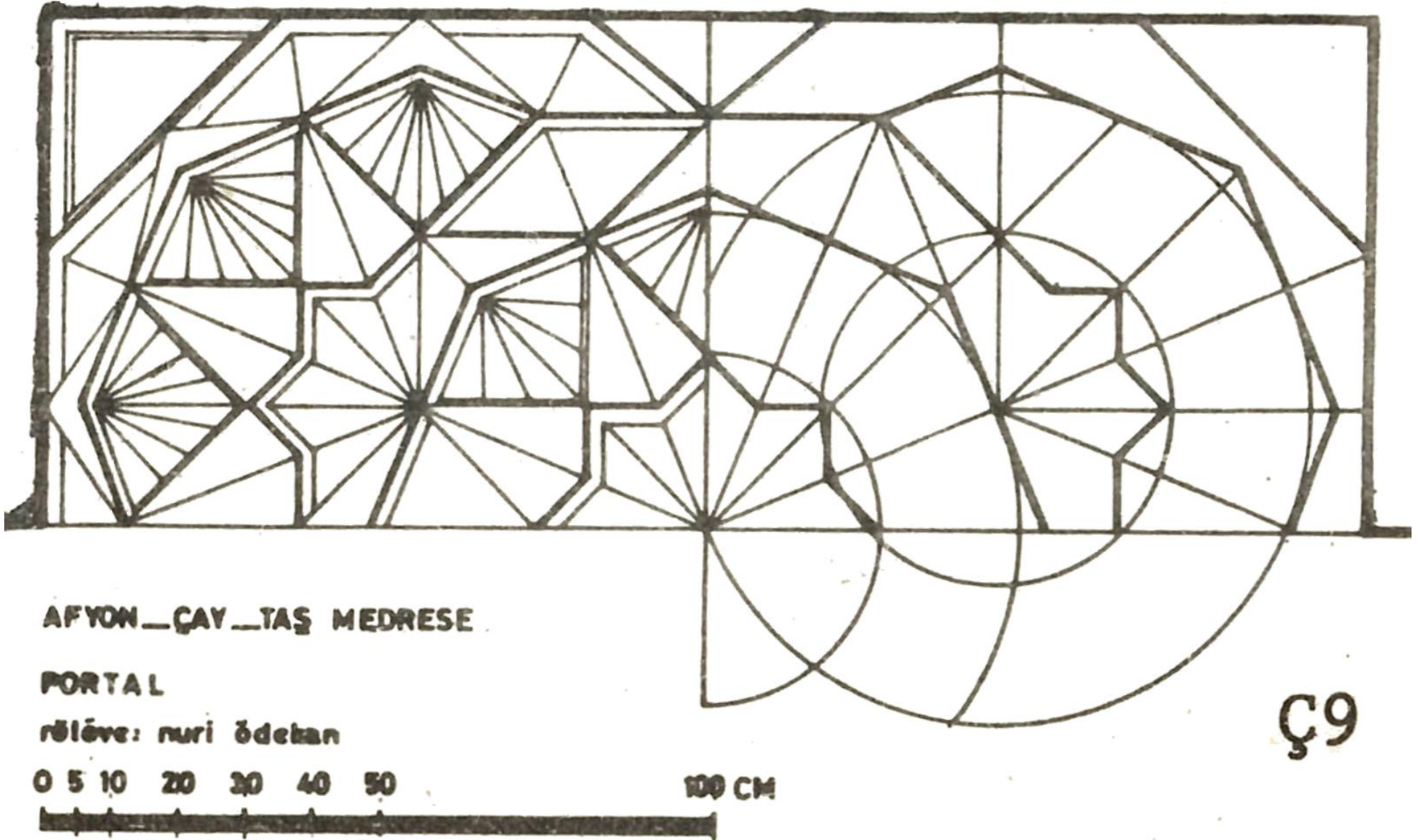
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Kayseri Sultan Han goes Up



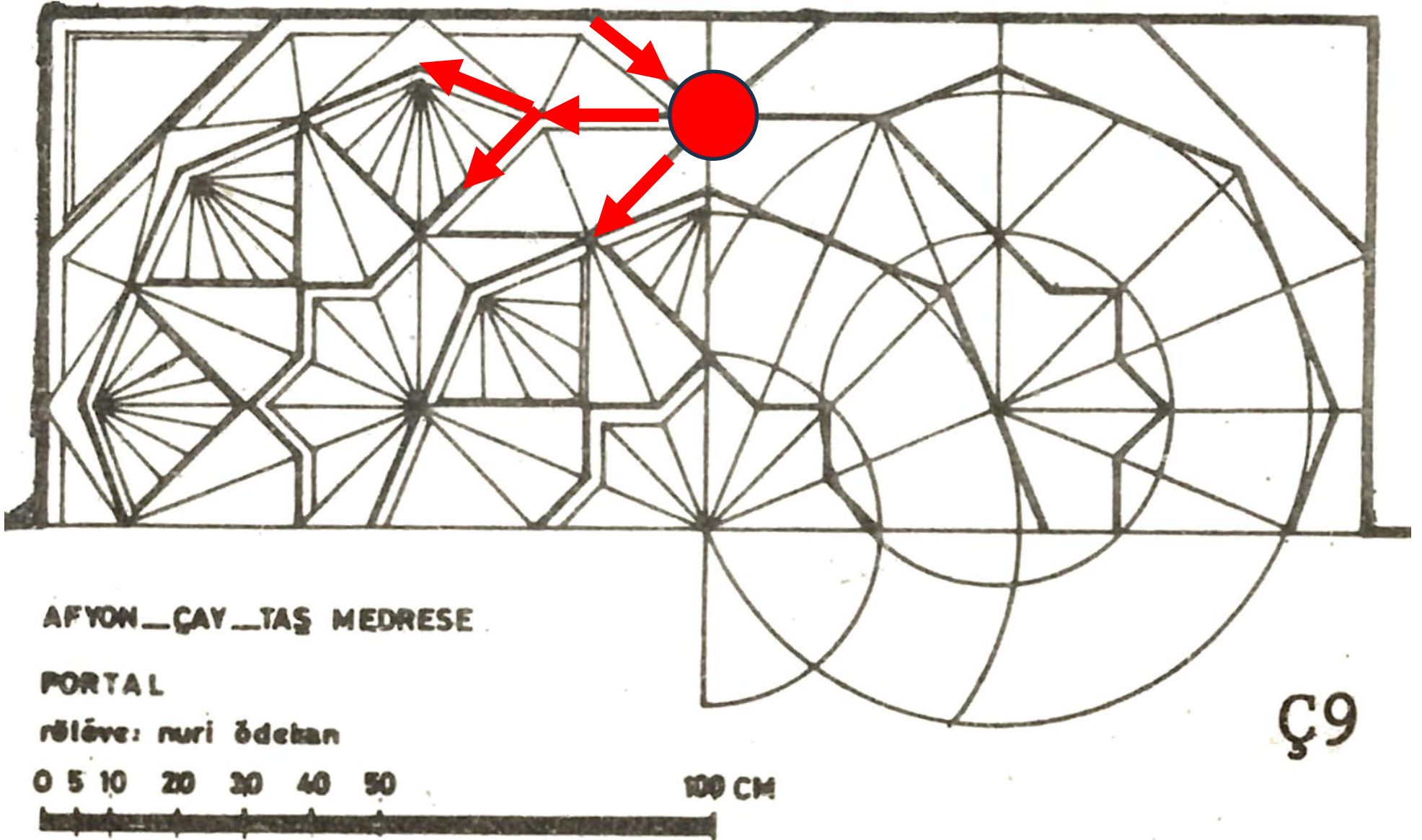
Afyon Tas Medrese: Consecutive Tiers?

© Prof. Dr. Ayla Ödekan



Afyon Tas Medrese: Consecutive Tiers?

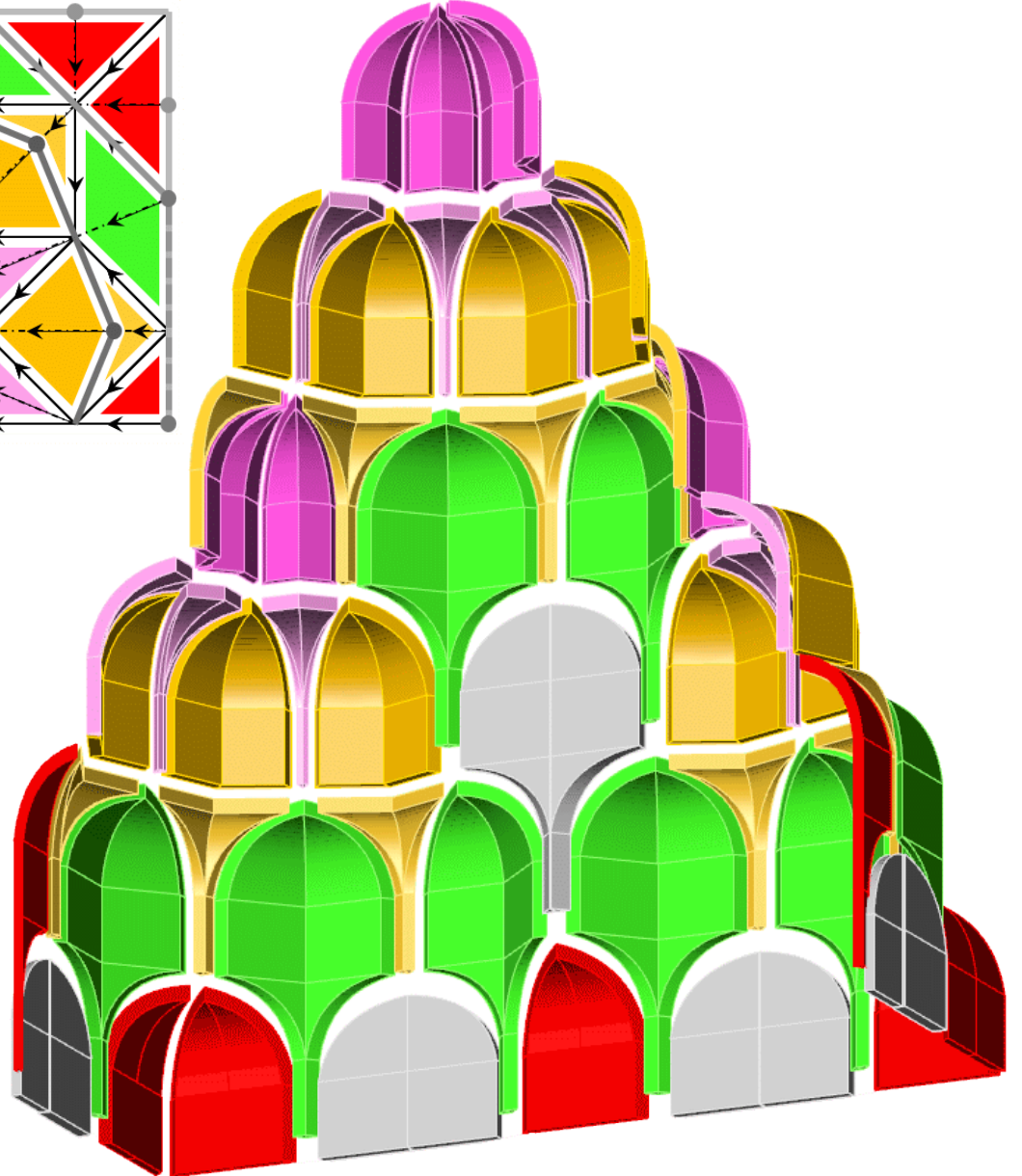
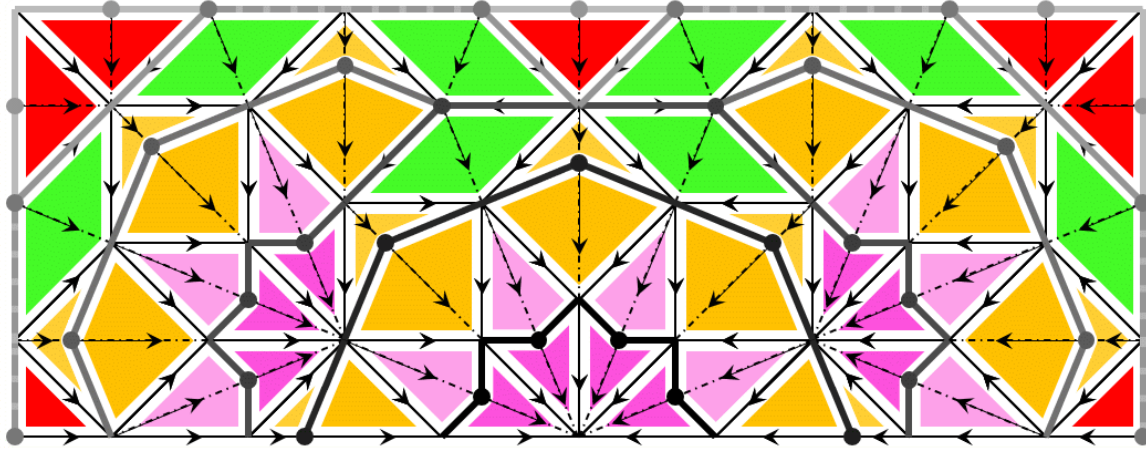
© Prof. Dr. Ayla Ödekan



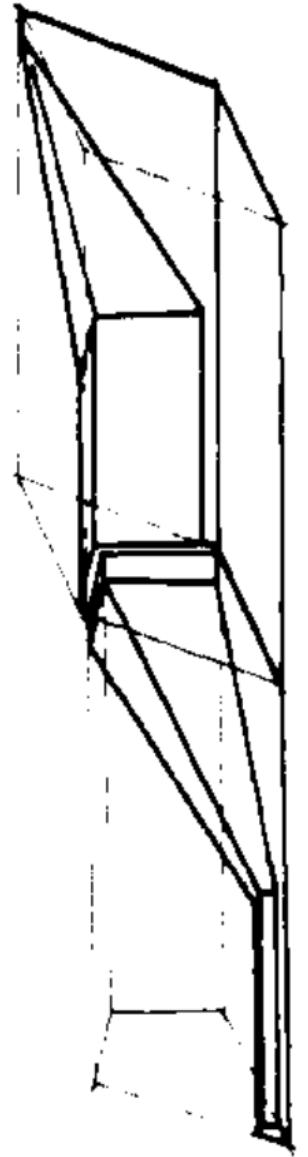
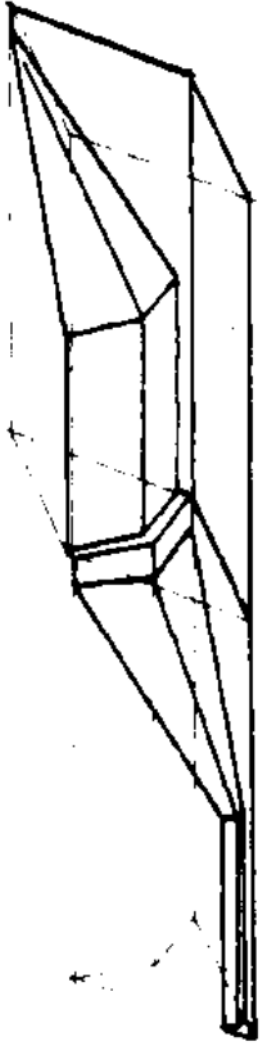
Afyon Tas Medrese



Afyon Tas Medrese



Example from Bursa Muradiye Complex



Example from Bursa Muradiye Complex

Exceptional pentagons



Click on a figure to open the corresponding webpage at www.henkhetbrink.nl/muqarnas

Istanbul Üsküdar Atik Valide Mosque

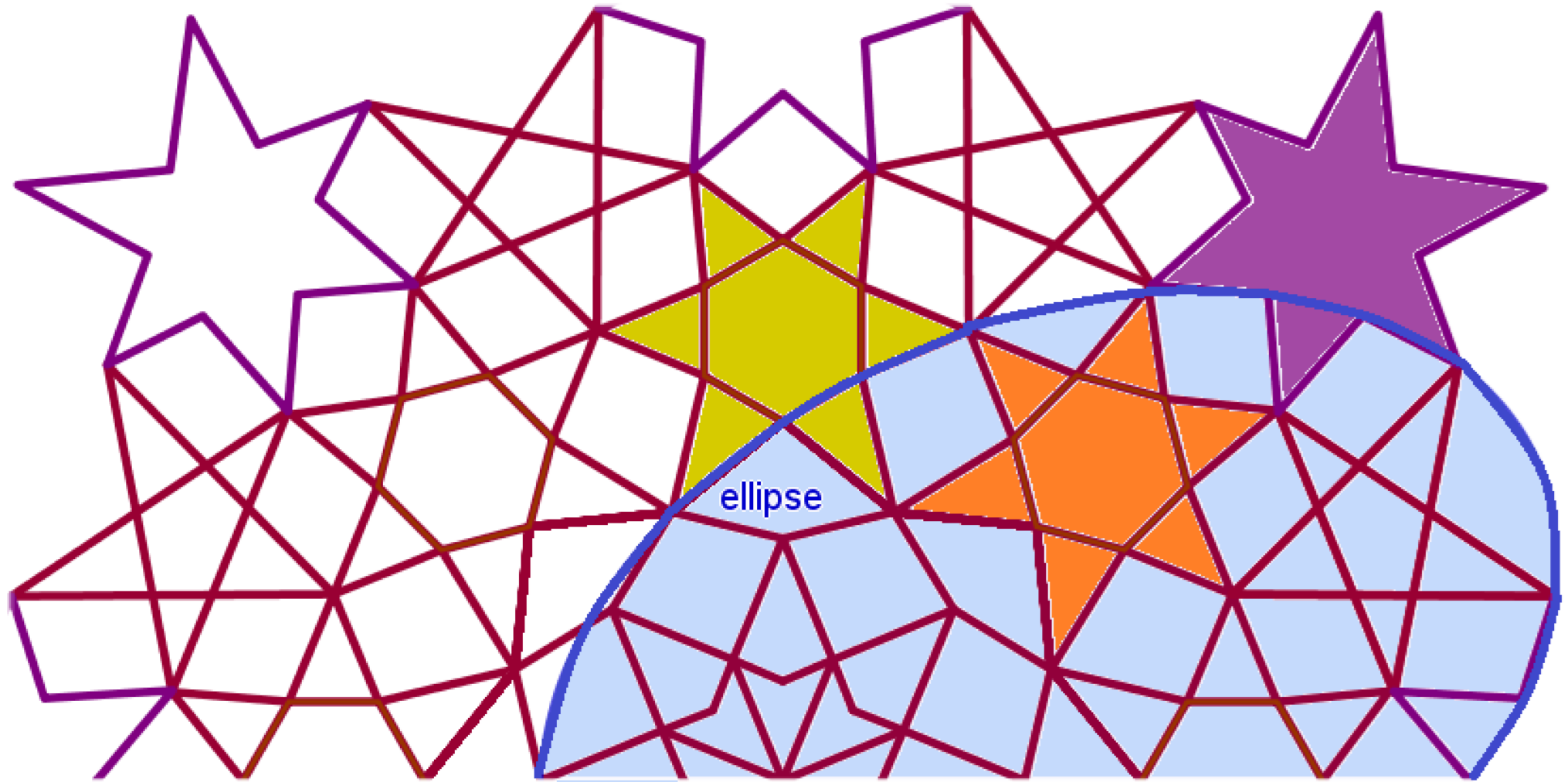
Curved lines, Pentagons, Hexagons



Click on a figure to open the corresponding webpage at www.henkietbrink.nl/muqarnas

New ideas about the grid

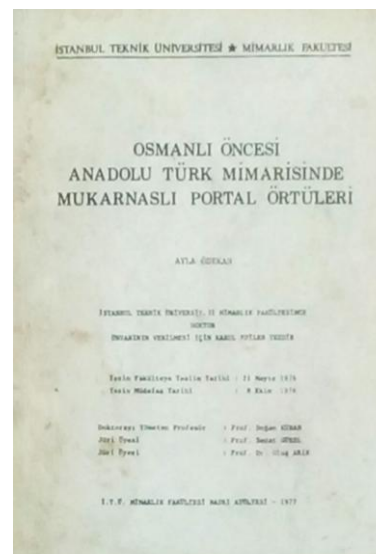
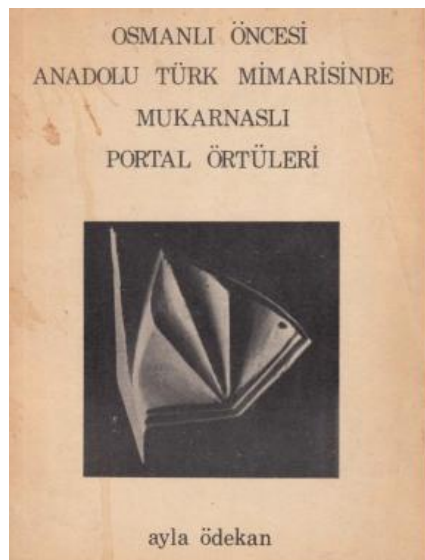
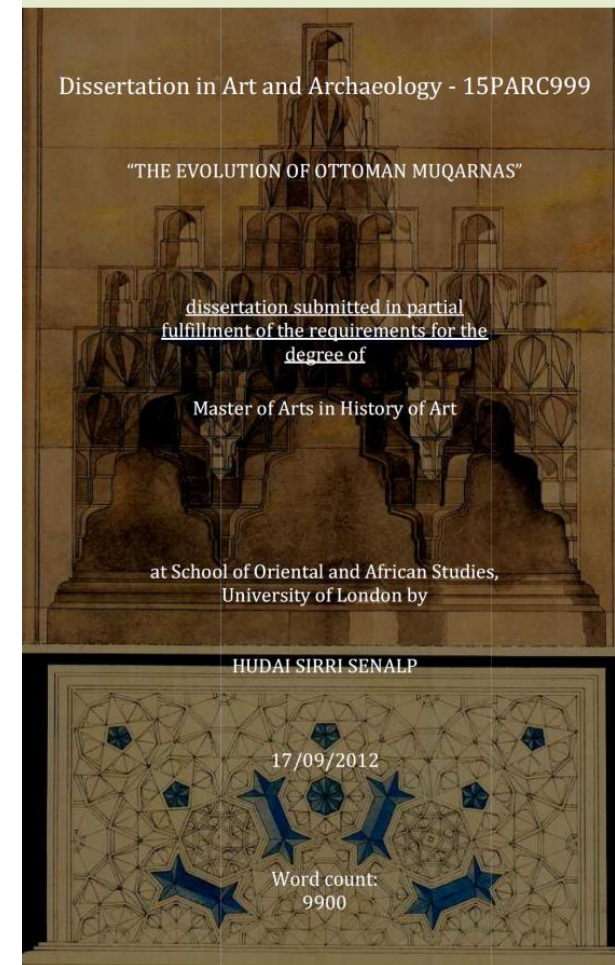
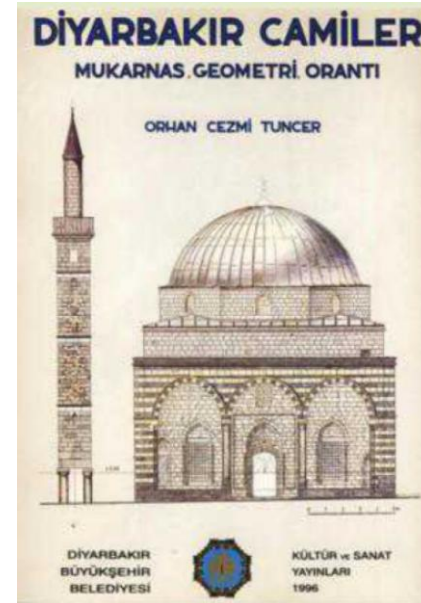
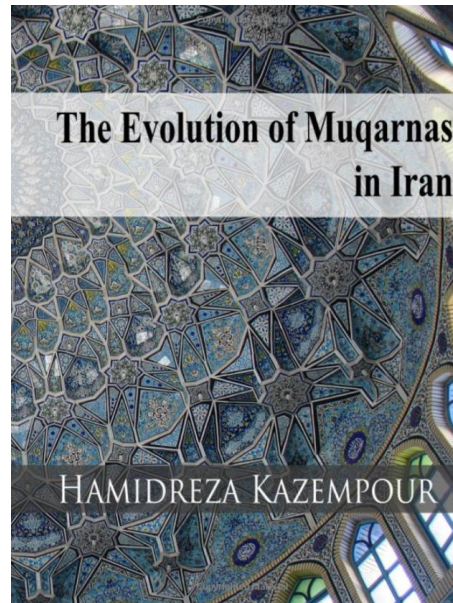
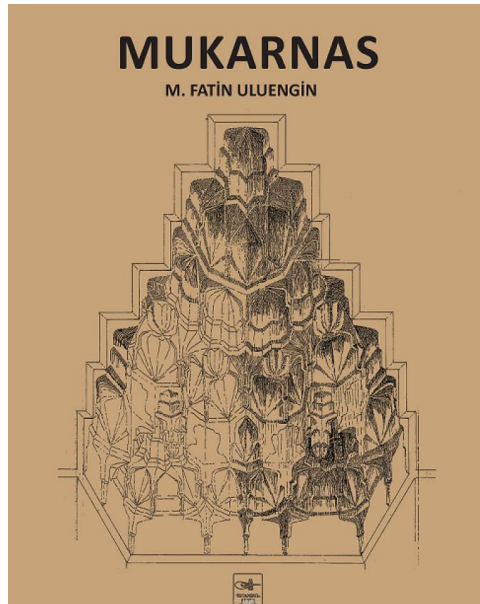
Agirbas suggests an elliptical grid



Conclusion

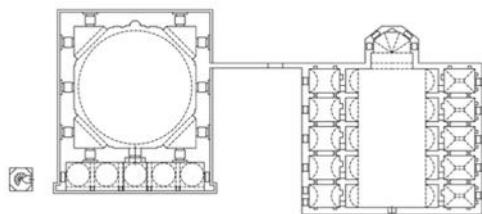
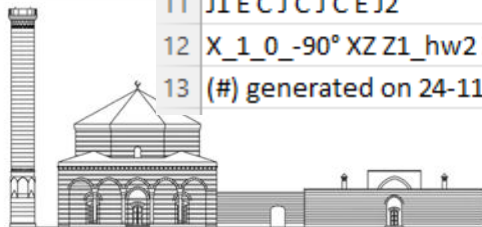
- **Muqarnas are not easy**
 - Huge variety
 - Exceptional constructions
 - It's art, not mathematics
- **Parametric software is a powerful tool**
 - Generating 2D floor plan
 - Generating 3D images and 3D prints
- **3D animations are essential**
 - to find correct interpretation of floor plans

Study muqarnas: read a book



Click on a figure to open the corresponding webpage at www.henkietbrink.nl/muqarnas

Create muqarnas: research, coding, modelling, 3D printing



Create

1 Diyarbakir Kasim Padisah Son Cemaat Yeri

2

3 (#) Tuncer page 223

4 (#) >_D,M,N)

5 (%_hw2_1_1) M

6 (%_hw2_1_1) D1 N D2

7 (%_hw4p2w2_1_1) I1 D I2

8 D~H D

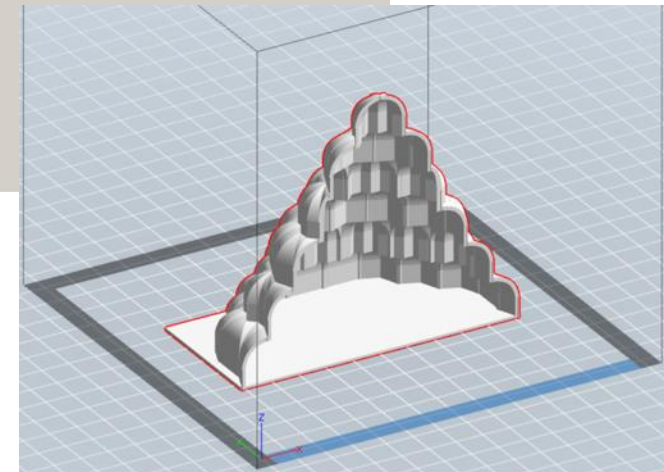
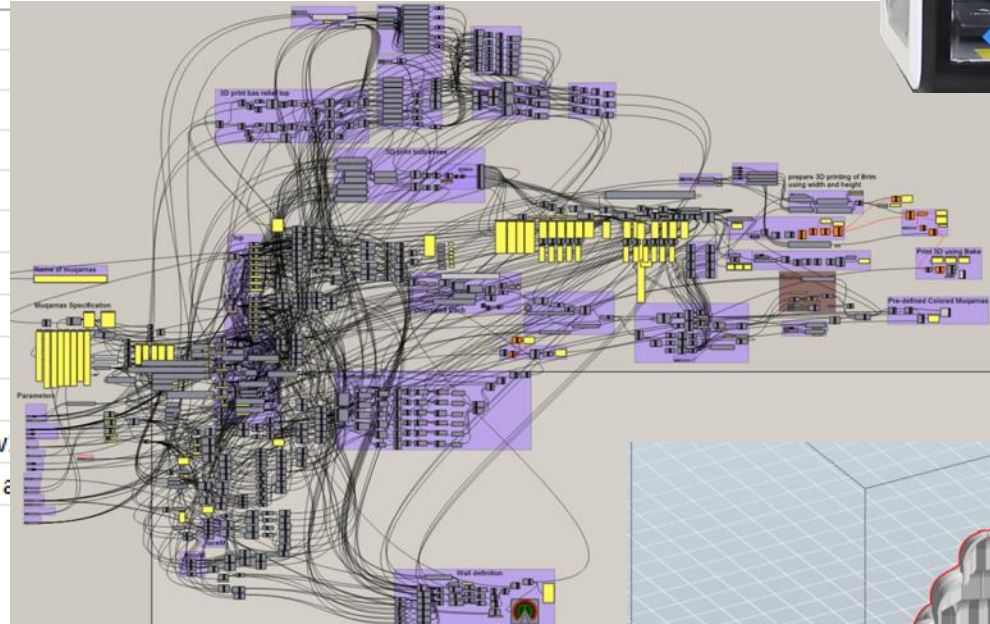
9 M C J C J C M

10 D1 N D I I I D N D2

11 J1 E C J C J C E J2

12 X_1_0_-90° XZ Z1_hw2 Z2_hw

13 (#) generated on 24-11-2021 a



Thanks for your attention



Exercises

Thank you for your attention.

This QR code brings you to my website.

